

ISTS-IUFRO Conference
on
**“Sustainable Resource Management
for
Climate Change Mitigation and Social Security”**

March 13-15, 2014

Souvenir cum Abstracts



Organized by



INDIAN SOCIETY OF TREE SCIENTISTS

Solan, Himachal Pradesh – 173 230



**INTERNATIONAL UNION OF
FOREST RESEARCH ORGANIZATIONS**

Vienna (Austria)

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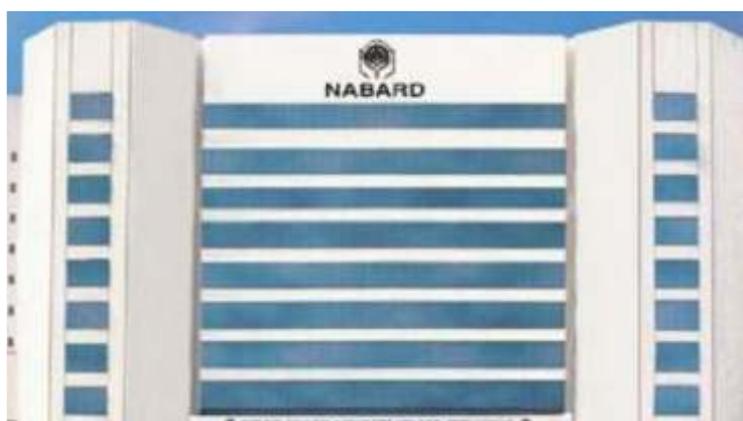
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ISTS-IUFRO Conference
on
**“Sustainable Resource Management
for
Climate Change Mitigation and Social Security”**
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Editors

K.S. Verma

Pankaj Panwar

Rajesh Kaushal

Sanjeev Chauhan

Jagdish Chander

R.S. Chandel

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INDIAN SOCIETY OF TREE SCIENTISTS

Solan, Himachal Pradesh – 173 230



INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

Vienna (Austria)



डा. गुरबचन सिंह
अध्यक्ष

DR. GURBACHAN SINGH
CHAIRMAN



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(भारतीय कृषि अनुसंधान परिषद्)
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Telegram: AGRECBOARD
E-mail: gurbachansingh@icar.org.in

MESSAGE

I am indeed very happy to know that the Indian Society of Tree Scientists in collaboration with the International Union of Forestry Research Organizations is organizing a conference on "Sustainable Resource Management for Climate Change Mitigation and Social Security" during March 13-15, 2014 at Chandigarh.

In India, about 80% of the population still lives in the rural areas. The conference holds a special significance to mitigate the rural farm and environmental problems. The climate change pose a big challenge in front of the scientific community around the globe and must be addressed in appropriate perspective so as to evolve and adopt improved and efficient, environmentally safe technologies and practices. The major concern today is to sustain the production so as to ensure sufficient food supply to the ever increasing population and the focus should remain at optimum resource utilization rather than exploitation.

I sincerely feel that the deliberations during the conference will go along way in finding solutions to the problems faced by the agrarian society guided by the climate change besides ameliorating the economic conditions of farmers by chalking out suitable eco-friendly strategies.

My best wishes for the success of the conference.

Guril
5/3/2014
(Gurbachan Singh)



DR. VIJAY SINGH THAKUR
Vice Chancellor



**Dr YS Parmar University of
Horticulture and Forestry
Nauni, Solan-173 230
Himachal Pradesh (INDIA)**

MESSAGE

India has attained self sufficiency in food production but food security is incomplete without ensuring nutritional security of the people. Low input use efficiency and over exploitation of natural resources especially land, soil, water and bio-diversity conjoint to the climatic threats have jeopardized the sustenance of the millions of poor people across the globe. Horticulture plays an important role in ensuring nutritional security and economic growth. However, fruit and vegetable production systems also require a paradigm shift in developing production technologies compatible with future climatic scenarios.

The conference on "Sustainable Resource Management for Climate Change Mitigation and Social Security" being organized during March 13-15, 2014 at Chandigarh by the Indian Society of Tree Scientists and the International Union of Forestry Research Organizations, I am sure the organizers will succeed in meeting the challenges before all of us.

I convey my good wishes for the success of the conference

(Vijay Singh Thakur)





ਡਾ. ਬਲਦੇਵ ਸਿੰਘ ਢਿੱਲੋਂ
ਕੁਲਪਤੀ

DR. BALDEV SINGH DHILLON
FNA, FNAASM FNASc, FPAS
VICE CHANCELLOR



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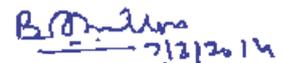
MESSAGE

I am pleased to learn that the Indian Society of Tree Scientists in collaboration with the International Union of Forest Research Organizations is organizing a conference on "Sustainable Resource Management for Climate Change Mitigation and Social Security" during March 13-15, 2014 at Chandigarh.

The destruction of the world's natural resources especially soil, water, air and agro-biodiversity is vital issue to the mankind. These issues are not confined to the national borders. During the coming years, the well being, the health and the quality of life of the people will be depending on our understanding of these vital problems and of efficient use of our natural resources.

I am sure that this gathering of scientists, administrators and other field functionaries will come out with some cogent and viable suggestions and recommendations to meet the emerging problems of climate change and management of depleting natural resources.

I wish the deliberations of the conference a great success.


2/12/2014

(B.S. Dhillon)





प्रो. (डॉ) पी.एल. गौतम
कुलपति

Prof. (Dr.) P.L. Gautam
Vice Chancellor



**CAREER POINT
UNIVERSITY**
Hamirpur (H.P.) 176041

MESSAGE

I am glad to learn that the Indian Society of Tree Scientists and the International Union of Forestry Research Organizations are organizing a conference of "Sustainable Resource Management of Climate Change Mitigation and Social Security" during March 13-15, 2014 at Chandigarh.

The green revolution helped the farmers achieve the food grain production to meet the food requirements of increased population pressure. Now there is time for another revolution which may be "Evergreen Revolution", which can be achieved through the use of natural resources in a manner that the production can be sustained under the changing climatic conditions. The conference will provide an opportunity to establish synergistic positive interactions among different stakeholders including the farming community, industry, scientists, administrators and planners.

I congratulate the organizers and extend my best wishes for the success of the conference.

(P.L. Gautam)





P.K. Khosla
Vice Chancellor
President,
Indian Society of Tree Scientists



**SHOOLINI
UNIVERSITY**

MESSAGE

I am indeed very happy that Indian Society of Tree Scientists and International Union of Forest Research Organizations are organizing a conference on Sustainable Resource Management for Climate Change, Mitigation and Social Security during March 13-15, 2014 at Chandigarh.

Accelerating environment degradation is eroding the natural asset base of poor rural people. About one billion of the world's 1.4 billion extremely poor people live in rural areas and depend on agriculture and related activities for their livelihoods. Poor rural people, including smallholder farmers, fisher, pastoralists, agroforesters and indigenous peoples - are central to both the causes of and solutions for sustainable environment and natural resource management. Sustainable natural resource management are fundamental in poverty reduction and mitigating the climate change. The integration of adaptation and mitigation strategies with sustainable utilization of land, water and forest resources will certainly benefit the human kind in sustaining the livelihood and accelerating the economic growth in an environmentally benign way.

I am sure all participants and the organizers together succeed in finding a way forward.

I wish grand success to the Conference.

(P.K. Khosla)





Dr. K.K. Katoch
Vice Chancellor



चौ. स. कु. हिमाचल प्रदेश
कृषि विश्वविद्यालय
पालमपुर – 176 062 (हि. प्र.)
**CSK-HIMACHAL PRADESH
AGRICULTURAL UNIVERSITY**
Palampur - 176 062 (HP) India

MESSAGE

It gives me immense pleasure to know that the Indian Society of Tree Scientists in collaboration with the International Union of Forestry Research Organizations is organizing a conference on “Sustainable Resource Management for Climate Change Mitigation and Social Security” during March 13-15, 2014 at Chandigarh. The conference will provide a platform for the different stakeholders to share their knowledge earned and skills acquired.

The scientific community around the globe and across the disciplines has assessed the effects, situations and evolved strategies for sustainable production, food and livelihood security under different situations. However, climate change has alarmed the planners, administrators and scientists with the effects becoming increasingly pronounced with the anthropogenic activities. To draw the roadmap for climate change mitigation and sustaining the natural resources production potential under the given climatic scenario, there is an urgent need for researchers, academicians, field functionaries and administrators to come together. Such a wide spectrum congregation, gathered for the noble cause with underlying objective of efficient and sustained utilization of natural resources, enlightens the society emanating rays of hope towards the common future of the mankind.

I wish the conference a grand success.

(K.K. Katoch)



EDITORIAL

It is a matter of great privilege and honour for the Indian Society of Tree Scientists (ISTS) to organize an international conference “Sustainable Resource Management for Climate Change Mitigation and Social Security” (March 13-15, 2014) in collaboration with International Union of Forestry Research Organizations (IUFRO) on issues of current importance in the city beautiful, Chandigarh. Country is blessed with almost all types of resources but the nation today faces a near crisis situation, both economic as well as environmental. This is particularly the outcome of overuse and abuse of the various natural resources under the inflating population pressure, urbanization and industrialization. The degradation is visible in all the renewable and non-renewable resources. But sustainability of resources is key to all developments, which probably is missing due to stress to produce more and more.

Indian Society of Tree Scientists was established in the year 1981 with the objective to advance and spread the knowledge of tree sciences in all aspects. The present International conference is one such effort of ISTS to bring together researchers, administrator and stake holders in sustainable resource management *vis-a-vis* climate and social security. Society has been receiving constant support from the IUFRO, which promotes global cooperation in forest related research and enhances the understanding of the ecological, economic and social aspects of forests and trees.

In the proposed ISTS-IUFRO conference, scientists, policy makers, managers, industrialists, etc. have expressed their interest in the resource conservation, climate change mitigation and livelihood security and more than 231 abstracts have been submitted for presentation (69 oral and rest 162 posters). We expect these issues will be discussed in length during the conference to plan future course of action to manage the natural resources judiciously. Many renowned internationally scientists (Dr Gurbachan Singh, Chairman ASRB, New Delhi; Dr P L Gautam, Vice-Chancellor, C.P University; Dr. S K Sharma, Former Vice Chancellor HPKV; Dr VS Thakur, Vice Chancellor, UHF Solan; Dr PK Mishra, Director CSWCRTI Dehradun; Dr (Mrs) M Maheswari, Director CRIDA Hyderabad; Dr. D K Benbi, National Professor, PAU; Dr. P K Khosla, President ISTS, etc.) have consented to participate and share their rich experiences. We are thankful to them all for their support and guidance in making this conference successful. We are thankful to all the sponsors for their liberal funding, without their support it would not have been possible to make this conference successful. We would like to acknowledge the gracious support of everyone who has directly or indirectly contributed towards this endeavour, particularly to all the contributors of abstracts, their organisations and other distinguished participants for their enthusiasm and best wishes. We are thankful to the progressive farmers and industry participants for sharing their valuable experiences to shape the future research and policy issues.

It is with great pleasure, editorial team extend their gratitude to all stakeholders specifically to NABARD for financial support to get this abstract booklet printed for the participants and hope they will find this conference informative, enjoyable and memorable. We wish a comfortable stay of all the participants at Chandigarh during this conference and hope they will carry back memorable moments.

Editors

**Organizing committee for the ISTS-IUFRO Conference on
“Sustainable Resource Management for Climate Change Mitigation and Social Security”
at
Entrepreneur Development Centre, IT Park, Chandigarh (March 13-15, 2014)**

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INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

(www.iufro.org)

Forests play a vital role for rural as well as urban populations all over the world. They are an essential natural resource providing multiple benefits to people. Their conservation and sustainable management are closely linked with global issues such as food supply and environmental protection. Scientific knowledge is needed all over the world to effectively address these issues globally and regionally and provide the technical basis for political decisions. Close international cooperation in forest science and related disciplines is required to enable forests to satisfy the manifold human needs in a sustainable way.

IUFRO is “the” global network for forest science cooperation. It unites more than 15,000 scientists in almost 700 Member Organizations in over 110 countries, who cooperate in IUFRO on a voluntary basis.

IUFRO mission is to promote the coordination of and the international cooperation in scientific studies embracing the whole field of research related to forests and trees for the well-being of forests and the people that depend on them.

IUFRO is open to all individuals and organizations dedicated to forest and forest products research and related disciplines. It is a non-profit, non-governmental and non-discriminatory organization with a long tradition dating back to 1892.

IUFRO stakeholders are research organizations, universities and individual scientists, NGOs, decision making authorities, forest land-owners and other people who depend on forests.

IUFRO attains its objectives by networking activities including the generation, exchange and dissemination of scientific knowledge, the provision of access to relevant information, and the assistance to scientists and institutions to strengthen their research capacities.

IUFRO vision is of science-based sustainable management of the world's forest resources for economic, environmental and social benefits.

IUFRO is exceptional, because it is the only world-wide international organization devoted to forest research and related sciences. It contributes to the promotion of the use of science in the formulation of forest-related policies.

IUFRO in Regions

- Africa
- América Latina
- Asia Pacific
- Northeast Asia

IUFRO has been devoted to global science cooperation since its creation more than 110 years ago. Due to a rapidly progressing globalization of society, there is an increasing need to expand and intensify cooperation within regions as well as between the regional and the global level. To meet these demands, IUFRO has been promoting collaboration among its member organizations as well as with regional networks of individual researchers and institutions by various means.





It has established a system of regional IUFRO Chapters which comprise groups of IUFRO members in a geographic region seeking closer collaboration within the IUFRO framework. IUFRO recognized the Asia Pacific Association of Forestry Research Institutions (APAFRI) as its Asia Pacific Chapter and the Northeast Asian Forest Forum (NEAFF) as its Northeast Asia Chapter. It also maintains close cooperation with regional networks and institutions in Africa and Latin America.

IUFRO's Special Programme for Developing Capacities promotes and supports science cooperation in regions by means of capacity development activities such as training courses and workshops in research management and extension; and collaborative thematic networking activities among scientists and institutions from different countries and regions.

In the future, IUFRO will strive towards further strengthening its cooperation with regional networks and institutions to promote synergies in collaborative research work and to further develop the research capacity of individual scientists and institutions in the regions.

IUFRO's Strategy

IUFRO Strategy 2010-14 addresses Research and Institutional Goals at the same time. The Research Goals strongly focus on the following six thematic areas:

Forests for People

- (Agro) Forestry, food security and livelihoods (including fuel wood)
- Forests and human health, recreation and nature-based tourism
- Economic benefits through the use of forests, goods and services
- The role of forests in landscapes and in urban areas

Forests and Climate Change

- Climate change impacts on forest ecosystems (including insects and pathogens) and forest-dependent people
- Feedbacks between land cover dynamics, forest disturbance processes and climate change (e.g. C, aerosol emissions, albedo changes)
- Options for adaptation and trade-offs between adaptation, conservation and/or socio-cultural needs
- Reducing Emissions from Deforestation and Forest Degradation (REDD), and other opportunities for carbon mitigation, including governance and institutional arrangements

Forest Bioenergy

- Resource competition, environmental and social impacts, cascades of use and life-cycle analysis
- Eco-efficiency' of forest bioenergy production systems and technologies
- Marketing of bioenergy and economic impacts

Forest Biodiversity Conservation

- Impacts and effects of biodiversity loss at various levels, including genetic resources
- Landscape-level strategies for biodiversity conservation (including fragmentation, conflicting land uses, role of plantations for biodiversity conservation, etc.)
- Ecosystem services of forest biodiversity, forest ecosystem resilience and adapted forest management for protected areas.

Forest and Water Interactions

- Effects of land-use and land-cover change on watershed hydrology
- Forest and water interactions under conditions of climate change, and response options





- Region specific interactions of forests and water (incl. water consumption of forest plantations, erosion
- Riparian and coastal ecosystems

Resources for the Future

- Trends in demand for innovative forest products, ecosystem goods and services and conflicting needs
- Management options (including conservation, avoided degradation, restoration concepts)
- Globalization and changes in governing systems

The three Institutional Goals adapted from the previous Strategy present IUFRO's commitment to high-quality science and interdisciplinary cooperation, to better visibility of science-based research findings and increased ability of responding to new and unexpected issues:

- To strengthen research and expand IUFRO's capacity for interdisciplinary cooperation
- To strengthen coordination within the scientific community and increase visibility of science-based research findings
- To further strengthen IUFRO's work at the science-policy interface

Attaining both research and institutional goals should help IUFRO and its members to effectively respond to the changes in paradigms concerning forests and forest science and to position itself as a truly global network for forest science cooperation.

IUFRO in International Processes

Forests are an issue that is addressed by a number of international conventions and policy processes. There are also several international and regional organizations that are active in the field of forestry. Forest science must, thus, strive at continuous interaction and collaboration with these policy actors at global and regional levels in order to enhance research uptake and make a stronger impact.

In recent years IUFRO, as a representative of forest science, has succeeded in systematically strengthening its participation in international processes and has provided various thematic contributions. In the Collaborative Partnership on Forests (CPF), for example, IUFRO cooperates with major forest-related international organizations, institutions and convention secretariats. IUFRO aims at making its scientific work even more relevant to policy and decision-makers in the future by addressing areas of prime concern for sustainable development and human well-being.





INDIAN SOCIETY OF TREE SCIENTISTS

Indian Society of Tree Scientists was conceived in November, 1980 and registered in December, 1981 as a Society with a mission to create a platform for the development of tree sciences, in general, with a multidisciplinary approach to improve the tree resources, with headquarters at Solan. It has the following objectives:

- To advance and spread the knowledge of tree sciences in all aspects by holding meetings, symposia, memorial lectures.
- To give awards/medals to honour persons(s) who have made outstanding contributions in tree sciences.
- To bring under one platform, tree scientists, professional foresters and all others interested in the activities of the society.
- To project the importance of trees in the overall economy of the country and their role in preservation/preserving the ecological balance in the nature.
- To provide technical know-how to forest based industries.
- To provide technical know-how to rural people for planting fodder, fuel, fiber, fruits and fast growing trees in order to promote small scale industries, in general and dairy industry in particular.

MEMBERSHIP OF THE SOCIETY:

The membership of the Society is open to persons actively involved in research or interested in trees or their natural products, industries, commercial or other organizations dealing with forest wealth/products or associated fields. It has the following kind of membership:

1. Honorary: No subscription (Persons of eminence whose technical cooperation to promote the interest of the Society, may be nominated as honorary members by the Governing Body).
2. Life Member: Rs.5000/- or its equivalent within Indian subcontinent and US Dollar 150 for other countries. The fee can be paid in lump sum or in four installments after registration.
3. Ordinary Member: All individuals who pay the prescribed fee as determined by the Governing Body, currently Rs. 500/- within Indian Sub-continent and \$50 for other countries + admission fee of Rs. 50-.
4. Institutional/Affiliate Members: All organizations/individuals interested or engaged in activities involving trees and donate towards the Society funds will be the Institutional/Affiliate members of the Society. The membership shall be valid for three years only.

ORGANIZATIONAL SET UP :

The organizational structure of the Society is made up of a General Body, which comprises of all categories of members and is the supreme authority for regulating the affairs of the Society. All members have a voting right to regulate the functioning of the Society. The members elect a Governing Body, which is the prime executive body of the Society.

The Governing Body effective w.e.f January 2014 is as under.



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AWARDS:

The Society has instituted two awards in memory of two great Indian forest scientists namely Sh.S.K.Seth and Prof. K.K.Nanda – the founder President of the Society. The Society also honours the best women social workers who are active in tree related activities.

PUBLICATIONS:

The Society publishes peer reviewed original research papers and reviews in tree sciences, half-yearly, in an international journal – 'Journal of Tree Sciences'. It has been in publication since 1981.

PRIVILEGES:

Members are entitled for a free copy of the Journal. The other publications of the Society are available to members at cost price.

For further information please contact:

INDIAN SOCIETY OF TREE SCIENTISTS

Dr.Y.S.Parmar University of Horticulture and Forestry

Nauni (Solan), Himachal Pradesh, India

E-mail: secretary@ists.in www.ists.in



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THEME

AGRICULTURE & HORTICULTURE



QUANTITY AND QUALITY OF CITRUS FRUITS IS AFFECTED BY THE EUCALYPTUS BOUNDARY PLANTATION

Sanjeev K Chauhan, R. Babuta*, Rajni Sharma, N. Gupta and W.S. Dhillon*****

*Department of Forestry & Natural Resources, *School of Climate Change and Agricultural Meteorology, ** Department of Soil Science, ***Punjab Horticulture Postharvest Technology Centre, Punjab Agricultural University, Ludhiana 141 004 (India)*

E-mail: chauhanpau@pau.edu; ritubabuta@gmail.com; wasakhasingh@yahoo.com

Wind breaks around the farm are created to check the adverse affects of hot and cold winds, but in Punjab state these are not raised for the protection of the crops but for additional income. But the windbreaks of timber trees adversely affect the fruit crops through competition for different resources including light, moisture, nutrients, etc. Such systems (horti-silvicultural) have very little been studied for biophysical and economic aspects. A study was conducted to quantify the effect of eucalyptus wind break on the citrus crop. Fruit tree growth, yield and fruit juice quality was affected, including competition for nutrition. The affect on tree growth, fruit yield and juice quality was variable on all the four directions and at different distances from timber tree line. Fruit tree growth was not much affected but the fruit yield on south and west direction of boundary was comparatively affected, though juice quality was not affected much. The per cent fruit yield reduction was in the tune of 65.55, 45.93, 45.18 and 58.44 in south, east, north and west direction, respectively. TSS was comparatively more near the tree line and decreased row after the row. Economically fruit and timber tree mixed cropping was found remunerative due to additive share of eucalyptus trees to the fruit crop yield. Eucalyptus trees also captures significant amount of carbon which can be put to long term locking. Results suggest to gainfully raising boundary trees during the initial years of orchard establishment.

FEASIBILITY OF AGRICULTURAL EXTENSION SERVICES FOR SUSTAINABLE DEVELOPMENT

Jasvinder Kaur*, Sushila Dahiya and P.S.Shehrawat***

*, *Dept. of Extension Education, College of Agriculture, **Dept. of Sociology*

Chaudhary Charan Singh Haryana Agricultural University, Hisar – 125 004 (Haryana)

E-mail: jasvinder.sidhu2012@gmail.com

In recent years, many developing countries, including India, are witnessing change of agriculture from mere subsistence to commercial, specialized and capital intensive, which requires quick and technically sound advice on production and marketing and do to so many private agencies has put their step forward. It's a fact that farming community get benefitted by the involvement of private agencies. In the view of this the study was undertaken to find out the feasibility of extension delivery mechanism of private agricultural extension agencies during 2011-12 in Ambala, Kurukshetra, Karnal, Hisar, and Fatehabad districts of Haryana state. A total number of 200 farmers were interviewd for the

study. After discussion with experts, 15 important services were identified to measure the feasibility. Farmers' responses were obtained on three-point continuum and the score were given accordingly. Ranking was also given on the basis of mean calculated scores against each service. Results showed that farmers had highest feasibility in 'High yielding varieties of crops' which ranked 1st followed by 'Vegetables and fruit production/flower production', 'Post harvest techniques' and 'Bio fertilizer/ bio pesticide' stood at 2nd and 3rd positions. Further 'Storage facilities', 'Field visits by private extension personnel' and 'Training program/ field day/ demonstration' occupied 4th, 5th and 6th place. While, 'Agricultural tools and implements' was placed at 7th rank. 'Crop protection techniques' and 'Diagnosis of pest and disease' jointly placed at 8th rank and 'Marketing information' at 9th place. 'Literature' and 'e-Information' jointly shared the 10th rank. 'Soil/water testing services' and 'Soil reclamation services' were placed at 11th and 12th ranks respectively. In case of overall feasibility majority of farmers were found to have medium to high feasibility in receiving the private extension services. The possible reasons could be high accessibility of private extension personnel with farmers.

INTEGRATED NUTRIENT MANAGEMENT FOR INCREASING LEAF YIELD IN *STEVIA REBAUDIANA*

Anil Kumar^{*}, L. M. Gupta, N.S. Raina, Stanzin landol and Aamir Reza

Division of Agroforestry

Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu, 180 009.

**E-mail: anilzkmr@gmail.com*

Stevia rebaudiana is in high demand due to presence of Stevioside and Rebaudioside A in its leaves, which is non-calorific and becomes an inevitable alternative to sugar. Besides sweetener, stevia is also used for treatment of various ailments such as cancer, diabetes, obesity, hypertension, fatigue, depression and in cosmetics and dental preparations. Due to its widespread use, there is a large scale demand for its leaves. The species can be successfully cultivated in subtropical plains and mid hills with assured irrigation. Production of leaves through cultivation will not only meet the demand of neutral-ceutical industry but will also help in diversification of the existing cropping scheme. To make it more economical and a profitable species, it is important to increase its leaf yield. Though the production can be increased by supplying the nutrients through chemical fertilizers, but their long term use may results in deterioration of soil quality. Keeping this in mind, a field experiment was conducted in the experimental farm of Division of Agroforestry, SKUAST-J, Chatha, Jammu with different combinations of manures and fertilizers to find out their effect on growth and yield of Stevia. Chemical fertilizers though performed better than control but leaf yield was more when 50% of recommended dose of nitrogen was substitute by vermicompost. From the present investigation, it was observed that application of manure, fertilizers and bio-fertilizers is not only necessary to achieve higher leaf yield but to maintain the fertility status of soil.

RESPONSE OF SOIL MICROFLORA TO VARIOUS PESTICIDES

I.D. Sharma¹ and R.S. Chandel²

¹*Pesticide Residue Laboratory, Department of Entomology, Nauni, Solan -17 3 230 (HP)*

²*Regional Horti. Research & Training Station and KVK Sharbo, Kinnaur - 172 107 (HP)*

Dr. Y.S. Parmar University of Horticulture and Forestry

Soil has millions of tiny organisms including fungi, bacteria, and a host of others. These microorganisms play a key role in helping plants utilize soil nutrients needed to grow and thrive. Microorganisms also help soil to store water and nutrients, regulate water flow, and filter pollutants. Modern agriculture largely relies on the extensive application of agrochemicals, including inorganic fertilizers and pesticides. The ultimate "sink" of the pesticides applied in agriculture and public health care is soil. Indiscriminate, long-term and over-application of pesticides have severe effects on soil ecology that may lead to alterations in or the erosion of beneficial or plant probiotic soil microflora. These pesticides also influence soil biochemical processes driven by microbial and enzymatic reactions. The key enzymes are dehydrogenase, phosphatase and urease. To assess the impact of pesticide on soil microflora, a study was conducted on tomato cropped soil. Mancozeb, endosulfan and chlorpyrifos (recommended pesticides) were investigated to study their effects on microbial population, CO₂ evolution (microbial activity) and enzymatic activities. The experiment was carried out under *in vitro* conditions. Tomato cropped soil was collected from top 0-15 cm layer at harvest. It was shade dried, ground in wooden pestle and mortar, sieved by passing through 2 mm sieve. Each soil sample (500g) was mixed with 50 and 100 mg/kg concentrations of each pesticide with four replications. The enzyme activity was measured colorimetrically, while soil respiration was measured by estimating CO₂ evolution. All the treatments were found to reduce the dehydrogenase as well as phosphatase enzyme activity significantly in comparison with control. The treatments were also found highly toxic to the soil micro flora showing mortality from 70-80 per cent. Also major biotic process such as respiratory activity was highly affected in the presence of all the pesticides.

EVALUATION OF INDIGENOUS AROMATIC RICE CULTIVARS IN NEW ALLUVIAL ZONE OF WEST BENGAL

Koushik Roy^{1*}, M. Ghosh¹, S. Dolui², A. Pal¹ and D. Mahata¹

¹*Department of Agronomy, ²Department of Agricultural Bio-chemistry*

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741242

**E-mail: roy.koushik64@gmail.com*

The increasing demand for small and medium grained aromatic rice in the recent-past focuses on evaluation, identification and large-scale cultivation of some promising cultivars in native areas of West Bengal. Thus, a field experiment was conducted to study the phenology, yield and quality of fourteen indigenous scented rice cultivars at 'C' Block Farm of Bidhan Chandra Krishi

Viswavidyalaya, Kalyani, Nadia, West Bengal, India during *Kharif* (wet) season of 2012. Mean cultivar days from sowing to emergence, 4th leaf emergence, active tillering, panicle initiation, 50% flowering, milk, dough and maturity stages were 4.2, 21.0, 47.6, 86.1, 118.7, 129.9, 138.1 and 148.6 days, respectively. All the cultivars were tall-statured (>130 cm) and long duration (>140 days) types, and had low or medium panicle producing ability (260.3-311.1 m²) and test weight (10.6-16.6 g). Based on grain yield, the varieties could be grouped as: NC 365, Kataribhog, Badshabhog and Kalojira, Radhatilak (≥ 3.0 t ha⁻¹), Kalonunia, NC 324, Gobindabhog and Radhunipagal (>2.5-3.0 t ha⁻¹), and Tulsimukul, Kaminibhog, Lalbadshabhog, Tulaipanji and Sitabhog (>2.0- 2.5 t ha⁻¹). Mean cultivar hulling, milling and head rice recovery were 77.5, 70.8, and 62.4%, respectively. Among 14 genotypes, five (Tulaipanji, Kalonunia, Kataribhog, NC 324 and NC 365) had medium slender (MS) kernels, while rest nine were of short bold (SB) types. Varietal differences in amylose content (16.02-20.85%), protein content (6.67-7.21%), kernel elongation ratio (1.56-1.93) and aroma (1.75-2.67) were noted in this study.

EFFECT OF GROWTH REGULATORS ON *LITSEA CHINENSIS* LAM. CUTTINGS.

Amir Raza, N.S. Raina, Sandeep Sehgal, Sudhakar Dwivedi, V.K. Razdan, S.K. Gupta,

M. Saleem and Stanzin landol

Department of Agroforestry

Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu

E-mail: aamirreza22@gmail.com

The present investigation was carried out at the experimental Farm, Division of Agro forestry, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Chatha during the year 2012-13. The investigation was conducted to work out the effect of cutting age and growth regulators on the growth and development of *Litsea chinensis* Lam. cuttings. The experiment was laid out in Factorial Randomized Block Design (RBD Factorial) with two cutting age classes (juvenile & mature) and 15 hormonal treatments (IAA, IBA and NAA each at 0, 500, 1000, 1500 and 2000 ppm concentrations). There were 30 treatment combinations in aggregate, which were replicated thrice. The parameters recorded were sprouting per cent, survival per cent, number of lateral roots, root length, fresh root biomass, dry root biomass, number of shoots, plant height, number of leaves, above ground biomass. The experimental results revealed that mature cuttings were statistically superior than juvenile cuttings with respect to sprouting per cent, number of shoots, number of leaves whereas there was no significant the effect observed in case of juvenile cuttings. The growth regulators significantly affected the sprouting per cent, survival per cent, number of leaves and above ground biomass but showed non-significant effect on number of lateral roots, root length, fresh root biomass, dry root biomass, number of shoots and plant height. The interaction of cuttings age x growth regulators for all the parameters was recorded statistically non significant.

CONSUMER SAFETY EVALUATION OF CAULIFLOWER AND CABBAGE FROM DIFFERENT PESTICIDES

RS Chandel, ID Sharma¹ and SK Patyal¹

Regional Horticultural Research & Training Station and KVK, Sharbo, Kinnaur -172 107 (HP)

^{1&2} *Pesticide Residue Laboratory, Deptt of Entomology*

Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan-173 230 (HP)

Cauliflower (*Brassica oleracea* L. var botrytis cv Snowball 16) and cabbage (*Brassica oleracea* L. var capitata cv Golden Acre) are important seasonal and off- seasonal cruciferous cash crops grown all over the hilly tract of western Himalayan range. These are attacked by many insect-pests and diseases like cabbage caterpillar (*Pieris brassicae*), diamond backmoth (*Plutella xylostella*), cabbage aphid (*Brevicoryne brassicae*), stalk rot (*Sclerotinia sclerotiorum* (Lib) de Baryl), bottom rot/head rot/Rhizoctonia root rot (*Rhizoctonia solani* Kuhn). To sustain the quality and productivity of these crops, the use of pesticides has become indispensable tool in the IPM programme. Keeping in view the growing awareness of consumers regarding healthy food and strict MRL regulations for export, studies were undertaken to determine the persistence of some pesticides in cauliflower and cabbage to work out their safety towards consumers. Each pesticide was sprayed at two concentrations i.e. recommended and double the recommended dose. The samples (curds/heads) were analysed for residue estimation at different intervals (0, 1,3,5,7,10,15,25 and 30 days) by gas chromatography except mancozeb which were analysed by spectrophotometry. The residue data for different pesticides were subjected to mathematical treatment for working out their half lives and safe waiting periods. The waiting periods calculated for endosulfan, carbaryl, quinalphos, fenvalerate and mancozeb were 7,11,8, 3 and 13 days on cauliflower and 4,5, 8, 1 and 27 days on cabbage, respectively. The half – life values for these pesticides ranged from 1.2-6.8 days.

BAEL (*AEGLE MARMELLOS*) BASED HORTIPASTORAL SYSTEM WITH MOISTURE CONSERVATION IN SEMI ARID CONDITION.

AK Shukla¹, Sunil Kumar, SN Ram, HV Singh, Santosh G Watpade¹ and KK Pramanick¹

Indian Grassland and Fodder Research Institute, Gwalior Road, Jhansi-336 004

¹*Indian Agricultural Research Institute, Regional Station, Shimla-171 004 (H P)*

E- mail: akshuklahort@gmail.com

Under rainfed condition monocropping is riskfull enterprise due to erratic nature of rainfall. Under such situation hortipastoral system (fruit tree + pasture, grass and /or legumes) is an important alternate land use system to fulfill the gap between demand and supply of fruit, fodder and fuel wood through utilizing IV and V type of land. In arid and semi arid agro ecosystem water is an important input and in-situ moisture conservation is a tool to provide regular moisture regime to root zone for proper growth and development of tree. Bael (*Aegle marmelos*) is an

important fruit species for arid and semi-arid ecosystem due to deep root system, tolerance to water stress, tolerance to high and low temperature, deciduous in nature. In hot summer leaves are dropped and plant start flowering in monsoon season and fruit matures in the month of May. Intercropping of perennial grasses with bael was fruitful under different moisture conservation practices for high biomass and fruit production in degraded land. The experiment was conducted during 2008-13 on bael cultivars CISH B-2 and NB-9 at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi. Tree was transplanted under square system of planting with 6 x 6m spacing. The understorey of each plot was intercropped with pasture viz; *Cenchrus ciliaris* + *Stylosanthes seabrana*. During the fifth year, tree height was ranged from 2.99-3.42 m in different treatments with maximum in stone mulch (3.42 m). Collar diameter was varied from 6.91-7.66 cm with maximum in stone mulch (7.66 cm) and minimum in control (6.91cm). Tree canopy varied from 1.94-2.49 m with maximum in stone mulch (2.49 m). Forage production was significantly influenced by different moisture conservation treatments and the maximum yield was recorded in staggered trench (7.35 t DM/ha) with minimum in control (5.32 t DM/ha). Fruit yield was maximum in Staggered trench (1.74 t/ha) minimum was found in control (1.11 t/ha).

EFFECT OF LIGHT ON DEGRADATION OF GLAUCINEHYDROCHLORIDE DURING STORAGE IN DRY CONDITIONS AND ORGANIC SOLVENTS

Som Dutt, A.K. Sharma, K.S. Verma and Kamal Sharma

Institute of Biotechnology and Environmental Science, Neri 177 001 Hamirpur (HP)

E-mail: sdsharma15366@gmail.com

Glaucium flavum Crantz a biennial herb, commonly known as Yellow Horned Popy belongs to family Papaveraceae. It is a rich source of Glaucine, an antitussive alkaloid used in cough syrups. Glaucine is not a stable compound and gets degraded in the presence of light. Hence, the present study was conducted to provide stability to this compound by transforming it into Glaucinehydrochloride. Glaucinehydrochloride was prepared by dissolving 500 mg of glaucine in benzene and by passing HCl gas through it. The effect of light was studied on degradation of Glaucinehydrochloride during storage in dry conditions and organic solvents. The results obtained on stability of Glaucinehydrochloride in dry condition indicated that it is a quite stable compound as degradation was insignificant. Maximum decrease in Glaucine i.e. 0.02 mg per 5 mg Glaucinehydrochloride was recorded in the samples stored under light for 60 days. However, no decrease in Glaucinehydrochloride was detected under dark for storage even up to 60 days. Storage of Glaucinehydrochloride in organic solvents indicated that maximum amount of Glaucinehydrochloride (4.92 mg) was found when it was stored in ethanol under dark conditions and minimum (4.88 mg) when stored in chloroform under light conditions. Maximum mean value of degradation of Glaucinehydrochloride (2.44 %) was observed in chloroform under light conditions and minimum (1.56 %) in ethanol under dark conditions. Thus, from this study it was concluded that the degradation of Glaucinehydrochloride in dry form and in chloroform or ethanol solvents was statistically insignificant.

SUGAR BEET (*BETA VULGARIS* L) PULP REMEDIATION THROUGH VERMITECHNOLOGY

Sartaj Ahmad Bhat, Jaswinder Singh¹ and Adarsh Pal Vig*

Department of Botanical and Environmental Science, Guru Nanak Dev University, Amritsar

^aDepartment of Zoology, Khalsa College Amritsar, Punjab

E-mail: dr.adarshpalvig@gmail.com, singhjassi75@yahoo.co.in

The aim of present work was planned for the vermiremediation of sugar beet pulp (SBP) from sugar factory into nutrient-rich vermicompost using earthworm *Eisenia fetida*. The sugar beet pulp was mixed with cattle dung in different ratios of 0:100 (SBP₀) (control), 10:90 (SBP₁₀), 20:80 (SBP₂₀), 40:60 (SBP₄₀) and 80:20 (SBP₈₀) (SBP: cattle dung) on dry weight basis. The minimum mortality and highest population size of worms were observed in 10:90 mixture of sugar beet pulp and cattle dung. However, increasing percentages of pulp significantly affected the growth and fecundity of worms. Nitrogen, sodium, potassium, phosphorus and pH increased from initial in the range of 10.5–333.8%, 21.1–29.1%, 218.1–426.2% and 3.2–33.5%, respectively. On the other hand C/N ratio, total organic carbon and electrical conductivity decreased in the range of 36.3–85.5%, 20.8–36.9% and 1.6–37.7%, respectively. The concentration of heavy metals increased significantly in the end products from the initial value and was within the permissible limit. Vermicomposting with *E. fetida* was better for option to change this pulp into nutrient-rich manure in a short period of time

EVALUATION OF POMEGRANATE CULTIVARS UNDER SUBTROPICAL CONDITIONS IN SUBMONTANE LOW HILL ZONE OF HIMACHAL PRADESH

Rajesh Kaler and S. S. Rana*

Litchi and Mango Research Station, Nagrota Bagwan, Distt. Kangra– 176 047 (HP)

**Regional Horticultural Research Station, Jachh (Nurpur) Distt. Kangra-176 201 (HP)*

Dr. Y. S. Parmar University of Horticulture and Forestry

Email: rajesh_papahan@rediffmail.com

Six cultivars of pomegranate namely : Kandhari Kabuli, Kandhari Hansi, Chawla, G – 137, Mridula and Bhagwa were tested for their fruit quality at the experimental farm of Regional Horticultural Research Station, Jachh (Nurpur) H.P. The climate of the zone is hot and dry during summer and hot and humid during rainy season (July – September). Study revealed that in term of fruit size Kandhari Kabuli, Kandhari Hansi and G – 137 were observed the best varieties in the hot and the humid zone of the Himachal Pradesh. Mridula and Bhagwa produced the small sized fruits . Fruit shape was observed globose in all the cultivars except Chawla where the fruit shape was oblate. Fruit colour very from greenish yellow in G-137, red in Kandhari Kabuli , Kandhari Hansi and yellowish pink in Chawla . Large fruited cultivars such as Kandhari Kabuli, Kandhari Hansi and G – 137 have significantly thicker rind when compared to the small fruited

cvs. such as Bhagwa and Mridula. Aril size and weight was observed significantly higher in Kandhari Hansi followed by G – 137 and Kandhari Kabuli. Aril percentage was observed significantly more in large fruited cultivars when compared to the small fruited cultivars mainly the Bhagwa . Juice content was vary from 63.4 per cent in Chawla to 72.4 per cent in G – 137 . Total Soluble Solids were observed maximum (14.4 %)in Bhagwa followed by Kandhari Hansi . Percent acidity was observed maximum (0.80)in Kandhari Kabuli followed by Kandhari Hansi (0.72). Fruit of Chawla cultivar was observed less acidic. All the cultivars tested were observed susceptible to the anar butter fly. Nutrient dynamics for cropping behavior of Pistachio plantations in Dry Temperate Ecosystem

NUTRIENT DYNAMICS FOR CROPPING BEHAVIOR OF PISTACHIO PLANTATIONS IN DRY TEMPERATE ECOSYSTEM

Pramod Kumar^a, Rajeshwar S. Chandel^a, Satish K. Sharma^b, Anil Kumar^a and Joginder Singh^a

^a *Regional Horticultural Research & Training Station, Sharbo (Reckong Peo), Kinnaur (HP)*

^b *Directorate of Research, Nauni, Solan-173 230 (HP)*

Dr Y S Parmar University of Horticulture & Forestry,

E-mail: pk43sharma@yahoo.co.in

Application of nutrients has a significant and vital effect on yield and productivity of nut plantations. In general, although fertilizers have played an important role in pistachio (*Pistacia vera* L.) production, It is imperative to evaluate the nutrient use efficacy to the standardize dose of application. We investigated the cropping behavior usually need to get high nut yield and quality as mainly the blooming non-contemporaries in dry temperate ecosystem of India. The aim of this research was designed in order to determine the effect of nitrogen (N), phosphorus (P), potassium (K) and boron (B) fertilization on vegetative growth attributes, fruit set and nut yield and quality of pistachio plantations. N, P, K and boron nutrition has been largely ignored. Limited use of fertilization could be partially attributed to a scarce knowledge of nutrient requirement and lack of documented effects on improving nut yield and quality in pistachio nut. The results inferred that the foliar application of B as boric acid @ 0.3% starting at early bud break to flowering stage, leafing out stage and fully expanded leaf stage along with soil application of NPK fertilizers @ 600 g tree⁻¹ Calcium ammonium nitrate, CAN; 600 g tree⁻¹ Single super phosphate, SSP; and 800 g tree⁻¹ Muriate of potash, MOP in the month of February resulted in improved plant height, stem diameter, leaf area, bloom density, percent fruit set, nut yield and quality characteristics.

SELECTION OF ELITE GENOTYPES OF OKRA (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH.) FOR YIELD AND HORTICULTURAL TRAITS IN MID-HILL CONDITIONS OF HIMACHAL PRADESH

Sudip Chandra¹, ML Bhardwaj¹, Dharminder Kumar^{1*}, Sandeep Kumar¹ and N Bharat²

¹Department of Vegetable Science

²Department of Plant Pathology

Dr Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan-173 230 (HP)

E-mail: dharmruder@gmail.com

The present investigations were carried out at the Experimental Research Farm, Department of Vegetable Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during *Kharif*, 2012 to evaluate diverse germplasm of okra for yield and horticultural traits. The experiment was laid out in a RCBD with three replications. Thirty five genotypes including check cultivars were evaluated for different horticultural traits. The observations were recorded on node number bearing first flower, days taken to 50 % flowering, number of primary branches per plant, average plant height, number of fruiting nodes, inter-nodal distance, days to marketable maturity, number of marketable fruits per plant, harvest duration, fruit length, fruit breadth, average fruit weight, green pod yield per plant, pod yield per hectare. Analysis of variance showed significant difference among all the genotypes for all the characters under study. Five genotypes namely IC-58235, LC-13-9, VRO-3, LC-12-5 and Arka Anamika gave higher yield and also performed better for other horticultural traits *viz.* days taken to marketable maturity, fruit breadth, average fruit weight, harvest duration, number of marketable pods per plant than the check variety P-8. High heritability estimates coupled with high genetic gain were observed for yield and other horticultural traits. Thus, these genotypes can be involved in further breeding programme and can be tested under multilocation on farm or adaptive trials before final release for commercial cultivation in mid-hills of Himachal Pradesh.

Effect Of Pinching Treatments And Plant Growth Regulators In African Marigold Cv. 'Pusa Narangi Gainda'.

R.K. Sharma*, R.K. Pandey, Deep Ji Bhat*, S. Dogra and R.K Samnotra

Division of Vegetable Science and Floriculture

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu

Main Campus, Chatha, Jammu 180 009

**E-mail: rajuxcoolx007@gmail.com*

The present investigation was carried out during the year 2012-13 in the Experimental Farm of Division of Vegetable science and Floriculture, SKUAST –J, Chatha. The study revealed that among the different pinching treatments no pinching treatment (P₀) recorded significantly maximum plant height (69.30 cm), minimum days taken to first bud initiation (37.52), minimum

days to 50 per cent flowering (53.00 days) and maximum flower diameter (7.88 cm) as compared to the pinching treatments at 25th and 35th day of pinching, however, maximum number of primary branches per plant (13.38), number of flowers per plant (53.55), fresh weight of flowers per plant (592.16 g), dry weight of flowers per plant (60.37 g), flower yield (277.56 q/ha), seed yield (402.56 kg/ha) and more chlorophyll content (50.03) were recorded significantly at 35th day of pinching treatment (P₂) in comparison to rest of the pinching treatments. Maximum Plant spread (48.81 cm), duration of flowering (64.34 days), higher germination percentage of harvested seed (64.70) and more seed vigour index (849.59) was recorded at 35th day of pinching treatment (P₂) but was found to be statically at par with 25th day of pinching treatment (P₁) respectively. Among the different plant growth regulators GA₃ @ 300 ppm significantly recorded maximum plant height (74.27 cm), minimum days taken to first bud initiation (36.11 days), minimum days to 50 per cent flowering (50.89 days), more number of flowers per plant (53.67), maximum flower diameter (7.92 cm), maximum fresh weight of flowers (631.32 g), maximum dry weight of flowers (61.39 g), higher flower yield (295.93 q/ha), more chlorophyll content (52.78), maximum seed yield (401.14 kg/ha), germination percentage of harvested seed (68.94) and seed vigour index (958.98) in comparison to rest of the treatments. However, maximum plant spread (49.35cm) was recorded with treatment GA₃ @ 300 ppm but, was found statically at par with GA₃ @ 200 ppm. The interaction effect revealed that no pinching (P₀) treatment in combination with GA₃ @ 300 ppm recorded significantly maximum plant height (79.40 cm) and maximum flower diameter (7.88 cm). The treatment pinching at 35th day in combination with GA₃ @ 300 ppm resulted maximum net returns Rs. 6, 42,429 per hectare with a benefit cost ratio of 1: 2.89 as compared to all other treatments.

AGRI-SILVI-HORTI SYSTEMS: PLANT GROWTH BEHAVIOR OF SILVICULTURAL AND HORTICULTURAL CROPS UNDER ARID IRRIGATED CONDITIONS OF PUNJAB

J S Brar, Avtar Singh and Navpreet Kaur

Regional Research Station Bathinda-151001 (Punjab)

E. mail: jsbrar74@rediffmail.com

To investigate the sustainable production through Agri-Silvi-Horti systems in arid irrigated conditions of Punjab, the experiment was established at Regional Research Station, Punjab Agricultural University, Bathinda in 2013. The different fruit crops viz. Peach, Plum, Guava and Citrus (Kinnow) was planted in between the rows of poplar planted at the spacing of 6x6 m. The agricultural crops such as moong and turmeric were planted on the interspaces of the silvicultural and fruit crops. The plant growth behavior of different plants was recorded for the first year. The data revealed that the growth of poplar planted as sole crop was maximum in terms of trunk girth and height. Although, the vegetative growth of deciduous fruit plants was affected under the shade of poplar, but, there was no significant effect on growth of evergreen plants such as guava and kinnow. The canopy volume of deciduous fruit plants was recorded maximum when planted as sole crops.

EVALUATION OF FUNGICIDES, BOTANICALS AND BIOCIDES AGAINST WILT OF CHICKPEA CAUSED BY FUSARIUM OXYSPORUM. F. SP. CICERI

Sonika Jamwal¹, Anamika Jamwal² and Arvind Isher³

¹ Dry land Research Sub-Station Dhiansar, Bari-Brahmana, SKUAST-Jammu-181 133

².Krishi Vigyan Kendra, Kathua, SKUAST-Jammu -184 101

³KVK-Rajouri, SKUAST-J-180 009.

E-mail: jamwalsonika@yahoo.com

Chickpea is one of the most important pulse crop, is affected by many diseases. Chickpea wilt incited by *Fusarium oxysporum* f. sp. *ciceri* is one of the severe disease causes heavy losses (20-100%) depending upon stage of infection and wilting. Minimizing this disease can only be accomplished by careful crop management. In this context an investigation was conducted to diminish Fusarial wilt of chickpea by fungicides, biocides and botanicals viz. Carbendazim, thiram, *Trichoderma viride*, *T. harzianum*, neem leaf extract, and Eucalyptus leaf extract. All the treatments were found effective against Fusarial wilt under "in vitro" and "in vivo" conditions. Among them *T. viride* was observed as most effective which inhibited the radial growth of *F.o.f.sp.ciceri* 39.2% after four days and after eight days with 71.2% over uninoculated control. Under "in vivo" seed treatment with *T. viride* @4g/kg was highly effective in the management of the wilt disease. The pooled data of both the years showed that the minimum wilt incidence (6.42%) was recorded with *T. viride* and the maximum root length (9.70cm), shoot length (27.42cm), root weight (2.30g), and shoot weight (10.15g) was recorded with the same treatment.

WHEAT YIELD RESPONSE TO TEMPERATURE VARIABILITY IN CENTRAL PUNJAB

Bharat Bhushan Vashisht and S.K. Jalota

Department of Soil Science, Punjab Agricultural University, Ludhiana -141 004

Email: bharatpau@pau.edu; jalota50@pau.edu

Wheat is the major winter crop sown following summer crops like rice, maize and cotton in the Punjab state. It requires cool climate. As climate conditions are inherently variable from year to year, it may cause inter- and intra- seasonal variation in temperature and sometimes heat stress at reproductive and grain development phases, which reduce wheat yield. A field and simulation study was undertaken to understand (i) impact of inter- and intra- seasonal temperatures variability on wheat yield, and (ii) minimization of seasonal temperature variability impact, based on year and management intervention interactions. The results indicate inter- seasonal variation in the four years (2008-09 to 2011-12) ranged from 20-28% in Tmax and 36-53% in Tmin. For the corresponding seasons the averaged intra- seasonal variability was 6.9, 8.1, 7.4 and 20.6 % in Tmax and 20.6, 21.3, 22.8 and 30.4% in Tmin. The inter- and intra-variability

was higher in Tmin than Tmax. In the study period inter- seasonal variability showed that the variation of 1.2°C in Tmax and 1.1°C in Tmin caused 16.8% variation in yield. Averaged across treatments, yield in the year 2010-11 was significantly higher by 643-844 kg ha⁻¹ compared to other years. There was a strong interaction of the year with management practices i.e. dates of sowing, irrigation and cultivar, which can form a base for deciding the adaptation measure to minimize the impact of climate variability. The apposite Tmax and Tmin by two models (DSSAT and CropSyst) were estimated at 26.6-27.2°C and 11.0-11.7°C, respectively. The regression coefficient for intra-seasonal Tmin during 0-30days, Tmax during 31-60 days and both Tmax and Tmin during 120-150 days were significant at 0.05 probabilities. These results indicate that increased intra- seasonal temperature during 0-60 and 120-150 days after sowing of wheat would decrease yield. Staggering date of sowing with selecting appropriate cultivar and irrigation schedule emerged as adaptation measures to minimize the effect of inter-and intra-seasonal temperature variability.

AONLA BASED AGROFORESTRY LAND USE SYSTEM FOR RESOURCE CONSERVATION IN DEGRADED SHIVALIKS

R. Prasad*, Y. Agnihotri, R.K. Aggarwal, R.P. Yadav, S.K. Yadav, A.K. Tiwari, and J.S. Samra**

**Central Soil and Water Conservation Research and Training Institute Research Centre Sector-27A, Madhya Marg, Chandigarh-160 019 (UT)*

***CEO, NRAA, Govt. of India*

The Shivalik region spread over 3.0 million hectare in the states of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana and Uttarakhand. The region is severely prone to soil erosion and requires suitable sustainable resource conservation techniques to alleviate various biotic and abiotic stresses. Considering soil and climatic factors, the alternate land use system of horti-pastoral is best suited as sustainable system. Mango, Guava, Aonla, Ber, Bael, Karonda, Citrus and Pomegranate are the most adapted fruit species in the Shivaliks. Amongst these fruits species, Aonla (*Embllica Officinalis Gaertn*) has proved to be the most successful as it thrives best in adverse agro-climatic conditions as well as degraded lands. It requires less moisture and nutrients for its growth and its maintenance cost is lower than other fruit species. Besides giving good economic yield, the fodder grasses like Napier and *Chrysopogon* also grow well under Aonla plants. Aonla based horti-pastoral land use system was with four combinations of pure Aonla, Aonla + *Chrysopogon*, Aonla + Napier, and Aonla + Arhar (Pulse) with tree spacing of 6m x 4m was established in 1991-92 at CSWCRTI, Research Centre Farm, Mansa Devi, near Chandigarh. The results have shown that intercropping with Napier adversely affected the plant growth parameters. Aonla started bearing from 1994 onwards and produced much higher yield (122.0 kg per plant) and the lowest 97.0 kg per plant in Aonla + Napier. Maximum yield of 130kg per plant was found in treatment Aonla + Arhar treatment. Plant growth parameters were obtained maximum in Aonla + *Chrysopogon* treatment. Napier and *Chrysopogon* grass yield showed

declining trend from 6.52 to 1.02 t/ha and 34.5 to 11.34 t/ha over the years from 1993 to 2003. During post bearing stage, Aonla + *Chrysopogon* grass produced minimum runoff as compared to control (23.5%), whereas sediment loss was found maximum in pure Aonla stand (3.46 t/ha) and minimum in Aonla + *Chrysopogon* combination (0.64 t/ha). Thus, study suggested that horti-pastoral system involving Aonla + *Chrysopogon* was most promising for most productive and economic utilization of degraded Shivalik foothills.

AGRI-HORTICULTURE LAND USE SYSTEM FOR RESOURCE CONSERVATION ON DEGRADED SHIVALIKS OF NORTH WEST INDIA

R. Prasad*, Pratap Singh, R.P. Yadav, S.L. Arya, and A.K. Tiwari

Central Soil and Water Conservation, Research and Training Institute, Research Centre Sector – 27A, Madhya Marg, Chandigarh

The Shivalik foothills of North West India covering an area of more than 3.0 million hectare are in a state of degraded condition due to soil erosion caused by various biotic and abiotic pressures. Besides, average rainfall of more than 1100 mm, this region is still rainfed. Considering soil and climatic factors, alternative land use system of agri-horticulture is best suited on sustainable system. An experiment on peach based Agri-Horticulture land use system was established in 2008 at CSWCRTI, Research Centre Farm, Mansa Devi, near Chandigarh. The main aim of the study was to identify most compatible inter/fodder crop with peach plants and to ascertain the effect of different moisture conservation practices on growth performance and yield potential of peach plants. One year old grafted saplings of peach cultivar Shan-I-Punjab were planted at a spacing of 6m X 6m in the third week of January, 2008. The intercrop viz; Sorghum (*Sorghum bicolor L*), Pearl millet (*Pennisetum typhoides*) and Cluster bean/Guar (*Cyamopsis tetragonaloba*) were sown in Kharif season only. The moisture conservation practices for peach plants include: - i. Control/flat basin; ii. Trench and iii. Circular trench. The result of 5 year study revealed that peach plants in treatment T₁₂ (Peach + Cluster bean + Trench) attained maximum height, basal girth, spread, yield of fruits as 4.8m, 75.8 cm, 6.32m and 114.70 kg/tree, respectively. Minimum plant height, basal girth, spread was found in T₆ (Peach + Cluster bean). Treatment T₁₂ (Peach + Circular Trench + Cluster bean) was also found most effective in conserving soil and water by producing minimum runoff and soil loss as 3.57%, 0.69 t/ha. Pure peach plantation recorded maximum runoff as 11%. Thus, Peach + Cluster bean + Circular trench treatment was found most effective in the rehabilitation of degraded Shivaliks without affecting the growth performance and yield potential of peach plants. Peach plants started bearing after 3 years of plantation and gave maximum yield of 114.70 kg/plant (5th year plantation) as compared to other treatments and gave gross returns of 3.30 lakhs from three acres of plantation.

EFFECT OF CONJOINT APPLICATION OF ORGANIC AND INORGANIC SOURCES OF NUTRIENTS ON NUTRIENT CONTENT AND SOIL NUTRIENT STATUS OF PEA

Nisha and Kuldeep S. Thakur

Department of Vegetable Science

Dr. Y. S. Parmar University of Horticulture and Forestry, Solan- 173230, Himachal Pradesh

**E-mail: nisha.uhf.simla@gmail.com*

Pea (*Pisum sativum* L.) is highly nutritious due to its important biochemical attributes viz. protein content, protein quality, minerals, oils and sugar content. In North Indian hills, it is the most important off season vegetable grown both as summer and autumn crop and thereby making the availability of green pods from March onward till October when these are not available in the plains. The experiment was laid out in a randomized complete block design with three replications comprising nine treatments viz. T₁ : Recommended dose of NPK (25:60:60 kg/ha); T₂ : Rhizobium isolate-1 +75 % N + 100 % P; T₃ : Rhizobium isolate-2 +75 % N + 100 % P; T₄ : Rhizobium isolate-1 +50 % N + 100 % P; T₅ : Rhizobium isolate-2 +50 % N + 100 % P; T₆ : Rhizobium isolate-1 + PSB + 75 % N & P; T₇ : Rhizobium isolate-2 + PSB + 75 % N & P; T₈ : Rhizobium isolate-1 + PSB + 50 % N & P; T₉ : Rhizobium isolate-2 + PSB + 50 % N & P. The observations were recorded on soil pH, EC (dSm⁻¹), organic carbon, available NPK content of soil before start and after completion of experiment and nutrient content (NPK) in the leaves. The results revealed that treatment T₉; Rhizobium isolate-2 + PSB + 50 % N & P were rated as the best treatment for majority of soil and plant nutrient status. Therefore, on the basis of present study it is concluded that application of biofertilizers (*Rhizobium* and PSB) in combination with inorganic fertilizers increase the yield and reduce the dose of chemical fertilizers at 25-50%.

BIOCHEMICAL EVALUATION OF SOME PROMISING VARIETIES/GENOTYPES OF UNDER-UTILIZED FOOD LEGUMES OF HIMACHAL PRADESH

Rishi Thakur, CP Awasthi, KS Verma and VK Rana

Institute of Biotechnology and Environmental Science, Neri, Hamirpur- 177 001 (HP)

The dried mature seeds of promising ten adzuki bean [*Vigna angularis* (Willd.) Ohwi&Ohashi] and fourteen rice bean [*Vigna umbellata* (Thunb; Ohwi and Ohashi)] genotypes procured from NBPGR Station, Shimla were analyzed for some biochemical constituents of nutritional significance. Variation in moisture, crude protein, crude fat (ether extract), crude fibre, ash, carbohydrate, methionine, tryptophan, *in vitro* protein digestibility, tannins, cooking time, calcium, iron and zinc content were observed to range from 5.1 to 11.2%, 20.5 to 23.8%, 0.29 to 0.52%, 4.4 to 5.7%, 3.9 to 5.5%, 54.6 to 62.3%, 0.70 to 1.49, 0.65 to 0.88 g per 100 g protein, 74.2 to 85.4%, 470 to 832 mg/100 g, 39 to 46 min., 300.8 to 338.9, 6.5 to 9.5 and 2.6 to 4.1 mg per 100 g, respectively in adzuki bean genotypes, whereas variation in these parameters in rice

bean genotypes was noticed from 5.0 to 11.8%, 17.5 to 21.0%, 0.31 to 0.62%, 4.6 to 6.6%, 3.8 to 5.8%, 57.9 to 64.7%, 0.72 to 1.46, 0.46 to 1.33 g per 100 g protein, 81.7 to 90.0%, 510 to 650 mg/100 g, 42 to 56 min., 302.0 to 383.0, 4.0 to 9.1 and 2.5 to 4.5 mg per 100 g, respectively. Moreover, on the basis of genotypic rating in respect of desirable nutritional quality attributes taken together EC-030256, EC-290652 and EC-340249 genotypes of adzuki bean, and LRB-452, PRR-2 and LRB-448 rice bean genotypes were found superior over others in that order. Variation was observed to be useful for further crop improvement value addition.

BACK CROSSING OF SUPERIOR HYBRIDS 'SONPARI' AND 'NEELPHONSO' WITH 'ALPHONSO' MANGO (*MANGIFERA INDICA* L.)

H. Rymbai^{1*}, C.R. Patel², K.N. Chaudhry², T.R. Ahlawat² and N.L. Patel²

¹*Division of Horticulture, ICAR-NEHR Umiam, Ri Bhoi, Meghalaya - 793 103*

²*ASPEE College of Horticulture & Forestry, Navsari – 396 450*

**E-mail: rymbaihort@gmail.com*

The study was carried out during 2012/13 cropping season to find out the ability of Alphonso pollen with its two newly developed superior hybrids Sonpari (Alphonso x Baneshan) and Neelphonso (Neelam x Alphonso) as female parents in hybridization programme. To further incorporate the desirable traits of Alphonso into these hybrids, a new breeding programme was initiated at RHRS, Navsari Agricultural University to back crossing these two superior hybrids Sonpari and Neelphonso with Alphonso as pollen donor parent. The results revealed that fruit set percentage was 88.91% in crossed Sonpari x Alphonso and 78.43% in crossed Neelphonso x Alphonso. Fruit retention percentage was reduced drastically from fruit setting stage till 14 days after pea stage (DAPS) but attained almost steady percentage from 35 DAPS onward till harvesting. The fruit retention percentage at harvest was higher in the crossed fruits of Sonpari x Alphonso (3.13%) compared to Neelphonso x Alphonso (0.94%). Regarding physical characteristics of crossed fruits, combination of Sonpari x Alphonso produced higher fruit length (13.4 cm) and fruit width (9.9 cm) than crossed fruits of Neelphonso x Alphonso with fruit length (10.8 cm) and fruit width (5.7 cm). Similarly, fruit weight of hybrid fruits derived from crossed Sonpari x Alphonso (512.4 g) was higher compared to that of Neelphonso x Alphonso (235.2 g). The drastic reduction in fruit number retained during the period of fruit set stage to 14 days after pea stage was due to wide variation between maximum and minimum of both temperature and relative humidity. Based on this experiment, pollens of Alphonso showed good compatibility with both Sonpari and Neelphonso and therefore, may be utilized as pollen source for pollination in these two newly developed hybrids varieties in mango crossing programme.

EFFECT OF PRE-HARVEST APPLICATION OF CALCIUM CHLORIDE, BAVISTIN AND BAYLETON ON SHELF LIFE OF AONLA UNDER RAINFED CONDITION OF JAMMU

Neeraj Gupta* and V. B. Singh

*Rainfed Research Sub-Station for Sub Tropical Fruits,
SKUAST- Jammu, Raya Samba, Jammu and Kashmir-181 143*

**E-mail: neeruguptapht@gmail.com*

The investigation was carried out at RRSS, Raya, SKUAST-Jammu during 2009-10 and 2011-12. Aonla (*NA-7* cv.) trees of 12 years age with uniform productivity were used for the study. The experiment comprised of pre-harvest sprays given 20 and 10 days before harvest *viz.*, Calcium chloride 1 %; Bavistin 0.1 %; Bayleton 0.1 %; Calcium chloride 1 % + Bavistin 0.1 %; Calcium chloride 1 % + Bayleton 0.1 %; Bavistin 0.1 % + Bayleton 0.1 %; Calcium chloride 1 % + Bavistin 0.1 % + Bayleton 0.1 % and Control. These treatments were given to the fruited trees on 10th and 20th November in the years 2009 and 2011. The fruits were harvested at full maturity on 30th November at the best physiological stage/size and then fruits were stored at room temperature. Physico-chemical characteristics were studied at 10 days interval upto 30 days. Results obtained in the present investigation indicate that foliar application of Calcium chloride, Bavistin and Bayleton influenced the physical characteristics of aonla fruit during storage at room temperature. The size (length and diameter) of fruits decreased with the increase in storage period. However, the treated fruits maintained higher value of fruit size as compared to control. Physiological loss in weight increased with the advancement of storage period. The data revealed that losses due to decay were observed from 20 days of storage and onwards. From 20 days of storage the decay losses increased significantly upto 30 days of storage. However the losses were less in treated fruits as compared to control in both the years. Calcium chloride 1 % and Bavistin 0.1 % treatment had best effect on percent TSS of aonla fruits stored at room temperature among all the treatments. Pre-harvest spray of Calcium chloride, Bavistin, Bayleton and their combination also influenced acidity of aonla fruit during their maturation on the tree and thereafter in storage at ambient temperature. Reducing sugar and total sugars increased upto 10 days of storage at room temperature followed by a decrease upto 30 days of storage. Non-reducing sugar in all the treatments increased during the storage for 30 days. Ascorbic acid content of aonla fruit decreased significantly during storage. From the present study, it is concluded that Calcium chloride 1 % + Bavistin 0.1 % was found to be the most effective pre-harvest treatment to enhance the post-harvest life of aonla fruit.

STATUS AND MANAGEMENT OF YELLOW RUST IN WHEAT UNDER CLIMATE CHANGE SCENARIO

Amrish Vaid, A.P. Singh, Vishal Mahajan, Anamika Jamwal and Berjesh Ajrawat

Krishi Vigyan Kendra, Kathua

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J&K)

In the wake of changing climate, yellow rust disease in wheat has changed its status from earlier being a disease of minor importance to a major disease of great economic importance. The changed climatic condition during wheat growing season particularly in the north-western plain zone and availability of host in the higher hills during rest of the seasons has proved to be the basis for the recurrence of this disease. Yellow rust also known as stripe rust caused by *Puccinia striiformis* is one of the most serious diseases of wheat, threatening its cultivation in the north western parts of India. During the year 2009-10, yellow rust appeared in epidemic form in Jammu and Kathua districts. Yield losses in wheat ranging from 2 to 6 q acre⁻¹ were recorded in the district. This was primarily due to high frequency of occurrence of new race of the rust pathogen 78S84. As a result, the popular wheat cultivar PBW 343 becomes susceptible to yellow rust. The first management strategy advised by KVK, Kathua to the farmers was not to cultivate wheat variety PBW-343 to reduce the initial build-up of inoculum of the pathogen. The farmers were advised to cultivate rust resistant cultivars like PBW-550 and DBW-17. Later on the rust resistant cultivars of that time like PBW-550 and DBW-17 were also succumbed before yellow rust and become low to moderate susceptible to yellow rust disease. With release of rust resistant wheat cultivars like HD-2967 and PBW-621, KVK, Kathua has promptly procured the seed of HD-2967, PBW-621 and DPW 621-50 in 2011-12 and multiplied them and became the first not only to introduce but to spread these three rust resistant cultivars in the plains of Kathua through frontline demonstrations. Farmers got great respite and not only be able to save their wheat crop from yellow rust but got higher yields and consequently the better returns. Simultaneously, farmers were also advised to spray propiconazole @0.1% which saved the crop from yellow rust and subsequently the losses were reduced. The farmers were advised to monitor their crop regularly and spray propiconazole @0.1% using 200 – 250 liters of spray solution per acre. Farmers were also advised to repeat the spray after 10-15 days if needed. Apart from this KVK, Kathua has been regularly sensitizing the farmers of the district for management of yellow rust in wheat by the conduct of rigorous extension activities independently and jointly with the Department of Agriculture. Campaigns were also organized in different pockets of the district to get the maximum impact. All the extension activities were also backed by the pertinent literature has catalyzed their impact by generating maximum awareness towards the yellow rust. The multipronged strategies of KVK, Kathua viz., laying out of demonstrations with yellow rust tolerant varieties like HD-2967 and PBW-621, distribution of pertinent literature, generation of awareness towards yellow rust through extension activities and regular vigil and disease forecasting services and other efforts in this direction had ultimately resulted into the visible and quantitative outcome in terms of reduction of prevalence of yellow rust disease in wheat and its consequent benefits in terms of higher wheat yields in Kathua district.

IMPACT OF DEMONSTRATION OF CLIMATE RESILIENT TECHNOLOGIES VIS-À-VIS AN APPRAISAL OF NICRA PROJECT IN DISTRICT KATHUA OF JAMMU AND KASHMIR

B.P. Singh, Amrish Vaid and Vishal Mahajan

Krishi Vigyan Kendra, Kathua,

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J&K)

Climate change impacts on agriculture are being witnessed all over the world, but the countries like India are most vulnerable in view of large population depending on agriculture, excessive pressure on natural resources and poor coping mechanisms. With the objective to reduce the vulnerability of agriculture to the adverse impacts of climate change and making it more resilient, NICRA project was initiated in the Said-Sohal village of district Kathua. Under technology demonstration component of NICRA project, an integrated package of proven technologies was demonstrated in Said-Sohal village for adaptations and mitigation of crop and livestock production systems to climate variability based on the available technologies. These interventions had covered four modules viz., natural resource management, crop production, livestock, institutional arrangements and capacity building. Under natural resource management module interventions like *in-situ* moisture conservation by deep summer ploughing across the slope, use of organic mulches and strip cropping with cereals and legumes were demonstrated over 120 ha area of the NICRA village and there is increase of 50 ha area under this technology as a result of its adoption. Water harvesting and recycling technologies were demonstrated through renovation of old, defunct farm ponds for providing supplemental irrigation to the crops during periods of peak demand over an area of 5.5 ha. Demonstrations on community nurseries (0.05 ha), plantation with G-48 and Uday clones of Poplar (2.26 ha), plantation with multipurpose forest trees like *Bauhinia*, Bamboo, Drek (5.0 ha) and plantation of fodder grasses viz., *Napier* and *Setaria* on farm bunds has made multidimensional benefits in terms of making the farmers in NICRA village self sufficient in fuel wood and fodder while enhancing the livestock productivity and conserving the precious land resource from erosion hazards. Demonstrations on recycling of locally available organic resources was made by establishment of 8 vermicompost units has apparently augmented the scientific management and use of organic resources for nutrient management of crops. This technology has turned the farmers from making the disposal of fresh cowdung in open to preparation of vermicompost. Soil analysis was done to have nutrient profile of the village for ensuring soil test based nutrient application in various field crops. Prior to commencement of project work, there was hardly any farmer practicing agriculture with different types of crops using high yielding varieties. Crop diversification seemed to be a distant dream. The farmers of Said-Sohal village were totally lacking the concept of intercropping, and thus, by and large were deprived of the benefits associated with intercropping viz., contingent crop security in case of weather vagaries avoiding and/or escaping total crop failures and *in-situ* moisture conservation by making unique combination of erosion permitting and erosion resisting crops. Under crop production module, demonstrations on

drought tolerant varieties of black gram, sesamum, gobhi sarson, gram, lentil, toria and okra resulted in an yield increase to the tune of 62.5%, 62.84%, 51.31%, 96.82%, 76.47%, 88.4% and 38.09% respectively, over traditionally grown varieties. Inclusion of drought tolerant varieties of cereals, oilseeds, pulses and vegetables made the village self-reliant in respective crops. Intercropping of maize with cowpea made optimum use of moisture conserved *in-situ*, mitigated risk of total crop failure, sustaining soil fertility and augment quality fodder availability. Crop diversification and intercropping practices proved to be the better option to impart climate resilience in agriculture. Under livestock module demonstrations on use of community lands for fodder production, improved fodder/feed storage methods, preventive vaccination, feed enrichment by UMMBs and mineral mixtures has radically ameliorated the mineral deficiencies and improved the productivity of the treated animals. Under institutional arrangements module, the establishment of custom hiring centre has enhanced the access of the villagers to various farm implements and machines and proved to be the best option for reducing the drudgery among rural folk while saving the time and improving the capacity of the farmers to perform field operations in time. Agromet based crop advisories issued by KVK, Kathua not only generated climate literacy among the farmers but also made them able to plan their agricultural operations while combating the weather aberrations. Under capacity building module various capacity building programmes were organised to sensitize, mobilize and aware the farmers about the various facets of climate change, its impacts and the strategies to impart resilience in agriculture to climate change. The interventions demonstrated under all the modules has been successful in transforming the status of agriculture in Said-Sohal village from insufficient, sustenance level to self reliant in most of the crops with enhanced resilience in agricultural production.

EFFECT OF ZERO TILLAGE ON SOIL CARBON SEQUESTRATION IN A RICE-WHEAT CROPPING SYSTEM IN NORTHERN INDIA

Pushpa Devi, A.K. Aggarwal and S. R. Gupta*

Department of Botany, Kurukshetra University, Kurukshetra -136 119(Haryana)

**E-mail: sgupta2002@yahoo.com*

Conservation agriculture including zero-tillage aims to improve livelihoods of farmers through the application of minimal soil disturbance and resource saving. In recent years, the zero-tillage with wheat succeeding rice is the most widely adopted resource conserving technology in the Indo-Gangetic plains of India. This study analyses the effect of zero-tillage on biomass carbon accumulation, soil organic carbon storage, and aggregate soil carbon in a rice-wheat cropping system (located at Tharwa; 30°17'N and 76°47' E; 245m asl) in Ambala district of northern India. The rice crop was grown under conventional tillage (CT) and the wheat crop under conventional tillage (CT) and zero-tillage (ZT) tillage systems. The zero-tillage in wheat had a favourable effect on soil carbon, nitrogen, carbon accumulation and plant nitrogen uptake. The accumulation of carbon in the cropping system was (kg C ha⁻¹): conventional tillage, 4529 to

5833; zero-tillage, 5215 to 5799. After ten years of zero tillage at the farm level, soil organic carbon storage in 0-100cm soil depth was greater in zero-tillage (30.29 Mg C ha⁻¹) as compared to conventional tillage (25.45 Mg C ha⁻¹). Soil organic carbon associated with aggregates is an important reservoir of carbon, protected from mineralization and enzymatic degradation. In the rice-wheat cropping system, macroaggregates (2mm-250µm) and microaggregates (<250µm to 53µm) formed 48.47 to 56.16% of total soil aggregates fractions and protected most of organic carbon in soils of the zero-tillage (ZT). There is large potential for managing soil carbon through conservation agriculture for climate change mitigation and increasing the efficiency of internal resource use.

INSECTICIDAL MANAGEMENT OF CUTWORMS (*AGROTIS* SPP.) ON CABBAGE AND TOMATO CROPS IN KULLU VALLEY OF HIMACHAL PRADESH

S. D. Sharma*

CSKHPKV, HAREC, Bajaura, Kullu-175 125 (HP)

**E-mail: sukhdevsharma40@gmail.com*

Agrotis spp. (Lepidoptera: Noctuidae) are polyphagous pests of economic importance that cause damage to numerous crops in many parts of the world. In India cutworms have been found to feed on a wide variety of crops including cereals, vegetables, pulses, cotton, tobacco, mustard, sugarcane, cucurbits, potato etc.. In Himachal Pradesh two species of cutworms, viz., *Agrotis ipsilon* (Hufnagel) and *A. segetum* (Denis and Schiffermuller) have been recorded from different parts of the state. Of these two species of cutworms, *Agrotis ipsilon* (Hufnagel) has been found to be predominant on vegetable crops in both Mandi and Kullu districts of Himachal Pradesh. Studies carried out in Kullu district of Himachal Pradesh, revealed that on an average the cutworm larvae caused 16.41, 20.24, 19.14, 17.62, 18.44, 33.50 and 19.31 per cent mortality of the seedlings of tomato, brinjal, capsicum, cabbage, French Beans, cucumber and bitter gourd, respectively. Whereas the average damage to the respective crop in Mandi district was 18.24, 19.91, 30.18, 20.48, 6.60, 27.03 and 12.92 per cent. The present studies were therefore carried out to control these pests of tremendous economic importance from April to August, 2013 in cabbage and tomato crops at farmers fields. Different chemicals applied in the soil at the time of transplanting of the crops. The observations were recorded on the number of seedlings per plot and those cut by the cutworm larvae and work out the percentage damage in both the crops. The observations were started immediately after the seedlings transplanting and continued till the crop became vigorous enough to withstand the damage. Immediately after the transplanting of the crop, 1 cutworm larva/plot (third instar) was also released besides the natural infestation occurring in the field. Among the various chemicals used against the cutworms in cabbage crop, it was found that all the chemical treatments were significantly superior to control but at par with each other in protecting cabbage seedlings from cutworms at 4, 6 and 8 days after its transplanting. Treatment T4, consisting of methyl parathion (Folidol 2% dust) @ 15kg/ha plus

carbofuran (Furadan 3G) @ 15kg/ha was found to be the best treatment as there was no mortality of the seedlings due to the attack of cutworms in the plots treated with these chemicals at 4, 6 and 8 days after its transplanting. In case of tomato crop also treatment consisting of methyl parathion (Folidol 2% dust) @ 15kg/ha plus carbofuran (Furadan 3G) @ 15kg/ha was found to be the most effective treatment.

EFFECT OF WATER AND CLIMATE CHANGE ON WHEAT PRODUCTIVITY IN JAMMU DISTRICT OF J&K STATE

N.K. Gupta, A. Samanta, A.K. Raina and Puneet Mahajan

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J&K)

With the increasing population and decreasing land resources, the pressure on the fragile land is increasing to produce more and more so as to feed the increasing population. For this we requires, improved seeds, fertilizers, insecticides, pesticides, improved tools and implements for land preparation, intercultural operations, harvesting, threshing, winnowing and latest know how to safely store the food grains. Having all these inputs in one hand if we do not have the most important input the main source of irrigation then our crop production will suffer badly as irrigation to the crops is the backbone to crop productivity. In Jammu district, Ranbir canal and Tawi lift irrigation schemes are the major source of irrigation to the crops. Both these canal system remains close for desiltation and repair purpose during *rabi* season from January to mid April when the major crop in the farmers field is wheat. Farmers of Jammu district irrigated belt are raising hue and cry as their yield of wheat crop is reducing because of non availability of water at the crucial stages and because of this, they are suffering huge losses. Survey of three villages Bishnah, Puro Bhana and Chak Agra were conducted so as to ascertain the losses being incurred by the farmers of command area in wheat crop due to closure of Ranbir Canal System from January to mid April for de siltation & repair purpose and also to confirm the effect of climate change on wheat. Result reveals that farmers of command area were suffering huge losses amounting to Rs. 17.11 crore in wheat crop from an area of 27548 ha due to non-availability of water at critical stages especially during March & April when the crop is milky and dough stage. Further rainfall analysis of three decade i.e from 1980-81 to 1989-90, 1990-91 to 1999-2000 and 2000-2001 to 2009-10 also confirms the decreasing trend in rainfall pattern, which clearly indicate that the rainfall pattern is not sufficient to meet evapotranspiration demand of the wheat crop resulting in poor yield and undersize grains. Water balance study based on crop growing period and canal closure period also confirms the same. It is recommended that de siltation & repair process of Ranbir Canal System be completed between January and February and canal should remain functional from March onwards so that the farming community can be saved from huge losses amounting to Rs. 17.11 crore as climate of the region is also changing.

EXPLOITATION OF FLORAL BIODIVERSITY OF HIGH ALTITUDE JAMMU REGION FOR PESTICIDAL ACTIVITY

Reena^{1*}, Munishver¹, S.K. Singh² and B. S. Jamwal²

¹*DLRSS, Dhiansar*

²*PRSS, Samba*

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J&K)

**E-mail: bkreena12@gmail.com*

The excessive application of chemical pesticides is also one of the major causal reason for environmental pollution, ecological degradation, etc. leading to climate change. The high altitude (temperate) region of Jammu province was surveyed for potential pesticidal plants. The plants / plant parts were collected keeping the few points in mind (Its abundance and medicinal properties based on available literature and information gained from local people). The collected plant material was shade dried and kept in plastic boxes for further use. The methanolic extracts of all the collected plants / plant parts were then prepared by following the standard procedure of refluxing and distillation. The extracts were assessed for their toxicity against *Fusarium oxysporum* f.sp. *ciceri* by poisoned food technique. Based on the growth inhibition effects of these extracts on the test fungus, *F. oxysporum* f. sp. *ciceri*, few plants / plant materials were selected for further evaluation. The methanolic extracts of these potential plants / plant parts were further subjected to fractionation using hexane first, followed by chloroform and acetone (based on their increasing polarity). These fractions were assessed for their fungicidal properties using the same poisoned food technique. *Arisaema flavum* (Forsskal) Schott roots / tubers extracts (200 ppm) proved to be highly toxic recording 100 per cent inhibition followed by its stem + leaves extract (94.44 per cent). For all the plants / plant parts hexane fraction showed maximum activity followed by acetone and ethanol fractions. The hexane fraction of all the four plants / plant parts selected for further evaluation recorded toxicities higher to those of control (Carbendazim). Use of botanicals in place of these chemical pesticides shall slowly and slowly benefit the environment, thus helping in prevention of climate change.

EFFECT OF WATER STRESS AMELIORATED BY INDOLE ACETIC ACID (IAA) APPLICATION IN WHEAT

B. K. Sinha*, M. Gupta and S.A. Mallick

Division of Biochemistry and Plant Physiology,

SKUAST-J, FOA, Main Campus Chatha, Jammu-180 009 (J&K)

**E-mail: sinhabkumar12@gmail.com*

Indole Acetic Acid in five gradual concentrations of IAA viz., 0, 5, 10, 20, 30 and 40 ppm were used for ameliorating the effects of water stress in wheat (*Triticum aestivum* L.) crop. Two varieties (PBW-343 and RSP-81) were taken. Different concentration of IAA were applied at the appearance of incipient wilting at three important stages viz., tillering (stage I) milking (stage II) and tillering + milking (stage I+II). The exogenous application of IAA @ 20 ppm showed

significant results in amelioration of drought stress irrespective of all the three stages. Proline contents, chlorophyll content, total soluble sugar (TSS) and Relative water content (RWC) were observed significantly higher, irrespective of variety and stages. While in RSP-81, 10 & 30 ppm recorded RWC at par with each other at all the stages. PBW- 343 showed higher chlorophyll content in 40ppm sprayed plants at stage I+II. Partitioning coefficient towards different plant parts varied and 20 ppm showed higher partitioning coefficients towards prime sink at the time of stress. Harvest index, Test weight, Grain yield were also maximum in 20 ppm sprayed plants (both varieties) whereas plants sprayed with 30 ppm recorded increased yield in RSP-81. Higher concentration of IAA neither showed significant growth promoting activity nor inhibiting activity.

**EFFECT OF DIFFERENT INSECTICIDAL TREATMENTS ON APHID
(*LIPAPHIS ERYSIMI*) INFESTATION, YIELD AND YIELD
CONTRIBUTING TRAITS IN *BRASSICA RAPA VAR SARSON* CROP IN
KULLU VALLEY OF HIMACHAL PRADESH**

S.D. Sharma* and Swaroop Kumar

CSKHPKV, HAREC, Bajaura, Kullu-175 125 (HP)

*E-mail: sukhdevsharma40@gmail.com

Rapeseed–mustard crops are attacked by a wide array of insect pests and mustard aphid, *Lipaphis erysimi* Kaltenbach is the most destructive one. It causes heavy losses in terms of quality and quantity. Bakhetia and Sekhon (1989) reported 35.0 to 73.3 per cent losses in yield in different agroclimatic regions with a mean loss of 54.2 per cent on all India basis. High incidence of this pest can cause complete loss of the crop. Among various practices recommended for the management of this aphid, use of chemical insecticides is a quite common practice among farmers. But their use particularly at flowering stage of the crop, *inter alia* results into serious losses of pollinators and natural enemies. The present investigations were therefore carried out to see the effect of the insecticides applied in the soil prior to flowering succeeded by post bloom sprays in order to avoid the spraying during peak bloom period and to perceive the effect of soil applied chemicals and post bloom sprays on the infestation of mustard aphid, *Lipaphis erysimi*, as well as the yield and yield contributing traits of the crop. The results of two years studies conducted during *rabi* 2009-10 and 2010-11 revealed that the treatment consisting of the pre flowering soil treatment of carbofuran succeeded by post bloom spray of cypermethrin (T₂) provided the best control of *Lipaphis erysimi* as significantly least dried siliquae/plant (3.03 and 2.09) were recorded during the two years observations. This treatment was followed by preflowering application of carbosulfan succeeded by post bloom spray of cypermethrin (T₄). In case of unprotected crop, significantly higher number of dried siliqua/plant (16.70 and 16.73) were recorded during the two years of observations. The number of primary and secondary branches/plant, seeds/siliqua, thousand seed weight and seed yield were also significantly higher under this treatment.

POPULATION DYNAMICS OF INSECT PESTS ON GREEN GRAM (*VIGNA RADIATA* (L.) WILZEK) DURING SUMMER

D. Nagle* and Abhishek Shukla

Department of Entomology

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur- 482 004 (M.P)

**E-mail: abhishek_shukla64@yahoo.com*

The experiment was conducted at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during summer season of 2011. Green gram variety Pusa Vishal was sown using recommended agronomic practices. Random sampling was conducted at weekly intervals, starting from germination till crop maturity, to record the incidence of insect-pests during different crop stages. Thrips, *Taeniothrips* sp. and jassids, *Empoasca kerri* populations were observed on 2 upper + 2 middle + 2 lower leaves (i.e. 6 leaves/ sample plant). Whitefly, *Bemisia tabaci* population was recorded by observing 10 cm twig, selected randomly / sample plant, using glass frame cage specially built for the sampling. Hundred samples were observed every week to record the incidence of insect pests. Corresponding weekly mean values of weather parameters namely maximum & minimum temperatures, rainfall (mm), morning & evening relative humidity (%), wind velocity (km/hr), and morning & evening vapour pressure (mm), were recorded to work out the correlation between weather parameters and pest population. The infestation of *Empoasca kerri* started in third week of April at 15 days after sowing (DAS) with mean population of 1.28 adults / 6 leaves. The population of the pest gradually increased up to standard meteorological week # 18 (2.28 adults/6 leaves). Highest mean population of *Empoasca kerri* was observed in week # 21 (3.88 adults / 6 leaves) at 50 DAS and thereafter the population declined gradually till the maturity of the crop. The infestation of *Taeniothrips* sp. started in week # 16 at 15 DAS, with mean population of 0.80 adult /6 leaves and continued till crop maturity. The population of *Taeniothrips* sp. increased progressively up to week # 20 and attained peak (6.96 adults/6 leaves). Population declined gradually with the crop maturity. The infestation of *Bemisia tabaci* started in week # 16 (15 DAS) with an average population of 2.40 flies / 10 cm twig, increased progressively up to week # 20 (5.55 flies/10 cm twig) at 50 DAS and declined thereafter but remained active till the maturity of the crop. Mean maximum daily temperature indicated positive correlation with *Empoasca kerri* population at 5% level of significance ($r = 0.78$), while the morning relative humidity (%) indicated negative correlation with the population of *Empoasca kerri* and *Bemisia tabaci*, at 5% level of significance ($r = -0.87$ & -0.80 , respectively). The value of regression coefficient of *Empoasca kerri* population on maximum temperature was found to be 0.79. The values of regression coefficients of *Empoasca kerri* and *Bemisia tabaci* populations on morning RH (%) were found to be -0.19 and -0.12, respectively. *Bemisia tabaci* is an important vector for transmitting yellow vein mosaic disease in *Vigna radiata* crop and hence its population dynamics plays a guiding role in preventing losses caused by it and the disease.

AGRICULTURE AND CLIMATE CHANGE

Shabir Ahmad Rather*

Faculty of Forestry, Camp Wadura, Sopore, SKUAST-Kashmir -193 201 (J&K)

**E-mail: sshab53@gmail.com*

In the wider context, there are two major issues to be faced in wake of climate change. First, there is the need to achieve food security to feed the 1 billion hungry which needs food production to be increased by 60 percent by 2050. Second, there is need to avoid dangerous climate change effects – in order to meet the “2 degree goal”, major emission cuts are required. As agriculture and land use contribute 30 percent of these emissions, reducing them must be part of the solution and one most important way is “Climate-Smart Agriculture (CSA)” which includes the agriculture, forestry and fisheries sectors at the local level contributes in meeting global objectives, primarily those of the United Nations Framework on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD) and the World Summit on Food Security (WSFS), leading to a sustainable development landscape. According to FAO, CSA is built on three pillars which focus on Sustainably increasing farm productivity and income, strengthening resilience to climate change and variability i.e. climate change requires adaption of food production systems for resilience both at the livelihood level and at the ecosystem level, mitigating the contribution of agricultural practices to climate change through the reduction or removal of greenhouse gas emissions by more resource efficiency, use of clean energy and carbon sequestration. It therefore enhances the achievement of national food security and development goals, and reflects the realities of the local and field levels. CSA differs from other concepts in that it addresses real-world situations, has multiple objectives and places the needs of the local stakeholders as the focal point, placing food security and climate change effects at the centre of these considerations. It is relevant to several international goals and process, for example, achieving food security, the Millennium Development Goals and those of the UNFCCC. CSA involves a people-centered approach, keeping farmers and those most vulnerable, including women, at the heart of dialogue, decision-making and action, and empowering them as critical agents of change.

CROP/VARIETAL DIVERSIFICATION IN RICE BASED CROPPING SYSTEM FOR CLIMATE CHANGE ADAPTATION

B. Lal*, B.B. Panda, Priyanka Gautam, A.K. Nayak and R. Raja

Crop Production Division, Central Rice Research Institute, Cuttack-753 006 (Odisha)

**E-mail: blalsgnr@gmail.com*

A field experiment was conducted at Central Rice Research Institute, Cuttack during 2012-13 on crop/variety diversification in rice based cropping system for climate change adaptation involving seven different cropping systems *i.e.* Rice-Rice, Rice-Green Gram, Rice-Horse Gram,

Rice-Coriander, Rice-Toria, Rice-Lathyrus and Rice-Black Gram on rainfed rice based system. The experiment was laid out in Randomized complete Block design and replicated thrice. These cropping systems represent common traditional and recent cropping systems in eastern India. Three-rice varieties of different duration (Naveen-120 days, Gayatri-160 days and Swarna-145 days) were transplanted during *kharif* season. After harvesting the wet season experiment, non-rice crops were directly sown on residual moisture of preceding crop to develop a crop calendar in respect to crop or varietal diversification under rainfed rice. Performance of rice varieties sown on 1st July was comparatively better than varieties sown during August. Similar trend was observed in non-rice crops followed by rice varieties in dry season. Rice equivalent yield (REY) was calculated to compare system performance by converting the yield of each crop into equivalent wet season rice yield on a price basis. The non-rice crops sown after Naveen and Swarna (1st July) were performed better in terms of equivalent yield compared to crops sown after Gayatri. Among seven cropping systems, Rice-blackgram, rice-toria, rice-green gram and rice-horse gram require fewer inputs and are also less risky, which probably makes them more suitable for resource poor small farmers.

SUBMERGENCE TOLERANCE IN RELATION TO NUTRIENT APPLICATION IN SUBMERGED RICE

Priyanka Gautam*, B. Lal, A.K. Nayak, R. Raja and Mohammad Shahid

Crop Production Division, Central Rice Research Institute, Cuttack -753 006 (Odisha)

**E-mail: priyanakagautam@gmail.com*

Transient complete submergence reduces survival and yield of more than 22 million ha of rice in rainfed lowlands and flood prone areas in Asia. Progress has been made in developing more tolerant germplasm, but fewer efforts have been devoted to identifying suitable nutrient management options. The study was carried out at Central Rice Research Institute, Cuttack during 2012-13 to compare IR-64 Sub1 and IR-64 for their tolerance to submergence at active tillering, panicle initiation and heading stages. The effects of N and P application and their application time on the plant's tolerance to submergence were also examined. We evaluated the shoot elongation, plant survival, specific leaf area, chlorophyll and non-structural carbohydrates (NSC) concentration, phenology, leaf senescence, photosynthetic (Pn) rate, yield attributes and yield. Both the cultivars suffered more to submergence at heading stage than other stages with devastating effects on IR-64. Submergence substantially reduced NSC, chlorophyll, biomass, Pn rate, yield attributes and yield across cultivars with more drastic reduction in IR-64. Post-submergence N and basal P application reduced shoot elongation and increased the concentration of NSC, enhanced survival percentage, Pn rate resulting in significantly higher yield and yield components. Pre-submergence N application enhanced under-water shoot elongation and leaf senescence, which leads to reduced survival, depletion of chlorophyll and NSC and yield. Soluble carbohydrates after submergence are more important for survival than at the initial level,

IR-64 Sub 1 could survive better under submergence because it possessed 12.5% more NSC after submergence as compared to IR-64. Submergence at reproductive stage proves to be most detrimental. Crop establishment and productivity could therefore be enhanced in areas where untimely flooding is anticipated by avoiding N application before submergence and applying N after desubmergence along with basal application of P.

CONSERVATION AGRICULTURE WITH TREES FOR CLIMATE RESILIENT FARMING FOR FOOD AND LIVELIHOOD SECURITY

Sangram Chavan^{1*}, Ram Newaj¹, SK Dhyani¹, Keerthika², Ankur Jha¹ and Anil Kumar¹

¹National Research Centre for Agroforestry, Jhansi- 284 003 (U.P)

²National Academy of Agricultural Research Management, Rajendranagar-500 030 Hyderabad, India

**E-mail: sangramc8@gmail.com*

Human efforts to produce ever greater amounts of food leave their mark on our environment. Today's global cultivated area has been strongly degraded. Even in high-yielding areas where soils are not considered to be degraded, crop requires ever increasing input to maintain yields. In the frame of the recent food crisis, it is clear that agriculture should not only be high yielding, but also sustainable. Conservation Agriculture (CA) is one of the best solutions to overcome these problems and to attain sustainability. The three principles of CA, namely minimum mechanical soil disturbance, permanent organic soil cover, and diversified crop rotations, are not always adopted by all farmers professing to be practicing CA. Keeping soils covered by retaining crop residues within the fields is challenging as there are competing uses for fodder, fuel and burning in field. The CA with trees is premised on the hypothesis that integrating trees with conservation agriculture has the potential to address the challenge of crop residue retention by adding nutrients removed through crop harvest and to attain resilient evergreen agriculture leading to more sustainable production and agro-ecosystems, and hence contribute to poverty reduction and increased food security while enhancing the resilience of systems in the face of climate change. The nitrogen fixing fertilizer trees have additional advantage as they add significant quantities of nitrogen via the biological fixation pathway particularly in low fertility sites. Therefore, the purpose of the proposed review is to develop a solid knowledge and partnership base for effective up scaling of a continent wide campaign for Conservation Agriculture with Trees among smallholder farmers in semi-arid regions including awareness, capacity development and policy guidance.

SCOPE OF FARM MECHANIZATION IN SMALL SCALE AGROFORESTRY SYSTEMS

B.M. Nandede¹* and S.B. Chavan²

¹*Central Institute of Agricultural Engineering Bhopal-462 038 (MP)*

²*National Research Centre for Agroforestry, Jhansi-284 003 (UP)*

**E-mail: bm8ciae@gmail.com, sangramc8@gmail.com*

The exponential population growth demands increased land for agriculture, roads, industry, urbanization, irrigation etc. which resulted in reduced areas under forest and it is alarming situation for India. On the other hands, depleting nature of fossil fuels and increasing demand forcing is to use of renewable energy sources with conservation of agriculture. Use of technologies like gasification requires wood chips for gasification to produce electricity for domestic and agricultural use. Limited use of agriculture waste in gasification development of small scale agroforestry systems to provide the raw material and make the farming independent. Therefore, small scale agroforestry with efficient use of farm machinery could be a good option in near future. Small scale agroforestry system could increase the working hours of the machines is being used in agriculture for sustainable and profitable agriculture. The paper reviews the machinery used for site preparation, plantation and harvesting operation for small scale agroforestry systems. Site preparation machinery mostly related to agriculture like laser land levellers, post hole diggers, soil media mixers, machinery for seedling planting and harvesting of small trees by tractor mounted machines, small power operated mobile saws, chip making machines etc. An agroforestry system requires the application of agricultural machinery to produce profitable mechanization options. It presents current of farm machinery used in agriculture and its use is related with agroforestry systems and requirement of innovative work in this area. The paper proposes future research directions that are needed to couple or develop appropriate technology and to make the agriculture more sustainable and profitable.

EFFECT OF VERMICOMPOST ON GROWTH AND YIELD OF *STEVIA REBAUDIANA* BERT. UNDER PLUM BASED AGROFORESTRY SYSTEM IN MID HILL ZONE OF HIMACHAL PRADESH

Silpa V. Kumar, C. L. Thakur and P. L. Bhutia*

Department of Silviculture and Agroforestry

Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni. Solan, 173 230 (HP)

**E-mail: bhutiapempa@yahoo.in*

The present investigation was carried out during the year 2010 to study the effect of different doses of vermicompost and chemical fertilizers on growth and yield of *Stevia rebaudiana* and bio-economics of plum based agroforestry system intercropped with *Stevia rebaudiana*. The experiment was laid out in a RBD with three replications comprising of seven treatments viz., T₁: Plum + *Stevia rebaudiana* + Recommended dose of NPK and FYM, T₂: Plum + *Stevia*

rebaudiana + 75% Recommended dose and 25% Vermicompost, T₃: Plum + *Stevia rebaudiana* + 60% Recommended dose and 40% Vermicompost, T₄: Plum + *Stevia rebaudiana* + 45% Recommended dose and 55% Vermicompost, T₅: Plum + *Stevia rebaudiana* + 30% Recommended dose and 70% Vermicompost, T₆: Plum + *Stevia rebaudiana* + 100% FYM only, T₇: Plum + *Stevia rebaudiana* + 100% Vermicompost only and Control: *Stevia rebaudiana* + Recommended dose of NPK and FYM. The plot size was 2m x 1m and spacing of 40cm x 20cm of the crop was maintained. Seedlings were transplanted in the month of July 2010. The observations were recorded on growth, yield and physiological parameters of *Stevia rebaudiana*. The findings indicate that the effect of different doses of vermicompost and chemical fertilizers on growth, yield and physiological parameters of *Stevia rebaudiana* was significant. Plum had a positive effect on growth and yield performance of *Stevia rebaudiana* and was found healthier and more thriving underneath plum than in open conditions. Among the different doses of vermicompost and chemical fertilizers tried, 75% recommended doses + 25% vermicompost was found to be most efficient. The bio-economics of this system revealed that the total net return was found higher in T₂. Thus, the cultivation of medicinal herbs by supplying organic manures in combination with inorganic fertilizers under plum based agroforestry system may be recommended for better economic returns.

FROST IMPACT MITIGATION FOR DEVELOPING CLIMATE RESILIENT FRUIT PRODUCTION SYSTEM IN THE SUBTROPICAL HIMALYAN REGION

Shashi K. Sharma and K. S. Verma

Institute of Biotechnology and Environmental Science, Neri, Hamirpur-177 001 (HP)

Dr Y.S. Parmar University of Horticulture & Forestry

Subtropical Himalayan region (28° 57' to 33°12' N latitude and 75°47' to 80° 08'E longitude) gradually arise from plains of NW India and goes on attaining height of 300m to around 1000m amsl with an average altitude of about 650m. Despite of being subtropical the region is suboptimal for subtropical fruit growing due to prevalence of intense winter and frost. Information reported herewith is the outcome of the studies conducted in the subtropical region of Himachal Pradesh during the years 2006 to 2013 at the Institute of Biotechnology and Environmental Science, Neri. It has been found that more economic losses are caused by frost induced freezing than by any other climatic hazard in this region. Mitigation of frost impact has been discussed as a tool for developing climate resilient fruit production system for the region. It has been reported that majority of the damage which occurs due to frost may be attributed to the interruption of acclimation process of the plants due to intermittent rise in atmospheric temperature during winters. Fruit crops' potential threat pre-warning system, frost intensity variation *w.r.t.* various adaphic factors, relative susceptibility and suitability of different species at different agro-ecological situations have been presented as useful frost impact mitigation strategies. Site specific priority index for different fruit crops has also been discussed.

EFFECT OF HORMONAL TREATMENTS AND MULCHING ON FRUIT DROP AND QUALITY OF MANGO

Sanjeev Kumar Banyal* and Deepa Sharma

Institute of Biotechnology and Environmental Science, Neri, Hamirpur, 177 001 (HP)

Dr. Y. S. Parmar University of Horticulture and Forestry

**E-mail: skbanyal@gmail.com*

An experiment was laid to assess the effect of hormonal treatments and mulching on fruit drop and quality on Mallika, Amarpali and Dashehari cultivars of mango on the experimental farm Bhota of IBES Neri, Hamirpur during the years 2010 -2012. Eight treatments viz. 2, 4-D (20 ppm and 40 ppm), NAA (25 and 50 ppm), 2, 4-D (20 ppm) + Black polythene mulch, A (25 ppm) + Black polythene mulch, Black polythene mulch and control were applied to mango cultivars Amarpali, Mallika and Dashehari. All the treatments were applied in the last week of April in the year 2011 and 2012. Randomized block design was followed for application of treatments and data analysis. The data on initial fruit set per panicle was recorded from these marked panicles before commencement of the experiment. Subsequently, the fruit retention on marked panicles was recorded at monthly interval till harvest. During the period of investigation it was noticed that all the hormonal treatments, mulching and their combination had significant effect on reduction of fruit drop in all three cultivars under study. Fruit retention at harvest in cultivar Amarpali was maximum (5.95%) in the treatment T₅ (2, 4-D 20ppm + Black Polythene Mulch) which was statistically at par with treatments T₁ (2, 4-D 20 ppm), T₇ (Black Polythene Mulch) and T₂ (2, 4-D 40 ppm). In cultivar Mallika and Dashehari also the same treatment i.e. T₅ (2, 4-D 20ppm + Black Polythene Mulch) had the highest fruit retention, 9.5 and 8.3% respectively.

A CASE STUDY ON AGRI-HORTICULTURE PRODUCTION SYSTEM FOR INCOME AND ENVIRONMENTAL SECURITY IN MAHI RAVINE LANDS OF GUJARAT.

V C Pande¹, R S Kurothe¹, H B Singh¹, S P Tiwari²

¹Research Centre, Vasad - 388 306, Gujarat

²Research Centre, Datia

Central Soil & Water Conservation Research & Training Institute

Agri-horticulture based cropping systems are influencing socio-economic and environmental problems facing Indian agriculture. This production system has potential to address second generation problem such as lowering of water-table, nutrient imbalance, soil degradation, salinity, environmental pollution and decline in farm profit lurking Indian agriculture over the decade. Shifting to tree based system holds lot of promise in alleviating these problems apart from fulfilling other objectives. The present case study draws from a research study, carried out during 2003-04 to 2008-09, on shifting from tobacco (*Nicotiana tabacum L.*) based mono cropping system to tree based agri horticultural systems including drumstick (*Moringa oelifera*

Linn.) and aonla (*Embllica officinalis Gaertn.*) on the reclaimed ravine lands of Mahi river in Gujarat state of India. Standard methodology was followed to examine profitability, dynamics, externality in terms of resource conservation and environmental security, market concerns for farmers and social constraints in adoption of agri-horticulture based cropping system in the region. The input and output data on different crops were analyzed based on the prevailing market price of the year 2011-12. Among the two agri horticultural systems, the drumstick based cropping system was not only found to be as remunerative as tobacco but also provided environmental services in terms of higher soil carbon built up and nutrient saving in the soil. Besides saving in irrigation water, the cropping systems enhanced returns over variable cost, saving in soil nutrients valued at Rs 657 ha⁻¹ and sustained soil carbon built up valued at Rs 3696 ha⁻¹. This holds promise for agro-ecosystem of central Gujarat, which has predominant tobacco mono cropping system that is averse to soil conservation. The environmental benefits provided by drumstick based agri horticulture system has implications for resource conservation and environmental security, thus, making it legitimate in view of the national action framework to find alternative crop after signing the Framework Convention on Tobacco Control of World Health Organization.

SCREENING OF COMMON BEAN (*PHASEOLUS VULGARIS L.*) GENOTYPES FOR DROUGHT TOLERANCE BASED ON PHYSIOLOGICAL INDICES

Usha Rana* and Meena Kumari

Department of Biology and Environmental Sciences

CSKHPKV, Palampur - 176 062 (HP)

**E-mail: rana.usha@rediffmail.com*

Sustainable agricultural production is an urgent issue in response to global climate change and population increase. Climate change catastrophes impact on all aspects of plant architecture represents a serious challenge for developing sustainable agriculture at a time of significant growth in the global population. Environmental stress factors such as drought, elevated temperature, salinity and rising CO₂ affect plant growth and pose a growing threat to sustainable agriculture. This has become a hot issue due to concerns about the effects of climate change on plant resources, biodiversity and global food security. Drought stress is a major abiotic stress, limiting common bean productivity throughout world. So, present investigation was conducted during the year 2012- 2013 with the objective to identify drought tolerant common bean genotypes on the basis of morphophysiological responses of plants to drought stress imposed at flower initiation stage. Seeds of fifty common bean genotypes were screened for drought tolerance under two effective levels (-0.3 and -0.5 MPa) of osmotic potential induced by PEG-6000. Germination percentage, radicle length and plumule length were decreased with increasing osmotic potential. Five best drought tolerant (KR 186-I, KR 60, KR 142, KRC 5 and KR 15) and most drought susceptible genotypes (KR 84, KR 257) were selected and subjected to pot trial.

Morphophysiological, traits like leaf area, chlorophyll fluorescence, root length, dry weight (g/plant) Relative Water Content (%), root-shoot ratio and Drought Susceptibility Index were observed. Marked reduction in these parameters was observed except for root-shoot ratio and Drought Susceptibility Index. Based on morphophysiological responses of all the genotypes of common bean (*Phaseolus vulgaris* L.) under water stress, it was concluded that genotypes KR 186-I, KR 15 and KRC 5 proved to be tolerant to water stress and genotypes KR 60, KR 142 were moderately drought sensitive, whereas genotypes KR 84 and KR 257 were highly susceptible to water stress.

RESOURCE GENERATION THROUGH BEEKEEPING IN HIMACHAL PRADESH

VK Rana, Sunil Kumar, Harish Sharma and BS Rana

Institute of Biotechnology and Environmental Science, Neri, Hamirpur 177 001 (HP)

Dr. Y. S. Parmar University of Horticulture and Forestry

In Himachal Pradesh, there are 1038 registered beekeepers having 93,866 bee colonies of *Apis mellifera* L. Out of the twelve districts in the state, the highest number of bee colonies is in district Kangra (719) followed by Shimla (140) and Kinnaur (53). The highest number of bee colonies is also in Kangra (59,556) followed by Shimla (19,154) and Kinnaur (6,417). Kangra is the major honey producing district (898.56MT) in the state. The other major honey producing districts are Shimla and Solan with 343.38MT and 54.67MT honey production, respectively. Beekeepers having more than 500 colonies can get net income about Rs 12, 25,000 in a year through migratory beekeeping. The net income of the beekeepers having number of bee colonies in the range of 301-500, 201-300, and 101-200 is 7,10,000, 5,06,000 and 1,54,000 respectively. The beekeepers having number of bee colonies up to 100 can get Rs 1, 05,500 in the year. Thus, it is evidenced that large beekeepers get substantial profit from beekeeping compared to small beekeepers. The average honey production is also more of large beekeepers than small beekeepers.

INCREASING PRODUCTIVITY OF MARGINAL LANDS THROUGH RAINFED FRUIT CULTIVATION IN SEMIARID TROPICS

S.S. Hiwale*

Central Horticulture Experiment Station, Vejalpur-389 340

(ICAR- CIAH), Godhra Baroda Highway (Gujarat)

** E-mail: sshiwale@yahoo.com*

The semiarid tropics extend over 2.1 billion ha. and supports a large population. To sustain increase in population and ultimately the demand for food, there is a need to increase productivity in these area on sustainable basis. Fruit trees can play a major role in increasing

productivity in this rain fed areas. Trees are known to reducing soil erosion, add leaf litter, provide fuel and fodder to the cattle's in times of drought and thus help in providing stability. There is therefore need to identify efficient multipurpose hardy fruit trees which can be successfully grown on degraded marginal lands under rainfed conditions. With this objective in view plantations of various fruit crops viz. Ber (*Zizyphus mauritiana* L.), Aonla (*Emblca officinalis* Gaertn.), Custard apple (*Annona squamosa* L.), Mango (*Mangifera indica*), Sapota (*Manilkara achrus* Mill.) and Pomegranate (*Punica granatum* L.) were raised at the station since 1986. The fruit crop orchards can be successfully established through *in-situ* budding, grafting technique, under rainfed conditions. The trees not only helped in increasing the productivity much higher than the traditional farming but also helped in ameliorating the marginal lands through addition of large quantity of leaf litter and other biomass to the soil. They also helped in reducing erosion losses through staggered trench planting, thereby reducing run off and conserving more water. Thus there is scope to improve the degraded lands through cultivation of fruit trees which can meet the demand of food, fodder and fuel. Highest production was recorded in Aonla at 10 years of age (94.5kg/plant) followed by Sapota(73.8 kg/plant) and Mango(69.5 kg/plant) and highest income per ha. was however recorded in Mango Rs 64500/-.It also reduced run off loss 32.63 % to 8.74 % in staggered trench planting. All the fruit trees also helped in soil enrichment by adding leaf litter to the soil helping in reducing the pH values 6.37 from 7.22. and organic carbon content from 0.278 to 0.596 %.The net income from fruit cultivation was Rs 64500/- in mango where as in traditional system it was just Rs.14750/-.which was 4.37 times higher. Thus fruit trees not only resulted in higher production but also helped in soil health improvement and reducing soil erosion and runoff of water. They also helped in higher carbon sequestration than the traditional system. Data on estimated carbon sequestration indicated that maximum carbon was sequestered by Ber (9.61 t/ ha.) and least was by Custard apple (2.45t/ha.)

IMPACT OF CHANGING CLIMATE ON APPLE PRODUCTIVITY

K.K.Pramanick^{1*}, K.K.Jindal², Poonam Kashyap¹, Y.P.Sharma¹, Santosh Watpade¹ and A.K.Shukla¹

¹*IARI Regional Station, Amartara Cottage, Shimla-4(HP)*

²*SILB, Solan (HP)*

**E-mail: kallolpramanick@gmail.com and kallol_pramanick@yahoo.co.in*

The low productivity of apple has become a serious concern for the farmers, research workers and development agencies at national and state level for the last two decades. Average yield of apple in India has been estimated at about 6 tonnes per hectare which is far below the level of 30 tonnes per hectare in most of advanced countries. Several factors can be attributed to the declining trend in productivity like expansion of apple cultivation to marginal areas, monoculture of Delicious varieties, declining standards of orchard management, improper chilling requirements and the fluctuating abnormal climatic conditions. The productivity has also not kept pace with the expansion in area under temperate fruits due to various biotic and abiotic

problems faced by the farmers in the Himalayas. This has caused a serious concern not only to the hill farmer community but also to researchers, development agencies and policy planners. With the global warming, the decline in productivity is being mainly attributed to changing climatic scenario. Increase incidence of warmer winters will have major impact on flowering & fruit set particularly in lower elevations (4500-6000 ft). Higher average temperature in future is likely to lead to earlier dates of bloom and maturity. Less precipitation may affect the water availability in early summers, affecting flowering & initial fruit growth. Hot summers could lead to more frequent problems such as water core & sun burn. Pest and disease regimes could change. In short term (over decade) the industry could cope up with measures already in place, particularly crop diversification in lower elevation areas. Increased attention should be paid to orchard floor management i.e. use of ground cover & mulching. In medium term (next 10-30 years) there could be an increased need for varieties with a lower chill requirement, they may not replace the Delicious cvs., which the apple industry presently expect to maintain. More emphasis will be required for cultural amendments to combat weather extremes. Over the next 50 to 100 years, it will probably be crucial to develop commercially viable varieties with low chilling requirements and maintain production of quality fruit in the higher elevations.

COMPARISON OF ORGANIC AND CONVENTIONAL INORGANIC FARMS FOR PRODUCTIVITY AND CARBON SEQUESTRATION POTENTIAL IN SHIWALIK REGION

Pawan Sharma*, Pratap Singh and R. P. Yadav

Central Soil and Water Conservation Research & Training Institute

Research Centre, Chandigarh -160019

**Email: pawan.dr.sharma@gmail.com*

Organic agriculture offers the best strategy to sustain production under extreme weather conditions in rain fed degraded agriculture lands, while providing environment protection. In order to compare the impact of organic vis-a-vis conventional inorganic farming practices on soil health and productivity, a survey was conducted in year 2011-12, by collecting data from seventy organic or conventional farms, located in fifteen villages of Shiwalik region. The organic farms invariably showed higher crop diversification index with crops like maize, wheat, rice, pulse and vegetable crops, while most of the conventional farms using inorganic fertilizers had rice/maize-wheat rotation. In the organic farms located in rain fed regions, the crop yields of cereal crops were almost at par with the farms using inorganic fertilizers. However under irrigated conditions, the organic farms had 20-30% lower crop yields. The main reason for reduced yields under organic agriculture was attributed to the inappropriate compost doses and other organic inputs, not based on the crop requirement or soil conditions. Soil analysis showed that the organic farms had a higher moisture, organic carbon, and mycorrhizal spores as compared to the conventional farms. The analysis of carbon storage in agriculture soils showed that average carbon stock of organic farms was 33 to 50 % higher than that of the conventional farms, indicating a possibility

to using organic farms as carbon sinks, thereby mitigating climate change.. The major constraints for adopting organic farming by the farmers were the non-availability of efficient compost, biofertilizers and bio-pesticides, lack of technical knowledge about modern organic technologies, and poor net returns due to no price premium for organic products. For higher adoption of organic farming in the region, there is a need to evolve suitable appropriate package of organic practices incorporating modern scientific tools with the indigenous farming knowledge, training of farmers in modern techniques, and improved policies on price premium and incentives like carbon credits to organic farmers.

FRACTAL BRANCHING ANALYSIS (FBA) A TOOL FOR NONDESTRUCTIVE BIOMASS ESTIMATION IN AGROFORESTRY

Pankaj Panwar*, Sharmistha Pal, V.K. Bhatt and Ram Prasad

Central Soil and Water Conservation Research and Training Institute

Research Center, Chandigarh-160019

**Email: dr_pankajp@yahoo.co.in*

Quantifying biomass yield, nutrient, net primary productivity and other important parameters for verification of plant C stocks requires periodic measurements of biomass estimates. Periodic measurements thus require cost-effective and reliable methods of measurements of biomass. Destructive sampling is not feasible horticultural plantation/orchards. Non-destructive sampling through allometric equations based on height and diameter at breast height (dbh) requires re-calibration for each tree species, stands density and cannot be easily applied in spatially-mixed agroforestry and in land uses where tree grows in open conditions like in horticulture. FBA is a suitable method of biomass estimation for trees that are intensively managed and are spatially distributed. FBA was applied for above-ground biomass estimation of twelve year old *Embilica officinalis* agrihorticulture system. The proximal and distal diameter, link length of branches and main stem of ten trees were measured along with other parameters as required in the model. The usual practice of non-destructive sampling was also applied to estimate the biomass. The allometric equation ($B = aD^b$; where B is biomass (kg tree^{-1}), D is diameter (cm) at breast height and 'a' is tree biomass when the diameter is 1 cm, 'b' is allometric scaling power) developed through FBA model for above ground biomass of *Embilica officinalis* was $0.0655 D^{2.4042}$. Allometric equation for branch biomass had a higher value of b factor then observed in total biomass. The allometric equation for branch biomass was $0.0007 D^{3.35108}$. The b factor for leaves + twig was lesser then the total biomass and the equation was $0.0656 D^{1.621}$.

IMPROVEMENT OF GROWTH, YIELD AND QUALITY OF MAIZE (*ZEA MAYS* L.) CROP USING VERMICOMPOST AS MANURE

Rakesh Joshi* and Adarsh Pal Vig

*Department of Botanical and Environmental Sciences
Guru Nanak Dev University Amritsar- 143 005 (Punjab)*

**E-mail: dr.adarshpalvig@gmail.com*

During the periods of 1960s to 80s, India achieved self-sufficiency in agriculture through "Green revolution". Although, green revolution increased the agricultural production but it lead to harmful effects on the health of humans and cattle due to the residues of agrochemicals in food products. Use .of agrochemicals also polluted our groundwater and surface water resources. These harmful effects shifted the interest of scientists towards organic fertilizers like vermicompost (VC). Vermicompost is an effective tool for solid waste management and hence, conversion of waste into wealth. Use of vermicompost increases porosity, aeration, drainage, water-holding capacity, enzymatic activity and microbial activity of the soil. It also contains plant growth hormones like auxins, gibberellins, cytokinins, ethylene and abscisic acid. So, vermicompost can be used as an alternative for chemical fertilizers. In the present study, Cattle dung was used as raw material to prepare vermicompost. A two year field trial (2009–10 and 2010-11) was conducted in the Botanical garden of Guru Nanak Dev University, Amritsar to study the effect of vermicompost on growth, yield and quality of maize crop and also to compare with NPK fertilizers. Three treatments of vermicompost i.e VC @ 5 t/ha, VC @10 t/ha, VC@ 20 t/ha and a treatment of recommended dose of NPK fertilizers were given in triplicates in a Complete Randomized Block Design. Various growth and yield parameters like mean plant height, mean stem diameter, number of leaves/plant, number of cobs/plant, number of grain rows/cob, cob length/plant, cob yield/acre, grain yield/acre and quality parameters of seeds like protein content, ash content, moisture content, crude fiber content, fat content, carbohydrate content, 1000 seeds weight were recorded each year at the time of harvesting. Most of growth, yield and quality parameters were found to be maximum in NPK treatment. No significant differences were observed between different vermicompost treatments and hence, lowest dose VC@ 5 t/ha was found to be the best dose.

PERFORMANCE OF CERTAIN RAINFED FODDER CROPS UNDER CUSTARD APPLE BASED HORTI-PASTORAL SYSTEM ON LOAMY SAND SOIL

A.G. Patel, R.R. Shakhela and J.A. Patel

*Centre for Agroforestry, Forage crops and Green Belt,
S.D. Agricultural University, Sardar krushinagar 385 506(Gujarat)
E-mail: arvind_patel100@yahoo.com, rrrshakhela@rediffmail.com*

The fruit growers do not commonly utilize the interspaces between the custard apple tree, though there ample scope to utilize the interspaces. The present experiment has been designed to assess the growth performance of fruit tree species (Custard apple) and to study the performance of

intercrops and the economics of return. Total nine treatment combinations comprising custard apple as a horticultural crop and four fodder crops viz; pearl millet, cowpea, sorghum and clusterbean were tested. The experiment was laid out in randomized block design with three replications. At the time of experimentation, the custard apple plants were 5 years old. The *kharif* drought tolerant fodder crops were sown on onset of monsoon in respective years. There was no adverse effect of fodder crops on the growth performance of custard apple, however, significantly higher custard apple fruit yield was recorded in sole custard apple compared to combination of the fodder crops. The green fodder yield of pearl millet, cowpea, sorghum and clusterbean were 3.6, 3.2, 0.90 and 2.5 tones ha⁻¹ in comparison to sole green fodder yield of 3.9, 2.7, 1.5 and 2.00 tones ha⁻¹, respectively. Significantly higher gross income was recorded by the combination of custard apple with pearl millet (8753 Rs ha⁻¹) which was followed by pearl millet sole (7901 Rs ha⁻¹) and custard apple with cowpea (7813 Rs ha⁻¹). The interspaces of bearing custard apple orchard may be successfully utilized by growing fodder crops mainly fodder pearl millet and cowpea increased yield of custard apple and income under rainfed condition.

RESPONSE OF ORGANIC MANURES AND BIOFERTILIZERS ON GROWTH AND HERBAGE YIELD OF BRAHMI (*BACOPA MONNIERI*)

Ajit Kumar

Department of Horticulture

G.B. Pant University of Agriculture and Technology, Pantnagar-263 145(Uttarakhand)

E-mail: ajitflori@gmail.com

Brahmi (*Bacopa monnieri*), is a herb belongs to family *Scrophulariaceae*. It is known by many names and in Hindi its name are Brahmi and Safed Chamni. It is valued in medicine as a tonic for nerves and prescribed in nervous disorders, mental diseases and constipation and as a diuretic, i.e. to promote urination. The plant contains an alkaloid braminine, which is a cardiac tonic. In order to assess its response to organic sources of nutrition, an experiment was conducted at Medicinal Plants Research and Development Centre, GBPUA&T Pantnagar. The experiment consisted of 10 treatments viz. FYM @ 15 t/ha, *Rhizobium*, phosphate solubilizing bacteria (PSB), *Azotobacter*, *Azospirillum*, FYM @ 15 t/ha + *Rhizobium*, FYM @ 15 t/ha + *Azotobacter*, FYM @ 15 t/ha + PSB, FYM @ 15 t/ha + *Azospirillum* and control. The experiment was plotted according to Randomized Block Design (RBD) with 3 replications. During present investigation maximum value for vegetative growth characters like branches/m² (2053.7), leaves /m² (37354.7) and plant spread (80.00 cm) was observed in treatment having composition of FYM @ 15 t/ha followed by 1870.33, 35017.30 and 72.3 (branches/m², leaves/m² and plant spread, respectively) in the treatment consisting of FYM @ 15 t/ha + *Azospirillum*. As far as yield (q/ha) for fresh herbage and dry herbage is concerned, it was also significantly more in FYM 15 t/ha (116.90 and 35.07 q/ha for fresh and dry herbage, respectively) as compared to remaining treatments except FYM @ 15 t/ha+ PSB, *Azotobacter* and *Azospirillum*. All the treatments caused significant increase in yield as compared to control and it can be recommended to use either FYM or FYM with *Azospirillum* for obtaining higher herbage yield of this wonder plant.

BIODIVERSITY OF UNDERUTILIZED FRUIT CROPS IN SUBTROPICAL ZONE OF HIMACHAL PRADESH

Vikas Kumar Sharma, Kamal Sharma and K S Verma

*Institute of Biotechnology & Environmental Science, Dr Y, S Parmar University of Horticulture
& Forestry, Neri, Hamirpur -177 001 (HP)*

The genetic resources underutilized fruits have not received the desired importance due to their comparatively less commercial importance and limited research on genetic improvement of cultivars. The genetic modifications in high value commercial fruits and their accessibility to the farmers are leading to great loss in genetic diversity of traditional underutilized fruits. India is leading to alarming loss of genetic resources of these species.

Efforts have been made to study and the biodiversity of wild fruits in the subtropical zone of Himachal Pradesh. The important wild fruits found growing in this zone comprise *Aegle marmelos* (Bael), *Berberis aristata* (Kashmal), *Carissa spinarum* (Garnu), *Citrus pseudolimon* (Galgal), *Cordia obliqua* (Lassora), *Embllica officinalis* (Himalayan wild aonla), *Ficus palmata* (Fegra), *Ficus roxburghii* (Taryamal), *Flacourtia sapida* (Kangu), *Fragaria indica* (Wild strawberry), *Murraya Koenigii* (Curry leaf plant), *Musa* sp. (Hill banana), *Phoenix sylvestris* (Wild Date), *Punica granatum* (Wild sour pomegranate), *Rubus ellipticus* (Aakhe), *Terminalia chebula* (Bahera), *Zizyphus jujube* (Ber) etc. The important characteristics of these fruits besides their nutritional significance are wider adaptability to the stressed, rainfed and degraded soils possess high potential for mitigating inevitable climate change scenario, and hence need proper characterization and conservation so as to avoid threat to their existence.

SHORT -TERM EFFECTS OF SEED DRESSING WITH AZORHIZOBIUM CAULINODANS ON ESTABLISHMENT, DEVELOPMENT AND YIELD OF EARLY MATURING MAIZE (ZEA MAYS L.) IN ZIMBABWE

Gabriel Vusanimuzi Nkomo

*Faculty of Agriculture and Natural Resources,
Africa University, PO Box 1320 Mutare Zimbabwe
Email: gvnkomo@gmail.com.*

The majority of soils in communal areas of Zimbabwe are sandy and inherently infertile and sustainable cultivation is not feasible without addition of plant nutrients. Most farmers find it difficult to raise the capital required for investments in mineral fertilizer and find it cheaper to use low nutrition animal manure. An experiment was conducted to determine the effects of nitrokara biofertiliser on early growth, development and maize yield while also comparing nitrokara biofertiliser on availability of nitrogen and phosphorous in soil. The experiment was conducted at Africa University Farm. The experiment had six treatments (nitrokara +300kg/ha Compound D, nitrokara+ 300kg/ha Compound D(7N;14P;7K) + 75kg/ha Ammonium Nitrate(AN), nitrokara +300kg/ha Compound D +150kg AN, nitrokara +300kg/ha Compound D +225kg/ha AN, nitrokara +300kg/ha Compound D + 300 kg/ha AN and 0 nitrokara+300kg/ha Compound D +0 AN). Early maturing SC 403 maize (*Zea mays*) was inoculated with nitrokara

and a compound mineral fertilizer at 300 kg/ha at planting while ammonium nitrate was applied at 45 days after planting. There were no significant differences ($P>0.05$) on emergence % from 5 days up to 10 days after planting using maize seed inoculated with nitrokarra. Emergence percentage varied with the number of days. At 5 days the emergence % was 62% to a high of 97% at 10 days after emergence among treatments. There were no significant differences ($P>0.05$) on plant biomass on treatments 1 to 6 at 4 weeks after planting as well as at 8 weeks after planting. There were no significant differences among the treatments on the availability of nitrogen after 6 weeks ($P>0.05$). However at 8 and 10 weeks after planting there were significant differences among treatments on nitrogen availability ($P<0.05$). There were no significant differences among the treatments at week 6 after planting on soil pH ($p>0.05$). However there were significant differences among treatments pH at weeks 9 and 12 ($p<0.05$). There were significant differences among treatments on phosphorous availability at 6, 8 and 10 weeks after planting ($p<0.05$). There were no significant differences among treatments on stem diameter at 3 and 6 weeks after planting ($p>0.05$). However at 9 and 12 weeks after planting there were significant differences among treatments on stem diameter ($p<0.05$). There were no significant differences among treatments on plant height from week 3 up to week 6 on plant height ($P>0.05$). However there were significant differences among treatments at week 9 and 12 ($p<0.05$). There were significant differences among treatments on days to early, 50% and 100% anthesis ($P<0.05$). There were significant differences during early, 50% and 100% days to silking among the treatments ($P<0.05$). Also there were significant differences during early, 50% and 100% days to silking among the treatments ($P<0.05$). The study revealed that inoculation of nitrokarra biofertiliser at planting with subsequent addition of ammonium nitrate has a positive effect on maize crop development and yield.



THEME

BIOENERGY :
SCALE, POTENTIAL AND BARRIER



INDUSTRIAL PINEAPPLE WASTE AS A FEASIBLE SOURCE TO PRODUCE BIOETHANOL AND OTHER VALUE ADDED PRODUCTS

P. Ramana

Department of Forest Products and Utilization

College of Forestry, Sirsi, Uttara Kannada – 581401(Karnataka)

Email: ramana_cofs@rediffmail.com

A field survey was conducted during 2013 to assess the available pineapple waste and the extent of usage for bioethanol and other value added products from the residues of the juice and canning industries. The field investigation was conducted in the Uttara Kannada district of Karnataka to document the existing pineapple processing units. Information on raw material, processing, waste generated by the industries was collected through industrial visits. There are 6 pineapple processing units existing in Uttara Kannada district of which 5 units are in Sirsi taluk , mainly concentrated around Banavasi region and 1 in Siddapur taluk. Pineapple waste consist basically of the residual pulp, peels, stem and leaves.. This is mainly due to selection and elimination of components unsuitable for human consumption. Besides, rough handling of fruits and exposure to adverse environmental conditions during transportation and storage cause up to 45- 55% of productwaste. Waste is having high biological oxygen demand (BOD) and chemical oxygen demand (COD) values. An average 5-6 tonnes of fresh fruit is processed in each unit and producing an average of 2-3 tonnes of waste per day. About 20-25 tonnes of total waste is generated daily from 6 units. At present, fruit residues cause serious environmental problems, since it accumulates in agro-industrial yards without having any significant and commercial value. Since disposal of these wastes is expensive due to high costs of transportation and a limited availability of landfills they are unscrupulously disposed causing concern as environmental problems. Only one unit is partly using the lignocellulosic waste for producing cattle feed in recent days. Majority of the pineapple waste is dumped in and around the industries as solid waste. With the initiative of Biofuel information and Demonstration Centre, Sirsi an interactive meeting was organized between industries and the agencies involved in the vale addition of pineapple waste at Banavasi with the active involvement of Karnataka State Biofuel Development Board (KSBDB). Possible uses and technologies on waste conversion into bioethanol, biogas, electricity generation, as low cost substrate for the production of lactic acid using *Lactobacillus lactis* and enzyme invertase etc were provided to the industries.

POPULARIZATION OF BIOFUELS AS A TOOL TO PROMOTE RURAL ECONOMY AND FOR SUSTAINABLE DEVELOPMENT THROUGH BIOFUEL INFORMATION AND DEMONSTRATION CENTRE –A CASE STUDY FROM UTTARA KANNADA

P. Ramana

Department of Forest Products and Utilization

College of Forestry, Sirsi, Uttara Kannada – 581401(Karnataka)

Email: ramana_cofs@rediffmail.com

The papers highlights the efforts were made by Uttara Kannada District Biofuel Information and Demonstration Centre to popularize biofuels among farmers, panchayat raj institutions, line departments of state agencies and students through exhibitions, awareness and training programmes. Sirsi centre is one among the 32 Biofuel Information and Demonstration centre's established by Karnataka State Biofuel Development Board (KSBDB) across 30 districts of Karnataka. The main objective of Biofuel Centre is to promote R&D and organize Training and awareness programme in Biofuels for various target groups. Centre has conducted awareness camps for farmers, NGOs, Panchayat officers, etc., Training program on Biofuel technology has been given to farmers, skilled workers/ Technician etc. Centre has prepared resource material for awareness and training programs and has collaborated with state agencies to conduct awareness program on Biofuel for farmers and giving field demonstration of techniques and application of Biofuels. Centre has established nursery for Biofuel species and yearly distribution of Biofuel saplings to schools, colleges and public in Uttara Kannada is been practiced. "Biofuel School Gardens" were established in few schools to provide information on biofuels. Biofuel Plantation are done through a network of villagers/farmers the same villagers can harvest the seeds and sell it to the nearest oil expelling units at the prevailing market prices with assured minimum support price (MSP) to oil seeds as per the KSBDB rates. This has generated employment in rural areas. KSBDB major initiatives through the State Government Programmes such as Suvarna Bhoomi Yojana, Hasiru Honnu and Bardu Bangara to promote the Biofuel Plantations on a large scale were promoted among the farmers of the region. Good number of farmers have benefitted from these initiatives. Centre is also encouraging them to use MNREGA funds for getting employment to farmers through biofuel related works at village level.

HYDNOCARPUS PENTANDRA - A POTENTIAL BIOFUEL SPECIES FROM UTTARA KANNADA DISTRICT OF CENTRAL WESTERN GHAT REGION OF KARNATAKA

P. Ramana¹ and N.R. Dhathri²

¹*Department of Forest Products and Utilization*

College of Forestry, Sirsi, Uttara Kannada – 581401(Karnataka)

²*Department of Biochemistry, College of Agriculture, Dharwad-580 005 (Karnataka)*

Email: ramana_cofs@rediffmail.com

Hydonocarpus pentandra is evergreen tree. It is endemic to Western Ghats is an underutilized non-edible vegetable oil source available in large quantities in Uttara Kannada district, Karnataka Its potential suitability as a biodiesel feedstock is still not evaluated comprehensively. Present investigation was carried out in 2013-14 to evaluate it for morphogenetic variations, oil content, fatty acid composition, and its biodiesel production potential. Fruits were collected from trees existing in natural forest. Seed oil was estimated by soxhlet extraction method. The extracted oil was analysed for fatty acid profile by GC-MS method and the oil was converted to methyl ester via transesterification reaction. The reaction result was two phases. The upper and lower layers were methyl ester and glycerin respectively. In the next step the produced methyl ester (biodiesel) was heated to 100 °C, and then dried with anhydrous Na₂SO₄ to get rid of any water. The properties of produced biodiesel were determined by using ASTM standards: Kinematic viscosity, Flash point, density Cetane value etc. Results revealed that tree height varied from 13.5 to 23.5 m, girth was in the range of 0.34 to 3.4 m, number of seeds per fruit varied from 1-24, seed size was in the range of 2.18 to 2.55 cm², seed to shell ratio was in the range of 1:3, oil yield was in the range of 28.88 to 55.9 %. The oil was rich with cyclopentene group of fatty acids like hydnocarpic acid, chaulmoogric acid and gorlic acid and a small amount of palmitic and oleic acid. Based on the potentiality of *H. pentandra* for biofuel sector, there is an urgent need to take up detailed scientific studies on the species.

BIOMASS PRODUCTION OF SUBABUL UNDER HIGH DENSITY PLANTATION CULTURE

G.P.S. Dhillon, Avtar Singh*, R.I.S Gill, Baljit Singh and K.S. Sangha

Department of Forestry & Natural Resources, PAU Ludhiana (Punjab)

** Regional Research Station, Bathinda (Punjab)*

**E-mail: avtar_69@rediffmail.com*

As the fossil fuel stocks are limited, major thrust is being given to find alternate sources of energy. The State and Central Government of India has approved a large number of units that prepare electricity from crop residue and wood fuel. A trial to study the production potential of subabul under very high density was planted in the last week of March 2010 at three spacing's

i.e. 30 x 30 cm, 40 x 40 cm and 50 x 50 cm with four replications under randomized block design. The trial was planned to consist two cutting cycles i.e. six monthly and annual cutting. The six monthly cycles was first harvested during September, 2010 from the collar region (10 cm above ground level) during April, 2011 all the treatment blocks were also cut from collar region. The data on plant height, collar diameter and number of stems collected during April 2011 is given in Table 1. The effect of spacing, cutting cycle and their interaction was significant on all the parameters. All growth traits recorded significantly highest values at spacing 50x50 cm. The lowest values were at spacing 30x30 cm. Plant height and collar diameter registered the highest values at annual cycle. It was expected as plants were of one year age in comparison to the latter which were of six month (after coppicing). The biomass production per plant was maximum in the wider spacing (50x50cm) and the lowest at spacing of 30x30 cm. However, the biomass production per unit area was maximum in case of 30x30 cm spacing. The distribution of biomass in above ground components showed that the percent biomass was maximum in wood (41.9) and was followed by branches (38.3) and the leaves (31.3).

SECOND GENERATION BIOENERGY CROPS (PERENNIAL FORAGES)

Shabir Ahmad Rather*

Faculty of Forestry, Camp Wadura, SKUAST-K, Sopore - 193 201 (J&K)

**E-mail: sshab53@gmail.com*

Perennial forage crop species known as "Second generation bioenergy crops" are considered to be the future of the bioenergy industry and are the focus of intense research. Compared with the first generation biofuels based on annual grain crops, perennial biomass crops require fewer inputs, produce more energy, and reduce greenhouse gas (GHG) emissions more than annual cropping systems. Switchgrass (*Panicum virgatum* L.) is particularly compelling in North America because of its relatively low production inputs and costs, perennial growth habit, and adaptability to a broad range of growing conditions. Perennial forage crops such as alfalfa (*Medicago sativa* L.), reed canarygrass (*Phalaris arundinacea* L.), napiergrass (*Pennisetum purpureum* Schumach.), bermudagrass (*Cynodon* spp.) and *Miscanthus* (a C4 grass native to Asia), soyabean and maize etc could also serve as perennial bioenergy crops for specific agroecoregions of North America and of India also. The lignocellulose in perennial forage crops represents a vast and renewable source of biomass feedstock for conversion into the second generation of bio-based products. Principle management factors that influence biomass productivity and feedstock quality of a particular species include; rapid seedling establishment to reduce the time to productive stands, optimizing fertilizer inputs and harvest management to optimize yield, persistence, and feedstock quality. Second generation crops currently supply the energy that fuels approximately 100 million ruminant animals on USA farms with a total estimated economic value of \$US 39 billion. Currently, bioenergy produced from second generation cellulosic feedstocks costs more than fossil fuels. Projected costs of switchgrass biomass range from \$40 to \$61 Mg⁻¹ in Tennessee and \$53 to \$74 Mg⁻¹ in Oklahoma. The value

of environmental benefits of bioenergy crops, however, may offset the price differential between biofuels and fossil fuels. The environmental benefits of bioenergy crops include increased soil quality, reduced losses of soil nutrients, soil C sequestration, protecting riparian zones and recycling nutrients from sewage sludge, livestock manure, and bioconversion byproducts among others.

BIOMASS PRODUCTION THROUGH SHORT ROTATION COPPICE FROM WILLOWS

R. Banyal*, N.A. Masoodi, T.H. Masoodi, K.N. Qaiser and A.R. Malik

Faculty of Forestry, SKUAST-K Camp Wadura, Sopore - 193 201(J&K)

**E-mail: drbanyal08@gmail.com*

Global energy projections predict that biomass will be an important source of renewable energy in the times to come. Short rotation woody crops will be the prime source of this biomass. The technology of Short Rotation Coppice (SRC) has been developed in hilly areas of temperate zone of North Western Himalayas to answer the prevailing problems of fuel-wood shortage and geographical constraints. The existing Willow production technology practiced by state and private sector can produce only 7 tons OD ha⁻¹ year⁻¹. Therefore, the present challenge was taken to develop the plantation technology which can increase the biomass production to many fold. The technology under question was standardized with potential Willow (*Salix spp.*) namely *Salix alba*, *Salix viminalis* & *Salix fragilis* existing in the region. The willow plantation under SRC was done in April, 2006 at Faculty of Forestry, SKUAST-Kashmir, Camp Wadura, Sopore, J&K in which 13,000 cuttings of *Salix alba*, *Salix viminalis* and *Salix fragilis* in each were accommodated in an hectare area. It is planted in twin rows formation (75x150 cm) under three years rotation cycle. The first rotation crop was harvested in December, 2010 (winter) when the plants have gone into hibernation and shed their leaves. The results reveal that the growth and biomass parameters were statistically significant over the years as per the *Salix spp.* planted under SRC are concerned. The growth in clumps attained average height of 8.31m in *Salix alba*, 7.35m in *Salix viminalis* and 7.13m in *Salix fragilis* with average of 11 to 16 clumps per stool. The average diameter of clumps recorded to 50.43mm in *Salix alba*, 50.03mm in *Salix viminalis* and 40.16mm in *Salix fragilis* at the end of first rotation. It was found that *Salix alba* produced 34.34 tons/ha followed by *Salix viminalis* (29.71 tons/ha) and *Salix fragilis* (28.73 tons/ha) OD biomass, respectively at the final harvest of first rotation. The second rotation was harvested in the December, 2012 (winter). The observations from the same rotation are in congruous with the first rotation cycle and presently the experiment is under third rotation. At the end of second rotation, *Salix alba* was found to top the list followed by *Salix viminalis* and *Salix fragilis*. Therefore, it may be recommended from the half way of the experiment that *Salix alba* is the better bioenergy crop for the production of biomass for the region. Wood energy can be

technically efficient, economically viable and environmentally sustainable fuel option during the prevailing energy deficit scenario. It is not only the answer to the fuel wood shortage but also to the wicker works, fodder and even to the electricity supply with no net addition of CO₂ in the atmosphere.

EARLY GROWTH PERFORMANCE OF SUPERIOR WILLOW CLONES IN ASSAM

Tara Chand^{1*}, Ranjeet Kumar¹, J.P. Sharma², N.P. Singh² and N.S. Bisht¹

¹ *Rain Forest Research Institute, Jorhat, Assam-785001*

² *Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Solan HP*

**E-mail: tarachand@icfre.org*

Willows are amongst the world's fastest grown species which can be in many agroforestry models. Its wood is best suited for sport items and artificial limbs. Environmentally acceptable source of biomass for wood and bioenergy is one of most emphasized potential of willows world over. Willows are suitable for reclamation of salt and water affected soils, vegetation filter and soil and water conservation. 22 best performing clones of *Salix* planted at different locations in India were sourced from Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture & Forestry, Nauni, Solan to study their adaptability and stability in Assam. The trial was established at RFRI campus in single tree plot RBD design with three replications. These clones planted at RFRI Jorhat, Assam were evaluated for their relative growth performance after one year. After initial leaf infestation by beetle, all the clones survived and established on the site. The data revealed that plant height and basal diameter significantly varied among the clones. Plant height was highest in UHFS-14, which is at par with clones UHFS-8, UHFS-7, UHFS-4, UHFS-18, UHFS-2 and UHFS-15, while diameter was maximum in UHFS-10 which is at par with clones UHFS-12, UHFS-19, UHFS-2, UHFS-11, UHFS-13, UHFS-14, UHFS-4 and UHFS-6. Many clones exhibited straightness in their growth. None of clone recorded any disease symptoms in one year growth period. This paper reports first year relative growth performance the clones established at RFRI.



THEME
FOREST RESOURCES



AGROFORESTRY SYSTEMS FOR CLIMATE CHANGE RESILIENCE IN AGRICULTURAL LANDS

C. Buvaneshwaran*, R. S. Prashanth and N. Krishna Kumar

Institute of Forest Genetics and Tree Breeding,

P.B.No.1061, Forest Campus, R.S.Puram, Coimbatore-641 002 (Tamil Nadu)

**E-mail: buvanesc@icfre.org*

Intergovernmental Panel on Climate Change reports that Tropical Afforestation and Tropical Agroforestry have major roles to play in mitigation of global emission of CO₂. In this regard, there can be two strategies for enhancing potential of Agroforestry option to mitigate climate change impacts viz. 1) Enhancing Productivity and carbon sink services of existing Agroforestry systems and 2) Increasing land area under Agroforestry through Windbreak Agroforestry systems so as to make existing agro-ecosystems as more climate change resilient systems. In implementing the first strategy of enhancing carbon sink services, tree improvement initiatives in tree species of Agroforestry importance need to be promoted to maximize carbon sequestration potential. In the second strategy, land area under Agroforestry need to be increased through Windbreak Agroforestry systems to make agro-ecosystems as more climate change resilient systems, particularly as an important tool for farming in semi-arid areas. It is also important to note that windbreak Agroforestry system will not replace the agriculture crops while increasing the tree cover in the country. By adopting windbreak agroforestry, agro-ecosystems are expected to become more climate change resilient system through i) enhanced productivity, ii) reduced evapo-transpiration and in turn increased water use efficiency of the agro-ecosystem iii) reduced crop damage and iv) increasing carbon sequestration in biomass and in soil. Research works relating to the above facts have been reviewed in this paper. The efforts of Institute of Forest Genetics and Tree Breeding, Coimbatore in developing i) productive, ii) end-use specific and iii) climate-change-ready tree varieties/clones for windbreaks as well as other agroforestry systems has also been discussed in this paper.

EVALUATION OF MULTI-LOCATION TRIALS OF SALIX IN PUNJAB FOR VARIOUS ENDUSES

Kulwinder Singh, Rajni Sharma and Sanjeev K Chauhan

Department of Forestry and Natural Resources, PAU- Ludhiana- 141 004 (Punjab)

**E-mail: rajni@dr.com*

In Punjab, *Populus*, *Eucalyptus* and *Melia* are priority agroforestry trees for enhanced economics than traditional crop rotation. But, an another species i.e., willow which is multipurpose, fast growing and has lots of potential in sports industry, phytoremediation and biomass production can be introduced for agroforestry under diverse climatic and edaphic conditions of Punjab. Government of Punjab is trying to diversify rice-wheat cropping system due to continuous decrease in ground water table and pollution of soil and water due to high use of agro-chemicals.

Willows are light demanding, deciduous trees and shrubs, found primarily on moist soils in cold and temperate regions of the northern hemisphere. Numbers of species of willows have adapted to a wide range of climatic and soil conditions. Being multipurpose agroforestry species, willows provide fuelwood, fodder, veneer, pulp, plywood, reconstituted wood products, artificial limbs, packing crates, agricultural implements, furniture, and sports goods. It is also helpful in protection of soil and water erosion and phytoremediation of degraded soils. They are often integrated with agriculture, horticulture, viticulture and apiculture. The study was carried out with twenty two willow clones at three locations i.e., University Seed Farm, Ladhawal, Ludhiana; Badhian Forest, Range & Division Dasuya and Alamwala, Range Malout, Division Faridkot). The objectives of this study was to identify the site specific clones based on their growth performance and to evaluate the clones for agroforestry, biomass and landscape use. Ranking of clones on the basis of performance showed large changes among three environments. Clones which performed good under one environment performed poorly under other environments and *vice versa*. Results of the study shows that for agroforestry, clone UHFS-2, UHFS-5, UHFS-12 and UHFS-18 will be suitable due to less number of branches, small leaf area, large days in leaf less phase and good growth. For biofuel or phyto-remediation, clone UHFS-3, UHFS-13, UHFS-14 and UHFS-16 will be suitable due to good growth, large number of branches, large leaf area, and less days in leaf less phase. Clone UHFS-10 can be used for landscape purposes due to its drooping nature of branches.

BIOMASS PARTITIONING AND CARBON STORAGE IN SHORT ROTATION TREE SPECIES

Tarun Sen and Sanjeev K Chauhan

Department of Forestry and Natural Resources, PAU Ludhiana - 141 004 (India)

E-mail: tarun_sen@hotmail.com; chauhanpau@pau.edu

Biomass and carbon storage in different short rotation trees plantation over eight years were evaluated at University Seed Farm, Ladhawal, which lies at central region of Punjab. Ten short rotation tree species were raised in a completely randomised design included planting density of 278 trees ha⁻¹ (*Acacia auriculiformis*, *Acacia nilotica*, *Ailanthus excelsa*, *Anthocephalus cadamba*, *Eucalyptus camaldulensis* (var *obtus*), *Eucalyptus tereticornis* (Australian seed introduction), *Eucalyptus tereticornis* (clone 288-14), *Eucalyptus tereticornis* (local seed source), *Eucalyptus tereticornis* var. *tereticornis*, *Gmelina arborea*, *Pongamia pinnata*, *Populus deltoides*, *Tectona grandis*). Total and component (stem, branch, leaf, bark and root) biomass among different species differed significantly. The ranking of the total plantation biomass in different tree species was in the order of clonal eucalyptus > *Gmelina arborea* > *Eucalyptus tereticornis* (Australian source) > *Ailanthus excelsa* > *Populus deltoides* > *Tectona grandis* > *Acacia nilotica* > *E. tereticornis* (local seed source) > *Anthocephalus cadamba* > *E. tereticornis* var. *tereticornis* > *E. camaldulensis* var. *obtus*. The component wise trend was in the order of stem > root > branch > leaf > bark for all the species and contributed 47.49 %, 24.48 %, 13.21

%, 7.64 % and 7.18 %, respectively. Mean carbon concentration among all biomass components ranged from 42- 50 %, with the highest carbon proportion in stem and lowest in bark. Over the study period, the dynamic pattern of biomass carbon sequestration potential of different tree species was similar to that of total biomass production. The highest carbon sequestration potential of clonal eucalyptus reached about 11.0 t C ha⁻¹ yr⁻¹, whereas, least was accumulated by *Pongamia pinnata* (2.75 t C ha⁻¹ yr⁻¹). After 8 years of plantation, total soil organic carbon (SOC) in surface soil (0-15cm) ranged 12.25 to 18.85 Mg ha⁻¹, which was 116 per cent higher than tree less area.

CLIMATE CHANGE IMPACTING DIVERSITY AND DISTRIBUTION PATTERNS OF FLORA – A STUDY IN THE WESTERN HIMALAYAN REGION OF INDIA

J.C. Rana*, Pankaj Sharma and Usha Devi

National Bureau of Plant Genetic Resources

Regional Station, Phagli, Shimla - 171 004 (HP)

**Email: ranajc2003@yahoo.com*

The scientists have found mountain regions as excellent laboratories to study the impact of climate change because no other single region in the world provide a better picture of structural variation in vegetation and cropping patterns under the influence of different altitudes. The present study was undertaken in the Western Himalayan region to analyze the influence of climate change on the diversity and distribution patterns of floral diversity. We found that out of 853 floral species reported in 'Flora Simlensis', 264 species are not available in the locations mentioned. The upward shift ranging from 400-800 meter was noticed for some species like *Aconitum heterophyllum*, *Polygonatum verticilatum*, *Habenaria intermedia*, *Lilium polyphyllum*, *Sorbus lanata*, *Swertia chirayita*, *Androsace salicifolia* and many others. The population dynamics of some species have changed e.g. *Prunus cornuta*, *Corylus jacquemontii*, *Quercus leucotrichophora*, *Rhododendron arboreum* and *Cedrus deodara* are found with fewer saplings and seedlings at elevation range of 1500-2000m than 2000-2500m. Crops wild relatives such as *Cicer microphyllum*, *Linum perenne*, *Allium* species inhabiting alpine tops have become vulnerable. The preponderance and aggressiveness of invasive species was found to be correlated with rise in temperature. The invasive species *Lantana* and *Parthenium* have not only outnumbered the native vegetation *Carissa spinarium*, *Adhatoda vasica*, *Dodonea viscosa*, *Cassia tora*, grasses, medicinal herbs and wild flowers but have also shifted upwards. The commonly occurring events like change in precipitation rate, decreasing snowfall, land degradation, drying up of water sources, outbreak of pest, changes in phenology (time of budding, flowering, leaf fall and so forth), changes in cropping patterns and food shortages are good indicators of the impacts of climate change. The trend analysis of cropping patterns of the last few decades showed that many crops have been affected in mountain regions. Farmers have

shifted from apple to vegetable crops like cauliflower, cabbage, peas, carrot, and other fruit crops- pomegranate, kiwi and pear cultivation at mid elevations due to lack of chilling hours. At present, the rate at which demographic and sociopolitical changes are taking place in response to global changes is outstripping the ability of traditional approaches and coping mechanisms to respond. Therefore, any adaptive strategy formulated without taking into consideration these anthropogenic factors will not work to mitigate the expected climate change. Nevertheless, scientists need to identify new sources of variation for beneficial adaptive traits to climate change. Breeding programmes must develop crop-specific (and region specific) strategies today in order that the products are relevant to problems and conditions 10-15 years down the line. It is also expected that some species will likely migrate to areas with appropriate climates, but many plant species will not be able to migrate fast enough to keep pace with current rates of warming especially poor competitors, species with narrow distribution and poor adaptability. It will, therefore, be critical to protect migration corridors and elevation gradients or even conservationists will likely need transplant some rare species to new locations either in the wild or in botanic gardens that have appropriate climate conditions.

LITTER FALL, NUTRIENT RETURN AND SOIL FERTILITY UNDER *BAUHINIA VARIEGATA*: AN AGROFORESTRY TREE SPECIES

Vijender Pal Panwar¹ and M.K. Gupta²

¹*Himalayan Forest Research Institute, Shimla (HP)*

²*Forest Research Institute, Dehradun (UK)*

E-mail: vppanwar@yahoo.com, guptamk@icfre.org

Plants, during their active growth phase take up available nutrients from their pools present in the soil and return a considerable amount back to it through regular senescence of aerial parts or through litter-fall. Litter once decomposed sets the nutrients free into the soil-system for their reuse by the plants. The concentration of nutrients in the litter component is also an important factor because it influences the rate of decomposition of litter and also the amount of nutrients those get liberated during decomposition process. The study was conducted in Aghar and Bilkar Kahan villages in Hamirpur District of Himachal Pradesh to quantify the litter fall, nutrient contents, nutrient return and soil fertility status in *Bauhinia variegata* which is an indigenous agroforestry species. Litterfall has been estimated on monthly basis from permanent quadrats. The litter for each of the month thus collected has been brought to the laboratory as such and later sorted out into the different litter categories. The processed litter samples were subjected to nutrient content analysis. The average production of annual litter-fall in *B. variegata* was 152.23 g/m²/yr and out of this leaves contribution was 106.84, bark 4.23 g m⁻² yr⁻¹ and miscellaneous litter contribution was 41.16 g m⁻² yr⁻¹. Maximum litter fall was recorded in the month of December 37.19 g m⁻², followed by January 27.94 g m⁻², November 19.00 g m⁻² and least litter fall was in February 1.48 g m⁻². Total nutrient return under *B. variegata* was 8.703 g m⁻² yr⁻¹ and out of this calcium contribution was maximum (4.63 g m⁻² yr⁻¹) followed by nitrogen 1.91 g m⁻² yr⁻¹, potassium (1.08 g m⁻² yr⁻¹), magnesium (0.76 g m⁻² yr⁻¹) and the least was of phosphorus

($0.32 \text{ g m}^{-2} \text{ yr}^{-1}$). Trend of nutrient return in *B. variegata* was, leaves > miscellaneous litter > bark. Soils under *Bauhinia variegata* were nearly neutral (6.65 to 7.19) with optimum concentration of organic matter. Soils were moderately enriched by nitrogen ($161.45 \text{ kg ha}^{-1}$ to $280.12 \text{ kg ha}^{-1}$) and potassium ($137.90 \text{ kg ha}^{-1}$ to $191.12 \text{ kg ha}^{-1}$) while well enriched with phosphorus (17.28 kg ha^{-1} to 29.34 kg ha^{-1}). Nutrients were higher in surface layer as compared to lower layers and decreasing down with increasing the depths. Bulk density varied from 1.09 g cc^{-1} in surface layer to 1.18 g cc^{-1} in lowest layer (60 – 90 cm). Trees are beneficial for the soil as they enrich the soil by providing litter and recycling of nutrients through litter-fall and subsequent mineralization and re-assimilation by the plant roots at the forest floor, hence, is a dynamic and important component of nutrient cycling in the ecosystem.

EFFECT OF CLIMATE CHANGE ON THE PERFORMANCE OF POPLARS UNDER MID HILL CONDITIONS OF HIMACHAL PRADESH

Vijender Pal Panwar and Rajesh Sharma

Himalayan Forest Research Institute

Conifer Campus, Panthaghati, Shimla-171 009 (HP)

E-mail: vppanwar@icfre.org, sharmar@icfre.org

Poplars occupy unique and important position in the rural economy of north Indian farming community for their fast growth and ability to provide substantial production over the years and have witnessed change. This change attributed to introduction and adaptability of new clones in farm forestry has assumed immense significance with changing climatic conditions. One such attempt to evaluate the performance of sixty three selected clones of *Populus deloides* and five clones of *Populus x euramericana* for the traits plant height, collar diameter, specific gravity and root biomass was made in the nursery under mid hill conditions of Himachal Pradesh. Non-significant differences were observed for all the traits except for plant height and root biomass where the clones differed significantly. The traits plant height and specific gravity also showed significant correlation coefficient amongst them. The plant height of the clones varied from 1.2 m to 2.3 m, collar diameter from 0.98 cm to 1.69 cm specific gravity from 0.37 to 0.52 and root biomass from 10.97g to 69.37g for different clones. The field performance of these clones will reveal the suitability of the clones for commercialization.

MANAGEMENT OF EXOTIC POPLARS FOR PRODUCTION OF QUALITY TIMBER AND REDUCING COTTON MENACE IN KASHMIR (J & K)

S. A. Gangoo and Shah Murtaza Mushtaq

Faculty of Forestry

Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir

Campus Wadoora, Sopore-193201 (J & K)

E-mail: gangoo_sajad@yahoo.com, smurtaza@rediffmail.com

Genus *Populus* includes 44 species in five sections. These are White poplar (Leuce), Black poplar (Aigeiros), Balsam poplar (Tecamahaca), Leucoides and Turanga. These are widely distributed in the temperate and sub-tropical regions of the Northern Hemisphere. Six indigenous species of Poplars viz., *Populus ciliata*, *P. alba*, *P. euphratica*, *P. gamblii*, *P. jacquemontii* Var. glauca and *P. rotundifolia* are reported in India. *Populus deltoides* has so far been the most important exotic species of the genus introduced in the country. In 1950 1st systematic attempt was made to introduce poplar clones and were tested in Himalayas by Uttar Pradesh Forest Department. FRI Dehradun laid trials in 1959, when 24 clones were imported from the British Forestry Commission. These clones were planted in Kashmir, Himachal Pradesh, Punjab, Uttar Pradesh, West Bengal and Tamilnadu. Clones of *Populus deltoides*, G3, G48, D67, D75, D82, D121, D161, D171 and D181 revealed superior growth in field trials laid in Tarai regions (Chattervadi, 1982). Most of these clones have found their way in Kashmir valley without any systematic laid trials. Most of these clones were female cultivars and during 1990's when these trees attained the age of 10 years and above they produced the seeds in the Kashmir valley. During the months of May, June and July these seeds are dispersed in air in the form of cotton flakes. These have resulted in cotton menace in Kashmir valley. Since the cotton flakes are flying in the atmosphere there has been a huge cry in the public and media that this menace of cotton should be eradicated. A field trial of *Populus deltoides* was laid at Faculty of Forestry, SKUAST-K, Wadura to study the effect of artificial pruning as management practice. 25 % clear bole, 50 % clear bole, 75 % clear bole and 100 % clear bole leaving only the leader shoot were compared with control with no pruning. There was a significant increase in the height of *Populus* trees when they are pruned with maximum increase in height with 25 % clear bole having an increment of 14.72 %. DBH percentage increment was greatest with 50 % clear bole having an increment of 18.89 %. Effect of pruning on commercial volume of timber was maximum in 100 % clear bole having an increment of 78.3% over control. There was significant decrease in the number of female catkins per tree which were counted only 9 catkins per tree in case of 100% clear bole against 481 in control. The study concludes, that the popular trees should be managed by intensively pruning them upto 50 % of their height and this pruning should be done in every autumn till the plantation achieves a height 15 meters, because upto this height trees can be pruned without much effort. This practice of pruning will produce more commercial besides being knot free and will also reduce the cotton menace during spring as the flower production is reduced considerably.

ABOVE GROUND BIOMASS PRODUCTION OF *GREWIA OPTIVA* POLLARDED AT DIFFERENT HEIGHTS UNDER AGROFORESTRY SYSTEMS IN MID-HILLS OF HIMACHAL PRADESH OF INDIA

H.K.Deshmukh*, V.K.Mishra, A.J.Deshmukh, G.R.Rao and S.W.Choudhari

Department of Forestry

Dr. Panjabrao Deshmukh Agricultural University, Akola – 444 104 (Maharashtra)

**E-mail: hkdeshmukh1@rediffmail.com*

The present study was conducted on experimental farm of Dr. Y.S.Parmar University of Horticulture and Forestry, Nauni - Solan (HP) to see the biomass production (leaf and branch wood) of *Grewia optiva* pollarded at different heights. Experiments were laid out in replicated factorial RBD comprising 18 treatments combination. The study reveals that biomass production of *Grewia optiva* increased with increasing pollarding heights from 1.5 m to 4.5 m. Leaf and branch wood biomass were influenced significantly due to pollarding height and were found to be recorded maximum at P2 (3m) followed by P3 (4.5 m)and P1 (1.5m). This shows that pollarding of *Grewia optiva* at 3m (P2) height is relatively better height for pollarding to form more sprouts and their growth.

***PINUS GERARDIANA* AS A SOURCE OF LIVELIHOOD PADDAR IN VALLEY OF JAMMU AND KASHMIR**

Manzar Masood, P.S. Salathia, R Peshin and S.K. Gupta

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu-180 019 (J&K)

E-mail: sushilgupta67@rediffmail.com

Paddar block of Kishtwar district is situated at an elevation of 1600-3350 meters above mean sea level, 30° to 37°N and 74° to 76°E. The block comprises of 10 panchyats and 32 villages with total geographical area of 24811, which including 10097 ha area under forest. *Pinus gerardiana* is abundantly available in Paddar Valley. The livelihood of these villages was mainly dependent on seasonal labour and collection of *Pinus gerardiana* nuts. The nuts collected fetch a price of 500-550/kg to the farmers. The role of *Pinus gerardiana* in socio-cultural and economic life of peasants has not been studied earlier. Various practices relating to processing, marketing, economic gain and constraints have also hardly caught the attention of the researchers. Thus, the present investigation was carried out to study the socio-personal characteristics of the people associated with *Pinus gerardiana*, identification and documentation of traditional practices, additional economic gain obtained from *Pinus gerardiana* collection, constraints and suggestions of the respondents involved in this venture in Paddar Valley of Kishtwar district. The study revealed that *Pinus gerardiana* played an important role in the livelihood of farmers. It is evident from the data that on an average income was Rs. 34252 including Rs.10092 from crops, Rs. 9240 from labour and Rs. 14920 from *Pinus gerardiana*. This showed that *Pinus gerardiana* contributed 43 % to household income. 83 % of the farmers showed their concern about

monopoly of the contractors/middleman and 33 % reported the constraints in terms of processing of nuts. Farmers suggested that regulated market should be established to check the monopoly of contractors besides skill up gradation of *Pinus gerardiana* (chilgoza) farmers on different aspects of processing, grading and storing.

EFFECT OF CUTTING MANAGEMENT ON THE BIOMASS AND CARBON STOCK OF OAK UNDER HIGH DENSITY PLANTATION IN INDIAN HIMALAYA

R. P. Yadav^{1*} and J. K. Bisht²

¹*Dr. Y. S. Parmar University of Horticulture and Forestry- Nauni, Solan (HP)*

²*Vivekananda Institute of Hill Agriculture, Almora, (Uttarakhand)*

**E-mail: rams34052@gmail.com*

The realization of the role of trees as cheap means to capture and store atmospheric carbon dioxide in vegetation has generated considerable interest among the climate change mitigation strategists. Tree growth and productivity are influenced by silvicultural strategies such as tree density and cutting management, which determine the potential of tree stands to store carbon in the vegetation. A field experiment was conducted at experimental farm of Vivekananda Institute of Hill Agriculture, Almora, India in a 30 year-old *Quercus leucotrichophora* to evaluate the changes in vegetation carbon pools as a function of four cutting management (1m, 2m, local practice, and above 1/3rd part undisturbed), under high density plantation (1.0 m X 1.0 m). The carbon stock of oak was estimated by multiplying biomass with carbon content (0.45). The height Tree cutting management significantly influenced the growth, biomass and carbon stock of *Q. leucotrichophora* trees. Height, DBH and volume per tree was highest at above 1/3rd part undisturbed (10.1, 12.2, 0.083) and lowest for coppicing at 1 m (2.0, 5.3, 0.020) respectively. Total vegetation (aboveground + below ground) biomass and carbon stock was highest for the above 1/3rd part undisturbed (793.2 & 356.9 Mg ha⁻¹) and lowest in the cutting at 1m (192.6 & 86.7 Mg ha⁻¹). Overall, less disturbance to stands promote carbon storage, but intense cutting management (e.g., cutting at 1m) may adversely affect tree growth and productivity, reducing vegetation carbon pools. Cutting management effects are very much visible on carbon stock of *Q. leucotrichophora* under high density plantation. By extension, tree cutting exerts negative or positive feedbacks on biomass accretion depending on tree density, which may also influence the amount of carbon sequestered by the trees.

PERFORMANCE OF WHEAT IN JATROPHA BASED AGRISILVICULTURE SYSTEM IN TARAI REGION OF UTTARAKHAND

R.P. Yadav^{1*}, O.P.S Bana², R.Kaushal³ and P. R. Rajput²

¹*Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP)*

²*G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand)*

³*Central Soil and Water Research & Training Institute, Dehradun, (Uttarakhand)*

E-mail: rams34052@gmail.com

The structural and functional of tree species in traditional agroforestry systems greatly affect the overall productivity of the system. Generally, the overall productivity (crops + trees) in agroforestry systems is higher than that in sole cropping systems. Pruning helps for optimization of resource (nutrient, water and light) sharing in agroforestry. The objectives of this study were to determine yield and yield attributes in Jatropha based agrisilviculture system in tarai region, Uttarakhand. The study was carried out at Pantnagar located at 29⁰N Latitude, 79⁰3' E longitudes and at an altitude of 243.84 m above the mean sea level. The experiment was laid out in factorial Randomized Block Design with twelve treatment combinations comprising four pruning height viz., no pruning, 50 cm height, 100 cm height, 150 cm height in Jatropha and three fertility levels viz., 50% of recommended dose of NPK (RDF), 100% (120 kgN+60kg P₂O₅+40 kgK₂O/ha) of RDF, 150% of RDF for wheat with four replications. The number of potential shoots (i.e. spikes)/m, spike length (cm), number of grains per spike, grain weight/spike, thousand grain weight were significantly influenced by fertility levels while, the effect of pruning height found to be non-significant, except for spike length. The maximum and significantly more number of spikes/m row (67.68) was recorded with 100 per cent RDF which did not differ from 150 per cent RDF for wheat. The grain, straw and biological yield was significantly influenced by fertility levels, whereas, the effect of pruning height appeared to be non-significant. The maximum (2826 kg/ha), (5226 kg/ha) and significantly higher grain and straw yield was obtained by 150 per cent RDF and minimum (1639 kg/ha), (3536 kg/ha) by 50 per cent RDF, which is significantly lower than other fertility levels. The biological yield increase followed exactly the trend of grain and straw yields.

AGROFORESTRY SYSTEMS IN SOUTHERN RAJASTHAN, INDIA

Hemlata Saini¹ and M.L. Meena²

¹ *MPUAT, Udaipur-303 301(Rajasthan)*

¹ *Krishi Vigyan Kendra, CAZRI, Pali-Marwar-306 401(Rajasthan)*

Present study was conducted in Udaipur district of Southern Rajasthan. The study was to examine the benefits, both tangible and intangible, of the agro-forestry and understand the utilization pattern of different products. Attempt was also made to identify the major problems of the agro-forestry growers in adopting the agro-forestry. For this purpose, a sample of 120 agro-

forestry growers from 12 randomly selected villages from similarly selected two development blocks viz. Kotara and Jadol were interviewed through participatory technique supported with pretested interview schedule through disproportion stratified sampling technique (controlled sampling). In the present study food, fodder, fuel wood, fruit, small timber, milk, wool, meat and FYM were examined as major tangible benefits of the agro-forestry. Intangible benefits of agro-forestry systems have been noted in form of diverse farm economy, prevention of air pollution, protection of biodiversity, demarcation of boundaries, soil conservation, wind break and industrial uses etc. brief structure of pattern of utilization of agro-forestry products showed that food grain (48.60%), vegetable (39.76%), garlic (72.22%), arid fruits (68.26%) and milk (56.44%) were sold out at market and remaining portion of all above commodities were being consumed at home, whereas fuel wood, leaf fodder, crop straw, wool, meat and FYM were entirely utilized by the households to meet out the domestic requirement of the family. Lack of technical know-how (100.00%), inadequate availability of desired plant species (95.23%), inadequate irrigation facilities and erratic weather conditions (96.55%), and small land holding as well as scattered land holding (91.09%) were identified as major problems in the way of adopting agro-forestry.

CANOPY MANAGEMENT IN *MORUS ALBA* FOR ENHANCING PRODUCTIVITY AND RESOURCE CONSERVATION

R. Kaushal*, A. Tiwari, J. Jayparkash, R. Ranjan, J.M.S. Tomar, H. Mehta and O.P. Chaturvedi

Central Soil & Water Conservation Research & Training Institute, Dehradun-248 195

**E-mail: kaushalrajesh1@rediffmail.com*

In agroforestry, inter-row spaces are mostly utilized for the cultivation of agricultural crops. The agriculture crops perform well in the earlier stages but, during the later stages the crop suffers adversely due to stress above and below ground competition for the limited resources. Appropriate canopy management practices like coppicing and pollarding in agroforestry however, can be helpful in reducing above and below ground competition and can enhance the growth and productivity of trees and associated crops. Canopy management practices also changes root architecture thereby mitigating the adverse effect of vegetation while retaining the beneficial effect on slope stabilization and erosion control. The study was initiated during January, 2012 in eight runoff plots (25 x7.5 m) to study the impact of canopy management treatment in *Morus alba* on productivity and resource conservation on sloping land (> 10%). Treatments viz., coppicing pollarding and lopping were carried out on existing trees of *Morus alba* in February 2012. Each plot consisted 15 numbers of trees. In one set of canopy management treatment, turmeric was raised as intercrop. Analysis of the data revealed that intercropping of turmeric increased growth and biomass production in *Morus alba*. Maximum

fuelwood (60.4 q ha⁻¹) and green leaf yield (48 q ha⁻¹) was recorded in Lopping + turmeric treatment. Average soil moisture (Oct-March) in 0-90 cm soil depth varied from 236.3 mm in cultivated fallow to 267.6 mm in pollarding treatment. Significant differences were also observed in fine root biomass.

GROWTH, BIOMASS PRODUCTION AND SOIL PROPERTIES UNDER DIFFERENT BAMBOO SPECIES

R. Kaushal¹, Salil Tewari², R.L. Banik² and S. Chaturvedi²

¹Central Soil & Water Conservation Research & Training Institute, Dehradun (Uttarakhand)

²G.B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand)

*E-mail: kaushalrajesh1@rediffmail.com

Bamboos are important resources in the Indian context with multiple economic possibilities. They have enormous potential which has only been partly harnessed. Majority of the bamboo production in Northern India is accounted from forests where productivity is very low. Efforts are therefore required for enhancing the productivity of bamboos by undertaking organized cultivation outside the forest areas. There is immediate need to screen suitable species and develop package and practices for undertaking plantation of bamboos on underutilized lands, rainfed areas and unutilized lands. The present work was therefore carried out to study the growth, biomass and carbon sequestration in different bamboo species. Eight commercial bamboo species. viz. *Bambusa bambos*, *B. balcooa*, *B. nutans*, *B. tulda*, *B. vulgaris*, *Dendrocalamus asper*, *D. hamiltonii*, *D. strictus* were planted in randomized block design in agrisilviculture system at 5 x 5 m spacing. Results after seven year of plantation revealed that height growth ranged from 5.8 m in *D. asper* to 17.6 m in *D. hamiltonii*. Culm diameter ranged from 3.2 cm in *D. asper* to 9.2 cm in *D. hamiltonii*. Number of new culms emerged were maximum in *D. asper*. Above ground biomass accumulation varied from 22 Mg ha⁻¹ in *D. asper* to 237 Mg ha⁻¹ in *D. hamiltonii*. Soil properties also showed remarkable improvement under bamboos. Overall it can be concluded that *D. hamiltonii*, *B. balcooa*, *B. nutans* and *B. vulgaris* outperformed other species in term of growth, biomass and soil improvement and thus should be promoted for cultivation.

DEVELOPMENT OF SUPERIOR LAND RACES OF SOME MEDICINAL TREES AS POTENTIAL FUTURE CROPS IN CHANGING CLIMATIC SCENARIO

Kamal Sharma, Sanjeev Thakur*, Som Dutt, Fattah Singh and Kartar Singh Verma

Institute of Biotechnology and Environmental Science, Neri – Hamirpur - 177 001 (HP)

**Department. of Tree Breeding and Genetic Resources, Nauri, Solan – 173 230 (HP)*

Dr. Y.S. Parmar University of Horticulture and Forestry

Global warming and climate change are the gravest concern of mankind in 21 century. Increased anthropogenic activities have stimulated the environmental changes like increase in atmospheric temperature, uncertainty in rainfall, higher frequencies of frosts, droughts, floods, etc. These

changes are affecting the ecosystem, productivity and sustainability of natural resources. In countries like the USA, there are more economic losses due to frost damage than any other natural hazard including earthquakes, floods, droughts, hurricanes and tornados. In Himachal Pradesh, apple belt is shifting towards north due to rise in atmospheric temperature whereas occurrence of frost in subtropical areas has put question mark on cultivation of many economic species like mango, papaya, banana, guava, litchi, teak etc. These species are vulnerable to sub-freezing temperatures resulting in death of plants and failure of plantations in frost affected areas. Moreover, monkey and animal menace is discouraging agriculture and horticulture in some areas. Hence, there is an urgent need to identify the species which can adapt well under changed climatic conditions and to develop superior land races of these for mass multiplication and plantation in frost prone as well as monkey inhabited areas to avoid economic losses to the growers. Some of the medicinal trees like Harar, Bahera, Aonla and Soapnut can grow unpretentiously in frost and monkey as well as stray animal affected areas in Himachal Pradesh. Hence, research efforts have been made by the authors during the last twenty five years to develop superior land races of these species and to standardize the vegetative propagation techniques for their mass multiplication for distribution of superior saplings to the farmers. So far, more than thirty thousand true to type plants of superior land races of these species have been supplied to the growers. The vegetatively propagated plants start bearing fruits at the age of just three – four years as against 10 – 15 years in case of seedling plants. The success story of the research is that farmers planted grafted/budded plants of improved land races of harar have realised better returns per unit area in comparison to many horticultural and agricultural crops. Most of the areas in Himachal Pradesh are not fit for agriculture and horticulture and moreover, the areas rendered abandoned due to nuisance of wild and stray animals can be put under plantations of improved genotypes of these crops profitably.

TREE NURSERY INFORMATION CUM MANAGEMENT SYSTEMS AND WEBSITES

R. Indumathy¹ and P. Ratha Krishnan²

¹CAZRI residential colony

²Central Arid Zone Research Institute, Jodhpur – 342 003

This paper explains the history, advantages, limitations of online nursery information system and its related websites. It also elaborated some nursery information software *viz.*, nursery sales and inventory management (<http://www.nurserysoftware.com>), one of the most comprehensive software for managing a wholesale plant growing or re-wholesales operation in a nursery; PASSFIELD data systems (<http://www.passfield.co.uk>), a fully integrated software system that gives nurseries unprecedented control over all their operations, from sales and stock to production planning; nursery and horticulture management software (<http://www.nurseryman.com>), a web site platform which gives a "smart availability list" service for growers and suppliers of plant material. Some common web portal platforms on nursery information systems managed at private level (<http://www.hccnursery.com> of HCC Nursery,

418, Indian Forest, Dr, Bostic, NC; <http://www.kapsenbergdesign.com/garden/home.php> of Victoria garden) and departments (AP forest Department, TN forest department, Gujarat Horticulture department, NMPB, Bamboo, etc) were also elaborated. Interestingly species level portals (<http://www.manakcitrus.co.in> for citrus; <http://www.rose-gardening-made-easy.com> for rose plants) and regional level portals (<http://agritech.tnau.ac.in/horticulture/html> for horticulture crops of Tamil Nadu) are also available online to encourage the planting of suitable species. This kind of concept on Nursery Management Information System (NMIS) was emerged in 1970s to support the nursery programs in US, mainly for tracking the seed collection, storage, sowing of seed, seedling production, seedling lifting, grading and culling, packing of seedlings for storage, shipment and distribution of seedlings. It also has the provision of orders from client, special services, amount transaction, etc. Mostly, an Oracle® version of the source subsystem is used, while some nurseries have been using MS Access® version too. The authors recently proposed and designed "tree nursery information cum management system" with Active Server Page (ASP), VB as frontend and MS – Access as backend. This database is designed in an interactive mode with customization of modifications, updates, revision, inventory and e-learning. This information system aimed to attract the youths towards agriculture while serving the valuable information on nursery management without the need of any domain experts.

POTENTIAL USE OF PLANTS EXTRACTS AGAINST SOME PHYTOPATHOGENIC FUNGI

Surender Kumar Bhardwaj

Botanical Garden/Herbal Garden, M. D. University, Rohtak-124 001 (Haryana)

E-mail: skbmdu67@gmail.com

There are concerns about the widespread use of chemicals in crop production in developing countries because of their possible adverse effects on human health. According to a World Health Organization survey, more than 50,000 people in developing countries are poisoned annually and 5,000 die as a result of the effects of toxic agrichemicals. In India 35,000 – 40,000 tons of hazardous chemicals are sprayed on crops every year and this is considered to increase the risk of cancer, sterility and death. There is an urgent need, therefore, for the development of safer and more sustainable methods of crop production. Plants are known to possess antimicrobial secondary metabolites that can inhibit the growth of plant pathogens and it is possible that these compounds could be used to combat plant diseases. In the present study, experiments were carried out to evaluate the antimicrobial properties of 20 plant parts samples of 20 plants against plant pathogenic fungi by the food poisoning method. The various plants tested for their antimicrobial activity have shown varied response. The results are promising and some of the plants have shown inhibitory activity against one or two fungi, whereas others have shown a broader spectrum of activity, some plants showing good activity against all the test fungi. Plants samples of some families such as Apocynaceae, Caesalpinaceae, Combretaceae, Compositae, Ebenaceae, Liliaceae, Lythraceae, Meliaceae, Mimosaceae, Rosaceae, Salvadoraceae, Sapindaceae, Theaceae and Zingibraceae were found to be comparatively more

effective against the test fungi. In view of the above facts, the present study has elaborated our knowledge by accessing the antifungal properties among the available natural flora which can subsequently be explored for the possibilities towards the identification of the key bioactive agents, through implying modern microbiology and biochemical techniques.

WHEAT PERFORMANCE IN RELATION TO POPULATION DENSITY AND AGE OF POPLAR (*POPULUS DELTOIDES*) ON FARMER'S FIELD IN BET AREA OF PUNJAB

Harinder Singh, Harjeet Singh and J.K. Arora

Krishi Vigyan Kendra, Ropar (Punjab)

Email: harinder06@rediffmail.com

Poplar is an important enterprise for farmers of bet areas of Punjab. The farmers of this zone intercrop wheat along with poplar stands. Wheat performance data was collected from farmers field with different population densities (i.e. 225, 250 and 300 plants/acre) and age (1, 2, 3 and 4 year old) of poplar. The perusal of data revealed that there was non-significant difference in number of tillers and ear length under 225 and 250 per acre population density however, these parameter were significantly less under higher poplar density (300 plant/ acre). Test weight decreased significantly with increase in poplar population density. Poplar density of 225 plants per acre produced significantly higher grain yield (8.0 and 25.6 per cent more than at 250 and 300 plants/acre, respectively). The number of tiller and ear length were not affected up to two year age of poplar, while reduced significantly afterwards. Test weight reduced significantly with age of poplar trees, which leads to significant decreased in wheat grain yield with increase in age of poplar. Wheat yield under 2, 3 and 4 years old poplar reduced by the margin of 9.9, 26.9 and 49.8 per cent as compared to one year old poplar. Poplar density of 225 and 250 plants/acre accrued equal or more DSH and DBH in three years as compared to population density of 300 plants/acre, in addition to higher wheat yield.

INTEGRATING CONSERVATION AND DEVELOPMENT

Shabir Ahmad Rather and R. Banyal*

Faculty of Forestry, SKUAST-K Camp Wadura, Sopore,, 193 201 (J&K)

**E-mail: drbanyal08@gmail.com*

The survival and well being of a nation depend on sustainable development. It is a process of social and economic betterment that satisfies the needs and values of all interest groups without foreclosing future options. At the same time human demand for natural resources is growing at very rapid rate which threaten their availability for future generations to come. One third of the world's arable land will be destroyed in the next 20 years at current rates of land degradation continue. Similarly, by the end of this century (at present rates of clearance), the remaining area of unlogged productive tropical forests will be halved. During this period, the worlds' population

is expected to increase by almost half from just over 4,000 million. The predicament caused by growing numbers of people demanding scarce and finite resources is exacerbated by high consumption rates. These consequences detract from the gains of development and worsen the standard of living of the poor who are directly dependent on natural resources. The action required to address the most serious concern about the conservation problems and to check for further degradation. So, it is the high time for planning, education, training and research on such vulnerable issues to protect precious natural resources. It is in this context that we need to give a new thrust towards conservation and sustainable development.

IMPLICATIONS OF PUBLIC POLICIES ON AGROFORESTRY AND FARM FORESTRY IN INDIA

Jignesh B. Bhusara, N.S. Thakur*, H. T. Hegde, S. K. Jha and Rajesh P. Gunaga

ASPEE College of Horticulture and Forestry, Navsari Agricultural University

Navsari – 396 450 (Gujarat)

**E-mail: drnsthakur74@gmail.com*

It has been advocated that agroforestry has a de facto "orphan" status in many national government settings, in principle is important to many ministries but in practice, it belongs to none. Initially it was associated with forestry sector. But mere distribution of seedlings promoted social forestry which eventually to some extent took shape of agroforestry since farmers planted those distributed seedlings on their farm land with agricultural crops. Since foresters were unfamiliar with agricultural practices and could not provide sound practices. The capacity for agroforestry to generate income is hardly ever recognized in policy documents. There are many governments that have put in place price floors for food products, subsidies for specific inputs like fertilizer, or favourable credit terms for certain agricultural activities and invariably exclude agroforestry leading to discourage its practice. Review suggest that cumbersome procedures for getting permission for harvesting trees on private lands act as a further disincentive against tree planting by farmer. Some of them impose restrictions on felling of some of the species on one hand and permitting some others to be felled and to sale. A global assessment of tree cover on agricultural land revealed that 48 % of all agricultural land had at least 10% tree cover. With the passage of time several issues have been discussed and the bottle necks are now narrowing. There are several policies on farming systems in India favouring tree planting on farm land to cater the industrial needs. Presently there is general agreement about the magnitude and scale of the integration of trees into agricultural lands and their active management by farmers with several Govt. polices and policies of private sector. Participatory forestry in various forms such as Social forestry, Community forestry, Farm/ Agroforestry, JFM etc. has evolved over the years by involving farmers and other land owners in tree plantations outside forests. Agroforestry has played an important role in providing valuable wood based raw materials to industry for meeting demand for various wood based products for society. The potential of agro/farm/social forestry has not been fully realized, as on one hand farmers are encouraged to grow trees on their land, at the same time they face difficulties in harvesting their produce, in view of various restrictions on

felling and transit of trees. Nevertheless, despite some difficulties, Government and private public policies have encouraged the agroforestry. However, issues like Payment for environmental services are needed to be worked out. Furthermore, the National Agriculture Policy, (2000) stresses that, "farmers will be encouraged to take up farm/agroforestry for higher income generation by evolving technology, extension and credit support packages and removing constraints to development of agroforestry". Such initiatives perhaps boost up the adoption scale.

ROLE OF AGROFORESTRY IN BIODIVERSITY COSERVATION IN CHANGING CLIMATIC SCENAREO

N.S. Thakur*, Jeegar S. Panchal, R.S. Chauhan, H.T. Hegde and S.K. Jha

ASPEE College of Horticulture and Forestry, Navsari Agricultural University

Navsari – 396 450 (Gujarat)

E-mail: drnsthakur74@gmail.com

Impacts of climate change and variability are now perceived more real on ecosystems worldwide. Implications are directly posing the threat for survival of all life forms. The floral and faunal populations are compliments to each other. Imbalance would directly affect the human populations. Biodiversity on earth support large human population. The man made agroecosystems are also not unaffected due to climate change. The land use systems and practices witnessed a sea change with climatic variability and change. In such situations, the land use systems which encompasses more species diversity and better ecological conditions to support other species along with diversified products has to play a significant role. Agroforestry by virtue of its complex nature, encompassing varied floral and faunal component both above and below ground, is acknowledged as an integrated land use that can directly enhance agro biodiversity and contribute to the conservation of landscape biodiversity. Diversification of land use systems through agroforestry not only provide diversified products but conserve biodiversity also. The diversified products provided by agroforestry, which otherwise would be derived from the forests, contributes to biodiversity conservation through reducing pressure on natural forests and protected conservation areas. It can serve as buffer zones to protected areas and contribute to biodiversity conservation by reducing of human impact on core areas, and provision of habitats and relatively benign environment for movement. Trees on farms may be considered as in situ conservation outside protected areas. This land use system not only help conserve biodiversity above ground (floral and faunal) but also below ground. The studies revealed that traditional, complex agroforestry systems are more supportive of biodiversity than mono-crop systems. There are various types of agroforestry systems and practices from two storeys to multi layered systems supporting many species of trees, shrubs, grasses, epiphytes above and bacteria and fungi below ground. Home gardens, throughout India, are the most abundant agroforestry systems with respect to biodiversity. The agro biodiversity in agroforestry systems particularly those which have evolved because of needs of the people are more as compared to those which

are market or product oriented like poplar and eucalyptus based systems. Agroforestry not only increase agro biodiversity but also create simulated conditions of forest ecosystem to nest birds, animals, insects etc. The overall contribution of agroforestry to biodiversity conservation depends on the type of land use that it replaces and attributes of the specific agroforestry system. The effectiveness of agroforestry in biodiversity conservation depends on the design of the system and the nature of the biodiversity to be conserved.

PROSPECTS AND STATUS OF AGRO FORESTRY AND INCOME GENERATED BY FARMERS PRACTICING AGROFORESTRY IN CHAMKAUR SAHIB BLOCK OF RUPNAGAR DISTRICT OF PUNJAB

Raminder Singh Ghuman, Harinder Singh*, Paramdeep Singh and Randhir Singh Mand

*FASS Rupnagar; * Krishi Vigyan Kendra Rupnagar (Punjab)*

Punjab Agricultural University, Ludhiana 141 004 (Punjab)

E-mail: raminderghuman@gmail.com, raminderghuman@pau.edu

District Rupnagar has diverse landscape in Punjab consisting of plains, bet (floodplains of river Satluj), sub mountaneous and kandi area. Planting fast growing trees is quite popular among the farmers in this district specifically in kandi and bet region while it is not so with those under plain region. A study was conducted to know the prospects and status of agroforestry in villages of Chamkaur Sahib block of Rupnagar district, where a considerable number of farmers are practicing agroforestry, mainly growing poplar trees. Fifty farmers were surveyed for generating data on their perception for adopting poplar based agroforestry. Out of 175 ha operational land holding of these farmers, 37.2% area has been diverted under agroforestry. All of these farmers prefer G-48 clone of poplar. Seven per cent farmers borrowed or purchased the planting material from other farmers while 36% raised their own nursery and 56% farmers purchased from commercial nurseries. The study also revealed that 70% of farmers kept the trees for 5 years for harvesting while 30% harvested the crop before completion of 5 years. 100% of the farmers said that they had a poplar crop before and will plant another poplar crop in succession. The most common reason for keeping a fixed area under agroforestry continuously was that it helped them to get lumpsum money after 5 years which, otherwise, they find difficult to save. This helps them to deal with big expenditures like a wedding, construction, buying of land, education of children or buying of automobile or tractor, etc. Farmers mentioned that the price of per quintal poplar varies between Rs 850 to 1000, which fetched an income between Rs 6.25 to Rs. 10 lakh/ha (Rs.2.5 to 4 lakh/acre). In addition to this, farmers are also getting wheat, sugarcane, fodders and maize as intercrops. The wheat yield during 1st year of intercropping varied between 38 to 50 q/ha, amounting to Rs 51000 to 68000/ha; with 46% of farmers growing HD-2967 variety of wheat. Other common varieties grown under poplar were PBW-621 (28%) and PBW-550 (24%). Farmers reported a plant population between 563 to 1000 plants/ha (225 to 400 plants/acre), with 60% of farmers maintaining a population of 750 plants/ha (300 plants/acre). All the surveyed

farmers followed block planting with varied spacing according to one's needs and all farmers planted the poplar trees in standing wheat crop during end of January to second fortnight of February. All farmers said that agroforestry is a viable cropping option and they wanted to follow it continuously though they were little apprehensive of price falls in poplar timber, which reduces the profits drastically. Similar sentiments were expressed by the non-adopters of poplar based agroforestry, besides the problem of stray animals, which they say destroy the young saplings.

STRUCTURAL ASSESSMENT OF *CEDRUS DEODARA* IN A SACRED GROVE OF INDIAN HIMALAYA: A CASE STUDY FROM HIMACHAL PRADESH

Hemant K Gupta¹ and Pankaj Sharma²

¹*Department of Environment, Science & Technology*

²*Himachal Pradesh State Biodiversity Board*

*Himachal Pradesh State Council for Science, Technology & Environment B-34, SDA Complex
Kasumpti, Shimla-9 (HP)*

E-mail: hemant.gupta@fulbrightmail.org, spankaj80@gmail.com

The Himalayan forests of India are one of the major forested zones of Asia, encompassing the headwaters of several major rivers of the Indian subcontinent. In the Western portion of the Indian Himalaya, *Cedrus deodara* (Himalayan Cedar) is a critical element of this forest region belongs to Pineaceae family and fill many roles in its natural and cultural landscape. *Cedrus deodara* forests possess highest levels of carbon, provide sacred landmarks and ancient links to the past, sustain life-giving waters, harbor wildlife and humans, and embody records of past-climate in their tree-rings. Worldwide research has highlighted the difference in structure, function and processes occurring in younger and older forests. We focus on the measurable physical structure of the forests, rather than the function (e.g. clean water, oxygen, timber) or processes (e.g. photosynthesis, soil accumulation, or tree mortality). Older forests tend to be more structurally heterogeneous, both vertically and horizontally, and include higher levels of distinct structures such as fallen dead logs, standing dead trees, and large, complicated living trees. *Sipur* sacred grove is an example of an old-growth cedar forests, located below *Mashobra* that is about 12 km from Shimla in Himachal Pradesh. It is situated on a northwestern aspect and is centered on 31.13° N and 77.23° E. The aim of this study was to establish a baseline for long-term forest measurement in an old-growth cedar forests and to create the seed of a network of Forest Inventory-equivalent plots and to compare the structure of *Sipur* sacred grove to that of the regional forest matrix. We present and provide a series of graphical tools to illustrate the cedar forests and the measurements obtained by the Forest Survey of India's (FSI) forest inventory plot network by using selected Google Earth random study plots and a grid of 32 points placed evenly across the grove at 50m intervals. Locations were marked using a high-resolution Global Positioning System (GPS) with an accuracy of approximately 6m. The

preliminary data presented is intended to form the first of several permanent sample plots, matching and/or exceeding the Forest Inventory methodology, placed by design in the older age classes of *Cedrus deodara* forests across Shimla District. Each plot was developed by following the square-shaped plots of 1,000 m², oriented with the edges parallel to the cardinal magnetic compass points. Total, 9.6% (8,000 m²/82,550 m²) of the area of entire grove was enumerated and 2.4% of the grove area was sampled. This study contributes towards the size distribution of *C. deodara* trees in a sacred grove, and compares it to FSI Forest inventory data on unprotected *C. deodara* trees. The differences in structure relative to the abundant matrix forest have been assessed. The monitoring and measurement of cedar forests has established a baseline for long-term forest measurement in an old-growth forest. The comparison of the structure of an old growth cedar forest and of the regional forest matrix and assessment of the suitability of canopy-measurement techniques in the cedar forests have been highlighted for further study.

ROLE OF CLIMATE CHANGE ON HUMAN HEALTH IN ARID RAJASTHAN, INDIA

M.L. Meena*, Dheeraj Singh and M.K. Chaudhary

Krishi Vigyan Kendra, CAZRI, Pali-Marwar—306 401 (Rajasthan)

E-mail: moti2007m@yahoo.co.in

The present paper is for the better understanding about the immense potential health effects of climate change. Climate change is the greatest health threat of the 21st century with implications for food production, water and health. The average global temperature has risen approximately 0.6° C over past century. World health organization has already documented the “human health effects of climate change” under a high priority research agenda. Climate change affects the health of individuals directly and indirectly. The effect of climate change varies by region, relative vulnerability of population, by the extent and duration of exposure and society’s ability to adapt to the change. In India one of the major consequences of climate change will be lack of food causing malnutrition and disease. Further, the modern food system which is a direct or indirect outcome of climate change is affecting health. Factors like exacerbation of unsafe water, disease, malnutrition, lack of awareness and nutritional knowledge affects the health. Extreme temperatures lead to air and water pollution which in turn may affect human health (respiratory, cardiovascular, various vector borne disease, emotional disturbances etc.). Any health related disaster (floods, draughts etc.) may cripple the already inadequate public health infrastructure. The risks of not only vector borne diseases like malaria, dengue fever, yellow fever, and encephalitis increase but the risk of diseases like diabetes, hypertension and other lifestyle disease also increase. The cause of diseases like migraines, indigestion, acid reflux, constipation, unexplained body pains, fatigue etc are untraceable. It can be due to climate change and changed food habits and availability. It’s reported that 47.90% of green house gas emission is by chemical agriculture, meat and food industry. Therefore, a vicious cycle is formed. With the food sector being contributing about one third of carbon emission today and affecting the health otherwise

too, there is no option but to review the situation. Response options to protect health from effects of climate change include mitigation and adaptation. Further, High quality research is needed to strengthen the awareness programmes and policies designed to influence environmental factors that affect human health. There is an urgent need to underpin the awareness programmes and nutrition campaigns at grass root level. Definitely, whatever is good for earth is good for human body too.

GENETIC ANALYSES OF *CATREUS WALLICHI*: A THREATENED SPECIES OF HIMACHAL PRADESH

Shipra Garg¹, Sandeep Ratan², Pradeep K Naik¹, Ashwani Kumar Gulati², Lalith Mohan² and Harvinder Singh^{1*}

¹*Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Wahnaghat, Solan-173 234 (HP)*

²*Wild life Wing, Forest Department, Shimla - 171 001(HP)*

**E-mail: harvinder.singh@juit.ac.in*

The Cheer pheasant, *Catreus wallichi*, is a globally threatened species, distributed in the highlands and scrublands of the Himalayan region. Protected in captive stocks of Himachal Wildlife department, this species has proved difficult to maintain and breed, since, chances of high sib-mating is believed to have affected the population due to inbreeding depression. Aiming towards reducing the chances of inbreeding, this study is the first to assess the genetic diversity, parentage and genotyping of the species using 42 different RAPD, ISSR and SSR molecular markers. Among ISSR, for all the polymorphic primers, the number of amplified fragments ranged between 67-147 totaling to 1289, with product size ranging between 100-700bp. These primers generated a total of 61 polymorphic loci (averaging 5.08 loci per primer), average PIC 0.37 per primer, demonstrating low polymorphism between individuals. Successively, 3 out of 10 RAPD primers tested on a population of 25 *Pheasant* individuals, generated informative profiles with a total of 37 loci (averaging 12.3 loci per primer), again demonstrating low degree of polymorphism (51.5%) between individuals. These RAPD primers generated a total of 353 fragments with product size ranging from 100bp-1.0kb. The observation of low heterozygosity from both these analyses is a clear suggestive of prevalent inbreeding depression in the population, strengthening the rationale for the circumscribed population growth for these birds. Another suspicion for the population decrease is the thin layering of eggshells, prone to fractures before hatching. Investigation through elemental analysis revealed the presence of transition metals, known for the thinning of eggshells. Using biological network analysis, a survey of core interacting genes and their neighbors involved in eggshell matrix formation has also been carried out with the aim of expression profiling and development of SNP marker for thin layering in the future.

POTENTIAL OF METABOLITE PROFILING TO DISCRIMINATE *SWERTIA* SPECIES

Kritika Kaushal, Rajinder S Chauhan and Harvinder Singh*

*Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology,
Waknaghat, Solan – 173 234 (HP)*

**E-mail: harvinder.singh@juit.ac.in*

Swertia chirata, a critically endangered gentian species gained dominant position in several pharmacopeias of the world and traditional systems of medicines like Ayurveda, Unani and Sidha etc. Presences of different phyto-constituents in the plant are responsible for its all broad range medicinal properties. Owing to high medicinal and pharmaceutical value, the plant is endowed with good domestic and international market. However, one of the main pitfall in its trade is of adulteration with other low-value species considered to be deficient from medicinal aspect. Species which are generally mixed with *S. chirayita* are *S.angustifolia*, *S.ciliata*, *S.chordata*, *S.alata*, *S. paniculata* etc. Misidentification of the true species is also accountable for adulteration. This highlights the need of having diagnostic keys for evaluating the authenticity of the true plant species. In this study, the concept of GC-MS that provides high separation efficiencies to resolve complex biological mixtures has been used to discriminate five *swertia* species. Analysis of metabolite data by GC-MS yielded total 362 compounds, present in all seven samples. Out of these 124 compounds were successfully categorized to discriminate the *swertia chirata* from its main adulterant, *Andrographis paniculata*. Furthermore, the heat map generated through statistical analysis performed on *swertia* species and one commercial sample revealed that the probability of mixing of *Andrographis paniculata* with the true species is more than other species. Dendrogram generated through N-J method revealed that *swertia chordata* can be used as a substituent to *Swertia chirata*. Thus combination of GC-MS data and statistical analysis suggested few compounds can serve as markers for quality control and discriminate *swertia chirata* from its adulterants. The chemo profile results obtained supports the potential of *Andrographis paniculata* to be used as adulterant whereas *swertia chordata* as a substitute of *swertia chirata*.

TREE CROP INTERACTIONS: RESOURCE MANAGEMENT IN AGROFORESTRY

Stanzin Landol, N.S. Raina and Sandeep Sehgal

Department of Agroforestry

Sher-e-Kashmir University of Agricultural Sciences & Technology-Jammu (J&K)

E-mail: stany_24@yahoo.com

Agroforestry is an age-old practice of growing trees along with crops. This type of management of land resources was practiced by farmers, grazers and indigenous people for centuries. Not only in developing countries, but in developed countries too, this concept was well appreciated for various reasons. In India, the national target is to establish forest cover on 33 per cent (10,90,000 km²) of the total geographical area, which shall be possible only through agroforestry

as forestland is only 23 per cent of the total geographical area.(Shirsath,2005). Incorporating trees into farming systems lead to greater prosperity and diversification at the farm level. Trees provide farmers with marketable products, such as fuel wood, fodder, fiber, fruits and medicines, all of which earn extra income. No doubt, trees surely offer economic and ecological advantages but both the tree and the annual crop compete with each other for their share of light, space and nutrients thereby affecting each other in some way or the other. The rate and extent to which biophysical resources are captured and utilized by the components of an agroforestry system are determined by the nature and intensity of interactions between the components. The net effect of these interactions is often determined by the influence of the tree component on the other component(s) and/or on the overall system, and is expressed in terms of such quantifiable responses as soil fertility changes, microclimate modification, resource (water, nutrients, and light) availability and utilization, pest and disease incidence, and allelopathy (Rao et al., 1998). Interaction is defined as the effect of one component of a system on the performance of another component and/or the overall system (Nair 1993). Types of interactions usually termed as complementary, supplementary and competitive. Positive impacts of interactions on trees & crops are soil fertility enrichment, improvement of microclimate, enhancing food security and carbon sequestration whereas negative impacts of interactions on trees & crops are shading, resource competition, allelopathy, invasive behavior of some introduced species (Chundawat and Gautam, 1999). Increased productivity, improved soil fertility, nutrient cycling, soil conservation are the major positive effects of interactions and competition is the main negative effect of interaction. There are many research reports indicating significantly higher yield of crops in different agroforestry systems compared to sole crop yields while some other reports indicate that competition is the major negative interaction which substantially reduces the crop yield. But, such yield/productivity loss can be minimized by minor modifications in the tree or crop components. Therefore studying tree-crop interaction in agroforestry is of utmost importance to devise appropriate ways to increase overall productivity of land.

STATUS OF SOIL ORGANIC CARBON AND FERTILITY AND THEIR RELATION UNDER DIVERSE LAND USES OF SOME NORTH EAST INDIAN STATES

P. K. Das^{1*}, I. Ao², D. K. Banerjee³, N. P. S. Nain⁴ and M. Baruah¹

¹Silviculture and Forest Management Division

Rain Forest Research Institute, Jorhat – 785 001 (Assam)

²Forest Secretariat, Nagaland State, Kohima (Nagaland)

³Forest Development Corporation, Andaman Forest, Port Blair (Andaman)

⁴Tropical Forest Research Institute, Mandla Road, Jabalpur (Madhya Pradesh)

E-mail: daspk@icfre.org

Soil is one of the big reservoirs and sinker of the total terrestrial organic carbon through the decomposition of plant litter naturally and thereby sequestered one of the main contributors of GHG. Due to different land use practices the rate of sequestration of organic carbon in soil

varies. Organic matter plays a big role for the productivity of soil by making plant nutrients in available form, acts as a buffer to rectify the toxicity and unfavourable soil conditions, reduces soil erosion, made the soil physical properties favourable for plant growth. So attempt was made to assess the present status of soil organic carbon (SOC) and their fertility under some land uses of some NE Indian states. In view of this aspect surface soil samples (up to 30 cm depth) were collected by removing the litter or grass. Soil was excavated vertically up to 30 cm and sample was collected (1 - 1.5 kg, depending on the gravel content of soil) from the whole depth, mixed well and put into cloth bag with tag from 313 numbers of location covering six different land uses consisting of Tea, Coffee, Rubber, Jhum land, Cardamom and Forest areas of six states of Assam, Meghalaya, Tripura, Meghalaya, Nagaland and Arunachal Pradesh states of NE India during 2009 to 2011. Soil sample collected from the field air dried, grinded and sieved through 2 mm mesh and stored in plastic bottle with proper tag for laboratory analysis. SOC was measured by chromic acid digestion, available nitrogen (N) via distillation with alkaline permanganate, available phosphorus (P) by Bray's method and available potassium (K) by flame photometer after extracting with dilute H_2SO_4 . Wide variation of SOC was found among the six different land uses (2.6 - 200.6 t/ha). Highest amount of organic carbon sinked in soil was found in forest area (200.6 t/ha) followed by cardamom (130.0 t/ha), Jhum land (73.2 t/ha), Rubber (52.0 t/ha), Coffee (47.0 t/ha) and Tea plantation area (42.4 t/ha). Variation in available nitrogen (N) content in soil sample was found (194 - 4180 kg/ha). Available phosphorous (P) content in soil was found low in most of the areas (0.2 - 105 kg/ha) with a few medium and high available P sites. Medium to high available potassium (K) status of soil was found (60 - 2640 kg/ha). Data analysis was carried out using Excel 2007-Software taking individual and combined land use data for correlation, ANOVA, regression and graph for regression line taking organic carbon as independent variable and available N, available P and available K as dependent variable to find out the effect of SOC on them. To study the effect of altitude and age on soil organic carbon sequestration potential, statistical analysis was also done taking SOC as dependent variable and the other two parameters as independent variable. Significant increase in soil available N and K (at 1% level) was observed under four land uses but only in tea areas insignificant decrease was found (at 5% level) with the increase of SOC. But for coffee plantation areas increase in available N and K found significant (at 1% level) and insignificant (at 5% level) respectively with the increase of SOC. With the increase of SOC insignificant decrease in available P (at 5% level) in soil was found for all the five land uses. Under only jhum land, significant increase (at 1% level) in available P in soil was found with the increase of SOC. Significant increase in SOC (at 1% level) was found with the increase of altitude of site for four land uses except that under cardamom and tea plantation areas where insignificant increase was found (at 5% level). Plantation age found an effect on SOC content in soil and it decreases significantly under coffee area and insignificantly for three land use areas with the increase of plant age (at 5% level). In case of jhum land areas SOC found increased insignificantly (at 5% level) with the increase of land cultivation age. It may be due to the addition of organic matter through slash and burning practice for preparing land for cultivation.

CARBON ACCUMULATION AND EFFECT OF POPLAR (*POPULUS DELTOIDES*) PLANTATION ON SOIL PROPERTIES

S.K. Gupta and Jagdeep Singh

Division of Agroforestry, FoA, SKUAST- Jammu, Chatha - 180 009 (J&K)

E-mail: sushilgupta67@rediffmail.com

Tropical forest species particularly fast growing have emerged as a dependable source of carbon stock and poplar (*Populus deltoides* Barter. ex Marsh) is one such option. It constitutes a prominent species for plantation forestry in India particularly the North-Western plains including the states of Uttar Pradesh, Uttarakhand, Haryana, Punjab and Jammu & Kashmir. Poplar based agroforestry is well adopted by the farmers in the region owing to its deciduous nature, fast growth, short rotation and high industrial requirement. Due its fast growth, it is also effective in carbon sequestration and returns a substantial quantity of nutrients to the soil through litter fall. Information on biomass accumulation, nutrient content, soil enrichment/ carbon stocks are of utmost importance in plantation forestry. Carbon concentration in above ground biomass components and effect of block plantation (9 years old) of Poplar planted at 5x 4 m spacing on soil properties was carried out in the sub-tropics of Jammu and Kashmir. The experimental site was located in the foot hills of Shivaliks at an elevation of 332 m amsl with average annual rainfall of 1100 mm and temperature ranging from 2 to 45⁰ C. The experimental site was characterized as low to medium in nutrient availability, with low soil carbon status. The effect of poplar plantation on soil physico-chemical parameters was compared with the adjoining cultivated and fallow area with respect to available nutrients at different depths (0-10, 10-30 and 30-50 cm). The results revealed that soil under poplar plantation had recorded significant improvement in physico- chemical status except soil texture as compared to that under cultivated and fallow land. The results therefore, adequately support the carbon build up potential of poplar in the irrigated sub-tropics of the North -Western plains.

KITCHEN GARDENS: A TRADITIONAL AGROFORESTRY PRACTICE IN SOUTH AND WEST SIKKIM OF EASTERN HIMALAYAS, INDIA

H.K.Deshmukh*, Y.B.Taide, A.J.Deshmukh, P.Bhattacharya and Suprava Patnaik

College of Forestry

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola - 444 001 (Maharashtra)

**E-mail: hkdeshmukh1@rediffmail.com*

Sikkim a state of India located in the Eastern Himalayas region with an area of 7096 sq.km. The elevation ranged from 270 m (lower hills) to 8598m (snow bound lands) and annual rainfall ranging from 1300 mm to over 4000mm. About 80% of the population depends on agricultural land for their livelihood. In Sikkim the ecological situations vary greatly at very short distances, which limits the adoption of crop species and their varieties within a narrow range. The present study was conducted to know the Kitchen-gardens and its composition and their role in

conservation and livelihood of the farmers in Sikkim. Three villages were selected from each district namely Bikmat, Borong and Kerabari in south district and Yuksum, Singling and Sankhu in west Sikkim and the data was collected from sixty farmers. In total 89 different plant species were recorded in Kitchen garden of Sikkim Himalayas which includes, 32 multipurpose tree species, 11 fruit trees, 06 wild fruit trees, 30 different types of vegetable of which 85 percent plants species are native. It was observed that the kitchen gardens are commonly found in every farmers house in Sikkim. The farmers usually grow seasonal and local vegetables in the garden with some multipurpose trees species. To fulfill the daily requirement of food and vegetables, the farmers depends mainly on these kitchens gardens. These gardens are invariable for home consumption, but sometimes the farmers take production for commercial purposes also. These gardens not only foster the vegetable component, but also enhance the biodiversity of local area. Research on choice of species, tree crop interaction, spacio temporal dynamics should be undertaken to maximize the socio-economic and ecological benefits of the Kitchen gardens.

CRITERIA AND INDICATORS FRAMEWORK FOR SUSTAINABLE FORESTS MANAGEMENT THROUGH COMMUNITY PARTICIPATION: A CASE OF AKOLA FOREST DIVISION, MAHARASHTRA, INDIA

**H.K.Deshmukh*, Y.B.Taide, V.B.Shambharkar, U.R.Chinchamatpure
and V.V.Ujjainkar**

College of Forestry

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola - 444 001 Maharashtra

**E-mail: hkdeshmukh1@rediffmail.com*

The first Earth Summit at Rio in 1992, it was realized that Sustainable Forest Management (SFM) is an important element of Sustainable Development. The over-exploitation and the consequent depletion of forests due to several biotic and abiotic factors over time poses a serious threat to the livelihood of millions of poor people, biodiversity and ecology. In view of this, it is an imperative now to preserve the forests and manage them sustainably so as to ensure livelihood security of the forest-dependent communities and ecological integrity of the country, particularly of Akola District in Maharashtra. With view to harness the degradation and overexploitation of forest resources in the Akola Forest Division, its periodic monitoring is essential. The Criteria and Indicators (C&I) is one of the world-recognized tools for SFM. The present study was conducted in Akola Forest Division to identify set of indicators for SFM for forest in Akola forest division and study the factors responsible for decrease and increase value of indicators. The methodological frame work for evolving C & I will be adopted were developed for forests in Akola Division with community participation and different stakeholders together with approach for their data collection and analysis of sustainability. In total 42 set of indicators have been identified out of which 32 are national indicators along with 10 site specific are applicable to forest in Akola Forest Division. The outcome of the project will be directly benefited to forest dwellers and the government functionary for the assessment of the sustainability of the forest.

MAN WILDLIFE CONFLICT: DETERRENT ASPECT

Vishnu Omprakash Bondhare

Department of Agriculture Economics & Statistics

Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola - 444 001 (Maharashtra)

The present study is undertaken in Yavatmal district. Area of study is located in Umardhed tehsil. All 15 villages are under great influence of Man Wildlife Conflict. For detail of conflict we studied rainfall. The amount of annual average rainfall (mm) in Umardhed tehsil i.e. in study area for year 2000-01 to 2009-2010 was observed as 639.60;647.40;452.20; 357.22;669.50;857.00;681.98;542.06;550.10;797.00mm respectively. The Nature and Number of incidence of Human-wildlife conflict was observed from year 2001 to 2010 as 83;85;100;112;87;76;85;90;89 & 78 respectively. Now, we have concluded that, the Period of incidence of Human-wildlife conflict are concentrated with rainfall scarcity period. From these numerical data which is obtained from collector office, Yavatmal & Forest Department, Sondabhi, Umardhed we can clearly concluded that, rainfall is inversely proportional to no. of incidence of Human-wildlife conflict. For avoidance of such conflicts, our project suggest construction of wildlife pond in sanctuarial area /forest which is very crucial for wild animals as well as well being of human society.

STUDIES ON PHYTOCHEMICAL VARIATION IN M₁ GENERATION AND GROWTH PERFORMANCE AS IMPACTED BY PINCHING IN SWERTIA CHIRAYITA

Pancy Thakur, Y.P. Sharma and Sandeep Chauhan

Department of Medicinal and Aromatic Plants

Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (HP)

BSI, CS Division, Ministry of Environrment and Forest, New Delhi

Present investigation was conducted under two sub experiments viz. i) to study the effect of γ irradiation on secoiridoid content in M₁ generation and ii) to study the effect of spacing and pinching on growth and yield parameters. Seeds of *S. chirayita* were subjected to different doses of physical mutagens (2 to 30 kR gamma rays) to study their impact on growth, yield and major bitter compounds at flowering stage. Maximum plant height (151.00cm), fresh aerial biomass (62.22g/plant), dry aerial biomass(20.72g/plant), fresh root biomass (5.05g/plant), whole plant fresh biomass (67.27g/plant) whole plant dry biomass (22.39 g/plant) was observed in 26kR γ rays doses. The impact of γ rays on two secoiridoid compounds namely amarogentin and amaroswerin showed an erratic and irregular trend, with maximum amarogentin in (i) leaves at 20kR and 22 kR γ rays dose, (ii) roots at 30kR and (iii) stems at 4kR and 8kR dose of γ rays. Amaroswerin content was recorded maximum in (i) leaves at 12kR γ rays dose and (ii) roots at 20kR and 30kR dose of γ rays. In stems, amaroswerin content decreased in comparison to control in all the treatments. Apart from changes in concentration of amarogentin and amaroswerin, some additional peaks in HPLC chromatograms were observed in roots of plants

treated with 20kR to 30kR dose of γ rays. In spacing and pinching experiment, it was observed that with the increase in pinching height there is increase in all the growth & yield parameters. Among different pinching heights, maximum fresh aerial biomass/plant (65.34 g), dry aerial biomass/plant (23.16 g), fresh root biomass/plant (5.53 g), dry root biomass/plant (1.76 g), whole plant fresh biomass/plant (70.87 g), whole plant dry biomass/plant (24.92 g), expected fresh biomass yield (49.80 q/ha) and expected dry biomass yield (17.49 q/ha) were recorded under 60 cm pinching height. Among all the spacings, mean plant height (107.30 cm), number of branches (12.20), fresh root biomass (5.03g), dry root biomass (1.63g), expected fresh biomass yield (54.38 q/ha), expected dry biomass yield (19.12 q/ha) were maximum under 30x30 cm spacing.

PHYSIOLOGY AND YIELD OF LEGUME CROPS IN AN AGRI-HORTI-SILVICULTURAL SYSTEM

W.S. Dhillon¹ and Sanjeev K Chauhan²

¹Post Harvest Technology Centre

²Department of Forestry and Natural Resources

Punjab Agricultural University, Ludhiana - 141 004(Punjab)

E-mail: wasakhasingh@yahoo.com, chauhanpau@pau.edu

The effect of shading on the physiology and productivity of two leguminous crop in the poplar-fruit tree based agri-horti-silvicultural intercropping system was studied. The micro-climatic interaction and resultant effect on physiology and yield of agronomic crops grown under poplar tree canopy was recorded. Results showed that net photosynthesis was directly related to photosynthetically active radiations (PAR) but not much affected by the temperature and humidity. The physiological differences in the crop behaviour under shade affected the plant growth resulting in reduced crop yield of both the crops under canopy shade, though the hundred seed weight was not influenced. Stomatal conductance, and transpiration in both the crops were higher in open areas than in shaded areas. Though the trees (timber-fruit) were in initial stage of their development but it is suggested that to minimize resource competition and improve physiological processes of crops, canopy management is essential to ensure better yield under poplar-based agri-horti-silvicultural system so that farmers may earn regularly from the intercrops before the commercial bearing of fruit trees.

BIODIVERSITY - CONSERVATION AND ITS ROLE IN CLIMATE CHANGE MITIGATION AND FOOD SECURITY

Meenakshi Gupta*, L. M. Gupta, K. K. Sood, Sandeep Sehgal and Vishal Mahajan

Division of Agroforestry, Faculty of Agriculture

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu-180 005 (J&K)

**E-mail: meenakshi2001@gmail.com*

Climate is probably the most important determinant of vegetation patterns and has a significant influence on distribution of biodiversity, species dominance, plant productivity and, in general,

ecology of forest, agriculture etc. Plant communities are associated with certain climate regimes. The degrees of sensitivity, however, vary from one species to the other and thus some of the impacts are irreversible such as loss of biodiversity and wetlands. The loss of biological diversity reduces the ecosystems ability to adapt to the change. Adaptation describes a plant's, animal's or ecosystem's capacity to adjust to changes such as heat, drought, or salinity—an adjustment enabling them to overcome constraints, take advantage of new opportunities and cope with the consequences of changing environments. The adaptation capacity of ecosystems relies fundamentally on genetic diversity. The loss of genetic diversity or biodiversity will cause ecosystem boundaries to move, allowing some ecosystems to expand into new areas, while others diminish in size as the climate becomes inhospitable to the species they contain. The present paper thus highlights the crucial role of biodiversity and ecosystems in climate change adaptation and importance of capacity building for ensuring food security. It further discusses how local traditional knowledge and the practices based on the sustainable use of natural resources and biodiversity can provide the basis for appropriate adaptation strategies to cope with the challenges of climate change.

INTEGRATED NUTRIENT MANAGEMENT FOR GROWTH AND YIELD IN *ALOE BARBADENSIS*

L. M. Gupta, Mir Awsaf Ahmad, M. Gupta, N. S. Raina and S. K. Gupta

Division of Agroforestry, Faculty of Agriculture

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu-180 005 (J&K)

**E--mail: guptalm@gmail.com*

Aloe barbadensis Mill. belonging to family Liliaceae, is an important plant species widely used in pharmaceutical, cosmetic and food industry. It is an exotic species and almost naturalized in tropical and sub-tropical climate in India. Drug Aloe(dried latex) which contains aloin, acts as purgative whereas, leaf gel due to its anti-ageing and nutritive properties used in cosmetic and food industry. To promote its commercial cultivation it is imperative to increase its leaf yield through fertilization and selection of the promising genotypes. In this context, a field experiment was conducted to find out integrated nutrient management technique suitable for increasing leaf and gel yield in *Aloe barbadensis*. At the inception of the experiment, the soil was sandy-clay loam in texture, slightly alkaline in reaction having low status of available N and medium in available P and K. The growth and yield attributes were best in substitution of 50 per cent (75kg/ha) of recommended dose of N (150kg/ha) through vermicompost + biofertilizer (*Azotobacter*) while, yield was slightly less in 50 per cent substitution of recommended dose of N with FYM + biofertilizer (*Azotobacter*) but were statistically at par with each other. Although sole application of N@ 150 kg/ha had a significant increase in yield over 100 per cent substitution of N with vermicompost + *Azotobacter* and Farm yard manure +*Azotobacter* combinations, but 50 per cent and 75 per cent substitution combinations recorded a significantly higher yield than sole application of N, Vermicompost+ *Azotobacter* and Farmyard manure + *Azotobacter*, respectively. The combination of organic, inorganic and biofertilizers is not only superior over application of manures or fertilizers alone for achieving higher growth and yield but also in maintaining the fertility status of soil.

SUSTAINABLE RESOURCE MANAGEMENT IN ENVIRONMENTALLY FRAGILE RAINFED (KANDI) ECOSYSTEMS OF JAMMU AND KASHMIR

A. P. Singh, Vishal Mahajan and Amrish Vaid

Krishi Vigyan Kendra, Kathua

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J&K)

E--mail: apsinghagron@gmail.com

The sub-mountainous rainfed areas of Jammu province popularly known as *Kandi* in local parlance and are primarily characterized by their poorly managed less productive soils with weak socio-economic status of the people dwelling in the region. Low productivity of such soils can mainly be attributed to the undulated and rugged relief of land with medium to shallow soil depth and presence of gravels and stones making the agricultural activity more challenging. *Kandi* region of Kathua district though houses a good cattle population but the low availability of quality fodder during most part of the year kept the animal keepers at distance from fetching fortune out of this activity. Moreover, the total dependence of agriculture on rainwater also adds another scar in the production constraints and makes it more vulnerable to the vagaries of weather and thus renders agriculture activity an uneconomical preposition. Land and water are the main production resources for agriculture and the conservation of both is more important for increasing the agricultural productivity on sustainable basis under rainfed ecologies. Deep ploughing across the slope during summer months is very effective for *in-situ* conservation of water and soil. *Kandi* areas receive more than 80 per cent of annual rainfall between the months July and September whereas, there is only about 20 per cent of the remaining rainfall is received during rest of the months. Moreover, the sloppy topography of the region does not support the rain water to get infiltrated in to the soil surface and as a result most of the rain water makes its way in the form of runoff into the seasonal streams (*Khads*). Rain water harvesting is a must to do technology for *Kandi* farmers as it holds the promise to store and conserve the rain water during the periods of rainfall for its use in meeting out the demand of different crops during the times of water scarcity. Besides, this technology ensures life saving or supplemental irrigation to the crops while protecting the precious land resource from erosion hazards. Plantation of multipurpose trees like *Bauhenia* Bamboo, Drek etc. can be encouraged as it has multiple benefits of providing fuel wood, fodder and wood for other purposes. Plantation of perennial fodder grasses such as *Napier*, *Setaria*, *Cenchrus* etc. on farm bunds should also be encouraged for protecting the soil from erosion hazards and to improve the green fodder availability during lean winters. Usage of area specific mineral mixtures and mineral blocks should be encouraged to ameliorate the nutrient deficiencies and consequently the productivity of cattle. Bamboo plantations should be introduced in areas where gullies have initiated and looming further incursion into the valuable land. It will not only plug the gullies but also check the valuable soil from erosion. Recycling and usage of organic resources should be augmented by making use of locally available resources. Proper composting methods should be adopted instead of making the disposal of cow dung in the open as it leads to nutrient losses. Soil should be analysed to know the nutrient status of the soil and nutrient application should be based on soil test recommendations in order to get maximum production and productivity of crops.

ENSURING FOOD AND LIVELIHOOD SECURITY THROUGH CLIMATE RESILIENT FARMING

Parveen Kumar¹, P. S. Slathia² and Liaqat Ali²

¹*National Initiative on Climate Resilient Agriculture*

²*Division of Agricultural Extension Education*

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu (J&K)

E-mail: pkumar6674@gmail.com

The recent times is witnessing unprecedented vagaries of weather as a result of global warming and the resultant climate change. Many important parameters like the carbon dioxide, water, temperature and the soil fertility status are affected by this phenomenon. This has made agriculture sector vulnerable. Research on climate resilient farming technologies is needed for ensuring food and livelihood security of the millions of poor farmer families for whom the agriculture is the main source of livelihood. Rainwater is the lifeline of the agriculture sector in rainfed areas which are expected to hit hard by the climate change. Technologies that could efficiently put to use the rain water should be developed. Another important component of the climate resilience is the seed varieties. The research institutes should come up with the varieties that could withstand stress. Field management with suitable strategies can lead to reduction of various Green House Gases. The Nitrogen emissions can be limited with the judicious use of Nitrogenous fertilizers. Crop intensification techniques like System of Rice Intensification has made it possible to grow Paddy with very less amount of water and other inputs. Integrated techniques like the integrated nutrient management, integrated pest management and integrated disease management also save the lot of expenditure of farmers in chemicals and other costly inputs besides maintaining the sanctity of the ecosystem. An effective weather monitoring and early warning system is also essential which could tell well in advance the situation of weather so as the farmers can decide well in advance which crop to grow. Changes in the cropping pattern, conservation measures, suitable farming systems and low input technologies for specific agro-ecological zones are necessary so as to offset the threat of increasing temperatures. All this can go a long way in making the farming more economical and thus retain the interest of the farming community in agriculture. It is also seen that the farming community is generally not aware of the climate change. They are still practicing their traditional methods of cultivation which are neither economically beneficial nor environmentally sustainable. The reasons for their unawareness may what so ever are but they should be made aware of the problem. It is also necessary that the relevant technologies do not remain on the shelves. It should reach the farmers fields. All this will definitely lead to the farmers having a better understanding of the threats associated with this and the ways and means to lessen the effects of climate change.

PRODUCTION POTENTIAL OF AGRICULTURAL CROPS UNDER DALBERGIA SISSOO BASED AGRI-SILVICULTURAL SYSTEM

Chhavi Sirohi*, R.S. Dhillon and K.S. Bangarwa

Department of Forestry, CCS Haryana Agricultural University, Hisar

E-mail: chhavisirohi22dec@gmail.com

In arid to semi arid regions, where the build up of organic matter is limited, nitrogen-fixing trees offer immense possibilities of supplying organic matter, conserving soil moisture and supplementary nitrogen needs of crops. *Dalbergia sissoo* has now emerged as very popular and commercially planted tree in agroforestry because of its quality timber production, deciduous in nature and nitrogen fixing tree. In tree planted considerable amount of nutrients are incorporated into the soil through leaf litter fall and its recycling which in balance the nutrient reserve of the soil. *Dalbergia sissoo* is known to fix nitrogen symbiotically and substantial improvement occurs in the soil system due to enrichment of soil by addition of organic matter and nutrient content, leading thereby which increase in agricultural production. Hence an experiment was conducted to assess the growth and yield of wheat and paddy cultivated under 4 year old *Dalbergia sissoo* based agri-silvicultural system on sodic soil. The experiment was laid in Factorial Randomized Block Design with treatment consisting three varieties of wheat (NW-1067, NW-1014 and HD-2643) and three paddy varieties (Sarjoo-52, Narendra Usar-2 and Narendra Usar-3). Under this study plant height and straw yield were found better for wheat variety HD-2643 (plant height 89.33 cm and straw yield 1.15 t ha⁻¹) and paddy variety Narendra Usar -2 (plant height 98.00 cm and straw yield 1.59 t ha⁻¹), when the crop was grown at 1.0 m away from tree base in the alley. However, maximum number of per ear/ panicle test weight (1000-grain weight) and grain yield were recorded in case of wheat variety NW-1067 (2.32 t ha⁻¹) and paddy variety Narendra Usar-2 (2.33 t ha⁻¹), when the crop was grown in open area. Amongst different varieties, wheat variety NW-1067 and paddy variety Narendra Usar-2 were found better for cultivation under this study.

VEGETATION PATTERN OF COMMERCIALLY IMPORTANT TREES IN EVERGREEN FORESTS OF BARATANG ISLAND, ANDAMANS

Thiru Selvan

Department of Forestry and Biodiversity

Tripura University, Suryamaninagar,

Agartala-799 002 (Tippura)

Baratang Island (11° 46' 10" to 12° 18' 35"N and 92° 36' 55" to 92° 10' 40" E) which is spread across an area of just 238 square kilometers and one of the main constituents of the 'Great Andaman' group are characterized by dense tropical forests. The Tropical Evergreen Forests of this Island were studied for its composition and Species diversity with regards to the commercial tree species both in the managed (worked) and unmanaged (unworked) areas. It was noticed that the tree layer in evergreen un-worked forests is dominated by *Dipterocarpus spp.* with the highest IVI of 28.76 and the second most dominant species is *Knemaandamanica* with IVI 26.21

followed by *Myrsticaandamanica* with IVI 18.16 but in worked area *Dipterocarpus spp.* retains its dominance with highest IVI of 55.36 while *Knemaandamanica* occupies second position with IVI 27.20 followed by *Pometiapinnata* with IVI 20.90. It was found that unworked areas have more number of tree species (84) than the worked areas. The composition of the species has to be maintained, so the biodiversity rich areas are intact in its natural form.

AGROFORESTRY SYSTEM IN LEAF NUTRIENT CONCENTRATION OF FORAGE CROPS UNDER DALBERGIA SISSOO

Vinita Bisht*, R.S. Dhillon and K.S. Bangarwa

Department of Forestry, CCS Haryana Agricultural University, Hisar (Haryana)

E-mail: jyotivinita89@gmail.com

Agroforestry has caught the attention of the farmers across the world, especially in developing countries, where forest trees and agricultural crops are grown with each other. Silvi-pastoral system is an integration of annual forage crops with woody perennials in a land use system that enhances productivity and ensures sustainability besides environmental benefits. The shisham (*Dalbergia sissoo* Roxb.) is a pioneer species, adapted even under nutrient poor sodic land condition. Although a leguminous N-fixer, it has tremendous potential to grow under diverse climatic conditions from low to high rainfall areas. *D. sissoo* is an important timber species next to teak, however it shows amazingly high salt tolerance even greater than many indigenous species of this region. From stand-point of agroforestry management, there is a need to understand the sustainability of the current harvest system and to suggest sustainable leaf harvest levels to support proper nutrient cycling under tree based fodder system (Silvipastoral system). Nutrient retranslocation during senescence is a biochemical in plants and a nutrient conserving strategy in green plants. Transfer of nutrients from senescencing leaves to woody parts of trees and shrubs reduces the likelihood of nutrient loss in litter dropped on the soil. Nutrient differs in extent of their retranslocation from senescing leaves. Plants adapted to infertile sites show greater propotional loss of nutrient at senescence than those adapted to fertile sites. However evidence contrary to this process is also available.

POTENTIAL OF MEDICINAL AND AROMATIC PLANTS UNDER INTEGRATED SYSTEM

Punit Choudhary*, Vikas Tandon and Rakesh Sharma

Krishi Vigyan Kendra, Rajouri

Sher-e-Kashmir University of Agricultural Science & Technology of Jammu, Jammu (J&K)

E-mail: pmd.choudhary@gmail.com

The increasing global interest and expanding market of herbal drugs have led to their introduction into cultivation to meet the demand at reasonable economic price. According to World Health Organization, herbal medicines are lucrative globally and they represent a market

value of about US\$ 43 billion a year. Under integrated landuse systems MAPs offers promise for integrating shade tolerant medicinal plants as lower strata species in multistrata system as well as inter-planting medicinal plants with food crops. Planting medicinal trees viz., Aonla, Harad, Moringa, Bael etc. on bunds and boundaries has potential of increasing returns to the farmers for the same farm. Cultivation of phenotypically elite planting material of medicinal plants like Mentha, Ocimum, Zinger, Ashwagandha, Aloe vera, Sarpagandha, Stevia, Safed Musli, Banafsha, Bhrami etc. under intermediate conditions in combination with traditional crops not only facilitate in maintaining standards in quality, potency, chemical composition of the produce required for export as well as provides remunerative profit to the growers. Agro-technology for many of rare and endangered medicinal plants of the northern India has been developed by different organizations. However, the per hectare cost of cultivation, total annual production and cost benefit ratio fluctuate with different medicinal plant species. Through incorporation of some of these economically suitable plants under cultivation, the potential of employment generation seems enormous as it involves range of entrepreneurial activities like cultivation, processing, extraction, product formulation and fractionation. Moreover, increased awareness about the medicinal and aromatic plants (MAPs) has encouraged many innovative and progressive growers and entrepreneurs to take up their cultivation as a commercial enterprise under integrated approach.

TREES FOR ENSURING LIVELIHOOD SECURITY IN RAJOURI AND POONCH (J&K)

Punit Choudhary*, Vikas Tandon and S K Gupta

Krishi Vigyan Kendra, Rajouri

Sher-e-Kashmir University of Agricultural Science & Technology of Jammu, Jammu (J&K)

E-mail: pmd.choudhary@gmail.com

Trees grown in agroforestry systems in Rajouri and Poonch districts of J&K play an important role in household food security. Multipurpose trees like *Albizia lebeck*, *Celtis australis*, *Bauhinia variegata*, *Ulmus laevigata*, *Quercus himalayana*, *Morus alba*, *Robinia pseudocacia*, *Grewia optiva*, *Melia composite*, *Alianthus excelsa*, and *Dalbergia sisoo* etc. occurring naturally as well as grown under agroforestry systems in twin districts provides small timber, fodder, fuelwood and are used in making ploughs and implement handles. Trees existing in agroforestry systems in these districts are source of green fodder during the period of shortage of the fodder to the livestock e.g. *Grewia optiva*, *Celtis australis*, *Ulmus spp.* and *Ficus roxburghii*. Tree fruits/fruit products of *Myrica nagi*, *Ficus roxburghii*, *Syzygium cumini*, *Juglans regia*, *Pyrus pashia*, *Morus spp.*, *Prunus amygdalus* and *Aesculus indica* grown under agri-horti system are not only widely consumed by the inhabitants of these districts as regular food supplement to diet but also add variety to diets, improve palatability and provide essential vitamins, minerals, proteins and calories. Since both districts are characterized by fragility, poverty, inaccessibility, marginality and harsh climatic conditions which in turn lead to limited livelihood options for the

people. In such a situation trees grown along with crops in the form of agroforestry provide a biomass reserve upon which people can fall back for subsistence and income in times of crop failure, unemployment and other kinds of hardships, contingencies or to meet exceptional needs. They help to meet contingencies by directly providing recurrent, seasonal or occasional flow of food, fodder, timber, and other products or earn cash to meet the contingencies thus helping in reducing household vulnerability to risk and there by ensuring the livelihood of the peoples of the districts.

EVALUATION OF ROOT DISTRIBUTION PATTERN OF *JATROPHA CURCAS* FOR AGROFORESTRY SYSTEM

Megna Rashid^{1*}, S.B. Lal², Samreen Mehboob² and Nusrat Jan¹

¹ *Central Institute of Temperate Horticulture, Old Air Field, Rangreth, Srinagar (J&K)*

² *College of Forestry Allahabad Agriculture Institute- Deemed University
Allahabad-211 007(UP)*

**E-mail: megnarashid@gmail.com*

Studies were undertaken to elicit information on root distribution pattern on *Jatropha curcas* in three different age classes (one, three, five year old) and in two distinct seasons viz, before rain and after rain to compare the seasonal variation. Root distribution study was carried out with dry excavation method which involves the partial excavation of soil sample to represent the whole part of the rooting volume of the tree. After removal of soil in three distances (50 cm, 100 cm, 150 cm from the base) of four depth categories (0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm), the samples were washed separately for the collection of roots. Among the two seasons of observations, after rains recorded the maximum rooting intensity, root density and root biomass followed by before rains. The result revealed that increase in distance and depth led to decrease in root activity by reduced rooting intensity, root density and root biomass. Maximum rooting intensity (340.44 m^{-2}) was observed in five year old trees at the 50cm distance of 0-15cm soil depth category after rains followed by three and one year old *Jatropha* tree. The maximum root density of (0.033 cm^{-3}) was registered in 50 cm distance of 0-15 cm soil depth category in one year old tree during rainy season followed by three and five year old *Jatropha* tree. Significantly higher root biomass of (499.33 gm^{-3}) was recorded in 50 cm distance of 0-15cm soil depth category in five year old trees during the rainy season followed by one and three year old *Jatropha* tree. Similarly minimum root density, root intensity and root biomass before rains was minimum with D_3d_4 (150 cm distance-45-60cm depth).

PRODUCTIVITY AND NUTRIENT UPTAKE IN WHEAT UNDER POPULUS DELTOIDES BASED AGRISILVICULTURE SYSTEM: A CASE STUDY FROM CHHATTISGARH

Alka Mishra and S.L. Swamy

Department of Rural Technology, Guru Ghasidasvishvidyalaya, Bilaspur - 495 009 (CG)

Academic Staff College, Bilaspur - 495 009 (CG)

N, P and K uptake and productivity of wheat were studied under five promising clones (G3, G48, 65/27, D121 and S7C1) of *Populus deltoides* in agrisilviculture system. Grain yield of wheat varied from 25.5 to 36.6 q ha⁻¹ and straw yield from 34.9 to 60.7 q ha⁻¹. The yields were highest in sole wheat and reduced under poplar clones from 15 to 30.3% and from 22.7 to 42.5%, respectively. The reduction of wheat yields in different clones was in the order: G3<S7C1<D121<65/27<G48. The total nutrient uptake varied from 34.17 to 66.09 kg N ha⁻¹, 12.04 to 25.32 kg P ha⁻¹ and 35.6 to 67.6 kg K ha⁻¹. After 6 years of poplar planting, N in soil increased by 14.9-24.1%, P by 17.2- 23.3% and K by 3.1-5.1% at 0-20 cm depth. The study suggested adopting lopping, root hoeing and nutrient management practices in poplar clones G48 and 65/27 to minimize yield losses in wheat under these clones.

LEGISLATIVE FRAMEWORK IN FORESTS AND BIODIVERSITY CONSERVATION IN INDIA- A REVIEW

D. Rajasekar^{1*} and J.Yogalakshmi²

**¹Dy. Conservator of Forests, O/O PCCF, Punjab, Mohali (Punjab)*

²Coconut Research Station, TNAU, Aliyar Nagar, Pollachi, Coimbatore (TN).

E-mail: rajasekar.ifs@gmail.com.

Biodiversity is a wealth to which no value can be assigned, the very survival of the human race is dependent on conservation of biodiversity. Biodiversity is essential for maintaining ecological functions, stabilizing of the water cycle, maintenance and replenishment of soil fertility, pollination and cross-fertilization of crops and other vegetation, protection against soil erosion, interlinking food chain and stability of food producing and other ecosystems. Biodiversity provides the base for the livelihoods, cultures and economies of several hundred millions of people, including farmers, fisher folk, forest dwellers and artisans through raw material for a diverse medicinal and health care systems, genetic base for the continuous up-gradation of agriculture, fisheries, and for critical discoveries in scientific, industrial and other sectors. With only 2.4% of the world's land area, India accounts for 7 to 8% of the world's plant and animal species. It is one of 18 mega diverse countries and contains three global biodiversity hotspots. 18 sites have been declared as Biosphere Reserves (BRs). India shows a high degree of endemism and conserving its biodiversity is essential for the future. India is endowed with 7,82,871 sq km of Forest and Tree cover, comprising 23.81% geographical area. India has 668 protected areas with 102 National Parks, 515 Wildlife Sanctuaries,

47 Conservation Reserves and 4 Community Reserves constituting 4.90 percent of the total geographical area. The total growing stock in India's forest is estimated to be 6047.15 m cum, including that of trees outside forests and the forests store about 6663 m tonnes of carbon in it. 23% of population obtains fuel wood from forests and about 38.49% of cattle are dependent on forests for fodder. India's forests play multiple roles and provide various ecosystem services. As a developing country, our dependence on natural capital is more than higher-income countries. The forests face dual challenge of meeting the aspirations of people and conserve the rich biodiversity. The National Forest Policy 1988 and National Environment Policy 2006 recognize the need to address the conservation of areas of biodiversity importance, increasing forest productivity, and restoring degraded areas. The finest pieces of legislation in forest and wildlife protection history are the Wildlife (Protection) Act, 1972 and Forest Conservation Act, 1980. The former paved ways to create designated protected areas exclusively for wildlife conservation with inviolate areas and the latter arrested mindless diversion of forests for various other non-forest purposes in the name of development. India is also signatory to various International Conventions such as Convention on Biological Diversity, Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and Convention on Wetlands of International Importance. We are also part of REDD+ policy regime. Various other legal framework that govern forest and biodiversity conservation are Indian Forest Act, 1927, Environment Protection Act, 1986, Biological Diversity Act, 2002, Protection of Plant Varieties and Farmer's Rights Act, 2001, The Scheduled tribes and Other Traditional Forest Dwellers Act, also referred as Forest Rights Act (FRA), 2006 etc. People's participation is also sought in terms of eco development and involving them in conservation.

DIVERSITY, INDIGENOUS USES, THREAT CATEGORIZATION AND CONSERVATION PRIORITIZATION OF MEDICINAL PLANTS IN BANJAR VALLEY, HIMACHAL PRADESH, NORTH-WESTERN HIMALAYA

Pankaj Sharma^{1*} and S.S. Samant²

¹Himachal Pradesh State Biodiversity Board

Himachal Pradesh State Council for Science, Technology & Environment

B-34, SDA Complex, Kasumpti, Shimla-171 009, (HP)

²G.B. Pant Institute of Himalayan Environment and Development

Himachal Unit, Mohal-Kullu-175 126 (HP)

** E-mail: spankaj80@gmail.com*

Mountains are among the most fragile environments on this planet. They are rich source of biodiversity, water, providers of ecosystem services on which downstream communities (both regional and global) rely. They are home to some of the world's most threatened and endemic species (including medicinal plants), as well as to some of the poorest people, who are dependent on the biological resources. The worth of medicinal plants in regular healthcare practices provides clues to latest areas of research and in biodiversity conservation is now glowing. However,

information on the uses of plants for medicine is deficient from interior areas of Himalaya. Keeping this in view the present study has been conducted to study the diversity, indigenous uses, threat categorization and conservation prioritization of medicinal plants in Banjar Valley of Kullu district in Himachal Pradesh, North Western Himalaya. A total of 357 species of medicinal plants belonging to 98 families and 237 genera were recorded and used by the inhabitants of the area. These medicinal plants comprise of 27 trees, 269 herbs, 54 shrubs, 02 climber and 05 ferns. From the total, 193 medicinal plants were native, 03 endemic and 43 were near endemic. Highest medicinal plants were reported in the altitudinal zone, 2801-3600m and decreased with increasing or decreasing altitude in the study area. These species have been also analyze for their nativity, endemism, rarity and are prioritized for cultivation. An area-specific threat categorization of species is very essential for squat or long term management planning. In present study such an effort in the study area, using information on different attributes was initiated. The presence of critically endangered, endangered and vulnerable medicinal plants indicates high anthropogenic stress on these species. The over-exploitation, habitat degradation and changing environmental conditions may lead to the extinction within a few years. Therefore, regular monitoring of population and habitats, development of conventional protocol, establishment of species *in-situ* conditions and associated habitats and replication of this approach in other parts of Indian Himalayan Region have been recommended.

SUSTAINABILITY OF BIOMASS PRODUCTION SYSTEMS: WAY FORWARD FROM CONCEPT TO PRACTICE

R .C. Dhiman

WIMCO Ltd. (Wimco Seedlings Division)

Rudrapur, USN, Uttarakhand-263153

E-mail: dhimanramesh@yahoomail.com

Sustainability, as a concept, is easy to comprehend but extremely difficult to put in practice. Species and communities continue to evolve to develop synergy with surrounding environment and as such cannot remain in pristine status for ever. The process of change is slow but accelerates with human interventions. The change may be retrogression or progression depending upon the change in surrounding environment and human intervention. Agriculture, forestry and agroforestry are three dominant biomass production systems. All the three are under intense pressure for meeting domestic and industrial biomass needs in overpopulated, land deficit and biomass dependent countries like India. The country has a traditions and practices for conservation, sustainable usage and over exploitation of biomass production systems for meeting immediate needs of rising economy and a very large human and cattle population. There are lessons to be learnt to design and plan balanced approach for their sustainable management. Heavy biotic pressure leads to overexploitation threatening the very survival of such systems. Excessive conservation and preservation on the other hand lock them for inefficient utilisation. In certain plant/forest communities certain level of management interventions retain them at

desired level for meeting specific objectives. There is a need to take a pragmatic approach and create a balanced land use approach rather than sectoral approach for efficient biomass production systems. Recent efforts to integrate trees with agricultural crops and intercrops on forest land are some of the pragmatic approaches towards their sustainable development. Integration of these components need to complement and supplement rather than compete with each other. The concept is needed to be viewed at macro level, yet management interventions are required at micro management unit level to achieve the desired results.

COMPARATIVE STUDIES ON THE PLANT FUNCTIONAL TRAITS OF INVASIVE *BROUSSONETIA PAPYRIFERA* AND NON-INVASIVE *MORUS ALBA*

Anjana Negi^{*1}, Daizy R. Batish¹, R.K. Kohli¹ and H.P. Singh²

¹*Department of Botany,* ²*Department of Environment Studies*

Panjab University, Chandigarh - 160 014

E-mail: anjananegi02@gmail.com

Exotic plant invasions are causing profound changes to the native ecosystems around the world. It is, however, very intriguing as to why some exotic species acquire invasive character while others belonging to same family or even Genus remain non-invasive. The plausible answer for this could be the presence of some unique set of functional traits in some species while others may lack these. Comparing the plant functional traits of invasive and non-invasive species may thus provide some useful clues in understanding the invasibility of species. In Northern Himalayas, *Broussonetia papyrifera* (Paper Mulberry; family Moraceae), a woody perennial from Japan and China is spreading very fast especially in the states of Himachal Pradesh, Uttarakhand, Punjab and Chandigarh. On the other hand, another species of the family Moraceae – *Morus alba* is non-invasive in nature. A study was conducted to determine the plant functional traits of the two - *B. papyrifera*, as invasive and *M. alba* as non-invasive tree. Various leaf traits determined were specific leaf area (SLA), tissue density, leaf thickness, leaf length, width and fresh and dry biomass whereas tree related traits included tree height, % cover, diameter at the breast height (dbh), allelopathic and reproductive ability. Invasive tree *B. papyrifera* had higher growth, dbh and % cover and reproductive ability in terms of number, size and weight of seeds and their dispersal and vegetative growth. SLA and other leaf related parameters were also significantly different in the two types of trees. Further, the rhizospheric soil of *B. papyrifera* significantly inhibited the growth of *Bidens pilosa* – a test plant (chosen on the basis of its availability in the invaded and un-invaded areas) whereas there was little effect in case of soil brought from under the canopy of *M. alba*. From the study, it was concluded that *B. papyrifera* (invasive tree) differ from non-invasive *M. alba* with regards to various functional traits indicating their role in imparting invasiveness to the species.

EFFECT OF GAMMA RADIATION ON BITTER CONTENT IN SWERTIA CHIRAYITA

Pancy Thakur*, Y.P Sharma, Sandeep Chauhan and Nisha Sharma

Department of Medicinal and Aromatic plants

Dr. Y. S. Parmar University of Horticulture and Forestry, Solan- 173 230 (HP)

*E-mail: pansythakur@yahoo.com**

Swertia chirayita (family Gentianaceae) is an important medicinal plant with bitter taste used since an early date in traditional medicinal systems of our country for treatment of varied human ailments. The plant has been valued for its extensive medicinal properties due to presence of large number of chemical compounds. As the presence of phytochemicals influences the therapeutic properties of the plant, there is need for developing strains with high quantities of phytochemicals. Broadening the genetic base through induced mutation is a supplementary tool that can lead the development of genetic variability. The present study was undertaken to increase the phytochemical constituents of the plant of M₁ generation using physical doses (gamma radiation of 2 kR to 30 kR at an interval of 2 kR) to evaluate the different parts of the plant for specific bitter compounds especially Amarogentin and Amaroswerin. The two main bitter compounds i.e Amarogentin and Amaroswerin in methanolic extract of different parts of *Swertia chirayita* were quantified using HPLC (High Pressure Liquid Chromatography) technique. The study confirmed that there is no dose dependent relationship and an irregular trend has been followed where either increase or decrease in concentration of chemical constituents in different plant parts in comparison to control has been observed. Apart from changes in concentration of Amarogentin and Amaroswerin in different plant parts, on the basis of HPLC analysis some additional peaks in HPLC chromatogram were observed in roots of plants treated with 20 kR to 30 kR dose gamma rays.

EFFECT OF SEED SIZE AND ORGANIC MANURE DOSES ON GROWTH AND DEVELOPMENT OF THE *SAPINDUS MUKOROSSI* (GAERTN) SEEDLINGS

G. S. Shamet, Varun Attri, K. S. Pant and M. K. Thakur

Department of Silviculture and Agroforestry,

Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan – 173 230 (HP)

E-mail: attrivarun86@yahoo.com

The study was conducted at College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, during the month of March-October, 2010 to know the effect of seed size and different organic manure doses on growth and development of the *Sapindus mukorossi* seedlings. Among three seed size categories viz., small (L₁), medium (L₂) and large (L₃), large sized seeds (L₃) showed significantly higher shoot length (26.68cm), root length (18.28cm), seedling height (44.97cm), collar diameter (4.64mm), number of lateral roots (63.03), dry shoot weight (3.29g), total root weight (1.12g), and total dry weight (4.52 g) which was closely

followed by medium sized seeds (L₂). Among the five organic manure doses treatment viz. no manure (control) (M₁), vermicompost @ 5 t/ha (M₂), vermicompost @ 10 t/ha (M₃), FYM @ 5 t/ha (M₄) and FYM @ 10 t/ha. (M₅), treatment vermicompost @ 10 t/ha (M₃) recorded significantly higher shoot length, root length, seedling height, collar diameter, number of lateral roots, dry shoot weight, total root weight, and total dry weight (26.44 cm, 17.46 cm, 43.91cm, 4.50 mm, 57.67, 3.29 g, 1.10 g and 4.38 g, respectively). It was followed by the application of FYM @ 10 t/ha (M₅). On the other hand various growth attributes were recorded minimum in control i.e. no manure (M₁) during the experiment.

FORAGING BEHAVIOUR OF AMEGILLA ZONATA (L.) ON OCIMUM KILIMANDSCHARICUM GUERKE: AN IMPORTANT AROMATIC AND MEDICINAL PLANT IN J&K, INDIA

Devinder Sharma, Vishav Vir Singh Jamwal and D. P. Abrol

Division of Entomology, Faculty of Agriculture

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu-180 009 (J&K)

E-mail: devskuastj@gmail.com

The studies conducted during 2012 to study the insect pollinators of Kapoor tulsi, an important medicinal plant of J&K reveals that insects belonging to 4 orders, 8 families, and 14 species frequented *O. kilimandrischium*. Of all these, the blue banded bee *Amegilla zonata* (L.) was the dominant flower visitor followed by *Apis dorsata*, *A. mellifera* and *A. cerana*. The number of bees foraging during different times on the day ranged between 4.7-11.30/ 5 plants/5 min; visited 12-25 flowers/ 5 plant and spent 2.3-7.9s/flower. Foraging populations of *A.zonata* responded significantly to environmentally factors. An understanding of the mutualistic relationship between flower-visiting insects and crop species, particularly on the diversity of pollinator species, their spatio-temporal variations, foraging behaviour and their pollination efficiency, is important as they are some of the crucial biological predictors of pollination success.

APPLICATION OF REMOTE SENSING AND GIS TECHNIQUES TO MAP THE EXTENT AND OCCURRENCE OF DEODAR (*CEDRUS DEODARA*) AND KAIL (*PINUS WALLICHIANA*) IN RAMPUR FOREST DIVISION OF HIMACHAL PRADESH

Divya Yadav^{1*} and S.D. Sharma²

¹*Department of Forestry Extension, ² Forest Informatics Division*

Forest Research Institute, Dehradun - 248 006 (Uttarakhand)

**E-mail: divyaa.yadav@gmail.com*

The present study was attempted to understand the extent and distribution of deodar and Kail in Rampur Forest Divisions of Himachal Pradesh state and to prepare the map of Deodar(*Cedrus deodara*) and Kail(*Pinus wallichiana*) distribution by using remote sensing and GIS techniques

in 2011. The data was collected from all the available sources like the toposheets, satellite data, Forest Survey of India, State Forest Department, Library etc and applied RS & GIS to geo-reference, classify and digitize the satellite data and toposheets. Generated maps showed the distribution of Deodar and Kail along with site characteristics like slope, aspect, altitude. The quadrant of the IIRS P6 LISS 3 scenes was selected for the study. The forest area were recorded/reclassified as value (1) means all densities were grouped together using ERDAS IMAGIN (9.3) software. The raster layer of forest cover were converted into vector format i.e. polygonization of forest area and generated maps using ARC (GIS 9) software. Result showed that out of the total area of 53826 ha in Rampur forest division Deodar-Kail mixture covers an area of about 15817.93 ha which is 29.39% of the total forest area. In the Rampur Forest Division it has been found that Deodar and Kail forests lie mostly in the northern and eastern aspects. Although Deodar and Kail forest was observed on all the slope angles however, these two species preferred 0-25% slope angle as compared to steeper slopes. These techniques have proved to be very efficient by saving lot of time, expenditure and field work for preparation of species map up to compartment level. The maps (Compartment, Range wise distribution, Slope, Contour, and Aspects) along with their attribute table contain concise information on extent and distribution of species and also on the characteristics of the sites where they occur. The study showed that Remote Sensing data including from Indian sensors has been of significant help in understanding the loss of forest cover, resource depletion and planning for sustainable use of forest.

CONSTRAINTS FACED BY VILLAGERS IN PARTICIPATION OF JFM PROGRAMME OF MALRAJURA VILLAGE OF AKOLA FOREST DIVISION

M.B. Thigale¹, H.K. Deshmukh², Y.B.Taide, U.R. Chinchmalatpure and A.S. Khandagale

¹*Range Forest Officer, Tiger Project, Wildlife Division, Amravati (Maharashtra)*

²*College of Forestry, Dr. Panjabrao Deshmukh Agricultural University, Akola (Maharashtra)*

^{*}*E-mail: rfochikhaldara.tigerproject@gmail.com*

The study was conducted in Malrajura village of Akola District with a view to assess the constraints faced by the respondents for participation in JFM programme. The total Sixty respondents were selected randomly on the basis of land holding i.e. landless, up to 1.00 ha, 1.01 ha to 2.00 ha, 2.01 to 4.00 ha and above 4.00 ha. The independent variables such as age, education, land holding, livestock, family size, sources of information and attitude with the dependent variables such as annual income, employment, and availability of non-timber forest produce was used to find out the impact of JFM programme on livelihood of rural people. The study revealed that majority of respondents faced the problems of less price of NTFP in market. Regarding the finding of constraints analysis it was found that processing units were not available in village, lack of training, lack of knowledge to the respondents. It was observed from the study that the independent variables are positive and highly significant with dependable variables like availability of Non-timber forest produce, Annual income and Employment. However, the training programme should be organized and the information source should be available for villagers to increase their participation and make programme more effective.

VEGETATIVE ANALYSIS OF ECOTOURISM AREA OF KATEPURNA WILDLIFE SANCTUARY IN AKOLA WILDLIFE DIVISION OF MAHARASHTRA

Rupali D. Mankar*, H. K. Deshmukh, Y. B. Taide and N. S. Hande

Department of Forestry

Dr. Panjabrao Deshmukh Agricultural University, Akola – 444 104 (Maharashtra)

**E-mail: rupaliagricoss@gmail.com*

Biological diversity is necessary for human survival and economic wellbeing as it provides food, medicine and industrial raw material and offers potential for providing many yet unknown benefits to future generation. To have a complete idea of the structure and composition of a community, it is essential to understand its various analytical characters viz. frequency, density, abundance, importance value index, etc. thus, the structure and nature of plant community is determined by the species contents and their ecological amplitude. The present study on vegetation analysis was conducted at Katepurna wildlife sanctuary in Akola district of Maharashtra. The area has different kinds of flora and fauna. The vegetation analysis of the selected forest stands was carried out by using the quadrates of 10×10m size. In each quadrate, the name and number of each tree species were recorded. Total 29 IVI values are calculated in the study area. The highest IVI of the species in case of trees includes *Tectona grandis* (66.15), *Butea monosperma* (45.66), *Diospyros melanoxylon* (25.23), *Pongamia pinnata* (14.12) and *Boswellia serrata* (12.49). Whereas the IVI values ranges from 1.35 to 66.15. The lowest IVI value recorded 1.35 for the *Semicarpus anacardium*. The contagious distribution pattern value recorded for all tree species except *Semicarpus anacardium* (0.054), which shows random distribution pattern. The distribution pattern ranges from 0.054 to 4.11.

EFFECT OF DIFFERENT CONTAINER SIZE ON ROOT BIOMASS OF TETU (*OROXYLUM INDICUM*) (L.) VENT

Harshada Surywanshi, S S Narkhede, R P Gunaga, A D Rane and S G Bhawe

College of Forestry, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli – 415 712

Oroxylum indicum is one of the important deciduous medicinal tree species of the Western Ghats. Entire plant parts are used medicinally to cure a number of diseases, roots, leaves, seeds and stem part of *Oroxylum indicum* have been used to cure various diseases / ailments. The roots of this tree are used in Ayurvedic preparation called "Dasamoola" as well as root bark is a valuable ingredient of Ayurvedic preparation Dashmularisht. Due to several medicinal properties, this species is under great demand. Standardization of nursery techniques is an important aspect of domestication which produces quality planting materials for raising commercial plantation. The present study was undertaken at College of Forestry, Dapoli, Maharashtra, to study the effect of container sizes on the growth and root biomass yield of *Oroxylum indicum* seedlings at nursery stage. To study the effect of different container size, four

different container sizes were selected *i.e.* 10 × 15 cm, 15 × 20 cm, 20 × 25 cm and 25 × 35 cm. Seedling growth attributes recorded upto six months after germination, revealed that seedling growth in container size 25 × 35 cm performed better than the other container size for height, collar diameter, number of leaves, fresh biomass and dry biomass of the *Oroxylum indicum*.

PARTICIPATORY EVALUATION OF GROUNDNUT AS A TOOL TO ENHANCE PRODUCTIVITY UNDER *TECTONA GRANDIS* BASED AGROFORESTRY SYSTEM IN SAT REGION OF CENTRAL INDIA

Inder Dev*, Ramesh Singh, Kaushal, K. Garg¹, R.K. Tewari, S.K. Dhyani, R.H. Rizvi, K.B. Sridhar, R.P. Dwivedi, Rajendra Singh and R.K. Singh

National Research Centre for Agroforestry, Jhansi 284 003 (UP)

ICRISAT, Patancheru, Hyderabad- 502 319, (Andhra Pradesh)

Agroforestry has traditionally been a way of life and livelihood in India involving combined production of trees and agricultural species on the same piece of land. India is one of the largest growers of groundnut in the world and it contributes nearly 33% of total oilseed production in the country with productivity level of 1.05 t ha⁻¹ only. Participatory groundnut evaluation trials were conducted under teak based (one year old plantation) agroforestry system during *kharif* 2012 in ParasaiSindh watershed (24° 11' and 25° 57' N, latitude and 78° 10' and 79° 25' E longitude) of Jhansi in central India, where only 20% of net sown area is irrigated by open wells as lifesaving irrigation. This study was undertaken with the objective of improving system productivity on watershed basis. One year old seedlings of teak were planted on bunds at a distance of 3.0 m. Most interestingly farmers borne 50% costs of inputs involved in the demonstrations. Seven improved varieties of groundnut *viz.*, ICGS-5, ICGV-350, ICGV-86015, ICGV-8784, ICGV-91114, ICGV-9346, TAG -24 and two local varieties *viz.*, Shivpuri and Kaushal were evaluated for yield potential. Maximum pod weight of 45g/100 pods⁻¹ was observed in ICGV-86015 followed by ICGV-91114. ICGV- 91114 produced highest pod yield 1.88 t ha⁻¹ followed by ICGV-9346 (1.62 t ha⁻¹); whereas Kaushal produced lowest yield (1.23 t ha⁻¹). However, the biomass potential was highest in Shivpuri (4.3 DM t ha⁻¹) followed by ICGV-8784 (3.84 DM t ha⁻¹) and ICGV- 86015 (3.66 DM t ha⁻¹). Teak attained on an average 53.76 cm (height) and 8.77 (collar diameter). Teak based agroforestry system having groundnut as crop component will have an immense impact on improving the system productivity in the years to come that will improve socio-economic conditions of the resource poor farmers in semi-arid regions.

PRELIMINARY STUDY ON THE EFFECT OF NANO-CLAY ON PHYSICAL AND MECHANICAL PROPERTIES OF PLYWOOD

Ismita Nautiyal

*Composite Wood Discipline, Forest Products Division
Forest Research Institute, Dehradun-248 006 (Uttarakhand)*

Wood based industries are looking for cost effective and new techniques to produce composite wood with less resin and better physical and mechanical properties. Nano- particles are presently considered to be high potential filler materials for improvement of mechanical and physical properties of composites. The present study investigates the effects of Sodium Montmorillonite (Nanoclay) on properties of laboratory made plywood board. This work was started in 2012. Plywood boards have been prepared at different pressures (200 psi, 250 psi, 300 psi) and 5 levels of Nano-clay of Sodium Montmorillonite (1, 2, 3, 4, 5 percentages) as filler. Species used for preparing plywood is *Melia composita*, it is a fast growing species and an important agro-forestry tree. Recently this tree has found a good place among the plantation grown species of Punjab Forest Department as well as in Southern India. Wood of *Melia composita* is used for packing cases, cigar boxes, ceiling planks, pencils, match boxes etc. but very little work has been done on utilization aspects of this species. Preliminary results indicate that plywood boards made from 1%, 2% and 3% at three pressure levels 200 psi, 250 psi and 300 psi show better results than plywood board at 4% and 5% Nano-clay.

GENETIC VARIABILITY AND CORRELATION STUDIES AMONG CLONES OF *DALBERGIA SISSOO* THROUGH MORPHOLOGICAL AND PHYSIOLOGICAL TRAITS

Shilpa Gautam^{1*}, Salil Tewari² and Rajesh Kaushal³

¹*Biodiversity Conservation Division, ICFRE, Dehradun - 248 006*

²*Department of Genetics & Plant Breeding, GBPUA&T, Pantnagar - 263 145*

³*Central Soil & Water Conservation Research & Training Institute, Dehradun - 248 195*

**E-mail: gautams@icfre.org*

The study was conducted in 2005 with the aim to estimate genetic variability among clones of *Dalbergia sissoo* with respect to morphological and physiological characters. The experimental material consisted of 30 diverse genotypes collected from different parts of India. Tree characters studied were: Tree height, Diameter at breast height, Clear bole length, Crown length, Crown width, Bark thickness, Girth at breast height, Diameter at ground level, Number of branches, Stem straightness, Crown height, Leaf bearing duration, Volume over bark and Chlorophyll content and fluorescence. Highly significant genotypic differences, supported by wide range of variation of mean for all characters indicated substantial inherent differences for all the characters under study in different genotypes. Little difference in genotypic and phenotypic coefficient of variations for most of the characters indicated that these characters are less influenced by environment, thus offering a better scope of improving these characters. Tree

height, dbh, bark thickness and gbh showed positive and significant correlation coefficient with tree volume suggesting selection for high tree volume based on these characters. Most of the characters showed high estimates of heritability with high to moderate genetic advance hence for improvement of these traits an early selection based on phenotypic performance may be recommended. Genotypes were grouped in 7 clusters. Presence of only single genotype in clusters V, VI and VII showed distinctness of these genotypes over all other genotypes. Highest distance between cluster IV and VII indicated that genotypes in these clusters were quite divergent. Eight genotypes showed higher volume growth and diversity thus proving their worth over other provenances. The results of the present study could be used in breeding and improvement of *Dalbergia sissoo* for various desired traits.

PEOPLE'S PERCEPTION ON THE EFFECT OF CLIMATE CHANGE - A CASE STUDY OF KINNAUR DISTRICT OF HIMACHAL PRADESH

D.D. Sharma* and Subhash Sharma**

Department of Social Sciences

Dr. Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan-173 230 (HP)

E-mail: dsubhashsharma@gmail.com

Kinnaur, a predominated tribal district of Himachal Pradesh is experiencing a lot of changes due to climate change. However before any appropriate strategy is adopted, it was very important to know whether or not the people are aware about these changes in climate and its effect on agriculture and other related issue including their socio economic life. The present study was undertaken with the objective to determine the perception of tribal people regarding effects of climate change on various aspects. The perception of the respondents on the effects of climate change was measured with the help of the scale developed for the purpose. The study revealed that a majority of farmers (66%) were aware about global warming and hence about the changes in the climate (85%). A significant percentage of them (80%) were agreed that persistent change in the climate has dried the water bodies, adversely affected the quantity and quality of apple, regeneration of chilgoza (*Pinusgerardiana*), wild apricot (chuli in local language), decreased production of food grains, traditional millet crops like olga, phafra, cheena, kodda etc. and 'guchhi'. The climate change has resulted in increased rainfall but decreased snowfall and ground water; and has incidences of attacks of insect-pest and diseases thus reducing crop yield. Inadequate chilling hours, problems in pollination, inclination towards cash crops and preference for early maturing varieties demanding less water etc. were the main reasons for change in cropping pattern due to climate change. Protection and preservation of chigoza, traditional millets, and local varieties of grapes / fruit crops, kirmala (*Artemisrabrevifolia*) and stabilising posture were some of the issues to be addressed. Therefore the study implies that concerted efforts are required to save and protect the forests, to initiate plantation at community level, proper mechanism to provide marketing, storage facility and critical inputs in time besides taking appropriate steps to tap solar energy in the area.

INTERVENTIONS OF AGROFORESTRY MODELS AND THEIR IMPACT IN AMELIORATING SOCIOECONOMIC AND BIOPHYSICAL CONDITIONS IN DIFFERENT AGRO CLIMATIC ZONES OF WESTERN HIMALAYAS. - A CASE STUDY OF HIMACHAL PRADESH.

Rajesh Uppal¹ and M. S Pathania²

¹*Department of Tea Husbandry and Agroforestry*

²*Department of Agricultural Economics*

CSKHPKV Palampur (HP)

Small scale subsistence or near subsistence farming dominate the hill farming system. The general neglect of interdependence in various sectors of the systems of farmer's field retards proper attention of research recommendations and increased gap in the transfer of technology from lab to lands. Ultimately, it leads to low agricultural Income besides degradation of ecology and un sustainable farming. The study conducted in different agro climatic zones of the state from 160 sample farmers revealed 1.70 ha as average size holdings. Farmers own lands contributed about 60% of the total availability of fodder. On an average each house hold is getting 32 q of straw, 27q of hay, 13 q of green grass(dry fodder equivalent) and 7 q leaf fodder from own land. Similar production trend was observed in different zones. The dependence for fuel wood from forests is inversely related to the size of the farm. On an average fire wood constitute 49% followed by agricultural waste. About 50% of the fuel wood requirements are met from government forests, 40% from own land and 10% from other sources. While fodder dependence on own farm lands and forests in overall situation was 48and 46 percent respectively. They face the problem of fuel and fodder to the extent of 40%. Under such situations it is suggested that fast growing trees grown with crops and along the field boundaries, improvement ghasnies and marginal lands can meet the increasing demand for fuel and fodder.

GENETIC VARIATION IN SEED GERMINATION PARAMETERS IN SELECTED GERMPLASM OF *PROSOPIS CINERARIA* (KHEJARI) , A TRADITIONAL AGRO-FORESTRY TREE SPECIES OF RAJASTHAN

Pravin. H. Chawhaan*, Suman Kanshana, Abha Rani and Shrawan Kumar

Arid Forest Research Institute, New Pali Road, Jodhpur-342 005 (Rajasthan)

E-mail: pravinchawhaan@icfre.org, sumankanshana@gmail.com

Khejari (*Prosopis cineraria*) is the state tree of Rajasthan the tree is a component of traditional agroforestry system practiced in western Rajasthan since time immemorial. It is a multipurpose species and linked with the socioeconomics of Indian Thar Desert by providing livelihood support to poor and marginal farmers inhabiting extremely harsh and dry region of north western Rajasthan and often been termed as life line of desert. Besides being pivotal in conserving the ecosystem of arid regions of the desert it also provide additional income to the rural folk. Due to many biotic and abiotic stresses its natural resources are under threat and a remarkable decline in its natural population has been observed resulting in adverse effects on socio economic status

and desert ecosystem. The pods of Khejari are eaten by wild and domestic animals, due to this and present farming practice natural regeneration is very low. Under this scenario it is pertinent to initiate efforts to conserve the genetic resources of this important specie. Keeping these view efforts has been made to select phenotypically superior trees and propagate the selected germplasm. The present paper encompasses the investigation in to genetic variation in seed germination and seedling parameters amongst the fifty two phenotypically superior trees selected across the state of Rajasthan. Highly significant variation was observed in seed germination parameters. Seed germination percent and germination velocity index amongst different trees ranged from 5.88 to 100 and 2.08 to 83.50 respectively. Other traits also exhibited wide genetic variation. Results also revealed that all the seed germination parameters were highly to moderately heritable and exhibited high genetic gain estimates. It is concluded that the present material can be utilized to make available the improved planting material for artificial regeneration and would help the society.

INVASIVE SPECIES RISK ANALYSIS USING ENSEMBLE MODELING TECHNIQUE IN *YUSHANIA MAILING* (L.) POIT. (MAILING BAMBOO)

Vivek Srivastava*, Hitendra Padalia and S. P. S. Kushwaha

Forestry and Ecology Department

Indian Institute of Remote Sensing (ISRO), Dehradun 248 001 (Uttarakhand)

**E-mail: viveksrivastava09@gmail.com*

Biological invasion is considered as the second most important threat to biodiversity after habitat destruction and is documented as a primary cause of global biodiversity loss and species extinction. Species distribution models are useful in risk prioritization of recently arrived; harmful invasive species because species may not yet have spread to all suitable habitats and preventive measures can be taken prior to it. Ensemble species distribution models combine the prediction strengths of several species distribution models, while minimizing the spatial uncertainty and prediction weakness of any one model. We used three well-known species distribution modelling methods for presence-only data to produce ensemble prediction map of an invasive species i.e. *Yushania mailing*, in Darjeeling Himalaya. Maxent, GARP and BIOCLIM were chosen for inclusion based on their good performance with presence-only data and because they differ both conceptually and statistically. The models are based on occurrence records combined with topographic, climatic, and vegetation predictors derived from satellite data. In this study attempt was made to prioritize/delineate risk zones at realized niche levels of the concerned species i.e. at the local level of the species occurrence using a novel multi-criteria risk zonation approach. To delineate invasive species risk zone ensemble habitat suitability output for mailing bamboo and risk determining factors like vegetation type, conservation status, species diversity and disturbance source (land use, road length) were considered. For the selected invasive plant species tested, Maxent model along with ensemble model ranked among all different models for both field validation and test data. Ensemble models may be more robust than individual species-environment matching models for risk analysis

CORRELATION COEFFICIENT STUDIES IN TEAK (*TECTONA GRANDIS* L.) FOR STEM VOLUME PRODUCTION

Dipika P. Ayate^{1*}, N.K. Kapse² and V.V. Ujjainkar³

¹*Department of Tree Improvement & Genetic Resources,*

Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan-173 230 (HP)

²*Department of Forestry, ³Department of Post Graduate Institute*

Dr. P. D. K. V. Akola (Maharashtra)

**E-mail: daayate@gmail.com*

The investigation on "Correlation studies in teak (*Tectonagrandis* L.) for stem volume production" was undertaken on thirty clones of teak from Teak seed orchard, Mohghata District, Bhandara, Maharashtra State. The observations were recorded on six characters viz. plant height, girth, leaf area, number of branches, dry weight of leaf and stem volume. The experiment was conducted during the year 2011-12, using Randomized Block Design with three replications. The genotypic and phenotypic correlation coefficient studied between stem volume and its contributing character indicated that plant height, girth and number of branches exhibited positive and significant correlation. The girth exhibited positive and significant correlation with volume ($r=0.836$), while it exhibited positive but non-significant correlation with leaf area ($r=0.172$), number of branches ($r=0.017$) and it exhibited negative but non-significant correlation with dry weight of leaf ($r=-0.254$) at genotypic level. Leaf area showed positive and significant correlation with number of branches ($r=0.753$) and volume ($r=0.482$) at genotypic level, while it exhibited negative but significant correlation with dry weight of leaf ($r=-0.475$) at genotypic level. Dry weight of leaf exhibited a positive and significant correlation with number of branches ($r=0.329$), volume ($r=-0.054$) at genotypic level. Whereas, number of branches exhibited a positive and significant correlation on volume ($r=0.553$) at genotypic and at phenotypic level on volume ($r=0.369$). This correlation amongst the volume attributes indicates that plant height and number of branches are in positive direction and they are helpful and advantageous for improvement in volume. The correlation coefficient is a statistical measure which is used to find out the degree and direction of association between two or more quantitative characters.

CARBON STORAGE POTENTIAL OF LAND-USE SYSTEMS UNDER MID HILL CONDITION OF HIMACHAL PRADESH

Priyanka Rajput* and D.R. Bhardwaj

Department of Silviculture and Agroforestry

Dr. Y. S. Parmar University of Horticulture and Forestry, Solan- 173230 (HP)

**E-mail: drpriyankarajput@gmail.com*

The present investigation were carried out under mid hill and sub-humid zone-II of Himachal Pradesh, to study the influence of land use system, altitudinal gradient on carbon storage potential with the objectives of identifying the land use system having high carbon storage potential. For conducting this study three sites were selected randomly and each site was

considered as replicates. Mountainous slope of each site was stratified into two altitudinal gradient viz., 900-1200 masl and 1200-1500 masl. In each altitudinal gradient eight land use systems i.e., agriculture, horticulture, agri-silviculture, silvi-pastoral, agri-horticulture, agri-horti-silviculture, forest and grassland. In different land use system, maximum above ground biomass ($99.03 \text{ t ha}^{-1} \text{ yr}^{-1}$), below ground biomass ($25.69 \text{ t ha}^{-1} \text{ yr}^{-1}$), total biomass ($124.48 \text{ t ha}^{-1} \text{ yr}^{-1}$) was recorded in the forest land use system. The biomass production of different land use systems followed the order: forest > silvi-pastoral > agri-horti-silviculture > agri-silviculture > agri-horticulture > horticulture > agriculture > grassland, respectively. This trend is same for carbon density of different land use systems. In the effect of altitudinal range, the above ground biomass, below ground biomass, total biomass and carbon stock were found to increase appreciably from 900-1200 masl to 1200-1500 masl. The study concluded that forest system is better land use system in comparison to other.

PYTHIUM ROT: A SERIOUS THREAT TO PINUS ROXBURGHII NURSERY

Amrish Vaid, Vishal Mahajan, Kanika Pagoch and A. P. Singh

Krishi Vigyan Kendra, Kathua,

Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu (J&K)

Pythium rot is one of the dreadful diseases in Pine (*Pinus roxburghii*) nursery. It has looming dangerous intentions at such a forest species which has great commercial as well as environmental value being the most dominant forest species of the region. Isolation, characterization and pathogenicity tests of *Pythium* were conducted in different nursery experiments. The affected portions of *P. roxburghii* were randomly collected from different locations in the forests range (Panthal and Batote) to isolate the test pathogen and pathogenicity tests were conducted in nursery thereafter, which confirmed the occurrence of the disease causing pathogen. Subsequent lab experiments were conducted for management strategy of the disease which included the dual culture experiments of different strains of *Trichoderma* spp. with the test pathogen. The most effective strains, *T. Viride* (Tv3 and Tv5) and *T. harzianum* (Th6) from the lab experiment were further used in the Pine nursery to manage the disease. Carbendazim @ 0.1 per cent, thiophanate methyl @ 0.1 per cent and metelxyl + macozeb @ 0.25 per cent were also used along with control. It was observed that metelxyl + macozeb @ 0.25 per cent was most effective in managing the disease followed by carbendazim @ 0.1 per cent and thiophanate methyl @ 0.1 per cent. Among biocontrol agents, Tv3 was most effective followed by Tv5 in the management of disease.

NURSERY EVALUATION OF INTRODUCED TREE WILLOW (*SALIX* SPECIES) CLONES

J.P. Sharma*, N.B. Singh, P. Chaudhary and IK Thakur

Department of Tree Improvement and Genetic Resources,

Dr Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan-173 230 (HP)

**E-mail: jaiuhfrajgarh@rediffmail.com*

The promising *Salix* species/clones and hybrids were procured from different countries and introduced at UHF Nauni, Solan, India in the year 2002-04. After nursery screening the selected clones were planted in the field. These selected clones were again raised in nursery every year from 2011 to 2013 repeatedly to find out the most adaptive and superior clones alongwith check clone Kashmiri willow. Plant survival, height and basal diameter were recorded and volume index was calculated. The data revealed significant differences among clones. However non-significant difference for interaction between clone and year was obtained except in plant survival. Plant survival was at par among clones except in clones J194, NZ1002 and V-311. Maximum plant height (389.77 cm) was recorded by clone J799 followed by clones J795 (355.36 cm) and NZ 1002 (344.95 cm). Basal diameter was recorded at par in the clones SI-64-017 (17.66 mm), J799 (17.52 mm), NZ1002 (16.49 mm), 131/25(16.25 mm) and NZ1140 (16.11 mm). The clone J799 recorded maximum (1329 cm³) volume index which is at par with clone SI-64-017 (1171 cm³) followed by clone NZ 1002 (1015 cm³). Check clone Kashmiri willow remained at 5th, 6th, and 7th position for basal diameter, plant height and volume index, respectively. Spearman rank correlation coefficient was recorded highest (0.965) between basal diameter in year 2013 and mean volume index. The selected clones have to be tested in the field conditions to find the genotype x environment interaction.

COMPARATIVE RESTORATION POTENTIAL OF SELECTED NATIVE AND EXOTIC WOODY SPECIES PLANTED ON COAL MINE HABITATS IN A DRY TROPICAL ENVIRONMENT, INDIA: A CASE STUDY

A. N. Singh*

Department of Botany, Panjab University Chandigarh-160 014

**E-mail: dranand1212@gmail.com*

Present study was conducted on a degraded ecosystem in a dry tropical region of India where mining is one of the serious problem. Mining operation not only degrade the forest cover even degrade the soil composition. But, soil restoration is a really challenging ecological problem; moreover, their recovery by natural succession is very slow. Given information is based on long term observation and data collection (1993-1996; 2007-2008; 2010-2013) on selected eighteen plantation sites as a total in different ecological models (mono- and mixed culture) for assessing restoration potential on degraded landscape of coal mine spoil. Fourteen plantation stands were selected as mono-cultured and four (1: *Albizia lebbbeck* + *Acacia catechu*, 2: *Azadirachta indica* + *Phyllanthus emblica*, 3: *Dalbergia sissoo* + *Tectona grandis* and 4: *Dendrocalamus strictus* +

Tectona grandis) as mixed cultured. Of which, eight woody species were indigenous and hardy; and in which, four of them (*Albizia lebbeck*, *Pongamia pinnata*, *Dalbergiasissoo*, *Albizia procera*) were leguminous tree with short stature in size; and four (*Azadirachta indica*, *Tectona grandis*, *Dendrocalamus strictus* and *Shorea robusta*) were non-leguminous. While remaining four woody species (*Acacia auriculiformis*, *Casuarina equisetifolia*, *Eucalyptus hybrid* and *Grevillea pteridifolia*) were exotic in nature. The objective of the present study was to assess restoration potential with respective time. Results indicated that influence of planted species in terms of restoration potential exhibited species specific effects; however values for the various important parameters (e.g. soil microbial biomass C, N and P) were significantly varied across planted species with age particularly in mixed culture plantations. In conclusion, mixed culture plantations, either legume or in non-legume exhibited dramatic effects for soil restoration and strong tendency in biodiversity recruitment under plantations stand evidently confirm ecosystem redevelopment in a short span of time.

AGROFORESTRY POTENTIAL IN MITIGATING CLIMATE CHANGE THROUGH CARBON SEQUESTRATION

Priyanka Tripathi*, S. D. Kashyap and Shipra Shah

Department of Silviculture and Agroforestry

Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan- 173 230 (HP)

**E-mail: ptripathisolann@rediffmail.com*

Field experiment was conducted during 2010-2011 and 2011- 2012 in the experimental farm of Department of Fruit Science, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. The objective of this study was to analyze the total carbon sequestration potential of peach based agroforestry system. In present study, carbon sequestration potential of agroforestry system was recorded 2.84 t ha^{-1} and in sole crop system it was found 0.83 t ha^{-1} . The rate of carbon sequestration was recorded $1.24 \text{ t ha}^{-1}\text{yr}^{-1}$ in agroforestry system and in sole crop it was recorded $0.83 \text{ t ha}^{-1}\text{yr}^{-1}$. Carbon mitigation potential was also high in fruit based agroforestry system than sole crop system. Agroforestry systems play an important role in reducing the concentration of CO_2 from the atmosphere as they sequester higher carbon because of the higher input of organic material to the soil as compared to sole crop agro-ecosystems. In agroforestry systems there is an integration of agriculture crops as well as woody perennials and this integration helps in solving different environment and climate change related problems.

TREE SPECIES DIVERSITY IN SOPPINA BETTA'S OF A VILLAGE ECOSYSTEM IN UTTARA KANNADA DISTRICT IN CENTRAL WESTERN GHATS, KARNATAKA

Jyothi B Patil*, Shilpa. S.Naik and P.Ramana

Department of Forest Products and Utilization

College of Forestry, Sirsi-581 401 (Karnataka)

**E-mail: ramana_cofs@rediffmail.com*

The present survey was conducted in order to document the floristic composition of the Soppinabettalands's in Sirsi region of Uttara Kannada district, Karnataka during 2013-14. The field investigation was conducted in the Soppinabettalands of Uttara Kannada district (13⁰ 9' and 15⁰ 31'N latitude and 74⁰ 9' and 75⁰ 10'E) which is rich in biodiversity under central Western Ghats region of Karnataka. The entire area is dominated by moist deciduous and evergreen forest types. Soppinabetta's are the forest area (previously) given by the British Government to farmers for 1 acre area for Areca plantations and as incentive for meeting the requirement of farmers such as collection of leaf litter, fuel wood etc. Highest numbers of tree species are present in Moist Deciduous forest type followed by Evergreen forest. Predominant tree species found in evergreen patches are *Garcinia indica*, *G. gummigutta*, *Terminalia bellerica* and *Terminalia paniculata*. In Moist Deciduous forest type, predominant tree species are *T. bellerica*, *T. paniculata*, *Artocarpus hirsute* and *A. integrifolia*. Few tree species are found in both the forest types. Different plant parts like bark, fruits, leaves, root, seed, flower and gum are used to cure various human and animal ailments. For local farmers, Soppinabettaland's forests are a vital resourceful land as they supply leaf litter and green leaves. Tree species have a special role in management of bettalands and also areca gardens. Soppinabetta forests help in preserving the regional flora and provide critical information that will aid in the development of more appropriate management practices to conserve the local floristic diversity.

UTILIZATION AND MANAGEMENT OF SOPPINA BETTA'S – A CASE STUDY FROM UTTARA KANNADA, KARNATAKA

Jyothi B Patil, Shilpa S. Naik and P.Ramana

Department of Forest Products & Utilization

College of Forestry, Sirsi-581 401 (Karnataka)

The present survey was conducted in order to document the extent of utilization and management of Soppinabettalands's in Uttara Kannada district, Karnataka during 2013-14. Data regarding land holding, species name, end-use and domestication patterns of several species that are grown in their betta's were collected through household interviews in three locations sampled. Information regarding nativity of species (exotic or native) and their physiognomic characters (evergreen or deciduous) was obtained from the literature. Soppinabetta's are the forest area (previously) given by the British Government to farmers for 1 acre area for Areca plantations and as incentive for meeting the requirement of farmers such as collection of leaf litter, fuel wood etc. The soppinabetta boundary is mainly drawn on the basis of the land owned,

cultivation, non-crop lands, settlements, streams, water bodies, roads, hills etc. Individual soppinabettaland holding varies from location to location (site-1, 2-27 acre; site-2, 5-25 acre and in site-3, 2-18 acre), highest was in moist deciduous (site-1 and 2) and lowest was in evergreen (site-3). Frequency of lopping of trees for getting leaf manure was highest in evergreen system (site-3, annually) followed by site-2 (every alternative year) and site-1 (once in three years). Only small number of farmers are having the prescribed share of soppinabettaland's in proportion to their areca gardens (site-1, 13.33% ; site-2, 6.66% and site-3, 18.18%). and majority are having far below the prescribed ratio. Few farmers have violated the practice of rotational use of forest products. In order to collect more compost raw material and fuel wood, primary branches of trees were being felled frequently, resulting in the trees growing short and stunted, and distributing them sparsely (degraded *Soppinabetta* forests). DSB forests have a corresponding thinning in canopy structure of trees.

**ISOLATION AND CHEMICAL CHARACTERIZATION OF
BIOACTIVE FLAVONOID FROM *CHROMOLAENA ODORATA*
WITH LARVICIDAL ACTIVITY AGAINST TEAK DEFOLIATOR,
HYBLAEA PUERA – A MAJOR PEST OF TEAK**

P.Ramana

*Department of Forest Products & Utilization
College of Forestry, Sirsi-581 401 (Karnataka)*

**E-mail: ramana_cofs@rediffmail.com*

The study was conducted to isolate a bioactive compound from *Chromolanaodorata* with larvicidal activity against teak defoliator, *Hyblaea puera* – a major pest of teak. The powdered plant material was subjected to Soxhlet extraction successively with petroleum ether, n-butanol, methanol and distilled water. The extracts were concentrated to dryness. The larvicidal activities were studied against third instar larvae of *Hyblaeapuera* following leaf-dipping bioassay. Most active butanol extract was subjected to the detailed chemical and biological investigations. Fractionation of butanol extract resulted in isolation of a flavonoid compound which was crystallized in ethanol. The larvicidal activity of flavonoid was studied against third instar larvae of *Hyblaeapuera* following leaf-dipping bioassay. Phytochemical tests of extracts showed the presence of flavonoids, glycosides, saponins, steroids and tannins. Isolated compound exhibited a positive ferric chloride test indicating the presence of phenolic hydroxyl group. It has also produced a pink colour with magnesium turnings and concentrated hydrochloric acid (Shinoda test) indicating the presence of flavonoid moiety. The UV, IR, NMR and Mass spectral data of isolated flavonoid compound was identified as 7-hydroxy-4'-methoxyflavone. The compound showed moderate larvicidal activity by causing 43.31, 37.63 and 23.53 per cent mortality of *H. puera* at concentration levels of 40, 20 and 10 mg per ml, respectively. In this experiment 75 per cent larval population was observed to move away from the treated teak leaves and die from starvation. The compound also caused reduction in the size of pupae obtained from larvae fed with treated leaves and there was no adult emergence from the pupae. Those larvae that fed did pupate but there was no adult emergence.

PHYTOSOCIOLOGICAL CONDITIONS UNDER BLACK WATTLE (*ACACIA MOLLISSIMA* DE WILD.) IN MID HILL CONDITIONS OF HIMACHAL PRADESH

Deep Shikha¹, N.K. Gupta¹, P.K. Mahajan² and Suresh Kumar^{1*}

¹*Department of Silviculture and Agroforestry*

²*Department of Basic Sciences*

Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan – 173 230 (HP)

**E-mail: sureshuhf@gmail.com*

The present study was carried out in the mid hill zone of Himachal Pradesh at two plantation sites (namely site-I and -II) of *Acacia mollissima* (De Wild.) in the main campus of Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan. In the composition of shrubs (*Osyruarborosa*, *Cryptolapesbachanani*, *Lantana camara* and *Lonicera japonica*) and woody regeneration (*Leucaena leucocephala* and *Grewia optiva*) at site-I, *Leucaena leucocephala* (135.84 IVI) showed the dominance followed by *Osyruarborosa* (89.91 IVI) and *Grewia optiva* (28.58 IVI), whereas at site-II, *Lantana camara* (130.66 IVI) was dominant, followed by *Berbaris aristata* and *Grewia optiva*. *Lonicera japonica* and *Pistacia integrissima* were least in dominance in site-I and II, respectively. The presence of *Grewia optiva* and *Cryptolapesbachanani* was observed at both sites, while among grasses, *Chrysopogon montanus* showed highest dominance, having value 49.90 (IVI) at site-I, followed by *Arundinella nepalensis* (27.34 IVI) and *Apluda mutica* (23.08 IVI), in descending order. Whereas, at site-II, *Chloris gayana* with 112.67 IVI was dominant followed by *Arundinella nepalensis* (84.49 IVI). *Echinochloa colonum* at site-I and *Chrysopogon montanus* at site-II was least dominant. Among herbaceous species at site-I, *Ageratum conyzoides* was dominant with 101.75 IVI followed by *Bidens pilosa* (22.15 IVI) and *Euphorbia hirta* (10.57 IVI), while at site-II, *Solanum nigrum* showed maximum dominance with 15.51 IVI followed by *Parthenium hysterophorus* and *Bidens pilosa* (with 9.90 and 9.50 IVI, respectively). Among grasses, *Chrysopogon montanus* and *Arundinella nepalensis* were observed at both sites. While, among herbs, *Parthenium hysterophorus* and *Bidens pilosa* were observed at both sites.

LINKING LIVELIHOODS AND BIODIVERSITY CONSERVATION: A CASE STUDY OF GREAT HIMALAYAN NATIONAL PARK (GHNP), KULLU, HIMACHAL PRADESH, INDIA

R.S. Prasher*, Y.S. Negi and Subhash Sharma

Department of Social Sciences

Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan-173230 (HP)

**Email: r.prasher@rediffmail.com*

Given the increasing importance of conservation of natural resources, the Government of India is making efforts to conserve the biodiversity through policies and plans like creation of Protected Areas (PAs). However, this often results in loss of welfare of the local communities who depend

on resources of the PAs for their livelihood and cultural survival. This study, based in areas peripheral to the Great Himalayan National Park (GHNP) in Himachal Pradesh, assessed the impact that biodiversity conservation in GHNP has on the local communities by using direct participatory observation approach. Traditionally, the GHNP ecosystem has been of crucial importance to communities living in the vicinity of the park. These communities draw many valuable goods from the park to sustain their subsistence oriented livelihoods. The household level analysis shows that the contribution of cultivation of crops and income earned from labour is relatively low, and without alternative options of meeting household needs, the restricted access to protected area is expected to adversely impact living standards of the local population. Thus the possibilities of serious conflicts between Park authorities and the resident population can be there which could jeopardize the long-term conservation goals. The study reveals that the local population would have to forego an estimated amount of Rs. 8.20 crores as net benefits under the new conservation programme in the GHNP. In addition to these costs, there are other indirect costs including health, cultural and social costs. Relative to total household incomes the total opportunity costs of local communities from the establishment of the GHNP are substantial. A notable impact of the biodiversity conservation policy has been on farming community. Farmers of the area are developing a somewhat negative attitude towards restrictive conservation efforts because a significant portion of their total household income comes from the forests. Also, wild animals are causing crop and livestock losses to the local farmers on a routine basis. To be more effective, the government should introduce a workable crop insurance scheme so that the farmers could be safeguarded from the risk of crop damage by wildlife. Eco-development schemes and associated ecotourism have not only begun to improve the status of the people but are enabling them to support and participate in conservation. So there is a need to resolve people-policy conflicts through increased community participation and alternative options of generating/augmenting family incomes have to be supported with a range of measures.

FUNCTIONAL PLANT DIVERSITY AND CARBON STORAGE IN FOREST ECOSYSTEMS OF SIWALIKS IN NORTHERN INDIA

S.R. Gupta* and Ravi Kumar

Department of Botany, Kurukshetra University, Kurukshetra -136 119 (Haryana)

**E-mail: sgupta2002@yahoo.com*

The forest ecosystems are an important sink for carbon, sequester carbon from the atmosphere and influence the patterns of climate. Maintaining the stores and sinks of carbon in forest ecosystems can play key role in climate change mitigation. This study deals with plant diversity patterns of trees, shrubs, herbs and climbers, and carbon storage in the soil-plant system as affected by disturbance and land-use changes in Kalesar Reserved forest, located in north-eastern part of Haryana Siwaliks. The northern tropical dry deciduous plain *Shorea robusta* forests (disturbed and undisturbed, *Haplophragma* plantation forest); Siwaliks *Shorea robusta* forests at LalDhang (disturbed and undisturbed forest), and mixed dry deciduous forests at Raiyanwala (disturbed and undisturbed, mixed plantation forest) were selected for analyzing functional plant

diversity, and carbon stock in the plant-soil system during 2012 to 2013. The diversity of various functional groups of plants varied across forest types as influenced by forest disturbance/conversion to forestry plantations. The *Shorea robusta* forests, occurring as continuous belt in Kalesar reserved forest, supported moderate plant diversity of various functional groups. The Shannon's diversity index for trees was greatest for the mixed forests (2.77 to 2.91). The concentration of dominance was greatest in plantation forests (0.29 to 0.34). The Pielou's Index of equitability was greatest for the Siwaliks *Shorea robusta* forest (1.45). The aboveground biomass of tree layer in the forests ranged from 20.54 to 241.72 Mg ha⁻¹, total tree biomass being 26.491 to 290.85 Mg ha⁻¹. Using the carbon fraction (0.5), the total carbon stock in tree layer (Mg C ha⁻¹) was: 145.425 to 71.757, undisturbed forests; 89.735 to 52.159, disturbed forests; 50.719 to 13.26, plantation forests. The biomass carbon stock in major forest types was in the order plain *Shorea robusta* forests > Shiwalik *Shorea robusta* forest > mixed forest. The basal area of trees across forest types was significantly related to biomass carbon stock ($R^2 = 0.79$). The soil carbon storage was affected by forest type and the spatial distribution of soil carbon in the soil profile. The predominance of illite and smectite in the clay, as analyzed using the X-ray diffraction, was related to soil carbon stability. Thus, the protection of natural forests provides ecosystem services of carbon sequestration and storage on a regional basis. Implementing practices to conserve biodiversity, and improving carbon stocks in natural and plantation forests could lead to considerable mitigation, adaptation and development benefits.

STUDIES ON RECOVERY PATTERN OF GROUND FLORA AND AMF ON DEGRADED LIGNITE MINE OVERBURDENS OF CHHATTISGARH, INDIA

K. K. Chandra*

*Department of Forestry, Wildlife and Environmental Sciences
Guru Ghasidas Central University, Bilaspur - 495 009 (Chhattisgarh)*

**E-mail: kkckvk@gmail.com*

Mining is vital natural resources to the development and economic growth of developing country like India. Unfortunately, mining operations necessarily involves deforestation, loss of productivity, biological diversity and environmental hazards. Rehabilitation and reclamation of such disturbed ecosystems is really a difficult task because its complete recovery takes very long time. AMF is a major soil microorganism forms a symbiotic association with plants species and play significant role and facilitate in the recovery of vegetation in degraded sites. In the present study, interactions between AMF and ground floral were evaluated in nearby coal mine fields of Korba, Chhattisgarh, India. Total nine overburdens, three each of 2, 3 and five year of age were selected, quadrates were laid out and soil and root samples were collected during August, December and April months. Eight tree species were planted in different overburdens under study in which *D. sissoo*, *P. ferrugineum* and *D. strictus* were found to be best on the basis of root colonization, sporulations and floral status. Spore population was also increased from 57 spores/100g soil in 2 year to 187 spores/100g soil in 5 year in overburdens soil. The diversity of

AMF was found 1.80, 2.14 and 2.49 in 2, 3 and 5 year overburdens respectively. Total 11 species, 25 species and 29 species of ground vegetation were recorded from 2, 3, 5 year overburden and 25 species from the site of natural forest. The member species from the family Asteraceae, Fabaceae and Poaceae were dominated on overburdens. The diversity of other soil fungal isolates was recorded 1.61 in 2 years, 1.73 in 3 years and 2.10 in 5 year overburden as compared to natural forest (2.21). The status of soil pH and P was also ameliorated in older dumps with the improvement in the status of organic carbon and microbial populations.

EFFECT OF STORAGE TEMPERATURE AND CHEMICAL SOLUTIONS ON SEED GERMINATION OF *WENDLANDIA EXSERTA* ROXB. DC- BIOFUEL TREE SPECIES OF HIMALAYAN REGION

Rajeev Dhiman and N K Gupta

Department of Silviculture and Agroforestry

Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan- 173 230 (HP)

Wendlandia exserta Roxb. DC. Commonly known as chila/ ratela/ tikli, is well distributed throughout the sub-Himalayan tract upto 1400m elevation, especially on the areas that are vulnerable to landslides. It is a good fuelwood species and also provides small timber. Larger areas can be covered with this species, particularly which are sloppy and prone to soil erosion. Intensive research is required on its propagation. The present investigation was conducted at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan during the month of June 2010. The seeds were stored at different temperatures viz., room temperature, $10 \pm 1^\circ\text{C}$ and $0 \pm 1^\circ\text{C}$. Thereafter, the seeds were treated with different growth regulators- IAA, IBA, NAA, GA₃, KIN, and Ethrel and salt solutions (MgSO₄ and KNO₃) at different soaking periods, viz., No soaking, 6 hour and 12 hour. Germination studies were carried out to record the Initiation of germination, germination percentage and germination energy. The experiment was laid out in Completely Randomised Design (factorial). The results revealed that treatment with GA₃ without soaking under $10 \pm 1^\circ\text{C}$ gave higher germination percentage (38.48%). The seeds took minimum 11.82 days for germination at $0 \pm 1^\circ\text{C}$ and 10.89 days (for no-soaking). The interaction effect of storage temperature with soaking period for germination per cent with maximum value of 28.47% (12hrs soaking at $0 \pm 1^\circ\text{C}$). For initiation of germination, the interaction of storage temperature with various treatments, storage temperature with soaking period and chemical treatment, storage temperature with soaking time was significant with minimum values in control at $0 \pm 1^\circ\text{C}$, 6.73 days under control at $0 \pm 1^\circ\text{C}$ (with no soaking) and 9.33 days in MgSO₄ for 6 hrs soaking at room temperature and IAA at $0 \pm 1^\circ\text{C}$ with no soaking. The interaction of storage temperature with soaking period and treatment, storage temperature with soaking periods was significant for germination energy with maximum value 47.27 per cent (no soaking at room temperature) and 77.05% in Kinetin at $0 \pm 1^\circ\text{C}$ with 6hrs soaking.

UTILIZATION OF TREES DERIVED ODOROUS COMPOUNDS AS SCHIFF BASES FOR PERFUMERY COMPOSITIONS

Prasoon Kumar Kaushik* and V. K. Varshney

Chemistry Division, Forest Research Institute, Dehradun-248 006 (Uttarakhand)

**E-mail: kaushik_prasoon@yahoo.com, varshney2000@yahoo.com*

One of the goods provided by the trees to the society is the scent manifested in form of the highly volatile aroma chemicals produced in their different parts. Now days a big challenge facing industries is the relationship of modern societies to the environment that requires reinventing the manufacture and use of materials. In the fragrance and flavor industry there is a lasting interest in the development of novel fragrances and flavors in order to create new odorant molecules in augmenting the aroma of compositions for perfumery, flavor or for new extended applications. Schiff bases (azomethines / anils / imines) (characterized by the $>C=N$ linkage) belong to a group of compounds widely used in flavoring and perfumery. Schiff bases are formed by the condensation of primary amine with a carbonyl compound (aldehydes or ketone). Schiff bases acquire significant importance for their use in fragrance compositions, biological applications as antimicrobial, anticancer, insecticidal agents, and as medical substrates, and intermediate in various reactions. Tree species such as *Eucalyptus citriodora*, *Cinnamomum camphora*, and *Citrus reticulata* contain citronellal, cinnamaldehyde (aldehydes), and methylantranilate (a primary amine), as major odorous constituents, respectively. In order to add value, these constituents were transformed to the Schiff bases using a conventional approach. Present paper describes the synthesis of these compounds employing the condensation reaction between methylantranilate with citronellal and cinnamaldehyde, and their characterization followed by odour evaluation. These compounds indicated their suitability for use in perfumery compositions.

INCLUSION OF PERENNIAL MEDICINAL CROPS IN POPLAR BASED AGROFORESTRY SYSTEM TO INCREASE THE FARM INCOME

K. Bimlendra* and V.K. Madan

Department of Forestry, Haryana Agricultural University Hisar-125 004 (Haryana)

**E-mail: bimlendra@hau.ernet.in*

Six medicinal plant species namely, ashwagandha (*Withania somenifera*), mulathi (*Glycyrrhiza glabra*), gwarpatha (*Aloe vera*), shatawari (*Asparagus racemosus*), kwanch (*Mucuna puririta*) and giloe (*Tinospora cordifolia*), were grown with poplar (*Populus deltoides*) based agroforestry/silvo-medicinal system. Poplar was planted at three different spacing's i.e. 5x4 m, 10x2 m and 18x2x2 m (paired row) in 200. Mulathi and aloe were planted between the rows of poplar as intercrops and giloe, shatawari being climbers were planted in one m radius of poplar and allowed to climb on the trees in all the three tree spacings. The presence of tree canopies did not influence growth and yield of economically important medicinal plant species although some adverse effect of trees was evident in kwanch and ashwagandha plants. Growth parameters like

plant height, branch number, leaf area and leaf area index; yield attributes namely fresh and dry yield and production efficiency per unit area in rest of the four crops were better in the closer spacing of poplar in comparison to the wider spacing and sole cropping. The standing tree biomass (wood of commerce) ensured additional income from the system (silvo-agri-medicinal system). The presence of trees resulted in reduced light transmission to the plants nearer to the tree lines. Out of the three tree spacings i.e. 5x4, 10x2 and 18x2x2 m; Poplar planted at 5x4 m and 10x2 m proved to be the best for no adverse effect, rather shade in closer spacing proved to be beneficial on the production efficiency and the chemical contents of four of the medicinal plant species. Diversification resulted in three fold increase of gross total income from silvo-agri-medicinal system than mono-cropping of medicinal plants or from the sole traditional agricultural crops.

EFFECT OF COPPING HEIGHTS ON BIOMASS PRODUCTIVITY OF FOUR MULTIPURPOSE SHRUB SPECIES OF WESTERN HIMALAYA

Mukesh Prabhakar* and Subhash Sharma**

**Department of Silviculture and Agroforestry*

***Department of Social Sciences*

Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan-173 230 (HP)

Himalayan forest ecosystem is subjected to severe pressure from the rising population in the wake of deforestation and widening gap between demand and supply of forest based products. Increasing demand for fodder and fuelwood can only be met when shrubs are also incorporated with the multipurpose trees. Shrub requires intensive management studies in regard to provide fodder, fuelwood and other forest based products. It is found that the forest trees that have good coppicing power can be properly utilised for fodder and fuelwood. Shrubs, as compared to forest trees have short rotation and have better coppicing power. In this regard, studies were conducted at Dr. YS Parmar University of Horticulture and Forestry, Nauni-Solan, HP in the year 2010 which lies at an altitude of 1220 m above m.s.l. at 30⁰51' N latitude and 77⁰11' E longitude. Four multipurpose shrub species viz., *Indigofera pulchella*, *Elaeagnus latifolia*, *Debregeasia hypoleuca* and *Vitex negundo*, were selected for the present study. The selected shrubs from their natural habitat were coppiced during last week of June, 2010 and harvested in the month of November, 2010 at different heights viz. 5 cm, 15 cm, 25 cm and 35 cm from ground level. The leaf biomass for *I. pulchella*, *E. latifolia*, *D. hypoleuca* and *V. negundo* was 0.73 kg plant⁻¹, 0.82 kg plant⁻¹, 1.35 kg plant⁻¹ and 4.61 kg plant⁻¹ respectively. The leaf biomass tended to increase with increase in the coppicing height. The significant increase, however, could be seen only from 5 cm to 15 cm. The branch biomass respectively for *I. pulchella*, *E. latifolia*, *D. hypoleuca* and *V. negundo* was 1.17 kg plant⁻¹, 1.30 kg plant⁻¹, 2.50 kg plant⁻¹ and 9.93 kg plant⁻¹. The branch biomass also tended to increase with increase in coppicing height. The improvement from 15 cm to 25 cm coppicing height, however, was seen to be non-significant.

RAPID PROTOCOL FOR MICRO PROPAGATION OF *DENDROCALAMUS HAMILTONII* (MAGGAR BAMBOO)

Shatakshi Kapruwan*, Meena Bakshi and Priyanka Jain

Plant Physiology Laboratory, Forest Research Institute, Dehradun-248 006 (Uttarakhand)

**E-mail: kapruwan1987shatakshi@gmail.com*

Dendrocalamus hamiltonii is a multipurpose bamboo with many well-known uses, has tremendous scope for use in eco-friendly agro-forestry projects in the hills, to bring marginal lands into use. Their peculiar monocarpic nature and the mass scale dying out after flowering has become a problem to the managers for programming a sustainable management. The traditional methods of propagation limit the number of propagules that can be produced, and is both labour intensive and time-consuming. Therefore, it is imperative to adopt alternative methods for rapid multiplication and tissue culture is one such technique which can fulfill the demand of planting material. Although multiple shoot formation is accomplished with comparative ease, rooting of such shoots is still inconsistent in *D. hamiltonii*, and only up to 25–30% shows rooting. Taking into consideration the difficulties of conventional propagation of bamboo, *in vitro* micro propagation constitutes a feasible alternative. Thus a rapid micro propagation protocol for simultaneous shooting and rooting of *D. hamiltonii* through axillary proliferation was developed in 2013. Bud sprouting and sterilization methods were standardized. It was found that mercuric chloride (0.15%) for 10 minutes was most effective in raising aseptic cultures. Explants were inoculated on Murashige and Skoog medium. Simultaneous shooting (5.03 ± 0.45) and rooting (6 ± 0.13) in explants were observed when 1 mg l^{-1} BAP in combination with Kinetin (0.5 mg/l) and NAA (0.5 mg/l) were incorporated into the culture medium with 70% response. Conclusively, micro propagation protocol developed here will ensure regeneration of large number of plants in a relatively short time, thus ensuring a sustainable environment for the society.

CARBON STORAGE POTENTIAL OF DIFFERENT PLANTATION TREE SPECIES

Mamata Ranot* and D.P. Sharma

Department of Silviculture and Agroforestry,

Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan-173 230 (HP)

**E-mail: mamta.ranot@gmail.com*

The present investigations were carried out to study the carbon sequestration potential of plantation species planted between 1985 to 1990 in the University campus. The carbon storage potential of plantation tree species was determined on the basis of the MAI. The MAI of each plantation block was determined by dividing standing volume with age at that time. Mean Annual Increment followed the order *Acrocarpus fraxinifolius* (0.028 m^3) > *Eucalyptus tereticornis* (0.026 m^3) > *Populus deltoides* (0.021 m^3) > *Pinus roxburghii* (0.020 m^3) > *Salix alba* (0.019 m^3) > *Albizzia lebbek* (0.008 m^3) > *Ulmus laevigata* (0.008 m^3) > *Melia composita* (0.008 m^3) > *Grewia optiva* (0.007 m^3) > *Acacia mollissima* (0.007 m^3) > *Quercus leucotrichophora* (0.006 m^3) > *Acacia catechu* (0.003 m^3) > *Punica granatum* (0.0003 m^3).

FOREST FIRE PROTECTION THROUGH LIVE HEDGE INTERVENTION

Neenu P*, H.K.Deshmukh, Y.B.Taide and V.B.Shambharkar

College of Forestry, Dr. Panjabrao Deshmukh Agricultural University, Akola – 444 104

**E-mail: neenu162@gmail.com*

Forest fire poses great threat not only to the forest wealth but also to the regime to fauna and flora seriously disturbing the bio-diversity and the ecology and environment of a region. So it is very essential to find out a convenient and practical solution to prevent the spread of this threat. Live hedges using agave plants are found to be effective to prevent the spread of forest fire, especially the creeping and ground fire. The implementation of agave species along the plains, fire prone areas, and in continuous contours with a plant to plant distance of 2m x 2m and a width of 18m at an interval of 162m, helps to maintain forest ecology and its diversity and to save wild fauna and flora eco-friendly and economically. The use of various agave species as fire belt or boundary helps in preventing the spread of forest fire efficiently. The agave belts are highly efficient and economical for forest fire protection than any of the existing forest fire protection method. As the plant species are highly adaptable to the changing environment it can be successfully implemented in any forest fire prone areas. In India, there is an urgent need to initiate research in the fields of fire detection, suppression, and fire ecology for better management of forest fires. Agave plants are promising species that can be made use in controlling the spread of forest fires especially the ground fires.

EFFECT OF DIFFERENT SALINITY LEVELS ON THE PERFORMANCE OF KARANJ [*PONGAMIA PINNATA* (L.) PIERRE] SEEDLINGS

R.S. Beniwal*, R.S. Dhillon and K.S. Bangarwa

Department of Forestry, CCS Haryana Agricultural University, Hisar-125 004 (Haryana)

**E-mail: rs_beniwal@rediffmail.com*

Karanj (*Pongamia pinnata*) is promoted as being able to produce oilseeds on low productivity, degraded or salt-affected land thereby lessening competition for higher productivity land used for agricultural production. However, plant biomass production is largely affected by salinity. Growth suppression is initiated at some threshold value of salinity which varies with species tolerance. In order to determine the threshold limit of salinity exposure before significant loss of planting stock occurs, karanj seeds were sown in pots at different salinity levels (0, 3, 6, 9, 12, 15, 18, 21, 24, 27 dSm⁻¹) in the Department of Forestry, CCS HAU, Hisar. Salinity levels of the soil samples were simulated artificially in the pot's soil by adding salts of magnesium sulfate and chlorides of sodium, calcium and magnesium. Data on seed germination and biomass accumulation revealed that the germination in saline environment was adversely affected and the karanj seeds failed to germinate beyond salinity level of 15 dSm⁻¹ and even at this salinity level, growth of seedlings was impaired and only 25 per cent of the seeds could germinate. Germination per cent and biomass of the plants decreased with increase in salinity levels from 3 to 15 dSm⁻¹. Although decrease in germination and biomass was perceptible even at lower levels of salinity i.e. at 9 dSm⁻¹.

FIELD PERFORMANCE OF *PONGAMIA PINNATA* PROGENIES UNDER SEMI-ARID CONDITIONS

R.P.S. Deswal*, N. Kaushik, Krishan Kumar and Suman Mann

CCS Haryana Agricultural University Regional Research Station, Bawal, Rewari-123 501 (Haryana)

**E-mail: rpsdeswal@gmail.com*

Pongamia pinnata (L.) Pierre (Karanja) is a medium sized tree species with short bole and spreading crown. It is indigenous to Indian sub-continent and south-east Asia. This tree species recently has drawn considerable attention of the scientific community for the use of its seed oil in biodiesel. Therefore, an investigation was carried out to study the pattern of variation in seed oil content and growth behaviour among thirty five progenies of *P. pinnata* and identify the superior progenies for further tree improvement program and afforestation of the tree species on large scale. To start with an intensive survey was conducted in different parts of Haryana to mark the candidate plus trees (CPTs) of *P. pinnata* keeping in view the characters of interest namely seed size, seed yield, seed oil content, height, age, pest/ disease resistance, etc. of the tree. Fifteen CPTs were marked and the sufficient ripened seeds were collected from each test tree for raising the progenies in nursery and further transplanted in the field at 6x5 m spacing in March, 2006 at research farm of Regional Research Station, Bawal having semi-arid conditions. Apart from these, seeds of twenty plus trees were received from the net work partners of four states and progenies of these trees were also raised. The plantation was raised in the field with randomized block design and three replications. The growth and yield data of each progeny plant was recorded and significant variation was observed among the progenies after five years of plantation. Maximum height (6.40 m), crown spread (5.9 m²), collar diameter (59.0 cm) was attained by the progeny (P-7) CSK-11 followed by progeny (P-14) NRCP-16. Progeny (P-26) IC 527952 was found best with respect to seed oil content (34.9%) and progeny (P-22) IC 527937 with respect to seed yield (600.0 g/plant) whereas progeny (P-2) IGAUFP-3 from Raipur recorded minimum seed yield (65.0 g/plant). Phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic gain were also computed and differences were recorded.

IMPACT OF ANTHROPOGENIC DISTURBANCES ON PHYTOSOCIOLOGY, STAND CHARACTERISTICS AND REGENERATION STATUS OF CHILGOZA PINE (*PINUS GERARDIANA* WALL.)

Raj Kumar^{1*}, G S Shamet², R S Kurothe¹ and Gopal Kumar¹,

¹*CSWCRTI, Research Center, Vasad-391830, Anand, Gujrat*

²*Deptt. of Silviculture & Agroforestry, Dr. Y. S. Parmar, UHF, Nauri, Solan-173 230 (HP)*

**E-mail: rajcswcrti@gmail.com*

Chilgoza pine (*Pinus gerardiana* Wall.) is an important ecological and economic species of dry temperate region of North-Western Himalaya. There are large numbers of anthropogenic and abiotic factors affecting regeneration processes of *P. gerardiana* and absence of regeneration could threaten the survival of species. A survey was conducted during 2009-10, to assess the impact of anthropogenic disturbances (e.g. nut collection) on phytosociology, stand characteristics and natural regeneration of chilgoza pine (*P. gerardiana* Wall.). The survey was

conducted in dry temperate zone of Kinnaur region, Himachal Pradesh, India, which is characterized by long winters from October to April and short summers from June to August. The phytosociological studies revealed that *P. gerardiana* was dominant tree species in the region. Growing stock and importance value index (dominance) of *P. gerardiana* was recorded 141.5 m³ ha⁻¹ and 180.00 respectively. Trees of *P. gerardiana* were found in the different region ranging from 10-20 cm to 90-100 cm diameter classes, with the absence of few classes in some region. The maximum growing stock (m³ha⁻¹) was observed in 50-60 cm (30.27) diameter class, followed by 60-70 cm (26.86), 40-50 cm (26.29), 70-80 cm (19.14), 80-90 (13.14), 90-100 (12.40), 30-40 (6.58), 20-30 (6.41) and minimum in 10-20 (0.43) diameter class. Regeneration survey was conducted to know the status of natural regeneration in different sites to plan afforestation programme of the species. Recruit, Unestablished, and established plants were recorded 437.00, 351.00, and 242.00 per hectare, respectively. The regeneration success of *P. gerardiana* was recorded 13.20 % respectively.

NURSERY PERFORMANCE OF PLUS TREES OF *AILANTHUS EXCELSA* ROXB. FOR GERMINATION AND SEEDLING GROWTH

N. Kaushik*, Abha Tikko, Vikram and J. C. Kaushik

CCS HAU Regional Research Station, Bawal, Rewari-123 501(Haryana)

**E-mail: nk20025@rediffmail.com*

Poplar (*Populus deltoides*) and eucalyptus (*Eucalyptus tereticornis*) based agroforestry systems are well established in India under irrigated conditions but in arid and semi-arid regions farmers are hesitating to adopt agroforestry due to lack of fast growing species. *Ailanthus excelsa* Roxb, known as Maharukh is a tree of considerable economic importance as its cultivation is being promoted for soft wood purposes in arid and semi-arid regions. *A. excelsa* is also recognized as a valuable tree in semi-arid regions because of its wider adaptability, fast growth and higher tolerance to biotic and abiotic stresses. It is very imperative and also demands of time to identify the fast-growing multipurpose trees. *A. excelsa* being cross pollinated crop offers tremendous scope for selection of high-yielding genotypes to increase the productivity. Therefore, the present study was conducted to identify the best performing genotypes of *A. excelsa* from the states of Haryana and Rajasthan. Thirty plus trees were identified on the basis of growth, straightness; more clear bole height etc. and sufficient quantity of mature pods were collected from these plus trees individually. The seeds were separated from pods manually. The seeds were sown in the polybags filled with equal proportion of sand, soil and compost during June, 2013. One hundred fifty seeds of each progeny of plus trees were sown in three replications and data was recorded on germination (%), height, collar diameter, no. of leaves, no. of branches and speed of germination was also calculated. The results showed wide variability for all the characters studied. The height varied from 33.93 to 44.70 cm. The seeds germinated within two weeks and germination percentage ranged from 38.33 to 100%. Number of branches ranged from 3.9 to 6.5. Twenty best performing progenies have been transplanted in the field to study the growth performance and to select the best progeny.

ECOLOGICAL IMPACT OF TERMITERIA ON THE DYNAMICS OF INVASIVE PLANT SPECIES IN A SUBTROPICAL WESTERN HIMALAYAN FOREST OF DOON VALLEY

Joyeeta^{1*}, V. Jeeva², Nirmal Ram¹ and Sudhir Singh³

¹Forest Ecology & Environment Division, ³Forest Entomology Division,
Forest Research Institute, Dehradun- 248 006 (Uttarakhand)

²Environment Management Division, ICFRE, Dehradun- 248 006 (Uttarakhand)

*E-mail: joyeeta.u@gmail.com, vjeeva@icfre.org

Invasive plant species greatly impact forest regeneration and is a major concern for forest health. Asia Pacific Forest Invasive Species Network has identified forest invasive species (FIS) of national and regional importance in India. Present study focuses on invasive plants in a Sal-teak mixed forest of subtropical western Himalaya in Doon Valley. Occurrence of termiteria is a characteristic feature of several forests in this region. In the present study, influence of termitaria on spatio-temporal dynamics of the FIS was assessed. The study area of 10 ha was divided into two sampling zones – ‘termiteria-influence’ and ‘off-termiteria’ zone. Floristic survey for herb (1m x 1m quadrats, n= 80) and shrub (3 m x 3 m quadrats, n= 40) layers was conducted for two consecutive seasons - monsoon and winter (August 2013- January 2014). Microclimatic data on temperature, moisture, soil nutrients and canopy cover were collected. A total of seven forest invasive plant species were observed of which four species (*Eupatorium adenophorum*, *Achyranthes aspera*, *Ichnocarpus frutescens*, *Ageratum conyzoides*) were nationally and three species (*Clerodendrum viscosum*, *Solanum torvum*, *Bidens pilosa*) were regionally distributed. Phyto-sociological analysis revealed higher density and basal cover of FIS at off-termiteria zone in herb layer whereas the shrub layer showed a reverse trend implicating that shrub can colonize termiteria-influence zone more efficiently than herbs. Based on Importance Value Index (IVI), *C. viscosum* (seedling) was the most dominant FIS in the herb layer in the termiteria-influence (IVI= 23) as well as off-termiteria zone (IVI= 48). In the shrub layer, IVI of *C. viscosum* was the highest (termiteria-influence zone IVI=64; off-termiteria IVI=49). All species showed contagious distribution pattern except *C. viscosum*, which was randomly distributed in some cases. Species composition in termiteria-influence and off-termiteria zone was more homogenous in winter (83% similarity) than in monsoon (66% similarity). Similarity between the monsoon and winter species composition was 54% in the termiteria-influence zone and 73% in the off-termiteria zone. Attempts were made to correlate the occurrence of FIS with microclimatic data. Overall, termiteria-influence zone was more dynamic, heterogeneous and unpredictable than the off-termiteria zone in terms of occurrence of FIS. Hence, spatio-temporal dynamics of FIS together with microclimatic conditions may contribute in monitoring and improving the forest health in termite dominated systems.

HOUSEHOLD AIR POLLUTION FROM DIFFERENT COOKING FUELS IN JAMMU (J&K): MEASUREMENTS, HEALTH IMPACTS, AND INTERVENTIONS

Anjana Chib and Rajkumar Rampal

Department of Environmental Sciences, University of Jammu, Jammu-180 006 (J&K)

E-mail: chib.nidhi@yahoo.in, rajrampal@gmail.com

Indoor air pollution from the combustion of biofuels is a significant public health hazard predominately affecting the poor in both rural and urban communities in developing countries. Women and their small children are at increased risk due to the amount of time spent close to the stove in the kitchen. In the present study attempt has been made to determine indoor SPM and NO₂ levels in the kitchen of households using different modes of cooking in Jammu. The sampling was done eight hourly (6am to 2pm) using Handy Air Sampler Envirotech APM 821 with flow rate of 1.5Lpm. Complied average values of SPM and NO₂ were used to calculate IPI (Indoor Air Pollution). The calculation of Indoor Air Pollution Index (IPI) from the average SPM and NO₂ of all the kitchens of study area rated the value above 0.4 and all these values were read off as 'hazardous'.

ROLE OF SARA-WCPM TOWARDS SUSTAINING ENVIRONMENT, EMPLOYMENT GENERATIONS, ENHANCEMENT OF THE LIVELIHOOD THROUGH ITS CAPTIVE PLANTATION PROJECT: VITAL ROLE IN SOCIAL SECURITY

R.K. Chopra*, M.P.S. Yadava, Sudhir Kumar Sharma and A. Gier

*Captive Plantation Project, Society for Afforestation, Research & Allied Works, Dandeli Uttar
Kannada -581 325 (Karnataka)*

**E-mail: rkchopra@westcoastpaper.com*

The West Coast Paper Mills Limited, Dandeli is one of leading paper industry of the country actively engaged in plantation programme under its Captive Plantation Project through CFF under the aegis of SARA since 2006 and has covered 51588 acres of planting area. Plantation under WCPM-SARA is duly certified with FSC-FM certificate for Well Managed Group Plantation since 2011. SARA, which is a non-governmental, non-profit organization registered under Karnataka Societies Registration Act 1960, in 2001. To date SARA has covered more than 8000 member farmers. The plantation activities are done on farmer's wasteland, barren, fallow land to promote plantation amongst farmer communities to raise their living standards and employments generation from plantations. These lands are no use of agriculture produce and farmers are not able to convert their land for agriculture purpose due to lack of sources. In this direction, a major breakthrough came in the year 2006 when WCPM-SARA initiated such a mega plantation programme to ensure the regular income for the farm communities and provided them a social guarantee of employments through plantation and other major work i.e. harvesting of pulpwood on their waste land. SARA is providing 850 person days per acre through its all plantation activities like development of land, plantation, maintenance and harvesting of crop.

Farmers are benefited from their crop and earned good amount of hassle free income from plantations. This practice has yielded him a ladder to enhance their standard of living in terms of employments, education etc. In Karnataka, some parts of Maharashtra and Andhra Pradesh, this project received wide publicity as it proved a boon for the farmers. Beside this SARA is also providing free fodder to the livestock of farmers and free fuel wood to the local community. Various types of fodder grass such as *Stylosanthes scabra*, *S. hamata* are grown with plantation. Farmers are also adopting Intercropping of various crops like cashew, peanut and ginger with plantations. This project is based on a simple agreement i.e. Contract for Farming that is for only five years. All the expenditures from land development to Harvesting are done by SARA-WCPM. Farmer need not to incurred a single penny. Under plantation, superior planting material of various high yielding clones of different pulpwood species suited to particular conditions i.e. Eucalyptus, Subabul, Casuarina and Acacia are planted. SARA is also promoting agroforestry along with plantation programme. All the species are widely accepted under captive plantation since they have a great importance. SARA-WCPM has set up a State-of-art Hi-tech clonal nursery in its campus and producing 50-60 lacs/year of superior quality clonal saplings. From first rotation crop in some area, we have received 1 lac MT of pulpwood from the plantation. The yield from the plantations of various pulpwood species i.e. Eucalyptus, Casuarina, Acacia and Subabul is coming around 25-35 MT/acre adopting best silvicultural practices after five years. These types of activities are proved beneficial for farmers by improving their standards as well as for paper industry, which are in great crisis of wood by securing raw material. It is also helpful to sustain environment in terms of conservation of Natural resources, HCVF and it reduces the pressure on Forest for wood. Under Corporate Social Responsibility activities, SARA has done a good job for the society by providing them employments, financial assistance, generate water resources avenue plantations and distributing books and study material to various village schools.

URBAN FORESTRY IN BUILDING CLIMATE RESILIENCE IN CITIES - EVIDENCES FROM THE MEGAPOLIS OF DELHI, INDIA

**Rajesh S. Kumar^{1*}, Nity Nishant¹, Keshav Jha², N K Binu³ Rupa Upadhyay⁴,
Suneesh Buxy¹ and Gopinath¹**

¹*Dept. of Forests and Wildlife, Govt. of NCT of Delhi, 2nd Floor A-Block, Vikas Bhawan
I.P. Estate, New Delhi-110 002*

²*ICLEI- Local Governments for Sustainability, South Asia, NSIC - STP Complex,
Okhla Industrial Estate, New Delhi-110 020*

³*College of Forestry, Kerala Agricultural University, Thrissur-680 656, Kerala, India*

⁴*University of Delhi, New Delhi-110 001*

**E-mail: rskumarifs@gmail.com*

There have been raising concerns about sustainability of urban systems across the world as more than half of the world population lives in the cities. The cities are complex organic systems which consume various resources such as food, energy, water etc in huge proportions and are

responsible for production of more than half global Greenhouse Gas (GHGs) Emissions. It is reported that various impacts of climate change will challenge the capabilities of cities to provide basic urban services and support life quality in the cities. However the climate change mitigation potential and adaptive capabilities of the cities could be potentially advanced through appropriate innovation, knowledge building, experience sharing, skill development and governance interventions etc. The well managed ecosystems in the urban landscapes support the societies in realizing various adaptation and mitigation strategies by providing various ecosystem services and products. The presence of green infrastructure in the city landscape contribute to the vital resilience and the forestry components in the landscape are viewed among important resources to be harnessed for various ecosystem services required for resilience building. In the paper we discuss various aspects related to urban forestry in the megapolis of Delhi in building the climate change adaptation and mitigation potentials. It also dwells on the pattern of expansion of the green cover infrastructure in the city, describes various urban forestry components with mitigation and adaptation potentials, urban forestry mitigation project, the urban forest governance instruments and mechanisms etc which contributes to climate change resilience enhancement. We also analyzed the various strategies followed in the development of the green cover infrastructure to secure green cover and its expansion in the city. The analysis identified that actor coordination, landscape approaches, strategic planning has been pivotal in the expansion of the green cover assets in the city thereby contributing to resilience building.

RELATIONSHIPS OF RING WIDTH IN CHIR PINE (*PINUS ROXBURGHII* SARGENT) TO CLIMATIC VARIATION IN THE MID HILLS OF WESTERN HIMALAYAS.

Shipra Shah*, D.P. Sharma and Priyanka Tripathi

Department of Silviculture and Agroforestry

Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan- 173 230 (HP)

**E-mail: shiprashah1984@yahoo.co.in*

The present study was carried out in the year 2011 to assess the relationships between ring width in chir pine (*Pinus roxburghii* Sargent) and annual variation in temperature and precipitation in Solan, Himachal Pradesh, India. Analysis of climatic data revealed that the region has experienced an increase in temperature while precipitation in the form of rainfall decreased over the years. Stump discs were subjected to standard dendrochronological procedures. Ring width Index (RWI) was found to have a significant relationship with the average annual temperature ($R=0.68$, $p < 0.05$) and rainfall ($R= 0.41$, $p < 0.05$). Radial growth in trees is sensitive to changes in climatic conditions of different localities. It is important to understand the response of forests to climate change for developing suitable adaptation and mitigation measures, improving the resilience of forests to future climate as well as effective policy development.

Tree Cultivation for the promotion of Sustainable livelihood of rural community and dedicated service for environments – An International Paper APPM Limited's Contributions

Manoj Sharma, Y. Christi Sagariya*, Dharmendra Bunga and Govindarao Chintala
Forest Department, International Paper APPM Limited, Rajahmundry-533 105

**E-mail: christisagariya.yobu@ipaper.com*

Over two decades, International Paper APPM Limited has been doing its farm forestry activities with Casuarina species. It was started with quality seedlings distribution to the farmers from decentralized nurseries. Casuarina nurseries were developed in 50 villages of 9 coastal districts of Andhra Pradesh by adopting the best nursery practices include selection of quality seeds, seed sowing, secondary bed transplantation, culling of inferior seedlings at nursery stage and proper root pruning. Generally, Casuarina seedlings were distributed to the farmer community by local nurseries as primary bed grown seedlings. This was leading to poor in growth performance, higher mortality, and lower yield in the plantations. After a keen observation, treated bare rooted seedlings were introduced by IPAPPM limited resulted in higher survival and better yield in field plantations. By implementing standardized silvicultural management practices, the productivity per unit area was increased significantly as treated bare rooted seedlings was giving 80 metric tonne ha⁻¹ when compare to conventional seedling was yielding only 50 MT ha⁻¹. The yield was 37.5 % more in treated bare rooted seedlings than that of conventional bare rooted seedlings. Whereas a hybrid clone which has been introduced recorded better yield (165 MT ha⁻¹ or 51.5 % more) than treated bare rooted seedlings. Upgrading and innovating technology in cloning process with low cost and zero energy poly hoses has improved the quality of clonal planting stock and implementing appropriate clonal hedges have played an important role in juvenility of clones resulting in uniform growth and yield in clonal plantations which will result in more productivity. Since 1989, more than 50 thousand farmers have experienced the fruitful benefits and have gained more in Casuarina cultivation, covering more than 1.88 Lakh hectare area and 93.83 million mandays were able to generate through farm forestry programme. By extending the activities of farm forestry in the coastal district of Andhra Pradesh, about 0.056 million metric tonnes of nitrogen have been enriched in low fertile soil besides 1.58 million metric tonnes of organic carbon have been supplemented in to the soil and estimated sequestered carbon is 8.28 million metric tonnes in farm forestry plantation.

PERSPECTIVE OF PRODUCTION AND CONSUMPTION OF WOOD AS RAW MATERIAL TO WOOD BASED INDUSTRIES IN PUNJAB

H.P. Singh* and Neena Khandekar

*Resource Survey and Management Division
Forest Research Institute, Dehradun-248 006 (Uttarakhand)*

**E-mail: singhhp@icfre.org*

The total geographical area of the state is 50,362 Sq. km out of which Forests and tree cover area is 1764 km² and 1699 km² which is 3.50 % and 3.37 % of GA, respectively. The growing stock

of the state is 35.015 m.cum out of which, the forest accounts 15.71 m.cum and ToF share 19.31 m.cum. The average annual production of timber from forest is 0.097 m.cum and the annual availability of timber from ToF is 2.65 m.cum. In the present scenario, due to increase in population and rapid industrialization of the country, the demand of forest products, especially timber, is continuously rising resulting in degradation of natural forests. In response to this, the government is giving emphasis on afforestation of number of tree species viz; Eucalyptus, Poplar, Drek, Shisham, Kikkar, etc that are being planted on government / community/ private lands in the state. To distribute the farm forestry produce to diverse and distant markets, services of different market intermediaries are utilized. These are contractors, commission agents, timber traders, saw mill owners, etc. In the state major industries/sectors which is use wood as raw material are categorized as: Saw mills, Ply wood, Veneer and MDF etc. Saw mills directly do not consume the wood but fulfill the requirement of construction, furniture, packing case, crates, agricultural implements, handicrafts and other small sectors. The present paper describes the current status of total availability of wood (production and wood received from outside the state), and consumption of wood by wood based industries in the state. The demand and supply status of wood in the state is estimated and, for filling the gap, the requirement of additional area for plantations annually, is also worked out.

GENETIC VARIABILITY, HERITABILITY AND ASSOCIATION STUDIES AMONG BIOMETRIC TRAITS IN JATROPHA HYBRID GENETIC RESOURCES

Keerthika A.¹, Sangram Chavan^{2*} and KT Parthiban³

¹*National Academy of Agricultural Research Management, Rajendranagar, 500 030 (AP)*

²*National Research Centre for Agroforestry, Jhansi-284 003 (UP)*

³*Forest College and Research Institute, TNAU, Mettupalayam-641 301(TN)*

**E-mail: sangramc8@gmail.com*

27 backcross derivatives of *Jatropha* established at the Forest College and Research Institute, Mettupalayam, Tamil Nadu, India were studied for quantitative traits such as plant height, basal diameter, number of branches, sturdiness quotient and seed yield during 2010-2011. These traits were assessed for variability, heritability, and association studies. Lines HC 14, HC 21 and HC 23 performed well for plant height, basal diameter, number of branches and seed yield at 28th, 32nd and 36 months after planting. Almost all the traits recorded high heritability values. The association study indicated that plant height, basal diameter and number of branches showed positive and significant phenotypic and genotypic correlation with seed yield. In path analysis studies, basal diameter exerted maximum positive direct effect on seed yield followed by sturdiness quotient, number of secondary branches and number of primary branches. Positive indirect effect on seed yield was exerted by number of primary branches through basal diameter, sturdiness quotient and number of secondary branches. Overall, backcross derivatives HC 14, HC 21 and HC 23 performed exceedingly well for all quantitative traits which can be further used for improvement programme for promoting *Jatropha* as biofuel crop.

OPTIMIZING THE AGRONOMIC REQUIREMENTS OF ARVI (*COLOCASIA ESCULENTA*) UNDER POTENTIAL AGROFORESTRY TREE SPECIES IN PUNJAB

Navneet Kaur*, R.I.S. Gill and Baljit Singh

*Department of Forestry & Natural Resources,
Punjab Agricultural University, Ludhiana-141 004 (Punjab)*

**E-mail: navik20@pau.edu*

Arvi (*Colocasia esculenta*) form an important article of diet; its several varieties are being cultivated in India and also has a high economic value in urban markets. Poplar is the main agroforestry tree species extensively experimented with annual and seasonal crops in North-western part of India. Whereas, dek (*Melia composita*), toon (*Toona ciliata*) and maharukh (*Ailanthus excelsa*) have the potential of being promising agroforestry tree species for the years to come. The growth and productivity of understorey crops varies under different tree plantations owing to difference in nature of tree-crop interactions. Arvi (*C. esculenta*) is a shade tolerant crop. The extent of shade that is required for its optimum growth and yield under agroforestry system needs to be established. The present study was done to work out the agronomic requirements of arvi intercropped under different aged block plantation of poplar (*Populus deltoides*), dek, toon and maharukh established at 5 x 4 m spacing during 2006 and 2007. Poplar trees were the tallest with maximum height of 12.45 m while the lowest height was recorded of maharukh trees (4.06 m) and the crown spread was maximum (27.2 m²) in dek trees at the age of three years, respectively. The preliminary results showed that the yield of arvi was significantly less under poplar and dek as compared to yield under maharukh plantation. This could be attributed to more height and crown spread of poplar and dek plantations. In general, the crop sown on ridges gave higher yield compared to the crop sown on flat beds. The arvi sown on ridges with additional seed (8.75 q/ha) and fertilizers (155 kg N, 62.5 kg P₂O₅ and 62.5 kg K₂O/ha) gave significantly higher yield (161.4 q/ha) as compared with crop sown on flat beds with recommended seed rate and fertilizers under higher aged plantations.

ASSESSMENT OF FLORISTIC DIVERSITY OF THE HADIMBA DEVI SACRED GROVE IN HIMACHAL PRADESH, INDIA

Deepak Kumar, Pooja Kumari and S.S. Samant*

*G.B. Pant Institute of Himalayan Environment and Development
Himachal Unit, Mohal, Kullu- 175 126 (HP)*

**E-mail: samantss2@rediffmail.com*

Sacred Groves are the wealth of forest ecosystem that provide provisioning (i.e., fresh water, NTFPs and timber), cultural (i.e., recreation and spiritual), regulating (i.e., carbon sequestration) and supporting (i.e., biodiversity, nutrient cycling, pollination, etc.) services. It is believed that these sacred groves are well protected by the village folk deities. About 13,270 such Sacred Groves have been reported from various parts of India. The state Himachal Pradesh which is known as "Devbhumi" supports about 5,000 sacred groves. The review of literature showed that

the Sacred Groves are unexplored or underexplored. Therefore, the present study was conducted in Hadimba Devi Sacred Grove, Manali in Kullu district of Himachal Pradesh to assess the floristic diversity, assess the floristic diversity for utilization pattern and assess the structure and regeneration pattern of tree species. Rapid sampling and quadrat methods have been followed for sampling the diverse habitats and aspects between 2033-2098m. Total 106 species of vascular plants i.e., Angiosperms (95 spp.), Gymnosperms (03 spp.) and Pteridophytes (08 spp.) were recorded. Of these, 07 species were trees, 11 shrubs, 80 herbs and 08 pteridophytes. These represented the shady moist, dry and boundary habitats. Among the identified species, 30 species were medicinal, 10 fodder, 09 fuel and 07 religious value has been recorded. Only one community i.e., *Cedrus deodara* has been recorded. The tree density ranged from 280 - 350 Ind ha⁻¹; shrub density 70 – 850 Ind ha⁻¹ and herb density 1.30 – 68.00 Ind/ m². The species diversity for trees ranged from 0.00 – 0.12; shrubs 1.06 – 2.22 and herbs 1.46 – 3.36. The study provides comprehensive information on vascular plants and tree community which will form the base lines information for developing management strategy. Similar studies in other Sacred Groves of the state will help in generating sound database and developing appropriate management strategy.

DIVERSITY, DISTRIBUTION AND INDIGENOUS USES OF MEDICINAL PLANTS OF SPITI VALLEY OF HIMACHAL PRADESH, NORTH WEST HIMALAYA, INDIA

Lipika Sharma, S.S. Samant*, Ashish Kumar, Kaushalya Devi and Deepti Negi

G.B. Pant Institute of Himalayan Environment and Development

Himachal Unit, Mohal, Kullu- 175 126 (HP)

**E-mail:samantss2@rediffmail.com*

Tribal communities of Himachal Pradesh largely depend on various plants as traditional remedies in treating several diseases they suffer from in their life. Considering, the importance of traditional medicinal plant wealth and various threats leading to their extinction, the present study has been focused on qualitative assessment of diversity, distribution and indigenous uses of medicinal plants of Spiti region of Lahaul –Spiti District in Himachal Pradesh, North West Himalaya. Information on the medicinal plants was obtained by conducting surveys, interviewing villagers and hiring local knowledgeable persons for the collection of medicinal plants during 2011-2013. Total 275 medicinal plants belonging to 150 genera and 53 families were identified between 2620-4585 m. Asteraceae was the dominant family and *Astragalus* was the dominant genera. The most commonly utilized plant parts were aerial part (101spp.), whole plants (77 spp.), leaves (90 spp.), roots (70 spp.), flowers (37 spp.), stems (27 spp.), seeds (19 spp.) and bulbs (6 spp.). The high diversity of the medicinally important species in the Spiti Valley indicates the high conservation and socio-economic value of the area. Regular monitoring of populations and habitats of native, endemic and commercially viable medicinal plants using standard ecological methods as well as identification of potential species for mass cultivation using conventional and *in-vitro* methods have been suggested. In addition, establishment of identified potential species mainly in cultivation and their marketing have been suggested.

STATUS AND REGENERATION OF HIMALAYAN YEW IN THE KAIS WILDLIFE SANCTUARY OF HIMACHAL PRADESH, NORTH WESTERN HIMALAYA, INDIA

Manohar Lal and S. S. Samant*

*G.B. Pant Institute of Himalayan Environment and Development
Himachal Unit, Mohal, Kullu- 175 126 (HP)*

**E-mail: samantss2@rediffmail.com*

The Himalayan Yew (*Taxus baccata* L. subsp. *wallichiana* (Zucc.) Pilger) is an endangered, native and high value medicinal plant of the Indian Himalayan Region. The anti-cancerous property of the bark and leaves of this species has increased pressure on the species to a great extent. Further, poor regeneration of seeds has enhanced the degree of threats on this species. This has necessitated studying its population and developing management plan for conservation. The population status and regeneration were examined in Kais Wildlife Sanctuary. The Kais Wildlife Sanctuary (31°59.684' -32°03.558'N Lat. & 77°09.092' -77°12.723'E Long.; area: 14.19km²; altitudinal range 2000-3850m) is one of the notified Wildlife Sanctuaries of Himachal Pradesh. Standard ecological methods have been followed for the assessment of populations of this species. The species was found in 25 sites, 3 habitats and 6 aspects distributed between 2,500 -3,300m amsl. Maximum sites were dominated by *Abies pindrow* and *Quercus semecarpifolia* communities. The *Taxus baccata* subsp. *wallichiana* was best represented in shady moist habitat and West and Northwest aspects. Among the sites, density of *Taxus baccata* subsp. *wallichiana* ranged from 10.00-422.00 Ind ha⁻¹; total basal area, 0.23-42.3m² ha⁻¹; IVI, 5.51-106.7; sapling density, 40.00-60.00 Ind ha⁻¹ and seedling density, 15-110 Ind ha⁻¹. Among the sites, richness of trees ranged from 2-11, shrubs, 1-21 and herbs, 16-56. Species diversity (H') for trees ranged from 0.27-2.17, seedlings, 0.10-1.68, saplings, 0.31-1.65, shrubs 0.70-2.87 and herbs, 2.82-3.86. It showed contagious distribution pattern across the sites. The density of saplings and seedlings is relatively poor indicating change in population dynamics in future. The continuous extraction of bark and leaves of this species from the wild may cause the extinction of species and loss of moisture and humus contents from the sites which may lead soil erosion and finally habitat degradation. It has been observed that due to unplanned collection of the resources, ecology of the forests has been seriously affected. In addition, it can influence vegetation by altering its composition and structure. Based on the study, it can be concluded that the species is under severe threat in the study area due to exploitation and poor regeneration. Frequent monitoring of the species is required to identify the underlying factors responsible for population depletion and develop appropriate management plan.

COMMUNITY DIVERSITY AND REGENERATION PATTERN OF TREE SPECIES IN NAINADEVI SACRED SHRINE BILASPUR, HIMACHAL PRADESH

Sunil Marpa and S.S. Samant*

G.B. Pant Institute of Himalayan Environment and Development

Himachal Unit, Mohal, Kullu- 175 126 (HP)

**E-mail: samantss2@rediffmail.com*

The recognition of Himalaya for rich biological and cultural diversity is well acknowledged all across the globe. The Indian Himalayan Region (IHR) forms the major part of the Himalaya and very well known for the religious places/Sacred Shrines. Amongst the Himalayan states, Uttarakhand, Himachal Pradesh and Jammu & Kashmir are very well known for religious places/sacred shrines. These sacred shrines are very rich in biodiversity and not explored so far. In view of this, the Naina Devi Sacred Shrine, Bilaspur (NDSSB), which lies between $31^{\circ} 16' - 31^{\circ} 24' N$ latitudes and $76^{\circ} 25' - 76^{\circ} 35' E$ longitudes has been investigated for community diversity and regeneration pattern of tree species. Total 30 sites were sampled representing six habitats, seven aspects between 500-1100m. Total 15 forest communities were identified. *Mallotus philippinensis-Eucalyptus tereticornis* mixed community represented maximum sites. In the identified forest communities, the total tree density ranged from 320.0-790.0 Ind ha⁻¹ and total basal area 3.24-18.10 m²ha⁻¹. *Hymenodictyon excelsum-Cassia fistula* community had maximum tree density (790 Ind ha⁻¹) and also showed maximum total basal area (18.10 m² ha⁻¹). Based on regeneration pattern indicated that 6 communities were with highest regeneration of dominant species; 01 community with highest regeneration of co-dominant species; and 08 communities with highest regeneration of one of the dominant species. Species diversity for trees ranged from 1.26-2.00, saplings, 1.31-2.05, seedlings, 1.27-2.01. Highest diversity of trees, saplings and seedlings was reported in *Ficus racemosa-Anogeissus latifolia* mixed (2.00), *Ficus racemosa-Anogeissus latifolia* mixed (2.05) and *Ficus racemosa-Anogeissus latifolia* mixed (2.01) communities, respectively. The Community wise Concentration of dominance for trees ranged from 0.16-0.42, saplings, 0.21-0.71 and seedlings, 0.19-0.63. The highest Concentration of dominance for trees, saplings and seedlings was recorded in *Acacia catechu* (0.42), *Cassia fistula-Ehretia acuminata* mixed, *Mallotus philippinensis-Diospyros montana* mixed (1.00, each), and *Acacia catechu* (0.70) communities, respectively. Due to high anthropogenic activities and changing environmental conditions the forest communities are facing high pressures. Therefore, frequent monitoring of habitats, communities and extraction of ecologically and economically biodiversity elements, rehabilitation of the natural habitats, restoration of the degraded sites, monitoring and management of the invasive species and people's participation in biodiversity conservation have been suggested.

DIVERSITY, DISTRIBUTION AND CONSERVATION PRIORITIZATION OF TREES IN UPPER BANJAR FORESTS OF HIMACHAL PRADESH, NORTH WEST HIMALAYA, INDIA

Aman Sharma and S.S. Samant*

G.B. Pant Institute of Himalayan Environment and Development

Himachal Unit, Mohal, Kullu- 175 126 (HP)

**E-mail: samantss2@rediffmail.com*

Like Indian Himalayan Region, Himachal Pradesh is rich in biodiversity. However, the state has not been explored for diversity, distribution and conservation prioritization of Trees. Therefore, present study has been conducted in Hirb and Shoja Catchments of upper Banjar forests, Kullu district, Himachal Pradesh during 2007-2011. Plots of 50x50m were selected based on aspect, habitat and altitude between 2000-3450m, and sampling of vegetation was done by laying 10 quadrats of 10x10m in each plot. Information on economic importance was gathered by interviewing and surveying the inhabitants. Overall 47 Trees were recorded and 23 in sampled sites. 18 communities were identified based on Importance Value Index. *Abies pindrow*, *Quercus semecarpifolia*, *Aesculus indica*, *Prunus cornuta* and *Picea smithiana* communities represented 31 sites and were dominant. Total tree density ranged from 60.0-1060.0 Ind ha⁻¹ and total basal area (TBA), 0.20-83.99 m²ha⁻¹. The species diversity (H') for trees, saplings and seedlings ranged from 0-1.749, 0.917-2.948, 2.744-4.125, 0-2.338 and 0.530-2.071, respectively. 9 communities showed highest regeneration of dominant and two with highest regeneration of co-dominant species. A significant positive correlation was found between total saplings density and total seedlings density ($r=0.570$, $p<0.02$ $n=18$) which showed that the seedlings were able to grow successfully. Identified species were analyzed for the Conservation Priority Index (CPI) based on habitat specificity, population size, distribution range, use values, extraction, nativity and endemism. The species having >60 % of the CPI were considered as Critically Endangered; 56-60% as Endangered; 51-55 % as Vulnerable; and 45-50 % as Near threatened and were prioritized for conservation. Based on CPI, 5 species were identified as Critically Endangered, 7 species as Endangered; 3 species as Vulnerable and 8 species as Near Threatened. The ecology of the forests has been greatly affected by the unscientific harvesting of the resources. The adequate management of these trees species will help in maintaining the natural ecosystem of the area. Further, frequent monitoring of the status and regeneration pattern of these species is urgently required to understand the dynamics of communities and effect on the sensitive species due to anthropogenic activities and changing environmental conditions including climate change.

ETHNO BOTANICAL ANALYSIS OF COMMON TREE SPECIES USED BY INDIGENOUS PEOPLE OF RAJOURI, J&K, INDIA

Bandana Gupta* and Sanjay Sharma

Department of Environmental Sciences, University of Jammu, Jammu-180 006 (J&K)

**E-mail: vandana.mahajan004@gmail.com, sanjaysharmann@gmail.com*

This paper describes the significant relation between different ethnic groups, their culture and uses of plant species, focusing primarily on how plants are used, managed and perceived across them in Rajouri tehsil of district Rajouri in J&K state, India. In the present study, an inventory of trees species was prepared in the study area through field survey. The detailed questionnaire was designed for this purpose as to gather information about the role of the indigenous people in biodiversity conservation, environment management and eco restoration and how they feel about the degradation and changes. Interviews were conducted at homes, sacred places and parks. Altogether a total of 629 individuals belonging to 53 species, 43 genera and 30 families have been reported. The study found that the plants are conserved by these ethnic and indigenous people for their use as food, rituals, medicine, fuel, fodder, construction etc. They are also used as antidotes for snake bites, bee and scorpion stings. Plants are conserved in the informally protected areas as in situ conservation of biodiversity and ecological restoration. Historical, cultural, and spiritual aspects of the ecology of indigenous societies are grounded in the biodiversity, ecosystems, and landforms in their habitat. Thus, indigenes are most important to consider in exploring the relationships between sacred places, biodiversity, and conservation. The study provides the details of botanical identity, family, local name, parts of the plant used, uses of plants for various purposes and local perception about their conservation.

GERMPLASM COLLECTION, EVALUATION AND BREEDING BEHAVIOR OF KARANJ (*PONGAMIA PINNATA*)

R. S. Dhillon^{1*}, R. S. Beniwal¹, R. N. Sheokand², S. Kumari¹, J. Tokas³, K. Ahlawat¹, M. Jattan⁴ and V. Dalal¹

¹Department of Forestry, ²Computer Section, ³Biochemistry, ⁴Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004 (Haryana)

**E-mail: rsdhillon67@gmail.com*

Based on an intensive survey 34 candidate plus trees (CPTs) of karanj were selected from different agro-climatic regions of Haryana and Punjab. Significant variation was observed for seed length, breadth, thickness and 100 seed weight. Protein and oil contents of seed varied from 22.1 to 32.2 and 29.0 to 38.3 percent, respectively among different plus trees. The germination and the plant growth characters also differed significantly among progenies of plus trees. Analysis of variance revealing significant differences among the plus trees indicated the existence of ample variability among the genotypes for all the seed and seedling traits under study and validated further quantitative analysis. In the present study high heritability coupled

with moderate to high genetic advance(% of mean) for 100 seed weight, oil and protein contents, collar diameter, root and shoot length which indicated that high heritability obtained for these characters was probably due to additive gene effects. The detailed studies on observations on flowering indicated that bud begins to appear as small protruding structure with the commencement of new leaves. Inflorescence was a long raceme or panicle with 43-88 floral buds, which anthesed acropetally over a period of 14-16 days. Maximum well developed buds were observed on all the trees during April end to beginning of May. The flowering pattern was asynchronous. The trees were in full bloom from second week of May to first week of June. The peak period of flowering varied from 13-21 days which was followed by copious flower dropping in all the trees under study. On all the marked trees, natural pod setting was noticed from second week to last week of May. Maximum pod development occurred from May last to mid-August and after that seed development took place. The pod maturity was observed from mid March to first week of April of the subsequent year. The studies on breeding behaviour showed that this versatile tree species is predominantly cross pollinated.

ANCIENT PERSPECTIVES OF SUSTAINABLE FOREST ETHNICITY IN INDIA

H. T. Hegde*, S. K. Jha, N.S. Thakur and R.P. Gunaga

ASPEE College of Horticulture and Forestry

Navsari Agricultural University, Navsari -396 450 (Gujrat)

**E-mail: hegdeht@gmail.com*

The reverence for all kind of life has been a part of Indian thought since time immemorial. The Ancient Hindu scriptures directed people to protect their environment. Principles of forest conservation and sustainable forest management were well entrenched in the ancient India. The forest cultures, anxiety over conservation have been documented in the holy text of our country for long. Especially the Vedic views revolve around the concept of nature and life. The oldest and simplest form of Nature-worship finds expression in Vedic texts. Both productive and protective features of forests were accentuated in Vedic forestry. These thoughts gave births to the concepts like sacred groves, sacred corridors and various ethnoforestry practices in traditional societies of this country. A good deal of information about forest is available in the Ramayana and Mahabharata. Existence of the flora and fauna mentioned by Valmiki in the Ramayan have been found to be true. The degradation of forest was noticed as early as in the Mahabharata period. Buddhism and Jainism specifically advocated the protection of all living beings. The texts of Mauryan period are a testimony to the fact that the concept of sound forestry and forest management practices was well developed during the time. The primary document that highlights the scientific approach to aspects of administration, forest policy and their enforcement is the Arthashastra of Kautilya, which is a treaty of the ancient Indian administration of natural resources. Collection of forest revenue and plantation of fruit trees in the forests were evidenced in Gupta period. Indian religious literatures for all time talk about the conservation, utilization and regeneration of forests.

EFFECT OF PLANTING TECHNIQUE OF CULM CUTTINGS ON GROWTH PERFORMANCE OF *BAMBUSA VULGARIS*

N. Bhol* and H. Nayak

College of Forestry, Orissa University of Agriculture and Technology

Bhubaneswar, - 751 003 (Odisha)

**E-mail: bhol_n@yahoo.com*

One of the important bamboo species in coastal regions of the world from economic and ecological point of view is *Bambusa vulgaris* (Common bamboo). This species is raised vegetatively because it does not produce viable seed. Keeping this in mind, an experiment was conducted at Orissa University of Agriculture and Technology, Bhubaneswar, India to study the effect of planting technique of culm cutting on growth performance of clumps. The treatments included combination of three types of culm cuttings (rooted plants with culm cutting, rooted plants without culm cutting and culm cutting directly planted) and three sizes of pit (45cm x 15cm x 30cm, 45cm x 30cm x 30cm and 45cm x 45cm x 30cm). The experiment was laid out in factorial RBD at a plant spacing of 5m x 5m and the bamboo clumps were evaluated for four years consecutively in the main field. The growth performance of clumps was evaluated in terms of total number of culms produced, number of new culms recruited in the year, height of culm, diameter of culm and number of internodes in culm. Among the 3 types of culm cuttings, the rooted plants (3 month old) with culm cutting and without culm cutting performed significantly better over the directly planted culm cutting and the former two were statistically at par with each other. Among the 3 pit sizes, the pit size of 45x45x30 cm³ and 45x30x30 cm³ were superior to 45x15x30 cm³, but the former two were at par with each other. The optimum pit size was considered to be 45x30x30 cm³. Regarding interaction of type of culm cutting with pit size, the suitable combination was rooted plants with or without culm cutting planted in 45x30x30 cm³ or 45x45x30 cm³. However, to avoid unnecessary soil working, the planting of rooted plants with or without culm cutting can be made in pit size of 45x30x30 cm³.

STANDARDIZATION OF POPLAR LEAF BIOASSAY OF *ALTERNARIA ALTERNATA* TOXIN FOR RESISTANCE SCREENING

**Yojana Thapa, Kavita*, Archana Bagwari, Kartik Uniyal, Y. P. Singh,
R.C. Dhiman¹ and J.N. Gandhi¹**

Forest Pathology Division, Forest Research Institute, Dehradun 248 006

¹*WIMCO Seedlings Limited, Baghwala, Kashipur Road, Rudrapur 263 152*

**E-mail: naharia.kavita2010@gmail.com*

Poplar is a prominent tree in plantation forestry in India. Poplar is attacked by a large number of pathogens in nurseries and plantations which result in economic losses. The changes in climatic factors may activate some sleeper pathogen (*Alternaria* sp.) species while others may cease to be economically important. In the period 2008-2011, there was high incidence of *A. alternata* in

poplar nurseries in Uttarakhand which, otherwise, is considered to be a weak pathogen. The environmentally safe method for managing plant diseases is resistance. Leaf bioassay against pathogen toxin is a quick and reliable method of disease screening. This method was employed to screen commercial clones of poplar (G-48, Udai, WSL-22 and WSL-39) against the toxin of *A.alternata* isolates. Experiments were designed to work out the concentration, volume of the toxin; position and age of the leaf. Observations on time of initiation and extent of symptoms were recorded after 24 hr and 48 hr of toxin inoculation. Toxin of isolate A-23 affected maximum and significantly more percent leaf necrotic area of G-48 than other three clones at higher concentration of 80 and 100%. The quantity of toxin also influences the time of symptom initiation. It was observed that with higher volume of 70 and 80 μ L, G-48 developed significantly higher necrotic symptoms. Younger, pricked leaves seemed more prone to toxin as there was significant difference in time of symptom initiation in older (lower; 37.9 min) than younger leaves (upper; 14.4 min), irrespective of isolates. In the leaves collected from different aged seedlings (2012 and 2013), the position based performance remained same, for example, the lower leaf developed necrotic symptom much late in 34.8 min. in comparison to earlier symptom in upper leaf (19.4 min). Isolate no. A-23 could not produce necrotic symptoms on unpricked leaves of the four clones tested signifying its non host specific nature. In shoots juveniles, the toxin affected the entire lamina in contrast to leaf bioassay where the spread of toxin as necrosis was limited.

CONSERVATION AND CULTIVATION STRATEGIES OF VULNERABLE MEDICINAL PLANTS SPECIES OF WESTERN HIMALAYAS

Vipan Guleria¹, Amol Vashist² and Atul Gupta¹

¹*Regional Horticultural Research Station Jachh-176 201 (HP)*

²*College of Horticulture & Forestry, Jhalawar-326 023 (Rajasthan)*

**E-mail: vip_an2003@yahoo.com*

The rich biodiversity of India, which is around 8% percent of the world's total biodiversity, is under sever threat because of habitat destruction and over exploitation of resources (anonymous,2002). Since, most of the raw material is sourced from developing countries and marketed in the developed world, mostly in US, Japan and European Union. In India itself, there are around 6500 pharmaceutical units which required thousand tonnes of raw material for their routine production. It is estimated that 1350 plant species of Himachal Himalayas are exported for the same kind of use. Raw material in case of about 90% of the traded medicinal plant species in Himachal is sourced from wild. Indian medicinal plant based raw material include USA, Germany, Japan, UK, France, Taiwan, Italy, Pakistan and Hong Kong. Some 1900qtls of medicinal plants and parts thereof harvested from the salooni region of Himachal Pradesh every year. A parallel illicit trade banned and high value low quantity herbs is also there for example the data in the table shows no exploitation of *Aconitum heterophyllum* but its planting material as well as dry root are easily available in the Chamba. Almost 25 species were identified for export

from wild ranging from vulnerable to endangered. The different regions having the natural population of the species were identified with the help of local plant collectors and were surveyed for collection, domestication, improvement and generation of quality planting stock of Suangandhwala, Atish Kutki (*Picrorhiza karrooa*) all are endangered species.

CARBON FINANCE – AN ULTIMATE OPTION FOR MITIGATION OF CLIMATE CHANGE

Amol Vasishth¹, L.K. Dashora¹, P.S. Chauhan¹ and Vipan Guleria²

¹*College of Horticulture & Forestry, Jhalawar-326 023 (Rajasthan)*

²*Regional Horticultural Research Station Jachh-176 201(HP)*

Global climate change has evidently emerged a serious challenge for survival and sustainability of mankind. It is certain beyond doubt that climate is changing very fast. It is one of the most important global challenges facing humanity with implications for food production, natural ecosystems, fresh water supply and health. According to the latest scientific assessment, the earth's climate system has changed on both global and regional scales since pre-industrial era. The environment security has become a serious concern across the globe. Carbon trading is the fastest growing commodity market in the world and through CDM based markets, only large companies; corporate houses have been access and benefit from it. The small holders who do sequester carbon and also reduce emission do not have capacity to comply with rigid market requirements. Therefore a grid based approach has been developed and validated by ICRAF. Under this approach in arid to semiarid area of Rajasthan an area of 5000 ha has been selected under Mavli Block in Udaipur District where 40 green house gas mitigation options implemented at farm level, house hold level and community level. At the farm level these consist of planting trees for timber, fruits and fodder at private lands, field boundary, and community lands and degraded & wastelands. The field level emission reduction interventions included practices such as the zero tillage, minimum tillage, spot irrigation, mulches, incorporation of biomass in the soil, etc. The energy based house hold interventions include replacing common Edison electricity bulbs by CFL bulbs, and of the large fuel wood consuming open flame cooking stoves "chulhas", with the smokeless chulhas. At the community level, using solar power charged batteries for street lights, torches, etc. For benefit sharing mechanism a cooperative society of 2500 beneficiaries were made as Gramyajaan Sahakari Paryavaran Samiti having own byelaws and responsibilities under Society Registration Act which coordinate all activities of interventions by farmers, validation, carbon trading and project sustainability. The important agroforestry interventions made as agri-horticulture, agri-silviculture, industrial wood block plantations and waste land plantations. Energy based household interventions are smokeless stoves, CFLs and solar lanterns. The potential certified emission reduction (CER) in grid area is more than 25000CERs whereas three years interventions more than 3000CERs were assimilated. Through tree interventions more than 750 ha area was covered under plantations of orange, bael, pomegranate; clonal teak, paraspipal and mix forest sps. tecoma, etc intercrops with maize,

Pearl millets, wheat, chickpeas, mustard and barley. Sustainable fund generated up to 2.90 lakhs is the most significant visible indicator for project sustainability. People especially tribal communities were convinced about the climate change, carbon sequestration and emission reduction. From zero to 750 ha area covered under tree interventions and generates CERs which would benefit the farmers if interventions process continued, it would improve the livelihoods of small and marginal farmers without changing their current agricultural practices.

CHANGES ON STEVIOSIDE QUANTITY IN SALICYLIC ACID ELUCIDATED CALLUS OF *STEVIA REBAUDIANA* BERTONI

Shailja Dwivedi and Afroz Alam

Department of Bioscience and Biotechnology

Banasthali Vidyapith, Tonk - 304 022 (Rajasthan)

¹*E-mail: afrozalamsafvi@gmail.com*

Stevia rebaudiana Bertoni, considered as a very important medicinal plant now days due to source of antidiabetic sweetener stevioside. But it's well known that normally production of this sweetener by plants is not always satisfactory. In present experiment (during the year 2013-14), the role of salicylic acid, a well known chemical elicitor on the callus culture of *Stevia rebaudiana* was observed in the enhancement of the production of steviol glycoside (stevioside). In this study, *in vitro* leaf generated callus of *Stevia rebaudiana* were used as explants. Best response (100% proliferation within week) of callus proliferation from the leaves of *in vitro* regenerated plants of *Stevia rebaudiana* was observed in the MS medium containing 3mg/L BAP and 4mg/L NAA placed in to a thermostatically controlled culture room maintained at 25±2°C temperature, 500µmol⁻² s⁻¹ and 16 hour photoperiod. 2-3 weeks old well matured calluses were treated with 0µM/l, 50µM/l, 100µM/l, 150µM/l, 200µM/l and 250µM/l concentrations of salicylic acid and harvested after 15 days for isolation and quantification of stevioside. Methanolic extract of isolated plant extract were analyzed with FTIR and HPLC for confirmation and quantification. Similar peaks of FTIR confirm the presence of stevioside in all samples with respect to standard solution of stevioside, while HPLC analysis reveals that the all concentrations of salicylic acid show the positive effect on stevioside production but the 150µM/l amount of salicylic acid increased the amount of stevioside upto two folds. 62mg/g stevioside was found in callus treated with 150µM salicylic acid while 30mg/g stevioside was found in callus without any treatment of salicylic acid. Least amount of stevioside was found 38.92mg/g which was in 250µM salicylic acid treated callus of *Stevia rebaudiana*. On the basis of present work it can be concluded with conviction that exploitation of this experiment at commercial level will increase the production of stevioside from the small amount of sample.

ESTIMATION OF SEQUESTERED CARBON AND DEVELOPMENT OF GENERALIZED ALLOMETRIC EQUATIONS FOR DIFFERENT FARM FORESTRY PLANTATIONS OF SUBTROPICAL-SUB TEMPERATE REGION OF HIMACHAL PRADESH

Pratima Vaidya*, K.S. Verma and S.K. Bhardwaj

Department of Environmental Science

Dr Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan -173 230 (HP)

Email: pratimaem@gmail.com

The investigations were carried out in different farm plantations of *Eucalyptus tereticornis*, *Populus deltoides*, *Quercus leucotrichophora*, *Eucalyptus tereticornis* + *Pinus roxburghii* and *Quercus leucotrichophora* + *Ulmus villosa* raised by Department of Silviculture and Agroforestry in 1987-88 at Dr Y S Parmar university of Horticulture and Forestry during 2012-13. The plantations were studied to access the carbon sequestered by 24-25 year old farm plantations and to develop generalized allometric equations to estimate carbon sequestered by biomass and biomass + soil. The observations regarding stem, leaf, branch, above ground, below ground and total tree biomass were recorded by non destructive method of sampling. The carbon content was determined by loss of ignition method and biomass was converted into biomass carbon density. Maximum stem carbon (935.56 t ha^{-1}), branch carbon (180.22 t ha^{-1}), leaf carbon (42.06 t ha^{-1}), above ground carbon ($1157.84 \text{ t ha}^{-1}$), below ground carbon (301.04 t ha^{-1}), total biomass carbon ($1458.88 \text{ t ha}^{-1}$) and total biomass + soil carbon ($1547.21 \text{ t ha}^{-1}$) was accumulated in the pure plantation of *Eucalyptus tereticornis*. Percent soil organic carbon and total soil carbon density was highest in soils below *Eucalyptus tereticornis* (1.63% and 88.33 t ha^{-1}). Biomass carbon and total biomass + soil carbon density of different farm plantations followed the order: *Eucalyptus tereticornis* > *Quercus leucotrichophora* + *Ulmus villosa* > *Populus deltoides* > *Eucalyptus tereticornis* + *Pinus roxburghii* > *Quercus leucotrichophora*. A similar trend was observed in CO₂ mitigation. For estimation of generalized biomass and carbon in different pure and mixed stands of studied farm forestry species, diameter was taken as independent variable and power function was the best fitted function. Based on R² value compound function was best fitted for total biomass + soil carbon in pure as well as mixed plantations.

GROWTH MODELLING IN ACACIA AND PROSOPIS SPECIES TO PREDICT THE HEIGHT, COLLAR DIAMETER AND ITS VALIDATION IN ARID REGION

P. Ratha Krishnan, L.N. Harsh and J.C. Tewari

Central Arid Zone Research Institute, Jodhpur – 342 003 (Rajasthan)

Acacia and *Prosopis* are well adapted tree genera in arid zone. Hence, introduction of several *Acacia* and *Prosopis* provenances to the Indian arid region from the iso-climatic parts of the world has been carried by Central Arid Zone Research Institute, Jodhpur since 1960s. *Acacia* and *Prosopis* provenances were planted in 3 X 3 m spacing, 3 replications with 36 trees / plot

under FAO/IBPGR projects during 1985 – 2000 at CAZRI. Their height and collar diameter data has been regularly recorded during the periods. This available data in respect of *Acacia senegal*, *A. tortilis*, *A. albida*, and *Prosopis pallida* provenances were archived to analyze the relation amongst different parameters. Regression relations were examined in the response variant (volume, biomass, etc) with respect to explanatory variants (age, total height, diameter at breast height, or combinations). It was aimed to develop growth models to predict the height and collar diameter of *Acacia* and *Prosopis* in arid region. Initially, species level growth models with relation to age were developed. Subsequently, growth phases (i.e. lag and exponential) wise models were also developed with respect to particular provenance of *Acacia* and *Prosopis* species. As the first step, age of lag and exponential phases of trees were fixed by analyzing the age vs height and age vs collar diameter (CD) relationships. Then identification of suitable trend lines, regression type (*viz.*, linear, exponential, logarithmic and polynomial) and equations were finalized with good fitness (R^2 value). Three each growth models / equations of *Acacia tortilis*, *A. senegal*, and *Prosopis pallida* for height and two growth models / equations of *A. albida* for height were developed. Total of 56 height growth equations and 22 collar diameter growth equations of 3 provenances of *Acacia tortilis*, 12 provenances of *A. senegal* and 2 provenances of *A. albida* were developed in accordance with their identified lag and exponential growth phase. Lag and exponential growth-phase wise heights and collar diameter growth equations for 7 provenances of *Prosopis pallida* were also developed. The validation of these models with published and field observed data using chi square test revealed its good fitness and field applications. Correlating height and CD of *Acacia* and *Prosopis* with age would enable prediction of their height and CD in arid zone over years which in turn will be helpful to succinctly estimate the biomass & carbon sequestration potential of *Acacia* and *Prosopis* species.

THE POTENTIAL OF BAMBOO CULTIVATION AS A WAY FORWARD TO CLIMATE CHANGE MITIGATION & IMPROVING LIVELIHOOD: A CASE STUDY

Hemant Kumar, B. Mehera, R.K. Anand, Rajiv Umrao and A.K. Singh

School of Forestry & Environment, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad - 211 007 (UP)

**Email: hemantfri@gmail.com*

Long-term storage of carbon in the terrestrial biosphere, belowground, ocean and soil, which helps in decreasing the carbon-dioxide concentration in the atmosphere, is termed as carbon sequestration. Carbon sequestration can be enhanced through the expansion of forest and management of degraded lands. Assessment of plant and soil carbon sequestered in any forest is important as it gives ecological and environmental benefits to the people. Being as a short rotation crop, soil binding quality, higher carbon sequestration abilities and stress tolerance capacity of the species were highly emphasized. It supports agro-industries for manufacturing handicrafts items, packaging materials, raw materials for fencing, paper industries etc. In this regard a study was conducted at School of Forestry & Environment, SHIATS, Allahabad (U.P)

to know the Carbon sequestration potential of bamboo cultivation. Bamboo clumps were planted with a spacing of 9 m x 9 m. After five year of planting, each clump produces 10-15 culms per year. In this paper, the potential of *Bambusa bambos*, *Bambusa vulgaris*, and *Bambusa balcooa* were highlighted. Simple random sampling was carried out for collecting the biophysical data for estimating above and below ground biomass of bamboo. One bamboo from each clump was felled and samples were taken for determining the carbon content of bamboo culms and leaves. Laboratory analysis showed that carbon content in culm components exhibited higher proportions in woody component (50–52%) than in branch (45–48%) and leaf (37–41%) for the three species. The above and below ground biomass carbon sequestration in bamboo was found as 1.45 t/ha and 0.07 t ha⁻¹., respectively, whereas the soil carbon sequestration was found to be 201.18 t ha⁻¹. Maximum carbon sequestration potential was recorded in case of *B. balcooa*. Further research on different climate, soil, locality and elevation range in Bamboo is needed to assess carbon sequestration potential.

INFLUENCE OF MONTH, AGE, POSITION AND SIZE OF CULM CUTTING ON PROPAGATION OF *BAMBUSA VULGARIS*

N. Bhol* and H. Nayak

College of Forestry

Orissa University of Agriculture and Technology, Bhubaneswar - 751 003 (Odisha)

**E-mail: bhol_n@yahoo.com*

Bambusa vulgaris (Common bamboo) is one of the important bamboo species in coastal regions of the world from economic and environment point of view. This species is propagated vegetatively because it does not produce viable seed. Keeping this in view, an investigation was carried at Orissa University of Agriculture and Technology, Bhubaneswar, India to study the influence of month of propagation, age, position and size of culm cutting on propagation of this species. Five months of propagation (February, March, April, May, June), four ages of culm cuttings (½, 1½, 2½, 3½ year), three positions of culm cuttings (lower 1/3rd, middle 1/3rd, upper 1/3rd portion of culm) and four sizes of culm cuttings (1, 2, 3, 4 noded culm cuttings) were considered as treatments and the experiment was laid out in split plot design. The cuttings were planted horizontally in nursery bed and evaluated after 90 days of planting. Observations were recorded on sprouting period of cuttings, survival percent, height of dominating shoot, collar diameter of dominating shoot, shoot biomass per node, root biomass per node, total biomass per node and quality index of plant. The sprouting period of cuttings ranged between 10 and 17 days under different treatments. Similarly, the ranges of survival percent, height of dominating shoot, collar diameter of dominating shoot, shoot biomass per node, root biomass per node, total biomass per node and quality index of plant were 30-100%, 33-140.2cm, 0.18-0.75cm, 8.00-32.35g, 0.91-5.30g, 9.42-37.74g and 0.049-0.196, respectively under different treatments. The culm cuttings of *B. vulgaris* were found to be best propagated in April followed by March with 1½ year old culm cuttings from lower and middle 1/3rd portion of culm having 1 or 2 node size.

CAN CAMPA ACCOMPLISH THE ECO-RESTORATION PROCESSES OF CRITICALLY DEGRADED FOREST LANDSCAPES IN J&K STATE?

Rajeshwar Singh Jasrotia* and Anil Kumar Raina

Conservator of Forests, Van Bhawan, Below Gumat, Jammu -180 001 (J&K)

E- mail: rsj_1956@rediffmail.com

Forests are multifunctional ecosystems which provide various goods and services on all spatial and temporal levels. While developmental activities are essential for economic development, precautionary principle necessarily entails to protect & conserve its invaluable natural capital –its forests. Under provisions of J&K Forest Conservation Act, 1980, 11748 ha of forestland have been diverted (involving felling of 12.23 lac trees) for non-forestry purposes upto Aug, 2013. To compensate these forest losses, 103.41 lac saplings stands planted over an area of 13231 ha during the last three years (against target of covering 23496ha) under State Compensatory Afforestation Management & Planning Authority (CAMPA) established in State of Jammu & Kashmir. In few cases, forest landscapes have been critically damaged; 84 km long Mughal Road (longitude 74°- 22 to 74°-50 and latitude 33°-37 to 33°-43 with elevation varying from 3500 to 11500 feet above MSL) is prominent among them. Construction of this road in Poonch division lead to felling of 6647 forest trees of *Pinus wallichiana*, *Abies pindrow*, *Pinus roxburghii*, *Quercus incana* etc over 132 ha of forestland in ecologically very fragile strata, which has triggered as many as 20 landslips/landslides. To balance the uncompensated benefits comparable to original forest area is a function of multiple ecological characteristics of forests area diverted but can never adequately compensate for natural forests. Against a corpus of 69092.00 lac generated under provisions of CAMPA, amount Rs. 9371.31 lacs stands incurred till March, 2013 but without any attempt for restoration of this acutely degraded & an extremely difficult landscape. Present paper critically analyses the problems associated with eco-restoration of this critically damaged landscape, various conservation measures & silvicultural interventions required to trigger processes of eco-restoration, particularly in view of its geo-physiographical limitations. And based on the past experience, it is concluded that routine CAMPA works shall be simply inadequate / improper as quantum of degradation afflicted in this landscape shall require a highly specialized & integrated treatment for its eco-restoration.

SPATIAL DISTRIBUTION OF ABOVE GROUND BIOMASS AND CARBON POOL IN DIFFERENT VEGETATION TYPES OF NORTH WESTERN GHATS OF KARNATAKA, INDIA

G.M. Devagiri^{1*}, Anilkumar Khaple², Sarnam Singh³, Maruti Gurav¹, Santosh Hubballi¹, G.S. Pujar⁴, S. Tomer⁵ and Anith Raj¹

¹*Dept. of Natural Resource Management, University of Agricultural and Horticultural Sciences, Shimoga, College of Forestry, Ponnampet 571 216, Kodagu (Karnataka)*

²*Department of Environmental Science, Gulbarga University, Gulbarga (Karnataka)*

³*Indian Institute of Remote Sensing (IIRS), Dehradun 248 001 (Uttaranchal)*

⁴*National Remote Sensing Centre, Hyderabad 500 625, Andhra Pradesh, India*

⁵*World Agroforestry Centre, South Asia, New Delhi*

**E-mail: gdevagiri@gmail.com*

The present study was carried out with the objective to assess the above ground biomass (AGB) and carbon density in Belgaum and Uttarkannada districts under North Western Ghats of Karnataka during the year 2010-11. The biomass assessment was based on the field measurements of sample plots (0.4ha) laid in different forest types. Tree density and basal area (BA) varied considerably across the different vegetation types. Highest tree density (≥ 10 cm DBH) was recorded in semi evergreen forests of Belgaum (132 stems ha^{-1}) followed by Uttar Kannada (123 stems ha^{-1}) district with BA of 88.74 $\text{m}^2 \text{ha}^{-1}$ and 73.22 $\text{m}^2 \text{ha}^{-1}$, respectively. Though the tree density was less (113 stems ha^{-1}) in dry deciduous forest of Uttar Kannada district as compared to moist and semi evergreen forests, but the BA was found to be highest (128.40 $\text{m}^2 \text{ha}^{-1}$). Total AGB was partitioned into tree, shrub and herb layer which ranged between 23.10 to 1012.50 t-dry wt ha^{-1} . Similarly, the carbon density ranged between 10.86 to 475.88 t-C ha^{-1} in the region. In general, moist and dry deciduous forests of Uttar Kannada district contained higher biomass coupled with highest carbon stock. Semi evergreen forests of Belgaum district also contained high AGB and carbon but relatively lesser than dry deciduous forests of Uttar Kannada district. Information on such spatial distribution pattern of AGB and carbon density would serve as useful database for designing management strategies for natural forests of Western Ghat region. The Carbon stocking potential in these forests can be enhanced by reforesting the degraded areas with suitable tree species which will also address the climate change adaptation and mitigation.

FEMALE SPECIFIC MARKERS IN *HIPPOPHAE SALICIFOLIA* AND *HIPPOPHAE TIBETANA*: A TOOL FOR USEFUL IN LARGE SCALE COMMERCIAL PLANTATION

Aseem Chawla¹, R.S. Chauhan¹, Tsering Stobdan², Ravi B Srivastava² and Anil Kant^{1*}

¹*Department of Biotechnology and Bioinformatics, Jaypee University of Information
Technology, Wagnaghat, Solan-173 215 (HP)*

²*Defence Institute of High Altitude Research, DRDO, Leh-Ladakh-194 101(J&K)*

Email: anil_kantv@yahoo.com

Hippophae (seabuckthorn) is a dioecious shrub which belongs to family Elaeagnaceae. The female plants bears berries that are rich in vitamins, organic acids, fatty acids, flavonoids and antioxidants, thus provides various health related benefits. The oil in pulp and seeds of berries has immense value due to its unique composition making it useful in cosmetics and skin healing purposes. There are seven species of genus *Hippophae*, out of which three are found in India, namely *H. rhamnoides*, *H. salicifolia* and *H. tibetana*. *H. tibetana* occurs in Leh -Ladakh only whereas *H. rhamnoides*, and *H. salicifolia* are found other parts of the country like Himachal Uttrakhand, Sikkim and North east regions of the country. Male and female seabuckthorn plants are morphologically similar and cannot be distinguished prior to 3–4 years of growth, i.e., at the time of flowering. Commercial seabuckthorn Plantation requires only 10% male plants for adequate pollination. Financial resources and valuable time can be saved if undesired male/female plants can be discarded at an early stage of research trials and commercial plantation. SCAR based sex linked markers *HrX1* and *HrX2* developed for sex determination of *H. rhamnoides* were tested for their applicability on *H. salicifolia* and *H. tibetana*. *H. salicifolia* extensively grows as wild population in many areas of H.P. including Lahul Spiti, Kinnaur and Chabma districts. Commercial plantations of this species could be helpful for the upliftment of economy local people and at the same time valuable raw material will be available on large scale and competitive prices to nutraceutical, cosmetic, wine and juice industries. SCAR marker *HrX1* produced female specific amplification from genomic DNA of 85% and 100% female plants of *H. salicifolia* and *H. tibetana* respectively. *HrX2* did not amplify in either male or female plants of *H. salicifolia* or *H. tibetana*. Thus SCAR marker *HrX1* was proved as a robust sex specific marker across three species of seabuckthorn, which would be useful in crop improvement research as well as to ascertain female plants before commercial plantations.

OPTIMIZATION OF HIGH QUALITY PCR USABLE DNA EXTRACTION FROM *AZADIRACHTA INDICA* A.JUSS

K.Rajarajan*, Deepika Khanna, S. Vimala Devi, A.K.Handa and S.K.Dhyani

National Research Centre for Agroforestry, Jhansi (UP)

**E-mail: rajesh.tinu@gmail.com*

Azadirachtaindica A. Juss, commonly known as neem, a native of Indian sub-continent is remarkable multipurpose tree species belongs to family Maliaceae. This tree is considered for its high commercial value due to its valuable biological properties also acts as bio pesticide. Genetic

improvement of this tree species needs further serious consideration especially molecular improvement of this species is very essential for conservation and utilization. Generally, it is difficult to extract high pure quality genomic DNA from this species due to high phenols, polysaccharides and secondary metabolites. Hence a method was developed for extraction of high pure DNA from neem by making a modifications in Walbot method. Modification includes Addition of (PVP) polyvinyl pyrrolidone 4% in the extraction buffer, increasing the volume of NaCl in grinding buffer, addition of 0.2% β - mercaptoethanol and increasing the volume of 20% (SDS) Sodium Dodecyl Sulphate. The method developed yielded high quality genomic DNA with a yield of 53-66 ($\mu\text{g}/100 \text{ mg}$ of leaf).The intact DNA with single band on agarose gel indicates that the genomic DNA was free from phenolics, polysaccharides and RNA contamination. The quality of genomic DNA were analysed for purity by estimation of absorbance ratio at 260/280, which ranged from 1.7 to 1.9 indicating no contamination The extracted genomic DNA was further used in PCR amplification with RAPD primers. The PCR products were proved that the genomic DNA can be useful in downstream nucleic acid applications and genomics studies.

FOREST MANAGEMENT PLANNING: RESPONDING TO CLIMATE CHANGE

M.P.Singh

Climate Change and Forest Influence

Forest Research Institute, Dehradun 248 195 (Uttarakhand)

Working Plan is the main instrument of forest management planning in the country. It is very useful for evaluating the status of forest resource of a forest management unit (e.g. division), assessing the impact of past management practices and deciding about suitable management interventions for future. Every Working Plan includes the area-specific scientific prescriptions for proper management of forests of a particular forest division, where as Working Schemes is prepared for smaller areas for a specific purpose or for forest areas under the control/ ownership of such bodies as private, village, municipal, cantonment, autonomous district council (especially in North Eastern States) etc. Periodical up-dating and revision of Working Plans is essential to keep pace with the trends emerging out of forest–people interface and to address other national and international obligations. All forests are mandatorily to be managed under the prescriptions of a working plan/scheme. The National Forest Policy clearly states “No forest should be permitted to be worked without an approved working plan by the competent authority. The forest working plans generally provide prescriptions for suitable silvicultural techniques aiming at sustainable yield of timber. However, global paradigm shift in the policy and approach towards forestry sector has shifted the focus from timber harvesting to environmental stability, protective functions of forests, monitoring and management of biodiversity and restoration of ecological balance. The challenges thrown by the growing demographic pressure on forest resources in the country lead to enactment of various conservation-centric policies and regulations during the

later part of 20th century. However, in the context of global climate change phenomenon and emphasis on ecosystem services in the early 21st century, these challenges have become more aggravated forcing a revisit of forest management planning procedure. An effort in this paper is made to highlight the knowledge gap, present drawbacks and future needs in the provisions for forest management planning especially in the context of climate change.

ASSESSMENT OF LAND USE CHANGES IN DOON VALLEY THROUGH REMOTE SENSING AND GIS APPROACH

C. Jana*, D. Mandal, S. S. Shrimali and Raj Kumar

Hydrology and Engineering Division, CSWCRTI, Dehradun-248 195 (Uttarakhand)

Email: chayna_4503@yahoo.co.in

The conversion of agricultural and forest areas to other uses associated with the growth of population and economy is one of the greatest challenges facing the developing countries. In this context, integration of Remote Sensing (RS) and Geographic Information Systems (GIS) has been recognized as a powerful and effective tool in detecting land use and land cover change pattern. A study was conducted focusing on identification and quantification of the land use/ land cover of Doon valley (study area) for different time periods to assess the spatio-temporal land use changes with the help of Remote Sensing and GIS. The SRTM data (90m DEM) were used for delineation of study area (Doon valley). Total study area was divided into two main watersheds (one with outlet Paonta sahib dam and another with outlet Rishikesh river) using GIS software. These main watersheds were again sub-divided into different sub-watersheds. Land use classification was carried out to generate land use images for two different periods 2000 & 2009 from multispectral Landsat TM data (30 m resolution). After comparing both images, it was evident that there is considerable decrease (8% area) in the dense forest cover from the period 2000 to 2009, whereas open forest, scrub land and settlement class are showing an increasing trend and thereby resulting to the inference that the population pressure is playing a very active role towards diminishing forest cover.

EVALUATION OF THE SUITABILITY OF BAMBOO (*DENDROCALAMUS STRICTUS* ROXB.) FOR PREPARATION OF PARTICLE BOARD

V.G. Kshirsagar, A. U. Nimkar*, Y.B. Taide, N.K. Kapse and S.S. Harne

Department of Forestry

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola 444 104 (Maharashtra)

**E-mail: au_nimkar@yahoo.co.in*

Bamboo is a promising source of lignocellulosic material growing in all parts of our country and it is easily available in large quantities. The experiment was conducted at Forest Products Workshop, Department of Forestry, Dr. P.D.K.V., Akola during 2010-11. The objective of the study was to standardize the suitable percentage of resin for the preparation of board. In this

study, phenol formaldehyde bonded particle boards were prepared from Bamboo (*Dendrocalamus strictus*) using hydraulic hot press with resin content viz., 6, 7, 8, 9, 10, 11, 12, 13 and 14 per cent. Subsequently, they were tested for different physical and mechanical properties according to Indian Standard Specification IS: 3087 (1985). The results showed that *Dendrocalamus strictus* is suitable for manufacturing of medium density particle boards. Satisfactory boards were prepared from bamboo using 11 per cent phenol formaldehyde resin met the requirement in respect of physical and mechanical properties as specified in IS: 3087.

POTENTIAL USE OF LEMON-SCENTED EUCALYPTUS OIL AS BIO-HERBICIDE FOR EFFECTIVE AND SELECTIVE CONTROL OF WEEDS IN WHEAT

Sumit Chaturvedi¹, Ankita Arya¹, Salil Tewari¹, V. C. Dhyani¹ and Rajesh Kaushal²

¹*Agroforestry Section, GBPUAT, Pantnagar, U S Nagar -263 145 (Uttarakhand)*

²*CSWCRTI Dehradun-248195 (Uttarakhand)*

Eucalyptus has succeeded as a preferred species for agroforestry and farm forestry interventions throughout the country. Among various species, lemon scented Eucalyptus (*Eucalyptus citriodora* Hook.) is well-known for its antimicrobial, antifungal, insecticidal and nematicidal activities. Eucalyptus oil is mixture of various sesquiterpenes and their precursors releasing volatile compounds which inhibited growth of crops and weeds growing near it. Allelopathy has emerged as an important area of weed research and has been accepted very recently as an important ecological phenomenon. The present studies were conducted to explore the possibility of use of *E. citriodora* essential oil for weed control. The laboratory bioassay was carried out to assess the inhibitory effect against wheat and associated weeds. Germination percent and shoot length of wheat and weeds were reduced significantly with increase in the concentration of leaf oil from 0 to 3.2 ppm. Decreasing trend in seedling root length was also observed with each successive increase in concentration of leaf oil. Based on germination, dose response curve was generated to calculate LC_{50} values showing differential selectivity for narrow, broad leaf weeds and wheat. However, none of the concentration inhibited wheat germination by 25 percent. Another greenhouse experiment was conducted to establish the herbicidal activity of Eucalyptus against wheat crop and associated weeds and to explore their possible mechanism of action. Spray treatment of volatile oil on the 4 week old mature plants of weed species adversely affected the growth in term of height, chlorophyll content and mortality percent. Hydrogen peroxide and electrolytic leakage were drastically increased in oil treated plant, thereby indicating the adverse effect on photosynthetic machinery and energy metabolism. Based on the study, it is concluded that *E. citriodora* oil possesses suppressing ability for both broad and narrow leaved weeds. Hence, it can be a useful natural plant product for developing bioherbicide.

MITIGATION OF HUMAN- ANIMAL CONFLICT THROUGH AGROFORESTRY INTERVENTION

Neenu P*, H.K.Deshmukh, Y.B.Taide Andv.P.Mane,

College of Forestry

Dr. Panjabrao Deshmukh Agricultural University, Akola – 444 104, (Maharashtra)

E-mail: neenu162@gmail.com

Rising population and development projects are causing great damage to country's natural resources and wildlife. Road kills and damage to human properties and life are the two important aspects of human-animal conflict. In order to maintain species diversity, gene flow, aesthetic value, ecological balance and also to reduce entry of wild animals into human dwellings and to protect their assets, implies necessity for introducing a practical and liable model for the same. Existing methods like closure of roads, restrictions to night- journey, fencing and guarding fields etc. are found to be less effective and inconvenient. Two agroforestry models have been designed to reduce human-animal conflict in which the first one is 'Two Storey Bio-hedge for village boundaries and road kill prone areas' built by planting Indian redwood tree (*Caesalpinia sappan*) as upper storey and agave species as lower storey in quincunx pattern with plant to plant distance 2mX2m and width 10m. In this upper storey plants helps in preventing the entry of large sized animals, while lower storey agave plants helps in preventing the entry of small sized animals and reptiles. The second model is 'Bio-hedges for field boundaries' built in single storey using Indian redwood tree (*Caesalpinia sappan*) in quincunx pattern with plant to plant spacing 1mX1m and width 3m. But fields which are close to forest having frequent occurrence of fire , can have lower storey of agave species as it prevent entry of fire to field to a certain extend. The innovative method of planting Indian redwood tree (*Caesalpinia sappan*) as bio-hedge alone or with agave spp. along road sides and field boundaries are eco-friendly and economical. Selected plant species also help to earn additional income.

CHLOROPHYLL FLUORESCENCE ANALYSIS AS AN IMPORTANT TOOL TO KNOW THE PLANT RESPONSE TO CLIMATE CHANGE: A CASE STUDY ON TREE SPECIES OF DIFFERENT SUCCESSIONAL GROUPS

K.A.Sreejith*, Jose Kallarackal and U.M.Chandrashekara

Forest Ecology and Biodiversity Conservation Division

Kerala Forest Research Institute, Peechi – 680653 (Kerala)

E-mail: sreejith@kfri.res.in

The measurement of chlorophyll *a* fluorescence has been widely used as a useful technique for obtaining rapid quantitative and qualitative information about the performance of photosynthetic system. The current study used chlorophyll fluorescence as a tool to understand the physiological response of photosynthetic system for the changing light regimes in case of primary, late-secondary and early-secondary species. Chlorophyll fluorescence parameters, especially Fv/Fm

(Photosynthetic efficiency of PS II) showed clear difference between the successional groups especially in extreme light regimes. In the case of primary (shade loving) species, optimum value for Fv/Fm was found in low light condition (10%). Late-secondary (medium light demanding) species, showed optimum value upto 50% light (10%, 25% and 50%) while in Early-secondary (high light demanding) species, the value was optimum at medium light environment (both at 25% and 50% light conditions). Comparing to Late-secondary species, Early-secondary species were poorly adapted at low light level (10%) which indicates the light-demanding nature of Early-secondary species when compared others. It is also noteworthy that none of the three groups having optimum Fv/Fm value at 100% light. All categories showed poor physiological efficiency for photosynthetic system at higher light regime (>50% light) due to the negative effect of photo-inhibition but the effect of photo-inhibition is negligible in the case of Early-secondary species in high light (100%) environment and showed significantly high photosynthetic efficiency than other two groups of plants in open light. The result clearly indicates that the chlorophyll fluorescence study at different light regimes could be useful to understand the ecophysiological response of plants in varying light environment. In addition to the response of plants to different light regimes, this technique can also be used as a diagnostic tool to know the optimum environmental condition for a plant as per any variable such as environmental stress, genotypic variation, soil and nutrient parameters, temperature and other climatic factors. In the context of climate change, identification and conservation of population of species having the genotypic plasticity in the changing climate is of practical importance and measurement of chlorophyll fluorescence in varying climatic condition can be an efficient tool to select the suitable population/species adaptable to climate change.

ADAPTATION AND MITIGATION MEASURES AGAINST CLIMATE CHANGE IN THE FORESTRY SECTOR OF KERALA STATE

U.M. Chandrashekara

Kerala Forest Research Institute Sub Centre, Nilambur, Chandakunnu P.O. 679 34 (Kerala)

E mail: umchandra@rediffmail.com

In the present paper, the climate change impact factors such as precipitation, atmospheric temperature sea level changes and emission of greenhouse gases (GHGs) are discussed in the context of Kerala State. The high resolution daily gridded dataset for a period of 100 years (1901-2000) provided by the Climate Research Unit Time Series (CRU TS- version 2.10) was used to analyse the long-term trend of rainfall and temperature in Kerala. The mean annual rainfall and seasonal rainfall over the State showed an insignificant declining trend. The number of wet days during the south-west monsoon increased significantly and decreased during pre-monsoon and winter seasons. However, throughout the State daily average, maximum and minimum temperatures increased irrespective of the season. The data available for a period of 68 years (1939-2007) showed that the sea level rose significantly at the rate of 1.49 mm/year. The forest cover in the State seems to be stabilised to around 17,382 km². However, increasing level

of anthropogenic disturbances in the State are accompanied by a reduction in forest biomass, impaired vegetation structure, altered regeneration spectrum, floristic changes and opening of the forest canopy. All these factors are leading the forest to become highly sensitive to climate change and reducing its inherent adaptive capacity. Thus, without adopting suitable mitigation and adaptation strategies forests are not in a position to cope up with the climate change. In the present paper, actions to maintain or enhance a) forest extent, b) biodiversity, c) forest health, d) productivity in forest ecosystems and e) forest soil and water, are identified as important adaptation strategies. A number of options are highlighted under each adaptation strategy.

FOREST HEALTH MANAGEMENT SCENARIO IN 21ST CENTURY

Jagdish Chander and Sanjeev K Chauhan*

Haryana State Forest Department, Panchkula (Haryana)

Department of Forestry and Natural Resources, PAU Ludhiana 141 004 (Punjab)

E-mail: jc845@hotmail.com, chauhanpau@pau.edu

In view of the global shift in the objectives of forest management from timber production and revenue generation to ecosystem management, forests in 21st century are no longer a timber and plantation management business. In view of the climate change influencing the species ecology, the forest managers are today entwined with the challenge of meeting the immediate fuelwood, fodder and timber requirements of the people on a sustainable basis on one hand and required to perform the role of a doctor of the forest ecosystems on the other hand. Looking back at the history of forest management and forest management training, the forest managers were trained for management of trees for timber production and revenue generation. However, the present forest management scenario requires to look forest as a single entity and that includes all form of life existing in the forest right from the invisible microorganism to biggest terrestrial animal - the elephant/the biggest aquatic animal - the whale. The total number of tree species in India are around three thousand and they constitute less than one per cent of the total biodiversity of the country. The rest 99 per cent biodiversity yet required to be explored and studied for its role in nourishing and maintaining forest health and wealth. We need to explore all forms of life other than trees like bacteria, virus, algae, lichens, ferns, herbs, shrubs, climbers, nematodes, earthworms, insects, arachnids, arthropods, fish, reptiles, birds and mammals for their role in maintaining ecological harmony. The forest health management in 21st century requires holistic integrated ecosystem management approach of all life forms, especially in light of their response to climatic change. Adequate plant protection management has to be ensured in view of the emerging new pests like *Leptocybe invasa*, and little leaf disease, which nearly devastated *Eucalyptus* recently besides not allowing invasive alien species to cross borders. Pest resistant, high yielding clones and varieties of short rotation crops have to be developed for maintaining adequate balance between the production and the conservation. Various aspects of bacteria, virus, fungi, plant and animal kingdoms, which are otherwise vital for the forest health but have been ignored historically, have been described in the paper.

BUILDING RESILIENCE FOR ADAPTATION TO CLIMATE CHANGE THROUGH SUSTAINABLE FOREST MANAGEMENT

Sabeena Nabi*

Faculty of Forestry, Camp Wadura, Sopore, SKUAST-K 193 201(J&K)

**E-mail: nabisabeena@gmail.com*

There are varied drivers of deforestation and causes of forest degradation around the world. Among others, these include conversion to other land uses (mainly agriculture), overharvesting of wood and non-wood forest products, poor timber harvesting practices, overgrazing, pest and disease outbreaks, invasive species and wild fires. Underlying drivers vary from place to place, including government policies that drive land-use changes, market forces altering demand for forest products, poverty and food insecurity, unclear or insecure and or resource tenure, among others. Climate change, and in some cases climate change responses, are adding to the existing stresses on forests by contributing to decreased productivity and dieback of trees from drought and temperature stress, increased wind and water erosion, increased storm damage, increased frequency of forest fires, pest and disease outbreaks, landslides and avalanches, changes in ranges of forest plants and animals, inundation and flood damage, saltwater intrusion and sea level rise etc. Successfully addressing the negative impacts of climate change on forests and forest dependent people will be crucial in making progress towards sustainable development goals by increasing the resilience of vulnerable people and to help build and maintain resilient landscapes in drylands, to ensure that adequate technical knowledge and expertise, an enabling policy and legal framework, responsive and effective institutions and governance mechanisms that can support timely, appropriate and equitable decision-making and action at local level are all in place. Sustainable forest management is an overarching goal for the forestry sector, applicable at international, national and sub-national levels with some of the key management strategies for increasing resilience of forests to climate change which includes; maintaining healthy forest ecosystems for resilience, forest health and vitality, restoring degraded forests like "The Bonn Challenge" agreed at a ministerial conference held in Bonn (in September 2011) the restoration of 150 million hectares of lost forests or degraded lands by 2020, conserving and enhancing biodiversity, integrated pest management, disease control, forest fire management, employment of reduced impact logging (RIL) in production forests, limitation of gathering of non-wood forest products or livestock grazing in forests at sustainable levels, and forest law enforcement.

A REVIEW ON MULTI-ENVIRONMENT PROGENY TRIALS OF *MELIA COMPOSITA* WILLD.: BROAD STUDY FOR G X E PERFORMANCE

M.S. Bhandari, Ashok Kumar, Rama Kant, Shruti Sharma and U.S. Rawat

Division of Genetics and Tree Propagation

Forest Research Institute, P.O. – I.P.E., Kaulagarh Road, Dehradun 248 195, Uttarakhand

E- mail: maneesh31803@gmail.com

The operational off-site species plantation helps in knowing the performance of genotypes well outside their current climatic range and allowable seed transfer zones. Moreover, G X E performance is always based on the Multi-Environment Trials (METs) of a particular variety or genotypes. Field trials of *Melia composita* were established at different sites of Punjab and Haryana during Monsoon season from June-2013 to July-2013. Data of these plantations trial have probability to indicate that not only can these species survive in non-optimal climates, but also that they have the potential to grow at rates that are as good as or better than the local species. All the seed-lots assessed and used for planting were collected from natural stand collections and mother plantations trials already established at Pandori-Mindo-Mind, Hoshiarpur, Punjab. With improved nursery practices at FRI, Dehradun seedlings were raised and varieties showing excellent potential were carried out for Multi-Environment plantation trials. At both Haryana and Punjab which are climatically different, appropriate site selection and designing of treatments are carried out as these are more important for achieving successful plantation establishment. The field assessment of the operational plantations made it clear that early survival was critical to establishing a viable off-site species plantation.

***GLIRICIDIA*: ALLEY CROPPING SYSTEM IMPROVED PRODUCTION OF VEGETABLE IN ANDAMAN ISLANDS**

B.L. Meena^{1*}, S.K. Ambast² and R.L. Meena³

^{1, 2, 3}Project Coordinating Unit

Central Soil Salinity Research Institute, Karnal-132 001(Haryana)

^{1, 2} Formerly with Division of Natural Resource Management, Central Agricultural Research Institute, Port Blair- -744101 (A&N Islands)

Email: blmeena2008@gmail.com

The study was conducted at Sippighat research farm of Central Agricultural Research Institute (CARI) Port Blair, during 2006-2010 to know production potential and economic benefit of an alley cropping system of agro-forestry in humid climate of Island ecosystem in which crops are grown between the hedgerows. Plant to plant distance of *Gliricidia sepium* within a hedgerow is 50 cm but distance between the hedgerows varies according to terrain, slope, terrace size and purpose of the system. One year after planting, harvesting can be started by lopping the plants at 1 m above the ground. Pruning should be done at least thrice during the year; *i.e.*, in June, November and March. Treatments included control, 3, 5 and 8 tonne fresh leaves of *Gliricidia* and three times of application (0, 2 and 4 week after sowing). After pruning the lopping, they are

made into smaller pieces and mixed into soil. The production of *Gliricidia* leaf dry matter value reported around 12.6 tonnes /ha/year. *Gliricidia* loppings applied in brinjal and okra intercrop grown in alleys. The 5 tonnes *Gliricidia* lopping ha⁻¹ applied properly for obtaining the significantly higher yield and net returns as compared to 8 and 3 tones of lopping treatments. Thus through indigenous application of *Gliricidia*, add sufficient nutrient to intercrops vegetables. *Gliricidia* leaves are found most suitable for green manuring in Islands ecosystem because it contains 2.5-3.0 % nitrogen in its leaves and also fix nitrogen. Release of nitrogen was maximum 64.12 kg ha⁻¹ within 30 days at the time of sowing crop that declined with time and was lowest at 75 days. It seems the rate of mineralization and nitrogen uptake synchronize best at the time of sowing treatment that facilitate higher crop yield compared to two and four week after sowing. Farmers need to encourage for growing of *G. sepium* on farm as per standardized design to get its potential benefit as manure, bio-mulching of intercrops, checking the soil erosion and improving soil health status in high rain fall areas.

GMELINA ARBOREA AS HIGH DENSITY PLANTATION TO RECLAIM THE RED LATERITIC WASTELAND LANDS OF CHHATTISGARH

M.N.Naugraiya* and S.S.Shaw

Department of Forestry

Indira Gandhi Agricultural University, Raipur - 492 012 (CG)

E-mail: drmn_13@yahoo.co.uk

Gmelina arborea indigenous tree species to Indian sub continents is locally known as Khamar / Gambhar and is fairly grown in natural forest area and also cultivated as farm forestry. It is a fast growing promising multipurpose tree species and belongs to Teak family-Verbenaceae, having potential to produce bole biomass. The plantation of *Gmelina arborea* was carried out at the spacing of 1x1m in the current fellow lands in the Dr Richhariya Research and Instructional Farm of IGAU at Baronda (Raipur). The growth performance of plantation was recorded up to 10.5 years. Trees were felled down to estimate the harvest of dry matter production, N, P, K and combustible energy in form of different tree components viz; root, bole, bark, branches, twigs and foliages. The coppice behaviour of felled tree's stumps was also studied for regeneration potential. The production of under storey herbage was recorded along with adjacent barren lands at different age of plantation. Soil properties of plantation site and adjacent open field were analyzed at four different soil depth viz; 0-15, 15-30, 30-60 and 60-100 cm soil depth. The result of study showed that wasteland of red lateritic, produced tree biomass of 16.0 kg dry wt/tree with harvesting of 56452.9 Kcal/tree combustible energy as well as N, P, K and carbon and improved the soil quality at every soil depth. Among felled trees 75% coppicing was seen to go second growth phase. Thus in this paper the resource utilization was discussed in light of high density plantation of *Gmelina arborea* in the red lateritic wastelands of Chhattisgarh.

SOIL FERTILITY AND CARBON FRACTIONS UNDER TREE BASED LAND USES IN LOWER SHIVALIKS

Sharmistha Pal*, Pankaj Panwar, V.K. Bhatt and Ram Prasad

Central Soil and Water Conservation Research and Training Institute, Research Centre, Madhya Marg, Chandigarh - 160 019

*E-mail: sharmistha.ars@gmail.com

The research was conducted in light-textured hyperthermic Udic Ustochrept soil of lower Shivalik Himalayan region of India, under different canopy positions of *Terminalia chebula*, *Embilica officinalis*, *Mangifera indica* and *Psidium guajava*. Soil pH varied from 7.04 to 7.6, and Electrical conductivity varied from 0.19 to 0.32 dSm⁻¹. The highest available nitrogen was recorded near tree trunk, irrespective of tree species. The highest available nitrogen was under *T. chebula* (335 kgha⁻¹), followed by *M. indica* (312.5 kgha⁻¹), *P. guajava* (308 kgha⁻¹) and least in *E. officinalis* (278.9 kgha⁻¹). At canopy edge, the available nitrogen varied from 324.9 to 280.1 kgha⁻¹ under *Terminalia chebula* and *E. officinalis*, respectively. Near tree trunk, the phosphorus was found to be maximum in *M. indica* (28.48 kgha⁻¹), followed by *E. officinalis* (24.65 kgha⁻¹), *T. chebula* (24.56 kgha⁻¹) and least in *P. guajava* (21.56 kgha⁻¹). The range of available phosphorus at canopy edge was 25.64 to 19.5 kgha⁻¹ under *M. indica* and *P. guajava*, respectively. The highest SOC content near tree trunk was in *Terminalia chebula* (0.705 %), followed by *M. indica* (0.683 %), *P. guajava* (0.596 %) and least in *E. officinalis* (0.514 %). The SOC at canopy edge ranged from 0.554 % under *E. officinalis* to 0.686 % under *T. chebula*. Highest zinc was found under *M. indica*, while, highest iron was recorded under *E. officinalis*. Canopy edge did not affect micronutrient concentration. Bulk density varied from 1.32 to 1.45 g cm⁻³. Pore space was 44.5% in surface soil of *Mangifera indica* and lowest 40% at 30 - 45 cm depth in *T. chebula*. Pearson's correlation matrix revealed significant correlations of soil organic carbon with other soil properties.

MOLECULAR CHARACTERIZATION OF SEVEN SPECIES OF BUTTERFLIES (LEPIDOPTERA: INSECTA) BY RAPD-PCR

M.S.Thakur

Department of Biosciences, Himachal Pradesh University Shimla-171 005 (HP)

E- mail: mahender74@yahoo.co.in

Molecular characterization of seven butterflies was carried out using five RAPD markers. Total 91 bands were scored with five decamer primers of which 91 were polymorphic and the percentage of polymorphism was 100%. Genus specific bands have been observed i.e. 1142bp with primer 1, 1166bp, 658bp, 570bp with primer 2, 1027bp with primer 12 & 428bp with primer OPP-5. Dendrogram based on average similarity coefficient of five primers grouped seven butterfly species in to three clusters. Cluster-I comprises of five species viz. *Dodona eugens*, *Lycaena phlaeas*, *Heliophorus sena*, *Celastrina cardia* and *Celastrina hugelii*. Cluster-II & Cluster-III comprises of one species each i.e. *Arícia astrarche* & *Lampides boeticus*

respectively. Cluster –I is subdivided in to two, sub-cluster-I consists of only *Dodona eugens*, sub-cluster-II consisting of *Lycaena phlaeas*, *Heliophorus sena*, *Celastrina cardia* & *Celastrina hugelii*. Su-cluster-II is further divided in to two sub-sub-clusters, sub-sub cluster-I comprises of *Lycaena phlaeas* & *Heliophorus sena* and sub-sub cluster-II comprises of *Celastrina cardia* & *Celastrina hugelii*.

**BIODIVERSITY AND BIOLOGY OF ACANTHOSCELIDES
MACROPHTHALMUS (SCHAEFFER) (COLEOPTERA: BRUCHIDAE),
A SEED PEST OF LEUCAENA LEUCOCEPHALA (LAMARK) DE WIT**

D R Thakur* and Kalpna

Department of Biosciences, Himachal Pradesh University, Shimla – 5 (HP)

*E- mail: *drdr4@rediffmail.com*

A large number of non-native insect species invading new areas either accidentally or through man mediated trading consignments. Similarly many pulse beetles have crossed the geographical boundaries and becoming cosmopolitan in distribution, thus posing major pest problem worldwide particularly in the absence of their natural enemies. A leucaena bruchid beetle, *Acanthoscelides macropthalmus* (Schaeffer) (Coleoptera: Bruchidae) native to Central and Southern America has somehow crossed the geographical boundaries and recently spread in different states of the India and found infesting seeds of *Leucaena leucocephala* (Lamarck) de Wit plant almost throughout the subcontinent. *Acanthoscelides* Schilsky (1905) is one of the largest genus of the tribe Acanthoscelidini containing more than 340 species globally and the species, *macropthalmus* was described by Schaeffer in 1907 and placed under genus *Bruchus* but Johnson in 1968 rightly put the species under genus *Acanthoscelides*. The congeneric species, *A. pallidipennis* reported from China, Korea and Japan and *A. obtectus* (Say) has been recently reported from India. Studies of Indian bruchids carried out so far did not reveal the complete taxonomy, biology and pest status of this species except a mere reference of its presence from southern part of the country. However, phytosanitary risk of thirteen bruchid species in legumes bulk imports has been alarmed by National Quarantine Division (NQD) and hidden infestation instances of different species belonging to *Acanthoscelides*, *Bruchidius* and *Caryedon* genera and their X-ray screening immediately on arrival in Indian Territory was advocated.

**WILD EDIBLE TREE FRUITS OF SIKKIM HIMALAYAS
C. P. Suresh¹, K. D. Bhutia², G. Shukla², K. Pradhan² and S. Chakravarty²**

¹*North Eastern Hill University (Tura Campus) Tura (Meghalaya)*

²*Uttar Banga Krishi Viswavidyalaya, Pundibari (West Bengal)*

sureshcp2112@yahoo.com, c_drsumit@yahoo.com

Wild edible tree fruit species are traditional sources of nuts, fruits, edible oil and beverages. In Sikkim, these fruit species is valuable in several other ways pertaining to social, economic and ecological services. Surveys were conducted to document the baseline information on use of wild

tree fruits in Sikkim Himalayas. Information on wild tree fruit species were collected during structured and semi-structured interviews with native people. Free listing technique enlisted 21 wild edible tree fruits represented by 15 families and 19 genera. These fruits were generally eaten fresh and raw. Some fruit species are socially and commercially important and also has medicinal value such as *Diploknema butyraceae*, *Terminalia chebula*, *Spondias axillaris* and *Castanopsis hystrix*. These fruits have a great potential to contribute towards nutritional security during food scarcity and can certainly boost the economy of poor people if value addition is encouraged.

DECIDING THE BEST PLUCKING STAGE OF *JATROPHA CURCAS* L. USING ITS FRUIT COLOUR AS A VISUAL INDICATOR

Sumit Chakravarty*, Gopal Shukla and Biplab Sharma

Department of Forestry

Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar - 736 165 (WB)

**E-mail: c_drsumit@yahoo.com*

Jatropha now has emerged as front runner and premier alternative to conventional fossil fuel. *Jatropha* can succeed if promoted through a systematic programme with realistic targets. Looking at the vital importance and the paucity of sufficient information regarding the cultivation of this crop in terai region of West Bengal, an experiment was carried out to identify the best *Jatropha* accession/collection and fruit colour to establish the best plucking stage of its fruits. The experiment was laid out in factorial RBD in the nursery replicated thrice in which the accessions (ten) were analyzed for suitable plucking stage (three). On the basis of oil content and germination of the seeds extracted from dark brown fruits, the best five accessions were ranked which had more than 36 % oil and 85 % germination. The results recommend that the classification of *Jatropha* fruits based on fruit colour and not on the flowering phenology (days after anthesis) has economic and logical application to obtain seeds of this species because the data recorded positively related the epicarp colour of *Jatropha* fruits at different maturation stages with morphometric characteristics of fruits and seeds and with seed germination characteristics indicative of physiological maturity of seeds. Thus, the ideal time to harvest the *Jatropha* fruits having a better physiological quality with high levels of vigor and germination that too with lesser visits reducing burden on the manpower is when the fruit epicarp turn dark brown. Alternately, fruit bunches having more than 10 % yellow are better because after two days in storage all fruits in the group start to turn yellow or ripe. The fruits harvested will have high extracted oil yield when allowed to ripen and or senesce off the tree. It is further recommended not to harvest fruit bunches which are 100 % green as not all of the fruits will ripen off the tree after five days of storage. This will increase harvestable fruits and indirectly reduce harvesting visits and cost.

SUSTAINABLE PRODUCE FOR FOOD & FEED SECURITY THROUGH AGROFORESTRY AND TREE FARMING

Manmohan J.R. Dobriyal, Rajesh P. Gunaga and Arvind Bijalwan*

Department of Silviculture and Agroforestry

College of Forestry, Navsari Agricultural University, Navsari (Gujarat)

**Division of Technical Forestry*

Indian Institute of Forest Management, Bhopal (MP)

Tree produce are used since ancient time for diverse purposes by prehistoric and present aboriginals. Besides timber, fuel wood and other industrial wood trees play a vital role in food and feed including medicine. Tree produces which still in use of 30-50% population of the world for their primary health and food-feed security of human and livestock. In India too, 40-50% of tribal and rural mass dependent on tree produce for food, feed and health besides fulfilling other needs. The ethnobotanical studies shows that primitive tribes and rural folks explored the uses of almost all the area of tree from wild to cultivated field and depending upon the need, taste, availability and region they are in use by society. Trees being perennial nature can be sustainable source for food & feed in present era of global warming and climate change. Traditionally wild fruits and food symbolizes famine food but now they equally relish by masses as ethnic food in most of urban food centers. Further, there will be upsurge in use of these products in ethnic cuisine with blend of agro-ecotourism. Many of MPTs are already in use in agroforestry and tree farming to cater the basic need of fuel and fodder in rural areas but there potential as food & feed security not prioritized. There is now need to screen the prioritized trees for food & feed produce and introduce these in the cropping system for crop diversification, integrated farming projects and ensure food & feed security for the society. The awareness about their use, silviculture, domestication and rational sustainable harvesting etc. in farm is the need of the hour. Formulation of specific agroforestry and tree farming projects for food and feed security in different ecologies of India from the indigenous trees and ITKs should be promoted through a national mission. The present paper focused on the trees for food & feed, current agroforestry & tree farming practices in different ecologies for these trees, approaches to include indigenous trees in agroforestry and tree farming and national policy initiatives.

TREE DIVERSITY PATTERN IN A SUB-HUMID TROPICAL FOOTHILL FOREST OF INDIAN EASTERN HIMALAYAS

Gopal Shukla, Mohit Subba, Tanusri Dey, Prakash Rai, Anju Puri* and Sumit Chakravarty

Department of Forestry

Uttar Banga Krishi Viswavidyalaya Pundibari- 736 165 Cooch Behar (WB)

**Barring Union Christian Colllege, Batala (Punjab)*

E-mail: gopalshukla12@gmail.com; c_drsumit@yahoo.com

The study of natural plant community is basic and prerequisite for understanding the structural and functional attributes specific to locate for better land scape management. A study was conducted at Chilapatta Reserve Forest, West Bengal India to assess its tree diversity and also to

document its floristic characteristics. Stratified random nested quadrat sampling was adopted for analyzing the quantitative characters. One hundred fifty nine tree species were recorded, of which twenty nine are yet to be identified. Identified species represented 41 families and 91 genera. The tree diversity index, concentration of dominance, Shannon and Wiener index and evenness index estimated was 2.07, 0.018, 4.70 and 1.43, respectively. Highest and lowest frequency recorded was 0.19 and 54.39 while relative frequency varied from 0.01 to 5.15. Tree density ranged from 0.44 to 172.81 individuals ha⁻¹ and relative density ranged from 0.01 to 1.96 %. Trees were widely distributed and its abundance ranged from 0.60 to 17.83 while relative abundance ranged from 0.07 to 1.89 %. IVI ranged between 0.13 and 8.74. The tree stratum was clearly distinguished in to three layers according to the size of the trees i.e. the height they attained (tall, medium and low heights). The forest can be classified as dense forest having more or less continuous tree canopy with more than 80 % interception of incident PAR. Higher IVI value indicates ecological significance of the tree species in the forest. The tree density, dominance and diversity will indicate its changes and susceptibility to anthropogenic stressors among various vegetation categories and their formation.

LINKING WATERSHED IMPROVEMENT WITH COMMUNITY LIVELIHOOD THROUGH A&R CDM PROJECT: A CASE FROM INDIA

Ajay K. Lal

Chief Conservator of Forests cum Executive Director HP Mid Himalayan Watershed Development Project

Solan – Himachal Pradesh

The Clean Development Mechanism (CDM) A/R Project, "*India: Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds*", is a pioneer effort - first in India and most probably in Asia- being implemented mostly on public degraded lands by a government Agency viz. State Forest Department. Further, under umbrella of the larger on going IBRD funded Mid-Himalayan Watershed Development Project (MHWDP), it has shown the way how Watershed Development with emphasis on enhancing livelihood of the local communities could successfully and efficiently be linked to CDM plantations and how fifty thousand poor people living in the 602 scattered villages around degraded lands spread in the mid and high hills (600 to 1800 meters above the mean sea level) falling in 10 districts of Indian Province Himachal Pradesh could receive multiple benefits from improved natural resource management practices.

The CDM Project involves local communities, particularly small and marginal farmers in plantation activities on degraded common lands, degraded forestlands and private degraded lands through planting of multi-purpose species and implementing sustainable forest management practices. While The MHWDP aims to protect watersheds improvement and livelihood enhancement, the A&R project is to sequester Green House Gases (GHG) through reforestation on and generate carbon revenue for the local communities. This combination has been able to

provide multiple benefits to the poor farmers through meeting their needs of small timber, firewood, minor forest produce along with carbon credits (as cash incentive), besides providing employment opportunities.

The Project in implementation since July 2006 has brought in several development perspectives (with relevant implementation tools). These include: development of local level institutional mechanisms for the sale of Certified Emission Reductions (CERs), testing of carbon purchase transactions and accumulation of experience in practical and technical measures for CDM project activities, development and testing of local financial arrangements for restoration of degraded lands; and identification of resource-poor farmers as the beneficiaries of the project. Being the first of its kind, the project is also expected to have significant demonstration effect in the country. It has effectively brought new awareness to local people about importance of trees. The project is instrumental in mobilizing farmers, who were earlier reluctant to take part in Forest Department driven afforestation work due to lack of incentives.

It is estimated that the A/R Project will sequester a total of 8,28,016 tCO₂-e of tCERs in the project area of 4003 ha. (421 parcels) over the first crediting period of 20-years at the rate of 10.34 tCO₂-e/ha/year. The Project will make the villagers strategic seller of carbon credits, in response to global demand for Certified Emission Reduction. 343 person days/ha of employment and an additional income of INR 3000 per ha per year will be generated from during the project period.

COMPARATIVE PERFORMANCE OF DIFFERENT TREE-CROP COMBINATIONS UNDER AGRIHORTISILVICULTURE SYSTEM.

Manoj Kumar Thakur and K.S. Verma*

Department of Silviculture and Agroforestry, COF, UHF-Solan-173 230 (HP)

**Institute of Biotechnology & Environmental Sciences, Neri, Hamirpur (HP)*

E-mail: drmanojthakur@gmail.com, ksv2002 @rediff.com

The effect of hedgerows of mulberry (*Morus alba* "M-5") and peach (*Prunus persica*) has been evaluated on the performance of lentil (HPL-5) under rainfed conditions, after six years of establishment of tree species. The lentil crop was grown in alleys comprising different combination of mulberry and peach thereby constituting six tree-crop combinations. The maximum plant height (32.95cm), number of plant (58.72m⁻²) and grain yield (1.80 t ha⁻¹) of lentil was recorded in treatment T₆ (under controlled condition). All the growth and yield parameters except crop maturity of lentil were found to increase with the increase in distance from the tree row. Lentil showed comparatively higher value for all the growth and yield parameters on south direction of mulberry and peach tree row as compared to the north. Height and diameter of mulberry and peach were recorded maximum in T₅ (mulberry + lentil) and T₄ (peach + lentil), respectively. Highest fruit yield (1.70 t ha⁻¹) and pruned wood biomass yield (0.94 t ha⁻¹) were recorded in T₄ (peach + lentil). Treatment T₅ produced highest branch wood (2.54 t ha⁻¹) and leaf fodder yield (1.20 t ha⁻¹) of mulberry. Based on biomass productivity and

output diversification, different tree-crop combination are found suitable in the following order of preference: peach + mulberry + lentil - T_3 > one peach tree surrounded by two mulberry tree + lentil - T_1 > one mulberry tree surrounded by two peach tree + lentil - T_2 > peach + lentil - T_4 > mulberry + lentil - T_5 > only lentil - T_6 and thus can be replicated under similar agroecological conditions.

TREE GROWING STOCK ESTIMATION IN FORESTS OF BIRHUN WATERSHED OF UDHAMPUR, J&K, USING REMOTE SENSING AND GIS

Sanjay Sharma

Department of Environmental Sciences, University of Jammu, Jammu (J&K).

E-mail: sansharman@rediffmail.com

A scientific survey of the natural resources is essentially a prerequisite for planning and development. The effective conservation and management of forest resources for the welfare of human beings and sustainable development requires to assess the phytodiversity, its distribution pattern and quantification. Growing stock inventory is essential for decision makers and managers to understand the tree crop condition and the quantity of timber growing in the forests, for planning and development purposes. The study of tree growing stock estimation at the micro level (watershed) can be important information to formulate a conservation strategy for the specific area. Remote sensing technology can be used for quick assessment of natural resources. Being cost-effective and repetitive in nature with synoptic coverage technology, it has endless application potentials. Therefore, an attempt has been made to assess the tree growing stock in Birhun watershed, J&K with the use of remote sensing and GIS. Birhun watershed of Udhampur district, J&K, lies in western Himalaya, covering an area of 111.95 km². The elevation of watershed varies from around 600 m to 2000 m. For growing stock estimation the watershed was classified into nine vegetation types using IRS P6- LISS-III satellite image of 2009. The watershed is predominantly represented by Chir pine forest (*Pinus roxburghii*) with few patches of *Pinus wallichiana* and *Quercus leucotrichophora*. The total growing stock in the forests of watershed was estimated to be 1,460,399.12 m³ with highest average volume per ha of 567.43 m³ for Blue pine forest. The low tree volume in the watershed can be attributed to high biotic disturbance in the forests.

CARBON AND NITROGEN STORAGE PATTERN IN PLANTATIONS ON DEGRADED WASTELANDS: A CASE STUDY FROM CHHATTISGARH, EASTERN INDIA

SL Swamy*

Academic Staff College

Guru Ghasidas Vishwavidyalaya, Bilaspur - 495 009 (Chhattisgarh)

**E-mail: swamy_101@yahoo.com*

Land degradation is a serious concern and achieved new dimension during recent times in tropics. Increased demands for wood and biomass products resulted in large-scale deforestation, along with rapid transformation of land use depleted the soil health and many of the productive lands became unproductive and some of them even turned into wastelands. In India, about 175 million ha of land area is subjected to various forms of degradation and leading to the formation of wastelands in different agro-ecological regions of the country. Chhattisgarh is one among the newly borne states of India, situated in sub-humid tropics where, degraded lands occupy 15-20 per cent of the geographical area of the state. Soils of these lands are biologically impoverished characterized poor soil depth, saline or alkaline deficient in nitrogen and low fixation capacity for phosphorous and also represent a higher topographic unit and thus prone to severe water erosion during rainy season. Tree based land use systems make a valuable contribution to sequester carbon and improve productivity and nutrient cycling in degraded ecosystem. A study was conducted to determine biomass production and C-sequestration on degraded lands in tree plantations of *G. arborea* as pure and agroforestry practices. At 5 year age, total stand biomass varied from 10.4 to 21.7 Mg ha⁻¹. Monoculture stands on abandoned agricultural lands had 52% and 35% higher biomass than on red lateritic wasteland and agrisilviculture system. For mean total standing biomass (15.4 Mg ha⁻¹) at five years age, leaves, stem, branches and roots contributed 4.1%, 65.2%, 10% and 20.7%, respectively. C concentration was highest in stem and branches (45%) followed by roots (43%) and leaves (41%). However, N concentration followed the order: leaves (1.8-1.9%) > branches (0.31-0.37%) > stem (0.31-0.34%) > roots (0.31-0.32%). Accumulation of C and N increased with plantation age. Total C in trees ranged from 4.6 to 9.8 Mg ha⁻¹ and N from 36.6 to 89.5 kg ha⁻¹ in 5 yr-old stands. Biomass and carbon storage followed differential allocation. Relatively more C was allocated to roots in red lateritic wasteland, while it was higher in above ground components in monoculture stands on abandoned agricultural land. Soybean, cowpea in rainy and wheat, mustard crops in winter are suitable for intercropping in agrisilviculture system. Planting of *G. arborea* increased soil organic C by 34%, 13% and 36%, N by 28%, 7% and 39% under monoculture stands on abandoned agricultural land, agrisilviculture system and monoculture stands on red lateritic wastelands, respectively. Net C storage (soil + tree) varied from 12.9 to 19.5 Mg ha⁻¹ with mean annual storage of 2.6 Mg ha⁻¹ yr⁻¹. The study suggests that *G. arborea* be planted as sole rather than agrisilviculture system in abandoned agricultural land for C sequestration

TREE - UNDERSTOREY ALLELOPATHIC INTERACTIONS IN *SHOREA ROBUSTA* FORESTS

Ombir Singh

Silviculture Division, Forest Research Institute, Dehradun - 248006 (Uttarakhand)

E-mail: ombirfri@gmail.com

Sal (*Shorea robusta*) forests in India have been a source of perennial supply of timber, fuel and various other products since time immemorial. These forests occupy ecologically and economically very vital position but large-scale mortality in moist as well as in dry sal forests coupled with absence of regeneration, recalcitrant seeds are posing great threat to these forests. The factors responsible to this state of affair are many e.g. recurrence of drought, deficient rainfall, excessive biotic pressure, illicit and irregular felling, and forest fires etc. To understand the process of natural regeneration failure in these forests, allelopathic interactions of one understorey species (*Ardisia solanacea*) and two invasive species (*Ageratina adenophora* and *Lantana camara*) with the tree species (*Shorea robusta*) were studied along with regeneration surveys in sal areas. The foliage leachates (0, 5%, 10%, 15%, 20%) of these species were investigated on the seed germination, root and seedling growth of *S. robusta* in laboratory as well as in nursery. The leachate concentrations have no effect on seed germination but affected the root growth, root hairs; causes yellowing of leaves and weakening of seedlings subsequently. Regeneration survey in these forests showed that there is no sal regeneration in areas having either *Ageratina adenophora* or *Ardisia solanacea*, and less regeneration with *Lantana camara* but interestingly good regeneration in areas infested with *Ageratum conyzoides*. These findings may explain the problems of seedling establishment in sal forests infested either with invasive or under-storey associates. By knowing which trees are particularly susceptible and which plants are most likely to produce toxic effects, these allelopathic problems can be avoided or dealt with by site preparation and weed control in plantations and assisted natural regeneration in these forests.

ASSESSMENT OF CARBON STOCK FOR DEFINING MANAGEMENT STRATEGIES FOR ALPINE PASTURES OF DISTRICT SHIMLA, HIMACHAL PRADESH

R.K. Verma* and K.S. Kapoor

Himalayan Forest Research Institute, Conifer Campus, Panthaghati, Shimla-171 009 (HP)

E-mail: vermaraj@icfre.org

Afforestation and reforestation activities in the forestry sector after becoming eligible for accounting under Clean Development Mechanism (CDM), assessment of carbon sequestration potential under different sets of conditions have gained significance in context to carbon credit systems. This whole process then necessitate the imperative need to provide an assessment on biological mitigation potential of various ecosystems. When we talk of Himalayas, we always find that there is always some uniqueness attached to its ecosystem. Geographically, Himalayan land in India comprises of 61.5 million ha, out of which, 17.8 million ha is covered by alpine

pastures found usually lying above an altitude of 2500 m amsl and where climate is not congenial for growth and development of any trees. Pastures however, in the alpine zone occupy about 1.52 per cent of the total land area in the country and are mainly concentrated in the Himalayan states. As far as Himachal Pradesh is concerned, alpine pastures cover around 10,052 sq km which otherwise constitute 17 per cent of its total geographical area. Assessment of carbon stock is yet to make specific dent in forestry in general and temperate forest and alpine pastures in particular. In view of the importance and relevance of the pastures in Himalayan ecology and economy, assessment of carbon stock of alpine pastures was conducted at Chansel (3600m-4000m) and Kawar (2800m-3000m) of Rohru forest division and Talra (3000m-3300m) of Chopal forest division falling in district Shimla of the state during 2012. For biomass estimations, quadrats of the size 1m x 1m was used whereas, carbon content in the biomass and soil was assessed by using CHN Analyser. Studies revealed that total biomass for Kawar, Chansel and Talra pasture was 3.80 t/ha, 5.5 t ha⁻¹ and 10.40 t ha⁻¹ respectively whereas, total carbon stock for these pasture was 1.99 t C ha⁻¹, 2.75 t C ha⁻¹ and 5.40 t C ha⁻¹ for these respective pastures. Values for total soil carbon stock (up to 45 cm depth) for Kawar, Chansel and Talra pasture were 133.11t C/ha, 160.00 t C ha⁻¹ and 132.16 t C ha⁻¹ respectively. Findings of the study lean towards and hint at some specific management strategies as far as the role of alpine pasture in carbon sequestration potential is concerned.

INSECTS AND CLIMATE CHANGE INTERACTION IN FOREST ECOSYSTEM AND THEIR MITIGATION IN NORTHWESTERN HIMALAYAS

Ranjeet Singh

Himalayan Forest Research Institute, Conifer Campus, Panthaghati, Shimla-171 009 (HP)

E-mail: ranjeets@icfre.org

India is one of the largest countries of the world with unique landscapes making it a distinct geographical entity and one of the mega diversity centers of the world. The Himalayan ranges are the youngest and loftiest among the mountain systems of the world. Himalayas is one of such region with diverse characteristics with effects of climate change has been quite revealing. Especially in the northwest Himalayas, where the glaciers are recognized as being among the sensitive indicators of these changes, the effect is quite distinct. It has been observed that the glaciers have been unable to regenerate enough ice during the winter to make up the ice lost during summer. The future of the Himalayas forest is at the forefront of environmental debate at nation level. Rising concerns over the effects of deforestation and climate change are highlighting the need both to conserve and manage existing forest through sustainable forestry practices. Climate change is likely to stress all the forest ecosystems, as a result of which forests may decline and many species may become extinct. The inter-Governmental Penal on Climate Change (IPCC) predicts that if no action were taken to limit Green Gas Emissions, a temperature would rise in the range 2.0 – 5.0° C by the year 2100. The Northwest Himalayas lies in Jammu and Kashmir, Himachal Pradesh and Uttarakhand, with the Shivalik range separating the

Himalayas proper from the Indo Gangetic plains. Physically the Northwest Himalayas is of intricate nature with diverse characteristics, in places it is highly deformed or in the form of flat alluvial valleys as in Kashmir. Generally it is rugged and deeply dissected by rivers, and eroded by glaciers exposing all kinds of rocks. Climate wise, due to the Himalayas obstructing the moisture laden winds from South, copious rainfall occurs along with snowfall in the mountains; these mountains also prevent direct invasion of extremely cold winds from Central Asia. Independent of these, the altitudes cause great variation in climate with mean winter and summer temperature being 7°C and 18°C, respectively, with valleys rising to 32-37°C in May-June. Rainfall is always due to the South West monsoon with an average of 2000 mm/ annum, of which 85 per cent falls between June and September. There are about 15,000 species of insect pests known to damage forests and forest products in the Indian sub-continent. Presently, Himalayan ecosystem faces a serious threat from insect and disease incidence. In recent years there have been several epidemic instances of insect and disease outbreaks causing economic damage to the forest trees in northwestern Himalayas. Epidemic of *Ectropis deodarae* in deodar forest, *Yponomeuta rorellus* on willow plantations in Ladakh region of Jammu and Kashmir, *Lymantria obfuscata* on ban oak in Himachal Pradesh, and outbreak of *P.scitus* in kail forest ecosystem in Northwest Himalayas are some of the examples encountered by the state forest department. Although less obvious, there are several other diseases and insect pests problems of serious concern in the Himalayan region. Ecosystems, water resources, food sources, health and human settlements shall be adversely affected. Floods and droughts are increasing, glaciers are melting and pest and pathogens are spreading. An increase in disease and insect caused losses in forest could become one of the first observed effects of climate change. Climate warming will affect host-pest interaction by different ways like Increasing pests and pathogen development rates, transmission and number of generations per year, Relaxing over winter restrictions on pest and pathogen life cycles and Modifying the host susceptibility to infection and infestation. Keeping in view the trend of climate change at present and the importance of forests in the Himalayas, there is an urgent need to address the problem accurately so that strategies are devised to overcome any epidemic in future because conservation and proper management of the forests in Himalayas would not only guarantee the survival of the people living in the hills but also the prosperity of the people living in the plains down below.

MULTIPLICATION OF *ELAEOCARPUS GANITRUS* ROXB. THROUGH ROOTER STRAND BY AIR LAYERING: A WATER EFFICIENT METHOD OF TREE PROPAGATION.

Kshitij Malhotra and Dinesh Kumar

Environment Management Division

Indian Council of Forestry Research and Education, Dehradun (Uttarakhand)

E-mail: rishipop@gmail.com

Elaeocarpus ganitrus Roxb., commonly known as rudraksha (Sanskrit word meaning Rudra's eyes), is a large evergreen broad-leaved tree. It grows in the areas from the Gangetic plain in the

foothills of the Himalayas. The tree has great religious significance for the Hindus as its seeds are traditionally used for making prayer beads. The tree is also used for avenue and aesthetic purposes. The multiplication of rudraksha through seeds is a difficult process due to the slow and poor germination of seeds. Depending on the humidity of the soil, it usually takes 1-2 years for germination. The tree starts giving fruit after 7 years when grown through seeds. In this study, an attempt was made for its multiplication by air layering using 'Rooter Strand'. Nine types of 'Rooter Strand' and a control were employed for root induction. Rooter Strand No. 5 gave 100 percent rooting. Survival after three months of planting was 100 percent which was significantly higher than the control. As rudraksha is highly demanding species by tourists and pilgrims. This will give local employment to youth with negligible investment. Along with this, it is an efficient method of tree multiplication which reduces the water consumption during plant propagation.

STUDIES ON THE EFFECT OF PRE-SOWING TREATMENTS ON THE GERMINATION BEHAVIOUR OF *RIBES ALPESTRE* WALL. EX DECNE SEEDS.

PS Negi and KS Kapoor

Himalayan Forest Research Institute, Conifer Campus, Panthaghati, Shimla-171 009 (HP)

E- mail: negips@icfre.org

Ribes alpestre Wall. ex Decne. Syn. *Ribes grossularia* auct. non. L commonly called as 'Asian Gooseberry' is an important small, erect prickly bushy type shrub normally attaining an height upto 2-2.5 m. The species belongs to the family Grossulariaceae and is found in dry temperate and cold desert areas of the Western Himalayan from Kumaon to Kashmir at an altitude of 2,500- 3,500 m a msl (Anon, 1972). It grows well in dry and open stony places among the boulders in alpine pastures. It is locally called as "Shutum" in Sangla Valley of Kinnaur district (H.P.), Askuta and Zasoot in Ladakh region of J&K. It is an important wild edible species. The berries of *Ribes alpestre* mature during August-September. The berries are sour in taste and local people and wild animals eat the berries. It is used as fuel wood by the local communities of cold desert areas. The natural population of this species is decreasing due to severe biotic pressure and poor regeneration in its zone of occurrence. The seed germination is low due to seed dormancy. In view of the importance of this species, a trial was conducted to study the effect of different pre-sowing treatments on the germination behaviour of its seeds. The berries of *Ribes alpestre* were collected from the naturally growing shrubs near Mane village of Lahaul & Spiti district of Himachal Pradesh during September 2007 and brought to the Seed Laboratory of Himalayan Forest Research Institute, Shimla. The seeds were extracted manually from the berries, cleaned and dried in the laboratory subsequently. The seeds were given different pre-sowing treatments viz., soaking in cold water for 24 hours (T₂), soaking in luke warm water and subsequent cooling for 24 hours (T₃), soaking in boiling water and subsequent cooling for 24 hours (T₄), soaking in Conc. H₂SO₄ for 1 minute (T₅), soaking in Conc. H₂SO₄ for 2 minutes (T₆) including control (T₁) to study their effect on its germination behaviour. Significant differences were observed for all the germination parameters viz., germination per cent, mean daily germination (MDG), peak

value (PV), germination value, germination speed and germination energy percent of the seeds treated with different pre-sowing treatments. The seeds treated with Conc. H₂SO₄ for 2 minutes (T₆) recorded maximum 69.33 percent germination which was followed by treatment T₅ i.e., soaking in Conc. H₂SO₄ for 1 minute which recorded 64.66 percent germination where as untreated seeds (control) recorded minimum 39 percent germination. Therefore, it is recommended that the seeds of *Ribes alpestre* should be treated with pre-sowing treatment i.e., Conc. H₂SO₄ for 2 minutes (T₆) before sowing in the nursery for breaking seed dormancy and getting maximum germination. This particular treatment registered a 77.76 percent increase in germination percent over control.

IMPACT OF *LANTANA CAMARA* ON PLANT DIVERSITY OF *SHOREA ROBUSTA* (SAL) FOREST

Anup Chandra and Ashok Kumar

Systematic Botany Discipline, Botany Division

Forest Research Institute, P. O. New Forest, Dehradun-248 006 (Uttarakhand)

E-mail: anup@icfre.org

Invasive species means an alien species whose introduction is likely to cause economic or environmental harm. Invasive alien species are usually considered to be the second greatest threat to biodiversity after habitat destruction. Variation in the geographical and climatic parameters has great influence on the ecological floristic diversity. Sal forests are known for their rich floristic diversity. Due to invasion of these species the regeneration of important tree species are greatly influenced. Invasive can be controlled by different methods such as mechanical, chemical, biological, utilization, etc. *Lantana camara* belongs to family verbenaceae and is native of American tropics. It has been introduced in India and other parts of the world an ornamental plant and is considered an invasive species in many tropical and sub-tropical areas. In the present study impact of *Lantana camera* on plant diversity of *Shorea robusta* (Sal) forest of Jhajjara Range, Dehradun Forest Division was carried out. Quantitative analysis of vegetation for frequency, density and dominance was calculated. Diversity indices for herbaceous layer showed higher species richness and density in the control site. In the *Lantana* infested sites, dry biomass of lantana was estimated to be 927 kg/ha. Prevention of spread of invasive species from uninfected sites is quite cost effective. *Lantana* infestation can be controlled if it is judiciously utilized for making some useful products i.e. paper making, handicrafts, baskets, toys, etc.

NATIONAL MISSION FOR GREEN INDIA – BIODIVERSITY CONSERVATION PEOPLE'S PARTICIPATION- STRATEGIES AND CASE STUDIES IN PUNJAB

D. Rajasekar^{1*} and J. Yogalakshmi²

¹*Dy. Conservator of Forests, O/O PCCF, Punjab, Mohali (Punjab)*

²*Coconut Research Station, TNAU, Aliyar Nagar, Pollachi, Coimbatore (TN)*

**E-mail: rajasekar.ifs@gmail.com*

Green India Mission launched in India will focus on two objectives, namely increasing the forest cover and density as a whole of the country and conserving biodiversity. The final target is to bring one-third of the geographic area of India under forest cover from the existing 23% in about 10 years. There are dual goals of increasing forest and tree cover as well as to increase the stocking density of existing scrub and moderately dense forest to that of dense forests. Punjab state being predominantly an agrarian state and grain bowl for the country has not much scope to increase its area under forests but attempt to increase the tree cover outside the traditional forests. It is also attempting to have equal or more areas under compensatory afforestation project with a unique land purchase policy as approved by the Government from the user agencies who seek diversion of forest lands for Non- forestry purposes under Forest Conservation act. The state in its Green Mission project, has identified the vulnerable areas due to climate change and has prepared its bridging plan for the first year and the mission plan to increase its Forest and Tree cover to that of 10% from its existing 6%. Punjab state is one of the largest wood producer and supplier in terms of Poplar and Eucalyptus for the wood based industries and saw mills across northern region. Trees outside Forests in Punjab are more than the national average. The productivity under agroforestry is also more. The community participation in protection of forests through Joint Forest management, community reserves, revenue sharing and other policy measures have aimed at achieve true participation of people in forest protection and management. Community reserves are declared in the state in 2007, which are India's first in its kind. In order to have a pilot project for Greening Punjab Mission, a model project at Talwara was prepared by people's participation using socio economic survey at different villages. The survey mainly focused on identifying suitable area for afforestation, supply of desired seedlings for homestead, increasing the tree cover along boundaries by free and subsidized supply of high yielding and quality seedlings etc. The unique idea of complete lantana removal and its utilization by supplying as fuel to the sugar mills are also explored. The components of the project were site specific treatments by lantana removal & utilisation, enrichment planting with Silviculture & Medipasture, degraded model plantations in Dasuyaplains, tending operation in existing forest areas, bamboo plantations in boundaries & blocks, Assisted Natural Regeneration, lease of delisted/other areas and plantation, free supply of plants, Soil & Moisture Conservation Works, Chain link fencing on partial funding in selected areas, Entry Point Activities in 246 Villages, Income Generation Activities, Training & Exposure Visits, Provision of machinery, equipment & tool kits, Corpus Fund for microcredit for 100 established SHG's, Cattle shed, Mangers for poor and landless persons in villages, Social Mobilisation Facilitators, Micro Planning & other meeting related works at a total cost of Rs 61 crores was prepared and being discussed in this paper in detail.

MAPPING FOREST CARBON IN THE SOUTHERN REGION OF KASHMIR HIMALAYAS USING REMOTE SENSING AND GIS

Akhlaq A Wani^{1,2}, P K Joshi² and Ombir Singh³

¹*Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Campus, Wadura - 193201 (J&K)*

²*Department of Natural Resources, TERI University New Delhi-110 070*

³*Silviculture Division, Forest Research Institute (FRI) Dehradun - 2480 06 (Uttarakhand)*

Email: akhlaqwani@yahoo.co.in

Forest loss in the form of deforestation and forest degradation accounts for significant greenhouse gas emissions. Forest carbon inventory has assumed importance in the recent past for its role in assessing such emissions. However there exists a wide variability in the carbon sequestration and storage potential of different forest types. Realizing this variability, the present study was conducted to estimate forest tree biomass carbon through sampled field inventory data and geospatial technology in the southern region of Kashmir Himalayas. After conducting preliminary survey, 45 quadrates of 0.1 ha were laid in six forest types for recording field inventory data viz. diameter at breast height, height, slope and aspect. Biomass carbon (aboveground + belowground) t ha⁻¹ was worked out for different forest types under different crown density classes (open with 10-40 % crown density and closed with > 40 % crown density). Maps were generated for forest type, forest carbon density and total forest carbon using satellite data. Sampled field data was brought into geographical information system (GIS) domain and tree biomass carbon (mt) was worked out for different forest types. Forest type maps were found to have more than 90% accuracy and kappa (k) of 0.84 through ground truthing. Highest carbon density (t ha⁻¹) was observed for Fir-Spruce (closed) (171.40) and lowest for Blue Pine (open) (37.15). However, the highest total carbon (mt) in the region was observed for Blue Pine (closed) (57.41) primarily owing to its larger extent and lowest for Deodar (open) (0.55). The study demonstrates the application of remote sensing and GIS coupled with field inventory data for type-wise assessment of forest carbon in temperate coniferous forests.

EVALUATION OF MORPHOMETRIC, VARIABILITY AND GENETIC PARAMETERS IN *MELIA AZEDARACH* LINN.

Shikha Thakur*, I. K. Thakur, N. B. Singh, Jaipal Sharma

Department of Forest Genetic Resources

Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan - 173 230 (HP)

**E-mail: thakur27shikha@gmail.com*

Among all plant families, the trees of Meliaceae are more useful to human beings, chiefly for their high quality timbers and for the ease with which they can be grown in plantations. Drek (*Melia azedarach* Linn.) is a deciduous tree belonging to family Meliaceae. It is a highly valuable species for its multipurpose importance and recognition as a species of agroforestry/ social forestry/ urban forestry. Various plant parts have insecticidal and fungicidal properties. *M. azedarach* has been used in medicine since ancient times. In the present study seeds were

collected from selected mother tree each at twenty seven locations and progenies were raised to study the extent and pattern of variation with respect to growth and biomass characters. Site S₂₇ (Nauni) exhibited outstanding performance for the growth and biomass characters of progenies followed by S₁₄ (Ropar) and S₂₃ (Subathu), whereas S₂ (Palu upper) showed the lowest values for these characters. High heritability with moderate genetic gain was observed for collar diameter followed by root length and root-shoot length ratio among growth and biomass characters. Highly significant and positive genotypic and highly significant phenotypic correlation was observed for majority of the characters. However, highly significant and positive genotypic and significant phenotypic correlation was observed for root-shoot length ratio and dry root-shoot weight ratio.

PERFORMANCE OF MAIZE-PLUM BASED AGROFORESTRY SYSTEM IN KULLU VALLEY OF HIMACHAL PRADESH

F. S. Meena, C. L. Thakur and Kamal Sharma

Department of Silviculture and Agroforestry, Dr.Y.S.Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh

Plum (*Prunus domestica L.*) is one of the most important stone fruits grown in the mid-hills of Himachal Pradesh. The economic returns from fruit crops are usually higher than those from cereals, pulses and vegetables in the hills. However, intercropping with such understory crops can further help realising higher returns than the sole agricultural or horticultural crops. Keeping this in view, a twenty four year old European plum (*Prunus domestica L.*) orchard with trees spaced at 6m x 6m was selected. Most commonly grown cereal i.e. maize in the area was grown underneath the plum trees as per the recommended packages of practices. The data on crop growth and yield parameters of maize were recorded at 1m, 2m and 3m distances from the tree trunk in all the directions along with growth and yield attributes of the trees. The maximum plant height (2.24 m), Number of cobs plant⁻¹ (1.00), Number of plants m⁻² (8.33), Weight of seeds cobs⁻¹ (33.67 g), Number of supporting roots plant⁻¹(9.55), Grain yield (29.17 q/ha) and Straw yield (49.71 q/ha) were recorded in at South direction, 3m away from tree trunk. The average values of tree height, Leaf litter, Crown spread and Fruit yield of plum trees in the orchard were 5.23 m, 2.25 kg/tree, 1.63 m and 19.63 kg/tree respectively. The net returns from agrihorticulture system were Rs. 26190.60/ha. as against Rs. 4923.55 in sole maize crop.

STUDY THE LIVELIHOOD OPPERTUNITIES OF TRIBLES IN RAINFED AREA AND ITS IMPACT ON FOREST IN CENTRAL CHHATTISGARH

Bhavana Dixit¹ and Neelima Tiwari²

¹*Department of Forestry Wildlife and Environmental Science, GGV Bilaspur, Chhattisgarh
2 Pt. Sunder Lal Sharma Open University, Bilaspur, Chhattisgarh*

Chhattisgarh is major forest state of the country comprising of more than 40% area (59700 sq. km out of 1.35 lakh sq km) under forest . The state comprises of 20379 villages out of which

11187 are forest fringe villages within 5 km from forest boundary. There are more than 80% tribal population in these villages for whom forest is major sources for their livelihood. Mankind has endeavored for better, comfortable, secured and suitable livelihood for himself within period of time. Some area flourished well economically but some are untouched due to its difficult geographical condition. Study has been taken in Arjuni Range of Raipur Forest Division their agriculture practices were still primitive and was totally rain fed. Data were collected with well structured questionnaire administered on 50 randomly selected household in 8 forest villages. Livelihood of Tribal communities mainly depends on NTFP including edible fungi, food items, oils, medicinal plants etc. Study revealed that local tribes collect a number of edible fungi collected during rainy season by women. Due to the poor economic status of the tribal people, they are induced in various activities like NTFPs collection, agriculture and forestry labours and self help groups for enhancement of their income and livelihood. Pertaining of developmental activities like irrigation transportation, drinking water facilities, agriculture and horticulture schemes, and health facilities and gender sensitivity are created during the period of intervention which has ultimately resulted in increase in productivity thus income of the tribal's. Forest protection and regeneration has also increased due to motivation of tribal's resulting in absolutely no fire incidence in whole area is reported.

INDEGENOUS KNOWLEDGE OF SOLIGA TRIBES OF BILIGIRIGANGAN TEMPLE TIGER RESERVE FOR THE SUSTAINABLE MANAGEMENT OF FOREST RESOURCE

M. Jadeyagowda¹, Shoba S¹, MN Ramesh and DA Sumana³

*1Assistant Professor, Dept. of Natural Resource Management, 2Head, Dept. of Forest Product Utilizations, 3Assistant Professor, Dept. of Forest Biology and Tree Improvement
College of Forestry, University of Agricultural and Horticultural Sciences (Shimoga),
Ponnampet-571216, Karnataka*

**E-mail: mjadegowda@gmail.com*

BRT Tiger reserve is situated in Chamarajanagar district of southern Karnataka in south India and is popularly known as BRHills. It is one of the richest biodiversity hotspots of the Western Ghats region of the country. BRT lies between Western Ghats and Eastern Ghats and is a live link in harbouring rich biodiversity of both flora and fauna. BRT is the only Tiger Reserve, where we find all types of vegetation including scrub, deciduous, evergreen, shoal, savanna grassland and riparian forests (Ramesh, 1989). Soligas are the main indigenous tribal community of Billigirirangana Hills (BR. Hills) located in Chamarajanagar district of Southern Karnataka in South India. According to the folklore, Soligas are believed to have originated from hollow portion of bamboo and hence are known as Bamboo Children. They have been worshiping a flora and fauna. Since time immemorial, Soligas led a semi-nomadic life and were engaged in shifting cultivation by living in harmony with nature. They have a rich wealth of indigenous knowledge on forest and sustainable utilization of forest resource. Collection of non-timber fruits of amla (*Embllica officianlis*), Chilla (*Strycnous patatorum*) and Alale (*Terminalus chebula*) is

another important but relatively recent occupation (Jadeyegowda et.al 2012). The indigenous knowledge of the existing communities was studied on the basis of description of forest typology, use of forest produce and bio-resource for food, medicine and also Agro forestry disease attack. This practice is gaining prominence in the current scenario, where the modern agricultural emphasis is towards organic practices. The traditional method of cultivation is eco functions such as nutrients recycling, regulation of microclimate, local hydrological processes and detoxification of noxious chemicals.

NUTRIENT CYCLING PATTERN UNDER POPLAR BASED AGRO FORESTRY SYSTEM IN HARYANA (INDIA)

B. S. Mandal* and Y. P. Singh**

*Krishi Vigyan Kendriya, Pinjore (Panchkula); **FRI, Dehradun*

Email: mandal.balwan@rediffmail.com

Agro forestry is gaining importance with recent emphasis on sustainable agriculture and improving land productivity. Agrisilviculture is a common agro forestry practice of growing food crops along with the trees for maintaining soil fertility and improving land productivity. Trees play an important role in nutrient cycling in agro forestry system by decreasing external losses of nutrients and making efficient use of nutrients from organic sources of the soil. Agro forestry has proved itself as an integral element of not only the farming system but also as a key component of sustainable agriculture. In the recent years, agro forestry has received considerable attention in several states like Uttar Pradesh (U.P.), Punjab, Haryana, Gujrat, Karnataka, etc. with the aim of integrating the use of land for agriculture and forestry. Although many tree species are raised in north Indian plains of India, but poplar (*Populus deltoids*) has been identified as one of the key agro forestry tree species. It can be raised as pure or along with agricultural crops like sugarcane, wheat, fodder crops like jawar and berseem, potato, etc. Like other species, poplar takes up nutrients from the soil and retains part of it for structural building. Remaining part is returned to the soil to compensate the loss. Thus, nutrients are transferred from environment to the organism and back to the environment. Likewise, intercrops too play their role in inter cropping system. The present studies were conducted at Krishi Vigyan Kendra's Farm of CCS Haryana Agricultural University, Kurukshetra (Haryana) during the years 2001-2002 and 2002-2003. The experiments were conducted with the objectives of the pattern of nutrient cycle under poplar based agro forestry system in Haryana. Two rabi season crops i.e. wheat (*Triticum aestivum* L.) var. PBW-343 and berseem (*Trifolium alexandrinum*) var. BL-1 and two kharif season crops i.e. sorghum (*Sorghum bicolor* L. Moench) var. H.C. 260 and dhanicha (*Sesbania acculeata* L.) var. local were grown as per the standard technique. These crops were sown under poplar (*Populus deltoids*) plantation and side by side in open area. The poplar (Clone G 48) was planted at a spacing of 5 x 4 m in Feb. 1999 in North – South direction. The experiment was conducted in randomized block design with three replications. The present investigation showed that the pH and EC decrease most in the crop-poplar followed by poplar, crop and fallow setting the soil reclamation process. The organic carbon follows the reverse

trend but in the same order. The available phosphorus decreases most in the crop-poplar followed by poplar, crop and fallow. Potassium increased in the soil in the same order. All the micronutrients (Zn, Mn, Cu and Fe) decrease in the similar fashion.

LE COMMERCE INTERNATIONAL DES BOIS TROPICAUX ET SES CONSEQUENCES ECOLOGIQUES ET SOCIO-ECONOMIQUES DANS LE BASSIN DU CONGO.

Gregoire BEMBE Monziba-Masongo*

**Prof. Ir. à l'Institut Supérieur d'Etudes Agronomiques (I.S.E.A.) de Mondongo, B.p. 60, Lisala,
République Démocratique du Congo.*

E-mail : greeoirebembe@yahoo.fr

Problématique: Alors que s'accroît le commerce international des bois tropicaux tels que l'Iroko (*Chlorophora excelsa*, le Sappelli (*Entandrophrasma cylindricum*), l'Afromorsia (*periscopsis elala*), l'Acajou d'Afrique (*Kvaha* spp), leur disponibilité dans la forêt naturelle congolaise diminue.

Objectifs de l'étude: s'interroger si les structures jusque-la mises en place, avec en plus les criteres et les indicateurs de l'aménagement durable des forêts tropicales naturelles de l'Organisation International des Bois Tropicaux (OIBT) sont vraiment de nature à favoriser la réduction sensible de la pau reté, et partant, à contribuer de manière significative à l'économie nationale, et si une commercialisation rationnelle peut résorber cette tension.

Méthodologie: La technique documentaire et la méthode systémique, nous ont permis de fournir les données de la présente étude.

Délimitation su sujet: La présente étude se réalise en République Démocratique du congo et couvre la période comprise entre 2003 et 2012.

Résultats:

- La pauvreté ;
- L'environnement à court, moyen et long terme ;
- L'évolution démographique ;
- Les lacunes du service local de conservation ;
- Le déficit en personnel et en équipement, favorisent la dégradation accélérée dans ce pays.

Conclusion:

- la destruction des ressources forestières pourrait être une menace au maintien des équilibres climatiques ;
- Leur dégradation ou leur disparition ne peut qu'avoir des conséquences préjudiciables sur toute l'humanité ;
- La communauté internationale devra prendre conscience du drame du réchauffement climatique et de la destruction des forêts tropicales.



THEME
WATER RESOURCES



WATER RESOURCE MANAGEMENT IN VIDARBHA REGION OF MAHARASHTRA

M.M.Kadam * and H.J. Wagh

Department of Agricultural Economics and Statistics

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444 001 (Maharashtra)

E-mail: maheshkadam600@yahoo.com, harshwagh25@yahoo.com

This study focused on the water as a resource in Vidarbha region and its management in all district of Vidarbha region. For this study, secondary data were collected from Handbook of Statistics on Indian Economy and Economic Survey of Maharashtra for the year 2010 and 2011. The objectives of the study were, to assess irrigation potential to total irrigated area and to assess proper exploitation of resource in Vidarbha region. Simple tabular analysis was employed to achieve the objectives of the study. The finding of the study reveals that, in Vidarbha region area estimates of Wetland is 284396 ha. Potential created is 1102.35 ha., While actual area is about 522.09 ha. And the percentage of actual area to potential created is 47.36 %. From the overall study regarding to the water management in Vidarbha region, concluded that, Potential irrigation should be achieved for Agricultural development and Exploitation of sources at its maximum level will create an avenue for industrialization.

SEA LEVEL TREND AND INUNDATION VULNERABILITY TO COASTAL AFFORESTATION ALONG THE EASTERN COAST OF BANGLADESH

M. Al Amin* and M. Arifur Rahman

Institute of Forestry and Environmental Science

University of Chittagong, Chittagong 4331, Bangladesh.

**E mail: prof.alamin@yahoo.com*

Repercussions of climate change are an inescapable reality in today's world. Nations around the world have already experienced the alarming consequences of such changes viz. sea level rise (SLR) etc., but none has been ravaged as the coasts of Bangladesh have. Venerated for its immense contributions to the country's economy and for its readily available natural resources, the eastern coastal zone of Bangladesh is an area whose destruction via SLR would be devastating. Analyses of previous 19-year Bangladesh Inland Water Transport Authority tidal data of the four eastern stations- Sadarghat (Chittagong), Sandwip, Teknaf and Cox's Bazar- were incorporated to determine the tidal variation trends in this study. Again, the NASA Shuttle Radar Topographic Mission digital elevation model (DEM) data was used to estimate coastal vulnerability to future inundation. The alarming rising trend (14mmyr^{-1}) of mean tidal level in the river Karnaphuli reflects a high vulnerability of the Chittagong coastlines to SLR and local factors like land subsidence. This steeper SLR trend may cause 1 m of inundation in this zone which may lead to about 97.32 km^2 of land to be permanently lost in sea by 2080. This is not only loss of land this is the loss of coastal afforestation. Loss of coastal land according to the

DEM based prediction was evidenced in the three Karnaphuli riverside upazillas of Chittagong coast- Patiya, Boalkhai and Raozan- interviewing the local inhabitants. SLR may be being exacerbated there by land subsidence. This study is providing adequate information and establishing generic form of assessment methodology regarding the extent and timing of coastal flooding for future coastal afforestation program planners and policy makers.

RAINWATER HARVESTING FOR MITIGATING FOOD AND LIVELIHOOD SECURITY IN RAICHUR DISTRICT, NOTHERN DRY ZONE OF KARNATAKA: AN ADAPTATION AGAINST CHANGING CLIMATE AND RESILIENCE ENHANCEMENT

Sankanur Mahantappa^{1*}, S. J. Patil¹, Sapna Thakur², Shivaputra Bammanahalli², Kamine², Rajendra Navale Manasi² and Sneha Dobhal²

¹*Department of Farm Forestry, Krishinagar, University of Agricultural Sciences, Dharwad-5, Karnataka, India*

²*Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni- Solan- 173 230, H..P.*

**E-mail: papusankanur@gmail.com*

The present study was conducted in forest fringe areas of northern dry zone of Raichur division, Karnataka to know the impact of rainwater harvesting as an adaptation against changing climate and resilience enhancement for food and livelihood opportunities of the villagers. A total of 5 villages which represents 2 ranges of Raichur division, Karnataka were sampled *viz.*, Kalamangi from Sindhanur range, Bapur thanda, Maliyabad, Aijapur and Undraldoddi from Raichur range were selected for the study. Most of the sampled villages have semi arid to arid climate with an average annual rainfall between 580 to 600 mm and soil type varied from red to black soil with loamy. The soil and moisture conservation (SMC) works were implemented in the study areas under various schemes *viz.*, KSFMB, DPADP, FDA and Hariyalli-I. The SMC structures such as percolation tanks, farm ponds, check dams and continuous counter trenches *etc* were built in the sampled areas. In all the sampled villages catchment areas ranges from 214 to 500 ha. Implementation of SMC works had better impact on water sources *i.e.* borewells and open wells with higher water yield and thus increased the irrigation potential in the sampled villages. Thus this has lead to change in cropping pattern, higher crop yields and hence higher returns to the farmers in the sampled areas. Besides this, increase in cropping area, fodder availability, tree density and natural regeneration were also noticed for the same. Further, the positive impact of SMC works had directly resulted in increased household income, employment generation and scope for allied agricultural activities *etc*. There is a decline in number of BPL families in villages. In almost all villages sampled, the drinking water problem is almost solved due to sufficient recharging of ground water resources. Therefore impact is more visible in terms of large quantity of water harvest and enriched greenery around the structures built. In this context, efforts should be made towards conserving and utilizing maximum amount of rainwater and recharging ground water by adopting low cost, successful and environment friendly techniques. Therefore, watershed approach needs to be followed on a community basis for proper water management and sustainable development.

TRADITIONAL INNOVATIONS AND TECHNOLOGICAL INTERVENTIONS FOR RURAL WATER AUGMENTATION, FOOD AND LIVELIHOOD SECURITY IN ADILABAD DIVISION, ANDHRA PRADESH: A RESEARCH STUDY

Sankanur Mahantappa^{1*}, Sapna Thakur², Shivaputra Bammanahalli², Rajendra Navale Manasi², Sanyam Rana² and Vipasha Negi²

¹*Department of Farm Forestry, Krishinagar, University of Agricultural Sciences, Dharwad-5, Karnataka, India*

²*Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni- Solan- 173 230, H.P., India*

**E-mail: papusankanur@gmail.com*

The present investigation was carried out to know the impact of traditional innovations and technological interventions for rural water augmentation, food and livelihood security of the villagers in the Adilabad division, northern dry zone of Andhra Pradesh. In this division three forest ranges were selected and from each range two Vana Samrakshana Samithi (VSSs) were selected to ascertain the impact of works for the same. Most of the villages sampled falls under dry zones with an average annual rainfall fall between 550 to 570 mm. The soil and moisture conservation (SMC) works, were implemented in the study areas under various schemes *viz.*, APCFM, IWLDP, FDA, JFPM, Hariyalli – II and MGNREGA. Continuous contour trenches and percolation tanks are most common SMC structures followed by check dams, staggered trenches and over head tanks (OHT) *etc.*, in the sampled areas. Implementations of SMC works had better impact on water sources with higher water yield and thus increased the irrigation potential of bore wells from 1.5-2.0 to 2.0-3.0 inches in the sampled VSSs. This has lead to a moderate increase in farm income of the villagers due to the increased agricultural activity in terms of area and number of crops grown/year. Later increased cropping area, fodder availability, tree density and natural regeneration were also noticed in the sampled areas after the implementation of SMC works. Further, the positive impact of SMC works had directly resulted in increased household income, employment generation and scope for allied agricultural activities *etc.* however, there is a decline in number of BPL families in villages are also noticed. In almost all villages sampled, before the implementation of SMC works villagers had to travel to a distance of 1.0-2.0 kms to fetch drinking water but, now except Narsapura B and Odderguda the drinking water problem is completely solved due to sufficient recharging of ground water resources. Therefore impact is more visible in terms of large quantity of water harvest and enriched greenery around the structures built.

CONSERVING NATURAL RESOURCES IN LOWER HIMALAYAS USING PARTICIPATORY WATERSHED MANAGEMENT APPROACH WITH COMMON WATERSHED GUIDELINES

R.P. Yadav, S.L. Arya, V.K. Bhatt, Pawan Sharma and A.K. Tiwari

*Central Soil and Water Conservation Research and Training Institute, Research Centre,
Chandigarh – 160 019*

Kajiyana watershed located between 30°46' and 30°48'N latitude and 76°56' and 76°59' E longitude in block Pinjore, tehsil Kalka, district Panchkula, Haryana project at Kajiyana was taken up for development as model watershed as per common watershed guidelines of NRAA, Ministry of Agriculture, Government of India, New Delhi. The watershed boundary encompasses five villages namely Janouli, Bhutali, Kajiyana, Dhattogran and Nala Dakrog. Detailed project report at a cost of Rs 54.00 lakhs was prepared taking 450 ha as treatable area out of total 509 ha. The watershed has limited facility for supplemental irrigations is available through *kuhls* drawing water from surface and sub-surface sources. A detailed watershed development plan was developed in participatory mode with active participation of villagers residing in the watershed. It comprised of effective utilization of soil and water resources, checking land degradation, crop diversification, alternative land uses, integrated nutrient management and organic farming. During 2009-2012, the area received 605 to 1618 mm rainfall during monsoon months (June-September) resulting in sufficient runoff for providing runoff water in streams and *kuhl*. Available water resources were utilized effectively by renovating the *kuhl* and laying underground water distribution system. Various sub-watersheds were monitored for runoff by installing silt observation posts (SOP). Agricultural sub-watershed produced runoff in the range of 2.93 to 19.04 per cent in comparison to 0.30 to 1.24 per cent from mixed land use watershed having 70 per cent area under forest. Techniques of improving crop productivity was demonstrated through large scale demonstration on integrated nutrient management, organic farming and crop diversification resulting in up to 50 per cent increase in yield. Livelihood of landless and women were improved by constituting six self help groups on paper bag making, cloth bag making, carpet weaving, tailoring and embroidery, fodder storage through silo pits and vermin- composting. The study established the utility of participatory watershed management as an effective tool of resource conservation and productivity enhancement in fragile ecosystem of lower Himalayas and effectiveness of new common watershed guidelines as a policy tool.

CLIMATE CHANGE IMPACTS ON HEALTH OF GROUNDWATER RESOURCES

Shabir Ahmad Rather* and Sabeena Nabi

Faculty of Forestry, Camp Wadura, Sopore, SKUAST-Kashmir 193 201

**E-mail: sshab53@gmail.com*

Climate change and climate variability will increase the risk to already vulnerable groundwater resources. In particular, future climate change and climate variability are likely to impact the

quantity and quality of groundwater resources. The speed at which these impacts will occur will be controlled by the location of the aquifer (inland versus coastal), local hydro-geologic conditions (including soil characteristics, whether aquifers are confined or unconfined, the size of the aquifer etc), the forcing climatic conditions, and the degree of utilization of the resource. It is expected that water-scarce islands such as Barbados, which rely exclusively on groundwater to meet the national water demand will be severely affected by climate change on groundwater resources. For example, preliminary climate change and climate variability scenarios for the Caribbean region, indicates that rainfall in the region will become intense and dry spells will become more pronounced. The amount of precipitation received annually is, however, not expected to change significantly. Increased rainfall intensity, is expected to lead to increased surface runoff thereby reducing infiltration and potential aquifer charge. In Karst terrains, some of the increased run-off may be captured by sinkholes thereby contributing to aquifer recharge this raises the potential for recharge water to transport sediments and other contaminants (e.g., pesticides and fertilizers) into the subsurface thereby contaminating aquifers. Also, in clay type soils, increasing temperatures coupled with prolonged dry spells will lead to desiccation cracking that will further enhance soil moisture loss. Climate change will not only influence the quantity of water entering aquifer systems, but may also reduce the quality of water within aquifers. In coastal environments for example, changing recharge patterns, including reduced long-term recharge and/or temporally variably recharge, coupled with rising sea-level will increase the likelihood of seawater intruding into coastal aquifers thereby degrading the water quality in the aquifers and hence reduction in groundwater quality.

WATER DEMANDS IN CHANGING CLIMATE SCENERIO

Shabir Ahmad Rather*

Faculty of Forestry, Camp Wadura, Sopore, SKUAST-Kashmir 193 201

**E-mail: sshab53@gmail.com*

A number of drivers are already changing patterns of water demand that includes population growth, land use change, economic growth and technological change. The most significant change is likely to be in the agricultural sector where climate related factors will increase the future demand for water as a result of changes in precipitation, runoff and evapo-transpiration rates. For instance, irrigation demand is projected to increase by 0.4%-0.6% per year up to 2030 and 2080, according to projections from the Food and Agriculture Organization (FAO). But if the anticipated impacts of climate change are added, the projected demand will lead to an increase of between 5-20% by 2080. It is projected that the sea level rise and resource scarcity linked to climate change will drive increased rural- urban migration patterns, and will increase the cost of water supply and sanitation infrastructure as a result of more frequent flooding, salinization of groundwater, and the increased need to re-use available water. A decline in water availability is also likely to have an adverse affect on the energy sector. Climate policies, including those on biofuel production, which could increase water pollution through increased nitrogen runoff and result in the overuse of water for irrigation, are also likely to have significant

impacts on water demand at national and sub-national levels. For example, ethanol production in 2005 was 36,800 million litres (worldwide) which led to a 2% increase in water withdrawals for irrigation. Projections indicate that this demand (depending on the type of crop grown and country conditions) will increase to 4% by 2030 as a result of the production of 141.2 billion litres of biofuel worldwide. Economic water scarcity may increase as groundwater levels decline as a result of over-abstraction by some users, which would make water more expensive. Integrated Water Resource Management (IWRM) can ensure inclusive decision-making and resolve conflicts between competing water uses and, therefore, facilitate adaptation in the water sector.

ECOLOGY AND FISHERY OF A FLOODPLAIN WETLAND (CHAUR) OF KOSI BASIN (NORTH BIHAR)

Arun K. Singh^{1*}, Rani Kumari^{2*} and Raj K. Singh¹

¹Department of Zoology, B.D. College (Magadh University), Patna – 800 001, Bihar

²Marwari +2 High School, Ranchi – 834 001, Jharkhand

* E-mail: arnksingh@gmail.com, ranisingh2474@gmail.com

The wetland associated with floodplains of rivers is a unique ecosystem, supports a rich biodiversity, but are biologically sensitive and fragile in nature. Floodplain wetlands are areas of land that are either temporarily or permanently covered by water. Such wetlands are an integral component of the Ganga and the Brahmaputra river basin, covering an area of 0.2 million hectares. This is particularly true in the Kosi basin of North Bihar (India), where the low lying areas (floodplains) adjacent to rivers are basically the cutoff river meanders (Ox-bow lakes) or tectonic depressions (Floodplain lakes), with and without a connection with the parent river. These water bodies locally known as '*chaurs*', '*mauns*', '*dhars*' etc. and get inundated with floodwaters during monsoon and remain perennial and accumulate fishes with floodwaters from river and other waters. Apart from being an important source of fisheries, floodplain wetlands also form the lifeline of Kosi basin and thousands of poor fishermen are dependent on these water bodies for their livelihood. The present work was carried out in a wetland (Tarawe *chaur*) of Madhepura district, a floodplain water body situated in Kosi basin (North Bihar). An attempt has been made to study the ecological status of '*chaur*' and its bearing on fishery during June, 2011 to July, 2012. It is a larger water body located at 26⁰02'38'' N latitude and 86⁰42'30'' longitude at an altitude of approx. 52 m (170 feet) above mean sea level and covers a water surface area of about 81 hectare. The incoming water brings in, tiny fry, fingerlings and adults of different fishes along with nutrients and planktonic organisms. The present '*chaur*' supports wild fishery and play vital role in the recruitment of fish populations in the riverine ecosystems besides providing excellent nursery grounds for commercially important fishes. The fishes collected from the '*chaur*' were represented by 9 families, 17 genera and 25 species. The dominant fishes encountered were *Channa* spp. can tolerate low oxygen conditions in '*chaur*' water because they are air breathers, *Mystus* spp., *Heteropneustes fossilis* and *Wallago attu*. The small species like *Puntius* spp. were also found in large quantity. *Mastacembelus armatus* and

Anabas testudineus were seen in large number only after the monsoon season. Ongoing fishery in the present 'chaur' reveals that there has been a severe decline in fish production. The data obtained indicates the dominance of less economic species resulting in poor income to fishermen community. In general, the catfish and air-breathing fishes were found in sizable quantities, while, the Indian major carps have dwindled down to an alarming low proportion. Floodplain wetlands face a number of anthropogenic threats and large scale destruction of natural habitats, feeding and breeding ground, indiscriminate killing of broad fishes and juveniles, alteration in river courses etc. appears particularly as the causative factors for decline in fishery. The present study mainly focused on the reasons for low production and suggests different strategies for optimizing fish yield to a sustainable level without disturbing its natural environment.

RESOURCE CONSERVATION AND MANAGEMENT STRATEGY ON CROP PRODUCTIVITY IN ARGAL WATERSHED OF FATEHPUR DISTRICT IN UTTAR PRADESH

S.C. Katiyar*, A.K. Singh, P.N. Yadav and R.P. Singh

Department of Soil Conservation & Water Management

C.S. Azad University of Agriculture & Technology, Kanpur-208 002, U.P.

**E-mail: dr_sck@gmail.com*

Five villages of Argal watershed in Fatehpur district of Uttar Pradesh were selected under World Bank funded National Agricultural Innovation Project implemented from the Department of Soil Conservation and Water Management, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur during 2008-09 to 2011-12 for improving the livelihood security of rural people living in disadvantaged areas through natural resource management and miniseed multiplication cum seed exchange programme. The earning of poor resource based farmers was enhanced by adopting soil and water conservation measures, good crop cultivation practices and providing them good inputs of agriculture. The average productivity of crops and seed replacement was increased by 76.18 & 41.91%, respectively due to resource management and timely supply of breeder and foundation seeds of site specific and promised varieties of cereals, pulses and oilseeds under miniseed multiplication and seed exchange programme.

SOIL MANAGEMENT INTERVENTIONS FOR ENHANCING WATER PRODUCTIVITY UNDER RICE-WHEAT CROPPING SEQUENCE

Jagdish Singh* and M.S. Hadda

Department of Soil Science, Punjab Agricultural University, Ludhiana, Punjab-141004

**E-mail: jagdishsingh@pau.edu*

Agriculture is biggest consumer of water resources; it utilizes 72% & 85 % water resources in developed and developing countries, respectively. During the last four decades, the farmers have shifted from maize-wheat or cotton-wheat cropping system to higher water demanding rice-wheat cropping system due to ease of cultivation and higher economic returns. It leads to

increased pressure on surface and ground water resources for irrigation. The excess irrigation water demand is met through over-exploitation of groundwater due to which the groundwater table is successively going down. The soil management practices conserving soil moisture such as crop residue mulching, tillage, deficit irrigation and yield enhancing management practices such as improved or balanced fertilization, use of manures, can increase yield up to 20-30 % and have great potential for improvement of water productivity. The management practices recommended to reduce water input and enhance water productivity in the state are: alternate wetting and drying in rice, soil matric potential based irrigation scheduling in rice, IW/CPE based irrigation scheduling in wheat, direct seeded rice, planting rice and wheat on raised beds, zero till wheat and proper land leveling. These management interventions are reported to save input water in the range of 3-30 % in rice-wheat cropping system. An integrated approach is recommended to use optimal tillage, irrigation scheduling, crop residue mulching and balanced fertilization for enhancing crop water productivity and sustainability of rice-wheat cropping sequence.

RAIN WATER HARVESTING TECHNIQUES ON MOISTURE CONSERVATION AND PRODUCTIVITY OF URDBEAN - MUSTARD CROPPING SYSTEM UNDER RAINFED ALLUVIAL TRACT OF UTTAR PRADESH

R.P. Singh, P.N. Yadav , S.K. Uttam, S.C.Katiyar and S.Kumar

Department of Soil Conservation and Water Management

Chandra Shekhar Azad University of Agriculture & Technology, Kanpur-208 002, U.P.

E-mail: rpsinghcsa@gmail.com

A field experiment was conducted during *kharif* and *rabi* consecutive seasons of 2005-06 and 2006-07 at Soil Conservation and Water Management Farm of C.S. Azad University of Agriculture and Technology, Kanpur to assess the in-situ rain water harvesting techniques on moisture conservation and productivity of Urdbean-mustard cropping system under rainfed alluvial tract of Uttar Pradesh. The experiment was carried out in Randomized Block Design with three replications. The treatments comprising six treatments viz. farmer practice, deep ploughing, compartmental bunding, inter-cultivation by wheel hand hoe, organic residue mulch@4tha⁻¹ and smoothing and scooping. It was observed that the treatment receiving organic residue mulch@4tha⁻¹ produced 10.13qha⁻¹ under Urdbean with residual production of 10.16 qha⁻¹ in mustard at remunerative cost during two years of experiment. Subsequently, the water use and water use efficiency were 295mm and 3.43kg ha⁻¹ mm⁻¹, respectively.

HYDROLOGICAL RESPONSE TO MICRO-CATCHMENTS WITH VEGETATION MANIPULATION

V.K.Bhatt, A.K.Tiwari, Pankaj Panwar, Pawan Sharma and P.Bhattachryya

*Central Soil and Water Conservation Research and Training Institute, Research Centre,
Chandigarh – 160 019*

Hilly watersheds with dense forest cover in Shivalik region improves the hydrologic regime as water which seeps down in these catchments may reoccur at far off distance or it may add to the ground water. However, they may not provide optimum water yield in the form of surface runoff to the water harvesting structure constructed in the nearby downstream area. This is due to over saturation of various soil and water conservation measures and growth of extensive vegetation in the watershed which tend to reduce the surface runoff. A hydrological study was conducted on five natural, micro hilly watersheds located in lower Shivalik region. Areas of these watersheds varied from 0.813 ha to 4.75 ha. These watersheds were densely infested with lantana, therefore, first of all lantana was removed from all the watersheds so that other useful vegetation could come up as ground cover. This resulted in growth of useful shrubs like meethi neem (*Murraya koengii*) and basuta (*Adhatoda vasica*). All the watersheds were calibrated for water yield and sediment yield for initial two years during 2005-2006. Vegetation manipulation in the form of thinning of vegetation was done in all micro-forest watersheds except control (grassland micro-watershed). On analysis of observed data it was found that in general surface runoff increased in all the watersheds after calibration period as compared to control. The increase varied from 1.3% to 8.4% during 2012. There was overall reduction in soil loss during 2007 to 2012 due to increase in ground cover by natural regeneration of other vegetation in place of lantana. On an average it reduced from 3.1 to 0.6 t/ha in these watersheds. Thus for increasing water yield in densely forest areas, over saturated with conservation measures, vegetation manipulation would be required for benefitting ponds and reservoirs.

ROLE OF SILVICULTURE SYSTEMS AND MANAGEMENT PRACTICES IN WATERSHED FORESTS FOR SUSTAINED WATER AVAILABILITY

Rajeshwar Singh Jasrotia*

Conservator of Forests, Van Bhawan, Below Gumat, Jammu -180001, J&K

E- mail: rsj_1956@rediffmail.com

Well-managed forested catchments play very vital role in maintaining hydrological flow in rivers and streams, thus, water may well be forest's most useful and important by-product. Currently, with a global forests cover of app. 4 billion ha of Earth's geographical area (App. 31% of land mass & 527, 203 million M³ of growing stocks), forests are highly instrumental in intercepting precipitation, capture the fog-water, promote soil infiltration, facilitate ground water recharge and affect water losses through evapo-transpiration processes thereby significantly influence water resources and their availability. Besides spatial distribution, structure & composition, the scientific management of forests play a critical role in sustained water availability as clear felling tend to increase streams flow while carefully executed light selective

falling have little or almost no impact. Forest thinning also trigger an increased runoff, albeit short duration, while grassland constitutes good watershed cover for water yield. As many rivers and streams originate from forested watersheds, relationships between forests & water resources ought to consider in conjunction with forest management. While it is impossible to change soil of watershed areas; extremely difficult to alter the gradient of slopes but definitely possible to modify the forest management systems/silvicultural interventions for sustained water availability without impairing their other ecosystem functions. Present paper critically analyse the effects of managing forests under different management systems and impacts of diverse silvicultural interventions on water availability besides underlining need to have delineated certified watershed forests, undertake water friendly management procedures and introduce payments for watershed service besides strictly monitoring the water footprints. The paper also calls for appropriate institutional mechanisms to enhance synergies and thus, suggest to include forests in national water policies and global agreements while undertaking actions to evolve strategies, not only for their role in mitigating climate benefits, but also to generate co-benefits of sustained water availability.

**COMMUNITY MANAGEMENT OF COMMON PROPERTY
WATER RESOURCES (CPWR) FOR MULTIPLE USES
IN HARYANA SHIWALIKS, INDIA**

Swarn Lata Arya, V.K.Bhatt and R.P.Yadav

*Central Soil and Water Conservation Research and Training Institute, Research Centre,
Chandigarh – 160 019*

Increasing participation of communities in the management of common property water resources is being tried as a means to reduce pressures on government finances and to improve efficiency and sustainability of irrigation systems. Drawing on qualitative and quantitative surveys conducted during the period from 2008 to 2011 from 176 households in five villages located in the foothills of Northern Himalayas, this paper analyses the impact of community based water storage structures on productivity, economic efficiency and social aspects. Most of the farmers belonged to marginal and small category (82%) and owned land less than 2 hectare of cultivated land. Mostly these farmers are dependent upon common property water resources for their domestic, animals and agriculture needs. Per hectare net returns from agriculture as a result of CPWR varied from ` 23901 to `53027. The results have also shown how communities based rain water harvesting storages structures have effectively contributed to closing the existing gap between demand and supply of water for its multiple usages. Nearly 40 tube wells have come up in these villages exclusively as a result of ground water recharge due to water harvesting structures, where none was earlier before the implementation of the water harvesting structure. The analysis revealed that supply of water in all the five cases exceeded the demand and more so especially in case of subsurface systems in two (Mallah and Jabrot) watersheds due to perennial flow throughout the year. Subsurface system recorded maximum yield and and crop productivity per unit of water than earthen dams whereas livestock water productivity was maximum in case of water-harvesting reservoirs.

STATISTICAL MODELLING OF EXTREME RAINFALL IN SHIWALIK REGION

N.M. Alam^{1*}, C. Jana¹, A.K. Tiwari² and P.K. Mishra¹

¹*Central Soil and Water Conservation Research and Training Institute, Dehradun-248 195*

²*Central Soil and Water Conservation Research and Training Institute, Regional Centre,
Chandigarh-160 019*

**E-mail: alam.nurnabi@gmail.com*

The occurrences of extreme events like heavy rainfall and associated flash floods in recent years have become a great concern for all of us. Annual maxima and daily rainfall for the years 1961–2010 are modelled for Shiwalik Region in India. We explore the possibility of trends in the data but find no evidence suggesting trends in the whole series. But there was an increasing tendency in the observed extreme rainfall during the last two decades (1990-2010) than in the previous years (before 1990). Generalised extreme value (GEV) and generalised Pareto distributions (GPD) were fitted to one day maximum rainfall and the daily rainfall in the region, respectively. It was found that both distributions are reasonable. The diagnostic plots and chi-squared goodness-of-fit test indicate the validity of the fitted model. The fitted tail distributions also allow the estimation of probabilities and return periods of the daily rainfall extreme. We derive estimates of 2 to 500 year return levels for daily rainfall and annual maxima series using the two distributions along with 95% confidence interval (CI). The 50, 100 and 500 year return level of extreme rainfall along with CI for the region estimated to be 226.46 mm (195.46,298.93), 246.95 mm (208.59,344.25) and 291.98 mm (232.69,462.17) respectively. The estimated return level for one day annual maximum rainfall with 95% CI will serve as an essential pre-requisite for any hydrologic design or planning of cropping system in this region which will not only help us to withstand with the adverse climatic condition in near future but also can help to achieve more efficient design of hydraulic structures. Moreover it can be very valuable information for economic and effective planning by various agricultural and engineering departments of Shiwalik region.

MANAGEMENT OF SHORT ROTATION COPPICE/ FORESTRY BY WASTEWATER

Sabeena Nabi*

Faculty of Forestry, Camp Wadura, Sopore, SKUAST-K -193 201(J&K)

**E--mail: nabisabeena@gmail.com*

The plantations of short rotation coppice/ forestry (SRC/F) usually based on poplar or willow species are promising source of biomass for energy use. The replacement of fossil fuel with biomass in the generation of energy and heat has recently been an important strategy promote by the European Union (EU) to mitigate effect of climate change an enhance the security of the supply and diversification of energy sources. The life cycle assessment for poplar SRC

plantations in Germany confirms the very low CO₂ emissions resulting from energy production using biomass from SRC. It produces just 0.015 kg CO₂ equivalent per kWh generated electricity. But water availability is usually considered as one of the main constraints of profitable SRC culture of these species on arable land. The practice of applying wastewater/sludge on SRC/SRF is a quite new approach in Europe. In most cases, research projects have been initiated in countries where the establishment of SRC/SRF for production of energy biomass always had a strong tradition (e.g. Sweden, Denmark, UK etc), and in countries where the scarcity of water resources has lately led to alternative uses of wastewater, namely the reuse with wastewater in SRC/SRF (Spain, Italy, Portugal, Cyprus, Greece etc). Nevertheless if located, designed and managed wisely, energy crop plantations can, besides producing renewable energy, also generate local environmental benefits. Such benefits could arise from the nutrient content in wastewater. Theoretically, the nutrients in domestic wastewater and organic waste are almost sufficient to fertilize crops. As much as 80-90% of the major plant nutrients (nitrogen, phosphorus and potassium) in wastewater are present in the toilet waste. This could reduce the need for additional fertilizer and increase profit margins due to lower input costs. An annual municipal wastewater load of 600 mm, containing about 100 kg N, 20 kg P, and 65 kg K, will supply not only the required water, but also the requirements of N and other macro-nutrients and in turn the generation of sewage sludge will also be significantly reduced when willow vegetation filters are used, by up to 80%.

CLIMATE CHANGE IMPACTS ON PRECIPITATION AND WATER DEMAND

Sabeena Nabi^{1*} and Burhan Nabi²

Faculty of Forestry, Camp Wadura, Sopore, SKUAST-K 193 201

Faculty of Veterinary Sciences and Animal Husbandry, Shuhama, SKUAST-K 190 006

**E-mail: nabisabeena@gmail.com*

Current projections based on the Special Report on Emission Scenarios (SRES) storylines depict a rise in global average surface temperature of approximately 1 degree centigrade by the 2020's. The temperature rise is associated with an anticipated increase in precipitation at higher latitudes (eastern Africa, the northern part of central Asia and the equatorial Pacific Ocean) and in the tropics, but decreasing precipitation in the sub-tropics (Mediterranean and Caribbean regions). Globally, there is growing evidence that snow cover has already decreased in most regions, especially during spring and summer. Climate models used in the Arctic Climate Impact Assessment project, showed a 9-17% reduction in the annual mean Northern Hemisphere snow coverage by the end of the century under the B2 scenario and also a projected volume loss of 60% of glaciers in various regions by 2050, which describes a world in which the emphasis is on local solutions for economic, social and environmental sustainability. Projections made by IPCC in 2009, indicated that summer low flows in the Rhine will decrease by 5-12% by the 2050's, which will have an adverse impact on water supply. Similarly, climate change will put a

large number of people at risk as a result of seasonal flooding of the Ganges, Brahmaputra and Meghna rivers in the Asian subcontinent and the rise of sea-levels in Bangladesh. According to projections made by Food and Agriculture Organization (FAO), irrigation demand is projected to increase by 0.4% - 0.6% per year up to 2030 and 2080, but, if the anticipated impacts of climate change are added, the projected demand will lead to an increase of between 5-20% by 2080. In terms of planned interventions, a number of technical, policy and market based instruments are needed that will take into account the effects of climate change, disaster risk preparedness and insurance frameworks to reduce the vulnerability of local communities.

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