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"Transforming agriculture in Bundelkhand through rainbow revolution....."

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Jhansi - 284 003 (U.P.) India

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From Vice Chancellor's Desk.....

The tribals practice low input agriculture and use indigenous methods and techniques to overcome. Constraints individual and community level. The diversification is an alternative approach which may be used for ensuring food, nutrition and livelihood security of tribals.

Tribal farmers in the country, face numerous production constraints such as uncertain and erratic rainfall, degraded forests, sloppy and hilly terrain, and thin fertile soil. These factors along with poverty and low capacity of investment; unavailability of inputs; inadequate knowledge about cultivation practices, improved variety of seeds and other inputs; and lack of proper markets, force tribal farmers to practise subsistence agriculture by cultivating traditional crops. The natural resources like land and water have undergone severe depletion, both in terms of quality and quantity. As a result, tribal farmers also face severe production constraints. Another important factor influencing tribal agriculture is the strong link between forests and the tribal population, as the latter is largely dependent on forests for food, fuel and fodder requirements. It is, therefore, imperative that the root cause of resource degradation in tribal areas should be addressed as an important component of the strategy for developing agriculture in tribal areas. As a thumb rule, enhanced and sustained productivity could be seen as directly related to regeneration of the natural resource base of the region.

To meet the ever-growing need of increasing population there is not enough scope of horizontal expansion of agriculture and forestry. There is enough scope for vertical expansion of natural resources over the available land area where two or more components may overlap each other. So the solution to combat the challenge of sustained food security and meet the energy requirement for domestic purpose, lies in encouraging scientific agro-forestry in available land resources. In turn, it will provide food security to the nation, conservation of soil, improvement of soil fertility, reclamation of degraded lands, stabilization of watersheds, protection of biodiversity, meeting the fuel requirement etc. In fact agro-forestry will play very effective role in the utilization of the natural resources in a most effective manner for sustainable crop production and socio-economic upliftment.

According to a study, tribal farmers used a total of 22 tree and 33 crop species in their existing agroforestry systems, indicating a rich knowledge among tribals about crop composition and high bio-diversity. Agroforestry practices increase species diversity, provide economic returns, and help tribal farmers to maintain their livelihoods.

There is an urgent need to formulate future policy interventions focusing on sustainable reforestation practices in association with tribals, to solve the problems faced by the farmers, and livelihood improvement in India.

The present issue of Agri-Life entitled' Tribal Agriculture and Agroforestry' is compilation of various issues pertaining to tribal agricultural practices and agroforestry interventions in different parts of the country. I hope this issue will highlight the very critical aspects of tribal agriculture and Agroforestry to understand the long term vision to develop agrotechnologies.

(A. K. Singh)
Vice Chancellor

Editorial

Tribal Agriculture and Agroforestry

"Indigenous and tribal peoples" is a common denominator for more than 370 million people, found in more than 70 countries worldwide, as mentioned by the ILO. Tribals world wide have their own cultures, languages, customs and institutions, distinguishing them from other parts of traditional societies. The tribal peoples of India are also known as "Adivas is", which means 'Original inhabitants of a given region. The tribal population of India ranks second in the world to South Africa. According to Population Census (2011), the number of scheduled tribes in India is 10,42,81,034, which accounts for 8.6 per cent of the total population of India. Tribal people have been strongly associated with the forests, hills and remote areas, practising their unique lifestyles with fantastic beliefs. They have made the forests their dwellings and survived on hunting and gathering, and fishing. However, with the growing population and the pressure of resources, tribals also developed livelihoods in settled farming. The term traditional tribal agricultural practices denote a type of knowledge that has evolved within the tribal community and has been passed on from one generation to another.

Tribals have a wealth of indigenous agricultural practices because of their autonomous social structures and limited contact with other people. Their lifestyle sharpens their intimate knowledge of environmental processes, which they wisely employ in agricultural practices. Nestled in the lap of nature, the tribal communities provide great scope for agricultural development and employment.

In addition, the tribals have inherent fundamental assets like capacity for hard work, labour dignity, and attachment to the region or land. Researchers have highlighted that a majority of agricultural labourers in India are drawn from the scheduled castes and tribes. It has been found that

the provision of extension and training of modern farming practices have facilitated tribals in adopting innovation in agricultural and agroforestry to their advantage. Yet, they require training and knowledge in applying fertilizer, organic and chemical fertilizer doses and method of application, method of transplanting, plant protection measures, methods of harvesting and inter-culturing and the like. The tribals have faced challenges like illiteracy, economic backwardness, indebtedness, small land holdings, improper land utilization, skill development and social deprivation.

The present issue of Agri- Life on "Tribal Agriculture and Agroforestry" attempts to provide insights into the agricultural practices of tribals, the current state and future of tribal agro-forestry, the policy interventions and research on the tribals who are significant contributors to indigenous agricultural wisdom and practices. New agrarian technology can improve the production and productivity of the agricultural sector in the tribal region and can cause an improvement in the economic condition of the people. For the development of sustainable agricultural practices, recognising the inherent strength of tribal agriculture is the need of the hour. As Bodley shows, it is the tribal world that knows how to reproduce culture.

(Anil Kumar)
Editor in Chief

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Jhum Cultivation: A subsistence farming system of tribal communities in Northeast India

Kambam Boxen Meetei[1], Meribeni Tsopoe[1], Krishna Giri[2*] and Gaurav Mishra[2]

Shifting cultivation is also linked to the formation of distinct sociocultural wealth among the indigenous communities who practice it. The entire jhum operation is associated with a variety of ceremonies and festivities. This article attempts to shed light on why jhum farming is a sustainable form of agriculture in terms of food security, livelihood, economic, environmental, and social aspects.

Introduction

Jhum cultivation has been and still is one of the most popular farming systems in North East India's (NEI) hilly areas. The term "jhum" refers to the shifting agriculture that is the primary source of livelihood for the ethnic communities living in the hilly areas of northeast India. Jhum is distinguished by mixed cropping, which mimics nature regarding species diversity. Shifting cultivation is vital in the *in-situ* preservation of numerous varieties of edible food crops. The hill tribes grow cereal grains, vegetables, and cash crops. Rice is the most significant crop, accompanied by maize, millet, Job's tears, and others. Another significant output of the jhum field is cotton. Potatoes have recently been introduced in some areas. Pumpkins, cucumbers, yams, and arum are the most commonly grown vegetables. These products are generally sold in the market, and the people receive cash, although the food crops are mostly consumed.

Although rainfall, topography, and crop types vary across NEI, the cultivation procedure and technique are more or less the same. The alder-based jhum and Kolar jhum cultivation are two distinct versions of this farming system in Nagaland. The alder-based jhum cultivation is practiced most commonly in Khanoma Village, Kohima district. Farmers in this system largely follow a pattern of two years of cultivation and two years of fallow through manipulating alder plantations in distinctive spacing in jhum fields. On the other hand, 'Kolar' jhum cultivation in Tuensang district is the year-round cultivation of a single species of bean (locally known as Kolar). Other variations include 2nd-year ginger cultivation in the Garo Hills and Broom-grass cultivation in the Meghalaya districts of West Khasi Hills and Ri-bhoi. Horticultural species are more popular as second-year crops in other states, such as Mizoram, Tripura, and Assam's Barak Valley.

Contribution of Jhum cultivation to Jhumias livelihood, the environment, and sociocultural

The tribal communities in the northeastern states of India have historically relied on subsistence farming with land and forest as their primary resources. They engage in intercropping and sequential cropping to grow a range of crops within the constraints of the available resources. Based on the ecological characteristics and requirements, they introduce a wide range of crop species onto a single plot. The harvest season for various crops is spread across six to eight months each year and includes both traditional cash crops and subsistence crops. Food is available all year long, and the risk of crop failure is reduced because of a wide array of crops that mature across a range of months. In NE India, "the National Bureau of Plant Genetic Research (NBPGR) has recorded 674 varieties of maize, 298 varieties of upland rice, 200 varieties of grain legumes, 37 varieties of eggplant, 60 varieties of ginger, 250 varieties of taro, and 242 varieties of yam, among other crops". It has been noted that the Adi tribe in Arunachal Pradesh's Upper Siang District cultivates more than 30 species and 75 varieties of crops in jhum fields for subsistence. Jhum is practiced for sustenance by the Jhumias and as an income source for them. By balancing food production and income generation, farmers can support themselves and earn money. Though a few studies have shown that shifting cultivation is associated with low productivity and is not economically feasible compared to other types of agriculture, these studies do not account for the difference in inputs. These studies also fail to consider the advantages of mixed or sequential cropping, which allows crop production during the whole jhum cycle. The livelihood of the community, especially women, has improved due to the resurrection of millets in Nagaland. Jhumias earn their livelihoods by selling organic farm products such as large cardamom

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and bhut jolokia grown in the Jhum field. The Jhumias' dietary needs and income are supplemented by various resources, including vegetables, firewood, medicinal plants, fodder, broom grass, and other non-timber forest products from the fallow lands.

Jhumias have historically practiced organic farming by relying on sustainable crop and soil management. It provides various ecological services, such as soil conservation and carbon sequestration, and hence aids in climate change mitigation. They have a significant pool of germplasm. It is believed that the wild relatives of cultivars that indigenous communities have retained are essential to guaranteeing the sustainability of food supply in the context of global warming. As a result, these findings refute the theory that jhum cultivation facilitates environmental degradation. In high mountain regions of North-east India, shifting cultivation is advantageous to other forms of agriculture in terms of biodiversity conservation, restoration and sustainable use of biodiversity, carbon sequestration, nitrogen fixation, nutrient cycling, soil erosion mitigation, and soil fertility maintenance. No other form of agriculture could have been as beneficial and prolific as jhum cultivation in the steep tropical highlands with heavy rainfall. Mountain communities worldwide are recognized for their resiliency, and the Jhumias have been engaging in this form of agriculture for many years and generations. They have provided the best illustrations of innovation and adaptation, such as zero tillage, mulching, mixed cropping, adjusting crop schedules, keeping stumps and setting logs across slopes for slope stabilization, incorporated livestock, and efficient resource management.

Shifting agriculture has been fundamental to highland farming communities' social, cultural, and economic activity. Jhum cultivation is inextricably related to the sociocultural ethos of the indigenous communities practicing. Traditionally, jhumia communities performed socio-religious events that are intertwined with jhum activities. For example, many indigenous knowledge systems, songs, dances, festivals, and tales revolve around the entire spectrum of shifting cultivation. The social customs and traditions associated with jhum cultivation, such as sharing seeds before sowing and sharing surplus harvests, promote social harmony and unity among many communities. Another social aspect of jhum cultivation is that it helps maintain the cultural identity of various ethnic tribal communities. The risk of loss of cultural identity has been noted as one of the immediate repercussions in the Tamenglong district of Manipur if the community discontinues jhum farming. As a result, many social scientists believe that jhum farming is more than simply a source of livelihood and food security; it is also a way of life.

Conclusion

Jhum cultivation has been an integral part of most of the indigenous communities of the North East India mountain region's culture and tradition from time immemorial, and it is still widely practiced today. Shifting farming has always been seen negatively because of its primitive and detrimental environmental impacts. However, due to the region's undulating and steep topography, many scientists believe jhum farming is feasible in northeast India. Several environmentalists and social scientists believe that jhum farming is a more diverse, sustainable method of agriculture that can ensure food security and economic, environmental, and sociocultural factors. Rather than perceiving jhum as a "problem" or "primitive," one should consider how Jhum can be upgraded to be more economically and environmentally sustainable agriculture without abandoning the farming system that is so ingrained in Jhumias' life and culture.

(a) Tree-based jhum

(b) Mixed cropping system

(c) Alder-based jhum

(d) Paddy jhum field

e and f: Agrobiodiversity in the jhum farming system

(g) Jhum cultivation landscape in Nagaland

Figure 1 a-g: Photographs of jhum cultivation

Tribal Agriculture- An age old practice of farming with new hopes

Shruthi M. K. and Shree Harsha Kumar S. S.

Tribal agriculture in India plays a major role in its contribution where it has its own way of unique nature of contribution to the country's economy as well as diversity. Mainly the tribes are resided in forest regions and hill areas in the country. The tribal economy mainly concentrates on collection and processing of minor forest products and cultivation is largely for domestic consumption. The tribal economies lack organized markets as well as financial institutions to promote the tribal products. There is a huge demand for tribal artifacts, textiles, ornaments, paintings, potteries, cane and bamboo products and organic and natural food products, but the supply side of this economy is way below the demand side and thus the community fails to profit from its produce. Thus, efficient production and effective promotion become imperative for the economic development of this community. On the other part of livelihood for the tribal community is from farming where the major form of agriculture practiced by tribes is shifting cultivation or slash and burn practice of farming which has both pros and cons form different perspective.

Introduction

A tribe is a social division in a traditional society consisting of families linked by social, economic, religious, or blood ties, with a common culture and dialect. A tribe possesses certain qualities and characteristics that make it a unique cultural, social, and political entity. Sometimes the tribes are also known by names of adivasi's in India. India being a diversity rich country has many numbers of tribes across different states. These schedules tribes of the country are occupying 8.6% of the country population with diversified culture and social nature and different for different tribes. The states like Madhya Pradesh, Maharastra, Orissa, Rajasthan, Gujarat, Jharkhand, Chhattisgarh, Andhra Pradesh, West Bengal, and Karnataka are the state having a larger number of scheduled tribes these states account for 83.2% of the total scheduled tribe population of the country. On the other hand Assam, Meghalaya, Nagaland, Jammu & Kashmir, Tripura, Mizoram, Bihar, Manipur, Arunachal Pradesh, and Tamil Nadu are accounting for another 15.3% of the total scheduled tribe population. The share of the remaining states / UTs is negligible.

Tribal Agriculture-Shifting cultivation: Among the different tribes the livelihood earned from agriculture is mainly from shifting cultivation form of agriculture. In some patches where shifting cultivation is not in vague upland cultivation is practiced. Recently some tribes are also practicing wet cultivation in central and western India. Shifting cultivation is predominantly followed in different parts of eastern and central India but it's not the only source for lively hood but it is supported by food gathering, hunting, house hold small scale industry and casual labour.

Upland cultivation practiced by tribal community is also inadequate to provide substistance to the population concerned and hence frequently it is supported by agricultural labour, hunting, forest produce collection and other sources of livelihood. In many parts of the country there are much demarcated areas being cultivated by tribal community and recognised both politically and have right of ownership or procession on tribal house holdings. But the lands under tribal community are not of more economic use and mostly occupied or utilised by other purposes like allotment of land to outsiders or taken over for public purposes. Whatever may be the situation in the area of recognition of tribes but the shifting cultivation is frequently associated with the tradition of communal ownership of lands.Shifting cultivation is previously had wide spread and now being considerably practiced by tribes in states like Madhya Pradesh, Nagaland, Andhra Pradesh, Orissa and nominally exists in Maharashtra, Mysore and Kerala.

Shifting cultivation is defined as any continuing agriculture system in which impermanent clearings are cropped for shorter periods in years than they are allowed to remain fallow. Sometimes it is also known as field forest rotation. The practices concerned to shifting cultivation vary from place to place and tribes to tribes. Here, the land with more sunny and less weeds levelled but not eroded and land lying fallow from many years is preferred for cultivation. But it is based on low technology and under utilization of human resources.

UAS Bangalore

The core principle of shifting cultivation is slash and burn method where generally the lands are cleared using traditional implements. The ash left after burning the plants are cleared bushes is spread all over the field. Some tribes sow the seeds along with ash and some sow the seeds by digging holes using digging sticks. Again some tribes follow the practices depending upon the nature of crop. Even in some patches ploughing with wooden implements is also practiced. But generally the plot remains cultivation for one or two years and after that the land is abandoned and the household concerned clears up another patch of land for cultivation. After a lapse of 5-6 years or 10-12 years or at times even more they may return to same plot. But it depends on the availability of land, population pressure, soil composition and its capacity to recoup naturally because the tribes do not apply any inputs to enhance soil fertility.

Shifting cultivation practices by tribes of different parts in the country

Negative shade of shifting cultivation: the shifting cultivation mainly includes slash and burn method which means clearance of forest or natural vegetation for cultivation induces some negative impacts. It may lead to springs to dry up, soil erosion, loss of valuable timber, flood and silting up of tanks and loss of crops due to flood.

Tribal agriculture towards climate risk mitigation: there are live examples where the tribal community is engaged in diversified crop cultivation including mixed cropping and mixed farming. This diversified crop cultivation shows that different crops are cultivated in such a manner that the forest diversity where it consists of number of plant species. In states like Orissa some tribal farmers grow a variety of crops in single farm where it consists of cereals, pulses, vegetables and some oilseed all together as mixed cropping and they opined that they harvest their livelihoods from the farm as well as the collect seeds from the same field for their next cropping. And they also said that it is like a crop insurance and throughout the season the harvest one or the other crop and they don't depend on any single crop and even sometimes some crop may fail. In addition it encourages natural biodiversity also. In addition to that the traditional agriculture is the way to mitigate climate change risk associated with agriculture and resilient to natural calamities. It need to be channelled in a more scientific and acceptable approach.

***Tribal agriculture and forest products*:** It very well established fact that there is great demand for tribal arts, forest product and unique natural products produced from tribal community On the other hand production and promotion of tribal products is the need of the hour and is critical to ensure improvement of the economic condition of tribes in India. Production of such products may result in large-scale employment generation of the tribal community. In absence of a sufficient supply of such products, marketing strategies fail to benefit the target community. Hence, measures must be introduced to increase the production of tribal products. And also there is a need to promote innovation in products and marketing facilities for tribal products by engaging franchises in small and medium towns and also in metropolitan cities which intern help to establish a brand of tribal products.

Encouraging tribal agriculture is the need of hour to promote the tribal products in Indian economy. In general the tribes mainly depend on forest for all the raw materials and produce products that have a significant symbolism in their culture. Further, the tribal communities are largely isolated from the rest of the civilization and due to limited exposure and lack awareness about government schemes and fail to benefit from them. It becomes imperative that the government promotes such schemes and encourages the tribal community to avail the benefits of such schemes. Additionally, these communities must be motivated to adapt to modernization so that they can obtain complete market information and can no longer be manipulated by the middlemen.

Tribal farming region into a carbon sequestration zone

Shidayaichenbi Devi

India accounts for 35% of the hilly and mountainous regions of the total geographical area covering a larger area practicing tribal farming by the tribal people. The slash-burn practice of the tribal people contributes to climate change owing to the release of Green House Gases (GHGs) leading to global warming. The GHGs especially carbon dioxide (CO_2) can be trapped maximum in the soil through "carbon sequestration" in the tribal farming regions through the improvement in the slash-burn practice into incomplete burning of the forest trees till the biochar production stage and soil incorporation of it became an approach to mitigating climate change and improving soil health and maintaining a sustainable environment without compromising crop productivity.

Introduction

The country, India, has 6.91 lakh square km of the hilly and mountainous region covering 35% of the total geographical area having more than 15% slope distributed to its 23 states (Assam, Andhra Pradesh, Bihar, Gujarat, Himachal Pradesh, Haryana, Jammu and Kashmir, Kerala, Karnataka, Mizoram, Meghalaya, Manipur, Maharashtra, Madhya Pradesh, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tripura, Tamil Nadu, Uttar Pradesh, and West Bengal) and the Himalayan regions. The regions are dominantly populated by tribal people practicing "tribal farming" which is the indigenous way of farming as per their knowledge and experiences in farming transferring them from one generation to the next generation. They have skills and ideas to produce more yield and can correspond the practices suitably with the soil and climate even though not knowing the scientific reasons. Mostly they conduct "slash-burn" practices for growing various crops for 2-3 years continuously and left the soil for a fallow period to recover the soil fertility and shift to another fertile area for farming, popularly known as "shifting cultivation". However, due to population pressure, the fallow period is reduced to only 2-3 years from a sustainable fallow period of 10-15 years thereby less soil fertility, severe soil erosion, low crop productivity, and depletion of biodiversity. Besides, the addition of GHGs to the atmosphere due to the slash-burn practice of the forest contributes to carbon dioxide (CO_2) gas for global warming into climate change. Moreover, the tribal people's shifting cultivation cannot be forced to avoid but can be improved for a sustainable environment with the trapping of excess atmospheric CO_2 into the soil through the "carbon sequestration" process which reduces climate change and enhances soil fertility. It is expected that tribal farming in the hilly regions can be a solution for mitigating climate change as covering the region a large geographical area through the carbon-sequestration process.

Tribal farming system

The livelihood of the tribal people is completely dependent on forest products. They depend on cultivated food as well as uncultivated forest food. The cultivation of crops is on the hilly slopes by clearing and burning down the forest called the "slash-burn" practice. They cultivate various crops and varieties depending on their requirement and the suitability of the crops to the soil and the climatic conditions. As they cannot rely on a particular area for cultivation over years due to a reduction in soil fertility and then crop productivity, they shift the cultivating area and their homes during the fallow period of the soil i.e., shifting cultivation. Different tribal areas have different farming systems which again vary from state to state and country to country. The common tribal farming in the hilly region is "shifting cultivation". The different local names of the shifting cultivation are as follows:

State	Name of tribal farming system
Manipur	Pam-lou
Assam, Meghalaya, Mizoram and Nagaland	Jhumming
Chhattisgarh and Andaman & Nicobar Islands	Dipa
Madhya Pradesh	Bewar / Dahiya
Andhra Pradesh	Podu / Penda
Odisha	Pama Dabi / Koman / Bringa
Western Ghats	Kumari
Southeastern Rajasthan	Valre / Waltre
Himalayan Belt	Khil
Jharkhand	Kuruwa

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Slash-burn into Carbon sequestration

The hilly area that is fully covered by forest is felled down the trees and completely burnt to ash. This ash is incorporated with the soil and when showering rains, the cultivation of the crops for continuous 2-3 years and then left the soil for a fallow period to rejuvenate the lost fertility which is "slash-burn" practice. As it involves the complete burning of the carbonaceous constituents contained in forest trees and plants releases CO_2 into the atmosphere causing global warming as well as declining soil health. Instead of complete burning in the slash-burn practice, the burning until the charcoal production stage, called biochar, can highly reduce the release of CO_2 into the atmosphere and incorporate in the soil can help in sequestering excess atmospheric CO_2 thereby mitigating climate change.

Tribal regions for mitigating climate change

The tribals are mainly populated in the hilly areas having a large geographical area, less urbanization and industrialization pressures, and enriched biodiversity with various fauna and flora. However, due to their lack of scientific knowledge, they follow continuously the traditional and indigenous farming practices contributing GHGs released and degrading soil fertility. The hilly regions are also the major forest zone maintaining the environment, so, better to utilize them productively and eco-friendly. Without completely changing the tribal's farming practice as difficult to convince them, only the improvements can be suggested for a sustainable environment i.e., the inclusion of carbon sequestration process in their familiar farming practices.

The main reason for the trapping of excess atmospheric CO_2 i.e., carbon sequestration is to reduce global warming in which plant absorbs the atmospheric CO_2 gas intercepting with water and sunlight for its photosynthetic process and storing in the plants as carbonaceous constituents until it is burnt down or decomposed. A carbon sequestration process is a promising approach for tribal farming regions so that maximum atmospheric CO_2 can be sequestered and maintain soil health.

Why does atmospheric CO_2 sequester in tribal farming region?

It is not like only in the tribal farming regions excess atmospheric CO_2 sequestration is happened, but a maximum of it can be sequestered there. The tribal regions are dominated by forests and the farming practices following there are contributing to higher GHGs in the atmosphere. However, the region can be an atmospheric CO_2 trapping zone by forestation, soil incorporation of biochar product, and reducing deforestation. More than the amount of releasing GHGs from tribal farming to the atmosphere, maximum atmospheric CO_2 can be sequestered and reduce global warming as it has potential and sufficient area cover.

Benefits of carbon sequestration in the hilly region

The benefits of carbon sequestration through the soil incorporation of biochar are as follows:

a) It traps the excess atmospheric CO_2 causing global warming.

b) It supplies the carbon nutrient as "feed for soil microorganisms" to the soil and enhances the soil biological properties.

c) It enhances soil's physical properties i.e., the soil structure formation and the soil aggregates stability thereby reducing soil erosion.

d) It also maintains the soil's chemical properties, especially the cation exchange capacity (CEC) as the biochar product has a higher specific surface area.

e) It increases the soil moisture content due to the porous nature of the biochar product having high water absorbance.

Carbon sequestration for a sustainable environment

The intensive farming in the tribal's hilly regions for excessive production in less time from the hilly soil to sufficient the population demands which drastically degrades the soil health along with reducing the crop productivity due to the reduction in the fallow period of the slash-burn practice. The new approach for sustaining an environment in the hilly region is carbon sequestration which can enhance the soil's physical (texture, structure, bulk density, moisture content, etc.) chemical (CEC, soil organic carbon content, macro-and micro-nutrients content, pH, etc.), and biological properties (microbial count, soil microbial biomass carbon content, etc.) leading to increment in the soil qualities into the soil health. The carbon sequestration takes a minimum of 3-5 years for stabilizing the soil into fertile soil and self-sustainable. However, it is a long-term solution for mitigating climate change and approaching to a sustainable environment.

Conclusion

Tribal farming is simply the traditional or indigenous farming practice i.e., slash-burn practice, that is adapted maximum in the hilly regions. With the advent of urbanization and industrialization, various GHGs are released into the atmosphere causing global warming. Tribal farming also contributes to atmospheric GHGs owing to its fault practice of completely burning down the forest for cultivation and reducing in a fallow period to recover the soil health due to population demands pressure. To combat global warming and declining soil health, carbon sequestration is a promising approach in tribal farming regions. The improvement in tribal's slash-burn practice with the inclusion of "carbon sequestration" process through incomplete burning of the forest trees till the biochar production stage and soil incorporation of it helps in trapping maximum atmospheric CO_2 in the soil as the tribal hilly region covers a large geographical area (35% of the total geographical area) which mitigating climate change with the enhancement in the soil health and crop productivity for a sustainable environment.

An outline of Nagaland's traditional farming culture

Meribeni Tsopoe[1], Kambam Boxen Meetei[1], Gaurav Mishra[2] and Krishna Giri[2*]

Agriculture has been the mainstay of the economy in the state and has been linked with the Naga socio-culture aspect. Through the transmission of traditional agricultural methods from one generation to the next, people have accumulated knowledge and strategies for cultivating their crops and increasing their output. Due to the geographical terrain of the state, terrace agriculture and traditional Jhum cultivation are two of the farming methods practiced frequently by tribal farmers in Nagaland.

Introduction

Nagaland, a landlocked state in the North eastern region of India, is characterized by hills and slopes and mountainous terrain richly endowed with natural resources and abundant agro-biodiversity. It is predominantly an agrarian state with more than 70% of its population engaged in varied forms of traditional farming systems. Besides, there are mixed cropping patterns, crop and livestock integration along with forestry, paddy cum fish culture, kitchen gardens, and wet paddy rice cultivation largely in the foothills of the state.

1. Traditional Jhum cultivation:

The age-old traditional slash-and-burn method of cultivation is the oldest and the most common farming practice in the state. This technique involves cultivating crops and vegetables on a plot of land for two consecutive years, followed by the harvesting of the crops, and the subsequent cutting down and burning of crop wastes because they believe that the ash from the fire aids in soil regeneration. After a period of time, they leave the land fallow, allowing some pioneer plants to thrive and replenish the soil. However, there are benefits and drawbacks to this traditional farming. Since chemical fertilizers are not used in the growing process, organic food is produced. However, the shorter fallow and jhum cycles are detrimental to the environment because they could accelerate landslides, soil erosion, and even deforestation. Being the staple food, rice is the predominant crop and occupies the maximum area under cultivation followed by maize, millets, and Job's tears. The secondary crops are mostly vegetables (peas, common beans, perilla, eggplant, potatoes, and sweet potatoes) that are intercropped. The intercropped vegetables are often grown between the areas left by the major crops.

2. Alder-based jhum cultivation:

The alder-based jhum cultivation is practiced by the Angami tribe of Khonoma village for about 100 years. This is a wise modification of the traditional jhum cultivation, where Alder trees are incorporated in the crop land and pollarded before crop cultivation. This farming system has been well recognized in the eastern Himalayan region of the country for its socio-economic and environmental benefits. Incorporation of Alder trees in the croplands boosts crop production as well as the fertility status of soil without additional inputs. The root nodules of the Alder tree fix atmospheric nitrogen through its symbiotic association with actinomycetes called Frankia.

The trees provide firewood; shade, and timber, and the leaf litter enhances the soil nutrients. Potato, pumpkins, chili, etc. are grown in this farming system. Besides, the Alder cum Cocoa farming system is practiced in the Wokha district of Nagaland without pollarding practice.

3. Terrace cultivation:

Step farming commonly known as wet terrace rice cultivation (WTRC) is practiced in the hilly parts of Nagaland. Terrace cultivation prevents soil erosion by allowing uniform water current flow on the slopes. Thus, it also makes efficient use of the water available. WTRC is practiced mainly by the Angami and Chakhesang tribes residing in Kohima, and Phek districts. Paddy is the major crop in terrace cultivation, whereas vegetables intercropped are *colocasia*, pumpkins, chayote, chilies, etc. Fruit trees like guava, papaya, banana, pomelo, and Indian juju be are grown at the edges of the terrace fields. Non-terrace paddy cultivation is observed in plain areas of Nagaland *viz*., Chumukedima, Jalukie in Peren, and the outskirts of Dimapur districts.

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4. Home gardens/kitchen gardens:

Vegetable cultivation is a major practice in the home garden farming system of Nagaland. The farming communities practice mixed cropping by incorporating different vegetables in a random manner. The most common vegetable crops seen in this system are tree tomatoes, leafy vegetables, chayote, spring, onion, etc. The home garden farming system makes the communities self-sustenance and reduces the dependence on market vegetables. Besides, kitchen gardens are maintained in

Figure 1 Home gardens in Nagaland

Fresh Jhum site

Terrace Cultivation

Alder based Agroforestry

Traditional underground bee keeping

Cocoa-Alder Agroforestry

Integrated livestock farming

Figure 2 Farming systems in Nagaland

all the villages in Nagaland which are much more popular in Jotsoma (Kohima), Niuland, Wokha, and Dimapur districts.

5. Integrated farming practice:

In Nagaland, different types of integrated farming systems are practiced by the local farmers viz., integrated farming with crops, livestock, and aquaculture. These farming practices provide sufficient food availability along with financial benefits from different sources to the farmers. Livestock rearing includes poultry, fishery ponds, pigs, and cows. For example, cattle rearing at the base of terrace fields in Jotsoma village are one of the integrated farming practices of Nagaland. Besides,

integrated paddy cum fish rearing is practiced by the local farmers in Mima and Khonoma villages. The best example of an integrated farming system in the state is the Zabo. 'Zabo' in the local dialect means "impounding of water". It is a time-tested integrated farming strategy established by the skilled Chakesang community in the Phek district to address water scarcity issues in the past. Today, this farming system is recognized for promoting smart farming methods by protecting the forest areas on its hilltop, which act as natural water reservoirs. The water catchment in the lower strata is used for runoff rainwater storage for paddy crop irrigation during the dry season. The system includes livestock, horticultural crops, fruit trees, and paddy cum fish culture at its base. Since these areas are large it becomes difficult for individuals therefore, communities come forward and work collectively.

6. Diversification beyond the farms:

Diversification beyond farming activities provides farmers to generate additional income. The tribal farmers in Nagaland in addition to crop production and livestock management also practice bee-keeping. Traditional underground beekeeping is popular in Mima village of Kohima. It is known as the honey bee village of India. It is an efficient, less labor-intensive method of integrated farming practice. The farmers of this village have developed alternate options to enhance their farming skills beyond crop cultivation. Where settings are created and forests with a wide variety of trees are found close to the hamlet. According to a recent study, conducted among 40 households in Mima, about 267 kg of annual honey production generates around 2,67,000 rupees, which was found to be higher than the total annual income generated from major crops in both shifting and terrace cultivation of approximately 98,352 rupees. Around 70% of households in Mima village practice bee keeping to supplement nutritional values, income, and employment generation.

Indigenous traditional knowledge of tribal farmers for pest management in Tamil Nadu and Maharashtra

P.P. Jambhulkar, V. David Chella Baskar and Vaibhav Singh

Among tribal cultures, adivasis or aboriginal people are considered early settlers. They reside in remote, unhealthy jungles. Tribal people use plant-based items, crop leftovers like ash, husk, etc., and animal products like cow dung, red earth, etc. to protect their agricultural plants in the field and in storage. Most of these compounds are harmless, biodegradable, less persistent, non-toxic, and widely available in their homes and land. Tribals eat tubers, fruits, and nuts from their woodlands and develop crops. This has led to the design and acceptance of their choice and ability crop production systems, allowing them to produce crops at specified seasons.

Introduction

Tribal agriculture remained a subsistence sector due to agroclimatic conditions, technological backwardness, lack of education, etc. Tribal agriculture in India is labor-intensive, arid, and stagnant. Tamil Nadu's indigenous groups grow many crops. Kurumbas, Irulas, Todas, Kotas, Mullakurumbas, and Panias tribes from Tamil Nadu do farming intensively. Tribal women collect, store, and safeguard grains, tubers, etc. from pests. Malayali tribal women have created simple, useful methods for picking seeds and preserving them from pests and diseases. In Malayali homes, seeds are stored in an atti. After monsoon rains, all crops are cultivated. Tribals say June-August rainfall determines crop success. Most tribes practice mixed cropping. Here are several pest-controlling crops.

Bhils, Gamits, Gavits, Kokanis, Mavachis, Pasvis, Pawaras, Tadavi, Valvis, and Vasaves are tribal groups in Nandurbar district Maharashtra. Pavari, Mavchi, Bhili, Kokani, etc. are dialects of several ethnic groups. In certain locations, multistory buildings have existed for millennia without sickness. Multistory systems may be effective in Nandurbar area home gardens by combining plant architecture, shading, landraces, and species diversity.

Through mixed farming, tribals attempt to meet food and economic needs. Land, water, and soil nutrients are used efficiently to grow food. Tribes rely on organic manures like cow refuse, green manure, and domestic wastes to nourish the soil. Green manure includes neem, pungam, *Calotropis gigantea* R. Br., and *Cassia javanica* Linn.

Tribal pest control knowledge

In view of the tribals' diverse farming practises, it's interesting to examine their traditional crop protection strategies. They want to store seeds and tubers pest-free. Tribals use indigenous pest management techniques to grow pest-free crops. Neem, Vitex negundo Linn., *Adhatoda vasica* Nees., and *Calotropis gigantea* R. Br. are used for pest management. No effort was made to document and preserve tribal pest management procedures, but reports of tribal pest control expertise from Tamil Nadu hills are accessible. Indigenous folk practises among Nilgiris Irulas, Malayali Gounder and Irula tribals in Palani hills in Tamil Nadu, Kalrayan and Kolli hill tribes in Tamil Nadu There are 5, 6, and 6 primitive tribal clans in the Nilgris District of Tamil Nadu. Pachamalai tribes in Tamil Nadu and Malayali tribes also have pest control strategies.

Malayali Gounder tribes in Tamil Nadu's Kalrayan hills have nearly 40 pest control strategies. Certain procedures were studied to improve their pesticidal activity for rice, vegetables, and storage grains. Irulas, Malayali Gounders, and Todas living in Kalrayan, Kolli, Javvadu, Yelgiri, Yercaud, Pachamalai, and Varusanadu have implemented more than 300 pest management strategies. Tribal wisdom documents a substantial share to eliminate store pests, followed by all pests and non-insect pests with 30, 27 and 20% adoption. Based on performance, several tribal traditions were chosen for further pest control research. In addition to pest evaluations.

Tribal practices for crop pests rice fuel wood ash and fish + neem leaf extract checked brown planthopper and green leafhopper. Sprays of table salt solution and fish + neem leaf extract controlled leaf folder, another rice pest. Dusting stem borer larvae with Acacia sawdust

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and wood ash was effective. *Vitex negundo* Linn. leaves extract+butter milk spray and *Adathoda vasica* Rice sprayed with Nees. leaves extract + cow dung slurry has also been observed.

Nandurbar's tribes cultivate many crops. Valvi, Kokani, Pawri, Mavachi, and Bhils perform intensified farming. Tribal women choose, store, and safeguard food grains, tubers, etc. from pests.

Tribals devised a slogan to summarise the names of pesticide-making plants. i.e. EK SIK GURU PAK NIGHA i.e. Erandi (*Ricinus communis* L), Kaduneem (*Azadirachta indica*), Sitafad (Annona squamosa), Karanj (*Pongamia pinnata*), Gulwel (*Tinospora cordifolia*), Ruichki (*Calotropis gigantean*), Papai (*Carica papaya*), Kanher (*Nerium indicum*), Nirgudi (Vitex negundo) and Ghaneri (*Lantana camara*). The pesticide is prepared by mixing 5 Kg of the extract with 10 Kg dung, 10 liters of Go mutra, 0.5 to 2 kg of lahsun, and 0.5 to 2 Kg of mirchi the cha in the form of paste in 200-liter drum and kept for fermentation for 21 days. Keep shaking the drum clockwise and anti-clockwise daily to release the gases. After 21 days spray pesticide using a knapsack sprayer. These tribal has formular for viral diseases also. It involves 2 liter old curd in liquid mixed with 2 liter Go mutra, 1 Kg garlic and 0.5 Kg chilli. Mix the content and warm it before spray.

Vegetables

- Calotropis leaf + garlic + onion + Chilli powder was efficient against brinjal Epilachna beetle, pumpkin caterpillar, and tomato fruit borer infestations.
- Jatropha and Calotropis leaf extracts showed potential in controlling brinjal fruit borer and whitefly.
- Vitex leaf extract killed bhendi whiteflies.
- Sweet flag leaf and rhizome extracts kill pulses grasshopper.
- Fenugreek + betel vine + onion + buttermilk + castor oil killed *Spodoptera litura* larvae, pests of vegetables, millets, pulses, and oilseeds.
- Vitex leaf extract controlled leafminers and thrips.
- Calotropis leaf extract beat all other tapioca whitefly treatments. Certain tribal insecticides are effective on rice, vegetables, groundnuts, and pulses.

Store grain pests

Tribal insecticides can effectively combat rice moth, red flour beetle, pulse beetle, and rice weevil. Salt powder, kitchen ash, Vitex leaves, Vitex leaf spray, cow dung ash, turmeric powder, and neem + Vitex + turmeric powder were successful therapies. Kitchen ash, chilli powder + lime + ash, and *Clerodendron* leaf extract were useful in godowns.

Trapping/repelling tribal pests

A ragi bird scarer and tribal rat trap were described. Granite rocks are painted with lime solution to deter pigs from tapioca crops at night. Wood ash with water form a paste or gel. Men and women smear the concoction on their bodies to repel mosquitoes. In tribal regions of Tamil Nadu, a mosquito repeller built of an iron container with top and bottom openings to hold neem, Leucas, Anna (a weed), and Chrysanthemum leaves was found. The Malayali gounder clan employed rat traps in Pachamalai, Kolli, and Kalrayan hills. Flat granite stone and three 10cm sticks make up the tribal trap. The trap is set up so that rats become trapped under the stone when the sticks are moved while the animal takes the meal. Sticks are readily damaged and should be replaced often. Therefore, a modified tribal rat trap was created and tested in rice field bunds. The modified rat trap has a 30 x 25 x 5cm concrete block, a Y-shaped neem wood pole with 7.5cm arms and a 16cm middle arm. The trap's performance against rats in rice fields during samba season was compared to a traditional Tamil Nadu trap termed a "Thanjavur bow trap". An acre of rice was trapped for 35 days with 30 of each type. The redesigned rat trap killed more rats with concrete than the other trap during the trial period. Low-cost rat trap kills rats for longer.

Tribal pesticides' economics

Most tribal pesticides are inexpensive and readily available. Non-toxic, eco-friendly, biodegradable materials were employed in the investigation. Neem, Adhatoda, Vitex, Calotropis, etc. are free in their native environments. Ashes from kitchen garbage, cow dung, Acacia twigs, etc. can be easily procured and used in the field.

Conclusion

Tribal crop protection knowledge and practise must be used in contemporary and future agriculture. In combination with biopesticides, resistant crop varieties, sex lures, light traps, etc., tribal pesticides are good alternatives to chemical pesticides. Tribal people require knowledge on non-chemical plant conservation. Tribal farmers must be contacted. Pest management requires concentrated plant and animal substances.

Intervention of floricultural crops to revolutionize tribal's livelihood

Amit Kanawjia, Rakesh Kumar, Satya Prakash, Ajay Kumar Singh and KS Tomar

Tribal economy is generally based on collection of forest produce, hunting and fishing or a combination of hunting, collection and shifting cultivation. With the growing population and resource pressure, tribal agriculture is now witnessing a rise in livelihoods based on settled farming. Most of India's 70 million tribal's are illiterate with shorter life expectancy compared to other communities. The marginal environmental conditions for agriculture often influenced by low/erratic rainfall and unreliable water supply for irrigation further create problems for their survival. Chhattisgarh, Orissa, Jharkhand, Madhya Pradesh, North Eastern States and the Andaman and Nicobar Islands constitute the major tribal population of the country.

Introduction

A tribe is a social group or community characterized by a common territory, dialect, name and cultural heritage. The tribal peoples of India are also known as "Adivasis", which literally means 'Indigenous People' or 'Original inhabitants of a given region'. Tribal population in India is the second largest population in the world next to Africa and form an integral part of India's social fabric. There are about 550 tribes in the country. As per the Population Census (2011), the total population of scheduled tribes in India is 10,42,81,034 which is 8.6 per cent of the total population of India. Out of these, 9, 38, 19, 162 people belonging to scheduled tribes reside in rural areas which is 11.3 per cent of the total population of rural areas, whereas, 1, 04, 61, 872 people live in urban areas constituting about 2.8 per cent of urban areas. Within the rankings of the traditional Indian caste system, tribal's are beneath even untouchables, thus the most downtrodden, economically and socially.

Major problems faced by tribal's in India

- Illiteracy
- Unemployment
- Poverty
- Indebtedness
- Land alienation
- Shifting cultivation
- Poor access to health facilites
- Addiction to alcohol
- Poor housing
- Poor communication leading to isolation
- Migration to cities in search of livelihood

Present scenario of agriculture in tribal communities

Tribal communities are characterized by a lifestyle distinct from agrarian communities, and their practices in agriculture are distinct. Shifting cultivation is the key to the livelihoods of many ethnic, indigenous and tribal groups in India. While 43 per cent of non-tribals depend on agriculture, 66 per cent of the tribal population survives on agriculture and forest related livelihood sources.

- Tribal's practice of mixed cropping, preserving seed genome, role of minor millets in their life, their fairs and festivals linked with agriculture, storage of crop produce, use of fertilizer and insecticide make tribal agriculture unique.
- Agriculture is showing signs either marginal improvement, stagnant or declining trend in status of production, productivity and input efficiency though there has been some improvements in cropped area, crops and cropping pattern, but only for small proportion of people.
- Women participate in almost all agricultural operations contributing between 70 to 80% of the total labour.
- A study on awareness and adoption of modern agricultural practices among STs in KBK districts of Odisha exhibited that relatively higher awareness levels were expressed by the farmers in tribal area on seed replacement (9% households), summer ploughing (6%), balanced use of chemical fertilizer (12%), soil testing and seed sowing techniques (2%) and use of organic farming (7%).

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- Tribal communities, namely Irulas, Malayalis and Muthuvans living in the state of Tamil Nadu, have been cultivating traditional cultivars of paddy, millets, pulses and vegetables.
- The livelihood of tribal communities in the Jharkhand state has traditionally been dominated by pig-based production systems poultry, goat rearing and artisan activities also played a vital role in the livelihood of tribal people.

Challenges faced by tribal's in agriculture

The major challenges faced by tribal farmers are summarized below:

- Tribal agriculture is characterized by small land holdings, improper land utilization, poor farming techniques, over grazing of pastures, low capital investment and low production inputs.
- Tribal people have limited capital and unmatched skills for practicing modern agriculture due to unawareness, illiteracy, insufficient capital and government aids, and lack of resources.
- Due to crop failure and loss they avoid the cultivation of superior crops and are mainly dependent on production of millets crops like maize, jowar, bajra, kodo, kutki etc.
- Limited access of agricultural services in tribal areas which results in low uptake of agricultural technology.
- Lack of skill development training facilities in tribal areas related to different off-farm activities.
- Unavailability of different farm inputs, quality seeds and planting materials.
- Post harvest management and marketing faculties are not sufficient in the tribal regions.
- Tribal youth are unable to produce sufficient resources to fulfill their livelihood requirements; and as a result they are migrating outside their traditional habitat in search of jobs in unorganized sectors.

Crop Diversification through floriculture in tribal areas

It is well known that flowers play a significant role in every occasion of human life and India has a long tradition of floriculture. Diversification in agriculture through floriculture is capable of generating more per capita income. Government of India has identified floriculture as a sunrise industry as commercial floriculture has higher potential per unit area than most of the field crops. The domestic consumption of flower products increased considerably, and so is the exports of cut flowers, value added products like dry flowers, potted plants, etc. India experiences 25 percent annual growth in its domestic flower market. As a result, commercial floriculture has emerged as a farm operation with scientific recommendations. It is an intensive type of agriculture and if done in a scientific way, the income per acre is much higher than any other agricultural product. Commercial floriculture can open up great opportunities to our poor farmers. Our country has diverse climatic conditions which offer the scope for growing several kinds of commercial flowers. The farmers can deploy a part of their land for growing commercial and common flowers such as rose, marigold, tuberose, gaillardia and china aster, etc. which do not require much care and generally earn more profit than any other crops.

Floriculture Scenario in India

India's share in the world trade of floriculture is about 0.6% only.

As per the National Horticulture database published by National Horticulture Board, during 2020-21, the area under floriculture production in India was 322 thousand hectares with the production of 2152 thousand tonnes of loose flowers and 828 thousand tonnes of cut flowers (www.apeda.gov.in, APEDA, 2022).

Flower cultivation is now commercially done in several states with highest area in states such as Kerala (16.5%), Tamil Nadu (13.3%), Karnataka (11.4%), Madhya Pradesh (11.1%) and Uttar Pradesh (7%) have gone ahead of other producing states like Andhra Pradesh, West Bengal, Mizoram, Gujarat, Orissa, Jharkhand, Haryana, Assam and Chhattisgarh (APEDA, 2022).

India's total export of floriculture was Rs. 771.41 crores/103.47 USD Millions in 2021-22 (Table1). The major importing countries were U.S.A, Netherland, Germany, U.K, UAE, Canada and Italy.

There are more than 300 export-oriented units in India. More than 50% of the floriculture products are produced in Karnataka, Andhra Pradesh, Tamil Nadu and Madhya Pradesh.

Table 1. India's total export of floriculture during the years 2021-22

	2021-22		
Country	**Quantity**	**Value (Rs Crore)**	**Value (US $ Mill)**
U S A	3,520.05	22,2.31	29.83
Netherland	2,206.37	147.11	19.73
Germany	1,208.63	50.71	6.81
U.K	917.69	39.62	5.33
UAE	3,074.79	36.59	4.90
Canada	768.59	33.56	4.51
Italy	261.18	21.36	2.86
Malaysia	882.13	18.33	2.45
Grand Total Including other countries	**23,597.17**	**77,141.48**	**103.47**

Source: APEDA, 2022, www.apeda.gov.in

Floriculture and Livelihood Security

As there are not enough job opportunities in tribal areas, many non-governmental organizations (NGOs) have taken on the task of empowering tribal men and women through microenterprises. One such intervention is the implementation of marginal floriculture in these areas. Although India's current contribution to the global floricultural export is negligible (0.6 %) compared to other countries such as the Netherlands (58 %), Colombia (14 %), Ecuador (7 %), Kenya (5 %), Israel (2 %), Italy (2 %) and Spain (2 %), the small-scale cottage industry appears to benefit many impoverished men and women in the most backward rural areas. Farmers are now growing various varieties of flowers for domestic and export markets. There has been a tremendous increase in the area under floriculture in India in a decade. The area under loose flowers has increased from 191 thousand ha in 2010-11 to 322 thousand ha in 2021-22 which is about 90.30%. Similarly, the production of loose flowers has also increased manifolds from 1031 thousand MT in 2010-11 to 2152 thousand MT in 2021-22. The increase in the area and production is due to the promotion of large quantity of export in the international market. Indian floriculture industry comprises flowers such as Rose, Tuberose, Gladiolus, Anthurium, Carnations, Marigold, etc. Floriculture has influenced the farmers and other stakeholders by way of transforming the options of livelihood available to farmers in agriculture in the past few decades. The fresh flowers are being transported to long distances due to the availability of air transport and refrigerators. Flower production at large scale and liberalization policy of Government of India has transformed the way farmers practiced agriculture. Policies unveiled by the government to promote the floriculture and other food grain crops has received appreciation by the farmers community as it gives quick and high return. Flower crops can be grown under the mixed farming culture (vegetables with flowers of marigold, rose and chrysanthemum) in the tribal areas. With the technological advancement and globalization demand of flower is growing locally and globally, which led to the increase in production of flower and generation of livelihood opportunities.

Successful Inclusion of Floricultural crops in Cropping/Farming Systems

A. Flower based cropping system

- Several researches have suggested that Rice-marigold crop sequence can be alternate suitable cropping sequences under low land rice-ecosystem of hill zone of Karnataka.
- Flower crop-based cropping systems viz. chrysanthemum (April planted)-wheat, chrysanthemum (April planted)-winter season onion, chrysanthemum (June planted)-groundnut and marigold-onion were found to be most economical in Ahmednagar, Maharashtra.

B. Integrated Farming System

Inclusion of flower crops in Integrating Farming System (IFS) models has been found to be more profitable and sustainable in different states. Few examples have been illustrated below:

- IFS models viz., crops + dairy, vegetables, mango orchard, fisheries, bee keeping and poultry, flower crop marigold in western Uttar Pradesh have resulted in highest BC ratio of 2.56 followed by vegetables (2.23). The marginal increase in economic profits over existing farming system (crops + dairy) ranged from 40 percent under vegetable cultivation to 75 percent with floricultural crops.

- The study conducted in two tribal dominated blocks i.e. Abroad and Pindwara of district Sirohi, Rajasthan reported that the IFS model including Cash crop + vegetable + flower + fruit production earned Rs. 5.30 lakh per year with maximum B:C ratio (4.38) and generated 1800 man-days per year at farmers field from 2 hectare land comprising 0.4 ha under flowers which was better than all other components viz. cash crop, vegetables, pulses cereals.

Likewise, intercropping of gladiolus and marigold in mango orchard, coconut chrysanthemum intercropping system, cauliflower + marigold intercropping system, cultivation of sugarcane with marigold intercropping, sugarcane + gladiolus intercropping system were found to be profitable venture.

Floriculture Intervention in Tribal Areas – Success Stories

A. Umarpada, a tribal village in Surat, Gujarat

Umarpada, a tribal village in south Gujarat, is set to change its economy by turning to rose production. Nearly 1,500 farm-workers have committed to join hands with Surat-based JJ Flora Cooperative Society to produce Dutch (exported) roses and gerbera flowers with a view to ship branded roses to western markets including the US, Europe and Japan by next Valentine season. The cooperative society along with 50 tribal farmers has already started an initial production of Dutch roses in 30 acres. In next three years, it is expected to grow more than 1 crore cut-flower roses of various varieties in an estimated area of 500 acres (20,000 rose stems per acre). *51-year-old Shyambhai Vasava, sarpanch of Umarpada says that "The wishful labour-turned-rose producer is expected to earn more than ten times of their current wage,"*

B. Rozam, a tribal village in Dahod Gujarat

Dahod district in east Gujarat, which borders Jhabua in Madhya Pradesh and Banswara in Rajasthan, has 74.3% Scheduled Tribes population as per the 2011 Census, the majority of them Bhils and Pateliyas.

Rose and marigold farming was the most frequent flower farming development activities, each accounting for 32.4 %, and followed by Gaillardia farming (28.6 %) and a mixture of rose and marigold farming (6.6 %). As reported the income revenue after floriculture development was 29.5 to 18.3 times of the previous income, with an average of 21.9 fold increase. A small village located in Dahod District called Rozam became the 'Village of Flowers' after the initiation of floriculture development. The village is inhabited by 100 % tribal population, where, a woman named Ramila cultivated two flower crops viz. rose and marigold in a small piece of land (0.3 acre) in 2006 and she sold roses and marigold worth USD 1,400 within three months. By seeing the huge profit, she started a nursery the following year with 2000 plants by grafting the mother plants and sold them at the rate of USD 1 per 10 plants. She earned a profit of USD 200 just from the plants. After seeing the instant economic benefits obtained by Ramila, other women in the village started nurseries. About 80 % of farmers in the village started floriculture development since 2007 beside their usual cereal crops. Additionally, 60 nurseries became operational as of September 2008.

Conclusion

Floriculture can play an important role in improving the livelihood of tribal farmers. Besides, cultivation of commercial flowers other segments like fillers, potted plants, seeds and planting material, cut greens, nursery, perfumes, colour pigments, dried flowers and turf grass industry can open up new avenues for the tribal youths to start entrepreneurship. There is need to create cold-storage facility at the air ports and railway stations along with cold-refrigerated vans and compartments for transportation via roadways and railways and arrangements of direct cargo flights from production centers to auction or destination centers for fresh delivery of produce. Proper strategies for infrastructural development, professionalism in market management and network management of flower industry needs to be developed for further expansion of floriculture trade. Awareness programme through seminars, demonstrations, flowers shows and exhibitions for popularizing flower cultivation increase the interest of the tribal people to enter into the floriculture business.

Agroforestry Systems: a way to reclaim wastelands

Saresh N. V.[1] and Archana Verma[2]

Wasteland in general it represents degraded, unused, and uncultivated lands and efforts have been done to utilize it in recent past to overcome the gap between demand and supply of food, fodder, timber and also for resource conservation. About 40 percent of our 1.3 billion population depends on land for livelihood. A large acreage of lands of the country can no longer be cultivated due to the degradation problem leading to wasteland development. Reclamation of these wastelands is a priority and agroforestry land use system can play a significant role for solving existing problem of land degradation. Reclamation of such wasteland requires systematic and scientific approach which includes proper survey, choice of species and techniques for establishment of plant species. It requires an integrated approach of using land according to land capability classes, soil and water conservation measures and putting land under permanent vegetation cover involving, afforestation, agroforestry, horticulture, pasture, and energy plantations.

Introduction

India's total land area is around 329 million hectares, out of which 146 million hectares are classified as wasteland land by NBSS and LUP (2004). The wasteland represents degraded, unused, uncultivated, and common land as (a) lands not available for cultivation, barren, and unculturable wastes, (b) other uncultivated land excluding fallow, culturable waste, permanent pastures and land under miscellaneous trees (c) fallows under wastelands. Different departments define the wasteland according to their land use pattern. National Wastelands Development Board (NWDB) defined wasteland as ''that land which is degraded and is presently lying unutilized (except as current fallow) due to different constraints'' and also suggested that any land which is not producing green biomass consistent with the status of soil and water must be treated as wasteland. As per the report of the Technical Task Group constituted by thePlanning Commission, the wastelands are the degraded lands which can be brought under vegetative cover with reasonable efforts and which are currently under-utilized and the land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. Thirteen categories of wastelands viz., gullied and/or ravenous land, underutilized/degraded notified forest land, mining/industrial wasteland, barren rocky/ stony waste/sheet rock area, landwith or without scrub, steep sloping area, snow covered and/or glacial area, degraded pastures/grazing land, degraded land under plantation crops, sands inland/coastal, water logged and marshy land, land affected by salinity/alkalinity coastal-inland, and shifting cultivation area have been identified in the country by National Remote Sensing Agency (NRSA), which constitute about 20.17% of total geographical area (NRSA 2011).

About 40 percent of our 1.3 billion population depends on land for livelihood, agriculture is the single most and important sector of India's economy. Moreover, agriculture sector is progressing towards development and has not yet attained its peak due to arid, semi-arid, and saline patches of land. Its impact is especially severe on the livelihoods of the poor, who are heavily dependent on this land for livelihood. A large acreage of lands of the country can no longer be cultivated due to the degradation problem. Due to the adverse edaphic environment they are devoid of any vegetation and restrict the choice of arable crops to be grown. As of no additional land resources are available for horizontal expansion of agriculture, we need to find out viable technologies for utilization of existing land resources including the wastelands in order to meet future requirements of food, fodder and fuel. This makes the reclamation of these wastelands not only a priority at national level but also on a global scale. Although due attention is being given by Indian governments at respective state level to increase the total area under cultivation and green cover. Therefore, it has become necessary to develop a suitable land-use system that can coupe up the existing situation and bring the marginal wastelands into productive land use system. Agroforestry land use system can play a significant role in sustaining agricultural production for livelihood and environmental security through improving biodiversity, enhancing ecosystem services, improving soil structure and health, reduced erosion, carbon sequestration, increasing income, sustaining agricultural productivity, limiting the

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impacts of climate change, as well as maintaining economic growth and social structure.

Status of wasteland

As per the varying definitions based on data sources, classification systems, methodologies and scales, various estimates of wastelands have been given by different shown in Table 1.

Table 1. Wasteland assessment by different organizations/agencies

Organizations/Agencies	Estimated extent (million ha)
National Commission onAgriculture	148
Ministry of Agriculture (Soil and Water Conservation Division)	175
Society for Promotion of Watershed Development (SPWD 1984)	129
NRSA	53
Ministry of Agriculture	107
NBSS and LUP	146
Department of Environment	95
National WastelandDevelopment Board	123

The area reported by different agencies showwide variation in the extent of wastelands so has harmonized area statistics, where total degraded area comes to 120.8 m ha out of which 73.3 million ha is estimated to suffer from water erosion, 12.4 m ha from wind erosion,17.4 m ha from chemical degradation, and 1.1 m ha from physical degradation.

Wasteland reclamation

Reclamation or restoration or rehabilitation implies improvement in overall condition of the land. As per IUCN guidelines, restoration is a process bringing a degraded ecosystem or landscape back to same prescribed, productive condition in short process of revitalization. Approaches for wasteland reclamation concentrates on processes such as persistence of species natural recruitment and survival, functioning food webs, systems wide nutrient cycling. Reclamation on the other hand is referred as means that the site will be similar in ecological functioning after disturbance and will be habitable by similar but not necessarily the same organisms. If damage is so severe that soils have to be replaced and landscapes may have to be reshaped and the intensive rehabilitationis sometimes termed reclamation.

Agroforestry systems and reclamation

Introduction of perennial component in cropped area provide cover and security against the fears of crop failure and assist in reducing the soil and nutrient loss from the lands. Apart from the benefit of product diversification, agroforestry systems has the potential of enhancing less productive lands. Depending on the glitches and needs of the area, trees may be introduced as alley, boundary plantation, block or scattered tree plantation in the field. Though introduction of trees on cropped lands the overall economic returns have been institute better than the sole cropping of agricultural crops. Agroforestry systems are effective in restoring degraded soil, systems such as agro-horticulture, agro-pastoral, agri-silvipastoral systems and others are the prominent example. The leaf litter on the floor in an agroforestry systems which decomposes and forms humus by the symbiotic effect of microorganisms ultimately enhances soil fertility, help in reducing losses of soil, water, organic matter and nutrients. More over many tree species have ability to conserve moisture by adding leaf litter in and above ground and enhance soil fertility in agroforestry systems; legumes trees and crops has also have an effective role for promotion of soil fertility. Systematic agroforestry enhances soil fertility, there are numerous evidence that agroforestry systems have potential for enhancing soil organic matter (SOM), crop productivity, water retention, carbon sequestration, biodiversity and soil sustainability. Trees improve soil fertility through a wide range of processes such as soil carbon pools by providing additional below-and above-ground biomass, reduction of losses and improvement of soil physical, chemical and biological conditions and nutrient cycling. Among mentioned processes soil fertility improvement is mainly augmented majorly due to the addition of tree litter fall, pruning and root residues.

Reclamation of salt affected area

Amelioration of salt affected soils with the domesticated agro forestry trees will reduce the pressure on the productive lands to fulfil the food needs of the growing population and environmental concerns. Agroforestry systems, provides alternatives for restoring soil health and amelioration of salt affected soils for their productive use. Exudation of organic acids by tree roots neutralizes the alkalinity of soils. Moreover, many scientists reported that agroforestry system play an important role in amelioration of salt affected soils. Revegetation using deep-rooted perennials is seen as a method of reversing the salinity problem. The deep and sturdy root systems of tree open up the soil and improve water permeability and facilitate leaching of salts. Fine roots have contributed significantly in the reclamation

of soil structure, pH and water permeability. Silvi-Pastoral, Silvi-Agriculture systems and multipurpose wood lots provide alternatives to check further deterioration, restore soil health and put lands to productive use. *Prosopis juliflora* and Karnal grass silvi-pastoral system is the most promising for firewood and forage production and also for soil amelioration. It improves the soil condition to such an extent that after some years, less tolerant but more palatable fodder species such as berseem (*Trifolium alexandricum*) senji (*Melilotus parviflora*) and shaftal (*Trifolium resupinatum*) can be grown under trees.

Alkali soils contain excess soluble salts capable of alakaline hydrolys is which interfere the growth of plants. Some tree species like *Cassia carandus, Psidium guajava, Zizyphus mauritiana, Aegle marmelos, Emblica officinalis, Punica granatum, Prosopis juliflora, Acacia nilotica, Casuarina equisetifolia, Tamarix articulata, Achras zapota* etc. can tolerate more than pH 10.0, *Pitchecellobium dulce, Salvadora persica, Salvadora oleoides, Capparis decidua, Terminalia arjuna, Albizzia lebbek, Cordia rothii, Pongramia pinnata, Sesbania sesban, Eucalyptus tereticornis, Parkinsonia aculeata, Phoenix dactylifera, Tamarindus indica, Syzygium cumuni* etc. can tolerate pH 9.1 to 10.0 and *Acacia auriculiformis, Azadirachta indica, Melia azaderach, Populus deltoides, Grewia asiatica, Vitis vinifera, Mangifera indica, Kijellea pinnata, Moringa oleifera, Grevillia robusta, Butea monosperm, Pyrus communis, Sapindus laurifolius, Ficus* sp. etc. can tolerate up to pH 9.0.

Introduction of vegetation in saline affected soil hinders the loss of water through evaporation results lower salinity in the area under green cover. Plant species such as *Atriplex* sp., *Prosopis sp, Tamarix* sp, *Casuarina Kochia, Zizyphus* sp, *Salvadora* sp and *Acacia* sp are most tolerant to underground saline water situation which can with stand high salt content and thrive under high water table conditions. *Termnalia arjuna, Albizzia procera*, Eucalyptus 'hybrid' and *Leucaena leucocephala* can tolerant and survive up to ECe12.2 dS/m and *Dalbergia sissoo* were slightly tolerant as it survived up to ECe 6.70 dS/m. *Acacia nilotica* and *Eucalyptus terticornis* lowered the soil pH from 10.5 to 9.5 in five years and electrical conductivity from 4 to 2 along with the application of gypsum and manure.

Limestone mined areas

Limestone is high in silica and magnesia, therefore almost equal quantity of waste and over burden is generated due to limestone mining. Planting of slips of *Eulaliopsis binata* was ideal on the degraded, steep mine spoil areas. Planting of leguminous species, such as *Leucaena leucocephala*, and *Peuraria hirsuta* in the mine spoil provided foliage rich in N which served as fodder, organic manure, mulch, etc. Species, such as *Thysonoleana maxima, Saccharum munja, Pennisetum purpureum, Eulaliopsis binata, Ipomoea carnea*, and *Vitex negundo* performed well under geotextiles. With continued biotic protection together with rehabilitation measures the retrogression and erosion came to stand still. The vegetal cover will increased from 10 to 90% due to reforestation over a period of 20 years. On an average, after 18 years, pH of the spoil came down from 8.1 to 7.4, organic carbon increased from 0.13 to 0.45%, whereas CaCO3 decreased from 54.6% to 29.5% and bulk density from 1.63 to 1.45 Mg m^{-3}. The Afforestation technology consists of planting seedlings of *Cassuarina equisetifolia, Leuceana leucocephala, Dalbergia sissoo, Acacia auriculaeformis, A. nilotica, Albizia lebbeck*, and *Eucalyptus citridora* in pits after filling 2/3 depth with red soil, FYM, and sand after leveling in mine spoil area, industrial units, and township got more than 80% survival in the planted area.

Ravine Lands

Ravines are the systems of gullies running almost parallel to each other and draining into a river after a short distance with the development of deep gorges which is often the productof stream cutting erosion. Ravines are classified as larger in scale than gullies, although smaller than valleys. The depth of small, medium,and large gullies are 1 m depth, 1–5 m depth, and 5–10 m depth, respectively. Ravines are usually > 10 m deep depth. Most of the ravenous lands are not fit for cultivation which are classified as non-arable lands. Cultivation is not desirable in these lands as it leads to erosion thus ultimately degradation. Ravine rehabilitation requires an integrated approach of using excellent scientific land use and bring them under forest, fruit trees, forage grasses, energy plantation and agroforestry according to land capability classes and using soil and water conservation measures and productive utilization of land according to gully reclamability classification. The classification is linked with treatment of gullies through soil and water conservation measures, gully control structures, etc. It takes into account the influence of soil characteristics and gully dimensions on suitability of reclaiming gullies for cropping, horticulture, forestry or growing grasses. Bali and Karale (1977) have suggested criteria for reclamation of gullies. Verma

(1981) and Verma and Bhushan (1986) proposed a detailed classification of ravines for optimum utilization in which gullies have been classified into six reclaimability classes.

Silvo-pastoral system is suitable for reclamation of medium and shallow gullies that can be brought under forest and fruit tree-based pastoral system. Grasses provide desired levels of protection to various mechanical structures erected for reclamation of ravines. *Dicanthium annulatum, Cenchrus ciliaris, Cenchrus setigerus, Panicum antidotale, Panicum maximum, Pennisetum purpureum, and Brachiaria mutica* are some of the important grass species suitable for fodder and as a soil binder in ravine regions. Bamboo and Anjan grass based silvo-pastoral system has been developed by Central soil and water conservation research and training institute's research centre Vasad in Anand district of Gujarat for enhancing productivity of ravines. For raising of grasses, palliated grass seeds are sown in 10 cm deep furrows dug along the contours at the onset of monsoon and rooted slips planted at a spacing of 50 × 50 cm to achieve quick establishment of grasses along with native multipurpose trees. Whereas, Agri-horticulture system is best suitable for Class IV reclaimability classes. Fruit trees such as lemon (*Citrus limon*), mango (*Mangifera indica*), ber (*Ziziphus mauritiana*), and aonla (*Emblica officinalis*) can be grown with agricultural crops in humps and gully beds. Based on the tree species, spacing of planting may vary from 2 × 2 m to 8 × 8 m with pits of 45 × 45 × 45 cm to 1 × 1 × 1 m size and are prepared during summer and planting is completed soon after onset of monsoons. In the interspaces inplanting of palatable grasses is a better option. Life saving irrigation is essential for the fruit cultivation in ravines at least during summers.

Erosion control and sand dune stabilization

The perennial component in agroforestry system have extensive root morphology which binds and anchor the weaker upper horizon of the soil profile and provide a strong interlocking system to the soil binder which reduces slipping and sliding of the soils which is very much important for checking the land to be turned down into wasteland.

Shifting of sand dunes are one of the important problems in desert areas all over the world. Sand dunes are highly mobile which causes obstacle in agricultural operations, establishment of vegetation, roads and rail traffic, and other infrastructures. Thus the stabilization of sand dunes by establishing of plantation stand is of vital important for desert region for combating desertification, rehabilitating fragile dune ecosystem and to meet the growing demand for ever increasing human and livestock demand. The sand dune stabilization technique developed by ICAR-CAZRI consists of (a) fencing of the area, (b) establishment of micro-wind breaks on the windward side of the dune in 5 m chess board pattern or in 5 m parallel strips, and (c) sowing of grasses and transplanting of trees and shrubs with the onset of monsoon. For raising micro-wind breaks, locally available brushwood materials like *Leptadenia pyrotechnica (Khimp), Ziziphus nummularia (Pala), Crotalaria burhia (Sania) and Panicum turgidum* (Murath) were used. Suitable tree species for sand dune stabilisation are: *Acacia tortilis, Prosopis* spp., *Acacia senegal, Parkinsonia articulata* and *Tamarix articulata*. Among grasses, *Lasiuruss indicus* and *Cenchrus ciliaris*, and among creepers *Citrullus colocynthis* were most suitable.

Reclamation of sand dunes using *Acacia tortilis*

Shelterbelts to reduce wind erosion to canal command area

Silvi-pastoral system in arid zones (*Prosopis cineraria* + different grass species)

Research and Development need in agroforestry for wasteland reclamation:

1. Survey, collection, assembling, and domestication of wild trees, shrubs and grasses suitable for reclamation purpose.
2. Enhancement of already existing technologies to make it more beneficial to the stakeholders.
3. Develop agroforestry models for different site conditions for optimizing multiple output production, carbon sequestration, and biodiversity conservation.
4. Development and distribution of quality planting material.
5. Managing below ground interaction among tree crop associations.
6. Capacity building through trainings on nursery production, tree growing, soil and water conservation techniques, biofuel production and other income generating avenues to the stakeholders.
7. Value addition through processing and marketing of plant based products.
8. Enhancing transfer of technology to the farmer's field.
9. Watershed programs need to be 'demand driven' and not 'target driven' as is usually the case.
10. Effective vertical and horizontal coordination among various and non-governmental organization.
11. Involvement of landless and assetless people in the watershed.
12. Strengthening of forestry component and involvement of Forest department and other line departments.
13. Livelihood through integrated farming system involving other components like honey bee, fishery etc.
14. Involvement of multi disciplinary professional's institutions.
15. Gender equality and empowerment.
16. Sustainable development of common pool resources (CPRs) of land, water, forest, wildlife, and agriculture.

Tribals and agriculture in Paderu region of Andhra Pradesh

A.R.S.S.H. Gupta, A.D.S.S. Ajay Nikhil, H. Sirisha, N. Aneesha and Rumana Khan

Tribe is a traditional social division in which families are linked by social, economic, religious, or blood ties and share a common culture and dialect. The indigenous peoples of India are also known as "Adivasis," which literally translates to "Indigenous People" or "Original Residents of a Region." After Africa, India has the world's second-largest tribal population. Tribal people have long been connected with the forests, hills, and distant locations, leading a distinct way of life and adhering to a distinct set of cultural and religious beliefs. Tribal societies have lived in forests for millennia, subsisting on hunting and gathering. However, as the population and resource pressures expand, it is becoming more common to see livelihoods based on settled farming. Hunting, collecting, and fishing are the mainstays of tribal economies, or a combination of hunting, collecting, and shifting agriculture. Nonetheless, due of their autonomous social structures and little contact with people in the plains, tribes are rich in indigenous farming traditions. Their way of living suggests that the tribes are well-versed in environmental processes. They use innovative agricultural management practises to make the most of the environment.

Introduction

The Paderu Tribal Agency is made up of 11 fully scheduled and two partially scheduled Visakhapatnam district mandals. It is separated into three sub-divisions for administrative purposes: Paderu, Chintapalli, and Araku Valley. In 244 Gram Panchayats, the agency oversees 2,312 revenue villages and 3,574 tribal habitations. The major tribes in this region are Kotia, Kondadora, Kodhu, Gadaba, Bhagata, Kammara, Poorja and Valmiki. These communities lack essential health and drinking water services. Households are forced to drink canal water due to a lack of protected water. Villages, likewise, lack access to basic health care. They must go to hospitals in far away cities if they have a health condition. Primary schools are around 2-5 kilometres from the communities and operate on a rudimentary basis. Among development officials, there is a significant rate of absenteeism.

HATZone

The HATZone High Altitude and Tribal Zone includes tribal areas in Srikakulam (8), Vizianagaram (7), Visakhapatnam (11) and East Godavari (11) that are located in a distinct agro-climatic zone. There are 11 totally scheduled mandals in the Visakhapatnam district. It is separated into three sub-divisions for administrative purposes: Paderu, Chintapalli, and Araku Valley. The district's average rainfall is around 1,200 mm, which is more than both the state average (940 mm) and that of coastal areas (1,078 mm). Farmers, on the other hand, lack reliable irrigation due to the lack of an effective irrigation system. Despite the fact that 591 minor irrigation projects serving 40,672 acres have been built across all 11 HAT agency mandals, many of these projects are in disrepair due to a lack of regular upkeep. Agriculture and horticulture crops are more suited to the area. During the winter season, the minimum temperature was 4 to 12 degree celsius, while the maximum temperature was 23 to 38 degree celsius. Red and black soils are the most common types.

Araku-HATZone in A.P (Source :World Travel Magazine)

Divergent Cultivation

Agriculture, horticulture, and the collecting of minor forest products are the principal occupations of the indigenous people in the designated region. Podu shifting farming is being phased out in favour of cashew, mango, pineapple, and turmeric plantations. In areas where shifting farming is still practised, crops like as jowar, bajra, korra, sama, and redgram are planted as mixed crops and harvested one after the other as the crops mature. They're also used to cultivate paddy in wetland areas and valleys. The indigenous people are increasingly changing their dietary patterns and consuming rice instead of their traditional foods. Rice takes up 12,676 hectares of the total cropped area of 14,473 hectares

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Blackpepper cultivation - Paderu (Source : Agefostock.com)

under TSP mandals, while major and minor millets take up 491 hectares. In the HAT zone of Srikakulam district, redgram and other crops occupy 1,306 acres, with a total TSP number of farmers of 32,080. The zone is dominated by land holdings of less than 01ha in size, with the majority of the irrigated area being under tanks.

Small and marginal farm holdings account for 70 to 80 percent of tribal agricultural holdings in these villages, with the average farm size being around two-thirds of an acre. Paddy was the most important crop, followed by other grains and millets.

The majority of the land is covered in silver oak trees. Coffee is cultivated in between the oak trees as an intercrop. In certain locations, black pepper dominates coffee cultivation, while in others, both are grown in similar amounts. There is undulation in the cultivable ground, which encourages the tribe to grow more forest products. These tribes' products are rarely exported, confirming the lack of marketing infrastructure in the area. The majority of silver oak and Eucalyptus plantations are used to meet the need for timber. Eucalyptus can be used for both medicinal and timber purposes. In a nearby town, there is a jam oil extraction unit, which helps the tribe manufacture therapeutic items. The majority of these tribals assist in the growth of tourism in A.P. It also draws visitors because of its high altitude beauty, which is particularly attractive in Andhra Pradesh's coastal zone.

Araku Valley's tribal farmers are preparing to sell pepper to Denmark, the first foreign country to receive Araku's tribal goods.

Pepper is currently grown on roughly 98,000 acres in Visakhapatnam's Agency areas, primarily as an intercrop inside coffee plantations in Araku, Ananthagiri, Chintapalli, and Paderu. The coffee grown in these tribal pockets is already exported to a number of European and non-European countries.

Terracing

Terrace cultivation takes place on flat or gradually sloping soil where water is readily available or can be retained by terracing. As a result, terraced field cultivation is a type of wet land cultivation with significantly better yields than jhum fields. However, the fundamental challenge is that good flat or gently sloping ground is uncommon in the hills. There are some sites where such parcels of land can be found, however many of these fields are actually stony areas with a thin coating of dirt covering them. Flatness is the result of centuries of rain water erosion in the hills, which has left only a thin layer of soil behind. For example, at Chinthapalli, one can witness large stretches of flat ground that stretch for miles. The soil becomes too dry in the winter to support even grass growth. However, they used to plant silver oak and Eucalyptus trees in that undulating topography to make the soil resistant to frost, allowing coffee, strawberry, and cauliflower to be grown as intercrops between the forest trees. The black pepper, which is the region's most important export, is grown on silver oak trees, which provide natural support. To supplement their income, some tribes in this region grow jack fruit and custard apple. However, tribes living deep in the forest with limited access to transportation place a lower value on fruit trees. Because they may not receive the desired profits owing to fruit deterioration and high transportation

Terracing in Coffee (Source : Times of India)

costs. Timber crops are usually the deep tribe's main source of income.

Transition

In the case of Paderu village in the Alluri Sita Ramaraju district, the change from communal to private ownership of terraced fields can be followed. Both forms of land ownerships can be seen in this hamlet now, but if one travels back in time, all lands were originally under community ownership. These territories were flat or moderately sloping country during the time. People were enticed to transform them into paddy fields by flattening, terracing, and irrigating them due to the proximity of water. After it was improved for cultivation, the process of land becoming private began. The occupation rights are terminated and revert to the village community upon termination of usage.Terraced lands, on the other hand, fall into a separate category. Because the development of the land necessitates some investment, the family involved gains a permanent claim to the land. Thus, it appears that two factors are at work when community land is converted into private property. First, the possibility of permanent cultivation on a specific piece of land worked as a motivator for individuals to secure it in private hands, resulting in higher money rewards. Such cultivation became possible when land improvements resulted in higher yields. Second, the absence of alternative economic opportunities, as well as the resulting pressure on property, has worked as a further drive to secure land under private ownership.The purchase and sale of cultivable lands (whether terraced or not) has not yet begun. The free selling and purchase of land in the region is restricted by natural, sociocultural, and governmental factors.

Tribals jhum kheti and its alternatives

H. Sirisha, N. Aneesha, A.R.S.S.H Gupta, A.D.S.S. Ajay Nikhil, Rumana Khan and A. Nishant Bhanu

Traditionally, dominant mode of agriculture for tribals is jhum cultivation which is very frequently related upto upland cultivation. Shifting cultivation is found to be not only source for the livelihood but supplemented by food gathering & hunting. But now JHUM is beginning to create ecological imbalance which leads to depletion of soil productivity & fertility as well as promoting deforestation. Various activities have been initiated by different states so that jhum & other agricultural operations can go hand in hand without disturbing the nature & simultaneously would be benefitial for the tribals .The most prominent alternative method to this shifting cultivation is found to be agroforestry.

Introduction

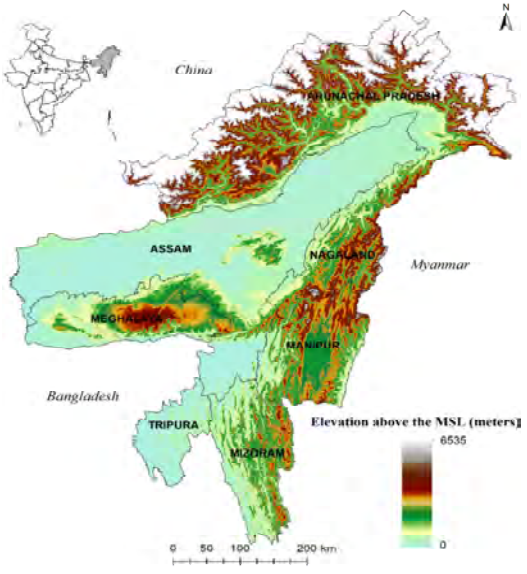
The Indian agricultural sector has undergone considerable changes since the green revolution in the mid 1960s. Though the introduction of specific technologies proved successful in irrigated areas, dryland crops and remote rural regions were left out of the process, which created increased regional disparities in rural incomes. The tribal communities in India constitute almost 7 per cent of the total population of the country. According to the 1971 population census, out of a total population of 548 million persons, the scheduled tribes constituted 38 million persons, *i. e.* 6.9 per cent of the total population of the country. The tribal communities in India constitute almost 7 per cent of the total population of the country. Agriculture end forests occupy a prominent place in the tribal lite end economy.

The tribal people reside both in the plains and the hill areas. Although their economies differ, there are certain common features among them like, primitive farming practices, high labour intensity and some traditional social and cultural rigidities affecting their principal occupation-agriculture.

Geographical distribution of tribals among the nation:

Eastern India like Mlzo, Naga, Kuki, Khasi, Adi Garo, etc,; Juang, Bhuinya and Bonde ot Orissa, and some ot

Strawberry cultivation by tribals at Lambasingi, Chinthapalli Mandal, Vishakapatnam, Andhra Pradesh



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the tribes of Andhra Pradesh, Bihar, Gujarat, Kerala, Maharashtra, Tamilnadu , Madhya Pradesh, etc., depend upon a primitive way ot "Slash and burn cultivation" or shifting cultivation.

Some ot the tribes ot Andaman and Nicobar Islands and of Lakshadweep depend upon plantation of coconuts and arecanuts. The tribal communities living in the Western Himalayan regions i.e. the Gaddis and Gujjars ot Himachal Pradesh and the Bhots ot U.P. are more dependent on animal husbandry than on agriculture tor their livelihood. The nomadic tribes of Rajasthan desert also earn their livelihood by raising animals through migratory grazing. The Birhors of Bihar and Orissa (called as the Makarakhiya Kols in the latter place) depend upon trapping small game and collecting plants and medical herbs.

Jhum Kheti ('Slash & burn Cultivation'):

The practice referred to as slash and burn represents a form of woodland use for agricultural purposes that are strongly associated with Nordic countries. It involved felling of trees and, after drying, setting the wood on fire and then sowing cereals in the clearings; in this way, the poor soils of forested areas were enriched with ash resulting from burning. After the crop was harvested, the area usually reverted to grassland and eventually woodland regenerated.

Lacunaes behind jhum kheti

Shifting cultivation, a resource-based subsistence farming, is no longer relevant because of the large population and its growing demands. The system is destabilized by long cultivation and short fallow periods. One of the most vital negative environmental impacts of shifting cultivation is the damage that causes to the soil system. It accelerates the soil erosion manifold. Besides causing air pollution due to burning, shifting cultivation is responsible for loss of soil nutrients and useful soil fauna and microbes. Burning of slash lowers soil acidity, organic matter and total nitrogen. The shortening of the shifting cultivation cycle is deteriorating the present ecological balance with respect to soil erosion, heavy silting of streams, extinguishing perennial water resources, depleting biodiversity for human and animal consumption, and lower soil fertility. Shifting cultivation cycle of 10–15 years over the years has shortened to about 2–3 years, thus leading to ecological imbalance.

Actually it is a practical approach to certain inherent difficulties in preparing proper seed bed in steep slopes where any disturbance of soil result in washing away the fertile top soil. The tribal people therefore take care not to plough or disturb the soil before sowing.

Jhum cultivation starts with cutting and burning of trees and leads to degradation of forest or deforestation in the hilly areas where they used the land to do jhum. Deforestation has negative effects on the environment which ultimately leads to climate change which nowadays a matter of global concern and many international, national and regional level agencies are working on it.

Adverse effects of Jhum cultivation

a) **Denudation of forests:** Ecological imbalance elimination of source of water

b) **Soil Erosion:** stream silting: floods loss of soil fertility: pressure on land low productivity

c) **Low Technology:** Labour intensive reservoir: derogatory development no subsidiary income

d) **Social Effects:** Social custom: large family size

The state Tribal Welfare Department, Agriculture Department, Rubber Board of Tripura, many organizations etc. are gathering informations about jhum cultivation and other allied activities of tribal people those are staying in the hilly parts of Tripura. Many Jhumias are also very well acquainted to it but still they are doing jhum or shifting cultivation. The existing land tenure system and ownership pattern has been viewed as the most important factor for restoring jhum or shifting cultivation in north-east India as well as Tripura. Besides, being a hilly region and a land-locked state, the people those who are existed in the hilly terrain, the only source of food production is jhum or shifting cultivation as there is no substitute source to meet the tribal people's food and other needs.

Case Study from the tribal Areas of Sundargarh district, Odisha (India)

Odisha is one of the most prominent states of India, surrounded by natural ambience and homeland of indigenous tribal communities with unique culture distinct. The state is inhabited by 62 tribal communities, 30 which is highest as compared to other states, out of 705 scheduled tribes are enlisted by the government of India, contributing 9.2 per cent of the total tribal population of India. A majority number of tribal population abode in Kandhamal, Koraput, Malkangiri, Mayurbhanj, Nabarangapur Rayagada and Sundargarh districts, declared as 5th Scheduled Areas by the government of India. 32 tribal economy survives in nature and it revolves around the forest, from gathering food to collecting all types of non-timber forest products.

The census report 2011 indicated poverty line among the tribal in rural Odisha is 39 per cent in comparison to 25 per cent among scheduled castes and 36 per cent others. Further, the tribals settled in rural belts of Odisha, the poverty percentage is highest than others i.e., 67 per cent in compared of other sections of the society, 50 per cent among the poorest of rural Odisha are the tribals and the poorest household carrying the labour type is 54 per cent again counted among the tribals.

Odisha sends around 1.5 million seasonal migrants into a distinctive pattern of labour to different regions. The research identifies Sundargarh district carries 17 blocks among which four blocks been selected for the study as Balisankara, Kaurmunda, Rajgangpur and Subdega. Rajgangpur is stated as industrial cum rural area, which has a large tribal population of 85,116. Their main occupation is farming, collecting forest products and work in nearby small Factories.

Attempts have been made by the State government and non-governmental organisations to replace shifting cultivation in Mizoram

- **Terrace** was introduced in small plots in Champhai area prior to the British regime in the 1890's.
- **Land Use Planning (LUP)**: This policy was introduced in 1980's but there was no successful result. New Land Use Policy (NLUP-I). This New Land Use Policy was exercised during 1981-1991 with negligible success. 3.4 Pit system: Pit system was introduced by All Mizoram Farmers Union (AMFU) in 2004-2005. The earth was dug and grew crops with composed manure but this was abandoned because of high labour cost and unsustainable production.
- **Tree-green hedge crop system**: This system was introduced by Prof. L.K. Jha in the year 1995-1996 in a small on-farm experiment but ended co-terminus with the project incorporation of trees in the farm was not appreciated by the farmers.
- **Contour trenches and ICAR 3-tier method**: Contour trenches was introduced by the Agriculture Department in 2005-2006, but it was discontinued because contour trenches were easily filled with soil due to steep open jhum land within a monsoon. This indicates the quantity of soil loss due to jhuming.
- **Sloping Agriculture Land Technology (SALT)**: SALT was introduced in South Mizoram by Rev. Harold Watson of Mindanao Baptist Rural Life Centre Kinuskusan, Philippines in 2004. It is still practiced and retained by some farmers in Lunglei area. The farmers planted crops between the hedge-rows without using chemical fertilizers.

Viable options to Shifting cultivation

- Home Gardens serve as an effective, fairly easy to replicate and scale up approach to transformations is the promotion of home gardens (or extended home gardens) provides access to traditional food crops and contributes to nutritional security, but also allows for income generating opportunities. Combined with horticulture and animal husbandry, the promotion of home gardens has helped many households to increase income significantly and improve their economic status.
- Fallow forestry by planting of native tree species for provisional and regulatory services has proved to be the underlying rationale for the widespread acceptance of this model by villagers across Nagaland.
- Traditional practices of cultivation of food crops Aji system of the Apatani, zabo system of Chakesang, bun system of the Khasi Hills, alder based system of the Angami, and the tree-based rice cultivation of the Konyak are some of the best practices being followed by traditional communities.
- Agroforestry, large scale plantation of fast growing timber and economically important tree species with intercropping of ginger, turmeric, black pepper, and

lemon grass has proved to be ecologically viable, economically sustainable and socially acceptable.

- Cash crop cultivation Broom grass cultivation in Meghalaya; rubber plantation in Tripura; tea cultivation in Tripura, Manipur, Meghalaya and Arunachal Pradesh; cashew nut plantation in the Garo Hills of Meghalaya; floriculture in Mizoram and passion fruit cultivation in Nagaland, Manipur and Mizoram are a few examples where cash crop cultivation has transformed shifting cultivation.
- Timber tree plantations in villages where the land is sufficient and people have moved out for jobs or business (de-population), a large area of shifting cultivation land has been converted into timber tree plantations. This has happened in the states of Nagaland, Manipur, Mizoram and, on a small scale, in Meghalaya. This practice has helped in restoration of land and creation of wealth for the land owners.

AGROFORESTRY – Alternative to shifting cultivation

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components. Agroforestry can also be defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In particular, agroforestry is crucial to smallholder farmers and other rural people because it can enhance their food supply, income and health. Agroforestry systems are multi functional systems that can provide a wide range of economic, sociocultural, and environmental benefits.

Table: Jhum cultivation vs Agroforestry

Factor	Jhum Cultivation	Agroforestry
Ecological Factor		
Fragility	High	Low
Homeostasis	Internal	External factor
Biodiversity	High	Low
Leaf Area	Less	More
Carbon sequestration	Low	High
Regeneration	Natural	Artificial/Managed
Dispersal	From Surrounding Natural vegetation	Man-made
Potential Nutrient Loss	high	low
Pathogen Disease Attack	Less risk	More risk
Connectance	Low	high
Nutrient source	High	High
Energy source	low	high
Irrigation	Rained	Moderate
Soil Fertility Management	Poorly managed	Well managed
Tillage	No Tillage	Minimum Tillage
Carrying Capacity Land	Low	High
Ecological Status	Complex	Complex
Economic Factor		
Labour	Intensive	Systemtic
Inorganic Fertiliser	Not used	Used sometimes
Monetary Input-Output	Low	High
Production / yield	Low	High
Land Required	Large (Extensive)	Relatively less (Semi-Intensive)
Socio – Cultural Factor		
Approach to Cultivation	Slashing & burning followed by cropping	Trees grown with crops
Cropping Pattern	1 rotation	More than 1 rotation
Harvesting Pattern	Multiple harvest	Multiple harvest
Integration of animal component	Poorly integrated	Well - Integrated
Cultural Value	Traditional value	Intervention
Local Adaptaibility	More	Less
Sustainability	Diversity conserved	Productivity sustained

Haveli system: A misprized tradition of water conservation

Ajita Gupta, Ramesh Singh and Anil Kumar

Water has been harvested in India since time immemorial, with our ancestors perfecting the art of water management. The practice of harvesting rainwater has beenan integral part of human civilization when the need to harvest water through structures that would provide plentifully was recognized. Rivers have always been the initial place of civilizations, and different civilizations utilized them in different ways. In India various water harvesting structures and water conservation systems have been develop to serve region specific problems and needs.

Introduction

Early man relied on locally developed water harvesting structures like ponds, lakes, tanks, wells, *baories, kutcha bunds, tankas, kund, khadins, ahars, haweli* etc. Most scarce raindrop was precisely conserved and stored for future purposes. Traditional systems integrate community and their participation in the best possible manner to ensure proper management and functioning of the natural resources.

The traditional water harvesting structures have been constructed with excellent engineering techniques and demonstrated a high-grade technological perfection. Some of technologies are so scientific that if they are adopted by the rest of us, the problem of water crisis can be solved in great extent. These technologies have got high degree social absorption whereas, the modern developmental systems are formula-based technologies and emphasises transfer of technology/ high level of performance, without any social concerns. Traditional water conservation structures were adopted depending on the cultural value system of the particular regions and hence were carefully maintained.

Such traditional water resource management systems are now fading due to lack of management maintenance and awareness, loss of traditional knowledge, apathy towards cultural values, modernization and uncontrolled development. Persons those who were experts in this field, especially rural communities have migrated to nearby towns and cities for better job opportunities and hence there is lack of knowledge flow from generation to generation. Thus, the knowledge of traditional water conservation was not put into practice or passed on to future generations. The younger generation have not been witness to such practices and cannot appreciate the importance these play during deficit rainfall conditions and during off seasons.

Other reasons are population growth, urbanization and the green revolution, big dams were constructed as the ultimate solution to the water distresses faced by. Irrigation water provided by canals as well as indiscriminately ground water was exploited and thousands of bore well and tube wells were developed for agricultural activities. As a result thousands of traditional water harvesting systems fell into decline for want of proper maintenance and use.But today, even with the big water reservoirs, the problem of water famine continues. Slowly, this is recognized that the traditional water harvesting systems will be a better and cheaper alternative to big or medium dams. In many parts of the country with the efforts of government, NGOs, community and at individual level these traditional water harvesting systems have been revived and peoples are enjoying the benefits.

In the southern region of country specially, Andhra Pradesh, Telangana, and Karnataka have impressive number of tanks during built long back. *Kund,Tanka, talab, baories* in Rajasthan desert also traditionally perform marvellous job of collecting and storing run off water. The *Bandharas, Phad* system in Maharashtra, *Haveli* system in Madhya Pradesh, *Khadin*in Rajasthan and *Ahar-pyne* in Bihar, *Surangams* of Kerala are excellent water harvesting systems.

The need of the hour is to rejuvenate or revive traditional water harvesting and conservation structures or alternatively to practice sustainable development strategies where in the modern technologies should adopt or incorporate the best of traditional technologies. As said by late reputed scientist Prof. Y. Nayudamma "Modernise the Traditional, Traditionalise the Modern".

Water Scarcity in *Bundelkhand*

Water is the most precious item in the hilly and plateau terrain of *Bundelkhand* spanning over six districts

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in Madhya Pradesh (MP) and seven districts in Uttar Pradesh (UP Bundelkhand is unique in respect of its water resources as compared to the rest of the country. Rainfall varies from 600 mm to 1000 mm across different agro-climatic zones. The average normal rainfall of Bundelkhand is about 850 mm. This region of India experiences acute scarcity of water for crop production and frequently faces drought and deficit rainfall. Almost entire crop production is under rain fed condition. About 90% of the geological area of *Bundelkhand* is a hard rock with unconfined or perched aquifer, fast depletion of water table and insufficient rate of replenishment or recharging. Groundwater sources are not very reliable and aquifer water should be prioritized and preserved for drinking purpose. In *Bundelkhand*, canal irrigation is unavailable in most parts which severely hampers agricultural production leading to poverty, indebtedness and farmers' distress. Therefore, watershed management, development of surface water resources, reviving of traditional structures, desilting existing structures, command area development, improving water and nutrient use efficiency, and efficient micro irrigation systems should get high priority of the investment portfolio.

What is Haveli/Haweli system?

Haveli Bundhies/Haveli system is an excellent traditional water harvesting and runoff farming system, practiced in black cotton soil area of central India. This practice has been followed traditionally since long back which gives a good recharge in monsoon and assured good yield in *rabi*. In this system rain water impounded in bunded fields during monsoon and direct sowing of *rabi* crops is done after draining the impounded water. Wheat crop can be grown successfully on the residual moisture without applying any irrigation inthe Haveli fields. Haveli cultivation systems can be incorporated with graded terracing in stream beds which involves construction of a series of low, small check dams or bund type structures across the runoff harvesting area to retain and store water in the soil profilewhich can support crop growth. Its main feature is a very long (100-300 m) earthen embankment built across the lower hill slopes lying below uplands. Sluices and spillways allow excess water to drain off. Embankment built across a slope in such a way that rain water is collected within an agricultural field. Size of the bund is decided based on the catchment area and expected runoff generated from this area.

This traditional system has received less attention of scientific community, but even today these are socially acceptable and widely popular. Haveli farmers require less field operations, less irrigation, less seed rate and also less fertilizer as compare to non-haveli farmers.

Hydrology of Haveli System

Haveli system comprises unique hydrology. In this system cultivated fieldsare kept fallow during *Kharif* season. Rain water is allow to be impounded during monsoon months and then drained in the month of October. Minimum tillage operation is required to sow *rabi* crop. Due to impoundment, rainwater gets large retention time and infiltration opportunity time which slowly recharge ground water aquifer. Field remains submerged during the rainy season and after drainage a moist seed bed is found at sowing time of *rabi* crops. This system can ensures sufficient moisture for *rabi* crops even without rainfall or irrigation from any sources between sowing and harvest. This practice make soil fertile that it can bear good *rabi* crop year after year in succession without manure and without irrigation even in years of deficit monsoon and winter rainfall. During monsoon the whole field acts as a small tank containing fresh water. Standing water during *Kharif* season destroy weeds and provides additional ground water recharge from Haveli fields. This system not only conserve soil moisture in the upper layer but continuous seepage and percolation contribute to ground water recharge underlying regions could maintain huge reverse of ground water.

Successful story

The ICAR-Central Agroforestry Research Institute, Jhansi (CAFRI) and ICRISAT Hyderabad in association with farming community identified Parasai-Sindh watershed in Babina block of Jhansi district during 2012-2016 as a pilot site for improving groundwater recharge and water use efficiency through reviving the Haveli system and other interventions. This region falls in the catchment of Sindh River and receives 877 mm annual average rainfall. Rainfall is highly erratic, both in terms of total amount and its distribution over time. The traditional rainwater harvesting structures (Haveli) on the upper reach was selected for renovation and rejuvenation. At initial stage of study, these structures were damaged and unattended for long period, which reduced capacity and performance of the Haveli system. The outlet of the Haveli was constructed on 2nd order stream. The Haveli checkdam was traditional structure

and was very old structure. So, the 240 m bund of Haveli checkdam already constructed. Whereas, length of crest and height of water drop were 5 and 1.1 m. Total catchment area and relief of Haveli system were 51.4 ha and 25 m. After renovation work, total submerged area of Haveli system was calculated and it was found that the submerged area of this system was 125 m^2 which can harvest total 0.45 million liter volume of water. Whereas, maximum submergence area was calculated as 87900 m^2which can harvested 73 million liters volume of water. The total cost of renovation of Haveli system was 2.51 lakh. Villagers are now using stored water for irrigation during monsoon and post-monsoon periods. This structure along with other interventions has increased groundwater increased groundwater level (2-5 meters), reduced storm flow and increased base flow (2 to 3 times) made it drought resilient even in case 25-30% deficit rainfall condition. Nearly 176 ha *rabi* fallow has been brought into cultivation and productivity of different crops has been increased in the range of 20-70%. Area under fodder cultivation has increased from 4.0 ha (pre-intervention) to 60.0 ha (post-intervention), which has led to improved livestock productivity. Average household income has increased more than two times within a span of four years. Parasai-Sindh watershed has been used as Launching Pad for Jal Kranti Abhiyan on 5th June 2015. Official from Govt. of India, state and district administration, officers and field functionaries of line department often visit the site. Farmers, students, NGO personnel also visit the site very frequently. Official/ Trainees from SAARC nations, ASEAN countries, Kenya, Sweden, USA and Germany have visited the site.

Before interventions, open wells were hardly supported for 1-2 hrs during rabi season due to low water column. Therefore, farmers generally took 10 to 15 days to irrigate one hectare wheat crop. Mainly women were engaged in irrigation to field crops and they spent 40-50 hrs to complete one irrigation in a hectare. Post-interventions majority of the wells are supporting round the clock and farmers are completing irrigation within a day (15-20 hrs). Now, the farmers, especially women have more time to care their school going children and other households' activities. It has also reduced the cost of cultivation of wheat crop by Rs. 6000.00 to 8000.00 per ha.

Post implementation, drudgery in collecting drinking water is greatly reduced through enhanced availability of water in wells and hand pumps due to augmented groundwater recharge. This model can be scaled up to overcome water scarcity in whole *Bundelkhand* region.

Conclusions

Public investments into surface, ground water resources and watershed management led to the neglect of Peshwa, Chandela or Bundela tanks, Haveli cultivation, dug wells and other traditional systems of *Bundelkhand* region. Haveli system of farming is an easy non-expensive technique method of ground water recharge, weed control and assured good yield (both in quality and quantity) in *rabi* season. All the rehabilitation measures of the traditional water resources are simple and easy to carry out through rural artisans and the farming community. They are highly cost-effective to create a similar water resource afresh and to provide lasting benefits for the small investments made.

Fodder round the year for tribal dairy farming

V. G. Bavalgave and N. N. Gudadhe

Cattles in most villages are left to fend for itself and graze in forestlands around the villages. Tribal people find supplementary income from forests, rather than from animal husbandry. Dairying is practiced by a few communities. Dairy farming does provide huge scope and benefits on the lives of tribal people. There are agro-climatic and physiographic issues in tribal hinterlands which would need to be tackled in addition to the issues of feeding, breeding and management of dairy animals for dairying to become a powerful instrument of poverty reduction in these areas. It has been recognized that not only the poorer section but also the upper section of the society not adopt more than 45 percent of the recommended practices for fodder crop production at farm level and in the tribal communities. The adoption of improved practices is negligible. This includes many aspect of about howto grow and harvest the different fodder crops to supply green fodder round the year in tribal dairy farming. The practices/suggestions are expected to be useful to tribal dairy farming.

Tribal people find supplementary income from forests, rather than from animal husbandry. Grass, which grows in the forest, is allowed to be cut, but in quite a few places, rather than using it for their own dairy animals, tribal people give it at throw away prices to middlemen, who sell it to such specialized dairy producers. Dairying is practiced by a few communities. Dairy farming does provide huge scope for increasing farmers' incomes as well as creating jobs in the value chain. These benefits brought to bear on the lives of tribal people and will produce desirable results for them and for the country. There are agro-climatic and physiographic issues in tribal hinterlands which would need to be tackled in addition to the issues of feeding, breeding and management of dairy animals for dairying to become a powerful instrument of poverty reduction in these areas.

Responsible factors for low productivity of livestock

- Feed & fodder deficiency (50.2%)
- Breeding & reproduction (21.1%)
- Diseases (17.9%)
- Management (10.5%)

LIVESTOCK POPULATION IN INDIA (2012 -2019)

Species	Population (in millions) 2012	Population (in millions) 2019	% Growth	Ranking in the world population
Cattle	190.90	192.49	0.83	Second
Buffalo	108.70	109.85	1.06	First
Sheep	65.07	74.26	14.13	Third
Goat	135.17	148.88	10.14	Second
Pig	10.29	9.06	-12.03	Second
Mithun	0.30	0.38	26.66	–
Yak	0.08	0.06	-25.00	–
Horses & Ponies	0.63	0.34	-45.58	–
Mule	0.20	0.08	-57.09	–
Donkey	0.32	0.12	-61.23	–
Camel	0.40	0.25	-37.05	Nineth
Total livestock	**512.06**	**535.78**	**4.63**	**First**
Total poultry	**729.21**	**851.81**	**16.81**	**Fourth**
Backyard Poultry	217.49	317.07	45.78	–
Commercial Poultry Chicken	511.72	534.74	4.50	–
Duck		33.51		Fourth

Source:- *APEDA & BAHS 2019* – Department of Animal Husbandry and Dairying, Ministry of Agriculture, Govt. of India.

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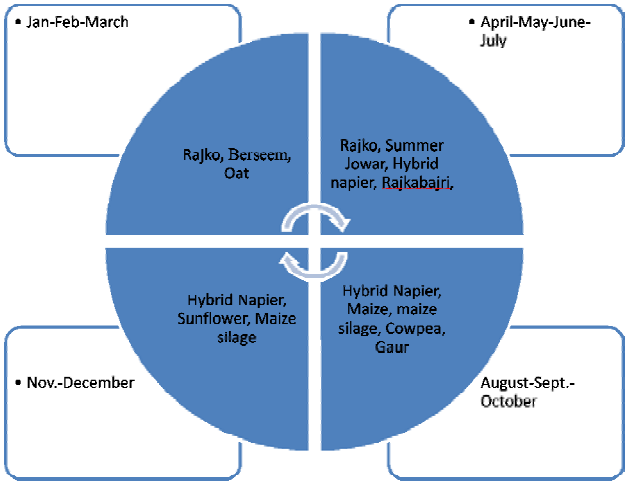
Major constraintin dairy farming is non-availability of adequate quantity and quality of feed/fodder resources.

Importance of forage crops

- Fodder crop provide nutritious diet. It is estimated that milk production can be increased to the extent of 300% even in the indigenous breeds of cattle in India, if managed properly.
- Feeds and fodders account nearly 70 to 80% cost to the total milk production.
- Daily animal requirement is of 25 to 30 kg per day per adult (Ideal req.: cereal green fodder: 12-15 kg, Pulse green fodder: 8-10 kg)
- Grown on marginal lands, grazing lands and Fallow lands
- Forage legumes add to soil fertility

It has been recognized that not only the poorer section but also the upper section of the society not adopt more than 45 percent of the recommended practices at farm level and in the tribal communities the adoption of improved practices is negligible to accelerated the adoption of improved farming practices is necessary to know the decision making pattern in the tribal communities. This includes many aspect of Howto grow and harvest the different fodder crops to supply green fodder round the year in tribal dairy farming. The findings and recommendations/suggestions of the study are expected to be useful to tribal dairy farming.



Package of practices for growing different fodder crops

Particulars	Improved variety	Soil	Sowing time	Seed rate (kg/ha)	Spacing (cm)	Fertilizer NPK (kg/ha)	Irrigation	Harvesting	Production (q/ha)
Cereals:									
Jowar (For one cutting)	S-1049 C-10.2 GFS-3 GFS-4 GFS-5 GAD JOWAR-11	Light, med black	K: June-July S: Feb-March	Improved : 60 Hybrid: 30	25-30	Total: 50:40:00 Basal: 25:40:00 Top: 25:00:00	Summar : 10-15 Days	50% flowering	350-400
Jowar (Multiple cutting)	MP chari, SSG-59.3 Pioneer hybrid, Guj forage sorghum hy-1, Harasona, safedmoti, COFS-29	Light, med black	K: June-July S: Feb-March	Improved : 60 Hybrid: 30	25-30	Total: 75:40:00 Basal: 25:40:00 1 Month: 25:00:00 After 1st harvest: 25:00:00	Summar : 10-15 Days	1 st cut: 55-60 Days , other cut at 40-45 days	2 cut: 650 for, multiple cut : 800-1000
Maize	African tall, ganga Safed-2, Ganga-5, Vikram, Farm Sameri, 1,2,3,4 and 6	Fertile and well drained	Anytime but not too cold	60	30	Total: 80:30:00 Basal: 40:30:00 1 Month: 40:00:00	Winter: 10-20 Summar : 10-15 Days int.	Tasselinitition to milky grain stage	K: 300-400 R and S: 400 -500
Bajra	Rajkabajri (Local), Jiant Bajra, Guj fodder bajra-1	Light, med black	K: June-July S:Feb-March	10-12	30-45	Total: 100:00:00 Basal: 50:00:00 1st cutting: 50:00:00 and For each multiple cut: 50:00:00	Summar : 10-15	1st cut: 45-50 Days and there after 30-35 days	1st cut: 300-400 and Multiple cut: 600-700
Oat	Kent, OL-9, JHO-822, JO-03-91	Sandy loam, medium black well-drained	2nd week Nov	100	25	Total: 80:30:00 Basal: 40:30:00 1 Month: 20:00:00 1st cutting: 20:00:00	12-15	1st cut: 50-55 days, 2nd cut: at 50% flowering	1 cut: 400-500 2cut: 500-600

Pulses:									
Rajko	GAUL-1 (Anand-2), GAUL-2, (SH-627), AL-3	well drained, Besar, med black, light soil	2nd week of Nov.	10	25	Total: 20:50:50 Whole at basal	Winter: 12-15 Summar : 10-12	50% Flowering or 2 month after sowing, there after winter 30 days and in summer 20-25 days	700-800
Cowpea	Kharif: GFC-1, GFC-3, EC-4216 Summar: GFC-2, GFC-4, EC-4216	Retal, well drained	K: June-July S:Feb-March	40	30	Total: 20:40:00 Whole at basal	Summar : 10-15	70-75	250-300
Guar	FS-277, HFG-2, Durgapur safed, Sirsa-1	Goradu, beasr, Medium black , light soil	June-July	35-40	45	Total: 20:40:00 Whole at basal	-	Initiation of pod or 60-70 days	250-300
Wal	IGFRI-1649, 2214	All soils but well drained	June-July	20-25	45	Total: 20:80:00 Whole at basal	Need based	Flowering stage	400-500
Dashrath	Local	Light medium	June-July	7-10	50x15	Total: 50:100:00 Whole at basal	Need based	60 cm above ground level	400-500
Shevri	Local	Sandy, light, med black	June-July	10-15	50x15	Total: 20:60:00 Whole at basal	-	Ist cut : After 3 month 1 m above ground level thereafter every 2 month	150-200
Subabul	Hawain, Solvedor, Peru	Well drained	June-August	20-30	200x50	Basal: 20:60:30 Thereafter 25 kg P every year	Need based	1st cut : 100 days thereafter in monsoon 40Days, Winter 60days and in summar50days	Irrigated: 600-1000 Rainfed: 150-250
Oilseed:									
Sunflower	EC-68414	Sandy, Goradu,	Anytime	40	45	Total: 60:30:00 Whole at basal	Need based	bud formation means 40-45 days	200-250
Grasses:									
Hybrid Napier (Gajrajghas)	CO-3, APBN-1, CO-1 and NB-21	Sandy,Goradu, med black and well drained	June-July, Feb-April	27,777 rootslip, 12345 rootslip, 10,000 rootslip	60x60, 90x90, 100x 100, 100x50	10 t FYM/ha Basal: 50:30:30 Thereafter at each cut 50-75kg N	K: need based R:15-20 S: 10	1 st cut; 60 days thereafter 45 days interval	1 year: 1500-2000 2year: 1500 3 year: 1000
Guinea grass	JHGG-8-1, Hamil, Colonial, Galtan	well drained, med black	June-July, Feb-April	27,777 rootslip, 12345 rootslip, 10,000 rootslip	60x60, 90x90, 100x 100,	Basal: 50:30:30 Thereafter at each cut 30kg N and 40 kg P every year	K: need based R:15-20 S: 10	1 st cut; 60 days thereafter 40-50 days interval	1000-1200 every year
Para grass	Local	Can be grown illdraind soil	Uttar Guj: 15 Feb and South Guj: any time	40,000 rootslip, 27777 rootslip,	50x50, 60x60,	Basal: 40:00:30 Whole at basal	Need based	1st cut after 60 days	1000 every year
Anjan grass (Dhaman)	Guj Anand-Anjan grass-1, IGFRI-1, Pusayalo-Anjan, Coimtoor-1	Sandy, light, med black and well drained	June-jully	2-3	60x60, 75x75 seedling	Basal: 30:10:30 Whole at basal	Need based	1st cut after 4 month	Rainfed:150-200 Irrigated:400-500
Marvel (Zinzvo grass)	Guj. Marvel grass-1, Guj Anand marvel grass-2	Sandy, light to med black	June-July	2-3	50x50, seedlings	Total: 40:00:00 Basal:20kg N After 30 DAS: 20 kg N	Need based	1st cut after 3-3.5 month thereafter 40 days every cut	Rainfed: 60-80 Irrigated:100-120

Integrated Farming system model for the hilly tribal areas of Manipur

Sanjenbam Dayananda Singh

Agriculture is the mainstay of livelihood for the tribal people inhabited in the hilly districts of Manipur. The hilly area occupies almost 90% and the valley, with just 10% land of the total state areas. The farmers in this region are practicing subsistence farming for their livelihood as shifting cultivation. Shifting cultivation contributed to low productivity, required intensive labour, soil erosion, deforestation and destabilisation of the ecology. It is required for an alternative way of production system which involved crops, livestock, fisheries, fruits, trees etc. by harnessing available resources without harming the ecosystem. Integrated farming system is an interdependent, interrelated often interlocking production systems based on crops, animals and related subsidiary enterprise in such a way that maximize the utilization of nutrients of each system and minimize the negative effect of these enterprises on environment.

Introduction

Manipur is entirely rainfed and rice occupies more than 80% of the agricultural area in the kharif season. The land holdings are small and the farmers practice subsistence farming for their livelihood. The size of the cultivated area is about 7.41% of the total geographical area of the Manipur. The agricultural operations are carried out up at an elevation of 3000 m above MSL on slopes up to 60% gradient. Problems of high rainfall (12.1 % of country's total precipitation), soil acidity, aluminium toxicity in upland and iron toxicity in valley land have added to the problem of low agricultural productivity in the region. The soils of the region are usually rich in organic matter and acidic to strongly acidic (pH 4.5- 5.0) in reaction. Most of the hill soils are shallow in depth except in valleys and plateaus.

The hilly area occupies almost 90% and the valley, with just 10% land of the total state areas. They largely practise shifting cultivation as the permanent terrace cultivation is limited in the foothills. Shifting cultivation is a labour-intensive mode of agricultural activity. It has a traditional characteristic concerning traditional agriculture where land and labour are highly complementary to each other. Productivity is low, multi-cropping method is adopted and use of human labour is the main input and labour is reciprocal in nature under the system. Shifting cultivation contributed to soil erosion, deforestation and destabilisation of the ecology. However, under it the use of chemical fertilisers and pesticides is insignificant. Directorate of Economics and Statistics (2014) data on fertiliser usage in the hills of Manipur show an insignificant amount, implying organic agricultural production under shifting cultivation.

The peoples of the state are meat lovers and a huge demand exists for poultry, pork and other meat products. Invariably, there exist deficit in crops, livestock and fishery products. With this backdrop, it is necessary for an alternative way of production system which implies for crops, livestock, fisheries, fruits, trees etc. by harnessing available resources without harming the ecosystem.

Integrated farming system

Farming system approach requires involvement of agriculture, horticulture, soil conservation, forestry, fisheries, animal husbandry (piggery and poultry), apiculture, etc. Integrated farming system takes into account the concepts of minimizing risk, increasing production and profits whilst improving the utilization of organic wastes and crop residues. Literal meaning of integrate is to combine two things in such a way that one becomes fully a part of the other. Integrated Farming System (IFS) is an interdependent, interrelated often interlocking production systems based on few crops, animals and related subsidiary enterprises in such a way that maximize the utilization of nutrients of each system and minimize the negative effect of these enterprises on environment. The inter-related, inter-dependent-interlocking nature of IFS involves the utilization of primary produce and secondary produce of one system, as basic input of the other system, thus making them mutually integrated as one whole unit. Primary goals of IFS are

- Maximization of yield of all component enterprises to provide steady and stable income at higher levels.

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- Rejuvenation/amelioration of systems productivity and achieve agro ecological equilibrium.
- Control the built-up of insects-pest, diseases and weeds population through natural cropping system management and keep them at low level of intensity.
- Reducing the use of chemical fertilizer and other harmful agrochemicals and pesticides to provide pollution free, healthy produce and environment to the society at large.
- Increase in natural resource use efficiency by early recycling of nutrients.
- Mitigation of negative impact of agriculture or livestock on environment.

IFS models for the tribal areas of Manipur

Considering the physical, social and economic limitations of the Manipur, an integrated farming system model was developed by ICAR Research Complex for NEH Region, Manipur Centre, Imphal. The model comprises 4 ha of fenced area in the vicinity of the tribal settlement integrated with several components.

i. Cereals (paddy and maize)
ii. Legumes (groundnut and pea)
iii. Vegetables (cabbage and cauliflower)
v. Fruits (tree bean, kachai lemon and orange),
vi. Livestock (6 piglets, 125 poultry)
vii. Fishery (fingerlings of Common carp, grass carp and Catla)

For harvesting of rain water, Jalkunds was constructed using agri-polythene sheets of 250 micron. Vermi composting unit for waste recycling was also developed.

From this Integrated farming system model, the farmer can harvest 4.80 t/ha of paddy as compared to 3.25 t/ha under traditional practices. Maize cultivar Pusa composite-3 produced 3.25 t/ha as compared to local maize cultivar yield 1.70 t/ha and the groundnut (ICGS-76) which gave 2.40 t/ha dry pod yield. The vegetable yield considerably increased in this model which gave 1.50 lakh net returns from cabbage and cauliflower. In the 2nd year, the number of piglets increased to 15 including with six pigs. In poultry farming, the chicken breed Gramapriya is performing well and farmers were getting 40-45 eggs/day. There was adoption of composite fish production in which grass carp was surviving on middle and upper layers of water and common carp in lower layers of water. The Jalkund structures can stored water upto 30,000.00. In improved practice, from four ha land, the total net returns Rs 3,63,500/ [(Paddy cultivation (2 ha)= Rs 82000, Groundnut production (0.5 ha)= Rs. 38000, Maize production as green cob (0.5 ha)= Rs. 23000, Vegetable production in rabi season (1 ha, Cabbage and Radish) = Rs. 150000, Fruit production (Fruiting not started) = Nil, Piggery = Rs. 37000, Poultry = Rs. 16000, Fishery = Rs. 17500] as compared to 105000 in normal monocropped. Theis model made a positive impact on the utilization of scarce resources under fragile hilly ecosystem benefitting tribal farmers at large.

A scientifically sound and economically viable production system under integrated farming systems suitable particularly for hilly regions of the North Eastern region are

- Integrated fish cum pig farming
- Integrated fish cum duck farming
- Integrated fish farming-chicken
- Integrated fish farming-cum-cattle farming
- Integrated fish farming-cum-rabbit farming
- Integrated fish farming-cum-agriculture

Conclusion

There are always integrations at different levels in the existing family farming system practiced by the small holding farmers in the region. Inculcation of scientific approach like integrated precision farming in management of different components will not only improve resource use efficiency in existing production system but will also help to climb up a step towards sustainability of small holder family farming production system in future by mitigating its negative on environment through proper recycling of nutrients.

Prospective of neem based agroforestry in zero budget natural farming (ZBNF)

Garima Gupta, R.P. Yadav and M.J. Dobriyal

The government has begun to draw attention to the dangers of chemical agriculture. The prime minister has urged the country to embrace natural farming on a large scale. Intensification of agriculture can be improved by using a natural solution such as agroforestry in order to redefine, refine, and reform current food systems. Indigenous neem based agroforestry particularly important have been contributing to the preservation of rural livelihoods through a wide range of products and services. Neem products are used as neem insecticide, neem pesticide, neem pest fumigant, neem fertilizer, neem manure, neem compost, neem urea coating agent and neem soil conditioner in organic and natural farming. Due to the above-mentioned advantages, neem agro-forestry has a significant chance of becoming a viable ZBNF in the future.

Introduction

India is self-sufficient in food-grain production and can feed its 130 crore population. It is also the world's second-biggest producer of wheat and rice and the leading exporter of rice in 2019-20. This crop production has achieved by using high-yield varieties, pesticides and fertilizers, as well as farm machinery and irrigation systems, a combination of intensification (increased yields per unit area of land) and extensification (cultivation of more land), which increased the cost of agriculture. Over the years, this resulted in several negative impacts related to ecological, economic and existential aspects of agriculture. This includes declining soil fertility and food diversity, increase in farmers' debt, dependence on agro-chemicals, and pest resistance. According to recent WHO reports, over half of all foods contain naturally carcinogenic chemicals. However, intensification of agriculture had led to considerable adverse environmental impacts, soil degradation, eutrophication of land and water bodies, greenhouse gas, with all these the decrease in the population of rural areas has resulted in a decrease in agricultural production, and it is projected to be ~12% up to 2050. These negative impacts have been widely considered over the past few decades and as a result, the agriculture movement has begun to gain momentum with the government passing its first policy on organic farming in 2005.

In a recent change, the government has started talking publicly in favor of organic and natural farming. Highlighting the ill-effects of chemical based farming, the prime minister recently appealed to make natural farming a mass movement in the country. It is promoted as 'Bharatiya Prakritik Krishi Paddhati' (BPKP) under the centrally sponsored scheme Paramparagat Krishi Vikas Yojana (PKVY). BPKP aims at promoting traditional indigenous practices- which are largely based on on-farm biomass recycling with an emphasis on mulching and use of cow dung and urine formulations. It excludes all synthetic chemical inputs. Currently several states are undertaking Natural farming through central programmes like RKVY, PKVY, BPKP and others state specific programmes.

Natural farming and its Principles

Natural Farming (NF) is a unique chemical-free farming method that is considered to be agroecology-based diversified farming system, which integrates crops, trees and livestock, allowing functional biodiversity. Natural farming was established by Masanobu Fukuoka, a Japanese farmer and philosopher, introduced in his 1975 book "The One-Straw Revolution". It is also referred to as "the Fukuoka Method" or "The Natural Way of Farming" or "Do nothing Farming". Natural farming philosophy is working with nature to produce healthy food, to keep ourselves healthy, and to keep the land healthy and distinguished from biodynamic agriculture.

There are many working models of natural farming all over the world. The zero budget natural farming (ZBNF) is the most popular model in India. This concept was pulled into the light by Shri Subhash Palekar, for which he was honored with Padma Shri in 2016. ZBNF is based on 4 wheels/non-negotiable guidelines/principles or package of farming practices that would increase soil health and crop yields at zero external inputs or cost. These include: (i) Jiwamrita (life tonic); (ii) Bijamrita (seed protection tonic); (iii) Acchadana (mulching) and (iv) Waaphasa (soil aeration/moisture). There are also a

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number of pest management measures such as neemastra, agniastra and brahmastra – which are homemade preparations used for insect and pest control.

ZBNF is self-nourishing and symbiotic in nature."- ***Subash Palekar***

Importance of agroforestry for ZBNF

As a result of green revolution Indian agriculture experienced a tremendous growth especially in food grain production. Although the green revolution has been a huge success, and India has achieved incredible food production, than to in the 2021 Global Hunger Index (GHI), India ranks 101st out of the with a score of 27.5, India has a level of hunger that is serious. As demonstrate in this report of GHI, that we now require not only food security but also nutritional security, both of which can be obtained through a more diverse food system. Basically agroforestry is a land use system that integrates trees, crops and animals in an approach that is scientifically sound, ecologically desirable, practically feasible and socially suitable to the farmers.

A natural solution based on agroforestry can help redefine, refine, and reform current food systems in order to ensure food production sustainability and thus improve human livelihoods. Agroforestry can be used as a future ecological tool to balance environmental principles and various human needs for food, fuel, fodder, fibre, and fertiliser, as illustrated by the above observations. Agroforestry is becoming increasingly popular but traditional ecological knowledge and appreciation of the many uses and services of indigenous trees are dwindling in rural societies around the world due to industrialization and the pursuit of greater profits. Indigenous tree based agroforestry particularly important have been contributing to the preservation of rural livelihoods through a wide range of products and services. India is known for having a diverse range of such native plants that are both traditionally used and have the potential to be commercialized, such as mahua, neem, rhododendron, kachnar, moringa, gulmohar, palash, and others. Out of all these neem is an integral component of tropical thorn forests, dry deciduous forests, and tropical dry evergreen forests. It establishes well even under severe biotic and edaphic conditions and is a hardy species that can tolerate drought.

Potential of neem based agroforestry in ZBNF

Neem is occupying a novel place among the valuable plant for rural life as well as the environment and economy of India. In India, neem is also called 'arista' in Sanskrit- a word that means 'perfect, complete and imperishable'. The Sanskrit name 'nimba' comes from the term 'nimbatisyasthyamdadati' which means 'to give good health'. Neem is recognized as a natural product which has much to offer in solving global agricultural, environmental and public health problems. During last three decades neem has been established as a multi-purpose tree that could be used for agriculture, forestry, medicine and household purposes. Keeping the multipurpose nature of neem tree as an adaptable tree species, this tree can be denoted as "agroforestry tree of India" due to its wide adaptableness, manifold scope and moreover as an alternate income source to the villagers/rural poor. Neem tree is also included in Agroforestry sub-Mission of the country and has been exempted by the states from felling and transit regulations as a sequel of having National Agroforestry Policy. Neem agroforestry in India is an example of inclusive growth model, which integrates local – rural income generating opportunities with the industry and has created multi-layer benefit strata: employment and income of the poor, including farming community, substantial savings in fertilizer use at the national level, and indirectly a positive impact on the environment. The model provides a replicable template for such efforts in other global agriculture based economies. Growing demand of industries has rejuvenated the neem based agroforestry system in India, as India is rich in neem trees heritage.

Source: https://naturalfarming.niti.gov.in/components

4.1 Utility of neem products in ZBNF

Researchers worldwide are now focusing on the importance of neem in the agricultural industry. The magical tree and hundreds of its active compounds are used to manufacture a number of products. Natural properties of neem do not have any toxic reactions, so they are helpful in plant protection and management. All the parts of neem like seed, flowers, bark, and leaf can be used to produce high quality product. Products derived from neem tree act as powerful Insect Growth Regulators (IGR) and also help in controlling several nematodes and fungi. Neem products reduce insect's growth in crops and plants. Neem products are used as neem insecticide, neem pesticide, neem pest fumigant,

neem fertilizer, neem manure, neem compost, neem urea coating agent and neem soil conditioner.

Neem plants contain several thousands of chemical constituents of special interest are the terpenoids from different parts of the neem plant of its biological constituents the most active and well studied compound is azadirachtin. However, in most traditional preparations of neem as pesticide or medicine a mixture of neem chemicals are present and provide the active principles.

4.2 Utility of neem products in ZBNF-neem as fertilizer and manure

The organic and inorganic components in neem plant material improve soil quality and crop quality and quantity as a fertiliser. Neem seed cake functions as a soil enricher, decreases soil pest and bacterium growth, supplies macro nutrients required for plant growth, and helps enhance plant production over time. It's biodegradable and eco-friendly. Neem manure is popular since it's environmentally friendly and increases soil nitrogen and phosphorus. Sulfur, potassium, calcium, nitrogen, etc. are abundant. Neem cake is used to make organic or natural manure that doesn't harm plants, soil, or other organisms. It's extracted via cold pressing or solvents. For optimal results, mix it with urea, farm yard waste, and marine weed. Neem, a strong nematicide, was supposed to be distasteful to annelids, yet earthworms devoured it, transforming 7% of the meal every day into vermicompost. Worms fed neem thrived and reproduced faster than those fed mango leaf litter. Neem seed cake can be used as a biofertilizer, delivering macronutrients for plant growth.

4.3 Utility of Neem products in ZBNF-Neem as Soil Conditioner

Neem is a natural soil conditioner that boosts plant and fruit growth. It helps plants grow and keeps pests and insects away. Soil conditioner is made from neem seed granules or powder. It can be sprinkled during sowing or raked into the soil. Sprinklers should be followed by irrigation to reach the roots. It's a natural soil conditioner that boosts plant and fruit growth. Organic soil conditioner is gaining popularity in agricultural industries in Asia, the US, the UK, and Australia. In agriculture, organic soil conditioner is popular. Because they're organic, they're cheaper and have no harmful effects. Multi-functional subtropical soil conditioner. Neem soil conditioner increases soil fertility in plantation crops.

4.4 Utility of Neem products in ZBNF-Neem as fumigant

Neem is an ideal organic pest control for plant protection in natural farming, which naturally protects

Recent research on neem essential oil for pesticidal potential in different agricultural crops

Crop	Pathogen/Disease	Treatment
Mango	Powdery Mildew and Mango Malformation	Neem oil (1%)
Cowpea (Brazil)	*Spodoptera eridania* (southern armyworm)	Neem oil (0.35% and 0.7%)
Brinjal	Shoot and fruit borer	Neem oil
Cowpea	*Maruka vitrata*	Multi nucleo polyhedron virus+neem oil
Kinnow mandarin	*Penicillium digitatum* and *P. italicum*	Neem essential oil
Cultivated crops	*Helicoverpa armigere*	Neem oil
Cotton	Cotton pest	*Beauveria bassiana* + neem oil
Cabbage	Cabbage aphid	Neem oil (1%)
Okra	Whitefly	Mineral oil+Neem oil
Western white pine	*Zootermopsis augusticollis* (Dampwood termite)	Neem oil
Cashew trees	*Toxoptera odinae*	Neem oil
Stone fruit	*Monilinia fructicola*	Neem oil
Watermelon	*Aphis gossypii*	Neem oil
Coconut	*Aceria guerreronis*	Neem oil (3%)
Jasminum auriculatum	Eriophid mite	Neem oil 30 ml/l
Tomato	White fly and Leaf minor	Neem oil
Cashew	*Ferrisia virgata*	Neem oil
Okra	*Bemisia tabaci*	Neem oil
Tomato	*Tuta absoluta*	Neem seed oil
Phaseolus vulgaris	*Bemisia tabaci*	Neem oil

the crop according to the principles of natural farming. If we give preference to neem on agroforestry/farm boundary, then the pest control benefits from neem can be easily obtained. According to studies undertaken, neem fumigant helps to protect stored rice grains from pests. This natural fumigant not only kills pests but also affects them negatively by acting as feeding and oviposition deterrence, mating disruption, inhibition of growth etc. One of the major benefits of this organic fumigant is that pests do not develop resistance to it. Neem fumigants are eco-friendly, do not harm other micro-organisms, are non-toxic, and do not contaminate terrestrial and aquatic environment. Pests do not develop resistance to it, there are no negative effects, relatively less expensive, pest repellent and nourish the soil and function as pest reproduction controller.

4.5 Utility of neem products in ZBNF-Neem as insecticide and pesticide

Neem is a key ingredient in *Agniastra*, *Bramastra*, and *Neemastra*, all of which are natural plant protection products in the ZBNF. Neem pesticides are generally water soluble and help in the growth of the plants. It acts as pest repellent and pest reproduction controller. Neem insecticides are used to protect both food as well as cash crops like rice, pulses, cotton, oils seeds, etc. Great for use on all crops, trees, plants, flowers, fruits and vegetable round the home as well as organic and commercial growers. Active ingredient azadirachtin, found in neem tree, acts as an insect repellent and insect feeding inhibitor, thereby protecting the plants. This ingredient belongs to an organic molecule class called tetranortriterpenoids. It is similar in structure to insect hormones called "ecdysones," which control the process of metamorphosis as the insects as the insects pass from larva to pupa to adult stage. It is interesting to note that neem doesn't kill insects, but alters their life process. The major parts/extracts of neem seed that are used for making neem insecticides.

Conclusion

Although the green revolution has been a huge success, and India has achieved incredible food production, than to in the 2021 Global Hunger Index, India ranks 101st out of the with a score of 27.5, India has a level of hunger that is serious. As demonstrate in this report of GHI, that we now require not only food security but also nutritional security, both of which can be obtained through a more diverse food system. Agroforestry helps to facilitate this kind of system diversification. Agroforestry is an agroecological approach based on the diversification of the agroecosystem production components (trees/shrubs, crops and/or livestock) and on the intensification of the agroecological relationships that exist between these components in space and time. Neem agroforestry in India is an example of inclusive growth model, which integrates local – rural income generating opportunities with the industry and has created multi - layer benefit strata: employment and income of the poor, including farming community, substantial savings in fertilizer use at the national level, and indirectly a positive impact on the environment. Neem acts as the most reliable source of pro-pesticide having no adverse effect on human and animals. Thus neem based products play a crucial role in organic and Natural Farming.

Role of tribals in germplasm and biodiversity conservation

Pavithra, B. S. and Channakeshava, C.

Tribals are indigenous groups who have been inhabiting forests for many years. They have a distinctive culture and connect with underprivileged groups in society. Tribes are the protectors of the ecosystem and are essential to nature conservation. These ethnic and indigenous people preserve plants that can be used for agriculture and horticulture as well as a source of edible wild food in the form of roots, tubers, rhizomes, seeds, and fruits. Some of the native cultivars that are preserved by ethnic groups are utilized in agricultural cultivar development programmes to boost production and to make plants more resistant to various pests and diseases. Many of the plants preserved by ethnic groups are used as antidotes for snake and scorpion bites and stings, by traditional healers to set bone fractures, to treat wounds or arthritis, as abortifacients, to treat monthly irregularities, etc. As part of in situ biodiversity conservation and ecological restoration, tribal people preserve plants on deserted sites of shifting cultivation as well as in sacred groves.

Introduction

The tribal population in India, even though a numerically small, it represents an enormous diversity of groups. Tribal populations are the original inhabitants of our country as Adivasis, Moolavsis and other ethnic minorities. Around 75% of the tribes are residing central Indian states, 12% of the population are in Northeastern region followed by the Southern region with 5% and the Northern states with 3%. The Gonds, Chenchus, Gaddis, Khasis, Gujjars, and Santhal are the most common tribes in India. All the tribes of are very closely related to the forest and because it is the only means for the energy sources for their survival. About 3,900 plant species are used by tribals as food (out of which 145 species comprise of root and tubers, 521 species of leafy vegetables, 101 species of bulbs and flowers, 647 species of fruits), 525 species are used for fiber, 400 species are used as fodder, 300 species are used in preparation and extraction of chemicals which are used as naturally occurring insecticides and pesticides, 300 species are used for extraction of gum, resins, dyes and perfume. Many native crops such as brinjal, pointed gourd, Indian round melon, bitter gourd, ridge and smooth gourd, snake gourd, cucumbers and leafy amaranths and leafy crops that have long history of cultivation in tribal tracts of India. In addition to these a number of plants are used as timber, building material and about 700 species are culturally important from moral, cultural, religious, aesthetic and social point of view.

The tribal people are the best protectors of the environment, who serves the environment without serving much of their own selfish interest. They have never gone beyond the interest and existence of forest ecosystems. This approach must be the crux of the forest management effort. They also hold knowledge, which have a positive bearing in the protection of forest and conservation of biodiversity and live in close harmony with forests. Women play a crucial role in conservation of valuable plant genetic resources by possessing unique knowledge associated with the seed selection, cultivation, processing and utilization, storage etc. This knowledge is then passing over to the next generation women and thereby playing an important role as the conservers of biodiversity.

Paddy is the predominant crop cultivated in the upland, medium and lowland ecosystems during *khariff* season, mostly under rain-fed conditions. The other main crops are pulses, oilseeds, sugarcane and minor millets grown in rotation at higher altitudes. The Bonda, Paroja and Langia Saora tribes still practice shifting cultivation along with settled agriculture. The intraspecific phenotypic variability is enormous; the populations are highly heterogeneous in morphological and agronomic character. The heterogeneity within the races and the microclimatic variations in the fields at different altitudes help them to reduce the risk of crop loss due to various biotic and non-biotic stresses. The diversity of species of minor millets in the farmers' fields shows in the varied space and time dimensions in which each species and its race are distributed across the geographical area.

Role of tribes in germplasm and biodiversity conservation

1) Plants are conserved in natural habitat are being worshipped:

Many plants/trees such as neem, tulsi, peepal tree,

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banyan tree, arjun tree, bel tree *etc*. are worshipped in the name of different home god and goddesses by the tribal people. Hence they will not harm any of the trees and this pursuit play an important role in biodiversity conservation.

2) Conserved plants as a source of food

The traditional farming methods of Adivasis have been successfully feeding their communities without the use of harmful substances. They save seeds from the previous harvest, sow several seeds at the same time, use animals to fertilize land and involve zero use of chemicals. In addition, mixed farming helps to recover the loss by failure of one crop. They conserved several plants and endangered cultivars of agricultural crops such as rice, maize, millets, grains, legumes, fruits and vegetables which have originated under diverse agro-ecological climates. Many rice verities which are conserved by tribals from different part of the country are genetically superior than existing cultivated rice varieties in characters like aroma, grain quality, protein content, digestibility and also found resistance to insects, pests and diseases. Tribals also preserved the endangered and rare types of seeds such as turmeric, tili, black cumin, mahakanta, phula, and ghantia and adopt organic farming for better harvest and soil fertility.

3) Conservation of Plant genetic resources

Over centuries, tribal or traditional farming communities have continuously adapted and shapened the dimensions of rich genetic material available with them. These resources or traditional varieties or landrace populations often bear specific traits-early or late maturing, adaptability to a particular soil type, uses and usually have local names which have enabled them to survive so long under various biotic and abiotic stresses in the centres of diversity along with wild progenitors of crop plants, wild and weedy relatives. Besides these resources, potential domesticates are involved in the Plant genetic resources spectrum; they are those wild species, which are not yet domesticated but are extensively used. Some of them grow widely, though genetically and culturally in a near wild state. With richness of plant genetic resources, the tribal regions have therefore been identified as "Hot Spots" of agri-biodiversty. In diversity rich areas farmers/tribals often cultivate several crop varieties in one season, and adaptive complex of crop genetic diversity enables them to adopt crops suited to their ecological niches and cultural crop production practices. For conserving the diversity they generally follow their local methods of preservation/conservation. Among the communities there is reciprocal and sometimes free exchange of material for their mutual benefits.

List of the plants conserved by tribes and used for different purpose

Edible plants	
Botanical name	**Common Name**
Achyranthes aspera	prickly chaff flower
Amaranthus viridis	slender amaranth
Basella rubra	Red Indian Spinach
Bauhinia purpurea	camel's foot
Chenopodium album	wild spinach
Commelina benghalensis	Benghal dayflower
Cyperus esculenta	yellow nutsedge
Dipsacus inermis	Himalayan Teasel
Chlorophytum tuberosum	safed musali
Coccinia indica	ivy gourd
Stellaria media	Common chickweed
Malva neglecta	common mallow
Calamus erectus	viagra palm
Cannabis sativa	Indian Hemp
Hydrocotyle javanica	Java pennywort
Pouzolzia zeylanica	Graceful bush
Mucuna pruriens	velvet bean
Carum carvi	Kala Jeera
Rumex nepalensis	Nepal Dock
Edible Fruit Trees	
Alangium salvifolium	Ankol
Aegle marmelos	Bel
Bauhinia purpurea	Kachnar
Chenopodium foliosum	Goosefoot
Ficus semicordata	Nala Dumar
Phoenix sylvestris	Khajur, Chind
Fragaria nubicola	Dhul-akhre
Antidesma acidum	Chempulinjamarom
Kirganelia reticulata	Abirangi
Litsea cubiba	Sernam
Bassia malabarica	Illippa, Adiyan
Indigenous trees used for medicinal/resin purpose	
Gardenia resinifera	Gardenia
Boswellia serrata	Indian olibanum
Butea monosperma	flame-of-the-forest
Shorea robusta	Sal tree
Pinus roxburghii	chir pine
Canarium strictum	black dammar
Commiphora wightii	Indian bdellium-tree
Trees/Plants used for religious and cultural Practices	
Ficus religiosa	Peepal Tree
Ficus benghalensis	Banyan tree
Aegle marmelos	Bael
Saraca indica	Ashoka
Mangifera indica	Mango tree
Azadirachta indica	Neem tree
Musa paradisica	Banana plant
Cocos nucifera	Coconut tree
Anthocephalos cadamba	Kadamba tree
Ocimum sanctum	Tulsi
Cedrus deodara	Deodar
Phyllanthus emblica	Amla
Curcuma longa	Turmeric

4) Conserve the exotic plants in natural habitat

The plants in the forest have "values" largely because the tribal communities have knowledge about their characteristics and the range of utility. For the community to test a plant, experiment and utilise, it has to be an integral part of their ecosystem. Plants that are alien to the tribal ecosystem may seldom be incorporated into their day-today life. The same holds good for plant species that may be of great value to the "outside" world. The knowledge of the native people in the non industrialized regions of the world on their bio resources is extensive. This knowledge enables them to identify any new element in that ecosystem. While alien species are often rejected, there are also cases where such species were accepted into the tribal societies. For instance, the Kondh of Kondhpungar use *Pterospermum xylocarpum*, *P. acerifolium* and *P. xylocarpum* in their ethnomedicine. The flowers of those trees are kept in the ears of women during child delivery to ease pain.

5) Conserve the plants for the medicinal purpose:

Many plant species which are grown by tribals are having great medicinal value. Different parts of plants are used for different purpose like the rhizomes of sweet flag stem bark of chironji, stem and leaves of drum stick, chaff flower, Spider flower, Malbar silk cotton trees are being used as antidote of snake-bite and scorpion sting. Paste is prepared from rhizome and applied on wounds. The root, stem and leaves of some plants are powdered and paste is prepared and applied by tribals on broken bone portions. The paste prepared from of stem and leaves of plants like Grey orchid, Sessile joyweed and roots of Cassia, Heartleaf Sida, Camel's foot, etc. are tied for healing of wound for 10-15 days on broken bones. These plants are conserved by tribal herbal healers in natural forests for orthopedic treatments. Primitive and indigenous people have been using several plants for combating disease from centuries and are found wide acceptance in traditional medicinal use. Plants like *Equisetum ramosissimum, Argemone maxicana* are dried, powdered and paste is applied on infested portion of skin and on wounds. Plants like *Bauhinia purpurea, Sida acuta, Jatropha curcus, Grewia hirsutum, Albizzia lebbeck, Capparis decidu*as are conserved as used in muscular pain, cure of fever, headcache, and body swelling. Decoction prepared from roots of *Curculigo orchiodes, Bombax ceiba*, to cure white discharge in urine of tribal women are also conserved by primitive tribes.

6) Conserved the plants in abandoned sites:

The shifting agriculture jhoom practice of cultivation of crops are practiced by tribals in many states like Assam, Tripura, Mizoram U.P., Maharashtra, Orissa, Chharisgarh, Tamil Nadu, Andhra Pradesh, Karnataka and Kerala. In this practice a forest is cleared by felling of trees and plant bio-mass is burnt and the ashes collected which are source of essential plant nutrients are spread in the fields. After a year of cultivation, the land is abandoned for several years for regeneration of fertility of soil. During this period the farmers are moved for cultivation in other land. The tribals do not perform complete felling of forest but they retain several useful species of horticultutral and agricultural importance such as *Mangifera indica* (Mango), *Citrus spps*. (Orange), *Musa spps*. (Banana), *Phyllanthus embilica* (Goose berry), *Zea mays* (Maize), *Saccharum spps.* (Sugarcane). Several useful plants like *Ardisia polycephala, Ardisia cripsa, Casearia glomerata, Meliosma ipñata, Rhus spps, Phoenisx spp.* etc. are colonized at abandoned sites.

2. Protection and Maintenance of Crops

Farmer of the fields construct the boundaries of their fields with construction of small (pardas) walls. They also use long clothes as boundary as well as protecting the crop from forest animals, like forest pig and bare and peacock. At night times they stay on open built hut and protect their crop from forest animals by throwing stones and shouting. After harvest the women farmers fill the selected seeds in a sack, seal it and store it in the granary, earthen pots or other structures made using mud or clay until the next season. Similarly for

Figure: Indigenous seed storage structures

vegetable seeds, once the fruit has matured, they dry the fruits, remove the seeds and then they store them. When the time for sowing is near, they retrieve them for use. The immediate impact of seed conservation is the reduced dependency on the market for purchase of seeds as well as food.

Conclusion

Tribals are living mostly in biodiversity rich areas posses a wealth of knowledge to use and conserve plant genetic diversity. They play very important role in food production, seed selection & storage, harvesting, food processing and maintaining soil fertility. They constitute a Most of the tribes prefer traditional cultivars which are drought resistant and to some extent disease resistant and pest tolerant. These crops have been preserved due to the conservation habit of these communities over the years. These traditional cultivars also suit local dietary habits and can be easily cultivated without external inputs women are traditional caretakers of crop genetic diversity in agriculture. Their knowledge of the growing conditions and nutritional characteristics of various species gives them a vital fund of experience in seed selection and plant breeding. This enables them to maintain the genetic diversity required to adapt to fluctuating weather patterns and biotic pressures and ensure the survival of traditional crops adapted to local conditions and tastes.

Integration of animal husbandry with agriculture crops and trees - a way for higher agriculture income

Pavithra B S and Garima Gupta

Animal-based agricultural systems occupy 45% of the global land area and contribute in a large proportion to agricultural income. The animal sector is dominated by resource-poor and small landholders of developing countries. Adverse effects of livestock on the environment are caused by the way animal husbandry is practiced because animals are not integrated with other agricultural and forestry-based practices. The raising of livestock separately from cultivating seasonal crops and perennial trees has decoupled the bio-geochemical/bio-geophysical cycling of carbon, water, nitrogen, phosphorus and sulfur. This decoupling is a causative factor of the increase in emissions of N2O and CH4, eutrophication and contamination of water resources, degradation of rangelands, and declines its biodiversity. Therefore, identifying and adopting systems that integrate livestock with crops and trees are critical for reducing the environmental footprint of animal-based dietary products. Incorporating pastures/forages in the rotation cycle along with controlled grazing, called ley farming and agroforestry, such as alley cropping, are examples of integrated farming systems.

Introduction

Integrated Farming System (IFS) is a sub system of a high-level land use system which includes crop production, raising livestock, fishery, poultry, bee keeping etc. on a particular farm with a objective of higher profitability without altering ecological and socio-economic balance on one hand and to meet the national goals on the other hand. The increasing pressure on has resulted in massive deforestation with consequent erosion and reduction in soil fertility as well as serious shortages of fuel wood. This makes agricultural scientists to think that trees have a crucial role to play in tropical agriculture and that should not be confined to intensive plantations but should instead be integrated with arable agriculture and livestock husbandry called agro-forestry. In agro-forestry, trees or shrubs are deliberately grown in association with agricultural crops or animals in some form of spatial mixture or temporal sequence in the same unit of land. The resulting systems will usually consist of crops and trees (agri-silviculture); trees and animals (silvopasture); or crops, trees, and animals (agro-silvopasture). Integration of livestock and trees makes excellent sense for farmers both in terms of intensification of land use and economic security. Because animals provide traction and manure in addition to meat, milk and hides, their inclusion in the farming system actually increases crop production. They need not compete for land with crops, so long as adequate forage is available throughout the year.

In addition to the above advantages leguminous trees, which fix nitrogen, can provide protein-rich leaves as supplements for ruminants and pigs and nutritious browse during periods when other feeds are unavailable. Farming systems that integrate trees with livestock, farmers encourage the growth of acacia trees; the highly nutritious foliage and pods provide an important source of dry fodder for their animals. Under-utilized land and labour are made more productive and farm income is increased. With careful management, improvements in growth and yield of the tree crop can be achieved and considerable savings can be made in costs of herbicides to control ground-cover herbage. Because the market price of the produce from tree crops fluctuates widely, inclusion of livestock in the system provides a buffer against falling prices. Since tree crops take a minimum of 6 to 7 years before coming into economic production, a combination of forage and food crops intercropped with young trees can help to offset the costs of establishing plantations. The cooler temperatures under tree plantations can provide a better microclimate for animal production than unshaded areas.

Advantages integration of animal husbandry with agro-forestry System:

Inclusion of tree component in the farming has many advantages. Some of the important advantages are:

- It meets the human needs of food, fodder, fuel, timber and pesticides (eg. neem).
- It provides sustainable income with low cost of cultivation and returns are higher as compared to other cropping system involving single crop.
- It controls soil erosion and improves soil fertility and productivity by regular leaf fall and drawn the nutrients from lower regions of the soil.

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- It is well adjusted with any unpredictability of nature. Efficient use of irregular rainfall is possible by trees.
- Trees act as resting place for birds, which are relatively beneficial for agriculture, since harm done by birds is more than compensated by their action for control of insect pests.
- Shade created by trees is beneficial in raising certain shade loving crops and nursery and for vermiculture.
- The risks climate change because of production of CH4 and N2O by practicing the single crop module have a high global warming potential (GWP), can be minimized by integrating livestock with crops and trees.
- Practices such as establishing vegetation buffers on agricultural fields to enhance biodiversity and conserve soil and water (i.e., agroforestry or alley cropping), can also reduce the environmental footprint of livestock raised on the same land unit.

Some of the Examples of livestock integration with perennial and annual crops

Crops	Trees	Animals
Sorghum	Leucaena	Cow, Goat
Forage Sorghum	Coconut tree	Cattle
Gliricidia	Leucaena	small ruminants
Butterfly pea, Neustanthu, Wild ground nut	Rubber and oil palm	Sheep
Soybean, Maize and Brachiaria grass	Eucalyptus	Livestock
Sesbania	*Eucalyptus, Acacia*	Cattle

Components of the integrated farming system

Woody perennial Trees: The selected trees should have proper height and good palatability to achieve successful integrated practices. Many hard wood trees like oak, *Eucalyptus, Acacia, Leucaena, Dalbergia etc.*, can be used in integrated forming system. Fruit-trees could also be used for integrated systems once they have reached a certain height. Among tropical fruit-trees, mango, avocado, rambutan and durian trees would be suitable, as would pear, peach, apple, orange and olive trees among the temperate fruit-trees.

Agriculture crops: Species growing spontaneously at any particular place might be a mixture of grasses, legumes and broad-leaved plants. Some of these would be consumed more than others, depending on the animal species involved for instance; sheep prefer tropical legumes and broad leaves over grasses. Cover crops can effectively protect the soil from hydric and aeolic/rain and wind erosion, increase the soil's organic matter, fix nitrogen (legumes), reduce soil moisture loss and topsoil temperature, reduce or eliminate weed growth and provide excellent forage for grazing or cut-and-carry systems. In tropical climates, legumes are preferred over grasses for integrated systems with small ruminants since they are generally more nutritious and contribute to higher levels of animal production. The standard mixture of legumes currently used as cover crops for rubber and oil-palm plantations in Southeast Asia includes butterfly pea, Neustanthu, wild ground nut and these species are the most shade-tolerant and last longer underneath trees.

Livestock/Animals: Cow, Goat, Sheep, buffalo *etc.*, can be integrated because of their docile nature and tendency to graze rather than browse, have been preferred in association with rubber, oil palm, hard wood trees and other fruit-trees. Direct grazing and cut-and-carry systems can be following in integrated forming system. Under cut and carry system all ruminant and herbivore animal species that can be kept in confinement may be integrated with perennial crops. It is only under direct grazing systems that the animals need to be well selected. Since it is unlikely that nutrient requirements for optimum performance of the animals can be met throughout the year only with forage, some sort of feed supplementation may be justified during certain periods of the year. Annual forage shortages resulting from seasonal dry periods can be prevented by preserving forage using traditional methods (hay and silage) during periods of abundance or by using forage trees or sugar cane that can be harvested during the dry season. Tree prunings can also be fed to animals. Manure and urine from the animals return mineral nutrients and organic matter to the soil. Since it is most likely that in all integrated systems the animals will spend a considerable amount of time inside barns, it is important that the excreta is returned to the plantation as this will contribute to the sustainability of the system and will reduce or eliminate the need for chemical fertilizers. The additional minerals provided in the supplementation partially enter the nutrient cycle of the integrated system via animal excretions.

Figure: Biological component of integrated farming system

Integrated forming system practices

Integration of crop, livestock and trees consists of growing forest species simultaneously with commercial

crops like soybeans, maize, or beans added for the first 2 or 3 years. After crop harvest, the area is planted with forages for livestock, associated with maize or sorghum. After grain harvesting, the pasture is already established between the tree rows, enabling grazing, until wood is harvested.

For an instance in semi-arid region of India using Leucaena in mixed sorghum and livestock smallholdings gave remarkable improvements in sorghum yields and provided a valuable source of fodder and firewood. Here, Leucaena was planted in rows 6m apart with sorghum planted between. The trees were pollarded at 2m height immediately before planting the sorghum, and the leaves were fed with sorghum stover to cattle. The researchers found that the value of produce from the leucaena/ sorghum combination was about one third greater than that from sorghum alone and that income from the forage accounted for about 20% of the total value. In southern India, the net return from small holder coconut plantations was calculated as approximately US$350 per hectare per year, but when milk cattle were included net returns increased to $942 per year.

Alley cropping in agroforestry consists of hedges of fast-growing shrubs inter-planted with food crops. Using nitrogen-fixing leguminous shrubs such as leucaena or gliricidia, crop yields have been maintained at reasonable levels over several years, without the need for a fallow period. The system has several advantages. The shrubs provide green manure or mulch for companion crops, a source of stakes and firewood and, most importantly, biologically-fixed nitrogen to maintain and enhance soil fertility. Additionally, alleys planted along the contours on sloping ground can help to prevent soil erosion and it also improving productivity of sheep and goats. Demand for fresh meat is increases, so if the productivity of local small ruminants could be raised, a large and easily accessible market for meat would be available to farmers.

Conclusion

In many areas, deforestation has resulted in critical shortages of fuel and timber as well as serious soil erosion. Integrated Farming system models at different situations could enhance the productivity of the farm as whole; improve the profitability in terms of additional net return and continuous flow of income to the farmer. Integration of trees in farmland simultaneously provides fuel and helps to control erosion. Including an animal component in the system not only provides meat, milk and hides but manure and traction as well. In many areas of the tropics, demand for meat and milk products far outstrips supply and the deficit is met by expensive imports paid for with scarce foreign currency. Self-sufficiency in livestock products should be seen as a national goal as well as an important source of farm income.

Impact assessment of linseed technology demonstrations in tribal area of Chhattisgarh

Sanjay K. Dwivedi[1], R. K. Satyaraj Guru[2] and Prerna Jaiswal[2]

There are tremendous opportunities for enhancing the production and productivity of linseed crop by adopting the improved technologies in Chhattisgarh. The present study comprised of total 937 agro-technology demonstrations on linseed varities namely RLC-92, RLC-133, IA-32, Kartika and Deepika under component of irrigated, partially irrigated, rainfed and utera were conducted at tribal farmers field in the districts of Kanker (North Bastar), Kondagaon and Sarguja of Chhattisgarh state during *rabi* 2012-13 to 2021-22. On over all crop productivity basis, 47.6 percent higher seed yield was recorded as compared to traditional farmers practices. The study revealed that extension and technology gap were estimated as 250, 213,187 and 112 kg ha^{-1}; 80, 80, 79 and 44 kg ha^{-1} under component of irrigated, partially irrigated, rainfed and utera, respectively. The technology index was reduced from 13.6% (rainfed) to 8.7% (irrigated) exhibited the significance of technology demonstrations in enhancing overall production and productivity of linseed in tribal area of Chhattisgarh. An impact study has been conducted among beneficiary farmers and concluded that linseed farmers were faced lack of fair selling price of linseed at local market (66.66%), and delay in payment of crop produce (51.67%). Some of the suggestions obtained from the majority of the respondents that marketing facilities should be increases (91.6%) and provision for instant payment of crop produce should be made (41.6%). However among agronomical consideration, the delay in sowing due to late harvesting of previous crops/*kharif* crops (paddy) is a major issue and followed by non adoption of line sowing due to presence of moisture of previous paddy crop especially in rainfed area.

Introduction

India is an important linseed growing country in the world and it contributes 7% to the world linseed pool. Among the oilseeds, linseed (*Linum usitatissimum* L.) is one of the oldest crop, grown in almost all countries of world for oil, fibre and seed purpose. Linseed is unique among oilseeds for its technical grade vegetable oil producing ability and fibre (good quality having high strength and durability) production. Linseed contains 35-45% oil with high content of omega-3 fatty acid and alpha lenolenic acid (ALA). Omega-3 fatty acid lowers levels of triglycerides in the blood, thereby reducing heart disease and also promise in the battle against rheumatoid arthritis. Linseed oil contains three times as much omega-3 fatty acid than omega-6 fatty acid. Its seed has 36% protein out of which 85% is digestible. Its oil cake is used to feed milch and fattening animals for milk and meat production. Its oil has a lot of uses apart from human consumption *viz.* oil paint, varnishes, printing ink, oil cloth, soap, patent leather and waterproof fabrics due to its fast volatility feature. Round the globe linseed crop occupies an area of 2.764 million ha yielding out 2.925 million tons having an average productivity of 1.06 t ha^{-1}. Our national production of 0.18 million tons is realized from an area of 0.32 million ha^{-1} with low productivity of 567 kg ha^{-1} in world arena.

Linseed is mainly cultivated in the states like Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Rajasthan, West Bengal, Karnataka, Odisha and Bihar. The average productivity of this crop is very low as compared to other oilseed crops, which can be attributed to several reasons. The major causes behind low production of linseed mainly in sub-marginal soils and input starved coupled with poor weed management.

Edible oil constitutes an important part of our daily diet and domestic consumption of edible oils has increased substantially over the years. Productivity of oilseeds has increased from 481 kg ha^{-1} in 1950-51 to 1271 kg ha^{-1} during 2019-20. As per projections per capita consumption of vegetable oils in India is likely to rise 15.33, 15.88, 16.43 and 16.97 kg year^{-1} by 2020, 2030, 2040 and 2050 respectively. Considering the current domestic production level, there is a huge gap between supply and demand, therefore need to increase productivity as well as area of oilseed crop in the country.

Crop production technology demonstrations on linseed varieties RLC 92, RLC 133, IA 32, Kartika and Deepika were conducted at 937 selected tribal farmer's field in cluster basis at tribal dominated area *viz.* Kanker (North Bastar), Kondagaon and Sarguja districts of Chhattisgarh state during *rabi* 2012-13 to 2021-22 under Tribal Sub Plan (TSP), ICAR (AICRP Linseed). All the

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demonstrations were of 0.4 ha area each and conducted using recommended package of practices as per the component allotted to the specific area of the state. Farmers were provided with quality seed of high yielding linseed varieties, Urea, SSP, and MOP fertilizer, insecticides for plant protection, suitable herbicide (Metsulfuron methyl @ 4.0g *a.i.* ha^{-1} as post-emergence) for weed control, required fungicide (bavistine @ 3.0 g kg^{-1} seed) and trichoderma culture packets for seed treatment and other need based inputs were incorporated in recommended package to raise good crop. The sowing was done during first week of November to second week of December and harvested during last week of March to April. The demonstrations on farmer field were regularly monitored by the scientists of AICRP on Linseed, IGKV Raipur, KVK personnel and extension functionaries of Chhattisgarh government from time-to-time. The seed yield of demonstrated crop was recorded and analysed. Furthermore, to evaluate the grass root penetration of improved linseed technology in tribal area, a study was also conducted at two blocks of Kanker district. Two villages from each selected block were considered for selection of respondent on the basis of maximum number of FLD participating farmers (4 villages), 15 beneficiary and 15 non-beneficiary farmers were selected as respondents from each selected village. Thus, total 120 respondents were selected randomly.

Findings

Results of 937 demonstration were conducted in 378 ha area on farmers' field is presented in Table 1. The result indicates that the use of improved varieties (RLC-92, RLC-133, IA-32, Kartika and Deepika), coupled with recommended package with balanced application of nutrients, control of insect and disease at economic threshold level gave the average 47.6 per cent higher yield of linseed as compare to farmer practice (420 kg ha^{-1}).The result indicated that the crop production technology demonstration has given an impressive impact over the tribal farming community of Chhattisgarh state and they were motivated by recommended/improved technologies applied in the cluster based demonstration fields. This clearly suggests that the positive impact of demonstrations over farmer's practices led to the crop popularization in these areas. The increase in seed yield under front line demonstration was noted to be from 38.3 to 63.7% over farmers or local practices.

The various component, *viz.* irrigated, rainfed, partially irrigated and utera demonstrations were conducted in tribal farmers field (Table 2). The highest percent yield increased over farmer practices were observed with rainfed component (59.1%) followed by utera (48.5%), partially irrigated (42.8%) and irrigated (42.7%). However, extension and technology gap were observed in irrigated condition followed by partially irrigated, rainfed and utera. The technology index was computed highest value with rainfed condition (13.6%) followed by utera (11.4%), partially irrigated (10.1%) and irrigated condition (8.7%).

The impact analysis revealed that more than 80% of the farmers faced delayed sowing due to late harvesting of previous crops/*kharif* crops as major constraint. In addition to this, non-adoption of line sowing, lack of irrigation facilities, non-assurance of minimum support price and low yield are some of the major setbacks in its acceptability in tribal area. Demonstration of low cost improved technology, market linkage and technical support and guidance by agricultural scientists were some of the suggestions as suggested by farmers to for higher adaption of linseed technology (Table 3 & 4).

Plate 1: Demonstration of linseed crop at farmers' field of Kanker district, Chhattisgarh

Table 1: Performance of linseed varieties in crop production technology demonstration under component of irrigated, partially irrigated, rainfed and utera during 2012-13 to 2021-22 (10 years)

Sl. No.	Year	Component	Variety	Number of demonstra-tions	Total area (ha)	Av. Yield in improved practice (kg ha-1)	Av. Yield in Farmers practice (kg ha-1)	Yield increase over farmers practice (%)
1	2012-13	Rainfed	RLC 92, Indira Alsi 32	50	20	506	309	63.7
		Utera	RLC 92, Indira Alsi 32	50	20	337	223	51.1
2	2013-14	Rainfed	Dipika, Indira Alsi 32	50	20	488	309	57.9
		Utera	Dipika, Indira Alsi 32	50	20	330	215	53.4
3	2014-15	Rainfed	RLC 92, Indira Alsi 32	50	20	517	332	55.7
		Utera	RLC 92, Indira Alsi 32	50	20	362	255	41.9
4	2015-16	Irrigated	RLC 92, Indira Alsi 32	56	23	810	560	44.6
		Partially irrigated	RLC 92, Indira Alsi 32	44	17	700	490	42.8
5	2016-17	Irrigated	RLC 92, Indira Alsi 32, Dipika	48	21	860	610	40.9
		Partially irrigated	RLC 92, Indira Alsi 32	44	19	730	520	40.3
6	2017-18	Partially irrigated	RLC-92, Dipika	25	10	770	570	35.1
7	2018-19	Partially irrigated	IA 32, Kartika	50	20	850	600	41.6
8	2019-20	Partially irrigated	RLC-92, RLC-133	50	20	650	470	38.3
9	2020-21	Partially irrigated	RLC-92, RLC-133	50	20	630	420	50.0
10	2021-22	Irrigated/ Partially irrigated	Indira Alsi-32, RLC-133, RLC-92	270	108	640	410	56.0
Total				**937**	**378**	**612**	**420**	**47.6**

Table 2: Component wise percent increase in yield over farmer practice, extension gap, technology gap and technology index of linseed crop demonstrated in tribal farmer's field

S. No.	Components	No. of demonstra-tions	Total area (ha)	Yield (kg ha^{-1})			Yield increase over farmers practice (%)	Extension gap (kg/ha)	Technology gap (kg/ha)	Technology Index (%)
				Potential	Demonst-ration	Farmer practice				
1	Irrigated	104	44	915	835	585	42.7	250	80	8.7
2	Partially irrigated	533	214	790	710	497	42.8	213	80	10.1
3	Rainfed	150	60	583	504	317	59.1	187	79	13.6
4	Utera	150	60	387	343	231	48.5	112	44	11.4
Total		**937**	**378**	**669**	**598**	**408**	**48.3**	**191**	**71**	**11.0**

Table 3: Problems as perceived by beneficiary farmers during the adoption of linseed production technology

S.N.	Problems	F	%	Rank
1	Delay in sowing due to late harvesting of previous crops/*kharif* crops (paddy)	50	85.00	I
2	Non adoption of line sowing due to presence of moisture of previous paddy crops	45	75.00	II
3	Lack of fair selling price of linseed at local market	40	66.66	III
4	Lack of irrigation facilities	35	58.33	IV
5	Less preference to linseed as compare to other crops	32	53.33	V
6	Delay in payment of crop produce	31	51.67	VI
7	Getting low yield in linseed as compare to other crops	30	50.00	VII

*F: Number of beneficiaries farmers

Table 4: The information regarding suggestions given by beneficiaries of FLD of linseed

S.N.	Suggestions	F	%	Rank
1	Marketing facilities should be increases	55	91.60	I
2	Low cost technology must be introduced	42	70.00	II
3	Regular visit and guidance should be done by KVK scientists	35	58.33	III
4	Post demonstration contacts must be maintained	32	53.33	IV
5	Extension activities i.e. kisanmela, demonstration, exhibition, training, visits etc. should be conducted in villages at proper time	30	50.00	V
6	Provision for instant payment of crop produce should be made	25	41.67	VI

*F: Number of beneficiaries farmers

Barahnaja cultivation: A traditional cropping system of northern Himalayan region

Kavita Gururani, Pankaj Lawania and Anil Kumar

As the world population continues to grow, much more effort and innovation will be urgently needed in order to sustainably increase agricultural production, improve the global supply chain, decrease food losses and waste, and ensure that all who are suffering from hunger and malnutrition have access to nutritious food. In order to be able to meet these demands, agricultural production would have to increase by around two-thirds by 2050. In order to achieve this, especially water, fertile land and biodiversity would have to be used and maintained more intelligently – and in particular more effectively. At present, roughly twelve million hectares of agricultural land are being lost in the world each year – as a result of over-grazing, unsuitable cultivation methods, erosion or road building and urban construction. If this trend were to continue unabated, agricultural output would fall by up to twelve percent in the next 25 years.

Not only lack of food security is looming large, but also the problem of chronic malnutrition among children and women is an emerging challenge. Barahnaja cultivation system that specifically followed in North-western Himalayan States, including the state of Uttarakhand is rich in biodiversity including a large number of Agri-horti-forestry crops, an important source of various compounds, genes and proteins of agricultural, industrial and pharmaceutical importance. Thus, there is tremendous potential to explore this cultivation system, and harnessing these crops in general and ethnic in particular, as viable sources for development of functional foods and nutraceuticals.

Introduction

Food Sustainability ensuring nutrition security without sacrificing the long-term health of the ecosystems and vital cultures that provide our food [Sustainable Development in the 21st century (SD21), Food and Agriculture: The future of sustainability]. Sustainable development facilitates the fulfillment of present requirement without compromising the future generation's ability to complete their needs. For sustainable development barahnaja system shows its huge importance because of the use of unique farming patterns which not only maintain the nutritional quality but also protects the environment and therefore provides the health benefits. Such type of cultivation patterns provides the economic advancement with long term environmental stability. Consumption of different combinations of multigrains (Barahanaja) is an access to safe and nutritious food that meets dietary needs and food preferences for disease free healthy life.

It is a form of poly-culture in which planting multiple crops at will allow the crops to work together. It can take the form of double-cropping, in which a second crop is planted after the first has been harvested, or relay cropping, in which the second crop is started amidst the first crop before it has been harvested. It is found in many agricultural traditions. The different crops are such that which can grow in harmony with each other so that they can plant together on the same terraced fields. According to the season combination of cereals, pulses and other creeper legumes, vegetables, and root vegetables are grown. In such cultivation system, different crops to be grown together are so selected that the products and waste materials from one crop stimulates the growth of the other crop. The different crops are supportive of each other and do not compete for light, nutrients and water. The diverse root system hold the soil tightly and much efficiently along with prevention of soil erosion, water loss and maintains the water holding capacity of soil particles with increasing nutrient quality of soil. In these traditional cropping system, Simultaneous cultivation of multiple crops prevents not only the losses by pests but also shows effective for weed control and therefore there is no need of chemical control measures.

The concept of this type of farming was to achieve self-sustainability all-through the year without any commercial interest by enlarge. The crops under this system make their own social society and nevertheless they are very much scientifically fit for the sustainability of agriculture in hills as well as in plains. In future, diversification in crop cultivation will even be more important because of providing variety of crops and

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breeding stock that enable farmers to change the productivity along with balanced environmental and climatic conditions. It also provides more emphasis on conservation of all these diversified local crop plants by the use of their natural genetic resources and their development for food and agriculture and the ecosystem services they provide, which is compulsorily required. The traditional barahnaja cultivation system is a symbol of our well-being and prosperity, and a hope for the future. The ultimate goal of this cultivation system is to provide high and quality productivity at low cost, preservation and maintenance of biodiversity and moreover economic upliftment and prosperity for its population depending on farming.

Benefits of barahnaja cultivation

The crops included in barahnaja cultivation system are inherently in tune with the local ecological and climatic system. The different crops are supportive of each other rather than competitive as the creepers of legumes uses stems of grain plants as a natural support and replenishing nitrogen, while the grain roots grip the soil firmly, preventing soil erosion. This traditional cultivation is still followed in the northern eastern Himalayan region due to its significant impact on agricultural sustainability and human health.

- **To improve productivity and nutrient quality**

Traditional crops included in Barahnaja cultivation system possess all the necessary ingredients for the community's food and nutrition security. It is a key to highly nutritious disease free food and healthy life. Field used for barahnaja cultivation following crop rotation contains a diverse microbiotic environment of soil. This plays significant role to increase not only the fertility and nutrient quality of soil but also the overall quality of plant so that highly nutritious products with higher yield can be produce. Use of such biofertilizers would play significant role to increase the productivity of these crops without the use of chemical or additional fertilizers.

- **For agricultural and environmental sustainability**

Use of chemicals may damage the soil flora and fauna or even microbiotic environment of soil. Barahnaja cultivation system facilitates the production of chemical free, nutrition rich and organic food. Some small plants and fruit plants grown along with crop plants will provide more diversity to the ecosystem. This makes the product organic by default as the fallen leaves and the remaining of previously harvested crop can serve as organic fertilizer. The diverse microbiotic environment of soil is responsible for leaf degradation and increases the fertility of soil therefore no need to add fertilizers further.

- **Provides several health benefits**

Since the traditional barahnaja cultivation system avoids hazardous pesticides, the cultivation of cereals and other crops and their product are safe for all the consumers as well as for environment. From the consumer's perspective, establishment of these crops as a nutraceutical can surpass the usual wait, efforts and cost inputs to bring conventional healthcare to the market and provides "self-care" for their satisfaction. Consumption of different combinations of multigrains is an access to safe and nutritious food that meets dietary needs and food preferences for disease free healthy life.

- **Improved economy of farmers**

As per the requirement of consumers the industries are exploiting the values of these crops for more production of all the nutraceutical products and facilitate more marketing of the products for greater sale and greater benefit. Therefore, initially at small scale following with for a global scale, exploitation of their rich nutritional value assumes importance to provide food security, agricultural development, self-dependence and economic enhancement of the farmers along with the country. As if the value addition to these crops and their products takes place there will be an automatic increase in the price of these products, which will lead to the upliftment of the farmers economically.

Biotechnological interventions to explore the benefits of barahnaja cultivation system

The main research efforts integrating three molecular strategies comprise Molecular marker technology, Functional genomics and proteomics to understand the structural and functional roles of potential candidate genes in conferring the complex agricultural traits such as nutritional quality & biofortification along with disease resistance, nitrogen use efficiency & responsiveness. Targeting of nutritionally important genes and proteins through the emerging biotechnology tools and techniques can lead to creation of 'smart' biofortified crops. Products from these value-added crops can help to cope with several health problems such as protein-energy malnutrition. Research should establish impact of these products on the body's absorption, defense, regulation of homeostasis and nervous systems, and then delve into hypo-allergenic foods and modern approaches to nutraceutical

production. Nano-bio-information technology integrates nanotechnology, biotechnology and information technology holds immense potential to accelerate agricultural and economical growth of farmers and producers by exploring all the important and beneficial factors and information about the barahnaja cultivation system.

Conclusion

Barahnaja cultivation cultivation system is very much beneficial for farmers as well as for the environment because there is no need to invest in seeds, organic fertilizers, and pest control. Moreover, due to the diversity of crops, it also provides for nutritional security along with organic produce as the remaining of pre-harvested crop is being used as organic fertilizer by the next cultivating crop. Integration of molecular biology with biotechnology and omics technology led to the development of biofortified crops and their value added products with greater yield so that the economy of the farmers can be increased. Food and nutrition requirement of large population can be fulfilled by the production of such value added products. Therefore, innovation in barahnaja cultivation system are required not only to give input to the scientific society but needed also for the welfare of local as well as global population, economically as well as nutritionally.

NEWS AND INNOVATIONS IN AGRICULTURE

1. **World's first Nano urea liquid plant:** On 28 May, 2022, Hon'ble Prime Minister, Sri Narendra Modi virtually inaugurated the world's first Nano urea liquid plant by IFFCO near Kalol town of Gandhi Nagar district of Gujarat. Nano urea has higher nutrient use efficiency and aims to reduce soil, water and air pollution. It contains 40,000 mg/l of Nitrogen in a 500 ml bottle which is equivalent to the impact of nitrogen nutrient provided by one bag of conventional urea. **(Source: Times of India)**

2. **India's First soft wheat variety: Pusa Soft Wheat 1 (HD 3443).** Pusa Soft Wheat 1 (HD 3443) has protein content (1.5%), Gluten level (8.9%) and productivity >5 tonnes per hectare. The softest variety of wheat is most commonly used in bakeries. For example, soft varieties of wheat are needed to make many Cakes, Biscuits, etc. prepared in bakery. **(Source: The Hindu)**

3. **Harit Dhara:** The ICAR-National Institute of Animal Nutrition and Physiology, Bengaluru, Karnataka commercialized the "Harit Dhara" Technology to the M/s. Saideep Exports Pvt. Limited on a non-exclusive basis through the Agri-Innovate India here today. Dr. Raghavendra Bhatta, Director, ICAR-NIANP, Bengaluru and Shri M.R. Aravind, C.E.O., M/s. Saideep Exports Pvt. Limited signed the Memorandum of Agreement (MoA) on the behalf of their respective Organizations for the licensing to manufacture and sell the formulation. It is an anti-methanogenic feed supplement prepared by using tanniferous natural phyto-resources. It helps to reduce methane emission from livestock and enhance productivity. The feeding of Harit Dhara leads to an increase of 0.4-0.5 kg milk/day through mitigating the enhance emission & and does not affect the nutrient intake and digestibility. Harit Dhara can be fed to cattle, buffalo and sheep. The harit dhara is a patent applied technology. **(Source: ICAR)**

4. **Thar Vaibhav: A new bunch bearing variety of acid lime:** Thar Vaibhav, developed at Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Godhra, Gujarat. Fruit is juicy (49%), acidic (6.84%) with less number of seed per fruit (6-8). It starts flowering and fruiting during third year of its planting. It gives an average yield of 60.15 kg/plant during the 6th year of planting under the rainfed hot semi-arid conditions in western India. Fruits ripen in 125-135 days in summer while rainy season and winter season crop may take 145-155 days from fruit set with excellent keeping quality at ambient storage. On an average, it bears 3-9 fruits per bunch and such varieties are in great demand by acid lime growers of country. **(Source: Indian Horticulture)**

5. **ICAR-CITH Rootstock multiplication technology for apple orchards Transforms life of nursery entrepreneur- Shri Pawan Kumar Gautam from Saloni, Chamba district (H.P.):** The intervention of this technology not only enhanced the family income by 4 times; but, the dream of transition from conventional to clonal rootstock has also been too fulfilled. Shri Kumar has become an early adopter and brand ambassador of the technology in the region by training and motivating other farmers for adoption of the technology. **(Source: ICAR)**

6. **Thar Karni variety of Ridge guard:** Early in harvesting and takes 51-55 days to first pick from sowing. Fruits 20-25 cm long, weighing 90-110g and cylindrical with 10 shallow longitudinal ridges. Plants bear short internodes and profusely branched. Yield potential is 180-240 q/ ha depending upon sowing season and climatic conditions. It is suitable for cultivation during the spring-summer and Kharif seasons. It is tolerant to the mosaic disease under field conditions. **(Source: CAIH)**

7. **Thar Sheetal variety of Long melon:** Early in harvesting and took 45-50 days in first harvesting from sowing. It produced 25-30 cm long fruits which are light green at tender and edible stage. The fruits are free from bitterness. It is equally suitable for cultivation in spring-summer and kharif seasons under open field conditions also suitable for cultivation under low tunnels for off-season cultivation. Yield potential varied from 150-200 q/ ha depending upon sowing season, prevailing climatic conditions, management practices, harvesting stage, etc. It is able to set fruits at high temperature (upto 42 ^{0}C) during summer season under hot arid conditions. **(Source: CAIH)**

8. **ICAR-IARI develops climate smart drought hardy chickpea variety PUSA JG 16:** ICAR-IARI, New Delhi, in collaboration with its JNKV,

Jabalpur; RVSKV, Gwalior and ICRISAT, Patancheru Hyderabad developed drought hardy and higher yielding chickpea variety Pusa JG 16. Pusa JG 16 will enhance productivity in the drought prone areas of central zone consisting of Madhya Pradesh, Bundelkhand are of U.P., Chhattisgarh, Southern Rajasthan, Maharashtra and Gujarat, where terminal drought is a major problem and sometimes lead to 50-100% loss of yield. The variety was developed by using genomic assisted breeding techniques that allowed precision transfer of drought tolerant genes from ICC 4958 in the parental variety J.G. 16. (Source: ICAR-IARI)

9. **Genetically modified purple tomato approved by US regulators:** The tomatoes have been gene edited to produce 10 times more antioxidants than pre-existing varieties. After more than a decade of development a nutritionally enhanced purple tomato has deemed safe to grow by the United States Department of Agriculture (USDA). The tomatoes have been gene edited to produce 10 times more antioxidant than pre-existing varieties. Back in 2008 a fascinating study was published in the Journal Nature Biotechnology. The research reported on type of tomato that had been gene edited to produce high volumes of antioxidants called anthocyanin. Anthocyanin is naturally found in plenty of foods, such as Blueberries and Red Cabbage. They are responsible for the purple pigment in those foods and have linked to a variety of health benefits, including reduced risk of heart disease diabetes. (Source: Royal Society of Chemistry)

10. **HT trait donor rice genotype technology**: ICAR-Indian Agricultural Research Institute, Pusa, New Delhi has developed non-GM herbicide tolerant rice genotype possessing tolerance to Imazethapyr 10% SL (100g a.i.), using an Ethyl Methane Sulphonate induced herbicide tolerant rice mutant (Robin), developed in the project involving network of institutes coordinated by ICAR-IARI, New Delhi, as donor parent through molecular marker assisted backcross breeding. These non GM herbicide tolerant rice genotypes tolerant to Imazethapyr 10% SL (100g a.i.), are in elite rice background, which will ease the transfer of herbicide tolerance trait into other rice proprietary rice genotypes of interested licensee for the development of non-GM herbicide tolerant rice genotypes tolerant to Imazethapyr. (Source: agriinnovativeindia.in)

11. **Method for Preparation of Green Chilli Powder:** Commercially red chilli powder is available in the market as spices. Many persons suffer from gastric problem upon regular usage. Gastric problem can be reduced after the consumption of green chilli powder. Further red chilli powder does not give any nutrition or health benefits to consumers. ICAR-Indian Institute of Vegetable Research, Varanasi has developed the technology of green chilli powder retains 94-96% chlorophyll, 35-38mg/100g vitamin C and contains 0.64-0.66% capsicin content. Also, the powder has consumer acceptability of 8-10 months at ambient storage. (Source: agriinnovativeindia.in)

12. **Predictor and Planner for Almond (PPA)-A software application:** ICAR-Central Institute of Temperate Horticulture (CITH) has the Predictor and Planner for Almond (PPA) software application. The PPA is first of its kind. It can be used to find out the production efficiency of an area for almond crop and further can suggest the suitability class and aptness of the area for the crop. The suggestions are based on the extent of area to be brought under almond. The application can be used for establishing new orchard as well as established orchards. The another important feature of the application is "Yield Prediction" well in advance that further helps in designing contingency planning for the crop. The application thus can be used to manage and establish almond orchards at suitable locations that will further reduce the chances of its substitution. (Source: agriinnovativeindia.in)

13. **Hot Water Dispersible Aonla-Herbal Tablet. ICAR-CISH:** Earlier sachet-based aonla tea was developed by the institute. However, it was not environmentally friendly as disposal of the sachets was a problem. Hence, the auto dispersible aonla-herbal tablet was developed which sorted the problem of discarding the sachets. Tablet is completely soluble and leaves no un-edible part as residue. The hot water-dispersible aonla-herbal tablet was developed using aonla, herbs, and other ingredients and is rich in anti-oxidant compounds having high pro-health properties. These tablets, when dipped in hot water, disperse very easily without the need for stirring which makes them friendly to use while traveling. (Source: agriinnovativeindia.in).

14. **Mango Wine:** Mango wine, developed by the ICAR-CISH, Lucknow is quite a good product with high market potential. It possesses inherent pleasing flavor of mango fruit coupled with required properties of a good wine. The mango wine with around 10 per cent ethanol is also a rich in carotene and ascorbic acid, the well-known anti-oxidant compounds. It also contains Lupeol, the highly potent anti-cancerous bio-active compound. It also possesses good mental relieving property. As no distillation process is involved during mango wine production technique of the Institute, nutritional properties of the product are better preserved. (Source: agriinnovativeindia.in).

15. **Improved Samba Mahsuri: a high yielding, bacterial blight resistant, fine-grain type, low glycemic index rice variety:** Improved Samba Mahsuri (ISM) is a bacterial blight resistant rice variety, jointly developed and released by ICAR-Indian Institute of Rice Research (ICAR-IIRR), Hyderabad and CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad through the novel tool of molecular marker-assisted selection. ISM is a fine and medium-slender grains variety having excellent cooking and eating quality with yield potential of 5.5-6 t/ha. It is highly resistance against bacterial blight disease, as it possesses three major resistance genes, Xa21, xa13 and xa5 incorporated using molecular marker based technology. Recently, it has also been confirmed to be low glycemic index (50.9) rice. It is one of the first biotechnology derived product in the country and has been registered with Protection of Plant Varieties and Farmer's Rights Authority. (Source: ICAR-IIRR).

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आत्मनिर्भर भारत

Swachh Bharat Abhiyan

स्वच्छ भारत

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