Introductory Issue

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Theme : Improvisation of Agriculture based economy in Bundelkhand








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From Vice Chancellor's Desk.....

It is often said that change is the only constant thing in the world. This maxim is particularly relevant to agricultural science. Throughout the history of human development, Agricultural science has been evolving and generating new knowledge. From prehistoric times, such new knowledge was passed down orally from generation to generation. The remarkable advances in technology bred by rapid developments in scientific knowledge and discoveries have resulted in enormous changes in human life and experience, especially during the past 50 years. Bundelkhand region, is a group of 14 districts spread across Uttar Pradesh and Madhya Pradesh. Though being situated at the heart of India, it is one of the most ignored part of country. One of the greatest problems faced by people is lack of efficient use of resources. Even this region has plenty of well connected rivers like Betwa, Ken with defining boundaries by Yamuna, and Narmada. Even Lalitpur and Jhansi are surrounded by a number of dams. Yet it faces heavy scarcity of water every year. Once abundant with forests and vast agricultural lands, now have very little vegetation, because of lack water conservation schemes. Infertile terrain is also one of the major causes. Only 30% of the crop area in Bundelkhand has any access to life source irrigation that too with ground water as the primary source. The only way to revive Bundelkhand to its glory is by proper agricultural research and extension planning at ground level, increase innovative agricultural research and development and providing water conservation methods on massive scale, which is an agro-ecological approach i.e. minimal soil disturbance, permanent soil cover, and crop rotations, may be boon for sustainable and profitable agricultural systems in Bundelkhand. The adoption of conservation agriculture farming systems has demonstrated tangible advantages in economics, environmental and soil quality aspects over conventional farming systems. Further, adopting innovative research based on low cost agriculture will strengthen the prosperity of the farmers of Bundelkhand. This first issue of 'Agri-life' intends to cover recent progress in different aspects related to the implementation of different approaches for promoting advanced agriculture in a wide range of cropping systems across different agro-ecological conditions that are so much variable. The articles in the introductory issue of 'Agri-Life' are quite informative and fit well scope of "Improvisation of Agriculture based economy in Bundelkhand" and going to help all the stakeholders.

It is my hope and expectation that this magazine under Prof. Anil Kumar and other members of editorial board will provide an effective learning experience and referenced resource to boost agricultural and allied sectors of growth in years to come that will in turn help people of the region to achieve prosperity.

(Arvind Kumar)
Vice Chancellor

Editorial

Improvisation of Agriculture based Economy in Bundelkhand

Agriculture contributed to incredible advances that have shaped contemporary society, such as the invention of the scientific method, specialization in trades and cultural activities, the formation of cities and the establishment of governments. Agriculture is the one of most important sector in Indian national economy with 17% contribution to the total gross domestic product (GDP) with involvement of 50% labour force. In order to achieve this national target of "Doubling Farmer's Income by 2022", we need to search, evaluate and validate the new avenues along with our traditionally followed avenues for their capacity to contributing to farmer wealth. Out of total income, the income from cultivation is highest (46%) followed by income from wages (32%). This situation signifies the need and scope for the promotion of other enterprises such as poultry, cattle rearing, sericulture, honey bee rearing, etc. to reduce the dominance of cultivation in farmer's income and ultimately dependence on vagaries of monsoon and weather in the era of climate change.

The development of agriculture has had profound effects on human behavior. Thus, there is intimate relationship of agriculture with life and Agri-Life has profound impact on the national growth. However, in the process of development of agriculture, we forgot to conserve and manage our natural resources such as soil, water and air and beneficial insects in holistic manner. We can enhance or reduce survival of the human species by the way we manage our soil, water and air but we do not understand such intricacy of agriculture and life. Roman Empire failed primarily because agricultural land became degraded and washed or blew away.

In order to have better appreciation, there is need to reform Agri-Life through generation of quality human resources by inculcating the sensitivity towards society which includes farmers, laborers and other stakeholders majorly dependent on agriculture and allied sector. To promote such unconventional thinking and innovative ideas amongst our stakeholders viz. students, faculty, non-teaching staff even farmers, there is need to apply the knowledge acquired over the years by all stakeholders for the welfare of society. Every stakeholder should strive to work on the principle of "Sarva-Sulabh Samriddhi Krishi" through providing their enough time, help & cooperation and novel ideas & thoughts for the development of innovative potential technologies in the various sectors of Agri-Food-Nutrition and health for the welfare of farmers, consumers and processor. Further to fulfill the national food demand and augmenting the socio-economic conditions of farmers, there is a urgent need to diversification of agriculture in order to achieve the goal of doubling the income of the farmers. In Bundelkhand region, steps should be taken to promote secondary and tertiary agriculture besides relying on primary agriculture. In these endeavors, deployment of modern tools and technologies play pivotal role in revitalizing the rain fed agriculture of the country. Application of science with human touch should be basic motto of agricultural education and thus to understand intricate relationship of agriculture and life as well as other factors affecting the agricultural productivity and quality of human life in more holistic ways. The theme of introductory issue of **"Agri-Life"** lies in **"Improvisation of Agriculture based Economy in the Bundelkhand"**. I am quite confident that the small initiative through Directorate of Education will be milestone in our endeavors to improve the socio-economic conditions of this backward region of the country.

Though our university is infancy stage of development but its gives me immense pleasure to provide you the first introductory issue of Agri-Life in your valuable hands so that your valuable inputs and suggestions will further improve the quality of this student's, scientist's, processor's and farmer's friendly magazine for the promotion of agricultural education.

(Anil Kumar)
Editor-in-Chief

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Challenges and opportunities for agricultural research and development in Bundelkhand region

A.R. Sharma

Bundelkhand is comprised of seven districts each in the state of Uttar Pradesh and Madhya Pradesh in the central part of India. These districts include Chitrakut, Banda, Jhansi, Jalaun, Hamirpur, Mahoba and Lalitpur in Uttar Pradesh; and Chhatarpur, Tikamgarh, Damoh, Sagar, Datia, Panna and Niwari in Madhya Pradesh. This region has an area of 7,53,700 km^2 with a population of 18.3 million, 78% of whom live in rural areas. The region is characterized by erratic and deficient rainfall, perennial droughts and harsh climate in summer, undulating topography and rocky terrain, traditional methods of crop husbandry and poor livelihood security. This region is regarded amongst the more backward regions, and in some sectors, it has the lowest indicators in the country. It is frequently in the news for ills like lack of food and water causing malnutrition and even starvation deaths, migration of people, over-exploitation of natural resources, social unrest and natural calamities. Despite being rich in mineral resources and vegetation, the region is inflicted by vagaries of nature and anthropogenic factors, and demonstrates low human development achievement, with limited access to good quality health services, education and employment opportunities. Development efforts in the past have been challenged by multiple factors like periodic drought, fragmented land holdings, feudal mind-sets, decline in water available for irrigation, low investment and low technological inputs in agricultural and industrial development.

Current status of agriculture

Agriculture in the Bundelkhand region is primarily dependent on rainfall as 60% of the cultivated land is rainfed experiencing deficit moisture in most parts of the year. Soils are generally light-textured, shallow, gravelly, saline or sodic, and deficient in organic matter and essential plant nutrients in most areas. Weather conditions are quite harsh especially during summer resulting in no agricultural activity for 3-4 months. Crop production is largely traditional, with age-old methods of cultivation, low spread of high-yielding varieties, food processing and other necessary infrastructure for value addition. Large tracts of land are barren or covered with sparse vegetation which are regularly cut for firewood by the local people and continuously grazed by animals. This region is not much known for horticultural and forest produce despite having considerable potential on the waste non-arable lands. Livestock population is quite large but mostly local and low yielding. Fishery is virtually non-existent due to lack of awareness and suitable technologies.

Most of the people depend on agriculture that operates with small landholdings, with a fixed crop mix of wheat, rice, pulses and some oilseeds. The irrigated area is 40% of the cropped land, crop productivity is low (below the averages in UP and MP), and much lower than the average productivity of the leading states, mechanization in agriculture is low, land holdings are small (average of two acres or so), inequality exists in land holdings, and strong feudal land relations keep a stranglehold on farm labour.

All these factors put together contribute to the low output in agriculture. Even with increase in productivity of some

crops in recent times, it has not been sufficient, given the increase in input costs, to make agriculture profitable. The per person productivity and per hectare output of agriculture are both extremely low, and it appears that both poverty and stagnation in agriculture cannot be escaped unless productivity and profitability increase substantially.

Many people are leaving cultivation for labour. Small farms are unsustainable, and as a consequence, more and more people turn to casual labour, to

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leasing land to sustain themselves, and their livelihoods have become peripatetic and precarious. The recent years of drought, with an ineffective drought mitigation system, with increasing debt burden have contributed to large-scale migration, which even though declining in recent years, has had an impact on the region. Families across the region have developed their own survival and growth strategies, which have involved mixed livelihood options, migration and dependency on local feudatories.

Livestock management is mainly a supplementary activity to agriculture, and except for some cases in goat rearing (in which traditional goat rearing families are involved), usually a few animals are kept for self-consumption or small sales to organized and unorganized markets. There are some areas where livestock management is flourishing, such as goat rearing in the uplands, fisheries in Tikamgarh and poultry in and around Jhansi.

Agricultural research and education setup

Bundelkhand has made limited progress in the establishments of agricultural research and education network, and thus lagged behind compared with other regions of the country. Currently, there is one state agricultural university, one central agricultural university, two central research institutes the ICAR, three general universities with agricultural faculty, one private university with agriculture faculty, 13 Krishi Vigyan Kendras, besides a host of other departments under the state government involved in the development and promotion of agriculture, animal husbandry, horticulture, forestry, fisheries and allied sectors.

Agriculturaluniversities:

1. Banda University of Agricultural Science and Technology, Banda
2. Rani Lakshmi Bai Central Agricultural University, Jhansi

General Universities with agricultural faculty

1. Bundelkhand University, Jhansi
2. Mahatama Gandhi Chitrakoot Gramodyog University, Chitrakoot
3. Dr. Hari Shankar Gaur University, Sagar

ICAR Institutes

1. Indian Grassland and Fodder Research Institute, Jhansi
2. Central Agroforestry Research Institute, Jhansi

Krishi Vigyan Kendras

Uttar Pradesh:

1. Village Kumarsin, Banda
2. Govt. College Farm, Kurara, Hamirpur
3. Govt. Agriculture Farm, Rura Mallu, Jalaun
4. Govt. Agriculture Farm, Khiria Misra, Lalitpur
5. Zonal Agricultural Research Station, Belatal, Jaitpur, Mahoba
6. Village Pahari, Ganiuwan, Chitrakoot
7. Village Bharari, PO Bhojla, Jhansi

Madhya Pradesh:

1. Village Hamirpur, Datia
2. Nowgaoin Paan Research Centre, Chhattarpur
3. Zonal Agricultural Research Station, Bamhori, P.O. Rajaua, Sagar
4. Jaisawal Qrts., Damoh
5. Village Laxmipur, Panna
6. Kundeswar, Tikamgarh

Emerging challenges

As per the Human Development Report by the Planning Commission (2012), there are four major challenges facing the Bundelkhand region: (i) environmental leading to water stress, loss of green cover, soil degradation, and disturbing natural resource based livelihoods; (ii) unequal social and economic order in a strongly feudal society, where the elite (mostly upper castes and the landed), exercise undue influence, suppressing wages, exerting control over the local administration and not permitting any change in the social and political order; (iii) administration that is not particularly different from that in the parent states, but the bureaucracy and at times even the political executive, considers this region as being on the periphery, and (iv) impression of a poor law and order situation, which has hampered investment in the region, and encouraged feudal patronage, feeding into the unequal social and economic asset base.

With increasing population of human beings as well as of the livestock, there is a great stress on natural resources leading to the excessive exploitation and indiscriminate exploitation and degradation. Land holdings are small which are further getting smaller due to division and disintegration and becoming unviable for livelihood security. Stray cattle menace is a serious issue affecting agriculture and also city life in the recent times. Large folks of rural people do not have access to quality education, health and sanitation, communication. Above all the adverse effects of changing climate are being experienced in the region as the frequency and severity of droughts due to erratic and deficient rainfall have increased over the years. It has also been experienced that weather in summer months is becoming harsher compounded further by deforestation.

Bundelkhand region, with its dependence on livestock and agriculture, is extremely vulnerable to climate change impacts such as warmer temperatures, lower precipitation and greater weather variability. These climatic uncertainties lead to more frequent spells of extended droughts, which in turn drastically affect agricultural yields. Some cases of climate change affecting people are mentioned below:

- The frequency of days of rain has changed from an average of 52 days of precipitation to an average of 24 days in the last eight years. Rains often get delayed which disturb sowing, and intermittent rains lead to inadequate irrigation at the required times and heavy rains in smaller periods lead to higher runoffs.
- Changes in temperature extremes have taken place. Heat periods have changed, disturbing paan cultivation, and cold temperatures have affected vegetable cultivation in the late winter.
- With unpredictable rains, fodder for animals has become deficient. Fodder prices in drought years and even in normal years are very high.

The challenges in agricultural sector are:

- Maintaining and enhancing productivity in agriculture, given the undulating topography, especially in rainfed farms and under recurring droughts
- Evidence of increased cost of agricultural inputs compared to agricultural incomes, primarily rise in cost of fertilizers and seeds, energy for agriculture and rising agriculture wage rates
- Untimely and inadequate availability of seeds, fertilizers and pesticides
- Land disputes
- Debt burden on farmers
- Unproductive indigenous livestock, with poor livestock services, small scale livestock production
- Little scope of agro-processing activities
- Subsistence and risky monocropping, and not utilizing the full potential of rabi crop, leaving large lands fallow
- Rising rural population pressure leading to fragmentation of land holding
- Low crop productivity in most cases, much below national and below state averages.

Opportunities

Bundelkhand is considered as one of the unexplored region for its rich biodiversity and other natural resources. Advances made in science and technology have not yet made a greater impact at the ground level in rural areas. Although total annual rainfall of about 800-1000 mm in most parts of the region is adequate for meeting year-round requirement of water if the rainwater is managed properly in situ and in water harvesting ponds. Large variations in sol type and physiographic land situation provide opportunities for diverse land uses including growing of different types of field crops, horticultural and forestry besides livestock and other subsidiary enterprises. Water so harvested in ponds and reservoirs can be utilized for meeting shortages during lea period and also for fisheries production. There is need for holistic development and managed of these resources for improving productivity, environmental sustainability and livelihood security.

Despite various adversities, the Bundelkhand region holds opportunities and possibility for steady growth through modernization of agriculture reinforced by better water management system and

technology; and above all, sustained through strong financial and institutional setups.

RLBCAU: An Institution of National Importance

Considering the backwardness and agrarian economy of the region, the Government of India decided to promote development of agriculture and allied sectors in a holistic manner. Thus, Rani Lakshmi Bai Central Agricultural University (RLBCAU) was established as an Institution of National Importance through an Act of Parliament published in 2014. The University named after the great warrior, Rani Lakshmi Bai who led the first war of independence in 1857, is a multi-faculty and multi-locational university, with headquarters at Jhansi, Uttar Pradesh. The Jhansi campus is located on the Jhansi-Gwalior highway, about 10 km from the city. Two colleges, viz. College of Agriculture, and College of Horticulture and Forestry are established for teaching and research in the related disciplines. This campus has 300 acre farm along the Pahuj Dam-Bharari canal, and surrounded by ICAR-CAFRI and ICAR-IGFRI on either side. The second campus of the University is under establishment on 200 acre farm along the Datia-Shivpuri highway, about 15 km from Datia city. Two colleges, viz. College of Fisheries, and College of Animal and Veterinary Sciences are proposed to be established at the Datia campus.

Research priorities

Besides human resource development through teaching at the undergraduate and postgraduate levels, training and capacity development of various stakeholders, the university is mandated to undertake research in agricultural sciences including horticulture, forestry, animal husbandry and fisheries. The main campus at Jhansi for agricultural, horticultural and forestry sciences has already been established and started the research activities, while the animal husbandry and fisheries are yet to be developed at the Datia campus of the University. The major research priorities are as follows:

Agricultural sciences

- Rainwater management *in situ* and *ex situ*, and development of cost-effective water-saving technologies for improving productivity of crops and cropping systems
- Integrated farming systems involving combination of farm enterprises and non-farm activities for improving livelihood security
- Resource conservation techniques aimed at improving efficiency of soil, water, energy, nutrients and other agro-chemicals
- Development of varieties / hybrids tolerant to biotic and abiotic stresses and quality produce
- Soil health improvement through integrated nutrient management, organic farming, natural farming and holistic land development
- Establishment of seed hubs with focus on low water requiring crops like pulses, oilseeds and millets, and ensuring quality seeds to the farmers.

Horticultural sciences

- Identification of promising fruit, vegetable and flower crops and their varieties / hybrids for higher productivity and quality
- Development of low-cost innovative production technologies of horticultural crops
- Development of agri-horticultural systems and models
- Post-harvest processing and value addition of horticultural produce.

Forestry sciences

- Identification of superior quality tree species for the relatively degraded lands
- Development of agroforestry and agri-silvicultural systems for effective utilization of degraded lands
- Techniques for raising quality planting material and establishment on rocky terrains
- Exploring the potential of medicinal and aromatic pants, and their processing and value addition.

Way forward

Modernization in agriculture with water management, micro-farm solutions and moving to high-value crops are the future of agriculture in the Bundelkhand region. Breaking the stranglehold of cereals and high-input agriculture and moving to high technology agriculture is the way forward.

Agriculture promotion should be through technology promoting agencies, farmer owned agencies, farmer-industry linked production and promotional tie-ups and special focussed promotion to meet the new emerging demand like that for organic crops and vegetables, and gluten-free cereal production. In addition, the growing demand for horticulture and other specific high-value crops need to be promoted. In this context, micro-planning on farm basis for profitable cropping choices supported by water management technology will be very beneficial. Bundelkhand's terrain, temperature and rainfall afford distinct advantages to certain types of fruits, vegetables and other vegetation, which can profit from scientifically managed technical interventions. These are aonla, ber, custard apple, lemon, pomegranate, etc. There is considerable wasteland in Bundelkhand which can be put to productive use by using new scientific production methods such as greenhouses and water management technologies, to produce high-value vegetables and flowers, to meet the growing demand in the cities. Agroforestry, horticulture, animal husbandry, rearing small ruminants (goat and sheep), cultivation of improved varieties of pulses, oilseeds and cereals could be important components of the farming system.

Water is critical to the development of agriculture. Hence, rejuvenation of the tanks that have fallen into disrepair and of their catchment regions is essential. Curtailing encroachment and destruction of the catchment area will need strong political will and administrative action.

Livestock management and development of fisheries is another area with considerable potential. Units in irrigated regions can be assisted with entrepreneurial level dairy units. Similarly, fisheries offer much greater opportunities than have been utilized so far.

Credit related promotion in agriculture, including in agriculture processing and small manufacturing is yet to take off in Bundelkhand. Credit services need to expand their reach, reaching every household, and servicing it in its time of need. Similarly, weather-based insurance needs to become a reality, and bankers need to look at small manufacturing units catering to the local needs as bankable.

Promotion of secondary and tertiary agriculture in Bundelkhand region

Dr. Anil Kumar

Agriculture is the important sector of India as the country is an agro-based economy. It utilizes the natural resources and produces raw materials and basic goods which may be used by the industries or by the end-users. The industrial sector is involved in manufacturing finished goods and tangible products and their distribution and sale of goods from producer to a consumer. In order to combat the problems related to food, nutritional and health security, there is need of science led innovations based on "Searching and Creating Values" in natural gene pools of crops for agri-food nutrition and health. The article tries to address the issues related to agricultural production, agri-processing and value addition through deploying tools and technologies of nanotechnology, biotechnology and bioinformatics i.e., Nano-Bio-Information technology. Recognising the importance of the agri-food-nutrition sectors in boosting the Indian economy through the linking of modern scientific technologies with large scale processed food manufacturing and food chain facilities. It will consequently generates employment and export earnings.

Bundelkhand provides one of the widest stretches of 14 districts of Uttar Pradesh and Madhya Pradesh which are generally included among the most backward districts of India. In all districts over 70 per cent of the people live in rural areas, the percentage going over 80 per cent in a few districts. The soil texture varies from rocky, gravely, sandy, sandy loam to clay loam and having gentle to steep (0.5 to 10 %) slope with low to medium organic carbon content and very low to high water holding capacity. Farming situations and cropping patterns vary as per soil type, water, vegetation and livestock availability. The main sources of irrigation water are reservoirs, canals and tube wells which are totally dependent on rainfall. Droughts and long dry spells occur during rainy season is the common feature in the district which directly affect the kharif and rabi production. Unfortunately the region of Bundelkhand has faced 17 droughts and one flood in just the last decade. The sufferings of the weaker section in many parts of the region appear to be increasing due partly to the deteriorating environmental conditions. Life for most people of all sections appears to have more tensions and stress in this region.

There is a need to identify the gaps and challenges associated with Indian agriculture especially in Bundelkhand regions addressing such challenges, efforts should be made through deploying modern scientific tools and technologies. This will supplement the quality of life, income generation and the economic growth of Bundelkhand region. Recently, the central government has announced the establishment of defence industrial corridor and also agri-processing cluster projects, in order to benefit the politically significant Bundelkhand region. Black gram, green gram, groundnut, sesame, pigeon pea, sorghum and paddy are major crops grown in kharif season while wheat, barley, chickpea, field pea, vegetable pea, lentil, mustard and linseed are grown during rabi season. The small & marginal farmers grow vegetables and spices mainly potato, brinjal, chilli, tomato, zinger, turmeric, garlic, onion and main fruits guava, aonla, ber, lemon, papaya etc.

In order to meet the challenging demand of food and to combat the problem of malnutrition and to address the complexity of food and nutritional security by the agricultural scientists, are the foremost and paramount important in the present century. Faced with the current economic realities, farmers worldwide are searching for new options of surviving, as well as expanding their agricultural productivity. One of the many opportunities to grow markets, turnover and profits is by adding value to farm produce through further processing.

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Challenges for Sustainable Agriculture

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. Roughly two billion people suffer from a shortage of vitamins and minerals. Another 1.4 billion are overweight or even obese as a result of unhealthy diet – not only in rich countries, but increasingly also in developing countries and emerging economies. Roughly half of the world's population does not receive an adequate diet. It is therefore not only a matter of increasing agricultural production, but of providing a balanced, healthy and sustainable diet for everyone. Some of the major issues associated are a) abundant food & nutritional insecurity, b)Increased demand for food, c) Unsustainable use of natural production factors such as soil, biological diversity and water d) degradation of approx. 60 % of ecosystem services, e) dependence of intensive agriculture on high energy but could be energy self-reliant, f) lack of preparedness for practicing agriculture to cope with unpredictability and adaptation to climate change, and g) more than 50% pre and post-harvest losses of crops besides > 50% food processing losses.

Value added products-oriented Agriculture

Value addition is the process of changing or transforming a product from its original state to a more valuable state. It involves taking any product from one level to the next. Value addition activities in the rural areas tend to increase local employment and income and usually have a positive impact on the local economy mainly due to forward and backward linkages. The country must have a market-oriented agriculture because there are more revenue opportunities for agricultural products once they have value addition. We produce a lot of goods but mostly primary products that aren't processed and value added. If they go that level, the chances for them to export their products will be a lot better.

Agri-processing Technologies

Agri-processing has gained importance in the past few decades. Increases in crop production have not been coordinated by technical improvements in post-production practices. Recent agricultural practices and the development of higher-yielding varieties have led to significant yield gains but the lack of post-harvest processing and storage facilities have resulted in greater post-production losses. Thus, in order to curb this huge economic loss, Agri-processing provides a sustainable means by transforming agriculture, forestry and fisheries subset into value added products.

Agro processing could be defined as set of techno-economic activities carried out for conservation and handling of agricultural produce and to make it usable as food, feed, fibre, fuel or industrial raw material. Hence, the scope of the agro-processing industry encompasses all operations from the stage of harvest till the material reaches the end users in the desired form, packaging, quantity, quality and price.

The Standard Industrial Classification categorizes the agri-processing activities under two divisions: upstream and downstream activities. Upstream agri-processing activities are engaged in the initial processing of agricultural commodities such as flour milling, leather tanning, cotton ginning, oil pressing, fish canning and saw milling. Downstream agri-processing activities undertake further manufacturing and processing of intermediate products made from agricultural materials such as bread, biscuit and noodles making, textile spinning and weaving, paper production, clothing, leather and leather-aided products.

Government of India is now promoting value addition and consumption through various programs. Ready to cook product market is growing and there is demand for health foods and most people would like to consume whole grain products for their health benefits.

Promotion of secondary and tertiary agriculture:

Sustainable consumption and production aims at "doing more and better with less," increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life. It involves different stakeholders, including business, consumers, policy makers, researchers, scientists,

retailers, media, and development cooperation agencies, among others. It also requires a systemic approach and cooperation among actors operating in the supply chain, from producer to final consumer. It involves engaging consumers through awareness-raising and education on sustainable consumption and lifestyles, providing consumers with adequate information through standards and labels and engaging in sustainable public procurement, among others. Further, the production and employment shift is moving from primary to secondary to tertiary agriculture and thus providing economically more dividend to farmers, consumers and processors (Fig. 1).

a) Primary Agriculture: Relies on agricultural productivity of different commodities
b) Secondary Agriculture: Relies on conversion of Agri-resources into value added products mainly food products.
c) Tertiary Agriculture: Relies on isolation of novel molecules, genes, proteins and metabolites for enhancing the quality of life.

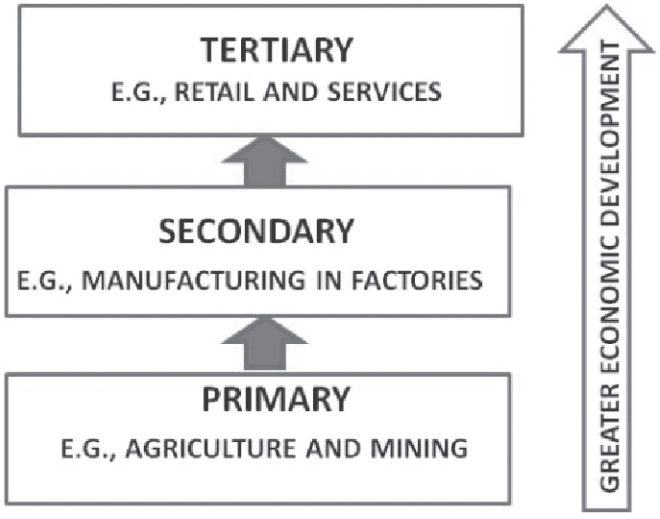


Fig 1: Production and employment shift from primary to secondary to tertiary makes economically more developed

Intervention of modern technologies

Bundelkhand region unequivocally need the help of such technologies to fulfill the vision for economic upliftment and prosperity for its population depending on farming. Nano-bio-information technology, which integrates three important technologies viz. nanotechnology, biotechnology and information technology, holds immense potential to accelerate agricultural and economical growth of this region. Furthermore, it is being felt that such interventions in agriculture and industrial sector would ensure production of value added products through harnessing natural flora and fauna of that region. This would further supplement the quality of life, income generation and hence the economic growth of these states. Strong R & D as well as education in these three areas needs high quality human resources for invention and creation of value added products. This has necessitated the requirement of highly skilled work force equipped with nanotechnology, biotechnology as well as information technology skills to analyze, annotate and make use of products through intervention of modern sciences. Effective implementation of nano-bio-information technology requires inputs from different but interlinked disciplines along with re-exploring the chemical & biological principles at nano-scale and using simulations tools at *in silico* level.

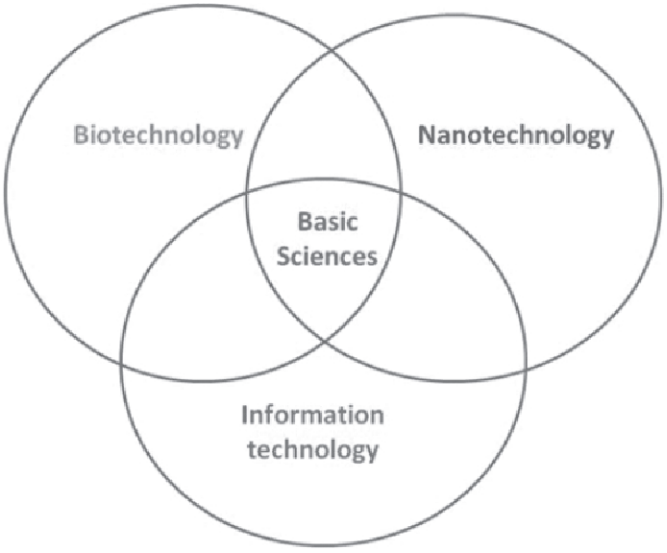


Fig 2: Amalgamation of nanotechnology, biotechnology and computational technology

The amalgamation of nanotechnology, biotechnology and computational technology i.e., Nano-bio-information technology (Fig:2) will provide research based solutions for augmenting crop productivity through nano-delivery systems and through plant architectural engineering and its management for efficient utilization of nutrients, air, water and sunlight to optimize production.

Agronomic biofortification: Nano-enrichment and nano-delivery of nutrients for nutritional security

Agronomic biofortification of food crops is a strategy, along with breeding/genetic engineering, for increasing micronutrient concentrations to reduce dietary deficiencies. Micronutrient deficiency retards the growth and development of both crops and humans. Soil micronutrient deficiencies limit crop productivity and nutritional quality of foods, which together affect nutrition and human health. Diets in Asian countries (especially among resource poor households) are often low in diversity and dominated by staple crops such as maize, rice, cassava, sorghum, millet, banana and sweet potato. Such diets are poor in micronutrients (minerals and vitamins) and consequently micronutrient deficiencies are widespread. Researchers focused on an interdisciplinary approach of converging nanoscience and engineering into agriculture sector has resulted into shift of emphasis on adopting nanotechnology in agriculture termed as agro-nanotechnology. Recently, investigators in the food and nutrition sciences have been applying the tools of nanotechnology in their research. The emerging application of nanotechnology to the food and nutrition sciences, suggest ways for further integration of these emerging technologies into nutrition research. Priming of seed with bioactive micronutrient nanoparticles as modern farming practice has proved its immense potential towards engineering seed micronutrient to optimum range.

Using inter-disciplinary approach, we have developed following process and products:

- Seeds were treated with nanoscale (nano Zn and nano Fe) could be used in pre-boosting seeds micronutrient which is required for maximizing yield potential by developing roots and shoots specifically designed to absorb more micronutrient ultimately increasing the bioavailability of Fe/Zn in full grown plants. Positive effect on the shoot and root growth of seedlings of cereals (finger millet and wheat) has been observed when treated with nano-ZnO, nano-FeO and nano-ZnFe-oxide nanoparticles.
- Green synthesis of Nano-formulation enriched with iron & other minerals having good scope for commercial production of syrup, soup, concentrate for anaemic patients and mineral supplements of plant origin having good bio-availability (Patent filed).
- Value added turmeric having nano-curcumin preparation for better bio-availability and could be used for medicinal properties for various inflammatory disorders and general health.
- Development of prolamin proteins based nano-delivery vesicles for delivery of hydrophobic (carotene-Vit A, Vit D, Vit E & others) molecules and preparation of biofortified milk and juices. The fortified milk can not only overcome vitamin deficiency in human population but also open new market for value added product from agricultural crops.

Priming of seed with bioactive micronutrient nanoparticles as modern farming practice has proved its immense potential towards engineering seed micronutrient to optimum range. This modern smart farming strategy has the potential to eliminate any seed based issue or critical micronutrient required for seed embryo sensing and seed metabolism which is required in the early stages of germination. This interdisciplinary approach of engineering seed at nanoscale could be used in pre-boosting seeds micronutrient which is required for maximizing yield potential by developing roots and shoots specifically designed to absorb more micronutrient ultimately increasing the bioavailability of iron in full grown plants.

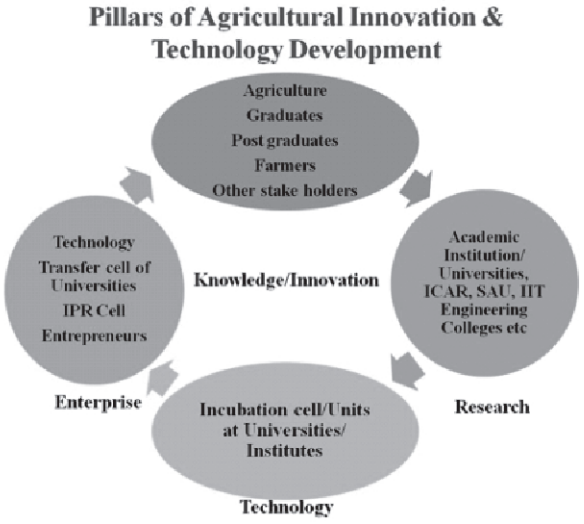
Innovation-Enterprise Development

The growing demand for healthier food, effectiveness and quality of consumed product, increased public and healthcare industry awareness are the major factors that have contributed towards the formation of a nutraceutical market that is envisioned to grow many folds in coming years. The Food and Drug Administration has also released regulations that support this emerging industry therefore fostering scientific research. Hence, an immediate goal should be identification of health benefitting factors to enhance the essential nutrient levels in staple crops to significantly impact human

nutrition worldwide. 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 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 from the consumer's perspective, establishment of nutri-dense crops as a nutraceutical can surpass the usual wait, efforts and cost inputs to bring conventional healthcare to the market and provide "self-care" for their satisfaction. Additionally, for a global scale, exploitation of their rich nutritional value assumes importance to provide food security, agricultural development, self-dependence and economic enhancement of developing countries. The innovations based on these frontier sciences and technologies hold immense potential for harnessing the rich biodiversity of Bundelkhand for solving the problems of region through strengthening crop and food bio-fortification programmes. It will further strengthen our efforts towards development of Enterprises/Start-Ups which generates enormous employment opportunities.

Institutional innovation and agriculture as enterprise:

The context for agriculture is changing rapidly and the process of knowledge generation and use has been transformed as well. In the changed context of agricultural development, the innovation approach has also changed. The agricultural innovation and enterprise development marks a sharp shift from earlier thinking on innovation as linear process of R&D leading to technical and economic change. It extends beyond the creation of knowledge to encompass the factors affecting demand for and use of new and existing knowledge in novel and useful ways. Thus, it is viewed in a social and economic sense and not purely as a discovery and invention. The agriculture innovation enterprise is attractive not only because it offers a holistic explanation of how knowledge is produced, diffused, and used but also because it emphasizes the components and processes that have become increasingly important in agricultural development.



Challenges faced by government research institutions and universities in the commercialization of agricultural innovation

Conclusion

There is a wide range of existing and emerging problems related to food security that can be tackled by crop biotechnologies in combination with other technologies. Nano-Bio-Information technology has tremendous potential for increasing food production and improving food processing. The knowledge gained from basic plant research will underpin future crop improvements but effective and robust mechanisms for the rapid and effective translation of research discoveries into public good agriculture remain to be developed. Maximum benefit will be derived if robust plant breeding and crop management programmes have ready access to all the modern crop biotechnologies, both transgenic and non-transgenic, to address food security issues. These science led innovations will be based on "Searching and Creating Values" in natural gene pools of crops for agri-food nutrition and health. Exposing traditional Indian agriculture to modern technologies, creating large scale processed food manufacturing and food chain facilities and consequently generates employment and export earnings.

Drought tolerant agri-horti-forestry crop varieties for climate resilient agriculture in Bundelkhand

K. Rajarajan, A.K. Handa and Lal Chand

The intensity of drought has been increased in India due to El Nino. Especially, in semi-aridregions insufficient precipitation and higher evapo-transpiration further leads to intensive waterscarcity. Bundelkhand region is well known example for semi-arid region, where the people arehighly engaged on agriculture and allied activities. However, this area is highly vulnerable todrought stress which in turn affects agriculture, horticulture and minor forests at varying levels.Drought impact on agriculture and allied activities includes; decline in cultivated area, fall inemployment in agricultural sector, fall in purchasing power, scarcity of drinking water, food-grains and fodder, rise in inflation rate, low intake of food and widespread malnutrition,migration of people from drought hit areas to other areas in search of livelihood and food. Hence,in this region it's considered that a cheap and durable form of drought mitigation strategy isparamount important. In this perspective, durable form of drought mitigation strategy as adoptingdrought resistant crops, drought tolerant varieties, planting rainfed varieties, short durationvarieties and late sown varieties are the best options for sustainable agriculture and helps inimproving farm income.

In India the rainfall events reveal that severe drought have been accompanied by El Nino. Insufficient precipitation, high evapo-transpiration and over-exploitation of water resources and/or combination of these parameters lead to severe water scarcity. Bundelkhand region, situated in North – Central India is a notable example for one of the semi-arid region in India. In this region native vegetation is represented by a variety of species, such as grasses and grass like plants, shrubs and trees. Many people in Bundelkhand region are engaged in agriculture as cultivators, or laborers, showing a higher reliance on agricultural land compared to other parts of rural India. However, these areas are vulnerable to climate change which in turn will have great impacts on geographic diversity, agriculture, forestry and socio-economic impact on livelihoods due to spatial and temporal variability of rainfall. This semi-arid region, drought impacts on beginning of crop growing season and crop establishment conversely result in reduced productivity or complete crop failure. In this background, this paper mainly to focus on a durable strategy for sustainable agriculture in drought prone Bundelkhand region through improved varieties of drought tolerant crops for improvement of farmer's economy.

Impact on agriculture and allied activities

Indian agriculture is monsoon dependent around two –third land area is rainfed. Climate variability has been, and continues to be, the principal source of fluctuations in food production, particularly in this semi-arid region. The major impact of drought in this region leads to economic loss, hunger, famine and dislocation. In general crop stages like anthesis and grain filling stages appear to be the most vulnerable one and occurrence of drought at these stages may result in reduced yield and/or complete crop failure. Besides agriculture many people in this region were primarily depended on minor forest produces for their livelihood. But, according to government of Uttarakhand drought stress has affected these minor forests at varying levels. Drought impact on agriculture and allied activities includes; decline in cultivated area and fall in agricultural production (including crops and milk), fall in employment in agricultural sector, fall in purchasing power, scarcity of drinking water, food-grains and fodder, rise in inflation rate, low intake of food and widespread malnutrition, migration of people from drought hit areas to other areas in search of livelihood and food. Impact on Environment and ecology as frequent

ICAR-Central Agroforestry Research Institute, Jhansi

Table 1. Moisture stress sensitive stages of some important crops

Crop	Sensitive Stages
Rice	Panicle initiation, flag leaf and milky
Sorghum	Booting and flowering
Maize	Silking and tasseling
Pearlmillet	Booting and flowering
Fingermillet	Flowering
Groundnut	Peg penetration and pod development
Sunflower	Head formation and early grain filling
Sesame	Flowering
Soybean	Flowering and pod filling
Blackgram and Greengram	Flowering and early pod development
Cotton	Square formation and boll formation and development
Sugarcane	Cane formation (Upto 120 days after sowing)
Banana	All stages especially shooting stage
Tomato	Flowering and fruit development
Onion	Blub formation and development
Flower crops	Bud formation and development
Ornamental	Flowering

Source: TNAU Agriportal

droughts tend to result in depletion and degradation of natural resources, which in turn tend to affect life and livelihood of many people in these regions. Ultimately, severe drought effects on these regions contribute to ecosystem instability due to deforestation, resource exploitation, and low water recharge and so on.

Adopting suitable variety; a potential drought management strategy

In modern agricultural production, producers in developed countries are able to alleviate moisture stress by providing supplemental irrigation and installing drainage systems for better production. However, India like developing countries these facilities are not amenable to manage drought stress. But, cheap and durable strategy is to breed cultivars that are able to resist these environmental stresses enough to produce acceptable crop yield. It is therefore genetic management strategies for drought stress focus on maximum extraction of available soil moisture and its efficient use in crop establishment and growth to maximize biomass and yield. Hence, enhancing the genetic tolerance of crops to drought stress is considered an essential strategy for addressing water deficits and is a critical element of effective drought risk management programs, especially in developing countries. Many of the varieties grown in rainfed ecosystems were originally developed for irrigated ecosystems, without screening for drought tolerance. Although high-yielding, these varieties generally produce poor crops or even fail to produce when exposed to drought. In this circumstance farmers may go for varieties which combining improved drought resistance with high yield may increase the farm income by stabilizing the crop production under these environmental extremities.

Rejuvenation of crop production through drought resistant/tolerant varieties

The Bundelkhand region is ecologically vulnerable to the vagaries of climate variability such as drought stress. These extreme events play havoc with agriculture and livelihoods of farmers. In this region farmer's predominantly practice cultivation

of chick peas, wheat, sorghum, paddy, maize, barley, lentil, sesame, mustard, groundnut, soybean, peas, urad, moong, vegetables and fruits are the most important crops cultivated. In this region short duration and drought tolerant varieties fit well into contingency plans for all types of farming situations. Generally, yield with short duration varieties are slightly lower as compared to long duration varieties due to early maturation. However, short duration varieties serve as best options for drought proofing in rainfed cultivation as they provide a significant yield advantage in drought years over the traditional long duration varieties. This implies a trade-off between risk and expected returns in areas experiencing increased frequency of droughts. According to Prasad and co-workers some examples of tolerant rice varieties are Sahbhagi dhan, Naveen and Anjali Birsa Vikas Dhan 109, Abhishek. Average yield of these varieties was higher over traditional long duration variety in seasons that experienced deficit rainfall situation in states of Odisha, Bihar and Jharkhand. Likewise, finger millet cultivation the delay in monsoon is about 4 weeks and more, the short duration varieties like ML-365 (105 days) and GPU-48 (100 days) performed better. These short duration varieties of finger millet are also suitable under rainfed conditions in medium to deep red soils. Less water demanding crops and varieties of wheat WH 157 and WH 283 can be successfully cultivated with limited water in Punjab, Haryana and Madhya Pradesh. Kundan variety of wheat is another such example which has comparatively higher dry matter production efficiency per unit water consumed. Vegetable crops such as garden pea (Arkel, Pragati), winter bean and vegetable mustard are the other examples requiring less irrigation water. Central Agroforestry Research Institute (CAFRI), Jhansi is located in Bundelkhand region, mainly to focus on various agroforestry systems including collection and evaluation of various multipurpose tree species for fuel, fodder and small timber production for improving the livelihood of farmers in this region. This center also identified some prominent accessions of various multipurpose tree species suitable for Bundelkhand region (eg. PT-2 and PT-6 of *Dalbergia sissoo*).

In this context, it is highly recommended that drought stress management can be through planting drought tolerant varieties, early maturing or late sown varieties with appropriate crop management practices in Bundelkhand region may help farmers to gain stable yield under rainfed condition together with increased farm income.

Some of the varietal information and agroforestry systems suitable for semi-arid regions of India as;

Table 2. Some of the important drought tolerant varieties/hybrids of different crops in India

Rice	Sahabhagi Dhan, Vandana, Anjali, Satyabhama, DRR Dhan 42 (IR64 Drt 1), DRR Dhan 43, Birsa Vikas Dhan 203, Birsa Vikas Dhan 111, Rajendra Bhagwati, Jaldi Dhan 6
Wheat	PBW 527, HI 1531, HI 8627, HD 2888, HPW 349, PBW 644, WH 1080, HD 3043, PBW 396, K 9465, K 8962, MP 3288, HD 4672, NIAW 1415, HD 2987
Sorghum	CSH 19 R, CSV 18, CSH 15R
Pearl Millet	HHB 67 improved, GHB 757, GHB 719, Dhanshakti, HHB 234, Mandor Bajra Composite 2, HHB-226, RHB-177, Pusa Composite 443
Barley	RD 2660, K603
Chickpea	Vijay, Vikas, RSG 14, RSG 888, ICCV 10, Pusa 362, Vijay
Groundnut	Ajaya, Girnar 1, TAG-24, Kadiri 6, ICGV 91114
Soybean	NRC 7, JS 95-60
Sugarcane	Co 98014 (Karan-1), Co 0239, Co 0118, Co 0238, Co 06927, Co 0403, Co 86032
Cotton	HD 324, CICR-1, Raj DH 7, Jawahar Tapti, Pratap Kapi, Suraj, Surabhi, Veena, AK 235

Source: Ministry of Agriculture and Farmers Welfare, 2015

Table 3. List of some early maturing crop varieties for semi-arid region

S.No.	Crops	Varieties
1	Ground nut	JGN-3
2	Soybean	NRC-7, JS 71-05
3	Chickpea	RSG-888, RSG-963
4	Pearl millet	HHB 197, GHB 732, GHB 744, RHB 121, GHB 558
5	Sorghum	CSV 17, CSH 23
6	Finger millet	VL 149, VR 520, GPU 45, KM 13, BM-9-1
7	Foxtail millet	PS-4
8	Kodo millet	JK-76, JK-62, GPUK-3

Source: Drought Management Strategy, Ministry of Agriculture and Farmers Welfare, 2009

Table 4. Forage crop varieties suitable for late sown condition

S.No.	Crops	Varieties
1	Pearl millet	Giant Bajra, Raj Bajra Chari-2
2	Maize	J-1006, Vijay composite
3	Sorghum	Pant Chari-3, Pusa Chari-9, Pusa Chari-23, MP Chari, HC-171, HC-308
4	Guar	Bundel Guar-1, Budel Guar-2, RGC-396, HG-365
5	Cowpea	Bundel Lopia-1, Bundel Lopia-2, UPC-287
6	Dinanath grass	Bundel-1, Bundel-2
7	Guinea grass	PGG-9, PGG-14

Source: ICAR website

Table 5. Some of common fruit varieties for arid and semi-arid regions

S.No	Fruit crop	Varieties
1	Pomegranate	Ganesh, Dholka, Jalore Seedless, Mridula, Phule Arakta, Bhagawa, Ruby, Amalidana, G-137, Jyoti, Basin SeedlessGanesh, Dholka, Jalore Seedless, Mridula, Phule Arakta, Bhagawa, Ruby, Amalidana, G-137, Jyoti, Basin SeedlessGanesh, Dholka, Jalore Seedless, Mridula, Phule Arakta, Bhagawa, Ruby, Amalidana, G-137, Jyoti, Basin Seedless
2	Aonla	Banarasi, Chakaya, Francis, NA-6, NA-7, NA-10, Kanchan, Krishna, Anand-1, Anand-2, Lakshmi-52, BSR-1, Chakaiya, BSR-1
		Banarasi, Chakaya, Francis, NA-6, NA-7, NA-10, Kanchan, Krishna, Anand-1, Anand-2, Lakshmi-52, BSR-1, Chakaiya, BSR-1
3	Ber	Gola, Seb, Umran, Banarasi Karaka, Kaithali, Mundia, Goma Kirti, Thar Bhubharaj, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel-1 & 2, ZG3, Sanaur
4	Bael	Kagzi, Mirzapur Seedling, Etawah, Gonda, Ayodhya, NB-5, NB-9, Pant Aparna, Pant Urvashi, Pant Shivani, Pant Sujata, CISH Bael-1 & CISH Bael-2
5	Custard apple	Balanagar, Mammoth, Island Gem, APK (Ca) 1, Arka Sahan
6	Fig	Poona Fig, Dinkar, Dianna, Conadria, Excel

Table 6. Suitable agroforestry species for semi-arid region

Trees	Grasses	Crops
Prosopis cineraria	*Chenchrus ciliaris*	Sorghum
Acacia nilotica	*Dichanthium annulatum*	Pigeonpea
Cacia tortilis	*Panicum antidotale*	Blackgram
Albizia lebbeck	*Chenchrus setigerus*	Taramira
Prosopis juliflora	*Brachiaria ramose*	Safflower
Holoptelea integrifolia	*Digitaria adscendens*	Pearlmillet
Acacia albida	*Dactylocterium scindicum*	Castor
Acacia senegal		Cluster bean
Acacia tortilis		Tobacco
Eucalyptus tereticornis		Cowpea
Hardwickia binata		

Source: Drought Management Strategy, Ministry of Agriculture and Farmers Welfare, 2009

The Bundelkhand regions of India have been facing the adversities of frequent drought for past couple of decades. Agriculture practices in these region is being rainfed, its productivity is heavily dependent on climate and monsoon rainfall. However, the impacts of drought are not restricted to the agriculture sector alone but they radiate to other sectors, including forestry, animal husbandry, environment and livelihood of farmers. In the developing country like India, the drought brings food crisis, affects people's health, invites social conflicts, and sometime compels farmers to take harsh steps such as committing suicides. In Bundelkhand region drought strategies at short and long term basis need to be planned and executed properly. Drought mitigation strategy through changing farming by adopting drought resistant crops, drought tolerant varieties, planting rainfed varieties, short duration varieties and late sown varieties are the best options in this region for stable farm income. Adopting resistant varieties is one of the cheapest strategy of drought management in this region, it also ecofriendly approach for sustainable agriculture. From breeder perspective point it is an urgent need to develop new cultivars of crops for new production environments. Breeders also need to develop new plant types that can resist various biotic (diseases and insect pests) and other abiotic (e.g., salt, drought, heat, cold) stresses in the production environment. Especially, in Bundelkhand type of semi-arid region adopting drought resistant cultivars can be a choice of drought stress management for increasing farm income.

Integrated disease management in gram (*Cicer arietinum*)

Shweta Meshram[1], Robin Gogoi[1] and Sunaina Bisht[2]

While agriculture in the predominant occupation in Bundelkhand, land available and used forcultivation in the region is considerably lower than in other agriculture zones of the country.Agriculture in Bundelkhand faces many challenges such as extreme weather conditions, likedroughts, short-term rain and flooding in fields add to the uncertainties and seasonalmigrations. The scarcity of water in the semi-arid region, with poor soil and low productivityfurther aggravates the problem of food security. Apart from size of land cultivated,agriculture production is primarily determined by availability of water and losses due toseveral diseases. Wheat and gram (chickpea) is the important and main cultivated crop inBudenlkhand region and are continuously suffer from many diseases that result in severelosses in yield. However, many pest management strategies are applied which are totallydependent on agrichemicals which put the environment and human health into danger. So,there is need to develop an alternative and eco-friendly way to control plant diseases andreduce the use of chemicals in agriculture.

Agriculture is main occupation of Bundelkhand region of Uttar Pradesh, India. The region is having hard rocky and alluvial soil and other important coarse grained soils (Rakar, Parua, Kabar and Mar). This region is prone to drought and floods. Apart from these challenges, losses due to diseases play an important role in over all crop productivity. Wheat and gram (chickpea) are the important and main cultivated crop in Bundelkhand region of Uttar Pradesh and Madhya Pradesh. Gram is cultivated all over the globe and spread in Middle East, the Mediterranean region, India and Ethiopia. Gram is an important *rabi* crop and among all pulses, its cultivation is comparatively more in Bundelkhand. It is one of the dry edible legumes with best nutritional composition. It does not contain any specific major anti nutritional or toxic factors often present in other legumes. Gram seeds contain an average of 23% proteins and the crop meets up to 80% of the nitrogen requirements from symbiotic nitrogen fixation. Main varieties of gram grown in Uttar Pradesh are KWR-108, Avrodhi, BG-256, K-850, Pant G-186, Pusa-372 and Radhey and in Madhya Pradesh JG-74, JG-315, Vijay, Pusa-256, Phule G-5 and Pusa-1053 are widely cultivated. The gram crop continuously suffer from many diseases (Table 1) that result in severe losses in yield. Moreover, complete dependence on the agro-chemicals in pest management put the environment and human health into danger. Considering the potentiality of impact of the usually practised pests management system on the environment, ecology and animal health, there is an utmost need to adopt integrated disease management strategies.

Table 1 Important diseases of gram

No.	Disease	Causal organism
1.	Alternaria blight	*Alternaria altemata*
2	Ascochyta blight	*Ascochyta rabiei*
3.	Black root rot,	*Fusarium solani*
4.	Colletotrichum blight	*Colletotrichum dematiun*
5.	Fusarium root rot	*Fusarium acuminatum*
6.	Fusarium wilt	*Fusarium oxysporum* f.sp. *ciceris*
7.	Verticillium wilt	*Verticillium albo-atrum, V. dahliae*
8.	Powdery mildew	*Leveillula taurica, Oidiopsis taurica*
9.	Downy mildew	*Peronospora* sp.
10.	Rust	*Uromyces ciceris arietini*
11.	Botrytis grey mold	*Botrytis cinerea*

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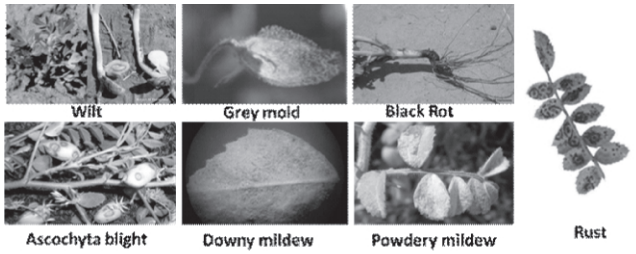

Image: Symptoms of some important diseases (PC: Google)

What is integrated disease management?

Integrated disease management(IDM) is the practice of using several measures to prevent and manage diseases in economically important crops. It involves theselection and application of a harmoniousrange of disease control strategies thatminimize losses and maximize returns. The aim of integrated control programs is toachieve a level of disease control that isacceptable in economic terms to farmers andat the same time causes minimal disturbance to the environments of non-target individuals. It involves principles of plant disease control in holistic manner like avoidance, exclusion, eradication, protection, resistance and therapy.

Suggested IDM strategies followed in Gram

A. Cultural practices

- Cultivation in infected field must be avoided.
- Use of healthy seeds for sowing.
- To avoid wilt it should be sown after 3rd week of October.
- Wilt root rot incidence decreases in deep sown crop.
- Crop rotation up to 3 years to minimize or restrict Ascochyta blight.
- Field sanitation and roughing to avoid powdery mildew.

B. Physical methods

- After harvest residues should be destroyed by deep ploughing or soli solarisation.
- Deep summer ploughing in month of June, it destroys resting structure.
- Hot water seed treatment to avoid seed borne diseases such as Ascochyta blight.

C. Biological method

- *Trichoderma* spp. is potential biocontrol agent against Fusarium, Ascochyta, Sclerotium and many other soil born and seed born pathogens of gram.

D. Resistant variety

- For wilt disease – Avrodhi, Uday, Phule G5.
- For blight disease – Pusa – 261, Gaurav, G 543
- For rust disease - Only resistant variety is Gaurav
- Resistant Varity for disease – GNG 146, PBG-1, Pusa 256 for Ascochyta blight.

E. Chemical management

- **Seed treatment**:For wilt - Carbedazim @ of 2.5g/kg and Carboxin + Thiram 1: 2 at 3 g/ kg and for blight – Brassicol and Captan10 k/ ha.
- **Foliar spray:**For grey mold -0.2 % Carbendazim spray on crop after arrival of infection at early stage.

For Rust- 0.2% Mancozeb 75 wettable powder when first symptoms appears.

For mildew, blight and wilt - Dithane M- 45 @ 2.5 g/ kg.

Combination of Carbendazim+neem cake, neem cake+*T. viride*.

Use of chemicals for the control of the disease is not an economical proposition. Secondly, these chemicals leave harmful residues and can lead to the development of resistance in pathogens with repeated use. IDM exercises the minimum risk and hazards effect to environment and human that promotes growth of healthy plant, sustainable disease management reduces contamination to water bodies. Also IDM reduces the exposure to harmful chemicals to workers, tenants and public. Above all it enables the simultaneous management of many pathogens at a time with insuring high yield along with promotion of cost effectiveness in disease management.

Grow amaranth for good health and higher yield

Shailaja Punetha[1], Meenakshi Arya[2], Anshuman Singh[3], Ranjit Pal[4] and Ghanshyam Abrol[5]

Amaranthus is the most common leafy vegetable grown during summer and kharif season inIndia. It fits well in crop rotation because of its very short duration and large yield of ediblematter per unit area. Green or leafy types are usually grown in kitchen and market garden. Itis gaining importance in the Indian plains also, particularly in Gujarat and Maharashtra.The tiny seeds of grain amaranthus are parched and milled for flour. Thegrain amaranthus is a rich source of protein and essential aminoacids like lysine, leucine andisoleucine which are required for growth of children. Considering the agroclimate of Bundelkhand its cultivation can help in enhancing nutritional and financial security of Bundelkhand farmers.

Amaranthus is the most common leafy vegetable grown during summer and kharif season in India. It fits well in crop rotation because of its very short duration and large yield of edible matter per unit area. Green or leafy types are usually grown in kitchen and market garden. It is gaining importance in the Indian plains also, particularly in Gujarat and Maharashtra. Grain types are usually grown as mixed crops along with cereals, pulses and vegetables. The fresh tender leaves and stem of amaranthus are delicious when cooked and consumed like other leafy vegetables. The tiny seeds of grain amaranthus are parched and milled for flour. The grain amaranthus is a rich source of proteinand essential aminoacids like lysine, leucine and isoleucine which are required for growth of children.

Health Benefits of Amaranth

The leaves and tender stems of Amaranthus are rich in protein, minerals, vitamin A and C.100g of edible portion of Amranthus consists of Protein 13.56.0 g, Calcium 159 mg, Iron 7.61 mg, Magnesium 248 mg, Phosphorus 557 mg, Vit C 4.2 mg and Vit A 9200 IU (Bruni *et al* 2001, Rodas and Bressani 2009 and Sousa and Farfan 2012). Besides, the soft fibrous matter provides necessary roughage in the diet.

Both the seeds and leaves of amaranth have widespread use in traditional medicine. Amaranth leaves have been found to be a good home remedy for hair loss and premature greying. The seeds and leaves have been found to be very effective in controlling diaorrhea and excessive menstruation. Amaranth leaves are a natural astringent, and make a great wash for skin problems like eczema, and a wonderful acne remedy. Amaranth also makes an effective mouthwash for treating mouth sores, swollen gums, and sore throat. Antioxidant activity has been reported in several of the various fractions of amaranth.

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How to grow?

Selection of varieties

Selection of varieties is an important criteria to enhance the yield of any crop. There are several improved and local varieties of amaranth that are grown in India and can also be grown in Bundelkhand region. Some of them are Co.1, Co.2, Co.3, Co.4,Chhoti chaulai , Badi Chaulai, Pusa Chaulai, Pusa Kiran,Pusa Lal Cahulai, Pusa Keerthi, Arka Suguna, Arka Samraksha, Arka Suguna, Arka Varna.

Climate

Amaranthus species are widely distributed in temperate and tropical regions of India. Different species differ in their day length (Photo period) requirements and respond differently to changes in photo and thermoperiodism. *A. caudatus, Amaranthus edulis* and *A.cruents* are short day (plants) species while *A. hypochondriacus* is reported to be day neutral. However it does well under warm situations temperature ranging from 22 to 30^0C. Grain as well as leaf Amaranthus is highly resistant to drought. Therefor it is suitable crop for Bundelkhand.

Soil

Amaranthus can be grown in a wide range of soil, however well drained loamy soils are best suited for this crop. Heavy soils with poor drainage and sandy soils with poor water holding capacity are unsuited for its cultivation. It can be grown in a pH range of 5.5.-7.5. However slightly acidic in nature are preferred.

Season

It can be grown throughout the year. However March to September are the best months to start the crop. In Bundelkhand where temperature doesn't go below 5^0C it can be easily cultivated throughout the year.

Recommendation of seed rate & fertilizer

One hectare area requires around 2.5 kg seeds with recommended NPK is approximately 100-50-50 kg inaddition to well decomposed 15-20 tons of FYM. Around 2-3 kg seed of amaranth is sufficient for one ha area. Before sowing seed is mixed with sand or red soil or fine vermicompost at 1:5 ratio. Since the seeds of Amaranthus are small in size, to achieve even distribution, mix the seed with fine sand or red soil before sowing.

Land preparation and sowing

Prepare the land thoroughly by ploughing, harrowing and bring the soil to fine tilth. Incorporate entire quality of organic manure into the soil. Prepare the beds of convenient size. 3mx2m or 2mx1.5m with irrigation channels running between every two rows of beds. After the beds are ready apply entire

dose of P and K along with 50% N and mix them well in the soil. Sow the seeds thinly. On account of smallness of seed ,it should be sown shallow to a depth of 0.5-1cm .the plants should maintained at a spacing of 30X 30 cm or 30 x 45 cm.

For line sowing spacing between rows is 20cm. In grain amaranthus (*Amaranthus hypochondriacus*), the plants are thinned that have a spacing of 30cm x 30 cm on 25th day and they are allowed for flowering. The crop will be ready for harvest in 80-120 days depending on the variety and season. The dried spikes are threshed to separate grain which is used to prepare popped grain, green cakes, infant foods and the preparation like amaranthus malt.

Water management & inter cultivation

Provide light irrigation after sowing. Three days once or weekly irrigation is necessary, depending on soil and weather conditions. Top dress the crop with remaining 50% of N 20-25 days after sowing. Keep the land free from weeds. Time to time hoeing is necessary for Proper aeration. After each cutting irrigate the crop along with the application of nitrogenous fertilizer.

Harvesting

Young leaves are cut out with petioles, washed, tied into bundles and sent for marketing. Crop will be reading for first clipping or cutting 25-30 days after sowing. The subsequent cuttings can be made at an interval of 6-10 days. It gives about 6-10 cuttings.

Yield

It is highly perishable hence leaves should be used same day of harvest. Average yield is 20-25 tonnes per hectare in leaf types whereas grain types yield is around 2 to 2.5 tonnes per hectare.

Common pests and diseases

Diseases

1. Anthracnose: *Colletotrichum gloeosporioides*

Symptoms: Necrotic lesions on leaves; dieback of leaves and branches, caused by Fungus

Management

Avoid damaging plants and creating wounds for pathogen to enter; plant resistant varieties

2. Damping-off :*Rhizoctonia* spp., *Pythium* spp.

Symptoms: Poor germination; seedling collapse; brown-black lesions girdling stem close to soil line; seedling fail to emerge from soil. Disease emergence favors wet soils

Management

Avoid planting seeds too deeply; do not plant seeds too thickly to promote air circulation around seedlings; do not over-water plants

3. Wet rot (Choanephora rot) *Choanephora cucurbitarum*

Symptoms: Water-soaked lesions on stems; lesions have hairy appearance due to presence of fungal spores; may cause loss of leaves. Fungus mainly attacks plants that have been damaged by insects or by mechanical means; spread by air currents and via infected seed; disease emergence favors warm, moist conditions

Management

Plant varieties resistant to disease; only use certified seed; do not plant crop densely; treat disease with copper fungicides.

Pests

1. Pigweed weevil *Hypolixus haerens*

Symptoms: Withering plants; stems bending and collapsing. Adult weevils feed on foliage, larvae hollow out stems, damage promotes colonization of fungi and other pathogens.

Management

Uproot and destroy infested plants to limit weevil population.

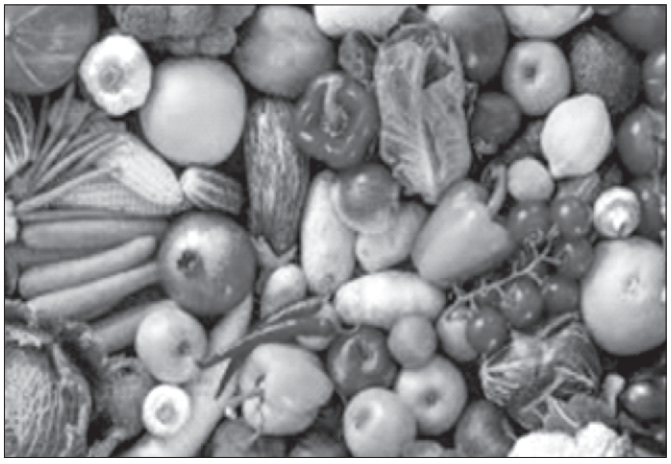
Vegetable cultivation as an alternative source of income for small farmers of Bundelkhand

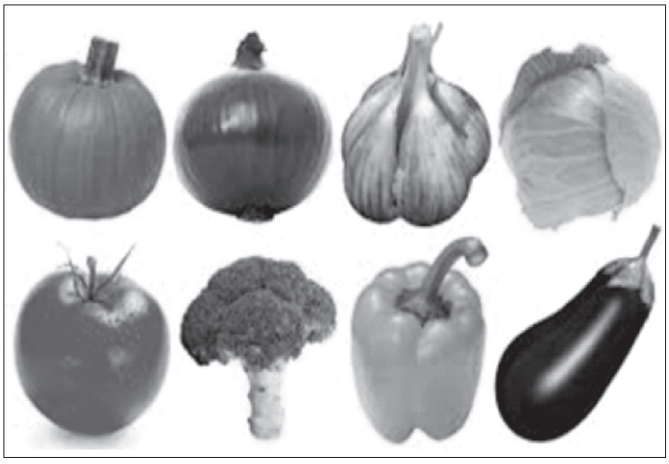
Amit Tomar[*], Harpal Singh[**], D.K. Upadyay[*] and Anil Kumar Gupta[*]

Traditionally, Bundelkhand is not known as a major vegetable production region. Cultivation of vegetables for sale in market and generation of income has been restricted to a few locations, such as Newari block of Tikamgarh district, and/or households of certain socioeconomic groups (egLodhs) having irrigation facilities, many heads of cattle (and thus FYM), and tradition of cultivating vegetables.However, there is scope and need for promoting vegetable cultivation as an alternative source of income for small farmers in the Bundelkhand region, for the simple reason that on a per unit of land basis, vegetable cultivation is far more profitable than cultivation of staple crops. Vegetable cultivation will also help improve nutritional status of families, especially women and children.

Traditionally, Bundelkhand is not known as a major vegetable production region. Cultivation of vegetables for sale in market and generation of income for improving the socio-economic condition of Bundelkhand region. Two kinds of soils are found in Bundelkhand region e.g. red soils and black soils. Across Bundelkhand soils of both categories have poor organic content. Black and red soils are suitable for cultivation of vegetables crops in Bundelkhand region. Around one-fourth of households cultivate vegetables in kitchen gardens and/or parts of their land. Main kitchen garden vegetables of Bundelkhand regions are tomato, brinjal, bottle gourd, pumpkin and bhindi (Lady's finger). Some of the farmers grow coriander and cucumber also. Some vegetables are grow brinjal according two-thirds of the area under commercial vegetable cultivation. However, there is scope and need for promoting vegetable cultivation as an alternative source of income for small farmers in the Bundelkhand region, for this simple reason vegetable cultivation is far more profitable than cultivation of staple crops. Vegetable cultivation will also helps improve nutritional status of families, especially woman and children.

As per recommendation of different every adult has to consume 250-300 g of vegetables per day. India is the second largest producers of vegetable with 2.8% of total cropped area under vegetable. An increase of necessarily. Supply only 145 g per capita per day against recommended vegetables of 300 g.





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Importance of vegetables:

Nutritional source: Vegetables are rich in vitamin A, vitamin C, folate, fiber and potassium. Folate helps the body form red blood cells. It is especially important for women of childbearing age to consume folate-rich foods such as bell peppers, tomatoes and spinach to prevent neural-tube defects in babies. Vegetables are valuable in maintaining alkaline reserve in the body. They are valued mainly for their high vitamin and mineral contents. Vitamins A, B and C are contained in vegetables in fair amounts. Farinaceous vegetables consisting of starchy roots such as potatoes, sweet potatoes, the tubers and legumes are also valuable. They are excellent sources of carbohydrates and provide energy to the body. Generally, deep green yellow and orange colored vegetables such as green leafy vegetables, carrots, papaya tomatoes and yellow pumpkin are rich sources of carotene. Several leafy vegetables like fenugreek leaves, turnip greens and beet green contain riboflavin, a member of the vitamin B-complex, this vitamin is essential for growth and general health, of eyes, skin, nails and hair. A deficiency can lead to cracking of the angles of the mouth, premature wrinkles and eczema. Generally, fresh vegetables are better sources of vitamin C than dried, stale or withered ones. The diuretic action of vegetables like potato, beans, spinach, radish, turnip and brinjal are important in cases of edema or swellings, kidney and heart conditions. Vegetables make good juices, but some bitter than others. Vegetable juices may be divided into three main types.

These are (i) Juices from vegetable fruits, that is, tomatoes and cucumber (ii) Juices from green leafy vegetables such as cabbage, celery, lettuce, spinach and parsley and (iii) Juices from root vegetables like beetroot, carrot, onion, potato and radish. Fibres in the form of cellulose help the elimination of cholesterol Beet root, cabbage, carrots, cucumbers, green peas and beans are specially valuable in this. They are useful in case of arteriosclerosis, high blood pressure and constipation, when there is inflammation in these intestines, vegetables having less cellulose content such as tomatoes, lettuce, potatoes and vegetable juices should be taken. Pectin found in vegetables such as brinjal, radish, pumpkin and beet root absorb water, kill certain bacteria and toxins and eliminate them from the body. Garlic, onion, radish and mint contain pectin as well as antimicrobic qualities. The importance of eating green vegetables cannot be overlooked. Green vegetables come across as quite unassuming, but they are packed with healthy nutrients such as Vitamins A, C, E and K (which are found in salad greens, kale and spinach). Vegetables are good sources of carbohydrates (leguminous vegetables, sweet potato, potato, onion, garlic and methi) proteins (peas, beams, leafy vegetables and garlic) vitamin A (carrot, tomato, drumstick, leafy vegetables), Vitamin B (peas, garlic and tomato), Vitamin C (green chillies, drumstick leaves, Cole crops, leafy vegetables and leaves of radish) minerals (leafy vegetables, drumstick pods). As per dietician, daily requirement of vegetables is 75 - 125 g of green leafy vegetables, 85 g of other vegetables and 85 g of roots and tubers with other food.

Importance as Food: Food production is increasing. If is essential to sustain increased production besides nutritional standard of people. It can be increased by increasing production of vegetables which will help to solve food problem as yield of vegetable crops is 4 to 10 times more than cereals. Thus, vegetables play a vital role on food front as they are cheapest-sources of natural foods and can admirably supplement the main cereals of the country.

Importance to a grower: Nature is in providing us-with all kinds of vegetable crops that can be grown in different seasons of the year in region. Different kinds of vegetables provide leaf, stem, flower, fruit or seed for consumption. Considering vividness in the requirement of soil and season farmers can grow vegetable crops throughout the year for earning regular and steady income to meet the daily expenditure. There are vegetables of very short duration that can be grown as rained and intercrops in either agronomical crops or vegetable crops. Thus farmer has wide choice to select suitable crop to adjust in his cropping pattern in given situation.

Climate and soil conditions of this region are conducive to grow different vegetables.

Employment: Since cultivation of vegetable crops involve intensive cultural operations starting from sowing to marketing, it provides more and regular employment opportunities in rural areas.

Industrial importance: The perishable nature of vegetables demand comprehensive planning for movement, Storage, processing and distribution of vegetable products. Most vegetables are short duration crop and it as compared to other crops can be raised throughout the year Some of Vegetables (i.e. potato, brinjal, spinach, pumpkin, lady's finger etc.) can be grown twice and even three a year, some green vegetables become ready for harvesting within 15-60 days of sowing.

Importance of vegetables Production for medicinal properties: Many of the vegetable crops possess high medical value for curing certain diseases. For instance, onion and garlic are found to possess antibacterial property. Many solanaceous and cucurbitaceous vegetables are found to possess Vitamin D.

Conclusion: Vegetables included in daily schedule of diet viz. Sweet Pepper, Cauliflower, Carrot, Cabbage, Lettuce, Spinach, Tomato, Potato, Reddish, and Bottle Gourd were analyzed for their proximate composition, vitamin and mineral contents to evaluate their importance in human nutrition. So, Bundelkhand farmers will get more income through growing of these vegetables and also improve their living standard.

Postharvest handling and storage of vegetables

Ghan Shyam Abrol, Amit Kumar Singh, Ranjit Pal, Shailja Punetha, Priyanka Sharma and A.K. Pandey

Considering all the horticultural crops, vegetables has the highest wastage index. Thewastage is due to poor technical know-how with the growers, poor infrastructure and out dated technologies and complex taxation laws. Moreover, comparing to developed countries in our country processing and value addition of horticultural crops is less than 2%. Therefore, different postharvest techniques such as pre-cooling, sorting, grading, packaging, waxing etc. can not only improve the quality but also increase the shelf-life of the vegetable crops. Modern methods transportation through cool chain, cold storage and different preservation techniques can minimise the wastage and improve the economy of vegetables grower of India.

India is the second largest producer of fruits and vegetables in the world. India produces a large variety of fruits and vegetable due to varied agro-climatic condition. The total production of fruits and vegetables in the world is around 370 MT, annually. Astonishingly, it may appear but it is a fact that the postharvest losses of fruits and vegetables in India amounts to Rs. 40,000 cores which is 30-40% annually. In India, the difference between price paid by consumers for value added products and farmer's realisation has been increasing rapidly. Further, the food processing industry is plagued by high-risk profile, poor infrastructure and out dated technologies and taxation laws. There is also a lack of backward linkage between farmers and processors. This leads to non-uniformity and inconsistent supply of raw material, longer chain of intermediaries and lack of adequate economic benefits to farmers.

A new dimension from the consumer point of view is added to the existing understanding of value i.e. how a consumer perceives the value delivered to him through a bundle of product services. This new approach of value addition through the consumer's mind needs special attention. In other words, consumer orientation is required in all spheres of agricultural sector.

At present India uses only a small fraction of fruits and vegetables in processing i.e. only 2% as compared to other countries which is presented in Figure1.

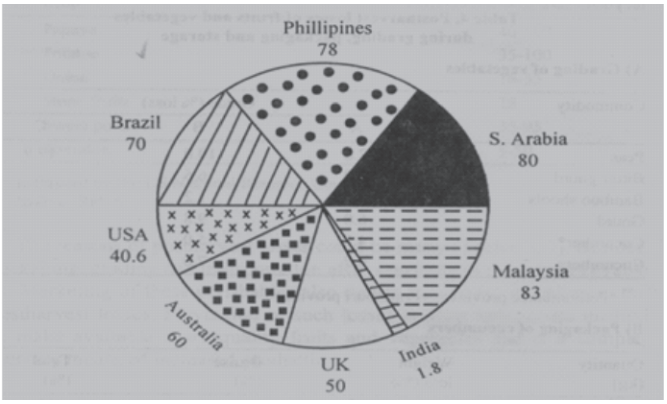

Fig 1: Percent of fruits and vegetables used in processing in different countries

Postharvest technique used for preservation and value addition

To process and preserve fresh produce successfully, the spoilage agents must be destroyed without ruining the nutritional value or palatability of the produce itself.

Different post harvest treatments in vegetables are as drying, chemical preservation and heat processing.

i. **Drying**: It is generally done to root crops for curing purpose. It is also essential practice for dehydration in many of vegetables like in de-podded peas, cut okra etc. Vegetables contain up to 85 percent water and thus are sufficiently moist to support both enzyme activity and growth of micro-organisms. The aim in drying is to reduce the water content of the produce to a level insufficient for enzyme activity or the growth of micro-organisms.

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ii. **Pickling:** Young fresh vegetables can be preserved by pickling in vinegar. The prepared vegetables are first soaked for a few days in a strong salt solution (brine) and then packed into jars which are then filled with vinegar. The vinegar is usually flavoured by steeping the desired spices in it for one or two months. The jars should be closed with plastic-lined covers.

iii. **Preservation with salt**: This method is usually used for preserving green beans. Young green beans and salt are placed in alternate layers in large glass or earthenware jars, the top layer being of salt. The jars are closed with moisture-proof covers and then they are stored on stands.

iv. **Fermented products:** Vegetables are also subjected to lactic acid fermentation in brine, such as sauerkraut, made from shredded cabbage, and *takuwan*, using radishes. A fermented product is made by burying peeled starchy produce in pits lined with Heliconia or banana leaves. The product, known as masi or ma, is mostly made from breadfruit, but green bananas, cassava roots or taro may also be used.

v. **Heat treatments:** Vegetables have also been preserved by heat, using canning or bottling methods. The object is to kill the enzymes and micro-organisms by heating the produce in liquid in cans or jars. The containers are then sealed while still hot to prevent contamination of the sterilized contents. Although moist heat inactivates enzymes and kills most micro-organisms, some bacteria, such as *Clostridium* and *Staphylococcus* are heat-resistant and are capable of growing and producing poisons in canned or bottled foods.

Non-acid foods such as peas and beans and almost all vegetables can be preserved only by heat at the high temperatures achieved in steam-pressure vessels. For this reason, heat-processing methods are not recommended for processing any vegetables under small-scale local conditions.

vi. **Freezing:** It is another technique commercially used for preservation of vegetables mainly peas. This method preserves their freshness, quality, taste and texture. The complete producer include the following operations

- Inspection samples of the unprocessed produce are taken to be graded and for grower payment.
- Raw receiving
- Peeling/depodding/cutting
- Grading pieces that are too small or misshapen are removed from the main processing line and used in other products.
- Blanching product like peas and sweet corn require blanching at 160°-180°F for 15-40 minutes to remove natural sugars, stabilize enzymes, and create a good texture.
- Pre-cool blanched produce is pre-cooled at 0°F for 15 minutes before entering the freeze tunnel.
- Freeze tunnel produce is quickly frozen for 30 minutes at -40°F.
- Packaging the frozen products are packaged into bags.
- Packages are stored in a cold storage.

Postharvest handling and value addition in vegetables

Onions and garlic

Onions and garlic of different types are grown worldwide for the flavour they contribute to food. They are also commonly regarded as having medicinal properties.

Harvesting

Since onion bulbs are normally formed at the soil surface, it is sometimes possible in sandy soils to pull the mature bulbs by hand. Where conditions make hand-pulling impossible, and with garlic where the bulbs develop below ground, harvesting is done by loosening the bulbs with a fork or hoe before lifting them, in a manner similar to that described for root crops.

Post-harvest treatment

Curing is a drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture and the attack by decay during storage. It can be carried out in the field under dry conditions by windrowing the bulbs as described above under Harvesting.

The essentials for curing are heat and good ventilation, preferably with low humidity. This dries out the neck and the two or three outer layers of the bulb.

Leafy vegetables and Immature flower

Include cabbage, Chinese cabbage, kale, rape, mustard, broccoli, chard, spinach beet, spinach, lettuce, celery, green onions.

Harvesting

Harvesting varies with the crop:

- Cabbage, Chinese cabbage, lettuce, celery and green onions form more or less compact heads; the entire head is harvested at one time.
- Kale, rape, mustard and broccoli. Young shoots, with or without immature flower heads, are picked by hand-breaking; can usually be harvested over a period of time as long as new shoots continue to develop.
- Spinach beet and spinach are harvested as individual young leaves; sometimes young shoots of spinach are harvested; harvesting is repeated as new leaves continue to develop.

Selection and grading

All produce which is damaged, decaying wilted or infested by insects or other pests must be discarded. Size-grading is not normally necessary for local and internal marketing.

Packaging

Packaging of leafy vegetables and immature flower heads for urban markets will vary with the type of commodity:

- Cabbages: woven sacks or net bags of 20-25 kg capacity are suitable.
- Lettuce: wooden crates or ventilated cardboard boxes each containing 24 heads of lettuce.
- Celery: wooden crates holding 20-30 heads of celery.
- Broccoli: well-ventilated cardboard boxes holding 5 kg.
- Green onions: normally tied in bunches by the grower; they are best transported in small wooden crates holding 10-15 kg.
- Kale, rape and leafy brassicas: may be tied in bunches or packed loose; they can be marketed in nets or cardboard boxes of 5-10 kg capacity.

Storage

Leafy vegetables and immature flower heads have a very short post-harvest life, especially under ambient conditions. Even under refrigeration most remain in good condition only up to two weeks. Ideally, they should reach the consumer within two days of harvest.

Tomato

Maturity for harvest

The actual stage at which they should be picked depends upon local preference and distance market. Mostly tomatoes are harvested at the early ripening or pink stage. Tomatoes to be consumed immediately can be harvested when fully ripe.

Harvesting

Tomato fruit stalks have a natural break-point. Tomatoes are best harvested into plastic buckets and transferred if necessary to plastic field crates holding not more than 25 kg weight.

Post-harvest treatments

Tomatoes which are in good condition are marketed, there should be no need for any post-harvest treatments. Tomatoes produced on a large commercial scale may be subjected to artificial ripening.

Potato

Harvesting

Potato harvesting is best done when the soil is slightly moist. Where they are produced on a small scale, harvesting is carried out with hand-tools. The tubers must be lifted carefully to avoid damage, and shaken free of soil. They are left to dry in the field, after which they are collected in field containers and placed in a cool, shady place.

Post-harvest treatments

Potatoes which are to be stored need to be cured to repair any skin damage which may be present. Curing is best carried out after the potatoes have been placed in store. It involves reducing ventilation to allow a build-up of the temperature and humidity needed to promote curing.

Table 1.The storage conditions suitable for curing potatoes are:

Temperature	13 to 20 degrees Celsius
Relative humidity	85% or more
Curing time	7 to 15 days

The highest temperature requires the shortest time. At the end of the curing time, full ventilation should be restored to the store.

Storage

Only sound potatoes with no apparent damage or decay should be stored. Potatoes to be used for food or for processing must be kept in the dark to prevent greening. Seed potatoes are stored in diffuse light to promote the development of several strong shoots on each tuber.

Packing

Although baskets or wooden boxes may be used to market potatoes, sacks are cheaper and more commonly used. In temperate climates potatoes are commonly packed for distribution in 25 kg multiwall paper sacks or woven synthetic fibre (polythene or polypropylene) sacks. The use of paper sacks is not recommended under warmer conditions because they lack adequate ventilation. Woven jute sacks are preferred for potatoes in the tropics. They are usually of 50 kg capacity and provide good ventilation.

Yams (*Dioscorea spp.*)

Yams are grown principally as a subsistence crop and for internal marketing. The main types are:

- Greater yam (*D. alata*)
- White yam (*D. rotundata*)
- Yellow yam (*D. cayenensis*)

Maturity for harvest

Yams are ready for harvest when the above-ground parts of the plants have died off. The greater and white yams can be left in the ground for a time after maturity. Yellow yams, which have a very short dormant period, should be lifted as soon as mature.

Harvesting

Yams are normally harvested by carefully scraping the soil away from the tubers in order to avoid damaging them. Wooden digging sticks or spades are less likely to cause damage to the tubers than are metal forks or hoes.

Selection and grading

Heavily damaged or decaying yams should be discarded. Those which are slightly damaged may be consumed immediately or subjected to a curing process before storage. Size-grading is not always practiced. It is mainly done when there is an advantage to be gained in the packaging for marketing.

Post-harvest treatments

Where yams are cut or deeply injured, a new skin can be formed on the damaged surfaces by curing the tubers at high temperature and humidity. Curing has been shown to be effective in yellow and white yams, but its effectiveness in other types is not known. Injuries caused by skin abrasion or bruising tend to dry out rather than form replacement skin.

Curing should be carried out immediately after harvest at the location where the yams are to be stored.

Table 2.Conditions found to be effective in promoting the curing of greater and white yams:

Temperature	32-40 degrees Celsius
Relative humidity	90% or above
Curing time	1-7 days

Packaging

Yams being sent to local markets may be carried in bulk by vehicle or in ordinary baskets. When they are carried in bulk, the floor and sides of the vehicle should be padded with sacks loosely packed with straw, or with grass mats or plastic foam covered with polythene sheet. For internal urban markets the tubers are best packed in wooden crates or ventilated cardboard boxes. These containers should not be overpacked and must be handled and transported carefully.

Strategies

1. Developing varieties suitable for processing,
2. Genetic manipulation for long life, diseases and environmental-stress resistant cultivars, Development of innovative technologies to enhance shelf life of the produce,
3. Development and promotion of indigenous technologies,
4. Development of simple and cost effective processing technologies,
5. Strengthening human resource development,
6. Development of infrastructure,
7. Encouraging private participation,
8. Strengthening quality testing laboratories,
9. The supply chain : growing-sorting/grading-packaging-storage transportation - processing - marketing, It is indeed a web, not a chain.

In most countries, the production of many perishable food crops is seasonal, making them available only during short periods of the year. During this short time, they are produced in greater quantity than the market can absorb, so the surplus of many of these crops must be processed and preserved to avoid wastage of the food and loss of income to the grower.

Modern methods of food storage and preservation, such as refrigeration and freezing, are now widely used in developed countries. These methods are, however, rare in many of the developing countries, but surpluses of many seasonal local crops can be preserved for later use by various processing methods requiring only simple and inexpensive equipment.

Farming of medicinal plants: A boon to Bundelkhand economy

S.P. Singh[1] and Govind Choudhary[2]

Bundelkhand situated in South- East of Uttar Pradesh and is one of the drought-prone regions covering thirteen districts of both Uttar Pradesh and Madhya Pradesh. The large tribal populationliving in forest fringes is largely dependent on forest for food and shelter. Several economicallyviable items are obtained from plants such as beetle, fibre, fragrance, gum, resin, oil, spices,dyes, rubber, wood, timber, etc also available abundantly in the region. There has very low levelof rainfall which has been unpredictable and declined during last few years resulting inuncertainty in agriculture production food crises in the region. There are about 66 herbs andshrubs and 38 tree species with medicinal value which are used traditionally by local residents ofthe region, however, some of the species of medicinal plants are also on threat of their extinctionand attention for their survival. The climate of the region, however, is suitable for farming ofvarious medicinal plants which could be boon to the economy of this region.

Bundelkhand is one of the important drought-proned regions of India spreading over southern Uttar Pradesh and Northern Madhya Pradesh, between 23°10' and 26°30' north latitude and 78°20' and 81°40' east longitude. It is a geographical and cultural region and also a mountain range in central India. The region covers a geographical area of around 70,000 sq km and includes seven districts of Uttar Pradesh and six districts of Madhya Pradesh viz Jhansi, Lalitpur, Jalaun, Hamirpur, Mahoba, Banda and Chitrakoot of Uttar Pradesh and Datia, Tikamgarh, Chhatarpur, Panna, Sagar and Damoh of Madhya Pradesh. The large tribal population living in forest fringes is largely dependent on forest for food, shelter, social and livelihood needs and subsistence on forest products. Jhansi is the largest city in Bundelkhand and is a major cultural, educational, transport and economic hub. In Bundelkhand region, average level of rainfall is 800–900 mm which has been fluctuating and declined during last few years. Agriculture production also decreased in this areas due to climate change. Due to climatic change, traditional betel leaf farming often suffer from food crises. In such circumstances farming of medicinal plants in this region could be boon to the economy of this region.

Bundelkhand region is rich in many plant species which are being used as food, shelter, clothing and medicines by rural communities. In addition to meeting out the requirement of food, vegetable and fruits, several economically viable items are obtained from plants such as fibre, fragrance, gum, resin, oil, spices, dyes, rubber, wood, timber, etc also available abundantly in the region. Plants play very important role in the daily life of human being and constitute one of the important resources of socio-economic development of the region. The people of village community mostly depend on the forest plants. Some plants species grow only at the time of rainy season which have multifarious uses but due to lack rain or due to broad communication gaps people remain unaware of those plants. Due to lack of proper records and over exploitation of these medicinal plants by local people, the natural resources along with related indigenous knowledge in the region is also depleting day by day. The traditional knowledge regarding the medicinal plants of the region needs to be studied and documented before it is lost to make awareness among the people.

Bundelkhand is one of the drought-proned areas of the country where farming is dependent on monsoon which is the only source of irrigation. But in spite of all these hurdles, nature has blessed the region with abundant indigenous medicinal plants or herbs which survive and grow even in these climatic conditions and impart a great potential for economic

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betterment and alleviation of poverty of rural population of the region. The farmers of Bundelkhand region have great opportunity to farming of medicinal plant which is best suitable to the climatic conditions of the region. The medicinal plants have been used by different pharmaceuticals company for producing their valuable products and they are also giving the subsidy and other facility to the farmers. Now, the time has come to change the farming system from food crops to the medicinal plants. But the major problem is the lack of awareness among the farming community regarding the medicinal plants which may be produced better in climate resilient and dry land.

There is big market for the medicinal plant and farmers have ample opportunity to sell their herbal raw material and products. In ancient days, the people were very much familiar with various herbal remedies and rely on these herbs for the treatment of many common and complicated ailments. However, with the emergence of allopathic medicines the usage of herbal remedies declined. Till to dates, due to alarming adverse effects of chemical drugs on health of man and animals, these natural herbs are again gaining importance and likely to occupy place in poverty alleviation programmes to be launched for the dry and rocky region of Bundelkhand.

Region of Bundelkhand is known to in habitat various medicinal herbs like ashwagandha (*Withania somnifera*), safedmusli (*Chlorophytum barivilianum*), punarnava (*Boerhaviaspp*) and palash (*Butea monosperma*) which grow naturally in the forests of the region. Adusa (malabar nut), which is used in to treat cough, asthma and backache are found in plenty. Kaamraj herb, used to cure mouth ulcer and diarrhoea, and arjuna herb (*Terminalia arjuna*) used for heart diseases, can also be grown here on large scale which can generate large revenue for farmers and tribes and other rural residents of the region. These precious herbs need more attention for their farming, processing and marketing.

In addition to some rare herbal remedies, some of the common medicinal herbs, used as day-to-day spices, like ginger also has a lot of scope of farming in the region. Ginger farming is done by few farmers of the Bruasagar, near Jhansi. Ginger produced in this region is considered one of the best quality and is in great demand in many nearby and other part of country as it is used during winters as ginger tea which cures cold as well as relieves from the problem of constipations. Along with the ginger, *Aloe vera* is another valuable medicinal plant in great demand and can be grown commercially in this region and thus can contribute substantially to boost rural economy as it has high demand in Ayurvedic arena these days.

In addition, in the forests of Jhansi, Orcha, Lalitpur, Chitrakoot and Shivpuri, herbs like jatamansi (spikenard), mahua, kher, giloy, bel and amla are grown in huge quantity and have potential for their commercial exploitation. A few more economically viable medicinal plants such as haridra, mustak, nagkesar, guggulu, bhrarangraj, apamarg, gunja and vacha also grow naturally across the region and can be grown on large scale as cash crops.

Although the era of Ayurveda has now returned with efforts of the governments by launching AYUSH programme but still these herbs of Bundelkhand are not being promoted and they are not getting their dues. The producers of these herbs do not have enough resources to market their produce which can make a way for them in getting appropriate benefit. There is a need to impart training to farmers and growers of medicinal crops and also to ensure the price and marketing so that farmers need not to worry about the sale and getting reasonable price of their products.

Thus, government agencies, regional and local bodies and institutes need to create awareness in the villages of Bundelkhand to promote medicinal farming and its production with proper marketing strategies. It has great potential to increase the revenue generation and help to alleviate poverty among the rural population of Bundelkhand. Training on farming of these herbal crops be given to growers so that they can produces quality herbs which would help to increase the demand of these herb globally. Thus, the Bundelkhand region with its vast forest and hilly lands has all potential to be developed as hub for medicinal herbs and the farmers could be greatly benefited financially from the cultivation medicinal plant crops.

Potentiality of common fig (*Ficus carica* L.) cultivation in Bundelkhand region of Uttar Pradesh

Ranjit Pal, Ghanshyam Abrol, A.K. Singh, S. Punetha, P. Sharma and A.K. Pandey

Bundelkhand region lies at the heart of India located below the Indo-Gangetic plain to thenorth with the undulating Vindhyan mountain range spread across the northwest to the south.The region span across thirteen districts seven in Uttar Pradesh and seven in MadhyaPradesh. Its area covered an area of 7.08 million hectares. The soil in this region is a mixtureof black and red-yellow soils which are poor in organic nutrients and climate is hot and semi-humid. These areas experience an annual rainfall 700 to 800 mm and the region ischaracterized by low and erratic rainfall with extremes of temperature (2–48 °C) with verylow relative humidity. Therefore, the region is marked by extreme environmental constraintsdue to which the cultivation of traditional crops is not economical. Above the climaticconditions this region has vast scope of Common Fig cultivation. The ideal condition forintensive cultivation of figs is an arid and semi-arid climate. Botanically identified as *Ficuscarica* L. belongs to family Moraceae moderate sized semi deciduous tree, growing 6-8 mheight with short twisted trunk and crown with irregular branches. The fruit are nutritionalrich in vitamins, minerals, anti-oxidants and with other medicinal properties. It's provided notonly stable income to the people but can also withstand under stressed and adverseconditions. Under such a situation, fig cultivation practices are considered an ideal strategyfor the overall development and wellbeing of its farming community of this drought pronearea.

The Bundelkhand region lies at the heart of India located below the Indo-Gangetic plain to the north with the undulating Vindhyan mountain range spread across the northwest to the south. The region span across fourteen districts: six in Uttar Pradesh - Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakut, and six in Madhya Pradesh - Datia, Tikamgarh, Niwari, Chattarpur, Damoh, Sagar and Panna. It is covering an area of 7.08 million hectares. The soil in this region is a mixture of black and red-yellow soils which are poor in organic nutrients and climate is hot and semi-humid. These areas experience an annual rainfall 700 to 900 mm and the region is characterized by low and erratic rainfall with extremes of temperature (2–48 °C) with very low relative humidity. Therefore, the region is marked by extreme environmental constraints due to which the cultivation of traditional crops is not economical. Above the climatic conditions of this region has vast scope of Common Fig cultivation. The ideal condition for intensive cultivation of figs is an arid and semi-arid climate. The common Fig is one of the oldest and economically important fruit crop cultivated extensively in arid and semi arid regions. Botanically identified as *Ficus carica* L. belongs to family Moraceae moderate sized semi deciduous tree, growing 6-8 m height with short twisted trunk and crown with irregular branches. The fruit are nutritional rich in vitamins, minerals, anti-oxidants and with other medicinal properties. It's provided not only stable income to the people but can also withstand under stressed and adverse conditions. Under such a situation, fig cultivation practices are considered an ideal strategy for the overall development and well being of its farming community of this region.

Composition and uses

Dried fig is a high-energy food. Glucose, fructose and sucrose are the major sugars in fruit. The glucose content of the fruit is always more than that of fructose. With advancement of fruit maturity, there is a decrease in polysaccharides, crude fiber, and protein. However, fig is rich in natural health benefiting phyto nutrients, antioxidants, vitamins and minerals (Table 1).

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Table 1. Nutrition value per 100 g. of fig (*Ficus carica*)

Principle	Nutrient Value	Percentage of RDA
Energy	74 Kcal	4%
Carbohydrates	19.18 g	15%
Protein	0.75 g	1.5%
Total Fat	0.30 g	1%
Cholesterol	0 mg	0%
Dietary Fiber	2.9 g	7%
Vitamins		
Folates	6 µg	1.5%
Niacin	0.400 mg	2.5%
Pantothenic acid	0.300 mg	6%
Pyridoxine	0.113 mg	9%
Riboflavin	0.050 mg	4%
Thiamin	0.060	5%
Vitamin A	142 IU	5%
Vitamin C	2 mg	3%
Vitamin E	0.11 mg	1%
Vitamin K	4.7 µg	4%
Electrolytes		
Sodium	1 mg	0%
Potassium	232 mg	5%
Minerals		
Calcium	35 mg	3.5%
Copper	0.070 mg	8%
Iron	0.37 mg	5%
Magnesium	17 mg	4%
Manganese	0.128 mg	5.5%
Selenium	0.2 µg	<1%
Zinc	0.15 mg	1%
Phyto-nutrients		
Carotene-ß	85 µg	--
Lutein-zeaxanthin	9 µg	--

(Source: USDA National Nutrient data base)

Health Benefits of Fig

Though the fresh ripe fig fruit is very delicious and highly perishable, the great bulk of the world production is dehydrated. It can be eaten either fresh or dry and has a sweet taste and variety of health benefits that it provides. Though in India fresh Figs are not easily available but can be found in the form of dry fruits popularly known as Anjeer. The details of health benefits are:

- The figs are a good source of flavonoids and phenols compounds have been found in numerous studies that eating one of two medium-sized dried figs equivalent (40 to 50 g) resulted in a significant increase in antioxidant capacity.
- Rich in calcium, figs enhance bone density. They help in overcoming the loss of urinary calcium and thereby preventing the bones from thinning out.
- Figs contain a high amount of fiber compared to any other dried or fresh fruit. While insoluble fiber provides protection against colon and breast cancer, soluble fiber helps in lowering blood cholesterol.
- Figs are known to lower and control high blood pressure since they are packed with potassium, a mineral useful for controlling hypertension. People often complain of potassium deficiency and figs are an excellent source that can be added to their daily diet.
- Enriched with high quality dietary fiber, figs are extremely beneficial for the digestive system. In fact, it improves metabolism and keeps stomach related ailments like constipation and indigestion, at bay.
- The fiber is also essential in reducing the risk of contracting chronic illnesses such as heart disease and diabetes. In addition, it adds bulk to stools thereby promoting proper bowel functioning.
- Fig helps to maintain the acid-alkali balance of the body by very effective neutralizing excess acid.
- Leaves of figs are beneficial for health. They help in lowering the levels of triglycerides, which are major form of fat produced and stored in the body. Increased triglycerides are often associated with obesity and heart disease.
- Since ages, figs have been used to reducing sexual weakness. Soaking 2-3 figs in milk is known to enhance sexual power.
- Fiber and fiber-rich foods such as figs promote weight loss and are highly recommended for obese people. However, when figs are taken with milk, they improve weight or induce weight gain.
- Elderly people often lose their eyesight due to macular degeneration. Fruits like figs are great in sharpening vision and keeping the risk of eye diseases away.
- Studies reveal that figs help in reducing the risk of

breast cancer in postmenopausal women. It was found that women who consume more fibrous fruits, such as apples, dates, figs, pears, and prunes, are at a lesser risk.

- Figs have been quite useful in various respiratory disorders like whooping cough and asthma. Furthermore, they are also good in treating constipation, indigestion, stomach ache, fever, earache, boils, abscesses, venereal diseases and promoting good health of the liver.

Why make fig suitable for Bundelkhand region

- Fig is one of the best for drought and salt tolerant fruit crops.
- Fig plants can survive summer temperature as high 45^{0}C and during winter season they can withstand low temperature up to 4^{0}C.
- It is tolerant to forest which is common feature during winter in some parts of Bundelkhan region.
- Availability of distinct summer and winter seasons and dry atmosphere during fruit maturity – a pre requisite for quality fig production.

Climate and Soil

The fruit being a deciduous nature and suitable in sub tropical fruit tree prefers areas having arid or semiarid environment, high summer temperature, plenty of sunshine and moderate water. Although fig tree can survive high temperature as 45^{0}C, the fruit quality deteriorates beyond 39^{0}C. Though the mature tree can stand against low temperature up to 4^{0}C, it makes good growth when the temperature is above 15 - 21^{0}C. The fruit production and quality are markedly affected by climate. But quality figs are produced in the region with dry climate especially at the time of fruit development and maturity size, shape colour of skin and pulp, quality and tendency towards parthenocarpy all are markedly affected by climate. This situation is ideally met out in semi arid region of Bundelkhand.

Fig is one of the most salt and drought tolerant crops. It's can be grown on a wide range of soils, including heavy clays, barns, and light sands, but ideally the soil should be well drained at least in the top 1.0 meter (m) soil having pH of 7-8 is ideally suitable cultivation of fig.

Varieties

A large number of cultivated forms are grown in which of the fruits vary in shape, size, colour of skin, colour and flavour of flesh and period of ripening. Some of the cultivars grown in India are Poona fig, Black Ischia, Brown Turkey, Deanna, Turkish White, Kabul, Marseilles and recent years, a variety called 'Dinkar' an improved over 'Daulatbad' variety for yield and fruit quality is gaining commercial importance.

Propagation

The fig is readily propagated by hardwood cuttings although all types of budding and grafting as well as air-layering are also successful.

a. **Cutting:** Hardwood cuttings, 20-30 cm long and 0.5-0.7 cm thick, taken from 1 to 2 year old shoots in late summer, are treated and root-promoting substance (IBA). Cuttings from the base of the shoot and lower part of crown have to be used as they root better. Best time of cutting in Bundelkhand region is taken during January - February at the time of pruning.

b. **Layering:** Figs can be air-layered successfully and monsoon is the best time for propagation. One year old branches if layered in June can be planted in the field by August – September.

Orchard establishment and management

1. **Planting time:** In Bundelkhand region of India, rooted cutting are transplanted during July – August.
2. **Planting Distance:** Traditionally a spacing of 8 x 8 m. Close spacing of about 5 m is adopted in High Density Planting system and this system is very effective in this region.
3. **Training:** To improve the fig plant more productive and to facilitate inter cultivation operations, the fig trees are trained to a desired height and shape. Fig trees are trained initially to single stem to encourage a wide, symmetrical crown with a mechanically strong framework having evenly distributed laterals. The tree is allowed to grow for about one meter and then it is topped, which induces side branches all round the main stem. The interior of the bush should be maintained free of suckers, dry and sick branches.

4. **Pruning**: It is most important cultural practices for successful fig cultivation. Pruning practiced annually to stimulate production of new growth, and bearing fruits. The time and type of pruning vary with location, variety and number of crops harvested annually. The best time to secure a mature crop is hot, dry summer. Therefore, pruning may be done 4-5 months in advance. During pruning, trees are headed back severely every year, leaving about 2 buds on each one year old shoot. If light pruning is adopted, shoots which have yielded fruits are lightly headed back after harvesting. Copper fungicide should be used to protect the cut ends.
5. **Irrigation:** Fig can sustain heat and drought. However, for commercial production timely irrigation is necessary. During May-June irrigation has to be applied after every 4-5 days interval. Drip irrigation is adopted 15-20 litres of water/day/plant needs to be provided for better growth and development of fig plants.
6. **Integrated nutrient management:** Figs should be manured regularly from the first year. Farm yard manure (FYM) should be supplemented with inorganic fertilizers. One year old trees should be supplemented with 30 kg of farm yard manure (FYM) and 455 g of cake or 35 g of N in the form of urea.
7. **Flowering and Fruiting:** Fig plant may bearing a few fruits even during year of planting but these crop should not be allowed because reduce vegetative growth. Regular yield can be taken when plant age above three years.

Physiological disorders

Sunburn: This is a serious problem of newly planted young trees. The affected parts crack and the bark peels off. Affected trunk or branches may be a centre for infection. Heavy pruning exposing the trunk and branches is responsible for sunburn.

Fruits splitting or cracking: Fruit splitting usually occurs if there is a shower during ripening of fruits. Fruit splitting damages the fruit, making it completely unfit for consumption as it invites infection of rot organisms.

Insect and Diseases:

There are several insects and diseases in fig. The major insect pests are stem-borer, leaf defoliators, scale insects and fruit flies. In addition, dried figs are damaged by the fig moth and the Indian meal moth. However, in arid region where harsh climate condition prevails, no serious insect pest could be observed. Among the diseases, serious one rust and it can be controlled by application of such fungicides like blitox or dusting sulphur or Dithane M-45. Other diseases are anthracnose, leaf spot etc.

Harvesting and yield

Fig tree start bearing from one year but commercial harvesting can be done from 3rd year. The fruit production will increases with increase in canopy size and age of the plant. The life span of this plant is about 30 to 35 years. The harvesting season starts in February to May and the fruit should be harvested in 2 to 3 intervals manually. Maturity time fruits of fig changes colour from light green to blue violate on ripening. Ripe fruits are picked either from the tree by twisting the neck at the stem-end. The average yield of figs is 180-360 fruits/ tree. A harvest of 12 tonnes / ha can be obtained from a well-managed orchard.

Post harvest handling and storage

Fresh fig is highly perishable. The fruits are graded depending on size, weight and type of market. Then the fruits are packed in corrugated fibre board boxes (CFB). Its shelf life is hardly a day or two after harvesting. For maximum life, the fruits should be precooled immediately after harvest to near 0^0C and placed at temperature of –0.5 to 0 ^{0}C and relative humidity (RH) of 85-90 % for only one week.

Processing for value added products

Since figs are very perishable and difficult to transport and cannot be stored long even under refrigeration, they are most suitable for processing into canned, dried, or frozen products depending on the cultivar.

In India, the demand has been increasing for dried fruits with higher than usual levels (15-20 %) of moisture. Such fruits are softer in texture and more readily prepared for eating. Traditional method of drying is sun drying and it is very easy method for drying. The semidry figs collected from the orchard are placed in one layer on wooden drying trays.

These trays are positioned in a special part of the orchard, the drying yard, usually located in a sun-exposed open area away from dust and potential sources of infection, but not far from a shelter used for storing the dried fruit in piles or sacks before selling it to a procurement agent. During sun drying, the fruits are kept on the trays, and each fig is periodically turned from one side to the other until water content of 15% to 20% is reached. Usually it takes 3 to 5 days, depending on the weather.

The main problem of the sun-drying method is the high risk of fruit infestation with pests and pathogens due to its contact with soil and prolonged exposure to open environment.

Future strategies for commercial fig cultivation in Bundelkhand region

- Development of package and practices for commercial cultivation.
- To develop technology for different types of value addition and its popularization.
- To develop data base on area & production.
- Standardization of effective technique for faster multiplication of elite clones.
- Awareness programme to educate farmers on fruit culture in adverse agro-climatic condition.
- Development of marketing channel for popularization and revenue generation.

Fresh Fig

Dry Fig

Integration of gums and resins yielding trees in agroforestry systems for livelihood support in Bundelkhand, Central India

Rajendra Prasad, R. Singh, B. Alam, A.K. Handa, Ashok Shukla, Prashant Singh and Anil Kumar

Natural gums and resins are among the most important non-timber forest products and their production base has been declining due to unscientific over tapping of existing trees in forests. Integration of gum/resin-yielding trees in agroforestry systems offers better utilization of available resources and increasing productivity on sustainable basis. Research experiences at ICAR-CAFRI Jhansi revealed that growth of *Acaciasenegal* (gum arabic) in semi-arid region of Bundelkhand has been better than that in arid region, and the trees are expected to yield good quantum of gum arabic. This will create an opportunity for farmers to earn extra income for their family besides ensuring ecological stability of the land-use.

Natural gums and resins are the most important non timber forest products (NTFP) widely traded in national and international market. In modern times applications of gums and resins have expanded world over in many industries such as paper, textile, petroleum, pharmaceutical, cosmetics, food, varnishes, lacquers and soap. The world's major producer of gums and resins include India, China, Sudan and Indonesia. India annually produces 281000 ton which include about 224000 ton of gums, 55500 ton of resins and 1500 tons of gum-resin. Traditionally, India is the largest producer of lac, guar gum and karya gum. The bulk of commercially important gums in the country come from the Central Indian Forests consisting of states like Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Odisha, Jharkhand and Bihar. The gum producing areas are the Western Ghats, Eastern Ghats, and surrounding areas. Though there are more than 30 commercially important gum and resin species available in India, the number of important trees with substantial production is rather small. Among thevarious kinds of gums, the important species are gum karaya (Sterculia Urens), gum dhawara (*Anogeissus latifolia*) and gum arabic (*Acacia senegal*). Among resins, the important ones are Sal resin (*Shorea robusta*), Salai (*Boswellia serrata*), black dammer (*Canarium strictum*) and Guggul (*Commiphora weightii*).

The gums and resins trade in India faces declining trend in the production base of the produce due to ruthless tapping and unorganized harvesting approaches. However, the demand for natural gums and resins has been continuously increasing in the world market since90's. Integration of gums and resins yielding trees in agroforestry land use may help in increasing production base of gums and resins, and provide a new option of livelihood support to small holders at the edge of climatic vulnerability. Besides, the gum and resin based agroforests will also contribute in mitigating enhanced CO_2 in atmosphere. This article is an attempt to showcase the potential of agroforestry land use for producing gums and resins for livelihood support.

Gums and resins

The terms gums and resins generally refer to sticky, smooth and elastic plant exudations. It is not easy to pin point precise difference between gums and resins. In day to day language both terms gums and resins are used interchangeably, however, experts differentiate between two terms on the basis of some characteristics. According to them some plants yield only gums, some only resins, andyet some yield both gum and resins. Gums are exuded by plants partly as natural phenomenon and partly as a result of disease or injury to the bark of wood. These arise chiefly from the stem but sometimes also from the roots and

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even from the leaves and other parts of plants. Gums are primary formed by the disintegration of internal plant tissue through a process known as gummosis. The process breaks down the celluloseand hemi-cellulose, both of which are complex carbohydrates located in the cell wall of plants. Gums are comprised of carbon, hydrogen, oxygen and found in a large number of families. Notable among them are leguminosae and sterculiaceae. Other important gum yielding families are Anacardiaceae, Combretaceae, Meliaceae, Rosaceae and Rutaceae. On the basis of solubility gums can be grouped into three category viz., soluble, insoluble and semi-soluble. Soluble gums dissolve in water and form more or less transparent, viscous and adhesive solutions, for example gum arabic. Insoluble gums often swell with the addition of water and forms gel, for example gum Karaya. The semi-soluble gums decompose completely without melting on heating. The use and commercial value of gum is determined by its physical and chemical properties.

Resins are oxidation products of various essential oils and complex in nature with varied chemical composition. They usually occur as derivatives of starch and are mixture of volatile and non-volatile compounds. All the natural resins are vegetable in origin with the exemption of lac (it is a natural resin and comes from an insect *Laccifera lacca* Kerr. Resins are not edible, aromatic and inflammable. They are insoluble in water but usually dissolve readily in alcohol, ether and certain other solvents. Resins can be classified into three categories. The first one is the Dammers, which are hard and transparent resins containing a small amount of essential oils. The important commercial species under this category are Canarium, vateria and shorea, Copals and Shellac. The second one is Myrrh, aromaticoleo resins containing considerable amount of essential oils, mainly from genus Commiphora. The third categoryis Frankincense that is gum resin from species Boswellia. Major resins available in India are Sal (Shorea robusta), Salai (Boswellia serrata), Frankincense, Black Dammer (*Canarium strictum*), Guggul (*Commiphora mukul*), Vellapine (*Vateria indica*), Chir pine (*Pinus roxburgii*), Gurjan (*Dipterocarpus terbinatus*) and Indian Gamboge tree (*Garcinia morella*). The major resin producing states are Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh and Odisha. Resins are found in a large number of families. Notable among them are Pinaceae, Fabaceae, Burseraceae, Dipterocarpaceae.

Production and market

India has always been an important trade center for high quality natural gums and resins. Some 20-30 years back, Mumbai used to be the most important center in India for trade in gums- both for exports and internal trade. Gums from all over India used to reach Mumbai for export to other countries. Besides, gums imported from other countries too were exported from here. But things have changed beyond recognition now. The number of traders has reduced tremendously due to change in profession and other factors. Twenty years ago, there were more than 20 gum exporters in the country. There are only four now. Though the volume of trade and the number of actors have reduced, the importance of Indian gums and resins is still intact. It is now operating on a much smaller scale and is a clear cut supplier and exporter relationship without many intermediaries. On the supply side, state level forest corporations or tribal development corporations like the GCC in Andhra Pradesh, Gujarat forest department in Gujarat, Madhya Pradesh MFP Federation and Chhattisgarh MFP Federation control more than half the production of gums and resins in the country. The rest of the trade is normally carried out in an informal way by itinerant traders. While it is a very lucrative proposition for those engaged in the trade, the collectors often receive a pittance for gums sold this way.

Among the natural gums, the gum Arabic exuded from *Acacia senegal (*Linn*)* Willdis the most superior in quality and highly priced in the market (Rs. 500-700/kg). World's 90% gum Arabic is produced from *Acacia senegal*. The quality of gum is very superior as compared to gum from any other species of *Acacia*. Nearly 90% of gum Arabic is produced by Republic of Sudan especially from (Kordafan). Production of gum Arabic is meagre in

India, and contribution to the world production is negligible. The total annual output of gum Arabic is only 800 Mt compared to world production and consumption of 60,000-70,000 Mt. The domestic production is insufficient even for domestic consumption and hence, imported from Sudan and Nigeria to meet India's requirements. Gum exudes from cracks in bark of trees, mostly in the dry season. In Sudan the annual yields from young trees ranges from 188 to 2856 g (av. 0.9 kg), and from older trees, 379 to 6754 g (av. 2.0 kg). In India, however, the productivity is low varying from 175 to 550g tree^{-1} year^{-1}. The main gum producing regions of India where natural as well as planted stands of *A. senegal* occur are in desert and arid region of Rajasthan, Gujarat, Haryana, and Punjab.

Gum-resin based agroforestry systems

Agroforestry is the integration of trees into farming systems for producing various marketable food and non-food products. Besides, agroforestry offer great potential of sequestering atmospheric carbon and an almost zero cost approach for restoration of badly degraded land through nitrogen-fixing trees and shrubs. The tree products viz. fodder, wood, fuel, fruits, nuts, resins, gums, extractives, medicines, etc makes agroforestry the best land use system in the era of changing climate. This is the reason why agroforestry has been widely promoted in tropical countries. In India, the area under agroforestry is likely to increase substantially in the near future. There are many gums yielding tree species which can be planted as woody components along with crops in an agroforestry model. The associated crop and trees can vary from region to region and such agroforestry models will be highly beneficial to the resource poor farmers in providing livelihood security. For development of gum and resin based agroforestry models, selection of tree species which produce gums and resin is first requisite. The tree species identified for different climatic region are given below:

i). **Arid and Semi-Arid:** *Acacia nilotica, Acacia catechu, Acacia senegal, Anogeissus latifolia, Bauhinia retusa, Bombax ceiba, Boswellia serrata, Butea monosperma, Commiphora mukul, Shorea robusta, Sterculia urens.*

ii). **Sub Humid:** *Acacia catechu, Bombax ceiba, Canarium stritum, Dipterocarpus turpinatus, Garcinia morella, Hopea odorata, Shorea robusta.*

iii). **Humid Tropics:** ***Bombax*** *ceiba, Canarium stritum, Cochlospermum religiosum, Dipterocarpus turpinatus, Garcinia morella, Hopea odorata, Kingiodendron pinnatum, Lannea coromandelica, Pinus wallichiana, Sterculia urens, Veteria indica*

iv). **Sub-Tropical:** *Acacia nilotica, Acacia catechu Acacia senegal, Anogeissus latifolia, Bauhinia retusa, Bombax ceiba, Boswellia serrata, Butea monosperma, Cochlospermum religiosum, Commiphora mukul, Garcinia morella, Hopea odorata, Kingiodendron pinnatum, Lannea coromandelica, Pinus roxburghii, Sterculia urens*

v). **Temperate:** *Butea monosperma, Dipterocarpus turpinatus, Garcinia morella, Kingiodendron pinnatum, Pinus roxburghii, Veteria indica*

vi). **Moist:** *Dipterocarpus turpinatus, Kingiodendron pinnatum, Pinus roxburghii, Pinus wallichiana, Veteria indica*

The agroforestry models can be developed by planting selected tree species for the given agro-climatic condition. Trees can be planted on boundary of the field or as rows inside the field. The distance between row to row and tree to tree in a row depends on growth behaviour of tree species and associated crops. Generally row to row distance should be such that agricultural operations can be performed without any hindrance. To reduce harm full effects of trees on associated crops, tree pruning must be conducted. Before establishing an agroforestry model, expert opinion of the specialist must be taken. The associated crops should be selected on the basis of selected tree species and its growth behaviour so that both components (woody and annual crop) offer minimum competition to each other. Gum and resin yielding tree species should be planted after getting complete information on produce quality and its market.

Among four major agroforestry systems based on the nature of woody perennial and annual components, agrisiliviculture system with different gum and resin yielding trees, fruit trees and agricultural crops in different combinations can be practised. As for as possible, wider spacing is advised to allow optimum sun light in the inter spaces and minimize reduction of annual crop yield. Choice of the annual crop will depend upon the farmer's interest and the local edapho-climatic conditions. In areas where soil quality is poor (degraded, sloppy, less soil depth, rocky out growth, low nutrient status), block planting of gum and resin yielding trees is recommended with 6 x 6 m spacing. In this system, intercropping of agricultural and fodder crops can be taken during the first 2 – 3 years. To ensure the seedling survival and better establishment, bigger pit size of 1x1x1 m is advocated in addition to soil and water conservation measures. The recommended spacing are 20 x 10 m for fruit tree and crop combination, 6 x 6 m for block plantations, 5 m spacing between trees for boundary plantation, 4 m spacing between trees for live fencing in case of thorny species and from 2.5 to 5 m spacing for fruit trees.

Research initiatives in Bundelkhand

Integration of *Acacia senegal* in traditional grazing grounds such as *orens* and *gochars,* systematically raised silvopastoral systems and other agroforestry landuse for production of gum Arabic can be a profitable proposition. It will not only provide alternative livelihood options to local people but also increase economic viability of the land use. In Bundelkahand, there is a good scope for extending area for large- scale plantation for production of gum Arabic. The area covered under forest, barren and uncultivable pastures, and community grazing land can be used for commercial plantation of *A. senegal.* The Bundelkhand region typically represents semi arid climate and is prone to frequent drought. Most of the terrain is undulating with rocky and gravely surface. Cultivation of gum Arabic can provide an alternative livelihood option to the poverty stricken farming community. Assuming average yield of 250g per tree, a farmer can harvest about 25kg gum per year by planting 100 trees/ ha on field boundary or at spacing of 10 x 10 m. This would generate revenue of Rs 12500 ha^{-1} $year^{-1}$ if, gum is sold at a minimum price of Rs. 500 kg^{-1}.

For developing suitable agroforestry models based on gums and resins yielding trees, research efforts are being made at ICAR-Central Agroforestry Research Institute, Jhansi (CAFRI); which is one of the co-ordinating centres in the network project on Natural Resin and Gums headquartered at Indian Institute of Natural Resin and Gums, Ranchi. Under this project the major thrust is given to gum production techniques on naturally growing *Butea monosperma* trees (palas) and development of agroforestry models based on gum yielding trees viz., *Acacia nilotica*, *A. senegal* and *Anogeissus pendula* in Bundelkhand region of Central India. In Bundelkhand region of Central India, *Butea* trees occur naturally and widely distributed on farmer's fields, degraded land common grazing areas and forests. Studies at CAFRI have revealed that on average, 10-15 trees/ha of *Butea monosperma* are available on farmer's field and used by local tribe (Saharia) for collecting gum-butea called *kamarkas*. Yield of gum-butea greatly depends on tree growth factors and incisions made on bark of the stem. Significant correlations exist between number of man-days employed and number of trees approached, total amount of gum collected and total income. *Butea* tree is also a host for lac insect and offers great potential for lac cultivation, besides yielding gum. Hence, studies were also conducted to assess effect of lac production on gum yield and vice versa in *Butea monosperma*.

For tapping of gum from the existing trees in the agroforestry system, improved tapping techniques and use of gum inducer (ethephon) are being experimented to obtain more gum yields. Results of studies conducted to assess whether type of incision on bark had any effect on yield of gum-butea revealed that out of four types of cuts *viz.* knotching, vertical cuts, slant cuts and horizontal cuts on bark of the stem, maximum gum-butea was obtained with knotching and minimum with slant

cuts. The initial results of a study conducted to assess effect of inoculation of lac insect on gum yield of butea trees revealed that inoculation of lac insect increases gum exudation. On use of ethephon for inducing gummosis in *Butea monosperma* (Lam.) in Bundelkhand region, it has been observed that the yield of gum-butea was significantly increased by application of ethephon, however, varying doses of ethephon had no effect on gum yield. On an average, maximum amount of gum-butea was obtained when ethephon was sprayed on surface on tree stem before knotching. The studies on use of ethephon to induce gummosis in *Anogeissus pendula* E. revealed that maximum gum yield was obtained in the month of October followed by March. During rainy season and summer months, exudation in *A. pendula* was not observed. Dose of 1170 mg ethephon yielded highest gum (65.3g/tree) while 390 mg the least (37.5g/tree). The exuded gum was of variety of forms viz. globular, tear shaped or irregular masses and good quality. Use of ethephon did not show any negative effect on tree health. In view of negligible gum oozing from *A. pendula* in nature, application of ethephon @ 1170mg/tree in the month of October has been suggested for enhancing gummosis and gum yield.

Research initiatives for developing agroforestry models revealed that after seven years of planting of various agroforestry models, survival and growth of planted gum yielding trees and horticultural plants was more in models developed at research farm than the models on farmer's field. Out of the two gum yielding tree species, better performance has been shown by *A. nilotica* than *A. senegaon farm,* however on farmers field reverse was true (Figure 1). Among horticultural species *E. officinalis*had shown maximum growth while *C. carandus* the least. The main reason for poor survival and growth of planted species on farmers' field was uncontrolled grazing due to practice of *annapratha.* In *anna pratha* the cattle are let loose, which openly graze and trembles growing saplings planted on farmers' fields. The planted seedlings require to be protected from moving cattle in beginning for 2-3 years.

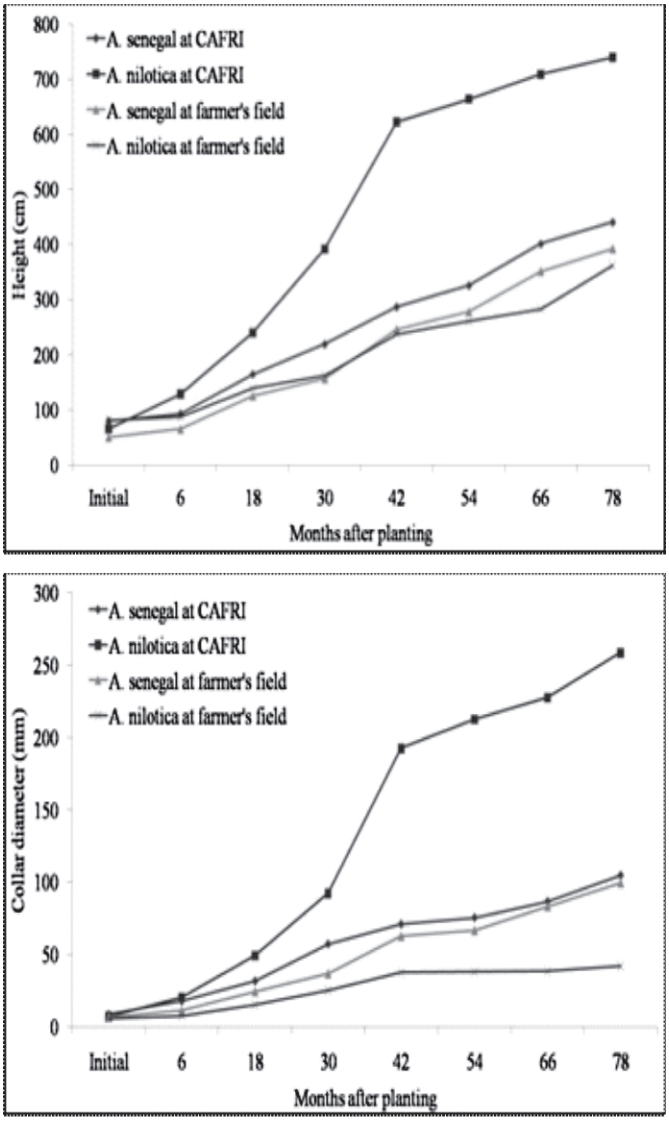

Fig 1. Comparative performance of gum-yielding trees (*Acacia senegaland Acacia nilotica*) at research farm and farmer's fields

A. senegal performed better in semi- arid region of Bundelkhand than arid region of western Rajasthan wherein after 12 years of age plants reported to attain height of about 3.0m on rocky and gravely soil. *Acacia nilotica* planted at farm has started exuding gum after 4 years whereas, gummosis in *A. senegal* was observed after 5 Year. On farmers field, no gummosis was observed either in *A. nilotica or A. senegal.* In agri-silvi-horti models established at CAFRI oozing of gum in *A. senegal* has been observed after five years and gum yield varied from 26.1 to 134.7 with mean of 58.7 g/ tree. The number of gum tears varied from 3 to 7 per tree (Plate1).*The yield of gum Arabic is likely to increase in future as the trees grow in age.*

Plate 1. Natural oozing of gum and gum-tears from tree of *Acacia senegal* in Jhansi, Bundelkhand

Despite constraint of *anna pratha* in Bundelkhand, the farmers of the region are getting attracted toward Gum arabic (*A. senegal*) based agroforestry models developed at CAFRI Jhansi (Plate 2), and many farmers have planted *Acacia senegal* on their fields. The Institute is helping farmers and providing seedlings free of cost. In last five years about 8000 seedlings of gum Arabic (*A. senegal*) have been planted in Parasai, Chhatarpur, Bachouni (Jhansi in U.P.) Shivrampur, Dabar and Garkundar (Tikamgarh in M.P) villages on farmers's field mainly as boundary plantation. The farmers preferred this species as it act as live fence besides yielding gum Arabic.

Plate2. Green gram intercrop in gum arabic based agroforestry model: *Acacia senegal* + Aegle marmelos + *Citrus limonin* Jhansi, Bundelkhand

Forage and livestock based strategies for enhancing livelihood of Bundelkhand farmers

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The agriculture in Bundelkhand region is a crop - livestock mix. The importance of forages and livestock sector is increasingly being realized from all corners in recent times due to their multifaceted role in sustainable production, employment generation, drought proofing, natural resource conservation, nutritional security and export potential. Forage and livestock have special significance in highly vulnerable areas like Bundelkhand. This article briefly describes all the prevailing issues in forage and livestock sector and strategies required to meet the challenges so as to give some insights to researchers, teachers, students, farmers and planners for this sector with specific reference to Bundelkhand.

Bundelkhand region is located in central India and comprises 13 districts of Uttar Pradesh and Madhya Pradesh. Jhansi, Jalaun, Lalitpur, Hamirpur, Mahoba, Banda and Chitrakut are seven districts of Uttar Pradesh and Datia, Tikamgarh, Chattarpur, Damoh, Sagar and Panna are six districts of Madhya Pradesh. Bundelkhand is the most backward region of India and suffering from natural resource degradation, absolute poverty, very low crop productivity (1-1.5 Mg/ha), low rain water use efficiency (35-45 %), high erosion, poor soil fertility, scarce ground water resource, erratic rainfall, frequent droughts, heavy biotic pressure, frequent crop failures resulting in scarcity of food, fodder and fuel and high migration. Frequent droughts in Bundelkhand region brings in varied difficulties for crop production and livestock rearing. Critical analysis of rainfall data of Jhansi revealed that its rainfall had decreased by 319.5 mm over the period of 76 years from 1068.4 mm with the rate of 4.2 mm/year. Moreover, out of past 17 years (2001-2017), 10 years experienced moderate to disastrous drought.Crop failure due to drought restricts availability of crop residue thus making rearing of livestock most difficult to farmers. Given this situation, farmers are left with only option of leaving their livestock, mainly the unproductive ones for free grazing. This system however has off late become bone of contention drawing attention of many technologists, administrators and policy makers. This many times is creating conflicts in the farm community besides forcing other farmers not to cultivate their fields during summer and kharif seasons. Lack of alternate employment opportunities in Bundelkhand forces farmers to migrate towards big cities in search of better livelihood. There have been reports on farmers' suicides and distress sale of animals in the region.

It appears that agrarian distress is spreading across the region and making agriculture as a profitable business is the biggest challenges before policy makers, scientists and farmers. Fortunately, the present government gave it a high priority and targeted for doubling farm income by 2022.Accordingly, Government of India allocated more resources to agriculture and started a number of programs for expanding irrigated area, improving soil health, promoting agro-processing, insuring production risk and raising minimum support price (MSP) among many others. Urbanization has brought a marked shift in the lifestyle of people in feeding habits towards milk products, meat and eggs with resultant increase in demand of livestock products. Rapidly developing peri-urban livestock farming, emerging fodder markets and vibrant cooperative dairy sector are indicators of fast changing economic scenario in livestock sector.Strong farm-gate prices and rising demand for

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value-added products due to increasing consumer income are stimulating increased milk production in India. Growing private investment in dairy processing facilities is providing further impetus. Therefore, livestock sector can be a major boosting factor in doubling farm income.However, to realize full potential of forage and livestock sector, we need to remove hurdles being faced by it.

Challenges and issues

- Low productivity (milk, meat and egg) levels of livestock.
- Huge gap in demand and supply of fodder.
- Regional and seasonal deficiencies or imbalances in fodder demand and supply.
- Forage is bulky in nature and it is not economical to transport the surplusforages over long distances.
- The available forages are poor in quality and deficient in available energy, protein and minerals. Farmers maintain large herds of animals to compensate for the low productivity, which adds to the pressure on fodder and other natural resources
- The area under cultivated fodder is only 8.4 million ha, and has been static during last two decades. The scope for further increase seems to be very low due to demographic pressure for food crops.
- The recent crop diversification where a commercial crop replacing the traditional cereal crops especially the coarse cereals is likely to have an impact on the availability of crop residues for animal production.
- The productivity of some prominent cultivated forages is highly variable.
- Genetic resource enhancement in forage crops remained confined to cultivated crops. Improvement programmes on range grasses and range legumes were not given proper attention which is a major constraint in the development of grassland and pastures.
- Quality seed availability of forage crops is just 15-20% of requirement.
- Forage crops in general and range grasses and legumes in particular are shy seed producers.
- There is also lack of seed standards for perennial grasses and legumes.
- Climate change and its impact on sustainable forage production is another important issue in recent times. Bundelkhand is comparatively more vulnerable to climate change due to large number of population depend on agriculture and therefore pressure on natural resource increases for their livelihood.

Strategies

The issues related to the development of forage based cropping system/silvi-hortipastoral system for extreme weather situations, mitigation and adaptation strategies, standardization and validation of district-wise forage production modules, precision farming in intensive forage based system of milk shed areas, livestock based integrated farming systems for efficient resource use and enhanced farm productivity, forage based contract farming and cooperative farming, utilization of problem soils for fodder production in existing system, silvipasture technologies for reclamation of wasteland and problem areas, region and need specific hortipasture technologies for wide adoption, non-competitive land use pattern for enhancing forage resources, augmenting production from range grasses and trees in watershed areas, grassland and pasture land resource survey and amelioration for enhanced optimum productivity and enhancing livelihood options for pastoral and nomadic communities by enhancing production of pasture lands/ grasslands etc are to be addressed. The specific strategies are as following:

Development of high yielding forage varieties

- Development and identification of novel planting material is an important issue for harnessing the full potential of both cultivated and non-cultivated lands.

- During last six decades, more than 300 forage crops varieties in berseem, lucerne, cowpea, guar, field bean, oats, pearlmillet, *Cenchrus*, Dinanath grass, guinea grass, *Sehima*, *Chrysopogon*, *Heteropogon* etc. have been released through national forage network.
- Breeding dual purpose cereals and grain crops, breeding specifically for stress tolerance and degraded lands and finding new niches for fodder production should be our focused area.
- The breeding strategies should be supplemented with appropriate pre-breeding procedures, biochemical and physiological basis of improved production.

Forage production from arable areas

- Enhancing forage productivity per unit land area through efficient natural resource management.
- Integration of fodder crops in the existing cropping system and development of new food-fodder systems. Introducing the leguminous fodder crops in the wider spacing of the grain sorghum is an excellent example of food-fodder cropping systems.
- Improved crop sequences and crop management practices for irrigated and rainfed conditions should be developed to ensure the maximum use efficiency of available resources.
- Intensive forage production systems include multiple cropping, intercropping, overlapping cropping and relay cropping. Under assured irrigation, multiple crop sequences like sorghum (multicut) + cowpea - berseem + mustard - maize + cowpea and sorghum (multicut) + cowpea - berseem + mustard are promising. Overlapping cropping system developed involving seasonal and perennial forage crops like guinea grass and napier bajra hybrid intercropped with cowpea during summer and *Kharif* and berseem in *Rabi*, has the capability of providing round the year green fodder (200-300 t/ha) to the dairy animals also small farmers having limited land holdings for food and forage production. In Bundelkhand region, maize – berseem cropping sequence recorded maximum wheat equivalent yield as compared to groundnut – wheat + mustard and black gram – wheat + mustard.
- The combination of graminaeous and leguminous fodder crops not only improves herbage quality but also maintains soil fertility over a long period due to biological N fixation, addition of root organic matter and better utilization of plant nutrients from different soil depth.
- Emphasis should be given for augmentation of forage production through INM, conservation tillage, contingent crop planning, climate resilient cropping system, crop diversification, soil carbon sequestration and its management, farming system research and micronutrient management in soil-plant-livestock continuum.
- Livestock based integrated farming system models for different target groups, such as, dairy farmers, peri-urban farmers, farmers practicing intensive agriculture and rainfed farmers, etc., are being tested and refined at IGFRI research farm as well as at farmers field.
- There is need and great scope for use of machines in fodder production, conservation and post-harvest management of fodder.

Forage production from non-arable lands and CPRs

- Grazing based livestock husbandry continues to play an important role in Bundelkhand as more than 50% livestock depend on grazing in forests, private lands,common property resources (CPRs) and other grazing areas.
- In order to increase the pasture productivity, it is essential to replace low yielding annual grasses with high yielding perennial grasses and introduction of multipurpose tree species that are adaptable to the prevailing conditions.
- Introduction of suitable pasture legumes is one of the best ways to improve the forage quality and soil health.
- The CPRs can also be effectively utilized for fodder production through participatory watershed based approach.

- Many studies have supported this view that grasses, legumes and trees in a silvipastoral system provide effective land cover as well as produce nutritious fodder for livestock, sequester carbon and upgrade the environment.
- Grassland restoration and improvement through protection of grassland for vegetation recovery, removal of unwanted bushes, re-seeding of grasslands with perennial and productive species of grasses and legumes, application of fertilizers for higher productivity and subsequently utilization of grassland either through cutting or grazing in a suitable manner.

Forage processing and post harvest management

- Post-harvest management of surplus fodder is the best mitigating strategy for abating regular phenomenon of seasonal and regional deficit of forage and during natural calamities like drought and flood.
- Major dependence of livestock on crop residues calls for its effective post-harvest processing, value addition, densification, storage and transport.
- Bailing and enrichment of crop residues particularly paddy straw and other leguminous crop residues for proper storage, balanced feeding with green fodder and minimizing wastage and storage loss.
- Use of leaf meals from leguminous fodder, crop residues from pulses (lentil, gram, grass pea, stylo) and tree leaves (subabool, gliricidia, khejri, etc.) may substitute costly concentrate.
- Technology has been developed to conserve surplus fodder for use during the lean period either as hay. silage, bales, fodder blocks, leaf meals, etc.
- Forage resource availability round the year needs to be enhanced through promotion of fodder bank which will include feed block, leaf meal and mandatory region specific mineral mixture supplementation.

Non-conventional and alternative niches for enhanced forage supply

- The non-conventional feed resources (NCFR) generally refer to all those feeds that have not been traditionally used for feeding livestock and are not commercially used in the production of livestock feeds.
- The term NCFR has been frequently used to describe sources such as oil palm by-products, cassava foliage, spent brewer's grains, rubber seed meal, single-cell proteins and feed materials derived from agro-industrial by-products of plant and animal origin, poor-quality cellulosic roughages from farm residues and other agro-industrial by-products such as slaughter-house by-products and those from the processing of sugar (bagasse, molasses) cereal grains, citrus fruits and vegetables from the processing of food for human consumption and some aquatic plants.
- The fodder sugar beet, fodder sugarcane, sugarcane tops, spineless cactus, lathyrus, vicia, tree leaf meals, etc. are also included in NCFRs.
- The availability of NCFR, especially of plant origin, is dependent to a large extent on the type of crops being cultivated and the prevailing degree of application of the crop technology.
- The NCFRs are not to replace the traditional feeds and fodder but to be used to supplement the existing limited feed resources.