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EDITORIAL

Agriculture is a priority sector accounting for the livelihoods of major population of the country. In recent years, the agriculture sector has witnessed a transformative wave driven by the integration of Artificial Intelligence (AI) technologies to tackle the obstacles of traditional farming and ensuring sustainable growth. The application of AI in agriculture has been considered as one of the viable solutions for challenges of agriculture sector. Farmers can optimize crop management, enhance productivity, minimize resource wastage and overcome various challenges associated with supply chains by harnessing the power of AI.

The significant advantage of AI in agriculture is precision farming. Implementation of advanced algorithms and machine learning techniques bring unprecedented precision and efficiency to crop management. AI algorithms can monitor factors like soil conditions, weather patterns and crop health in real-time by analyzing images and data from various sources such as field sensors, satellites and drones. This enables farmers to make informed decisions on irrigation, fertilization and pest control. The ability to apply inputs precisely where and when they are needed optimizes resource usage, reduces waste and increases crop yields. Additionally, AI algorithms can provide recommendations for optimal planting patterns, crop rotation strategies and fertilization schedules, leading to improved crop health and productivity. With AI as a partner, farmers can enhance their decision-making process, resulting in healthier plants and more productive harvests.

AI-driven automation is revolutionizing traditional farming practices. Autonomous vehicles like self-driving tractors, robotic harvesters equipped with computer vision and machine learning capabilities can perform tasks such as seeding, planting, and harvesting with unmatched accuracy and efficiency. These robotic systems alleviate the burden of labour-intensive activities, thereby overcoming labour shortages and reducing costs. Additionally, robots can work tirelessly in harsh conditions, ensuring consistent output and minimizing post-harvest losses. By embracing automation, farmers can focus on higher-level tasks and overall farm management, leading to improved productivity and profitability.

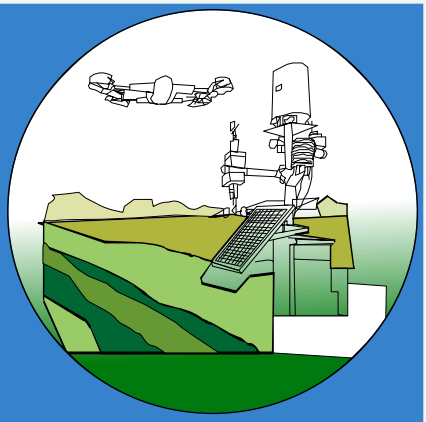
In the face of mounting environmental challenges, AI offers innovative solutions to foster sustainable agriculture. By optimizing inputs and reducing wastage, AI-driven systems contribute to more sustainable farming practices. AI algorithms can provide recommendations on optimal input levels, taking into account local conditions and specific crop requirements. By implementing precision agriculture techniques, farmers can minimize chemical runoff, protect biodiversity, reduce carbon footprints and conserve natural resources, contributing to a more sustainable and environment friendly farming ecosystem.

Climate change is another factor which poses significant challenges to agriculture, with extreme weather events becoming more frequent and unpredictable. AI, coupled with climate data and predictive analytics, can assist farmers in managing risks associated with weather fluctuations. By analyzing historical climate patterns and current data, AI algorithms can provide early warnings for droughts, floods or disease outbreaks hence, enabling farmers to adapt their practices accordingly and mitigate potential losses.

While the potential of AI in agriculture is immense, it is crucial to acknowledge and address potential challenges. Adoption barriers such as high costs, lack of infrastructure and limited access to technology hinders widespread implementation. Additionally, concerns about data privacy, security and potential displacement of farm labour must be carefully addressed through appropriate policies and regulations.

Dr. Sanjay Kumar Joshi

Transforming Future of Agriculture Through Internet of Things (IoT) and Smart Agriculture



Nidhi Kumari[1], P. K. Singh[2] and M. L. Meena[3]

The UN Food and Agriculture Organization have estimated that world would need to produce 70% more food in 2050 to fulfil the requirement of its exponentially growing population. It is high time to enhance farm yield in the scenario of shrinking agricultural lands and depletion of finite natural resources. Limited availability of natural resources such as fresh water and arable land along with slowing yield trends in several staple crops, have further intensified the problem. Another hindering concern over the farming industry is the shifting structure of agricultural personnel. Moreover, agricultural labour in most of the countries has declined. As a result of the declining agricultural workforce, adoption of internet connectivity solutions in farming can play a major role. Espousal rates for Internet of Things (IoT) are accelerating worldwide reaching nearly 43% of enterprises. However, use of IoT applications in today's agricultural landscape is just the beginning. IoT enables devices embedded with sensors to connect and interact with each other via the internet. Devices can be remotely monitored and controlled in real time, and can include anything from pumps and tractors to weather stations.

Smart farming is a management concept focused on providing agricultural industry with the infrastructure to leverage advanced technology including big data, the cloud and the internet of things for tracking, monitoring, automating and analysing operations for precision farming. Smart farming is software managed and sensor monitored having importance due to increasing global population and demand for higher crop yield, need for judicious use of natural resources, increasing use and sophistication of information and communication technology and increasing need for climate-smart agriculture. Smart farming and smart agriculture are mostly used to refer to the application of IoT solutions in agriculture. Such applications include farm vehicle tracking, livestock monitoring, irrigation scheduling, surveillance of disease and pest, storage monitoring etc. The approaching years will see the cumulative use of these smart farming and other technologies. In fact, IoT device installations in the agriculture world are projected to experience a compound annual growth rate of 20 percent, and according to a January 2016 machina research report, the number of connected agricultural devices is expected to grow from 13 million at the end of 2014 to 225 million by 2024. Internet of things, with its real-time, accurate and shared characteristics, will bring great changes to the agricultural supply chain and provide a critical technology for establishing a smooth flow of agricultural logistics. The IoT technology is more efficient due to following reasons:

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- Global Connectivity through any devices.
- Minimum human efforts
- Faster Access
- Time Efficiency
- Efficient Communication.

IoT modernization helps in assembling information on circumstances like climate, dampness, temperature and fruitfulness of soil, Crop web-based examination empowers discovery of wild plant, level of water, bug location, creature interruption in to the field, trim development, horticulture. Role of IoT is shown in Fig.1.

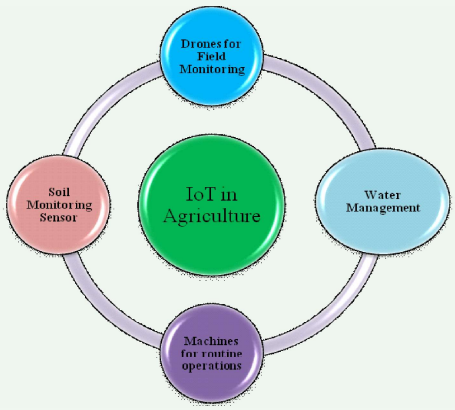

Fig.1. Role of IoT in Agriculture

The key advantages of using IoT in enhancing farming are as follows:

1. Water management can be done efficiently using IoT without wastage of water using sensors.
2. IoT helps in continuous monitoring of the land so that precautions can be taken at early stage of cultivation.
3. It increases productivity, reduces manual work & time and makes farming more efficient.
4. Crop monitoring can be done easily to observe the growth pattern of the crop.
5. Soil management such as pH level, moisture content etc. can be identified easily so that farmer can sow seeds according to soil moisture level.
6. Sensors and RFID (Radio frequency identification system) chips aid in recognizing the diseases incidence in plants and crops. RFID is an automatic technology and aids machines or computers to identify objects, record metadata or control individual target through radio waves. RFID tags send the Electronic Product Code (EPC) (information) to the reader and are shared across the internet. The farmer or scientist can access this information from a remote place and take necessary actions. Hence, the crops can be protected from coming diseases automatically.
7. Crop sales will be increased in global market. Farmers can easily connect to the global market without restriction of any geographical area.

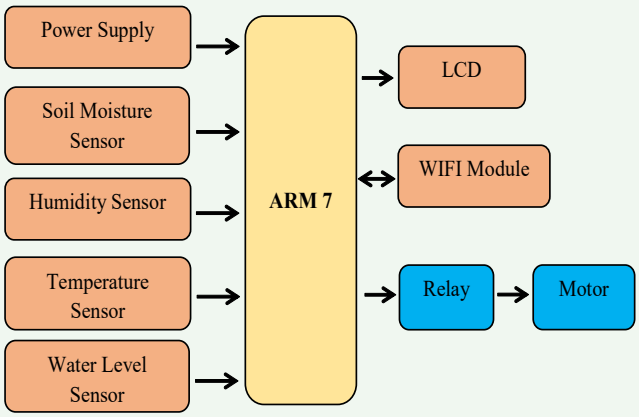

Fig.2. IoT System Block Diagram

The intelligent farm includes the use of smart farming technologies such as:

- Sensors for soil scanning and water, light, humidity and temperature management.
- Telecommunication technologies such as advanced networking and GPS.
- Hardware and software for specialized applications and for enabling IoT-based solutions, robotics and automation.
- Data analytics tools for decision making and pre-

Fig.3. Agriculture Drones

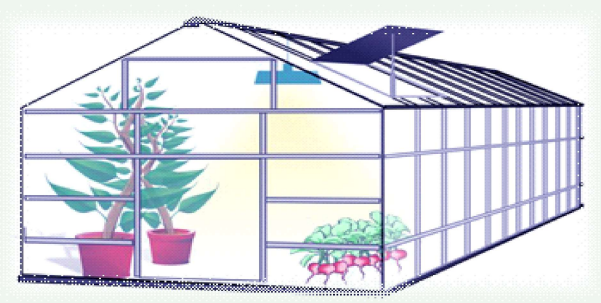

Fig.4. Automatically controlled protected cultivation by sensors

diction. Data collection is a significant part of smart farming as the quantity of data available from crop yields, soil-mapping, climate change, fertilizer applications, weather data, machinery and animal health continues to escalate.

- Satellites and drones for gathering data round the clock for entire field. This information is forwarded to IT systems for tracking and analysis to give an "eye in the field" or "eye in the barn" that makes remote monitoring possible.

IoT use cases in agriculture (with examples):

1. Monitoring of climate conditions

Most popular smart agriculture gadgets are probably the weather stations which combine various smart farming sensors. Located across the field, they collect various data from the environment and send it to the cloud. The provided measurements can be used to map the climate conditions, choose appropriate crops, and take the required measures to improve their capacity (i.e. precision farming).

2. Greenhouse automation

Typically, farmers use manual intervention to control the greenhouse environment. The use of IoT sensors enables them to get accurate real-time information on greenhouse conditions such as lighting, temperature, soil condition, and humidity. In addition to sourcing environmental data, weather stations can automatically adjust the conditions to match the given parameters. Specifically, greenhouse automation systems use a similar principle

3. Crop management

One more type of IoT product in agriculture and another element of precision farming are crop management devices. Just like weather stations, they should be placed in the field to collect data specific to crop farming; from temperature and precipitation to leaf water potential and overall crop health.

4. Cattle monitoring and management

Just like crop monitoring, there are IoT agriculture sensors that can be attached to the animals on farm to monitor their health and log performance. Livestock tracking and monitoring helps in collecting data on stock health, well-being, and physical location. For

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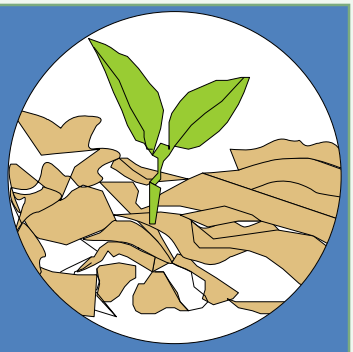
Climate Change and its Impact on Indian Agriculture



Rajesh Kumar, Surender Mittal and Dheeraj Panghaal

Climate change has significant and diverse impacts on Indian agriculture, posing both challenges and risks to the sector. Changing scenario of rainfall patterns, temperature fluctuations, extreme weather events, water scarcity, floods, shifting crop patterns are major indicators of climate change. The agricultural sector in India is highly dependent on monsoon rainfall, which provides water for irrigation and supports crop growth. However, climate change is altering rainfall patterns, leading to increased variability and uncertainty in monsoons. Addressing the challenges posed by climate change in Indian agriculture requires a multi-faceted approach. It involves implementing climate-resilient agricultural practices, promoting water conservation and efficient irrigation techniques, developing heat-tolerant crop varieties, enhancing weather forecasting systems and strengthening rural infrastructure. Additionally, policy measures, farmers education, and international collaborations are crucial for mitigating the impact of climate change on Indian agriculture and ensuring food security in the face of a changing climate.

Climate is the long-term average of weather, typically averaged over a period of 30 years. More rigorously, it denotes the mean and variability of meteorological variables over a time spanning from months to millions of years. Global climate change means a gradual change within the climate system both by natural and artificial causes. Natural causes include the change in solar activity, eruption, seawater temperature, ice cap distribution, westerly waves and atmospheric waves. On the other hand, artificial causes include CO_2 emission from industry and agricultural production activities, deforestation, acid rain and the destruction of the ozonosphere by Freon gas. This issue has attracted international interests as the scientific knowledge of climate has accumulated since the 1970s and it has been widely accepted by scientists that the anthropogenic greenhouse gas emissions are the explanation for heating. There is now clear evidence for an observed increase in global average temperatures and change in rainfall rates during the 20th century around the world. The most imminent climatic changes in recent times are the increase in the atmospheric temperatures due to increased levels of greenhouse gases such as carbon dioxide, methane, ozone, nitrous oxide and chlorofluro carbon. The carbon dioxide (CO_2) concentration was in the steady state at 280 ppm till the preindustrial period (1850). It is rising since then at the rate of 1.5 to 1.8 ppm per year. The concentration of CO_2 is likely to be doubled by the end of 21st century. Scientists' observation shows changes in earth's climate across the whole climate system. Even a small change in earth's temperature leads to very harsh outcome such as 1.5^{o}C of global warming results in

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shorter cold seasons and longer warm season and increasing heat waves. Global warming is not only about temperature but it also affects several other natural processes like intensification of water cycle, affect rainfall pattern, increase in sea level, amplification of permafrost thawing etc. Scientists are observing alarming change in earth's climate which drastically affects the agriculture and leads to increase in food insecurity in the upcoming future due to increased food prices and reduction in food production. Rising sea level in coastal areas leads to complete degradation of agricultural land and warmer climate results in origin of different pests and diseases. Continuous increase in world's population will increase demand of livestock production by 70% from 2005 to 2050. In order to stabilize climate change we need strong, rapid and sustainable reduction in greenhouse gases and limiting net zero carbon dioxide level. Agriculture also contributes a significant amount of share in GHGs emission like nitrous oxide releases from soil, fertilizers and manures whereas methane produces by ruminant's animals and paddy rice field. Both of these gases lead to significant amount in greenhouse gases emission.

Climate change and India:

Our nation follows industrial model of agriculture which heavily relies on fertilizers and pesticides that makes our agriculture system susceptible to climate change. Drastic combination of climate change with already vulnerable industrial system creates a chaotic condition for farmers. Climate change drastically affecting the Indian agriculture as the selection of crop is totally dependent on the climate of specific region. Climate change negatively affects agricultural sector through reduction in crop productivity due to temperature rise, quality degradation, increase in the number of weeds, blights and pest, increase in disasters related to agriculture like flood and drought condition and increase in soil erosion. The first Assessment of climate change over the Indian region has been published by the Ministry of Earth Sciences (MoES). It is India's first ever national forecast on the impact of global warming on the subcontinent in the coming century. The highlights of findings are as follows:

Temperature:

- In a worst-case scenario, average surface air temperature over India could rise by up to 4.4°C by the end of the century as compared to the period between 1976 and 2021.
- The worst-case scenario is defined by the Representative Concentration Pathway (RCP) 8.5 that calculates a radiative forcing of 8.5 watt per square meter due to the rising greenhouse gas (GHG) emission in the atmosphere.
- Radiative forcing or climate forcing is the difference between sunlight energy absorbed by the Earth (including its atmosphere) and the energy that it radiates back into space. Under an intermediate scenario of RCP 4.5, the country's average temperature could rise by up to 2.4°C.
- The rise in temperature will be even more pronounced in the Hindu Kush Himalayan region where the average could reach 5.2°C. By 2100, the frequency of warm days and warm nights might also increase by 55% and 70% respectively, as compared to the period 1976-2021 under the RCP 8.5 scenario.
- The incidence of heat waves over the country could also increase by three to four times. Their duration of occurrence might also increase which was already witnessed by the country in 2021.

Rainfall:

- Another significant highlight of the assessment is the projected variability in the rainfall, especially during the monsoon season which brings 70% of the rainfall received by India and is one of the primary drivers of its rural agrarian economy.
- Monsoon rainfall could change by an average of 14% by 2100 that could go as high as 22.5%. It is not mentioned if this change will be an increase or decrease but still represents variability.
- Overall rainfall during the monsoon season has decreased by 6% between 1950 and 2021.
- In the past few decades, there has been an increased frequency of dry spells during the monsoon season that has increased by 27% from 1981 to 2021, as compared to 1951-1980.
- The intensity of wet spells has also increased over

the country, with central India receiving 75% more extreme rainfall events between 1950 and 2021.

Effects of climate change in agricultural field crops:

- An average of 30% decrease in crop yields is expected by mid-21st century in South Asian countries. North Indian states and Bangladesh are highly susceptible due to erratic changes in rainfall and temperature (World Bank, 2008). For example, in India, a rise in temperature by 1.5° C and reduction within the precipitation of 2 mm, reduces the rice yield by 3 to 15 per cent.
- The drastic climate changes alter the progressive stages of pathogens that eventually affect the growth and yields of crops severely and also could lead to an increase in pest population, ultimately devastating the overall productivity.
- Vegetable crops when exposed to extremely high temperatures are subject to very high transpiration losses, and it also limits fruit set in citrus fruits.
- High temperature causes the burning or scorching effect of blossoms, predominantly on young trees. The fruit setting stage of navel oranges is recorded to be severely affected by high temperatures during flowering.
- High temperature induces moisture stress conditions leading to sunburn and cracking symptoms in fruit trees like apricot, cherries and apples. The temperature enhancement at the ripening stage causes fruit burning and cracking in litchi plantations.

Most of the vegetable crops are severely affected by flooding, particularly tomatoes. Another possibility of causing severe damage to crops is due to the accumulation of endogenous ethylene. If the ozone concentration reaches >50 ppb/day, the yield of vegetable crops will be reduced by 5 to 15 per cent.

Sector-wise impact of climate change on Indian agriculture:

Continuous increase in Indian population over the years might disturb food security once again in the future due to greater food demand. Demand for pulses, fruits, vegetables is also expected to increase very sharply in the coming time. Further effects of gradual increase in temperature and environmental degradation are visible in areas which had been largely benefitted from green revolution. The situation of northwestern India is of great concern due to rapid decline in soil fertility, change in water table depth, rising salinity, increase in number of pesticide resistant harmful pests and degradation of irrigation water quality. Now the farmers have to apply more fertilizers to obtain the same yield as achieved 20-30 years back. Climate change is already affecting agriculture, with effects unevenly distributed across the world. Climate change will probably increase the risk of food insecurity for some vulnerable groups, such as the poor. For example, South America may lose 1–21% of its arable land area, Africa 1–18%, Europe 11–17%, and India 20–40%.The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere.

Major impacts of climate change on Indian agriculture:

- Agriculture depends on rainfall. Climatic change disturbs the pattern of rainfall distribution due to which it leads to increasing temperature, long time dry region, high solar radiation that is very much harmful to the growth and development of plants.
- Due to increasing temperature, the availability of groundwater is decreasing and the productivity of crops are highly affected by decreasing groundwater level because 89 per cent of groundwater is used for irrigation.
- Increasing temperature leads to reduced productivity of soil and gradually turns in soil degradation by which important essential minerals are lost due to erosion.
- Disturbed rainfall pattern, also results in flooding which directly destroy crops, it washes fertile topsoil by which productivity of crop reduces at an extreme level. In waterlogged soil the leaching of important minerals increases and due to denitrification exchange of gases is not possible hence the soil becomes infertile.
- Change in climatic conditions sometimes leads to an increase in the pest population. It provides favourable conditions for the growth and reproduc-

tion of harmful pathogens so it may cause severe disease incidence in crop which reduces yield.

- Due to the irregular distribution of rainfall, weed population also increases hence the cost of cultivation increases and productivity decreases.
- Cereal productivity may decrease by 10-40% by 2100.
- Greater loss is expected in rabi season crops. Every 1°C increase in temperature reduces wheat production by 4-5 million tons. This losswould be reduced to 1-2 million tons if planting is done in time.
- Increased droughts and floods are likely to increase production variability.
- Considerable effects on microbes, pathogens and insects would be observed. The increasing temperature would increase fertilizer requirement for the same production targets, and result in higher emissions.

Livestock, Poultry and Fishery sectors:

- Higher temperatures abruptly change the animal's body physiology such as rise in respiration rates (> 70- 80/minute), blood flow and blood heat (>102.5º F).
- Dairy breeds are more vulnerable to heat stress than meat breeds. A rise in metabolic heat production in higher milk producing breeds results in higher susceptibility to heat stress; while the low milk-producing animals are resistant.
- An increase in temperature and temperature humidity index value beyond the critical intensity reduces the dry matter intake and milk yield. It also interrupts the physiology of an animal's body.
- During 2009-10, acute events like floods and cyclones devastated agricultural production in a large home in southern and central Mozambique, consequently loss of livestock, its infra structure and feed.
- Poultries are extremely sensitive to temperature-associated issues, specifically heat stress. Endocrinological changes caused by prolonged heat stress in broiler chickens enhance lipid accumulation reduced lipolysis and induced aminoalkanoic acid catabolism.
- Heat stress harms the strength, weight, ash content and thickness of the eggshell.
- The rising environmental temperature may cause seasonal improvement in the growth and development of fishes, but increases the risks to the populations living beyond the thermal tolerance zone.
- The increase in temperature of 1° C will affect the mortality of fish and its geographical distribution.
- The temperature rises of 0.37° C to 0.67° C alter the pattern of monsoon differences due to the season, eventually shifting the breeding period of Indian main carps from June to March in West Bengal and Odisha's fish hatcheries.

Strategies for adaptation and mitigation of climate change:

Mitigation and adaptation strategies for the sustainable agriculture are interconnected to each other, mitigation is considered as one of its belongings so adaptation is an important counter measure against degrading environment. Mitigation strategies for the agriculture majorly include advancement in cultivation system through enhanced irrigation and fertilisation control to reduce the major greenhouse gases like methane, nitrous oxide and improvement in the carbon fixing technologies in the farmland soil. Adaptation according to UNFCC is a "regulating process of ecological and socioeconomic systems to reduce possible damages from actual and expected climate change that is, actions taken to help communities and ecosystem cope with changing climate conditions". Adaptation measures include research and development, infrastructure management, economic means related to carbon grants, legal and institutional improvement, enhance public relation education, continuous monitoring, and technology and management applicable to farm households. The goal of adaptation is to scale back our vulnerability to the harmful effects of global climate change (like sea-level encroachment, more intense extreme weather events or food insecurity). It also encompasses making the foremost of any potential beneficial opportunities related to global climate change (for example, longer growing seasons or increased yields in some regions). In reality, it's almost impossible to implement the first-best solution to ac-

curately measure the external effects of worldwide warming and impose the economic costs to the precise greenhouse gas emitters. Under this background, the second-best solution for developing relevant policy programs and forming appropriate portfolios to approach is addressed as a practical method employing a policy mix. Considering the circumstances realistically means for greenhouse emission reduction are classified into economical means, regulatory means, voluntary agreement, R&D and popularization, information provision, and promotion of public awareness. The goal of mitigation is to avoid significant human interference with the climate, stabilize greenhouse gas emission levels during a timeframe sufficient to permit ecosystems to adapt naturally to global climate change, ensure that food production isn't threatened and enable economic development to proceed in a sustainable manner. The important adaptation and mitigation Strategies include:

- Efficient water and nutrient management options to enhance use efficiency.
- Evaluation of carbon sequestration potential of different land-use systems.
- Understanding opportunities offered by conservation agriculture and agro-forestry.
- Identifying cost-effective methane emission reduction practices in ruminants and rice/paddy cultivation.
- Farmer should adopt sustainable agriculture.
- Farmers should go with crop diversification and take mixed farming so that they will be able to take profit from other sources of farming in an adverse condition also.
- Take contingent crops in adverse conditions and grow those varieties that are adaptable to local climate and able to give a high yield in that area.
- Use stress and disease-resistant varieties of the crop.
- Reduce the use of harmful insecticides, pesticides and herbicides.
- In the area where drought is a major problem using water conservation practices like maintaining individual ponds on farms so that they can store water during the rainy season and farmers can use them in water scarcity situations and save the crop from drought.
- Improved irrigation practices by capture and retention of rainfall.
- In flooding, proper drainage of water should be done so that water cannot store and the field is free from waterlogged conditions and the problem of leaching and de-nitrification may be reduced up to some extent.
- Farmers should aware of available natural resources and their uses so that it reduces the cost of production and increases yield.
- Farmers may have direct contact with KVK and other Agricultural institutes so that they are aware of the weather of that area. It will help them to take crops according to climatic conditions.
- Farmers have proper knowledge and idea about new agricultural technology so they may help in reduce the cost of cultivation through limited use of inputs and help in increasing productivity of crops.

Conclusion:

Climate change as well as rise in the temperature is a reality and we have to deal with it. If one analyses different studies related to climate change, we can see its severe effects on various fields. Its effects can easily be noticed in environment. Unseasonal rains, increase in number and intensity of tropical storms, prolonged drought conditions, prolonged heat conditions etc. impacted the normal life functions of many communities/countries. Climate change not only impacts agriculture sector but all the possible areas also. Various reports suggest that climate change will affect the quality and quantity of various crops. In serious situation this can also affect the food security of concerned region. It is also reported that impact of climate change will not be same for every sector and region. The possible effects would be high in tropical regions as compared to temperate regions. So, proper plans should be made according to the area. As far as India is concerned, it will face great challenge due to climate change. Most of the agriculture is dependent on monsoon rains. Its unevenness and varia-

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Millets: The Super food with Nutritional and Health Benefits

S. Karak & U. Thapa

Millets, a group of small-seeded grasses, have been a staple food in many parts of the world for thousands of years, particularly in arid and semi-arid regions of Africa, Asia, and Latin America. They are highly adaptable to harsh environmental conditions and can grow in poor soils with limited water, making them an ideal crop for smallholder farmers in these regions. Millets are also highly nutritious, providing essential vitamins, minerals, and amino acids. They are gluten-free and easy to digest, making them a suitable alternative for people with gluten sensitivities. In addition, millets are a valuable source of food security, as they have a long shelf life and can be stored for extended periods without deterioration.

Millets are cereals from the Poaceae grass family and are considered one of the oldest cultivated crops. They are traditional staple food of the dry land regions of the world. Millet is a low maintenance and drought-resistant grain. People often use it to feed livestock, but consumer interest is growing. Millets are now the sixth most important cereal grains in the world. In India, millets are grown on about 17 million ha with annual production of 18 million tonnes and contribute 10 percent to the country's food grain basket. India is the top most producers of millets followed by Nigeria for the year 2000 and 2009. In India, eight millets species (Sorghum, Pearl millet,Finger millet, Foxtail millet, Kodo millet, Proso millet, Barnyard millet and Little millet) are commonly cultivated under rain fed conditions. They are nutri-cereals which are climate compliant and highly nutritious and are known to have high nutrient content which includes protein, essential fatty acids, dietary fibre, B-Vitamins, minerals such as calcium, iron, zinc, potassium and magnesium. Millets also have antioxidant and antimicrobial properties and protein content of Pearl millet (14.5%), Foxtail millet (11.7), Proso millet (11%), Kodo millet (8.3%) and little millet (7.7%) is more than that present in Rice (7.5%). The major reasons of decrease in consumption is the lack of awareness of nutritional merits, in-

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Various types of millets with some of their traits:

Crop	Scientific Name	Vernacular Names	Traits
Sorghum	*Sorghum bicolor* (L.)	Great millet, jowar, cholam, jola, jonna, durra, Egyptian millet, feterita, Guinea corn, jwari, juwar, milo, shallu, gaoliang, .	Drought tolerant, excellent recovery mechanism from stresses, highly adapted to wide range of soils, altitudes and temperatures, responsive to high input management
Pearl millet	*Pennisetum glaucum* (L.)	Bajra, cattail, bulrush, candlestick, sanyo, munga, seno	Highly resilient to heat and drought, come up in very poor soils, but responsive to high input management
Finger millet	*Eleusine coracana* (L.)	Ragi, Mandua,Nagli, Kapai, Marua, Nachni, African bird's foot, rapoko, Hunsa, wimbi, bulo, telebun, koracan, kurakkan	Moderately resistant to heat, drought and humidity, adapted to wide altitude range (Up to 2100 m amsl), rich source of calcium.
Barn yard millet	*Echinochloa crus-galli* (L.)	Japanese, Jhingora, Kudraivali, Oodalu, sanwa, sawan, Korean, kweichou	Very short duration (Fastest growing), voluminous fodder, not limited by moisture, high altitude adapted (Up to 2700 m amsl)
Foxtail millet	*Setaria italica* (L.) *Setaria verticillata* (L.)	Kauni, Kangni, Korra, Tenai, Rala, Italian, German, Hungarian, Siberian, navane, thanahal Bristley foxtail millet	Adapted to low rainfall, high altitude (Up to 2000 m amsl), short duration, tolerant to low fertility and drought
Kodo millet	*Paspalum scrobiculatum L.*	Varagu, bastard, ditch, naraka, water couch, Indian paspalum, creeping paspalum, amu	Long duration, but very hardy, needs little rainfall, comes up in very poor soils, grown well in shallow and deep soil, good response to improved management
Little millet	*Panicum sumatrense*	Little millet, Kutki, Samalu, Same, samai, Blue panic, heen meneri	short duration, Adapted to low rainfall and poor soils- famine food; withstand water logging to some extent, adopted up to 2000 m amsl
Proso millet	*Panicum miliaceum* L. ssp. *miliaceum*	Cheena, Panivaragu, Variga, Baragu Common, hog, broom, samai, Russian, panic,	Short duration, adopted to low rainfall and high altitude area, tolerant to heat and drought
Brown top millet	*Brachiaria ramosa* (L.)	korale	Short duration, adapted to poor soils with less rainfall. Seed used as feed for game bird.
Fonio	*Digitaria exilis* (Kippist)	Fonio, acha, fundi, hungry rice	Shorter duration (70-150 days), Adapted to poorly fertile sandy and stony soils, low rainfall
Source: Pal (1997), Prasad (2012), Annonymous (2015), Annonymous (2018), Sujata *et al*. (2018)			

conveniences in food preparation, lack of processing technologies, and also the government policy of disincentives towards millets and favoring of supply of fine cereals at subsidized prices. Given the current challenges regarding sustainable food production, climatic changes, and water scarcity, coupled with overpopulation, an interest has been developed regarding millets. Now people are becoming health conscious and they are demanding for millet based products. This has provided an opportunity for farmers, nutritionists, and food and feed manufacturers to engage in research in order to understand the nutritional and functional characterization of millet grains.

Nutritional profile of millets:

Nutritionally, the energy value, protein and macro nutrient contents of millets is comparable and sometimes higher than conventional cereals. They significantly contribute to human and animal diets owing to

their high levels of energy, calcium, iron, zinc, lipids, and high quality proteins. In addition, they are also rich sources of dietary fibre and micronutrients.

Nutritional Importance of Sorghum:

Sorghum (*Sorghum bicolor* (L.) Moench) is a warm season crop, intolerant of low temperatures but fairly resistant to serious pests and diseases. Grain sorghum has certain properties which makes it suitable to be consumed by population suffering from chronic disorders. Each sorghum nutrient has specific nutritional significance, which is suggested to prevent and control life style diseases and disorders. The sorghum carbohydrate content is composed of starch, soluble sugar and fiber. Carbohydrates in sorghum are classified into non-structural (sugars, starch and fructosans) and structural (cellulose, hemicelluloses and pectin substances). Sorghum also contains good amount of dietary fiber that is 9.7-14.3g, which has a significant positive effect on preventing and managing the diseases like constipation, irritable bowel syndrome and obesity.Sorghum is an important source of B vitamins except for vitamin B12. Yellow coloured sorghum grain is rich in beta carotene, leutin and zeaxanthin. Grain sorghum is good source of potassium and adequate source of Mg, Fe, Zn and Cu but a poor source of calcium and sodium. Sorghum is excellent source of polyphenols, flavonoids and condensed tannins which are antioxidant potent in nature.

Health Benefits of Sorghum:

- Sorghum can be a healthy diet for those who are ailing from celiac disease as it is gluten free.
- Sorghum is rich in dietary fibre and has unique chemical and physical characteristics (bulk to the diet, viscosity, water holding and absorption capacity) which determine the subsequent physiological behaviour. It aids to the hunger satisfaction, increases satiety and thereby reducing the risk of development of obesity.
- Diabetes Mellitus - complex metabolic diseases a major health concern in many countries. Sorghum is rich in dietary fiber and has low glycemic index, which could help in prevention and control of T2D in Indians. The fibre, magnesium, vitamin–E, phenolic compounds and tannins present in foods reduces the risk of diabetes as they slower the sudden increase of blood glucose and insulin levels.
- The polyphenols and tannins present in sorghum have anti-mutagenic and anti-carcinogenic properties.

Nutritional Importance of Pearl Millet:

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) Originated in Central tropical Africa and is widely distributed in the drier tropics and India. Pearl millet is the most widely grown type of millet. It has been grown in Africa and the Indian subcontinent since prehistoric times. In different pearl millet genotypes the starch content of the grain varied about 62.8 to 70.5% and soluble sugar 1.2 to 2.6%. In high-protein varieties of pearl millet, protein content ranges from 14.4 to 27.1%.

Health Benefits of Pearl Millet:

- Beneficial in treating stomach ulcers, diabetes and heart health.
- Helps in weight loss.
- Anti-allergic properties.

Nutritional Importance of Finger Millet:

Finger millet (*Eleusine coracana* (L.) Gaertn) is a cereal grass grown mostly for its grain. Finger millet is an annual plant widely grown as a cereal in the arid areas of Africa and Asia. Nutritionally, finger millet is good source of nutrients especially of calcium, other minerals and fibre. Total carbohydrate content of finger millet has been reported to be in the range of 72 to 79.5%. The total dietary fibre (TDF), insoluble dietary fibre (IDF), and soluble dietary fibre (SDF) content in finger millet was found to be 12, 11 and 2%, respectively.

Health Benefits of Finger Millet:

- Finger millet/ Ragi helps in losing weight and for lowering blood cholesterol.

- Finger millet/ Ragi is good for anaemia.
- Green *Ragi* is recommended for conditions of blood pressure, liver disorders, *asthma* and heart weakness.

Nutritional Importance of Small Millets:

They are rich source of minerals like copper and iron. Unlike rice, they release glucose steadily without affecting the metabolism of the body. The incidence of diabetes is rare among the population which consumes small millet diet.

Foxtail millet (*Setaria italica* (L.) P. Beauvois) is regarded as a native of China, it is one of the world's oldest cultivated crops. Foxtail millet ranks second in the total world production of millets and continues to have an important place in the world agriculture providing approximately six million tons of food to millions of people, mainly on poor or marginal soils in southern Europe and in temperate, subtropical and tropical Asia .The foxtail millet is also known as Italian millet.

Barnyard millet (*Echinochloa crusgalli (L.) P. Beauvois*) is a multi-purpose crop which is cultivated for food and fodder. Millets are good sources of magnesium and phosphorus. Magnesium has the ability to help reduce the effects of migraine and heart attacks, while, phosphorus is an essential component of adenosine triphosphate (ATP). Barnyard millet is most effective in reducing blood glucose and lipid levels.

Proso millet (*Panicum miliaceum* (L.)) is an annual grass, growing from seed each year. Its origin goes back in history at least as far as 2000 B.C. when it is reported to have been grown in the Central regions of Europe. Proso millet is the best alternative crop for diversifying and intensifying winter wheat-based dryland production systems. Proso Millet is calculated to have 356 Kcal energy per 100 gm. The protein content is similar to that of wheat, but it contains no gluten and by itself is not suitable for yeast-leavened bread. The protein content was found to be (11.6% of dry matter) and was significantly rich in essential amino acids (leucine, isoleucine, and methionine) than wheat protein.

Kodo millet (*Paspalum scrobiculatum* (L.)) is widely distributed in damp habitats across the tropics and subtropics of the world. Kodo millets are rich in B vitamins, especially niacin, B6 and folic acid, as well as the minerals such as calcium, iron, potassium, magnesium and zinc. Kodo millets contain no gluten and is good for people who are gluten intolerant.

Health Benefits of Small Millets:

- Helps control Blood sugar levels when consumed on regular basis.
- Ideal food for people suffering from Diabetes & Gastric problems.
- Helps in the development of Body Tissue & Energy Metabolism and reduces risk of Heart Attack.

Conclusion

Now it is an established fact that the whole world is facing many health challenges because of fiber-less foods. Millets have multiple health benefits to include these ancient prized grains-like seed in our regular diet. Most of the civilized people have not even heard about millets and much less understand the benefits of millet nutrition. And yet, millet is one of the best-kept secrets of our ancestors. All the millet foods are having significant health benefits, with their rich content of nutrients like fibre which helps in metabolic disorders like Diabetes, Obesity, Cardiovascular diseases etc, their good protein content which helps in child growth and development, with calcium content which helps in the bone development in both children and geriatric people, with good iron content helps in ailing of anaemia and with gluten free characteristics helps the celiac disease patients and helps in gluten insensitivity. Phytosterols and policosanols are cardio-protective compounds present in the waxy layers of the millets. If these millets are ground into flour without de-hulling, then one can have multiple benefits. They have antioxidants also, which are substances that may protect cells against the effects of free radicals.

Empowering Tribal Women through Value Addition of Millets

Dr. Narendra, H. Tayade and Dr. Birbal Sahu

Krishi Vigyan Kendra, Kanker, IGKV Raipur introduced minor millet processing technology in the district. Minor millet processing and value addition units were established in two blocks. Front line demonstration of improved variety of minor millet crops like ragi, kodo and kutki were also carried out to increase the production of these millet crops. Self Help Group was also formed and group members were engaged for production and collection of raw materials from members and other farmers for processing. Processed products are being sold to 1600 Anganbadi centers under the Government Suposhan Abhiyan. Women and children are getting nutritive and fresh food as well as women members of group are getting self employment through procurements, processing and value addition of minor millet products.

Minor millets play important role in hu man life as well as impressive source of powerful antioxidants. Farmers are growing these millet crops on upper land having less production potential of soil in the tribal area of Chhattisgarh. Generally three type of minor millet crops such as ragi (finger millet), kodo millet and little millet (kutki) have been grown in Kanker district of Chhattisgarh. Farmers of these areas are not too much aware on cultivation and value addition of the millet crops. Farmers conventionally prepare kodo rice, kutki rice and ragi atta by using locally made domestic pulveriser i.e. Jata and Dhekhi. This process was very laborious and highly time consuming. Output of this process was also less i.e. 8 to 10 Kg product was processed in 8 hour (1 Days) and quality of these products was also not good hence minimum net return was received by the farmers. Keeping all the points in view, Krishi Vigyan Kendra Kanker, IGKV Raipur not only introduced mechanically minor millet processing technology through organizing training programmes, exposure visit etc.,but also established minor millet processing and value addition units in two blocks i.e. Durgukondal and Bhanupratappur of the Kanker district with the help of District Mining Development Fund (DMFT) of Kanker district. Front line demonstration of improved variety of minor millet crops like ragi, kodo and kutki has been done to increase the production of these millet crops. Self Help Group (SHG) having 300 members has been created and these group members have been engaged for production and collection of raw materials from members and other farmers for processing. Another two separate SHGs having members 10 to 12 in each group has been engaged in processing, packaging and marketing the value added product through making supply chain from farmers to consumers. Processed products are being sold to 1600 Anganbadi centers of district under Chief

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Before intervention Processing of millets by traditional method


After intervention Processing by Mechanical processing unit


Final Processed product

Impact of mission

Minister Suposhan Abhiyan since January 2021 and through Angabadi centers these processed products has been given to anemic women and malnutrition effected children by preparing kodo/kutki khichadi and ragi halwa as supplementary feed. Hence, under the Government Suposhan Abhiyan women and children are getting nutritive and fresh food within time as well as women members are also getting self employment through procurements, processing and value addition of minor millet products in the district. On processed products, SHGs members has been getting benefit of Rs 20 and Rs 15 per Kg of Kodo/Kutki rice and Ragi Atta respectively. They have supplied 2490 qt processed kodo/kutki/ragi into different Aganbadi centers since January 2021 to November 2022 and earned Rs 7.43 lakh from these products.

Impact of the intervention:

- Productivity has been increased by 20 to 25 percent by introducing improved variety of crops.
- Farmers are selling their produce directly to the SHGs members hence, they have got profit of Rs 5 to 7 per Kg of produce straight in the field.
- Malnutrition level of the district has been reduced through nutritive availability of food in time.
- Cultivation area under minor millet crops has been increased from 5460 ha to 9500 ha. which is nearly 74% increase in area under cultivation.
- This intervention is playing an important role in doubling farmers income, generating self employment throughout the year and reducing migration percentage in the district.

Turmeric Cultivation: Bringing Prosperity and Self Reliance to Rural India

Priyanka Suryavanshi[1] Dipender Kumar [2] and Pooja Maurya[1]

Turmeric is a popular and sacred spice from India. It is also known as 'Indian Solid Gold' and 'Indian Saffron' owing to its golden yellow color. Turmeric has been used in Asia for thousands of years and is a major part of Ayurveda, Siddha medicine, traditional Chinese medicine, Unani and the animistic rituals of Austronesia peoples. It has profound significance as a condiment, dyeing agent, flavoring agent and even as a medicine. There is a vast scope of increasing area and productivity of turmeric cultivation by adopting Good Agricultural Practices developed by scientists, thus bringing prosperity to rural India.

Curcuma longa L. (Zingiberaceae), commonly known as turmeric, is not only one of the most popular spices for Indian cuisines; it is also one of the most valuable medicinal plants of traditional systems of Indian medicine due to its large repository of preventive and curative effects. The pharmaceutical importance of turmeric is due to its curcuminoids which are credited with anti-inflammatory, hypo-cholesterolemic, anti-oxidant, anti-parasitic, anti-spasmodic, anti-microbial, anti-rheumatic, anti-aging and anti-cancer properties. Turmeric holds much promise for a large number of traditional Indian homes where it is not just one of the popular spices, but also a valuable first aid-cum medical ingredient to tackle a range of anti-inflammatory problems. The active ingredient curcumin has a wide spectrum of medicinal properties. India is the largest producer and exporter of turmeric and accounts for nearly 80 per cent of the global production. The spice is cultivated on over 150,000 ha in at least eight large States. The estimated consumption of the spice domestically is about 100 mg per capita, amounting to around 480,000 tonnes per annum. However, turmeric farmers have been facing trouble with stagnation in yields and inadequate market price. India produces 80 per cent of the total global turmeric production.

Climate and Soil: This crop requires hot and moist climate. It is recommended for cultivation in irrigated areas. Turmeric grows in all types of soils, but it thrives well in well drained sandy loam to loamy soils with moderate organic matter content.

Improved Varieties:

Prathibha: This variety was released by ICAR-IISR,

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in the year 1996. It has proved to be more adaptable to different states of India like Kerala, Karnataka, Andhra Pradesh, Maharashtra, Punjab etc, owing to its better phenotypic plasticity and other favourable conditions. It matures in 225 days under rainfed conditions and gives an average yield of 39.12 tonnes per hectare. Relatively higher levels of curcumin (6.25 percent), oleoresin (16.2 percent) and essential oil (6.2 per cent) make this variety a good choice for industrial, medicinal, and culinary purposes.

CIM-Pitamber: A new variety named CIM-Pitamber is available for commercial cultivation. Scientists at the Lucknow-based Central Institute for Medicinal and Aromatic Plants, CSIR-CIMAP conducted extensive research for eight years to identify and finally developed the high yielding variety. An average yield of 50 tonnes of rhizomes/ ha, containing more than 10 per cent curcuminoids has been demonstrated in multi-centre field trials. One of the super yielding varieties with expected production of 60-65 tonnes of rhizomes/ha also contains more than 12.5 per cent curcuminoids. The general duration of the crop is 180-190 days. The CIM-Pitamber is tolerant to the common leaf botch disease, affecting the turmeric crop.

Punjab Haldi 1 (2008) : Its plants are erect and medium in height. Leaves are green and medium in size. Rhizomes are long and medium-thick. Skin colour of rhizomes is brown and the flesh is dark yellow. It matures in 215 days and average yield is 108 q/ acre.

Punjab Haldi 2 (2008): Its plants are erect and tall. Leaves are light green and broad. Rhizomes are long and thick. Skin colour of rhizomes is brown and the flesh is yellow. It matures in 240 days and average yield is 122q/acre.

Agronomic Practices:

Land Preparation: To get fine seedbed, 2 or 3 ploughings followed by planking are necessary. The field should be free from stubble and weeds.

Seed Rate: Turmeric is propagated through mother and primary rhizomes. Fresh, healthy and uniform sized rhizomes weighing 6-8 quintals are sufficient to plant an acre.

Sowing Time: For getting higher yield, crop is to be sown directly in the field by the end of April. In sub-mountainous and northern districts, the sowing can be delayed for a week. It can also be raised by transplanting upto first fortnight of June without losing much in yield. For this, rhizomes should be sprouted in the nursery by planting them in close spacing and 35-45 days old seedlings should be transplanted in the field.

Method of Sowing: Ridge planting improves the size of turmeric rhizomes. It is planted in lines, keeping 45 cm row to row spacing for manual operations and 67.5 cm for mechanical, whereas, plant to plant spacing is maintained at 15 cm. After 114-115 days of planting, apply straw mulch @ 2.5 tonnes per acre. Keep the soil moist until the sprouting of rhizomes.

Manures and Fertilizers: Turmeric responds

Planting of turmeric rhizomes (CIM- Pitambari) at farmer's field

Turmeric field at maximum vegetative growth stage

favourably to organic manuring. Apply 10-12 tonnes of well-rotten farmyard manure per acre before planting. Turmeric does not need much nitrogen. A basal dose of 10 kg P_2O_5 (60 Kg Single Superphasphate) and 10 Kg K_2O (16 Kg Muriate of Potash) can be drilled at planting.

Irrigation: Turmeric takes a long time to sprout and needs frequent irrigation. Apply light and frequent irrigation.

Weed Control: In order to keep the field free from weeds, 1 or 2 hoeing may be given. Uniform spreading of paddy straw mulch @ 36 quintals per acre over the entire field can also be used.

Harvesting, Care and Processing: Maturity of turmeric is indicated by the complete yellowing and drying up of the plants. The crop is ready for harvesting in the month of November-December. After digging, clean the rhizomes by removing roots and soil.

Processing/curing of turmeric: Curing of turmeric is a lengthy and challenging process of turmeric production. Challenging because if not done properly the turmeric may not be extracted upto its full capacity. Also care must be taken to see that no chemicals are used for processing.

Step 1: Boiling and drying

Boil the cleaned rhizomes in a vessel having narrow mouth after adding water sufficient to cover the rhizomes. Boiling should be continued for an hour till the rhizomes become soft. If boiling is to be done under pressure (15 Ib/sq.inch), then 20 minutes are sufficient. Boiled rhizomes are dried in the sun.

Step 2: Re-boiling

Within 2-3 days of sun drying, the rhizomes are again boiled with just enough water to soak them. This boiling is done in copper or earthen vessels. They are boiled till the rhizomes become soft. Some farmers cook in perforated baskets.

Step 3: Separation from water

The cooked rhizomes are taken out of the pan and water is allowed to drain off from the turmeric back into the pan. This water can be reused for cooking the next batch of harvested turmeric rhizomes. Usually the mother and finger rhizomes are cured separately.

Step 4: Sun drying

Once cooked, these rhizomes are spread under the sun on cement floor. Sometimes bamboo mats are used. While they are spread on the floor during daytime for sun drying, they are heaped together and covered at night so that no moisture affects the turmeric. This step lasts for 10-15 days. In case of artificial drying, cross-flow hot air at 60°C is used.

Polishing of turmeric

Dried turmeric has a rough dull color on the scales. The outer surface is polished and smoothened out to improve the appearance. On a small scale, dried rhizomes are polished by rubbing them against a hard surface whereas on commercial scale, special polishing drums are available. In case of manual polishing, the finger rhizomes are rubbed on hard surface. An improvised technique is to use hand-operated barrel mounted on a central axis. The barrel is filled with rhizomes and rotated. They get polished by mutual rubbing against each other and abrasion against the surface. The essence of turmeric for a buyer is its color. Therefore, in a bid to attract the buyers, a suspension of turmeric in water is added to the polishing drum during the last ten minutes. This helps the rhizomes get uniformly coated. After this, the rhizomes are dried under the sun.

Seed Production: The fresh rhizomes are kept at a cool and dry place or preferably in cold storage for sowing in the next season. Alternatively, for field storage rhizomes are left in soil till late winter without giving the irrigation.

Turmeric is not a new crop for rural India. Earlier, it was grown primarily for domestic use in small quantities. Due to its importance as a high value cash crop that can be grown by small, marginal, women and tribal farmers, government research organizations have developed improved package and practices to promote its cultivation, processing and marketing through Farmer Producer Organizations (FPOs) and self help groups. As a low investment crop that needed fewer inputs, much less demand for labour, turmeric promises high income generation, hence, its commercial cultivation definitely can make rural India prosperous and self reliant.

Bael Varieties for Nutritional and Economic Security in Dryland

Arvind Kumar Singh

Bael is known from the pre-historic times for its nutritional and medicinal values. It is a deciduous tree with 6-8 meters in height with greenish white and sweet scented flowers and oblong and pyriform fruits. Bael is found growing along foothills of Himalayas, Uttar Pradesh, Bihar, Chattisgarh, Uttarakhand, Jharkhand, Madhya Pradesh, The Deccan Plateau and along the East Coast. Good sandy loam soil, sunny condition, warm humid climate are suitable for cultivation of this plant. The plants are grown with farm yard manure, vermi-compost, green manure etc. with low dose of chemical fertilizers and low use of pesticides. Several products like juices, squash, jam, candy and powders are made after processing ripen bael fruits. Awareness with respect to its medicinal, nutritional and potentiality of crop can play significant role in alleviating the socio economic conditions of poor farmers of the country.

Bael (*Aegle marmelos* Correa) is an in digenous medicinal fruit tree which is known since ancient times, and bestowed with several nutritional and medicinal properties, being rich source of riboflavin, vitamin A, carbohydrate, fibre content alkaloid etc. It is an important plant in formulation of various medicines in *Ayurveda*. It is well known as panacea of stomach ailments, and has tonic, digestive and laxative properties. It is hardy tree and can be cultivated in degraded and marginal lands under semi-arid rainfed conditions to ameliorate

Bael orchard under rainfed semi-arid conditions

7th year old plants of Goma Yashi bael laden with fruit under zero irrigation

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degraded, marginal, alkaline and saline wastelands. Now-a-days, the bael is subjected to value addition by processing for making *sherbet*, squash, candy, *murabba,* powder and several such preparations which have high market value and can generate income and provide nutritional security. Introduction of high yielding varieties with scientific cultivation practices have been found to be helpful in increasing its production and productivity. Awareness with respect to its medicinal, nutritional and potentiality of crop can play significant role in alleviating the socio economic conditions of poor farmers of country.

Cultivation of rainfed bael

Soil and Climate

Bael tree is very hardy, deciduous and can thrive well in alkaline, saline and stony soils having pH range from 5.0 to 10.0 where many trees fail to establish. It has wide range of adaptability to adverse soil and climate. The extent of hardiness of bael plants has also been observed, and the plants are giving good yield in rainfed conditions having soil depth from 0.75 to 1.0 m, derived from mixed alluvial basalt, quartzite, granite and layers of limestone, and falls under semi-arid hot climate. It has ability to tolerate to the extremes of temperature and soil moisture stress. Bael can be grown up to an altitude of 1200 m and is able to grow as low as 4^0 C and higher temperature up to 48^0 C, but it is sensitive to frost.

Varieties for dryland

Previously, bael fruits were generally named after the locality where they are easily available. Bael trees with desirable fruit characteristics have been collected and evaluated for their growth, flowering, fruiting behaviour and quality attributes and many promising varieties have been developed through selection at ICAR Institutes/Regional Stations and State Agricultural Universities. The performance of different varieties developed by Central Horticultural Experiment Station (CHES) under rainfed semi-arid environment is as follows:

Goma Yashi:

This variety is thornless and matures during March and belongs to early maturing group under semi-arid ecosystem. It possesses high qualitative attributes like papery shell, very less fibre and mucilage and attractive pulp colour with pleasant aroma and flavour. It is highly suitable for *sharbet*, squash, candy and M*urabba*. Because of dwarf stature, it is highly suitable for high density planting, accommodating 400 plants/ ha, planted at 5mx5m.

Characteristics: Yield 65.45 kg/plant during 8^{th} year, fruit weight 1.00-1.62 kg, fruit size 13.00 cm x 12.50 cm, fruit girth 41- 45 cm, shell thickness 0.17cm, seed weight 25.37-32. 50g, fibre weight 40.24-51.20 g, shell weight 180-210g, locules in cross section 13-15, pulp 68.00-72.25%, TSS pulp 35-39^{å} Brix, TSS mucilage 41-43^{å}Brix, acidity (0.29-0.34%) and vitamin C 19.00-22.00 mg /100 g pulp.

Thar Neelkanth

It is a superior genotype with desirable characters like compact canopy, medium in height, less spiny, better yield with quality fruits having pleasant flavour

Ripe fruits on tree

Transverse section of fruit

Branches laden with fruits

and attractive colour of pulp. It starts flowering and fruiting from 3rd year of budding. The fruit of this genotype is having good flavour and aroma. It is highly suitable in draught prone areas and suitable for sharbat, powder, candy and squash making.

Characteristics: Average yield per plant 75.67 kg (8th year), average fruit weight 1.45 kg, fruit size 15.10 cm x 15.00 cm, fruit girth 47.30 cm, shell thickness 0.18 cm, total number of seed 73, seed weight 0.21g, total seed weight 15.46g, fibre weight 110.17 g, shell weight 265.00g, locules in cross section 13-16, pulp 71.30%, TSS pulp 40.10ÅBrix, TSS mucilage 51.50ÅBrix, acidity (0.30%) and vitamin C 19.90 mg / 100 g pulp.

Branches laden with fruits of uniform shape and size

Branches laden with fruits

Thar Divya

Fruits of this variety are comparatively less affected (40%) by sunscald due to dense canopy and luxuriant growth. This variety starts ripening after 270 days of fruit setting under rainfed conditions of hot semi-arid ecosystem. This variety matures during February and belongs to very early maturing group and can be grown successfully under rainfed semi-arid ecosystem.

Harvested fruits

Characteristics: Average yield/tree (kg) 70.50 during 8th year, fruit weight 1.62 kg, fruit size 18.60x14.80 cm, fruit girth 45.80 cm, shell thickness 0.19 cm, number of locules in cross section (seed cavity) 14.72, peel weight 235.50 g, pulp weight 1.30 kg, fibre weight 61.10 g, seed weight 0.13 g, total seed weight 32.00 g, total number of seed 120.75, TSS of pulp 38.50 °brix, TSS of mucilage 51.00 °brix, acidity 0.30 %, TSS/acidity ratio 128.33.

Thar Srishti

This variety of bael is having very distinct character with respect to locule arrangement adhere in the centre, highly centric locule arrangement, rich in fine fibres and having very less flavour and aroma, seeds embedded in the mucilage in cavity can easily scooped out by spoon and can be consumed fresh as table fruit. It is very sweet in taste and having high pulp and mucilage total soluble solid and high TSS/acidity ratio (128.33) under rainfed hot semi-arid ecosystem.

Characteristics: Average yield/tree during 9th year 91.50 kg, fruit weight 1.55 kg, fruit size 21.00 x 14.00 cm, fruit girth 43.53 cm, shell thickness 0.20cm, number of locules in cross section (seed cavity) 14.00, peel weight 200.00 g, pulp weight 1.20 kg, fibre weight 62.32 g, total seed weight 19.00 g, total number of seed/fruit 98.15, TSS of pulp 36.58 °brix, TSS of mu-



Highly centric locule arrangement


Bunch bearing

cilage 51.50 °brix, total sugar 21.40%, acidity 0.35% and TSS/acidity ratio 128.33.

Thar Prakriti

Based on desirable horticultural traits, it has been identified promising genotype, collected from Anand, Gujarat in 2010. The fruits of this genotype are having good flavour and aroma and rich in antioxidants. It is highly suitable for sharbat, *murabba* and powder making and various ayurvedic medicines. Time taken from fruit setting to ripening is 315 days; fruits are round and rich in fibre content.

Characteristics: Average yield per plant 115.75 kg in 12th year, fruit weight 1.40 kg, fruit size 14.05 cm x 15.10 cm, fruit girth 44.10 cm, shell thickness 0.14cm, total number of seed 60.23, seed weight 0.20g, total seed weight 17.40g, fibre weight 28.42 g, shell weight 190.60g, locules in cross section 14-17, TSS pulp 38.00^{0}B, TSS mucilage 51.00^{0}B, acidity (0.33%) and vitamin C 22.50 mg/100g pulp.


Thar Prakriti: branches laden with uniform fruit shape and size


Ripened fruit colour


Transverse section of fruit

in shape with peculiar styler end cavity. It belongs to late maturity group (1st week of May) having uniform and peculiar roundish fruit shape and size. Distinct character of the variety is papery shell, very less seed

Thar Shivangi

Luxuriant growth, peculiar leaf shape, drooping branches, curved petals and high phenolic content are




Bael variety Thar Shivangi: drooping branches laden with fruits

the distinct traits of this variety. Being small in stature, it is highly suitable for high density planting (5mx5m).

Characteristics: Average yield/plant is 109.15 kg in 11th year, fruit weight 1.35 kg, fruit size 15.50 cm x 12.87 cm, fruit girth 44.80 cm, shell thickness 1.9 mm, total number of seed 75.32, total seed weight 32.00g, fibre weight 35.00g, shell weight 190.21g, locules in cross section 15.50, pulp 70.50%, TSS pulp 37.10^{0}B, TSS mucilage 50.50^{0}B, acidity (0.35%) and vitamin C 20.40 mg/ 100 g pulp.

Propagation

Selection of bud wood

Bud wood becomes available during the active growth period in rainy season. The bud sticks (1-1.5 months old), with well swollen and recently matured buds (but still not open) are collected. The active growth period is indicated by easy and clear separation of the bark from the wood of scion sticks. After collection, the bud wood is often stored for some period or takes some time in transportation. During this period, considerable loss of survivability may take place. Bud woods retain good survival when kept under ventilated shade and wrapped in moist jute cloth.

Patch budding

In this method, a healthy bud is selected from the axils of leaf. Leaf blade is removed with the help of a sharp knife leaving petiole intact. The upper cut is given about 1-1.5 cm above bud which goes downwards up to 1.0-1.5 cm below the bud without wood portion and then lower cut is given about 1.0 cm below the bud. The similar rectangle incision is made on the rootstock by placing the bud on the root stocks to mark the exact size of the bud on them and after removing the bark of root stock, the bud is placed at the juncture. The bud is pressed by hand to remove open space if any and tied tightly except the place of bud with white polythene strip (200 gauge thickness and 2 cm wide). In case, the cuts on rootstock are wider, at least one side bark of scion and stock must be matched properly. One year old, 0.8-1.20 cm thick rootstocks budded in June showed better success under Gujarat conditions. Budding is most suitable method for bael propagation.

In-situ patch budding

In bael, the tap root system is very vigorous. The root system is, therefore, disturbed during the process of planting of grafts, which ultimately affects growth and establishment adversely in the field conditions. The plants propagated by *in- situ* patch budding in the month of June recorded maximum success (94.14%). Budding in bael in June from one month old scion gave 80 per cent success and patch budding is an ideal method of bael multiplication.

In arid and semi-arid regions, *in situ* budding is the most successful method for establishment of bael orchard. This is done by sowing 2-3 seeds directly in the field or by planting seedlings. After one year, budding is done in the field. This method not only saves time but also ensures higher success. Generally, 2-3 rootstocks sprout developing from ground level are budded and ultimately only one of them is allowed to grow which encourages the growth of scion shoots. Sprouts emerging from the rootstock portion should

Selected scion shoots

In-situ patch budding

be removed from time to time.

Softwood Grafting

About 15-20 cm long mature shoots (4-6 months old) are defoliated 10-12 days prior to grafting operation. These shoots are detached from the mother plant with the help of secateurs or sharp grafting knife for grafting by cleft method. For this, seedling rootstock is cut at 20-25 cm height and the top portion is removed. With the help of knife, 5 cm long vertical downward incision is made in the center of the rootstock. A sharp cut of 5 cm is made on both the sides

Softwood patch budding and soft wood grafting

on the base of the scion shoot to make wedge shape. Thereafter, prepared scion is carefully inserted in vertical slit of the rootstock and tightly secured with the help of 200 gauge thick and 2 cm wide polythene strips. The polythene strips should carefully be removed after completion of the union.

Planting

There is only one planting season under rainfed conditions of western India *i.e.* June- July. Normally, the pits of 1m x 1m x1m are dug at distance of 6m to 8m and for high density at 5m x 5m. They are filled with 50:50 FYM and top soil mixture and it is also advisable to mix 125 g SSP and 150 g *neem* cake. Drenching of pit with insecticide is advised to avoid the termite attack. For *in-situ* budding, seeds are directly shown in the pits or planting of rootstocks should be done in June immediately after first rain and patch budding can be followed as soon as new leaves started to emerge out in planted rootstocks (after one to one and half months) and after a year in the plants directly sown in the field under rainfed conditions.

Fertilizer Application

Fertilizers are applied in two split doses, 10 kg FYM, 75g nitrogen, 50g phosphorus and 50g potassium per year per plant is given to one year old plant and this dose should be increased in same proportion up to the 10 years age for its better growth. FYM plus half dose of nitrogen and potassium and full dose of phosphorus should be applied just after first rains while remaining doses should be applied in the last week of August under rainfed conditions of hot semi-arid ecosystem.

Canopy Management

The growth of plants can be managed at desired size and shape by canopy architecture. During first year after planting, plants are headed back at 1 m from the ground level during leafless condition of plant (April-May) to facilitate emergence of new growth below the cut points. Three to four equally spaced shoots (limbs) are retained around the stems to form the main scaffold of the trees. These shoots are allowed to grow

Pruning at 25% of annual growth extension
High density planting (5m x 5m)

approximately for 6-7 months then these selected shoots are further pruned to 50% of their total length to promote emergence of new shoots below the cut point. As the new shoots emerge, they are allowed to develop further. It is better to train the plant in modified leader system of canopy architecture and it should be completed within initial 3-4 years. While pruning, dead, diseased, criss-cross and infested twigs should be removed in March- April when trees are in leafless condition.

High density planting

Based on its potentiality, a field trial on high density planting (5mx5m), accommodating 400 plants/ha, was initiated to find out the efficacy of Goma Yashi variety of bael to maximize the yield per unit area. *Deshi* rootstock were sown directly on the field and *in-situ* patch budding was performed from the scion shoot of single mother plant of Goma Yashi variety. Fruit setting started from 2nd year, but economic yield was harvested after 5th year of budding under rainfed semi-arid conditions. Results of study revealed that the fruit setting and fruit retention showed linear increase as the age of tree increased. However, after 7th year, canopy management is required for proper aeration and light interception in the orchard. Bael tree respond to pruning well, for which pruning at 25 per cent of annual growth extension during May, when the plants were in leafless condition, should be done uniformly after attaining the age of 7 year at alternate years, which not only helps in maintaining the proper canopy but also in improving the fruit quality. Net profit of Rs. 2-3 lakhs can be earned from one hectare land.

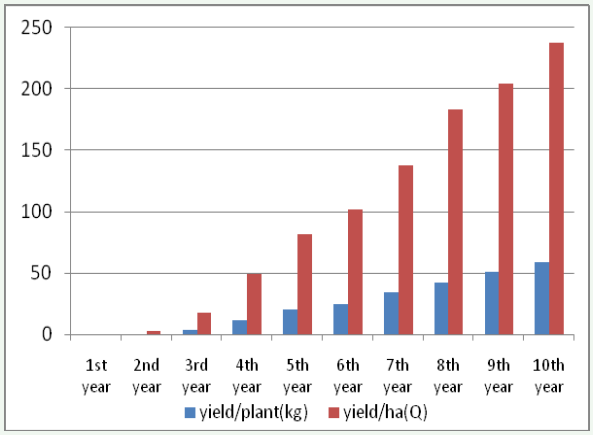


Fig. 1.Yield increment in Goma Yashi as per age under rainfed dry land condition, CHES, Godhra

Flowering and Fruiting

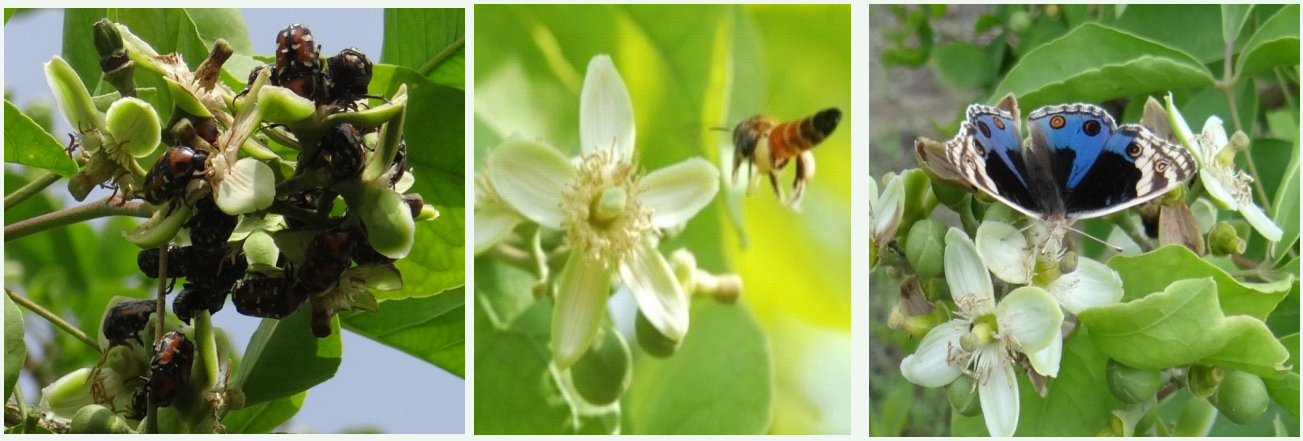
The budded plants start bearing fruits at the age of 3 to 4 year. The flowering in bael tree starts from April to June and fruits become ready for harvesting after 8-10 months or by forthcoming February to June under rainfed semi-arid environment. It is a climacteric fruit. Anthesis and dehiscence took place between 5.00 a.m. to 12 p.m.

Irrigation

Though bael is a hardy tree and it can be grown successfully without watering under rainfed condition, however, plant may be irrigated on need based basis for initial 1-2 years, particularly during summer at 15 days interval for better establishment, afterwards young plants generally do not require watering. Regular soil working around the tree should be done at appropriate time to avoid loss of water through evaporation under rainfed conditions.

Mulching

Under rainfed condition, application of organic mulch in tree basin is found very beneficial for successful cultivation of bael under rainfed condition. Mulching can be done with any suitable locally available organic material like paddy straw, maize straw,



Pollinating agents

grasses, husk etc. which not only conserve soil moisture, but also impart manifold beneficial effect like tolerance to extreme of fluctuation of soil temperature, reduction in water loss through evaporation, resulting in more soil moisture conservation, increase in organic matter and microbial population, suppression of weed growth, and improvement in soil quality, plant growth

Mulching with paddy straw

and yield of quality fruits. Leaf litter of bael under the canopy is not only an effective mulch to retain soil moisture during summer but also improves the soil properties.

Ripening

Fruit attained maximum size up to September and then more or less stationary phase until the fruits were harvested. Almost all varieties exhibited similar pattern of fruit growth and development. Variety Goma Yashi starts ripening from the first fortnight of March, Thar Neelkanth and Thar Srishti in April whereas Thar Prakriti and Thar Shivangi in May under rainfed semi-arid conditions of western India. Thar Divya is the earliest maturing variety which starts ripening in the February under rainfed semi-arid conditions of western India.

Harvesting

Proper care should be taken during harvesting. Individual fruit along with little portion of stalks should be handpicked and not to be allowed to drop. Easy separation of stalk is a common indication of ripened fruits but the stalks of few varieties could not be separated even from ripened fruits. Fruits at full maturity can be stored up to 7-15 days after harvesting under ambient condition in rainfed conditions of semi-arid ecosystem.

Insect Pests

Lemon Butterflies (*Papilio demoleus* L.)

Papilio spp. or swallow-tail butterflies are amongst some of the- most beautiful butterflies found throughout the year in gardens and orchards, visiting various flowers but causing no damage. However, the caterpillars feed on foliage and cause economic loss. Eight species of these papilionids have been reported feeding on different crop leaves in India. Of these, only one *i.e., Papilio demoleus* is the major pest of bael. Others are of minor importance, as these are either sporadic in occurrence or confined to certain pockets.

Diseases

Bacterial shot-hole and fruit canker of bael caused by X*anthomonas bilvae* is the major disease. The symptoms are characterized by round, water soaked spots (0.5 mm) on leaves, twigs, thorn and fruit. The disease can effectively be controlled by 2-3 sprays of 500 ppm streptomycin at 15 days interval. The new

Lemon butterfly

flush of young plants sometimes may be infected with powdery mildew (*Oidium* sp.) and the disease is found to be controlled by the spray of carbendazim (0.05%) or sulfex (0.2%). Gummosis caused by *Phytophthora nicotianae* can be controlled by pasting of stem with Bordeaux paste up to the height of 1-2 feet and spray with Ridomil Mz (0.02%).

Powdery Mildew

The disease is characterized by appearance of white floury patches on leaflets, especially on younger leaves which increase in size and cover entire lamina soon within 7-10 days (during November–December). Later the colour of the colony turns slightly pinkish or greyish. Tender shoots are also found infected with the mildew. The disease is caused by *Oidium* sp. Spray with Carbendazim 50 wp (Bavistin 0.1%) or wettable sulphur (0.2%) is found useful to control the disease. However, during warm weather and flowering period, the application of sulphur should be avoided.

Fruit Rot *(Aspergillus nidulans)*

Internal rotting of fruit is a serious problem, which is mainly caused by damage to fruits during harvesting, storage, transportation or harvesting. Such disorders can be avoided by maintaining proper ventilation, avoiding polythene enclosures during storage, harvesting of fully mature fruits and also by avoiding damage to the fruits and wrapped/stored with newspaper or phenol papers.

Powdery mildew affected leaves

Gummosis

Like other rutaceous plants of citrus family, oozing of gum is common in bael orchards. The disease is characterized by oozing out of pale or amber coloured gummy substance initially from bark of lower portion of trunk and later on other branches. The gum oozing takes place from vertical splits in bark which turns dark from outside at the point of oozing but from inside other surrounding bark tissues turn light brown or white and very soft and sticky when touched with fingers. Because of gummosis, the vigour of tree is severely affected and in severely affected twigs defoliation and dieback occurs. To manage the disease, it is suggested to scrap off the infected portion of bark with the help of a sharp knife, which should be followed by application of Bordeaux paste. Spray with Copper fungicides (Bordeaux mixture 1% or copper oxychloride, 0.3%) are suggested to be applied at monthly interval after rainy season. Removal of highly infected twigs and incorporation of *Trichoderma viridae* propagules in the soil of rhizosphere of bael were found helpful to control the disease.

Gummosis in branches

Physiological Disorders

Fruit Cracking

Fruit cracking has not been observed under rainfed semi-arid environment, but it is a major physiological disorder and its degree of damage depends according to genotypes/varieties and agro-climatic conditions. The cracking can be minimized by maintaining optimum soil moisture regime and by provision of wind breaks against hot desiccating wind inside of orchard. Organic mulches like paddy straw, maize straw, *subabul* loppings can effectively be utilized in maintaining soil moisture of tree basin particularly during summer under rainfed conditions of hot semi-arid ecosystem.

Fruit cracking in bael

Fruit Drop

Fruit drop is a natural phenomenon, but its extent of damage is a matter of concern. The extent of fruit drop varied according to genotypes/ varieties and locality. Immature fruit drop (marble size) has also been observed. Sometimes ball size fruits also fall down. The extent of fruit drop in bael can be reduced effectively by adopting better orchard management practices and application of growth hormones like NAA (15-20 ppm / litre).

Sun scald

Sun scald is major disorder of bael under dryland conditions. It is manifested by turning of normal green shell into dark brown at the point. Where it is exposed to hot sun for maximum period during day hours. Sometimes the pulp of fruit beneath the shell also gets affected due to moisture loss and irradiation. The main reason of sun scald may be ascribed to intense solar radiation affecting the shell for long time during the day coupled with unavailability of sufficient soil moisture. The temperature of sun scalded portion is increased by 8-10° C as compared to unexposed portion of the fruits. This malady reduces the market price of the fruit even though the pulp of fruit is not much affected below the scorched shell. Mulching and canopy management are useful to reduce down this disorder up to some extent. It has been observed that the variety having thin rind are more affected by sun scaled than thick one under rainfed semi-arid conditions of western India. Initial studies have revealed that the organic mulch and covering of fruits are helpful in avoiding the sun scald up to some extent.

Fruit drop in July-August

Sun scald

Conclusion

The bael tree has been found to grow successfully in the purely rainfed conditions and its cultivation has been viewed very economic for small and marginal farmers and it is promising for ameliorating marginal degraded wastelands as well as drylands of country. Therefore, its cultivation will not only ensure economic security but also environment and health security of the farming community particularly resource poor farmers of the country.

REPORT

Launch Programme of Atal Tinkering Labs with KVKs & ATMA Collaboration Initiative

Dr. Shailesh Kumar Mishra

Atal Innovation Mission (AIM), NITI Aayog and Ministry of Agriculture and Farmers Welfare (MoA&FW) have come together to promote innovation in the agricultural sector among school students across India. The two government bodies have agreed to connect Atal Tinkering Labs (ATLs) with Krishi Vigyan Kendras (KVKs) and Agricultural Technology Management Agencies (ATMAs) under the initiative. The collaboration is a result of the vision of Hon'ble Prime Minister Shri Narendra Modi who seeded this idea during a conversation and proposed to connect the ATLs with the KVKs across the country. Hon'ble Prime Minister also suggested both the government bodies to look into the idea of linking soil testing labs to ATL schools.

KVKs function as a "Single Window Agricultural Knowledge Resource and Capacity Development Centre" and this collaboration will provide numerous stakeholders with necessary information, training, and inputs. KVKs, in partnership with ATMA, will collaborate with nearby ATLs to support agricultural-related innovation.

During the first phase of the implementation, one KVK under each of the 11 Agricultural Technology Application Research Institutes (ATARIs) have been involved, providing technology backstopping and facilitating knowledge-sharing and skill-building exercises. KVK experts will also undertake need- based visits to nearby ATLs, while KVKs will provide literature, seeds, planting materials, and other inputs as required. The pilot project will be extended after assessing the positive outcomes after two years.

Under the leadership of Shri Samuel Praveen Kumar, Joint Secretary (Extn.) the officers of Extension Division visited Amity International School, Saket, New Delhi, ATL Lab and interacted with innovator students on 12.04.2023. During the visit JS (Extn.) alongwith the team interacted each and every student of Atal Tinkering Lab. It was innovative and new experience of students involved in the innovations. During the visit it was informed by the students that sum of the students have been awarded for their innovation including one student was awarded Rs. 1 crore for her innovation. It was also informed by student that about 10 patents have been made to their credit by

Director (Extension), Directorate of Extension, Ministry of Agriculture and Farmers Welfare, Govt. of India, Krishi Bhawan, New Delhi.

Amity International School.

The launch programme was held in two parts:

I. Launch event for ATL and KVK-ATMA collaboration

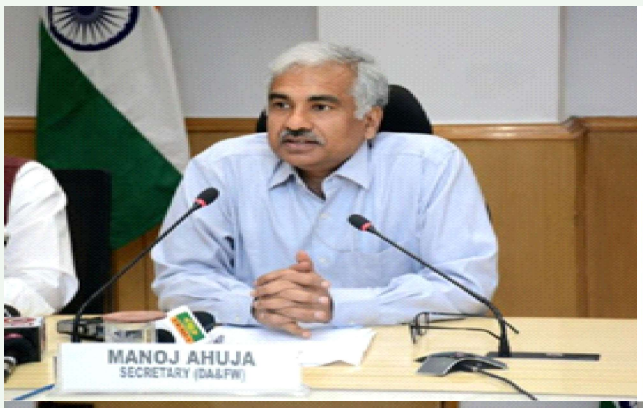
II. Orientation session for ATL and KVK-ATMA collaboration

I. Launch event for ATL and KVK-ATMA collaboration:

Ms. Deepali Upadhyay, PD, AIM, NITI Aayog welcomed Secretary, DA&FW, Mission Director, AIM, NITI Aayog, JS (Extn.), DDG (AE), ICAR, officers from DA&FW, NITI Aayog and Teachers and Students from Amity International School, Saket, Kendriya Vidhyalya, Vikas Puri, DAV Public School, Vasant Kunj and Media personals.

In the opening remark Shri Samuel Praveen Kumar, JS (Extn.) briefed the august gathering about new initiative of Ministry of Agriculture and Farmers Welfare in-collaboration with NITI Aayog and ICAR. JS (Extn.) further, explained that Atal Innovation Mission and Ministry of Agriculture and Farmers Welfare have come together to promote innovation in the Agriculture sector through Atal Tinkering Labs (ATLs) and Krishi Vigyan Kendras (KVKs). This collaboration will provide an opportunity for school students to understand the challenges faced by farmers and develop innovative solutions that will help the sector grow. Further he added that KVKs have played a crucial role in providing agriculture extension services to farmers and their partnership with Atal Tinkering Labs will enable them to reach out to a larger audience and promote innovation in agriculture among school students.

Dr. U.S. Gautam, DDG, (AE), ICAR briefed the participants about KVK functioning and its role in implementation of ATL.ATL and KVK-ATMA collaboration to foster innovation by school students in agriculture sector was launched on 13.04.2023 in NITI Aayog by Shri Manoj Ahuja, IAS, Secretary (DA&FW) and Dr. Chintan Vaishnav, MD, Atal Innovation Mission, NITI Aayog addressed the participants and informed about the Mission of Hon'ble Prime Minister for linking of ATLs with KVKs. Mission Director said, "In my mind this step is going to be a giant leap towards boosting agriculture innovations in India. There are two aspects of this collaboration that are worth replicating across many sectors. First, the idea of linking the existing government platforms with a purpose. For example, public health centers and ATLs could be linked similarly for better healthcare and so on. Secondly, linking children, the most important change-makers of society to the real, most important challenges, and opportunities" he spoke. He further



said that both AIM and MoA&FW are also mulling to create a quarterly showcase at MoA&FW where stream of Agri-student innovators would be felicitated by Atal Innovation Mission. He informed that AIM has mapped and shared a list of 55 ATLs (mapping each of the 11 KVKs, ATMAs with up-to 5 ATLs) based on the list of KVKs and ATMAs shared by MoA&FW.

Shri Manoj Ahuja, Secretary (DA&FW) addressed the participants and informed about the new initiatives being taken by DA&FW in the form of ATL and KVK-ATMA.Addressing the gathering, Secretary, DA&FW, spoke about the potential of this collaboration to address the various challenges of Agriculture. He further added that under this framework, MoA&FW and ATL can develop a problem finding

platform and organize hackathons. He stressed the need for adopting an "integrated learning approach" to find solutions to the problems of farm sector.

Innovation experience was shared by many school students from Amity International School, Saket, Kendriya Vidyalaya, Vikas Puri and DAV Public School, Vasant Kunj, New Delhi. At the end of the launch programme vote of thanks was given by Dr. Shailesh Kumar Mishra, Director.

II. Orientation session for ATL and KVK-ATMA collaboration:

During the orientation session held on 13.04.2023 at NITI Aayog a welcome address was given by Ms. Deepali Upadhyay, MD, AIM, NITI Aayog.

Shri Samuel Praveen Kumar, JS (Extn.), DA&FW delivered key note address to the august gathering during orientation session and invited Krishi Vigyan Kendra to provide full support to the ATLs spread throughout the country benefiting young students in the field of Agriculture sector. JS (Extn.) also informed that Atal Tinkering Labs (ATLs) established by Govt. of India have been playing an instrumental role in promoting innovation among school students, by providing a platform for students to experiment and innovate. ATLs have been instrumental in nurturing the next generation of innovators and entrepreneurs. Further, he added that promoting innovation in the agriculture sector among school students is the crucial step towards the growth and development of our country. He assured that this collaboration will bring forth new ideas and solutions that will benefit farmers and our nation as a whole.

Dr. Sujith Kumar Jha, Principal Scientist, Agriculture Extension, Division ICAR briefed the participants about functioning of Krishi Vigyan Kendras. Ms. Vishnu Priya Beejapur, Innovation lead, AIM, NITI Aayog made a presentation of Atal Tinkering Lab covering 10,000 schools in the country. Dr. Y.R. Meena, Additional Commissioner (Extn.), DA&FW briefed the participants about functioning of ATMA. Meanwhile, young student innovators from the ATL schools KV Vikaspuri, DAV Vasant Kunj and Amity International School also shared their ATL experiences and spoke about their innovations in agriculture sector.

Ms. Anupriya Nayak, Amity International School, Saket, New Delhi shared her innovation idea which gave her an award of Rs. 1 crore. At the end of the orientation session, vote of thanks was given by Dr. Punam Tiwari Sharma, JD (WP), DA&FW.

Continued from page 6

example, such sensors can identify sick animals so that farmers can separate them from the herd and avoid contamination. Using drones for real-time cattle tracking also helps farmers reduce staffing expenses. This works similarly to IoT devices for pet care.

5. End-to-end farm management systems

A more complex approach to IoT products in agriculture can be represented by the so-called farm productivity management systems. They usually include a number of agriculture IoT devices and sensors, installed on the premises as well as a powerful dashboard with analytical capabilities and in-built accounting/reporting features. This offers remote farm monitoring capabilities and allows to streamline most of the business operations. Similar solutions are represented by FarmLogs and Cropio. In addition to the listed IoT agriculture use cases, some prominent opportunities include vehicle tracking (or even automation), storage management, logistics etc.

Conclusion

IoT technology enhances control on agricultural processes to reduce production risks and boosts the ability to foresee production results, which helps farmers in better planning and distribution of product. Data about exact batches of crops and the quantity of crops to harvest can support farmers cut down on labour and waste. Smart agriculture with the assistance of IoT can facilitate agriculture work proficiently.

Continued from page 11

tion in timing is impacting the agriculture and will also impact in future. The incidences of hailstorms, cyclones and flash-floods have been increased and have great impact on agriculture. These challenges have potential to limiting the income of farmers in the country. Climate smart agriculture should be adopted to minimize the effect of agricultural practices on the environment. Crop rotation, minimal tillage, integrated approach for minimizing use of chemicals and natural resources, livestock waste management etc. are some of the practices to be adopted widely. Integrating different fields of agriculture for using by-products and efficient work will definitely help in reducing some of the potential effects on environment. Development of relevant irrigation infrastructure will also help in reducing the effect of possible global warming. Desertification of useful lands needs to be stopped which can be exploited for agriculture. Planting of tree species near farm lands is good option to maintain soil biodiversity, which also enhances the soil quality and helps in avoiding soil erosion in certain cases. Role of honey bees in agriculture is well known and highly acknowledged. Various groups also highlight that change in climate and use of some insecticides impacts the population of these pollinators which will absolutely affect the yield in coming years. Different ways to tackle the impact of climate change is need of the hour and adoption of improved production technologies in agriculture sector will certainly help in dealing with changing scenario.

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