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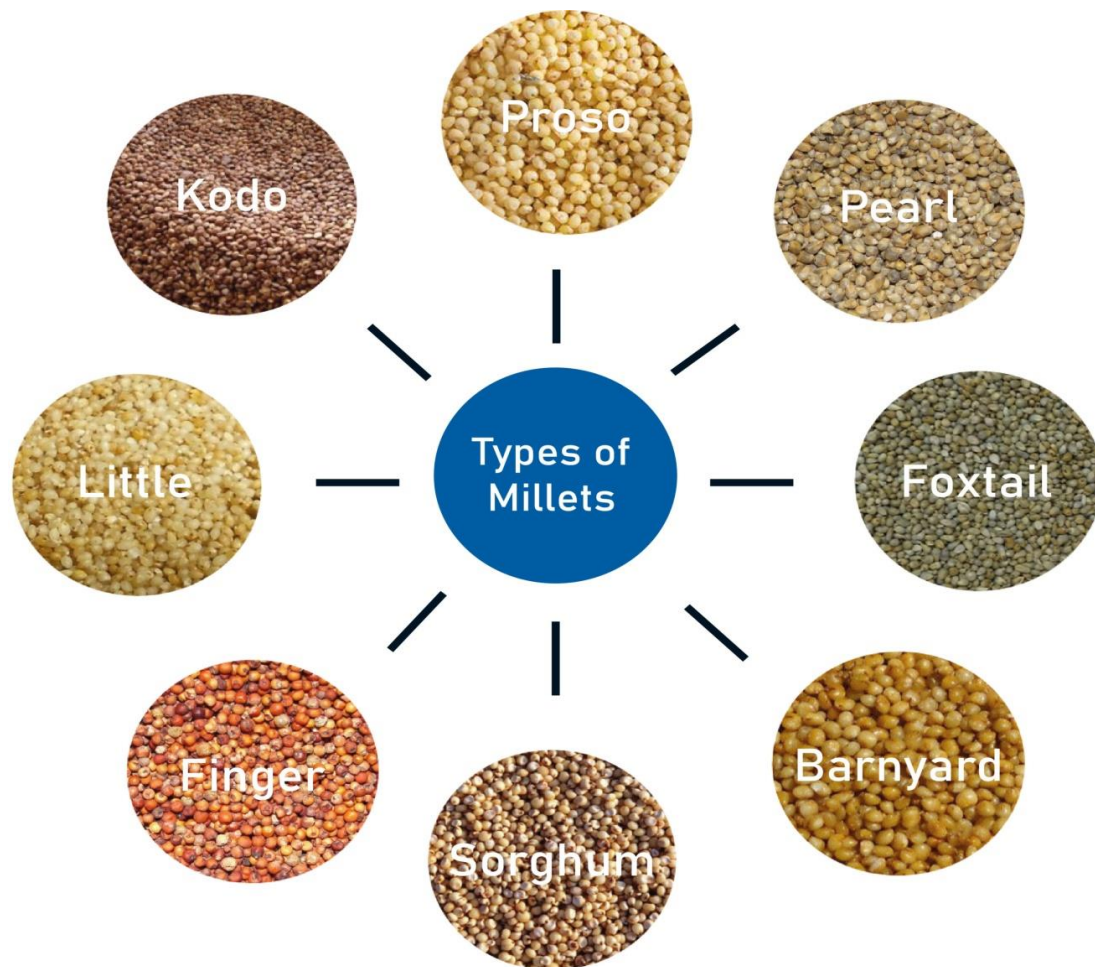
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1. GENETICS AND PLANT BREEDING

Mighty Millets: - Employing the Untapped Potentiality of Millets for Food Security, Nutrition and Sustainable Agriculture

Mitali Tiwari

Rani Lakshmi Bai Central Agricultural University, Jhansi Uttar Pradesh-284003



Introduction

Millets are a group of small-seeded meadows that have been cultivated for thousands of times as a staple food in numerous corridor of the world, particularly

in Africa and Asia.

They are highly nutritious ,failure –tolerant and can grow in poor soil conditions, making them an ideal crop for food security. Still, millets have been largely neglected in recent times in favor of other crops such as rice, wheat and

sludge. This has led to a decline in millet production and consumption, performing in a loss of traditional knowledge and biodiversity.

- Employing the untapped eventuality of millets for food security involves crucial strategies:-
 - **Originally**, there is a need for increases investment in exploration and development to ameliorate millets varieties, enhance their productivity, and make them more adaptable to different agro-climatic conditions. This includes breeding programs to develop high-yielding and disease –resistant varieties, as well as agronomic practices to optimize millet production.
 - **Secondly**, there is a need for policy support and request impulses to promote millet civilization and consumption. This includes furnishing growers with access to credit, subventions and insurance schemes to encourage millet civilization. Government can also play a role in promoting millets through public procurement programs, academy feeding programs and awareness campaigns to educate consumers about the nutritive benefits of millets.
 - **Thirdly**, there is need for value addition and market development for millet-grounded products. This includes promoting millet processing technologies, such as milling, dehulling and fortification, to ameliorate the shelf life and nutritional quality of millet products. It also involves creating market linkages

and value chains for millet-based products, including breakfast cereal, snacks, bakery products, and beverages to increase their demand and availability in both domestic and international markets.

Incipiently, there is a need for capacity structure and knowledge sharing to empower farmers, researchers and other stakeholders in the millet sector. This includes training programs on millet cultivation, processing and marketing as well as the establishment of millet research and extension centers to disseminate best practices and innovations.

- **Employing the untapped potential of millets for Nutrition:-** These are highly nutritious but also retain unique characteristics that make them an ideal crop for addressing nutrition challenges and promoting food security.

One of the crucial advantages of millets is that their exceptional nutritional profile. They are rich in fiber, protein, vitamins and minerals and have a low glycemic index, making them an excellent choice for maintaining blood sugar levels. It involves several crucial strategies-

1. **Promoting mindfulness and education-** Increasing awareness about the nutritional benefits of millets is crucial.
2. **Investing in research and development** to ameliorate millet varieties, increase yields and enhance their nutritional content is essential. It includes breeding programs to develop high-yielding and disease-resistant varieties as well as exploring the potential of millets for value-added products like millet flour, flakes and snacks.
3. **Market development-** Developing a strong market for millets is essential to incentivize farmers to grow them. This involves creating demand through marketing campaigns, promoting millets as healthy and sustainable food option and ensuring availability in supermarkets, restaurants and food processing industries.
4. **Capacity structure-** Building the capacity

of farmers, processors and other stakeholders in millet production and processing techniques is crucial. This can be done through training programs, workshops and sharing platforms.

• **Employing the untapped eventuality of millets for Sustainable Husbandry:-** Millets

form an important part of sustainable agriculture and are nutritionally dense, failure-tolerant and can be grown and harvested quickly making them valuable for small-scale husbandry.

- Millets are one of the world's most productive and climate resilient crops. As global demand for cereals and grains continues to rise, millets have the eventuality to create a more sustainable agriculture and provide precious nutrition for millions of people around the world.
- Although millets are a historically significant food grain, their nutritional value has been overlooked, leading to a dearth of innovation and research into its cultivation. Millets acclimatize well to a wide range of agro-climatic conditions and even on poor soils.
- Millets are extremely failure-tolerant compared to other crops such as wheat, rice and maize.
- In India, millets are traditionally grown on poor soils without the use of

chemicals fertilizers and pesticides therefore in this way these are organic grains.

- By virtue of their unique C4 photosynthetic activity millets utilize water in a highly efficient manner and require low inputs.
- It has been prognosticated that due to accelerated climate change production of major cereals will decline in the future therefore drought tolerant and low input demanding crops like millets should be rooted in an extensive way to mitigate the effects of climate change and food insecurity.
- Thus, millets offer several agrarian advantages which make them crops which are less demanding on agrarian inputs yet are organic and environment friendly. Thus, millets are the key alternative to the anticipated food insecurity problem.
- Millets are considered smart food which is good for growers as well as good for earth.

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2. AGRICULTURAL METEOROLOGY

Monsoon, its onset behavior & impacts on Indian Agriculture

M. K. Nayak¹ & Dolly Chouhan²

¹Krishi Vigyan Kendra, Karauli Rajasthan, ²Shri Agrasen Mahilla T.T. College, Hindauncity, Karauli, Rajasthan

Introduction

Monsoon is traditionally defined as a seasonal reversal of wind accompanied by corresponding changes in precipitation associated with the asymmetric heating of land and sea. The term was first used in British India and neighboring countries to refer to the seasonal winds blowing from the Bay of Bengal and Arabian Sea bringing heavy rainfall to the area.

Process of Monsoon creation

Monsoons may be considered as large-scale sea breezes, due to differential heating of land and the adjoining oceans; and the resultant development of a thermal low over a continental landmass. This differential warming happens because heat in the ocean is mixed vertically through a "mixed layer" that may be fifty metres deep, through the action of wind and buoyancy generated turbulence, whereas the land surface conducts heat slowly, with the seasonal signal penetrating perhaps a metre or so. Additionally, the specific heat capacity of liquid water is significantly higher than that of the land. Together, these factors mean that the heat capacity of the layer participating in the seasonal cycle is much larger over the oceans than over land, with the consequence that the air over the land warms faster and reaches a higher temperature than the air over the ocean. The hot air over the land tends to rise, creating an area of low pressure. This creates a steady wind blowing toward the land, bringing the moist air of maritime origin with it.

This moist air is lifted up due to orographic barriers or low pressure areas. The air on lifting cools due to expansion, which in turn produces condensation and precipitation. In winter, the land cools off quickly, but the ocean retains heat longer. The cold air over the land creates a high pressure area which produces the wind flow from land to ocean. Monsoons are similar to sea and land breezes, a term usually referring to the localized diurnal cycle of circulation near coastlines, but they are much larger in scale, stronger and seasonal.

Southwest monsoon

The southwest monsoons occur from June through September. The Thar Desert and adjoining areas of the northern and central Indian subcontinent heat up considerably during the hot summers, which cause a low pressure area over the northern and central Indian subcontinent. To fill this void, the moisture-laden winds from the Indian Ocean rush in to the subcontinent. These winds originate in the south Indian Ocean and move northward. On crossing the equator, these winds are deflected to their right due to rotation of the Earth. They approach the Indian land mass from southwest and, therefore, are called southwest monsoon.

Onset and advance of Southwest monsoon

The southwest monsoon is generally expected to begin around start of June and fade down by the end of September. The moisture-laden winds on reaching the southernmost point of the Indian Peninsula, get divided into two parts: the Arabian Sea Branch and the Bay of Bengal Branch.

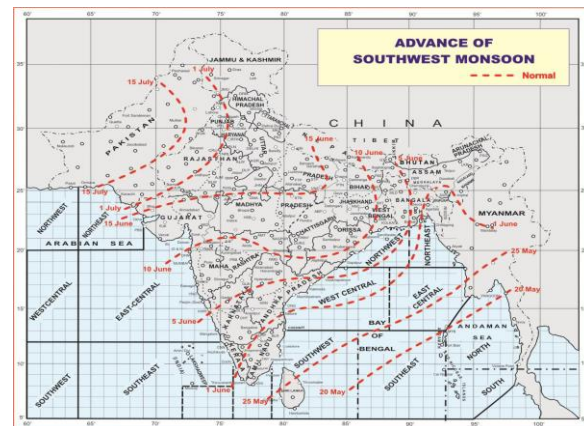


Fig. 1. Normal dates of onset of southwest Monsoon

The **Arabian Sea Branch** of the Southwest Monsoon first hits the state of Kerala around 01 June. This branch of the monsoon moves northwards along the Western Ghats (Konkan and Goa) and reaches Mumbai around 10 June. Simultaneously, the **Bay of Bengal Branch** flows over the Bay of Bengal heading towards North-East India. Picking up more

moisture from the Bay of Bengal, the Monsoon reaches northeast India around 01 June. After the arrival over northeast India, the winds turn towards the west, travelling over the Indo-Gangetic Plain. It reaches upto eastern parts of Uttar Pradesh around middle of June. The Arabian Sea Branch, by the same time reaches upto Gujarat; and the two branches generally merge over central parts of the country. It then progresses as a combined current and covers the remaining parts of the country by middle of July. The normal dates of onset of southwest monsoon are given in Figure 1 above.

Rainfall Distribution during Southwest Monsoon

The monsoon accounts for 80% of the rainfall in India. Indian agriculture is heavily dependent on the rains, for growing crops especially like cotton, rice, oilseeds and coarse grains. A delay of a few weeks in the arrival of the monsoon, its early withdrawal or prolonged dry spells during the season can badly affect the economy, as evidenced in the numerous droughts in India. Influence of orographic features is clearly seen in the distribution of rainfall. As the prevailing winds blow almost at right angles against the Western Ghats and the Khasi– Jaintia hills, highest seasonal rains are experienced over these regions. In the north Indian plains, a minimum rainfall belt runs from northwest Rajasthan to the central parts of West Bengal, practically along the axis of the monsoon trough. Rainfall decreases considerably with a very steep gradient to the east of the Western Ghats which fall in the rain-shadow zone. With all the significant amounts of rainfall occurring over the Ghats, a saving feature of economic interest is that all the important rivers of south India emerging out of the western Ghats to flow east through the plateau which otherwise receives considerably lower rainfall. Eastern and central parts of the Himalayas also receive heavy rains due to orographic effect. Parts of Jammu and Kashmir, western parts of Rajasthan and extreme southeastern parts of peninsula receive the lowest amounts of rain during the season.

The interannual variability of all India seasonal monsoon rainfall expressed as the

percentage departures from long period average (LPA). The years in which the percentage departures are less than -10% (more than +10%) are called drought (flood) or deficient (excess) monsoon years. Remaining years are called normal monsoon years. It is seen that during the period 1901 -2011, the lowest seasonal rainfall have occurred in 1918 (75.1% of the normal) and 1972 (76.4%); and highest in 1917 (122.9%) and 1961 (121.8%). The red (blue) bars correspond to El Nino (La Nina) years. Out of the 20 drought years during the period of 1901-2011, 13 years (65%) were associated with El Nino events. Most of the La Nina years (blue bars) received normal or excess rainfall.

Impact of Southwest Monsoon Rainfall on Agricultural Production and GDP

During most of the years, the deviation of rainfall has been within $\pm 10\%$ of the normal. Though the amplitude of the variation of monsoon rainfall from year-to-year is not large, it has a substantial impact on agricultural production and economy of the country. Initially, large impact of monsoon on the economy of the country was thought to be the result of prime dependence of economy on agriculture. With planned development since independence, the contribution of agriculture to the Gross Domestic Product (GDP) decreased substantially.

This should have lessened the impact of monsoon on the economy. However, a recent analysis of the variation of the GDP and the monsoon by Gadgil and Gadgil (2006) has revealed that the impact of severe droughts on GDP has remained between 2 to 5% of GDP throughout. The large impact of droughts on GDP (despite the substantial decrease in the contribution of agriculture to GDP) can be attributed to adverse impacts of drought on other sectors of economy dependent on agriculture; and indirect impact on the purchasing power of the large fraction of the population dependent on agriculture.

Forecasting the Monsoon rains

Monsoon rains are predicted in three broad temporal ranges – Short Range (1-3 days), Medium Range (4-10 days) and Long Range Forecast (more than 10 days to a season or beyond).

1. **Short and medium range forecasts:** The short and medium range weather forecasts

are nowadays made using the Numerical Weather Prediction (NWP) Models. The basic idea of NWP is to sample the state of the atmosphere at a given time and use the equations of fluid dynamics and thermodynamics to estimate the state of the atmosphere at some time in the future. The main inputs to these models are surface observations from manned and automated weather stations over the land, weather buoys at sea and observations at different heights of the atmosphere obtained with specialised instruments (radiosonde) flown into the atmosphere with the help of hydrogen filled balloons. Data from weather satellites are used in areas of where traditional data sources are not available. Meteorological radars provide information on precipitation location and intensity, which can be used to estimate precipitation accumulations over time.

The models are initialized using this observed data. The irregularly spaced observations are processed by data assimilation and objective analysis methods, which perform quality control and obtain values at locations usable by the model's mathematical algorithms (usually at evenly spaced grids). The data are then used in the model as the starting point for a forecast. Commonly, a set of equations are used to predict the future state of the atmosphere. These equations are initialized from the analysis data; and rates of change are determined. The rates of change predict the state of the atmosphere a short time into the future. The equations are then applied to this new atmospheric state to find new rates of change, and these new rates of change predict the atmosphere at a yet further time into future. This time stepping procedure is repeated until the solution reaches the desired forecast time.

- 2. Long Range or Seasonal Forecast of Monsoon:** The summer monsoon accounts for major share of the total annual rain in 75% of the geographical area of the country. Although the

duration of monsoon over various parts of India varies from about 2 months to 6 months, long range forecasts are generally issued for monthly and seasonal scales for June to September. The year to year variation in the Indian summer monsoon rainfall (ISMR) is primarily attributed to its association with the slowly varying boundary forcing such as sea surface temperature, snow cover, soil moisture etc. Two main approaches are used for the long range forecasting (LRF) of the ISMR. The first approach is based on the empirical statistical methods; and the other is based on dynamic models which uses General Circulation Models (GCM) of the atmosphere and oceans to simulate the summer monsoon circulation and associated rainfall.

Statistical Long Range Forecast System

The statistical approach uses the historical relationship between the ISMR and predictors derived from global atmosphere-ocean parameters. The statistical models have shown better skill than the dynamical models for the seasonal forecasts of ISMR. Therefore, India meteorological Department (IMD) currently uses statistical methods for issuing long range forecasts of monthly and seasonal monsoon rainfall over India.

At present, IMD issues forecasts for monthly (for July, August, September), second half (August + September) and seasonal rainfall over the country as a whole and for seasonal rainfall over four geographical regions (Northwest India, Central India, Northeast India and South Peninsula) with useful skill. The seasonal forecast for the country as a whole is issued in two stages - in April and June. A set of 8 predictors that have stable and strong physical linkage with

ISMR is used. For April forecast, first 5 predictors are used. For the update forecast issued in June, the last 6 predictors are used that include 3 predictors used for April forecast. The RMSE of June forecasts for the independent period 1981-2010 is 5.6% of LPA. The months of July and August are the rainiest months of the south-west monsoon season (accounting for 33 % and 29% of the season's total rainfall, respectively) and play important role in production of kharif crops in the country. The monthly rainfall forecasts for July and August over the country as a whole are prepared using a

principal component regression models based on separate sets of predictors. Forecast for the rainfall during the second half of the monsoons season (August + September) and for the month of September over the country as a whole is prepared using another regression model.

Dynamical Model Forecasting System

Ministry of Earth Sciences (MoES) has launched the National Monsoon Mission (NMM) for developing a state-of-the-art dynamical prediction system for monsoon rainfall on different time scales. Indian Institute of Tropical Meteorology (IITM) is coordinating and working along with different climate research centres from India and abroad on the development of a coupled model for the forecasting the ISMR. IMD has adopted the latest high resolution research version of the coupled model being implemented at IITM for generating experimental forecast for southwest monsoon rainfall. For the first time, anywhere in the world, such a high resolution coupled model (horizontal resolution of approximately 38 km - T382) has been used for generating seasonal prediction of monsoon rainfall. The model is still in an experimental stage and shall be made operational once the desired level of accuracy is achieved.

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3. PLANT PATHOLOGY

Pathogenesis of bacterial plant pathogens

Naila Shohrat

Ph.D Scholar, Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Raichur, 584104

Introduction

Bacterial plant pathogens can cause enormous losses in yield and quality of field crops, fruits and other edible plant materials this becomes increasingly a more important issue to human health and the global economy, with increasing human populations and climate change threats to arable land. Deciphering bacterial

pathogenesis not only allows us to better understand how bacterial pathogens infect host plants but also provides valuable information for the management of plant diseases, including new strategies to prevent, delay or inhibit bacterial development. The pathogenesis of bacterial infection includes initiation of the infectious process and the mechanisms that lead to the development of signs and symptoms of disease.

History

Arun K. Chatterjee: Reported that besides pectinases bacterial motility is the other factors that augment bacterial virulence in soft rot causing bacteria.

Dennis C. Gross: Focused on genetics of toxin produced by *Pseudomonas syringae* pv. *syringae* and its relationship to pathogenicity.

Tim P. Denny: Understand the basic process leading to wilt pathogenesis.

Mary Beth Mudgett: Worked on the biochemical mechanisms used by bacterial pathogens to alter plant physiology during infection.

Definition: Pathogenesis/Disease cycle: A series of events that occur in succession during a pathogenic relationship of a pathogen and host that leads to disease.

Mechanism of Pathogenesis

- Survival
- Dispersal
- Penetration
- Colonization
- Reproduction
- Exit

Survival

The means of survival is the **first link** in infection chain or disease cycle. The initial infection that occurs from the sources of pathogen survival in the crop is **primary infection** and the propagules that cause this infection are called **primary inoculum**. After initiation of the disease in the crop, the spores or other structures of the pathogen are sources of **secondary inoculum** and cause **secondary infection**.

Mode of Survival:

- **Soil:** Bacterial blight of solanaceous vegetable caused by *Ralstonia solanacearum*
- **Seed:** Black rot of crucifers caused by *Xanthomonas campestris* pv. *campestris*
- **Crop debris:** Black arm of cotton caused by *X. campestris* pv. *malvacearum*

- **Insect-vector Corn flea beetle:** Bacterial wilt of corn caused by *Pantoea stewartii*

- **Weed hosts/collateral hosts:** Common blight of bean caused by *X. campestris* pv. *phasioli*

Disease tissues/cankers oozing: Gummosis of sugarcane caused by *X. axanopodis* pv. *vescullorum*

Dispersal of Plant Pathogens

The second link in infection chain is the dissemination of plant pathogens. Transport of spores or infectious bodies, acting as inoculum, from one host to another host at various distances resulting in the spread of the disease, is called dispersal, dissemination or transmission of plant pathogens. In bacterial diseases, the bacterial cells come out on the host surface as ooze or the tissues may be disintegrated so that the bacterial mass is exposed and there by various physical and biological agencies.

Mode of Dispersal:

- **Soil:** Black arm of cotton caused by *X. campestris* pv. *malvacearum*
- **Insect vector:** Fire blight of apple caused by *Eriwinia amylovora*
- **Nematode:** Yellow year cockle of wheat caused by *Clavibacter tritici*
- **Cultural practices:** Ring rot of potato caused by caused by *Clavibacter michiganensis* pv. *sepedonicus*

Penetration

- **Hydathodes:** Special glands or pores at the end of vascular tissue on leaves through which water exudes and are a natural opening for black rot bacteria
- **Lenticels:** small pores or openings in the outer skin of plants that provide a pathway for gas exchange between the atmosphere and plant cells. Develop on any part of the plant such as roots, twigs, stems, or trunks.

Colonization

Establishment of relationship between the pathogen with susceptible cells of the host. Successful infection evident as symptom.

Invasion: Pathogens enter to variable extents inside the host. Vascular pathogens

(*Pseudomonas solanacearum*).

Reproduction in Bacteria

- **Binary Fission:** The cytoplasm and the nucleoid divide equally into two without mitosis, and the two daughter cells formed are identical to each other hence the name binary fission.
- **Fragmentation:** After reaching a certain length, the bacterium breaks up into pieces called fragments. Each fragment is the beginning of a new colony.
- **Budding:** Some bacteria continuously produce protrusions, called buds, which on detachment form new individuals. *Hyphomicrobium vulgare* and *Rhodomicrobium vannielia* are common examples of budding bacteria.

Conclusion

Phytopathogenic bacteria have evolved different mechanisms that mediate

adhesion to the host cell, colonization dissemination and also different strategies to prolong their survival in the host. The knowledge of pathogenesis of bacterial plant pathogens is critically needed in order to provide new tools for developing sustainable and economically viable control measures. Moreover, understanding the bacterial mechanisms by which plant pathogens attack their hosts is central to the study of plant Pathology.

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4. PLANT BREEDING

Hyper-Recombinant Plants are a Burgeoning Area in the Field of Plant Breeding

Gopi M. Patel¹, Harshita Patel¹, Ashita Patel¹

¹. Ph.D. Scholar, Dept. of Genetics and Plant Breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari -396 450, Gujarat

Introduction:

In plant breeding, the generation of novel cultivars is of utmost importance and relies heavily on genetic variation in the offspring. However, meiotic recombination, which is responsible for genetic material mixing, is limited in plants, resulting in a restricted number of crossovers (COs). Recently, researchers have identified anti-CO factors that restrict meiotic recombination in plants. Knock-out mutants lacking these factors have shown a significant increase in recombination frequency. With the advancements in genome sequencing and gene editing technologies, the genomes of numerous plant species have been sequenced, and the efficient CRISPR-Cas9

system has been established in plants. This presents an opportune moment to overcome the constraints of meiotic recombination and create novel cultivars in the era of genomics.

Meiotic Recombination Mechanisms

Meiotic recombination starts by creating breaks in the DNA double strands (DSBs) (Robert *et al.*, 2016). This is then followed by the removal of the 5' ends of the damaged DNA strands, leading to the production of single-stranded DNAs (ssDNAs) with 3' ends (Paull and Deshpande, 2014). After the DNA strands are broken, they proceed to invade either a homologous chromosome or a sister chromatid, resulting in the formation of a stable intermediate with a single invading end (Da Ines

et al., 2013). This invading strand from one chromosome extends into the corresponding double-stranded DNA (dsDNA) of the other chromosome, creating a structure known as a displacement loop (D-loop). The D-loop can be resolved into various joint molecules (JMs), leading to the formation of either a crossover (CO) or a non-crossover (NCO) duplex product. NCOs are predominantly generated through the synthesis-dependent strand annealing (SDSA) pathway using different mechanisms.

demonstrated that the determination of crossover (CO) formation is controlled by three distinct mechanisms:

1. Obligate CO
2. CO interference
3. CO homeostasis

Together, these mechanisms regulate CO formation, which typically occurs at a relatively low frequency, and they also influence the nonrandom distribution of CO events along the chromosomes.

Multiple observations have consistently

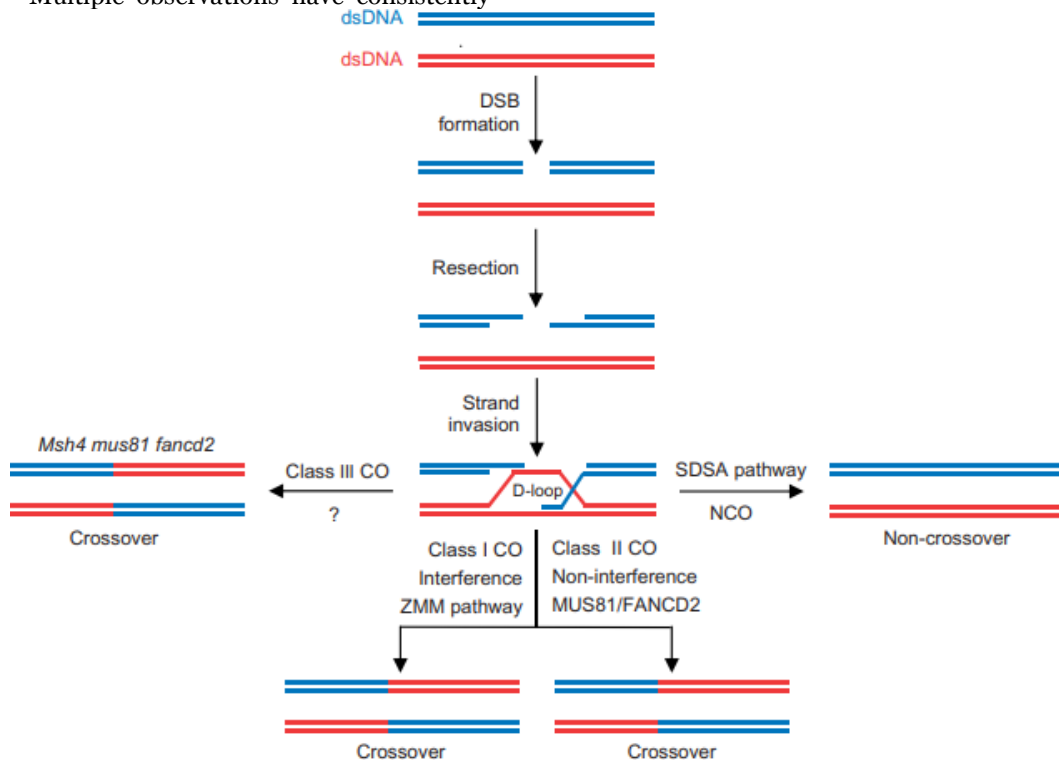


Fig. 1: Meiotic recombination pathway model in plants.

During meiotic recombination, there are typically two distinct pathways for crossover (CO) formation in most eukaryotes, known as class I and class II COs, which are differentiated based on their sensitivity to CO interference. Class I COs, comprising the majority (80-85%) of crossovers, are sensitive to interference and rely on conserved ZMM proteins such as MSH4 (MutS homolog 4), MSH5, MER3 (Meiotic recombination 3), ZIP4 (Zinc transporter 4

precursor), SHOC1 (Shortage of crossovers 1), HEI10 (Human enhancer of cell invasion No.10), RFC1 (Replication factor C1), PTD (Parting dancers), and POL2A (DNA polymerase 2A). On the other hand, the minority class II COs are insensitive to interference and require MUS81/FANCD2 for their formation (Kurzbauer *et al.*, 2018). In most eukaryotes, including budding yeast, mammals, and plants, these two CO pathways coexist (Hunter, 2015). However, in fission yeast, only class II COs are formed during

meiosis and in *Caenorhabditis elegans*, all COs exhibit interference (Hillers and Villeneuve, 2003). Notably, in *Arabidopsis*, a triple mutant lacking essential proteins required for both class I and II repair (*msh4/mus81/fancd2*) still exhibits some level of CO formation, suggesting the

existence of an aberrant type of CO formation that operates in the absence of the normal class I and II CO pathways. This phenomenon has also been observed in *Drosophila melanogaster* (Yildiz *et al.*, 2002) and yeast (Argueso *et al.*, 2004), implying the presence of additional and alternative CO pathways (class III).

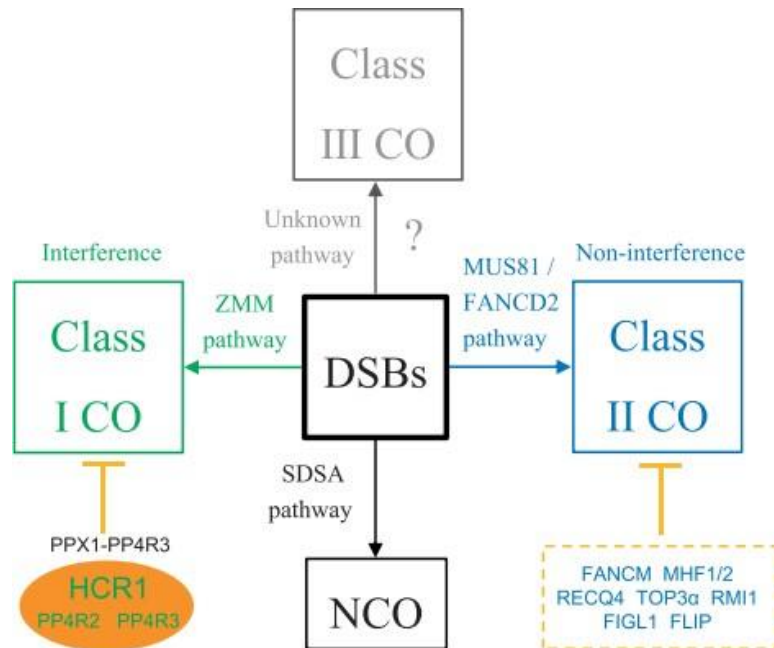


Fig. 2: Anti-crossover formation pathway model in plants

Mutating Anti-Co Factors Can Greatly Enhance The Recombination Frequency In Agricultural Crops.

The presence of anti-CO genes naturally restricts the frequency of crossover events, which can limit genetic diversity during hybridization. Recent advancements in understanding the molecular mechanisms behind meiotic recombination suppression have led to the study of these anti-CO factors in important crop species. In *Brassica* species, specifically *B. rapa* and *B. napus*, the anti-CO gene *FANCM* was investigated using EMS-induced mutations, and several mutants with nonsense or missense mutations were identified using the Tilling technique (Blary *et al.*, 2018). Interestingly, the enhanced CO frequency in *fancm* mutants was less pronounced in the heterozygous background (*Col/Ler F1*) compared to the homozygous background

(*Col/Col*), suggesting that the effectiveness of *FANCM* mutation in promoting recombination frequency depends on the plant genome's heterozygosity. Recent research in lettuce demonstrated that *LsFANCM*, when replacing *AtFANCM* in transgenic *Arabidopsis* plants, retained its anti-CO function. However, unlike previous findings in *Brassica*, the *fancm* mutant of lettuce displayed abnormalities in chiasmata location among chromosomes, resulting in reduced pollen viability and seed set. Furthermore, the distribution of meiotic class I COs was altered, forming multiple foci on short chromosome stretches, indicating a divergent role of *FANCM* in meiotic bivalent formation.

Two other anti-CO genes, *FIGL1* and *RECQ4*, were also studied in crops. *FIGL1* mutations led to infertility in rice, pea, and tomato, limiting its application in crop breeding. In contrast, *RECQ4* emerged as the most significant meiotic recombination suppressor. In *Arabidopsis*, *RECQ4* mutation resulted in an almost six-fold

increase in recombination frequency, and this effect was efficiently conserved in crops, as the *recq4* single mutant exhibited over a three-fold increase in CO formation in rice, pea, and tomato. More recently, recombination frequency variation was examined in a biallelic *recq4* mutant of an interspecific tomato hybrid created through CRISPR/Cas9 mutagenesis. *RECQ4* knockout led to a 1.5-fold increase in recombination frequency in the F1 *recq4* mutant and a 1.8-fold expansion of the genetic map in the F2 progeny, demonstrating that *RECQ4* manipulation is not restricted by the plant genome's heterozygosity. Thus, manipulating *RECQ4* may serve as a universal and more reliable approach for generating hyper-recombinant plants

Hyper-Recombinant Ornamental Plants Offer A Wide Range Of Possibilities For Utilizing Anti-CO Genes.

In recent years, the genomics of ornamental plants has made significant progress thanks to the rapid advancements in sequencing technology. Ongoing genome projects involving ornamental plants like *Gerbera hybrida*, *Tagetes erecta*, and *Gypsophila paniculata* are currently underway (unpublished data). These projects offer the potential to identify meiotic recombination suppressors within ornamental plants. In fact, genomic data from these projects have already yielded the isolation of meiotic recombination suppressors, such as *FANCM* and *RECQ4* (Li, Cheng, Sun, *et al.*, 2021). Multiple species exhibit the presence of two or more copies of the *RECQ4* gene, which can be traced back to whole genome duplications that occurred in various clades. Examples of these clades include *Arabidopsis*, *Brassica*, lettuce, soybean, and sunflower. Previous studies have reported the retention of multiple *RECQ4* copies in these species, highlighting the impact of whole genome duplications (Mieulet *et al.*, 2018). Further analysis of *RECQ4* in eight ornamental plants has uncovered conserved functional domains, including *DEAD*, *HELICc*, *RQC*, and *HRDC*.

This discovery suggests that *RECQ4* may have a preserved function across ornamental plant species. These findings indicate that *RECQ4* could serve as a key target gene for manipulating meiotic recombination in ornamental plants, offering potential opportunities for genetic manipulation in this context. With the advent of the CRISPR genome editing tool, there is now a potential to directly knock out anti-CO (anti-crossover) genes in F1 hybrids, enabling the rapid generation of hyper recombinant populations (Gao, 2021). This presents an opportune moment to study the function and explore the application of anti-CO genes in the emerging field of enhancing current ornamental breeding practices. We are now in an era where we can manipulate the recombination rate of ornamental plants by leveraging the latest genetic information and advanced gene-editing technologies.

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5. GENETICS AND PLANT BREEDING

Whole Genome Sequencing- An Introduction

P.Ahila Devi

Agricultural College and Research Institute, Keezhvelur, Nagapattinam District

Introduction

Whole genome sequencing (WGS), also known as full genome sequencing, complete genome sequencing, or entire genome sequencing, is the process of determining the entirety, or nearly the entirety, of the DNA sequence of an organism's genome at a single time. This entails sequencing all of an organism's chromosomal DNA as well as DNA contained in the mitochondria and, for plants, in the chloroplast.

Whole genome sequencing has largely been used as a research tool, but was being

introduced to clinics in 2014. In the future of personalized medicine, whole genome sequence data may be an important tool to guide therapeutic intervention. The tool of gene sequencing at SNP level is also used to pinpoint functional variants from association studies and improve the knowledge available to researchers interested in evolutionary biology, and hence may lay the foundation for predicting disease susceptibility and drug response.

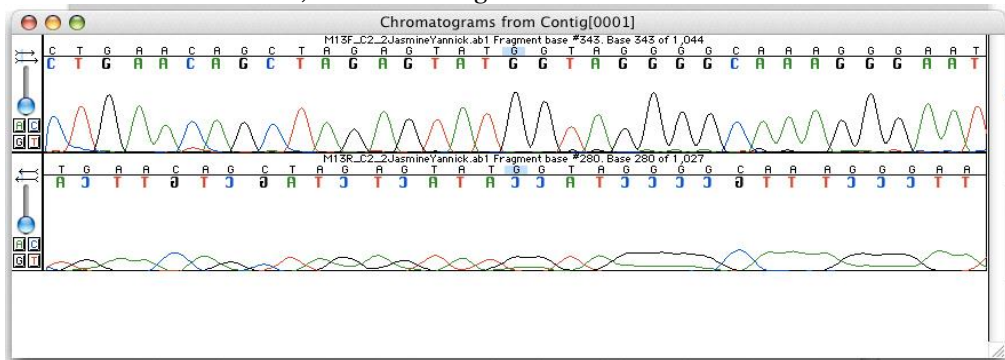


Fig. **Electropherograms** are commonly used to sequence portions of genomes.

Whole genome sequencing should not be confused with DNA profiling, which only determines the likelihood that genetic material came from a particular individual or group, and does not contain additional information on genetic relationships, origin or susceptibility to specific diseases.^[7] In addition, whole genome sequencing should not be confused with methods that sequence specific subsets of the genome – such methods include whole exome sequencing (1–2% of the genome) or SNP genotyping (< 0.1% of the genome).

History

The DNA sequencing methods used in the 1970s and 1980s were manual; for example, Maxam–Gilbert sequencing and Sanger sequencing. Several whole bacteriophage and animal viral genomes were sequenced by these techniques, but the shift to more rapid, automated sequencing methods in the 1990s facilitated the sequencing of the larger bacterial and eukaryotic genomes.

Current techniques

While capillary sequencing was the first approach to successfully sequence a nearly full human genome, it is still too expensive and takes too long for commercial purposes. Since 2005 capillary sequencing has been progressively displaced by high-throughput (formerly "next-generation") sequencing technologies such as Illumina dye sequencing, pyrosequencing, and SMRT sequencing. All of these technologies continue to employ the basic shotgun strategy, namely, parallelization and template generation via genome fragmentation.

Other technologies have emerged, including Nanopore technology. Though the sequencing accuracy of Nanopore technology is lower than those above, its read length is on average much longer. This generation of long reads is valuable especially in *de novo* whole-genome sequencing applications.

Analysis

In principle, full genome sequencing can provide the raw nucleotide sequence of an individual organism's DNA at a single point in time. However, further analysis must be performed to provide the biological or medical meaning of this sequence, such as how this knowledge can be used to help prevent disease. Methods for analyzing sequencing data are being developed and refined.

Because sequencing generates a lot of data (for example, there are approximately six billion base pairs in each human diploid genome), its output is stored electronically and requires a large amount of computing power and storage capacity. While analysis of WGS data can be slow, it is possible to speed up this step by using dedicated hardware.

Comparison with other technologies

DNA microarrays

Full genome sequencing provides information on a genome that is orders of magnitude larger than by DNA arrays, the previous leader in genotyping technology. For humans, DNA arrays currently provide genotypic information on up to one million genetic variants, while full genome sequencing will provide information on all six billion bases in the human genome, or 3,000 times more data. Because of this, full genome sequencing is considered a disruptive innovation to the DNA array markets as the accuracy of both range from 99.98% to 99.999% (in non-repetitive DNA regions) and their consumables cost of \$5000 per 6 billion base pairs is competitive (for some applications) with DNA arrays (\$500 per 1 million basepairs).

Applications

- Mutation frequencies
- Genome-wide association studies
- Rare variant association study.

6. BIOTECHNOLOGY

RNAi in Agricultural Biocontrol

P.K. Jadhav*, G.N. Ansari*, U.S. Shaikh*, K.K. Gholave**

M.Sc. Student* and B.Tech. Biotechnology Student** Department of Plant Biotechnology, V. D. College of

Introduction:

Recent advancements in RNAi-based biocontrol showcase significant potential for revolutionizing agriculture. Major players like Monsanto, Bayer, and Syngenta, along with startups like Greenlight Biosciences and AgroSpheres, are actively developing RNA-based biopesticides, sparking a surge in research and development investments.

Materials and Methodology:

Case Study on Fusarium Control: A case

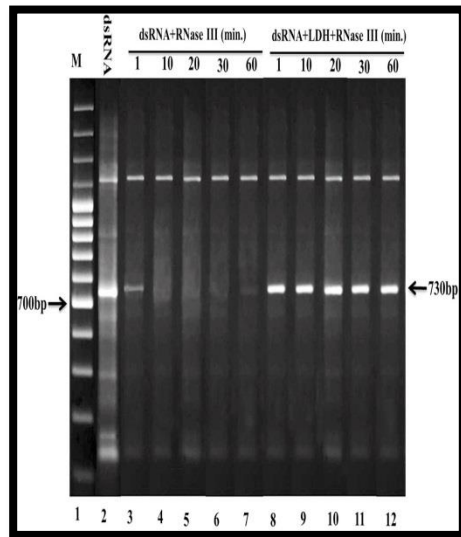


Fig 1 Showing LDH potentiality to protect dsRNA from nucleases

Results:

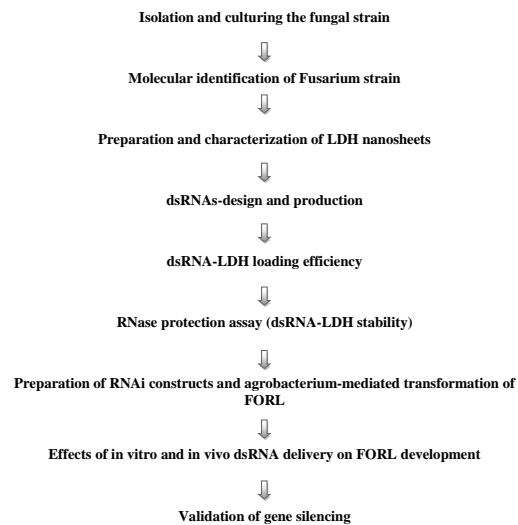
Gene Identification and LDH Nanosheet Characterization

PCR analysis confirmed the identity of *Fusarium oxysporum*, and LDH nanosheets with positive charge and hexagonal structure were successfully synthesized. In vitro experiments demonstrated the effectiveness of Fo-dsRNA and LDH-Fo-dsRNA in inhibiting *F. oxysporum* growth.

In Vivo Efficacy and Application Methods

In greenhouse experiments, three application methods—leaf spray, petiole adsorption, and root dipping—were compared for their effectiveness in controlling *Fusarium* crown and root rot. Leaf spray was found to be the most efficient method, with lower dsRNA

study focused on combating *Fusarium* crown and root rot in tomatoes was conducted using RNAi. Essential genes *FoCYP51*, *FoChs1*, and *FoEF2* were targeted with naked dsRNA delivered on biodegradable LDH nanosheets. Three delivery methods—leaf spray, petiole adsorption, and root dipping—demonstrated varying levels of spray-induced gene silencing (SIGS) efficacy, with LDH nanosheets providing sustained protection for at least 60 days.



application leading to higher efficacy in disease control.

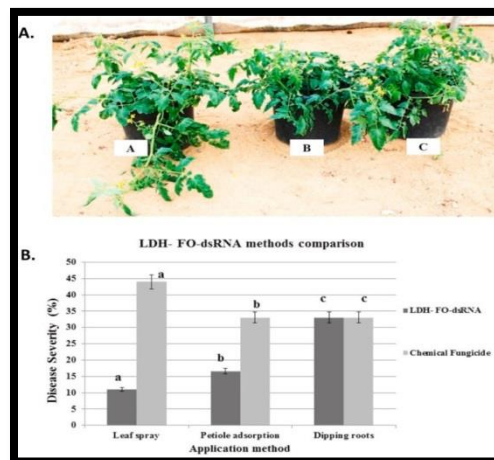


Fig 2 Showing a comparison between the activity of the three application methods in delivering LDH-FO-dsRNA: (A) Leaf spray; (B) dipping roots, (C) Petiole adsorption. (B) Comparison of disease severities among application methods used in this study using FO- dsRNAs. Different lowercase letters above bars indicate significant differences between treatments as statistically determined ($p \leq 0.05$).

Conclusion

- **Versatile Crop Management:** Topical application of dsRNA emerges as a versatile crop management strategy, avoiding the need for plant
- **LDH Nanosheets as Delivery System:** LDH nanosheets prove to be a sustainable and effective delivery system for dsRNA in crop protection, highlighting the potential of RNAi technology.
- **Host-Induced Gene Silencing (HIGS):** HIGS of *FoCYP51*, *FoChs1*, and *FoEF2* genes is identified as a safe and effective solution for Fusarium control in tomatoes.
- **Comparative Efficacy:** Spray-Induced Gene Silencing (SIGS) through leaf spray is identified as the most effective application method compared to root dipping and leaf petiole adsorption.

Future Prospective:

Limitations and Concerns: Despite promising potential, concerns like off-target effects, uncertainties in dsRNA fate, regulatory

challenges, and high production costs need addressing.

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7. BIOTECHNOLOGY

Positional Gene cloning

K.K. Gholave ***, A.S. Deshmukh*, G.N. Ansari**P.K. Jadhav **

Senior Research Fellow* (DNA fingerprinting), M.Sc. Student* and B.Tech. Biotechnology Student***
Department of Plant Biotechnology, V. D. College of Agricultural Biotechnology, Latur. Pin: 413 512.

Introduction

Positional cloning is a molecular genetics technique used to identify and isolate specific genes based on their location within a genome. The process involves cloning and isolating the

gene, introducing it into a host through genetic transformation, and analyzing the resulting phenotypic effects. Transgenic plants have various applications, including aiding in research on gene function and plant development, and creating improved varieties

with unique characteristics. Mutagenesis induces mutations that result in noticeable changes in phenotype, and the mutated genes are identifiable based on their specific effects. Insertional mutagenesis disrupts the normal function of a gene, resulting in a loss-of-function mutant allele, which can be isolated using transposable elements or *Agrobacterium* T-DNA sequences as probes. Positional cloning requires individuals within a population exhibiting variations in a trait and knowledge of DNA markers closely linked to the gene responsible for the trait. This approach is applicable to most traits, including those controlled by multiple genes.

The Three Steps of Positional Cloning

Positional cloning, also known as map-based cloning, involves three stages: (1) Isolation of a mutant strain and pinpointing the location of the mutant allele within a genomic area through mapping. (2) Identification and isolation of the DNA fragment containing the mutant allele using markers. (3) Determining the function of the isolated gene. The process involves genetic mapping, creation of a genomic library, screening the library, chromosome walking, and complementation tests. The candidate genomic region is narrowed down through linkage mapping and screening with new markers. The gene of interest is identified through various methods, such as high-resolution mapping, expression pattern analysis, and homology searches.

Positional Cloning of Some Plant Genes

The gene *ABI1* in *A. thaliana* has a dominant mutant allele known as *ABI1*, which confers resistance to abscisic acid. To locate the *ABI1* gene, a population of 300 F₂ plants was analyzed, leading to its mapping between two RFLP markers: marker B (0.16 cM) and marker C (11.3 cM) relative to the gene. Marker B was used to explore YAC genomic libraries containing the *ABI1* mutant, leading to the assembly of contigs that covered the *ABI1* region via chromosome walking. The end DNA sequence of each YAC clone within the contig served as a linkage marker in F₃ generation mapping, defining a 150 kb candidate genomic region harboring the *ABI1* locus, in conjunction

with marker E. This candidate genomic region was isolated in a binary cosmid vector (pBIC20) suitable for *Agrobacterium*-mediated genetic transformation. DNA inserts from cosmid clones were aligned to form a contig, and specific DNA fragments from the contig conveyed ABA insensitivity when introduced into transgenic plants. A single-point mutation within the *ABI1* gene was identified as responsible for the mutant phenotype.

In another study, the nuclear gene *Rf-1* in the BT CMS lines of *O. sativa* var. *japonica* restored pollen fertility. Through linkage mapping, two markers flanking the *Rf-1* gene were identified, with one situated at a mere 0.1 cM from *Rf-1*. A chromosome walk from this marker led to the creation of a contig comprised of λ clones spanning the *Rf-1* genomic region between the two markers. DNA inserts from these clones were used to generate new markers, which were then utilized to fine-map the *Rf-1* region within the recombinant plants. A 15.6 kb fragment from the contig revealed variable fertility restoration, and cDNA clones derived from this fragment enabled the elucidation of the *Rf-1* gene's structure, encoding a protein featuring 16 tandemly repeated pentatricopeptide repeat (PPR) motifs, designated as PPR791.

To ensure a consistent direction for the walk-in positional gene cloning, various strategies can be employed, such as successive screenings using the same genomic library, selecting an appropriate vector for constructing the genomic library, and using probes containing unique sequences. It is important to maintain the walk's direction and delineate a precise genomic region for subsequent analysis. Tight genetic linkage may correspond to a large span of DNA, so DNA markers linked to the target gene should be positioned within <1.0 cM of the target gene, necessitating further experiments for fine mapping. Long-distance walks using genomic libraries housed in vectors like BACs and YACs can reduce the number of steps required to reach the target gene. Before the advent of such vectors, scientists used innovative tactics, including the use of genomic libraries constructed from specialized cytogenetic stocks featuring inversions and translocations to bring distant chromosomal regions into proximity.

Problems in Positional Cloning

Map-based cloning encounters several practical challenges. (1) Dealing with vast eukaryotic genomes is a formidable task due to their immense size. Take, for instance, the wheat genome, which comprises approximately 16 billion base pairs. Even if 16,000 markers were evenly distributed within such a genome, the distance between adjacent markers would still be around 1,000 kb, making it challenging to pinpoint a nearby marker for the target gene. Consequently, a second round of mapping, employing a large mapping population and novel markers derived from contig clones, is often undertaken to narrow down the candidate genomic region. (2) Additionally, the correlation between a single map unit (cM) estimated from recombination data and the actual physical distance measured in base pairs between two genes is influenced by various factors. For example, 1 cM could represent a mere 140 kb in *A. thaliana*, 750 kb in tomato, or a whopping 4,600 kb in wheat. Furthermore, significant variations exist in the physical distance per centimorgan within different genomic regions of the same species. For instance, the physical distance equivalent to 1 cM can vary up to 100-fold in various regions of the tomato genome. Fortunately,

traversing such lengthy distances has become more feasible thanks to the availability of high-capacity vectors like BACs, PACs, and YACs. (3) The presence of highly repetitive DNAs scattered throughout eukaryotic genomes adds complexity to chromosome walking. Nonetheless, this challenge can be addressed using effective strategies, including chromosome jumping. Moreover, (4) chromosome walks are notorious for being time-consuming, (5) identifying the DNA insert containing the target gene within the contig formed by chromosome walks is a demanding and time-intensive task, and (6) some of the large insert libraries like YAC libraries may contain chimeric or modified DNA inserts, further complicating the cloning process.

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8. BIOTECHNOLOGY

Genetically Modified Microbes as Biofertilizers

¹Kadam P.R., ²Jadhav P.K., ³Shaikh U.S., ⁴Ansari G.N.

¹M.Sc student, ²M.Sc Student, ³M.Sc Student, ⁴M.Sc Student, Department of plant Biotechnology, V.D.College of Agricultural Biotechnology, (VNMKV, Parbhani) Latur (M.S) India

Introduction

The efficient productivity of crops and the production of healthy food are intricately linked to the availability of plant nutrients and the maintenance of soil quality. Traditionally, inorganic chemical-based fertilizers have been the go-to for soil maintenance, despite their known environmental drawbacks. Acknowledging these issues, there is a growing recognition of biofertilizers as an alternative to enhance both crop productivity and soil fertility. Incorporating beneficial microorganisms into agriculture as biofertilizers has become crucial for plant

nutrient management systems, contributing significantly to soil sustainability and productivity, while also offering environmental benefits and cost-effectiveness.

Advancements in molecular biotechnology, particularly recombinant DNA technology, have facilitated the production of biofertilizers with enhanced capabilities. Genetic modification of microbes through this technology has opened new avenues for harnessing the potential of beneficial microbes, thereby promoting plant development. The term GMO (Genetically Modified Organism) encompasses any organism whose genetic

material has been modified using genetic engineering techniques. From its inception in 1973 with the creation of the first genetically modified organism, the field has evolved, and there is a current emphasis on designing safer GMOs for environmental release, especially in applications like plant growth-promoting rhizobacteria, biological control of plant diseases, and biodegradation for improved agricultural production.

In the contemporary era, the utilization of beneficial microorganisms as biofertilizers remains critically important in agriculture, playing a pivotal role in advancing soil sustainability and productivity. This article explores the shift from traditional chemical-based fertilizers to biofertilizers, highlighting the role of genetic modification in enhancing their effectiveness and the need for safe GMOs in various agricultural applications.

Applications of Genetically Modified Microorganisms as Biofertilizers:

1. **Soil health improvements:** Extensive efforts have been made in the field of genetic modifications to enhance soil fertility, particularly through large-scale developments. For instance, *Medicago sativa*, commonly known as alfalfa, exhibits improved root nodulation when subjected to a genetically modified *Sinorhizobium* (*Rhizobium*) *meliloti* expressing the *nifA* gene from *Klebsiella pneumoniae*, in comparison to plants in the same nitrogen-rich soil exposed to the wild-type *S. meliloti* (Vázquez et al., 2002). Another study demonstrated a substantial increase in plant biomass when utilizing the recombinant *S. meliloti* compared to the wild-type strain (Galleguillos et al., 2000).
2. **For the plant growth-promoting bacteria:** The prosperous development of crops relies on the genetic composition of the plant, sufficient nutrient availability, advantageous microbes in the soil, and the absence of plant pathogens. Plant-beneficial bacteria, referred to as PGPR, play a positive role in promoting the growth of plants.
3. **Nitrogen-fixation in soil by genetically modified microorganisms:** Genetic modifications

carried on rhizobia have attempted to improve strains used as inoculum by enhancing their ability to successfully compete with indigenous soil rhizobia for increased nodule formation and their capacity to fix N₂. Transfer of ACC deaminase from *E. cloacae* into rhizospheric *Azospirillum brasilense* increased the root-elongation potential of this strain in tomato and canola, suggesting that similar transgenic techniques may increase the root growth-promoting ability of endophytic strains.

Molecular Tools and Methods for Genetic Engineering of Microorganisms: -

Various strategies have been applied to improve the competitiveness of a bioinoculant in the plant environment. These are either by promoting rhizobial multiplication in the plant environment, by inhibiting the growth of competing microorganisms, or by interfering with some of the signals perceived by the competing microbes provided these signals control (at least in part) the expression of functions central to microbial fitness (Savka et al., 2002). Because this is a triple interface (bacteria, plant, and soil) interaction, it is possible to modify one, two, or three of these factors to improve microbial colonization. An improvement of plant-microbe symbioses should involve the coordinated modifications in the partner's genotypes resulting in highly complementary combinations (Tikhonovich and Provorov, 2007).

1. **Gene transfer method**
To deliver the selected genes into desired hosts.
 - a. Transformation
 - b. Electroporation
 - c. Conjugation
2. **Cloning vector**
3. **Promoters**
To control the expression of desired genes.
4. **Selectable marker genes to identify recombinant microorganisms**
Different Genes Used In Genetically Modified Microorganisms To Use As Biofertilizers:

Sr.No.	Gene Name	Transfer from	Transfer to (Host)	Referances
Nitrogen Fixing microbes				
1.	ACC deaminase	<i>E. cloacae</i>	<i>Azospirillum brasilense</i>	Holguin (2001)
2.	nifA and dctABD	<i>nifA and dctABD from S. meliloti</i>	<i>S. meliloti</i>	Bosworth et al. (1994)
3.	ACC deaminase	<i>Sinorhizobium sp. BL3</i>	<i>Rhizobium sp. strain TAL1145</i>	Tittabutr et al. (2008)
Phosphorus solublizing microbes				
1.	Gcd	<i>E. coli</i>	<i>Azotobacter</i>	Sashidhar and Podile (2009)
2.	PPC gene	<i>Anacystis nidulans</i>	<i>Pseudomonas fluorescens</i>	Srivastava et al. (2000)
3.	napA phosphatase gene	<i>Morganella morganii</i>	<i>Burkholderia cepacia IS-16</i>	Fraga et al. (2001)
4.	PQQ	<i>Erwinia herbicola</i>	<i>B. cepacia IS-16 and Pseudomonas sp. PSS</i>	Rodriguez et al. (2000)
Potassium				
1.	pcc gene	<i>Synechococcus PCC</i>	<i>P. fluorescens 7942</i>	Kim et al. (1998b)
Iron				
1.	fhuA	<i>E. coli</i>	<i>fhuA</i>	Rajendran et al. (2007)
PGPR				
1.	ipdC [phytohormone IAA]	<i>Azospirillum brasilense Sp245</i>	<i>A. brasilense</i>	Baudoin et al. (2010)
2.	IAA,	<i>Sinorhizobium meliloti</i>	<i>Sinorhizobium meliloti 1021</i>	Bianco and Defez (2010)
3.	mps genes for GA	<i>Ranella aquatilis</i>	<i>E. coli</i>	Kim et al. (1998)

Limitations of GM Biofertilizers

Limitations of genetically modified (GM) biofertilizers include variable effectiveness influenced by factors like soil and crop types, requiring consistent management and monitoring. These biofertilizers may have a limited nutrient range, focusing on specific nutrients like nitrogen or phosphorus, necessitating supplementary fertilization in some cases. Storage conditions and shelf life are critical for biofertilizers containing live

microorganisms, as improper storage may reduce their effectiveness. Cost considerations may be a hindrance, as some biofertilizers can be more expensive than traditional chemical fertilizers. Regulatory issues, especially concerning genetically modified organisms (GMOs) or non-native species, can pose logistical and legal challenges for the use of biofertilizers.

Future Aspects of Biofertilizer

The future of biofertilizers holds promising

developments, driven by advances in biotechnology. Novel biofertilizers, potentially involving genetically modified microorganisms tailored to specific soil types and crops, are anticipated. Integration with other sustainable agricultural practices, such as conservation agriculture and agroforestry, is likely to increase. Biofertilizers may find new applications beyond crop production, such as improving soil fertility in degraded lands or supporting plant growth in urban environments. Quality control and standardization will become crucial as biofertilizer usage expands, ensuring effectiveness and safety. Small-scale farmers in developing countries may benefit from biofertilizers, but efforts are needed to overcome barriers like limited resources and information access. The commercial market for biofertilizers is expected to expand, driven by the growing demand for sustainable agriculture, leading to increased investment in research, development, and wider adoption by farmers and growers.

Conclusion

Biofertilizers, composed of living microorganisms like bacteria, fungi, and algae, play a vital role in enhancing soil fertility and promoting plant growth. They offer advantages such as eco-friendliness, sustainability, and cost-effectiveness, contributing to improved soil structure and reduced soil-borne diseases. Despite their benefits, the effectiveness of biofertilizers is influenced by factors like soil conditions and microorganism types. Biotechnology techniques, including genetic modification, aim to address these limitations. It is crucial to carefully select and apply the right biofertilizer for specific crops, following

recommended rates and methods. Overall, biofertilizers have significant potential in fostering sustainable agriculture and mitigating the environmental impact of chemical fertilizers.

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9. AGRICULTURE

Evaluation of National Agricultural Insurance and Weather Based Crop Insurance Schemes in southern Rajasthan

Santosh Devi Samota¹

¹Sri Karan Narendra Agriculture University, Jobner

Insurance: Insurance is the transfer of risk between the insured and the insurer at a

cost which reduces the intensity of loss that would have otherwise been suffered by the insured. Insurance not only reduces the uncertainty faced by the insured, but it evades out the burden of a loss especially if the loss is of a large scale one.

Crop Insurance: Crop insurance is an arrangement that aims at mitigating the financial losses suffered by the farmers due to damage and destruction of their crops as a result of various production risks. The weather based crop insurance uses weather parameters as proxy for crop yield in compensating the cultivators for deemed crop losses. It provides a good alternative both to the farmers and government. Farmers get an accurately fair insurance with swift payments at little administrative costs to the government. Rainfall insurance is a specific form of weather insurance programmes in Mexico, Japan, Australia, United States, Japan, and Brazil. Weather based crop insurance scheme (WBCIS) has been introduced in the country from Rabi 2007-08. WBCIS aims to mitigate hardships of insured farmers against likelihood of financial loss on account of anticipated crop loss resulting from incidence of adverse conditions of weather parameters like deficit or excess rainfall and also other parameters like temperature, frost, humidity and wind, etc.

Need for Crop Insurance:

Crop insurance is an alternative to manage risk in yield loss among the farmers. It is the mechanism to reduce the impact of income loss on the farmers (family and farming). Crop insurance is a means of protecting farmers against the variations in yield resulting from uncertainty of practically all natural factors beyond their control such as rainfall (drought or excess rainfall), flood, hails, other weather variables (temperature, sunlight, wind), pest infestation, etc. As such, it is a risk management alternative where production risk is transferred to another party at a cost called premium.

The principal benefits derived by the farmers from crop insurance are as follows:

1. Crop insurance prevents farmers from financial disasters due to crop failure through its indemnity function.

2. It improves the position of farmers in relation to agricultural credit. As crop insurance guarantees protection against crop failure, the insured farmers have a better credit rating, when a loan is provided to them. It also considerably strengthens the financial position of the involved agricultural cooperative credit institutions,
3. The crop insurance scheme, besides stabilizing farmers' income by indemnifying them for damage to their crops, plays a positive role of increasing productivity through prevention and limitation of the operation of natural calamities especially plant, pests and disease infestations and
4. Crop insurance contributes to greater stability of the economy by spreading economic damage resulting from crop losses over time and space.

The Government of India had temporarily suspended the operation of the comprehensive crop insurance scheme (CCIS) from April 1, 1988 but again started the scheme during *kharif* 1988 (while in Karnataka, the State Government decided to continue the crop insurance scheme during 1989-90). The Comprehensive Crop Insurance Scheme (CCIS) was in operation till Rabi 1999.

Objectives of crop insurance

1. To provide insurance coverage and financial support to the farmers in the event of failure of the notified crops as a result of natural calamities, pests and diseases.
2. To encourage the farmers to adopt progressive farming practices, high value inputs and higher technology in agriculture
3. To support and stimulate production of cereals, pulses and oilseeds.

The CCIS has been replaced by the National Agriculture Insurance Scheme (NAIS). The NAIS is considered to be an improvement over the CCIS, but it has simply replaced one flawed scheme with another slightly less flawed one. Government crop insurance has proved to be a failure worldwide, but India seems to have ignored both its own failure and the failure of other countries. The main flaws of the NAIS are the goal of financial

viability, its mandatory nature, its failure to address adverse selection, arbitrary premiums, and the area approach. Internationally, private crop insurance is not highly developed but various successful private programmes do exist. Even if India withdrew from crop insurance schemes, it could still support farmers through an income guarantee or investment in infrastructure.

Comparison between National Agricultural Insurance Scheme (NAIS) and Weather Based Crop Insurance Scheme (WBCIS)

S.No.	National Agricultural Insurance Scheme (NAIS)	Weather Based Crop Insurance Scheme (WBCIS)
1.	Practically all risks are covered (drought, excess rainfall, flood, hail, pest infestation, etc.)	Parametric weather related risks like rainfall, frost, heat (temperature), humidity etc.) are covered. However, these parametric weather parameters appear to account for majority of crop losses
2.	Easy-to-design if historical yield data upto 10 years are available.	Technical challenges in designing weather indices and also correlating weather indices with yield losses. Needs upto 25 years historical weather data
3.	High basis risk [difference between the yield of the Area (Block / Tehsil) and the individual	Basis risk with regard to weather could be high for rainfall and moderate for others like frost, heat,

	farmers]	humidity etc.
4.	Objectivity and transparency is relatively less	Objectivity and transparency is relatively high
5.	Quality losses are beyond consideration	Quality losses to some extent get reflected through weather index
6.	High loss assessment costs (crop cutting experiments)	No loss assessment costs
7.	Delays in claims settlement	Faster claims settlement
8.	Government's financial liabilities are open ended, as it supports the claims subsidy	Government's financial liabilities could be budgeted up-front and close ended, as it supports the premium subsidy

Just before the inception of WBCIS, NAIS was winded up. As per the field officers, farmers and other stakeholders, there is earnest need of evaluation and partial comparison between NAIS and WBCIS, so that their strengths and weakness could be determined. The comparison may lead to further strengthening the existing scheme or to evolve any new crop insurance scheme.

The above outcomes by and large tell whether NAIS was better or WBCIS is superior to NAIS. The results are of great significance to the government, farmers and all concerned for crop insurance for evolving and executing most suitable crop insurance scheme in future.

10. BIOTECHNOLOGY

Microencapsulation of Pomegranate seed oil

P.K. Jadhav*, P.R. Kadam*, U.S. Shaikh*, K.K. Gholave**

M.Sc. Student* and B.Tech. Biotechnology Student** Department of Plant Biotechnology, V. D. College of Agricultural Biotechnology, Latur. Pin: 413 512.

Introduction:

Pomegranate seed oil (PSO) is a valuable by-product of the pomegranate fruit, rich in

tocopherols, phytosterols, and phenolic compounds. Its functional benefits, such as cytotoxic effects and anti-diabetic properties,

are linked to its unique fatty acid profile, particularly the presence of punicic acid. However, the susceptibility of unsaturated fatty acids to oxidation poses challenges for its use in food products. To address this, microencapsulation using the ionic gelation method is explored. This study focuses on enhancing the two-stage external ionic gelation technique to produce microparticles of alginate-starch-chitosan encapsulating PSO. The combination of sodium alginate, starch, and chitosan aims to improve stability and controlled release of PSO. This approach has the potential to preserve and utilize the bioactive components of pomegranate seed oil.

Materials and Methodology:

Fig 1. Ionotrophic Gelation Technique

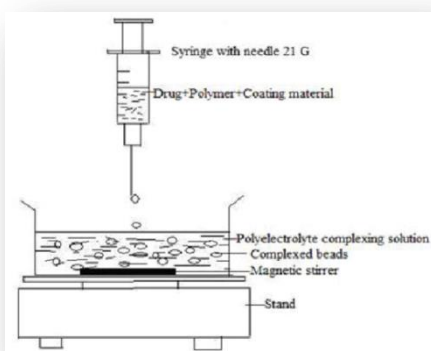


Fig 2. Formation of beads using Encapsulator

In this study, we used pomegranate seed oil (PSO) extracted from cv Bhagwa seeds to create microcapsules using the ionic gelation method. PSO is rich in tocopherols, phytosterols, and phenolic compounds and is often discarded as a by-product of juice industries. The goal of microencapsulation was to protect the unsaturated fatty acids in PSO from oxidation and improve its stability. The encapsulation process involved dissolving sodium alginate in distilled water, mixing it with starch and PSO, and creating an alginate-oil emulsion that was sprayed into a calcium chloride solution using an Encapsulator. We evaluated parameters such as encapsulation efficiency (EE), loading capacity (LC), sphericity factor (SF), and rupture force (RF). We used analytical grade chemicals and equipment, including a hydraulic cold press for PSO extraction and a texture analyzer for measuring rupture force. This study highlights the importance of encapsulating PSO to prolong its shelf-life and improve its suitability for use in food products.

Results and discussion:

The effect of variation in independent variables viz. oil loading, starch concentration and chitosan concentration on the response variables and Results were discussed in detail here and optimised process conditions for microencapsulation of PSO were arrived at to obtain desired microsphere features for industrial applications.

Encapsulation Efficiency (EE):

It is an important parameter, which refers to amount of oil encapsulated within the microsphere to the total oil used. In the present study, EE is change with th change in oil loading.

Loading Capacity (LC):

It refers to quantity ofencapsulated to the total weight of microspheres formed. This LC is significantly changing with the changes of concentration of chitosan and starch.

Size & Sphericity Factor (SF):

These are the morphological features that can be effectively measured by equivalent diameter and sphericity factor. In this study by using light microscope these two features are measured and nearly all beads are spherical.

Rupture force (RF):

The maximum force (N) required for compression represents the maximum resistance of the bead to compression by the probe, which indicates hardness of the beads. In this study, chitosan treated beads are harder than only alginate beads.

Conclusion

- The only alginate used as wall material which protects oil from the oxidation due to external environment.
- The alginate coated beads, oozing out oil after some time.
- Therefore, along with alginate starch is also used as wall material which gives more stability to oil means it remains in the beads.
- The chitosan treatment proves to be effective, the beads treated with chitosan were hard after drying and they showed more oil content than the non-chitosan treated beads.
- Hence, the chitosan treated beads showed delay release.

- The application of PSO containing microbeads is in the-
 - Pharmaceutical Industries
 - Chemical Industries
 - In cosmetic products such as sunscreen creams, face wash, etc

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11. BIOTECHNOLOGY**Genetic Engineering Approach for Drought Tolerance**

Kadam P.R.¹, Jadhav P.K.², Shaikh U.S.³, Gholave K.K.⁴

¹M.Sc student, ²M.Sc Student, ³M.Sc Student, ⁴B.Tech(Biotechnology) Student, Department of Plant Biotechnology, V.D.College of Agricultural Biotechnology, (VNMKV, Parbhani) Latur (M.S) India

Introduction

The CRISPR system is a natural defense mechanism in prokaryotes that also serves as a genome editing tool. It involves short palindromic repeat sequences that complement foreign DNA, such as viral DNA. The CRISPR cleavage method uses a synthetic guide RNA (gRNA) and the Cas9 nuclease enzyme to cut the target DNA, which is widely used in plant and animal genome editing. The process involves three steps: recognition, cleavage, and repair. A designed single-guide RNA directs Cas-9 to the target sequence, inducing double-stranded breaks at a site upstream of the protospacer adjacent motif (PAM). The Cas-9 protein recognizes the PAM sequence, triggering local DNA melting and forming an

RNA-DNA hybrid. Cas-9 then cleaves the DNA, with the HNH domain cutting the complementary strand and the RuvC domain cutting the non-complementary strand. The resulting double-stranded breaks are repaired by the host cellular machinery. The CRISPR system has been widely used in genome editing, with numerous applications published between 2010 and 2018.

Stress

In the widest biological sense, stress can be any factor that may produce an adverse effect in individual organisms, populations or communities. Stress is also defined as the overpowering pressure that affects the normal functions of individual life or the conditions in which plants are prevented from fully

expressing their genetic potential for growth, development and reproduction.

Abiotic stresses

stress refers to the adverse effects of non-living elements on living organisms within a particular environment. Addressing abiotic stress is a critical challenge in agriculture, as it has the potential to consistently restrict the selection of crops and impede agricultural production on a large scale. Extreme events stemming from abiotic stress can even result in complete crop failures. These stressors not only have detrimental impacts on the livelihoods of individual farmers and their families but also pose a threat to national economies and food security.

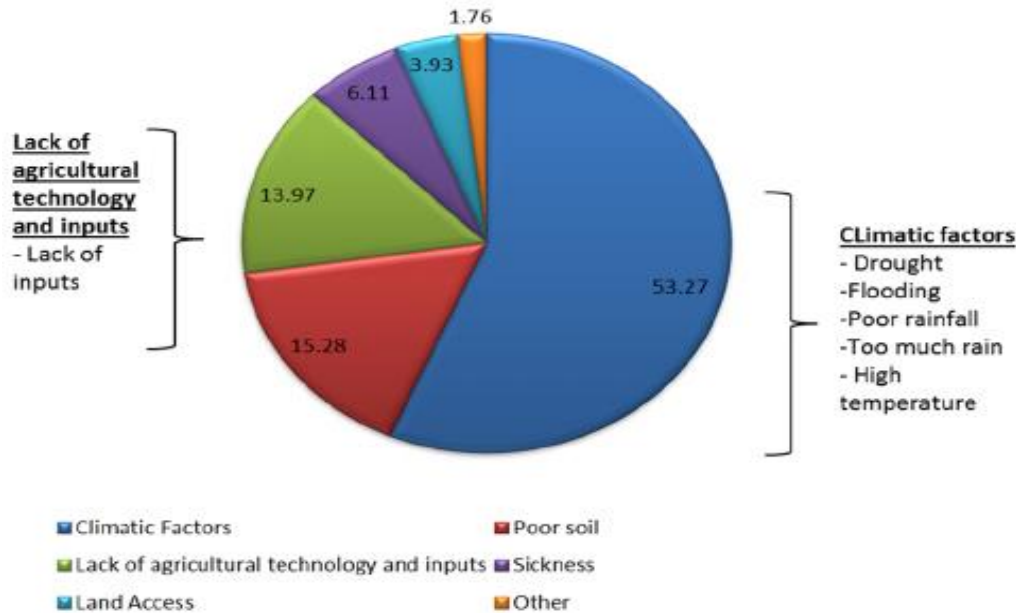
Abiotic stresses include:

Abiotic stresses encompass a range of environmental factors that adversely affect plant growth and development. These stressors include salinity, drought, flooding, metal toxicity, nutrient deficiency, temperature extremes, and cold conditions. The impact of these abiotic stresses poses significant challenges to agricultural productivity and plant resilience.

Drought:

Drought is described in a variety of ways, including as "a time of dry weather" (Nagarajan, 2003); "a state of abnormal dry weather resulting in a severe hydrological mismatch, with consequences such as crop losses and water shortages for people and livestock" (Nagarajan, 2003; Alexander, 1993).

Major Causes of Crop Loss Due to Abiotic Stresses:



Genetic engineering approaches for drought tolerance:

Various genetic engineering approaches have been employed to enhance drought tolerance in plants. These include marker-assisted selection, R-DNA technology, RNA interference (RNAi), and the revolutionary CRISPR Cas-9 technology. These methods enable precise modifications and improvements in crop plants, contributing to

their resilience under drought conditions.

CRISPR Cas-9

CRISPR Cas-9 is a genome editing technique within genetic engineering, involving the deliberate insertion, removal, or modification of DNA in living cells. The term CRISPR refers to the unique arrangement of short, partially repeated DNA sequences present in prokaryotic genomes. Functioning as an adaptive immunity mechanism in

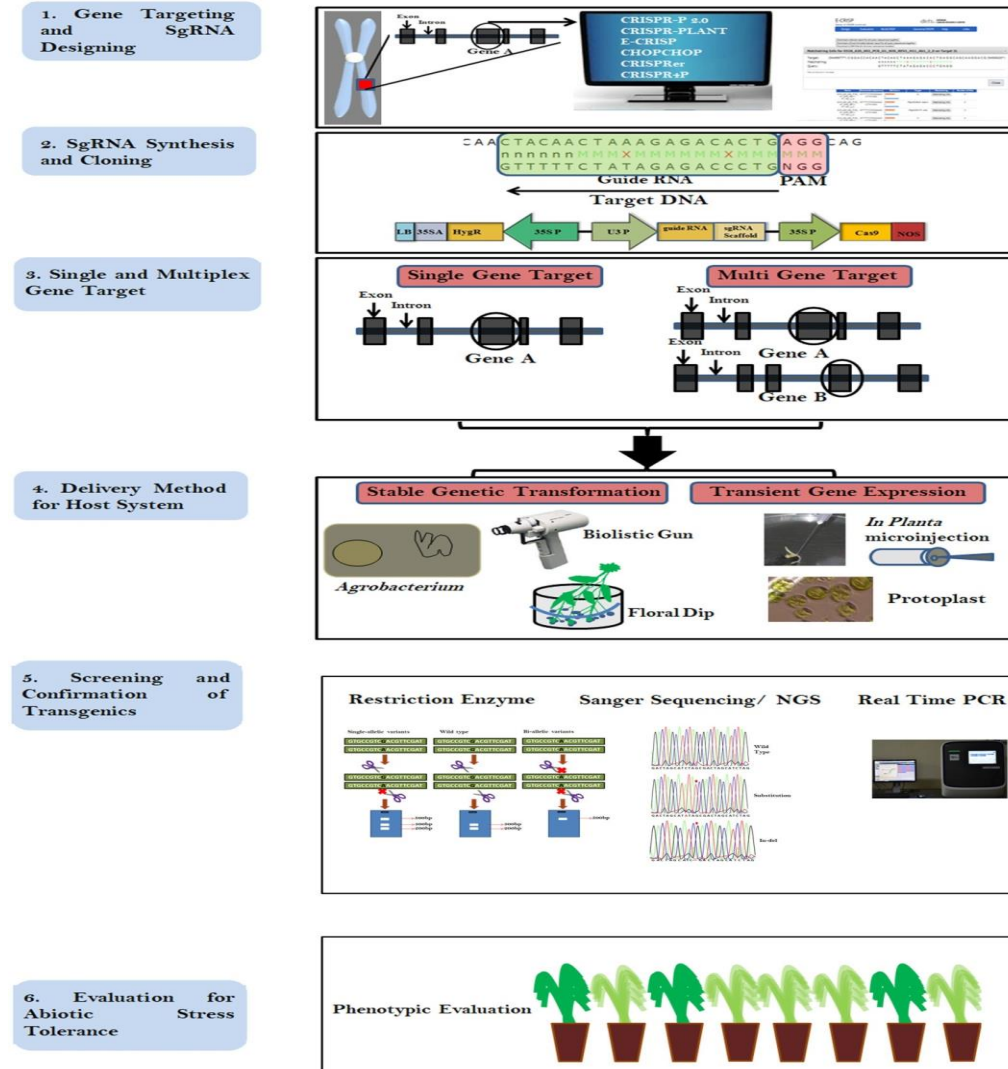
prokaryotes, CRISPR and its associated protein, Cas-9, provide defence against viruses or bacteriophages through stages of adaptation, crRNA synthesis, and target interference. This defence system safeguards bacteria from repeated viral attacks by precisely identifying and neutralizing foreign DNA sequences.

This serves as a defence mechanism against viruses and a genome editing tool. The CRISPR cleavage method involves a guide RNA and the Cas9 nuclease enzyme, and has been widely used for genome editing in plants and animals. The process involves recognition, cleavage, and repair of the target DNA. The Cas-9 protein induces double-stranded breaks at a specific site, leading to DNA cleavage, and the breaks are then repaired by the host cellular machinery.

Mechanism of CRISPR CAS- 9:

The CRISPR system is a type of short palindromic repeat sequences found in prokaryotes, which can bind to and cut viral DNA with the help of the Cas nuclease enzyme.

General protocol for development of drought tolerance plants by using CRISPR CAS-9



Advantages of CRISPR CAS -9:

CRISPR Cas-9 offers several advantages, including low off-target effects, cost-effectiveness, and ease of use. It boasts high on-target efficiency, allowing for small nucleotide deletions or insertions, precise single-nucleotide substitutions, and sequence-specific DNA modifications. Additionally, the technology enables the editing of multiple genes using gRNA cassettes designed with one or more promoters in a single vector system, known as Multiplex CRISPR Cas-9.

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12. SOIL SCIENCE**Significance of Nitrogen in Paddy****A. Premalatha***Scientist (Soil Science) ICAR – Krishi Vigyaan Kendra, Erode District, Tamilnadu***Introduction**

Rice is the staple food for about half of the global population and for more than two thirds of the people of India. Rice production in the world was more than 740 million tonnes (Mt) in 2014, 90% of which was produced in Asia. In 2017-18 Rice production in India was 112Mt from the gross rice cropped area of 43 million hectares (Mha). Since the demand for food in the world is projected to double by 2050, there remains a greater challenge to achieve still higher rice production, that too, ensuring the environmental sustainability. Efficient management of fertilizers is one of the major options to meet this challenge. Nitrogen is the single most important essential nutrient element that has profound effect on growth and yield of rice. Nitrogen is an essential plant nutrient being a component of amino acids, nucleic acids, nucleotides, chlorophyll,

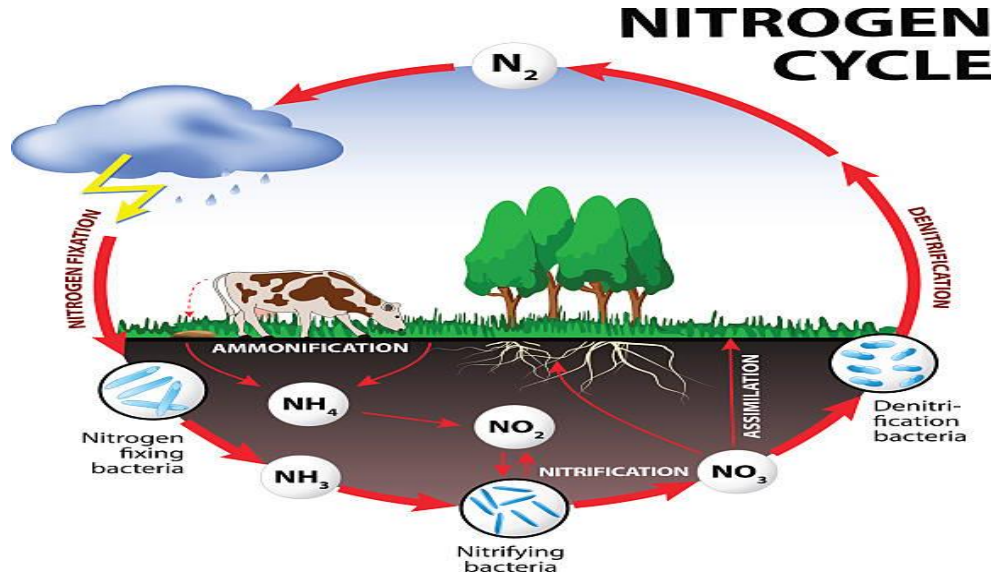
enzymes, and hormones.

Role of Nitrogen (N) in Rice

- Nitrogen encourages the vegetative development of plants by imparting a healthy green color to the leaves.
- There are two stages in the growth of rice crop when nitrogen is most needed; early vegetative and panicle initiation stages.
- Fertilizing the crop during early vegetative growth promotes tillering leading to higher yield. Application at panicle initiation or early booting stage will help the plant produce more and heavier grains per panicle.
- N promotes rapid plant growth and improves grain yield and grain quality through higher tillering, leaf area development, grain formation, grain

filling, and protein synthesis. N is highly mobile within the plant and soil.

Nitrogen Cycle



The nitrogen cycle is a repeating cycle of processes during which nitrogen moves through both living and non-living things: the atmosphere, soil, water, plants, animals and bacteria. Microscopic living organisms that usually contain only one cell and are found everywhere. Bacteria can cause decomposition or breaking down, of organic material in soils. In order to move through the different parts of the cycle, nitrogen must change forms. In the atmosphere, nitrogen exists as a gas (N_2), but in the soils it exists as nitrogen oxide, NO , and nitrogen dioxide, NO_2 , and when used as a fertilizer, can be found in other forms, such as ammonia, NH_3 , which can be processed even further into a different fertilizer, ammonium nitrate, or NH_4NO_3 .

There are five stages in the nitrogen cycle,

Stage 1: Nitrogen Fixation

In this stage, nitrogen moves from the atmosphere into the soil.

Stage 2: Mineralization

This stage takes place in the soil. Nitrogen moves from organic materials, such as manure or plant materials to an inorganic form of nitrogen that plants can use. The first form of nitrogen produced by the process of mineralization is ammonia, NH_3 . The NH_3 in the soil then reacts with water to form

ammonium, NH_4 .

Stage 3: Nitrification

The third stage, nitrification, also occurs in soils. During nitrification the ammonia in the soils, produced during mineralization, is converted into compounds called nitrites, NO_2^- , and nitrates, NO_3^- . Some bacteria in the soil can turn ammonia into nitrites. The bacteria that we are talking about are called nitrosomonas and nitrobacter. Nitrobacter turns nitrites into nitrates; nitrosomonas transform ammonia to nitrites.

Stage 4: Immobilization

sometimes described as the reverse of mineralization. Micro organism living in the soil require nitrogen as an energy source. These soil microorganisms pull nitrogen from the soil when the residues of decomposing plants do not contain enough nitrogen. When microorganisms take in ammonium (NH_4^+) and nitrate (NO_3^-), these forms of nitrogen are no longer available to the plants and may cause nitrogen deficiency, or a lack of nitrogen. Immobilization, therefore, ties up nitrogen in microorganisms. However, immobilization is important because it helps control and balance the amount of nitrogen in the soils by tying it up, or immobilizing the nitrogen, in microorganisms.

Stage 5: Denitrification

In the fifth stage of the nitrogen cycle, nitrogen returns to the air as nitrates are converted to atmospheric nitrogen (N₂) by bacteria through the process we call denitrification.

Sources of N

- Ammonium sulfate (21% N, 24% S)
- Urea (46% N)
- Diammonium phosphate or DAP (18% N; 44–46% P₂O₅).

Nitrogen deficiency symptoms

Stunted plants with small yellowish green leaves and fewer tillers; lower yield due to less panicles per unit area and less grains per panicle.

Occurrence of N deficiency

Almost all soils are deficient in N; coarse textured acid soils with low organic matter content (less than 0.5% organic C); acid sulfate, saline, poorly drained, and P-deficient soils with low N mineralization and biological N fixation capacity; calcareous and alkaline soils with low soil organic matter level and a high potential for ammonia volatilization.

When to Apply N Fertilizers?

Leaf color and crop appearance indicate the plant N status and help determine the need for N fertilizer application. See Fact Sheets on a) Leaf Color Chart (LCC) for crop need-based N management, and b) Nitrogen split applications for growth stage-based N management using the LCC.

Nitrogen fertilizer losses from rice field

Nitrogen fertilizer losses through ammonia volatilization, denitrification and leaching may cause environmental pollution and health problems. Ammonia volatilization losses can be

reduced by (1) Applying soluble chloride or nitrate salts of calcium, magnesium and potassium (2) Using urease and algal inhibitors (3) Deep placement of N fertilizers and use of modified forms of urea and (4) Use of slow release fertilizers.

Denitrification losses can be reduced by (1) Use of nitrification inhibitors, (2) Deep placement of N fertilizers, (3) Use of slow – release fertilizers and (4) Application of plant residues having high polyphenol content and high protein binding capacity.

Leaching losses can be reduced by (1) increasing water-use efficiency, (2) Using slow – release fertilizers and nitrification inhibitors (3) Puddling the rice fields, (4) Planting catch crops, and (5) using crop residues in situ.

The use of plant growth promoting the microorganisms in rice culture can reduce the need of N fertilizer by efficient N use by the rice crop and can thus reduce the environmental pollutions due to N losses.

Conclusion

Demand for food in the world is projected to double by 2050. Rice is the staple food for majority of Indian population and about half of the global population. Nitrogen is the for most essential nutrient element that plays a very crucial role in enhancing rice production. Hence N management in rice assumes greater importance in ensuring food security and environmental sustainability. In an efficient N management strategy, N fertilizer, especially urea, needs to be applied to rice crop in such a manner that N supply synchronizes with the N demand pattern of the rice crop maximizing utilization of native and applied N and minimizing N losses from rice soil system such as ammonia vitalization, nitrification-denitrification, run-off, leaching and removal of N by weeds.

13. AGRICULTURAL EXTENSION EDUCATION**Extension Strategies for empowerment of rural youth in Agricultural**

Channappa¹, Vaijanatha² and Veena Bushetti³

Research scholar, Department of Agricultural Extension Education¹ Research Scholars, Department of Agricultural Economics University of Agricultural Sciences, Raichur And³ Research Scholar, Department of

Introduction

India is a land of diversity. Among all the types of varieties, rural-urban divide is the most fabulous one rural youth and women are engaged in agricultural. Different activities like formal and informal wage work, unpaid family labor, self-employment, and cooperative membership and across all levels of the value chain, somehow youth earn "mixed livelihoods" from various sources on-farm, off-farm, and non-farm and with self-employment and migration playing particularly important roles, Youth being more enthusiastic, ready to acquire knowledge very quickly, vibrant in decision making, accepting innovative thinking and dynamic in nature.. and also youth shows strong passion to desirable things, In motivation others and they have more will power which also helps in make them the most valuable human resource assets for fostering economic, cultural and political development of a nation. When we look at the growth pattern in the youth segment differs substantially from that of general population. Current predictions suggest a steady increase in the youth population to 464 million by 2021 and finally a decline to 458 million by 2026 (India census, 2011), so youth are the major assets for the India by converting these categories of the into useful no doubt we can create wonder the country formal education and vocational training, able to access Information and Communication technology, unemployment, malnutrition, are the main challenges. Hence, there is need of effective strategies for empowerment of rural youth. Rural youth empowerment includes improvement of educational status, better reasonable healthcare services, proper distribution of productive resources, creating opportunities in economic and commercial sectors, creating awareness of their rights, roles and responsibilities, improved standards of living and acquiring self-reliance, self-esteem and self-confidence. Thus the framework of empowerment encompasses the welfare of rural youth. (Ambarao Uplaonkar, 2005).

Extension strategies for empowerment of women and rural youths

1. **Education:** By facilitating combination of teaching cum vocational training method for rural youth is more effective to acquire theory as well as practical knowledge to face his life. Motivate and support the use of innovative technologies in affordable price and by combine of modern technologies with traditional knowledge for sustainable rural development which helps in documentation of traditional knowledge. Support resilience and to prevent, cope with and recover from natural disasters by raising awareness about climate change mitigation and adaptation possibilities Educating and advice the adoption of environment-friendly activities in agriculture like organic farming and benefits to the future generation relating the soil health as well as human health.
2. **Rural entrepreneurship:** Entrepreneurship development is the driving force of socioeconomic growth of any nation. Developing entrepreneurs in agriculture and allied sector will helps in engaging more young in agricultural field. Because more than 50% of population is dependency on agriculture, rural unemployment and migration from rural to urban areas, Personal qualities of an agri-entrepreneur, significantly affect the agribusiness. India is predominantly a rural economy where agriculture and allied sectors play a important role in national income, output, employment generation and foreign exchange earnings. To attract rural youth towards agriculture, as a first step, agriculture needs to be transformed into a high profitable venture with low risks and stable income. Farm activities will have to be diversified with cash yielding, low volume, high-value and demand-driven quality output. Sectors of interest in this regard would include organic farming, vertical use of farmland, horticultural products, such as exotic flowers and vegetables, medicinal mushrooms and herbs, high-value spices, animal husbandry sector, *etc.* Value-addition and primary food processing are

easy to adopt enterprises, especially for youth.

3. **Empowering rural handicrafts:** India's rural artisans have contributed significantly to the nation's economy, the art and handicrafts sector is the second most largest with the help of economically cheaply available resources employment generator after agriculture rural area These include handicrafts of clay, paper, embroidery, bamboo, cane, jute, shell wood, rock, bell metal, bone, horn and brass. The pandemic has created a situation where even the urban dwellers chose to temporarily migrate to the safer, untouched rural lands for months or more. The government and other social development organizations must grab this opportunity and initiate policies explicitly targeted at reverse migration. Companies can explore this window of opportunity to test the possibilities of 'rural shoring'. 'Rural shoring' is a great option for companies who want to realize the benefits of outsourcing by giving work to service providers in rural locations where the cost of living and operations will be much lower. With the expanding digital infrastructure and targeted interventions in skilling, this could prove to be a win-win situation for both companies and rural youth.

ICTs for the Empowerment of Women and youth

Information and Communication Technology (ICT) is a wonderful tool which benefits all spectrums of people in the world wide and it reaches millions of people every day. It is the communally and economically marginalized assess source. Enabling environment for ICT, Content development in local knowledge, Need-based development of software, Bridging the divide from age, gender, community and geography are essential., Low-cost training institutes and 'no cost trainers'

NSS/NCC students, Marketing development and management skills, Women to be involved in designing ICT policies, ICT centres can be part of existing institutions such as health centres, school, community centres, panchayat and ICDS centres, Gender and ICT awards good practices.

Conclusion

Young people in all countries are both a major human resource for development and key agents for social change, economic development and technological innovation. Their imagination, ideals, considerable energies and vision are essential for the continuing development of the societies in which they live rural young people can only commit themselves to active participation and full integration in society when they find enabling environments for the fulfillment of their civic potential and when their actual needs and conditions are taken into account There must be need of effective and suitable policy which is one in another way to continuous engaging rural young people and encouraging by proving bank loan for startups at higher subsidy rate.To be able to make informed decisions take and accept responsibility to be more independent and to be able to effect change in them in others and in their communities.

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