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Growing seed

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PROSPECTS OF WATER HOLDING POLYMERS IN AGRICULTURE

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India's population is growing at a worrisome rate and is anticipated to present significant issues in the near future. The demand for water is anticipated to increase by 50% due to population expansion. The use of water-holding polymers in agriculture has given answers to the issues facing modern agriculture and increased the soil's ability to store water. Water-holding polymers may have an impact on the rate of soil evaporation and water infiltration. In particular, the polymers lessen the need for irrigation and have a tendency to compact soil, which prevents erosion and water runoff. The purpose of this article was to provide information on the potential uses of water-holding polymers in agriculture.

The condition of water resources in India is a cause for concern. India is facing increasing challenges with regards to water scarcity, water quality, and access to clean water. Groundwater, which provides drinking water for over 60% of the rural population and nearly 25% of urban population, is being over-exploited in many regions. Water is a critical resource for agriculture, as it is necessary for plant growth and the production of food. In many regions, irrigation is used to supplement insufficient rainfall or to provide water during dry periods. However, the increased demand for water in agriculture has put pressure on water resources, leading to over-extraction of groundwater, depletion of rivers, and water scarcity. This has resulted in water stress and reduced crop yields in some areas. To address these challenges, farmers are using various water management practices such as precision irrigation, rainwater harvesting, and conservation tillage to conserve water and improve efficiency. It is estimated by 2025 water scarcity will be a major issue in India requiring immediate redressal. The Central Water Commission reports that although the need for water is steadily increasing, the supply of clean water is expected to decrease much more rapidly in the future. In the case of India, agricultural irrigation methods appear to be the main consumer of 80% of the potable water available. With the continued intensification of agrobased sectors, this trend is growing. Modern irrigation techniques can still only support 40% of the planted crops due to the subcontinent's vast geographic size, variable soil, and farming methods. The effectiveness and wise use of available water for crops is substantially reduced in the remaining areas because they are far more vulnerable to bad practises.

Water-holding polymers (WHP), are a type of polymer that can absorb and retain large amounts of water. These materials are used in various applications, agriculture and food processing. They are typically made of a network of polymer chains that are cross-linked to form a three-dimensional structure that can hold onto water molecules. The water-retaining properties of WHP make them useful in a variety of settings where moisture management is important. The soil's ability to store water was increased as a result of water-holding polymers swiftly forming gels with irrigation water. Plants get access to the water that is kept in this way for a long period of time. In addition to the water they receive during building, fertilizers, nutrients, and mineral salts are also present in the soil along with the polymers. This method effectively supplies irrigated water to plant roots at critical times.

Natural polymers, semi-synthetic polymers, and synthetic polymers are the three main forms of water-holding polymers employed today. Starch-based natural polymers come from grains like corn and wheat and are based on starch. Natural polymers are frequently used in the food sector as a thickening. First, cellulose is converted into semi-synthetic polymers, which are then combined with petrochemicals. The cation or anion of these polymers varies. Agriculture is the principal application for synthetic polymers. The most common sources of synthetic hydrophilic polymers are polyvinyl alcohol and polyacrylamides. The chemical composition of polymers operating as a type of soil microsponge is cross-linked acrylamide, acrylic acid, potassium salt, and ammonium salt in potassium-based water absorbers. The materials are rendered insoluble in water by the cross-linking molecules that create a three-dimensional network in the polymer structure. These substances absorb water and nutrients that are water soluble when they come into contact with water, swelling quickly and forming a gel structure.

Super Absorbent Polymers

A new class of macromolecular synthetic water absorbing polymer material, super absorbent polymers are also referred to as hydrogel, absorbent polymers, absorbent gels, super soakers, and super slurpers. By osmosis, it has the ability to absorb up to 100,000% of its own weight in water in a short amount of time and forms granules in soil to improve soil qualities. SAPs are typically hygroscopic materials that resemble white sugar and swell in water to produce a clear gel consisting of distinct individual particles. They can hold moisture even under pressure without burning up or rupturing or blasting.The majority of super absorbent polymers used in agriculture are made via solution or suspension polymerization from acrylic acids and a cross-linking agent like potassium. The polymer created in this way is known as a polyacrylate, and the amount and type of cross-linker utilized considerably influences its swelling capacity and gel modulus. Polyacrylates have been shown to be biodegradable with a degradation rate of 10%–15% annually. They are non-toxic, non-irritating, and non-corrosive by nature. They have a high water absorption capacity and may freely release 95% of the same when plant roots apply suction. Two significant examples of SAPs made by agriculture

1. **Pusa hydrogel**: To satisfy the needs of water productivity in agriculture, the Indian Agricultural Research Institute, New Delhi, has created an absorbent polymer named "Pusa Hydrogel."Natural polymer backbone-based water absorber based on cross-linked potassium polyacrylate polymer, exhibits maximum absorbency at temperatures (40- 50^{o}C) characteristic of semiarid and arid soils. Absorbs water 400 times its dry weight and gradually releases the same. Stable in soil for a minimum period of one year. Less affected by salts and low rates of soil application.

2. **Casava starch-based SAP**: A semi-synthetic SAP is developed by Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.Uses cassava starch backbone (other starches can also be used, but absorbency may vary) Contains no detectable level of the monomer, acrylamide. Absorbency ranges from 400-425 g/g of the dry sample.

Benefits : SAPs have several applications in agriculture, including:

1. Improving soil moisture retention: SAPs can be added to soil to increase its ability to retain moisture, reducing the need for frequent watering and improving plant growth.
2. Drought management: SAPs can be used to mitigate the effects of drought by retaining water in the soil and making it available to plants when needed.
3. Seed coating: SAPs can be used as a coating for seeds to improve germination rates and seedling growth.
4. Irrigation: SAPs can be used in combination with irrigation systems to increase the efficiency of water usage, reducing waste and conserving resources.

5. Fertilizer enhancement: SAPs can be added to fertilizer to increase its effectiveness by retaining moisture and nutrients near the roots of plants.
6. Soil remediation: SAPs can be used to clean up contaminated soil by absorbing and retaining pollutants.
7. Landscaping: SAPs can be used in landscaping to improve soil moisture retention, reducing the need for frequent watering and promoting plant growth.

SAPs have some disadvantages, including:

1. Environmental impact: SAPs are not biodegradable, so they can persist in the environment for a long time, potentially causing harm to wildlife and ecosystems.
2. Production process: The production process of SAPs often involves the use of harsh chemicals and requires large amounts of energy, which can have negative environmental impacts.
3. Cost: SAPs can be relatively expensive compared to traditional absorbent materials, making them less accessible to some consumers.
4. Disposal: Disposing of SAP-containing products, such as disposable diapers, can be challenging as they do not break down in the environment and can take up space in landfills.
5. Health concerns: There is limited research on the long-term health effects of SAPs, but some studies have suggested that exposure to SAPs may be linked to skin irritation and other health problems.

Conclusion

In dry and semiarid areas, water is increasingly the limiting constraint for sustainable crop production. Water holding polymers can be used as a soil conditioner to enhance the hydro-physical, physicochemical, and biological environments of the soil, increase soil water retention and release capacity, boost irrigation, water and nutrient use efficiency, raise crop yield and quality, and maintain environmental quality. In terms of increasing yield and reducing soil moisture stress, this technology may become a radical and practically useful one in water-stressed locations. This article envisages that, the widespread implementation of SAPs could benefit farmers and other stakeholders by optimizing water resource management for greater agricultural productivity.

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BIO SEED PRIMING: SUSTAINABILITY TOWARDS ECOSYSTEM, FARMERS & HUMANITY

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Bio-priming is an alternative way of chemical priming of seed. Nowadays, sustainability towards ecosystem, farmers and humanity is significant over unsustainable practices. Various microbes (e.g.- Plant growth promoting bacteria, Biophos etc.) are applied to well acquaint bio- priming. Maize, Sunflower, Ground nut, Bengal gram, Kidney bean are some of the successful bio- primed field crop. Ideas of organic farming also support bio-priming for humanity. Farmers are exhausted of applying excessive chemical for seed treatment, resulting into death of the seed tissue, hampering seed growth and affecting germination. Bio-priming is a effective approach to replace farmer harmful chemical practice. Overall ecosystem getting benefitted by bio-priming, helping seed for positive growth, enriching nutrient intake, high germination capacity, vegetative growth and ultimately enhancing yield and productivity. That is why we can say that,

"If Bioprimng Is Possible, Then Our Ecosystem (**E**) and Humanity (**H**) Is In the Safe Hand of Farmer (**Art**) Who Are the Artist of Agriculture, Saving Our Mother **Earth**"

Bio seed priming is techniques of seed treatment with beneficial microorganisms (Bacteria, fungus, actinomycetes etc.) that may be improve seed health, seed quality, seed morphology. Biopriming is an alternative method of chemical priming. In simple words, biological contact with seed material is Biopriming. Biological contact can be fair for seed or may not be in the mean of beneficial or non-beneficial microbe contact. Seed generally attacked, damaged by seed borne pathogen (non-beneficial), controlled by Integrated Disease Management (combination of physical, biological, chemical management). But prevention is better than cure, therefore, at primary stage only if seed subjected to biopriming then seeds are getting force for growth, chances of seed borne pathogen becoming less. With this approach, we are minimizing post disease management and also incrementing the flourishing energy of seed material resulting to high germination percentage.

Fig 1: Germinated Bioprimed Seed

Biopriming Diversification among Farmers

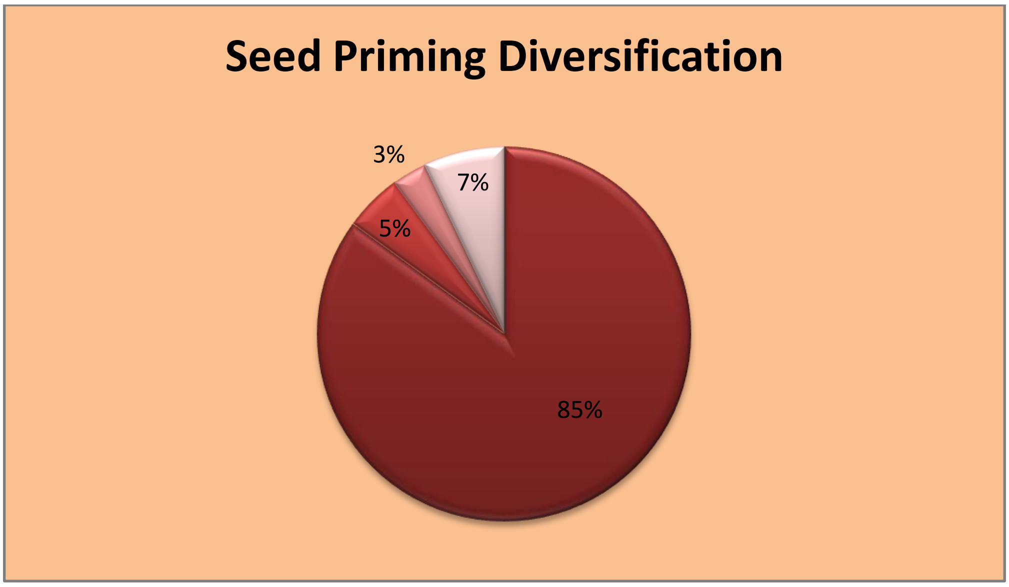

Fig 2: Chemical priming (85%), Bio priming (5%), Physical Priming (3%) and others (7%)

Bio priming percentage is very less (5%) among all types of seed priming method. Chemical priming occupying 85% which is more as well as harmful for seed material, farmers and humanity. Its prime important to reduce chemical priming, so that negative effect of chemical (disease like cancer, lungs disease) priming can minimize. And Physical priming is mostly laboratory oriented (3%). So long gap will create between all types of priming which can occupy by bio seed priming.

Bio Priming Microorganisms

Various types of microorganisms are applied in bio-priming for seed treatment. Some of the microbial entity are as follows,

1. Plant growth promoting rhizo bacteria / PGPR (Mahmood *et al*. 2016), *Azospirillum lipoferum (*Rozier *et al.* 2019*).*
2. Biophos
3. Trichoderma strains.
4. Purple non-sulfur photosynthetic bacteria (Hayashi *et al*. 2022)
5. Drought alleviating bacteria.
6. Beneficial bacteria (Ex-*Pseudomonas fluorescens,* Raj *et al.* 2004)

Method of Seed Treatment with Microbial Consortia: An Example of Making Consortia for Bio Priming

For the treatment with Biophos, Drought Alleviating Bacteria (DAB) & cold adaptive Plant Growth Promoting Bacteria (PGPB), the following method was used:

- The 50 ml of formulation was diluted in 500 ml water. Addition of sucrose @ 10% was done. This quantity was sufficient to treat seeds required for 1/2 acre.
- The bacterial suspension was sprinkled on the seeds and the seeds were slowly but thoroughly mixed to have a uniform coating. The seeds were left as such for 30 minutes.
- Then the seeds were spread uniformly for drying on a gunny bag in shade for 30-45 minutes avoiding direct sunlight.

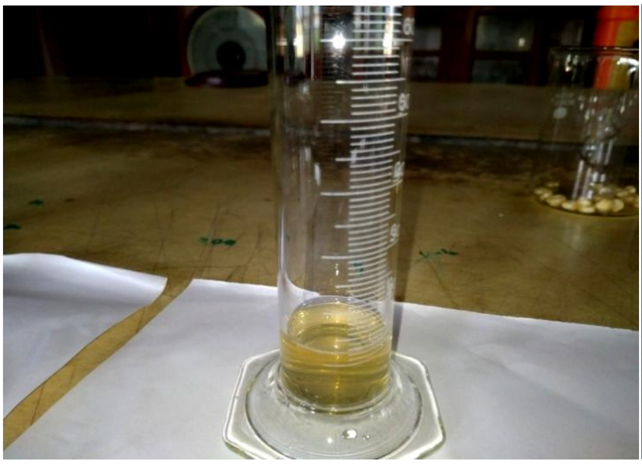

Fig 3: Biophos + DAB + PGPB

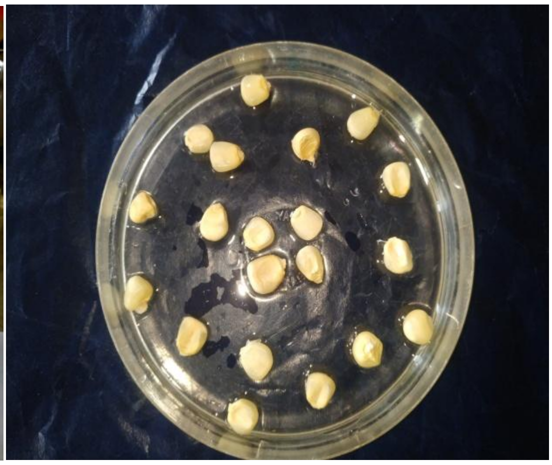

Fig 4: Bio Primed Maize Seed

Fig 5: Germinated Bio- primed Maize Seed (Crystal Sand

Like bio-primed maize seed (**Fig 4),** other seed also germinate after treatment with bio priming materials e.g.- Sunflower (**Fig 6**), Cowpea, Ground nut, Bengal gram, Horse gram etc. Kidney bean or Rajmah like crop is fail to germinate in the normal weather but bio-primed seed is successful in germination.

Fig 6: Germinated Bio- primed Sunflower Seed (Crystal Sand Media)

Advantages of Bio Seed Priming:

- Minimizes seed borne pathogen (biotic stress), improving seed health and reducing abiotic stress too.

- Increases speed and uniformity of germination; also ensures rapid, uniform and high establishment of crops; and hence improves harvest quality and yield.

Conclusion

Biopriming becoming popular day by day in the climate change era. Biopriming enhancing supporting organic farming. Farmers, ecosystem and humanity become sustainable day by day. For giving more importance to bio seed priming require more shout out to rank and file by government, non- government organizations through several schemes like MOVCD, other campaigns etc. Then we can convert whole chemical seed priming into bio priming generation.

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ARTIFICIAL INTELLIGENCE AND ITS APPLICATIONS IN AGRICULTURE

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Artificial intelligence (AI) is a technology that demonstrates behavior that can be described as human intelligence. Artificial intelligence is a branch of computer science that deals with the simulation of intelligent behavior in computers. AI refers to the ability of machines to perform cognitive tasks such as thinking, perceiving, learning and problem-solving and decision making. AI technologies can predict the most accurate crop for a specific area and time. Today, how to ensure food security for the world's growing population is one of the major global challenges, while at the same time ensuring long-term sustainable development. According to the FAO, food production must grow by 70% to feed the world's population, which will reach 9 billion by 2050. Policy makers need to make AI a key element in flagship programs such as Make in India, Skill India and Digital India. Farmers need to look for cognitive technologies (e.g. AI) to increase crop yields. It largely solves the problem of shortage of resources and manpower. Artificial intelligence can prove to be a technological revolution and boom agriculture to feed the growing human population of the world.

Agriculture is extremely important to India's economy. Agriculture is the primary source of income for more than 58 per cent of rural households. Agriculture and allied sectors (including agriculture, livestock, forestry, and fishing) are anticipated to account for 15.87 per cent of Gross Value Added (GVA) in 2018-19 at 2011-12 prices, according to the Central Statistics Office (CSO). Agriculture accounts for around 17.3% of GDP.

While the demand for agricultural products is tremendously increasing year by year, the resources are constrained. Therefore, to produce more with minimal inputs, the main machine interaction method will lead to quality outputs with sustenance by removing several barriers in agriculture sector. In consideration of man machine method, artificial intelligence plays an influential role in establishing the best production and management practices. Most of the developed countries have customized Artificial Intelligence based technologies implemented at farm level for site specific farming viz. appropriate distribution of fertilizers and chemicals in farms, smart irrigation, intelligent processing, crop health monitoring, disease analysis, positioning of farm machineries, pest surveillance, secure storage and distribution analysis, consumption analytics of agriculture products and monitoring of animal health. The implementation of artificial intelligence in agriculture has been used more effective precision farming tool for post- harvest productions, minimizing the wastage and simplifying the transportation of output products etc. (Anonymous 2018)

Artificial Intelligence

Artificial intelligence (AI) is a technology that displays behaviour that resembles human intellect. Artificial intelligence (AI) is an area of computer science concerned with simulating intelligent behaviour in computers. The ability of machines to execute cognitive functions such as thinking, perceiving, learning, problem solving, and decision making is referred to as artificial intelligence (AI). Artificial Intelligence is not a battle between man and machine; rather, it is a collaboration between man and machine. But the question is whether artificial intelligence can be used in agriculture. Is it possible for a machine to outperform a human in making judgments involving other living organisms in a complicated environment? Is it possible for an algorithm to outsmart a farmer's instincts and experience?

Need of Artificial Intelligence in Agriculture

One of the most pressing global issues today is providing food security for a growing global population while also assuring long-term sustainable development. In this regard, one of the most pressing needs is the application of cutting-edge technical solutions to make farming more precise and efficient. Scarcity of labour and rising labour expenses, as well as crop failures owing to illnesses, lack of rainfall, climatic changes, and loss of soil fertility, as well as shifting market prices in agriculture commodities, have all had a substantial detrimental impact on farmers' socio-economic position.

On the other hand, rising population has increased demand for food grains, resulting in agricultural commodity price inflation. We can design smart and exact farming procedures using artificial intelligence to reduce farmer losses and offer them with high yields with accuracy, allowing farmers to manage all the unknown difficulties they encounter in the agriculture business.

Evolution of Artificial Intelligence

1950: Alan Turning, He published a landmark paper in which he speculated about the possibility of creating machines that think.

1951: In the field of artificial intelligence, Christopher Strachey created a checkers programme while Dietrich Prinz created a chess software.

1956: The phrase "Artificial Intelligence" was coined by John McCarthy in a Dartmouth conference.

1959: The first AI laboratory, the MIT AI Lab, was established.

1960: General Motors' Robot debuts in 1960. On the GM assembly line, the first robot was introduced.

1961: First Chatbot-In 1961, ELIZA, the first AI chatbot, was introduced.

1997: In the game of chess, IBM's Deep Blue defeats champion Garry Kasparov.

2005: The autonomous robotic car Stanley, built by the Stanforf Racing Team, wins the 2005 DARPA Grand Challenge.

2011: IBM in 2011.

Types of Artificial Intelligence

1) **ANI (Artificial Narrow Intelligence):** it's all over the place, like Google maps, and it's great for discovering efficient routes to places when driving, or it can be compared to a chess programme. It's also characterized as "weak AI," because it only applies AI to select activities. Examples: Alexa, Siri, Sofia, and self-driving cars are just a few examples.
2) **AGI (Artificial General Intelligence):** imagine a computer that is as intelligent as a person in every way. So, anything we can do with our brain, including learning, is possible.
3) **ASI (Artificial Super Intelligence):** AI is becoming more powerful every day, with applications leading to machines and systems leading to more advanced AI, such as ASI (Artificial Super Intelligence).

Applications of Artificial Intelligence in Agriculture

1. Internet of Things (IoT)

The Internet of Things, or IoT, is a network of interconnected computing devices that can send and receive data without the need for human-to-human or human-to-computer contact. IoT technology enable for the linkage of structured and unstructured data to deliver food production insights. Every day, massive amounts of organized and unstructured data are generated. These include information such as historical weather patterns, soil reports, fresh research, rainfall, pest infestation, and photographs from drones and cameras, among other things. All of this data may be sensed by cognitive IoT devices, which can deliver powerful insights to boost yield. The IoT enabled sensors must be installed in the field at the prescribed locations to collect data on climatic conditions, soil moisture & fertility, root & shoot growth, profuse leaves growth, photo-period monitoring, floral & seed setting, grain/fruit bearing, pest & disease as critical growth factors symptoms and harvest readiness.

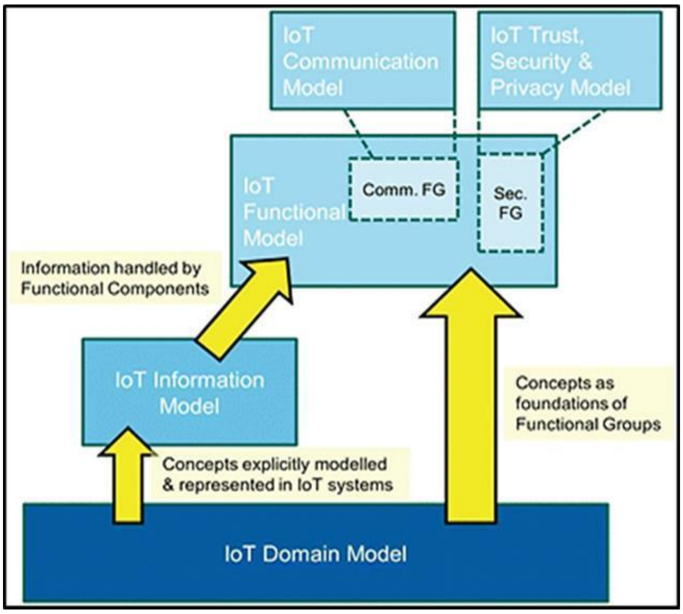


Fig 1: Internet of things (IoT) Domain Model

2. Precision/Site-Specific farming

Precision farming is defined by the four R's: right place, right time, right method, and right product. This is a more precise and controlled process that takes the place of the labor-intensive and repetitive aspects of farming. It also includes information on crop rotation.

Precision Farming Objectives

Profitability: Profitability is determined through carefully identifying crops and markets, as well as projecting return on investment based on cost and margin.

Efficiency: Investing in precise algorithms allows for better, faster, and less expensive farming options. This ensures overall accuracy and resource efficiency.

Sustainability: Improved social, environmental, and economic performance ensures that all performance measures improve incrementally each season.

3. Drone Based Technology

Agriculture is one of the most promising fields, where drones have the ability to solve huge problems. Agriculture is getting a high-tech facelift thanks to drone technology. Drones will be employed in six different ways throughout the crop cycle:

Soil and field analysis: Drones can help with seed planting and data collection for irrigation and nitrogen management.

Planting: Drone-planting technologies developed by start-ups have reduced planting expenses by 85 per cent. These systems fire pods containing seeds and nutrients into the soil, supplying all of the nutrients required for crop growth.

Crop spraying: Drones can scan the ground and spray crops in real time for even coverage. As a result, aerial spraying with drones is five times faster than traditional gear.

Crop monitoring: Drones can use time-series animations to depict the progress of a crop and uncover inefficiencies in production, allowing for improved management.

Irrigation: Sensor drones can detect areas of a field that are dry or in need of improvement.

Health assessment: Drone-carried gadgets can assist track changes in plants, indicate their health, and alert farmers to illness by scanning a crop using both visible and near-infrared light. Unmanned aerial vehicles (UAVs) could one day be made up of autonomous swarms of drones that collect data and perform tasks.

4. Artificial Intelligence in Image-Based Insight Generation

Precision farming is one of the most hotly debated topics in agriculture today. Drone-based photos can assist with in-depth field analysis, crop monitoring, field scanning, and other tasks. Farmers can use a combination of computer vision technologies, IoT, and drone data to take quick actions. Drone image data feeds can create real-time alerts to speed up precision farming. The following are some examples of applications using computer vision technology:

Disease detection: Pre-processing of the image ensures that the leaf images are split into areas such as background, non-diseased part, and diseased part. After that, the infected area is clipped and sent to distant labs for further analysis. It also aids in pest detection, nutrient deficit detection, and other tasks.

Crop readiness identification: Under white/UV-A light, images of various crops are collected to determine how ripe the green fruits are. Before shipping their crops to market, farmers can develop several levels of readiness based on the crop/fruit category and stack them separately.

Field management: By developing a field map and identifying places where crops require water, fertilizer, or pesticides, real-time estimates can be created during the cultivation period using high-definition photographs from airborne systems (drones or copters). This significantly aids resource optimization.

5. Artificial Intelligence in Optimal Mix for Agronomic Products

Cognitive solutions give suggestions to farmers on the best crops and hybrid seeds based on many characteristics such as soil condition, weather forecast, type of seeds, and infestation in a specific location, among others. The advice can be further customized based on the farm's needs, local conditions, and historical data on successful farming.

Farmers may also consider external elements like as market trends, prices or consumer wants in order to make an informed decision.

6. Artificial Intelligence in Remote Sensing

In contrast to on-site observation, such as of the Earth, remote sensing is the collecting of information about an object or phenomenon without establishing direct contact with the object. The phrase "remote sensing" is now commonly used to describe the use of satellite-or aircraft-based sensor technology to detect weather, crop infestation, irrigation management, and soil profile, among other things. This technology will also be used to track crops during their whole existence, as well as generate reports in the event of anomalies.

7. Artificial Intelligence in Automatic Irrigation System

An automatic irrigation system automates the operation of a system without the need for human intervention. Electronic appliances and detectors like as computers, timers, sensors, and other mechanical equipment automate every irrigation system, including drip, sprinkler, and surface watering. The use of an automatic irrigation system reduces crop production costs, making the industry more competitive and sustainable. Average crop yields must be maintained (or increased). Excessive applied water and subsequent agrichemical leaching have a negative influence on the ecosystem. Maintaining an adequate soil water range for plant growth in the root zone Low labour input for irrigation process maintenance and significant water savings when compared to irrigation management based on historical weather patterns.

Example: The Enorasis wireless sensor network is one example. (To produce a detailed daily irrigation plan that best matches the demands of each crop, this model integrates weather forecast and sensor data about the farm's crops.)

8. Artificial Intelligence in Quality Grading (Potato Sorting System)

The Robotics Lab at the University of Lincoln developed an artificial intelligence robotic system that sorts and detects potato illnesses like silver scurf and common scab. TADD, or the Trainable Anomaly Detection and Diagnosis system, can detect, classify, and quantify a variety of typical potato defects. In comparison to manual selection on an industrial scale, a potato sorting machine can display superior precision in detecting impacted or sick potatoes. It also has the potential to reduce labour costs and increase food safety assurance.

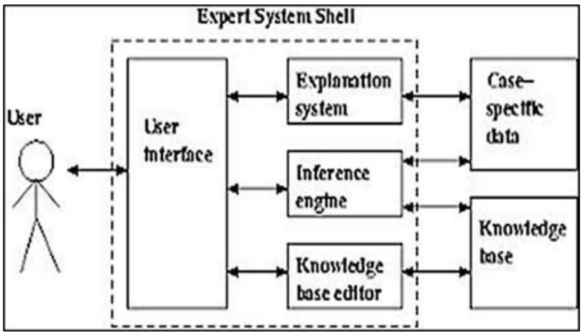
9. AI in Self-Driving Cars and Autonomous Navigation (Driverless Tractors)

The system allows a combine operator to set the course of a driverless tractor pulling a grain cart, position the cart to receive grain from the combine, and then send the fully loaded cart to be unloaded using increasingly sophisticated software combined with off-the-shelf technology such as sensors, radar and GPS.

10. Artificial Intelligence in Expert Systems

An expert system is software that seeks to replicate the performance of one or more human experts, usually in a particular issue domain. The expert system could be used for decision-making and technology distribution in specific locations. Expert systems aid in the selection of a crop or variety, the diagnosis or identification of pests, diseases, and problems, and the making of critical management decisions. The user, user interface, knowledge base, and inference engine are all critical components of an expert system.

Examples: Rice Crop Doctor, COMAX, COT FLEX, CUE, CROP LOT, SMART SOY etc.



The public installation where computers are deployed to make services available to the farming community is known as an information kiosk. The information kiosk serves as a hub for information tailored to the requirements of the community. Agri-kiosk is a one-stop shop for all agricultural needs, including soil testing, seed selection, appropriate pesticides, herbicides and fungicides, nutritional deficits and their management and video clips on various agricultural technology.

11. Artificial Intelligence in Decision Support System (DSS)

Decision support systems (DSS) are now widely utilized in a variety of industries to assist professionals in making decisions. A decision support system (DSS) can help with both organized and unstructured decisions. However, it cannot completely replace the decision maker because DSS lacks some human decision-making characteristics such as intuition, creativity, and imagination. It is, nonetheless, useful for enhancing a decision maker's ability to digest information or solve complex situations. It can also save a lot of time that a decision maker would need to grasp and process many parts of the problem. It can assist the decision maker in thinking out of the box and introducing new techniques, but DSSs are not ubiquitous; they are usually tightly focused on a single topic, such as yield prediction or fertilizers. A DSS's capabilities are also restricted by the computer system on which it runs, as well as the models and knowledge on which it is built.

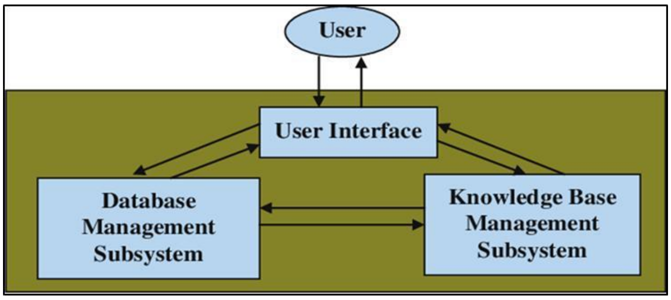


Fig 2: Decision Support System Model

12. Artificial Intelligence in Computer Vision Technology

Face recognition system for domestic cattle: Facial identification of cows in dairy units can track all elements of their behaviour in a group, including body condition and eating. When it comes to lameness, measuring the cow's back arch may provide an early indication of the problem. As a result of using this approach, you will be able to feed cows for a lot less money if you know what they will and will not eat. It's also possible to treat a lame cow before she displays signs of being lame, potentially saving months of diminished milk supply.

13. Artificial Intelligence in Gas Fermentation System

The gas fermentation system is an artificial intelligence-based system that predicts the outcome of the fermentation process in cattle. It can provide a degree of nutritional analysis of a feed in four hours that traditional methods take 48 hours to achieve. It provides a diagnostic technique to delivering qualitative and quantitative data on the rate and extent of carbohydrate digestion by cattle, allowing for the prediction of fermentation outcomes and the isolation of additive effects during the fermentation process.

14. Artificial Intelligence in Predictive Agriculture Analytics

Various AI and machine learning methods are being utilized to estimate the best time to sow seeds, get insect attack notifications, and other tasks.

15. Artificial Intelligence in Supply Chain Efficiencies

To establish an efficient and smart supply chain, companies use real- time data analytics on data streams from different sources. ICT Tools: Bhoomi, aAqua, e-choupal, Ikisan, mKisan, Agris Net, IFFCO, Agri watch, and other ICT tools. Applications for mobile devices: PAU Kisan App, Myhco Farmer's App, Plantix App, and so on.

AI Models for Farmers Services

The following service models can be offered to the recipients of this service.

a) Agri-e-Calculator for crop selection and resource estimation
b) Chatbot
c) Crop maintenance.
d) Market forecasting and guidance
e) Crop financing and insurance.

16. Artificial intelligence start-ups in agriculture

Blue river technology: Blue River Technology has developed a robot named See & Spray that uses computer vision to monitor and accurately spray weeds on cotton plants, according to the company. Herbicide resistance can be avoided by precision spraying.

Farm Bot: Everything is taken care of by this physical bot using an open source software system, from seed planting to weed detection and soil testing to plant watering.

Plant diseases diagnosis app-plantix: Plantix is plant disease diagnosis software that detects probable flaws and nutrient deficits in soil. The programme uses photos to detect plant problems; a smart phone collects images, which are then matched with a server image, and a plant health diagnosis is delivered.

Crop in-increasing per-acre value with artificial intelligence: Crop ins smart farm solution assisted with remote sensing and weather advisory, scheduling and monitoring farm activities for complete traceability, educating farmers on the adoption of the right package of practises and inputs, Microsoft India-AI-based Sowing App: Microsoft India has developed an AI-based sowing app in partnership with ICRISAT, which sends out sowing tips to farmers on the best time to seed. crop health and harvest estimation and pest, disease and other alerts.

Challenges of Artificial Intelligence in Agriculture

Despite the fact that Artificial Intelligence has a wide range of applications in agriculture, there is still a lack of familiarity with high-tech machine learning solutions at most farms throughout the world. Farming is highly exposed to environmental elements such as weather, soil conditions, and the existence of pests. Though spatial data can be easily acquired in the case of huge agricultural area, temporal data is difficult to come by. Most crop-specific data, for example, can only be gathered once a year, when the crops are growing. Because data infrastructure takes time to grow, it takes a long time to develop a reliable machine learning model. This is one of the reasons AI is more commonly used in agronomic items like seeds, fertilizer, insecticides, and other agronomic products mostly by in in-field precision solutions.

Limitations

- Before large-scale agricultural AI implementation can be successful, the farm's data infrastructure will need to become more robust and IT-equipped.
- While AI is ideally suited for precision agriculture, it may be used more quickly for the creation of new seeds, fertilizers, or crop protection products. The issue isn't with AI deployment and development; it's with the lack of compatibility between the two environments when it comes to validation and testing.
- Machine learning and AI are still a long way from being able to forecast crucial agricultural outcomes solely based on machines' cognitive capacities.
- The issue with AI's success isn't that it doesn't function; it's that industry hasn't spent enough time recognizing that agriculture operates in a highly volatile environment.

Conclusion

AI technology assist farmers in analyzing land, soil, crop health, and other factors, saving time and allowing farmers to grow the optimum harvest for each season. AI-based forecasts allow for the recommendation of appropriate pesticides/crops/locations at the proper moment, prior to disease outbreaks on a big scale. There is a huge opportunity for the agriculture industry to leverage emerging technology of catboats for assisting farmers with all their queries and giving relevant advice and recommendations to their specific farm related problems, with a huge space still untouched in agriculture for the intrusion of automatic response systems. As a result, the AI market in agriculture is growing at a rapid pace.

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SOIL METAGENOMICS

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In terms of the microbial community, soil is arguably the most difficult of all natural environments for microbiologists. According to Paul *et* al. (1989), cultivated soil and grasslands have 2×10^9 prokaryotic cells per gram, and forest soil is thought to hold 4×10^7 bacterial cells per gram (Richter *et* al., 1995). Analyses may not have included genomes from rare and unrecovered species. These figures may be understated (Torsvik *et* al., 2002).It is considered that the high degree of spatial heterogeneity, multiphase nature and intricate chemical and biological features of soil habitats are responsible for the diversity of microorganisms found in soil samples.

Soil as a Microbial Habitat

The soil biota, organic molecules in varying states of decomposition and mineral particles with a range of forms, sizes and chemical properties make up soil. Prokaryotes are the most prevalent organisms in soil and can make up the majority of the biomass in soil (Hassink *et* al., 1993). Sand grains and clay-organic matter complexes are two examples of soil components where soil microorganisms frequently adhere or adsorb heavily. The surfaces of soil aggregates and the intricate pore spaces between and inside the aggregates are microhabitats for soil microorganisms (Foster *et* al., 1988). Due to size limits, some pore spaces are inaccessible to microorganisms. The makeup of soil microbial populations changes as a result. The availability of water and nutrients has a significant impact on the metabolism and viability of soil microorganisms.

Prokaryotes are a crucial part of the system that breaks down soil, which is a significant organic carbon storage area. Only small amounts of organic carbon are readily accessible to microbes, despite the high levels of organic matter found in most soil types. Through a mix of microbiological and abiotic processes, the majority of the organic matter derived from plants, animals, and microorganisms is converted into humus during this phase. The half-life of these stable organic matter complexes with respect to biological degradation is roughly 2,000 years. Humic compounds are stable and resistant to microbial decomposition processes. The scope of soil surveys must be broad in order to adequately document the microbiological diversity and the corresponding gene pool.

Why Metagenomics?

- Discovery of
  ✓novel natural products
  ✓new antibiotica
  ✓new molecules with new functions
  ✓new enzymes and bioactive molecules
  ✓diversity of life
  ✓interplay between human and microbes
  ✓how do microbial communities work and how stable are they
  ✓holistic view on biology

Soil Meta-genomics

Methods that depend on culture restrict analysis to microorganisms that can grow in a laboratory setting. Most people agree that only 0.1–1% (depending on by using a laboratory, microorganisms can be cultivated (depending on the environmental sample). Agricultural practises that underexploit 99% or more of the microbial diversity. Furthermore, bacteria can enter a state known as "viable" under environmental stress but unculturable," which further restricts these bacteria's exposure to conventional cultivation technique. As a result, microbial identification that depends on culturing risks underestimating microbial diversity. In order to analyse genomes that are similar but not identical in the environment, the term "metagenomics," which refers to the direct extraction of genetic material from the environment, was developed. Metagenomics may be used to describe the functions of environmental DNA through direct cloning for heterologous expression in a surrogate host organism or to target the structure of the metagenome through cloning and sequencing technologies. No sequence homology to previously defined genes or other a prior sequence information is necessary for the functional metagenomics method because it relies on the cloned ambient DNA's capacity to provide a phenotypic function to the host. Accordingly, functional metagenomics can be seen as a genuine discovery technique for locating and describing novel gene families, metabolic characteristics, bioactive substances or pathways from uncultured soil bacteria.

Metagenomics as a Tool for Sustainable Agriculture

The soil-dwelling micro-flora and micro-fauna are an essential component of soil biodiversity systems (SBS) and integrated nutrient management (INM) and they play a significant impact in plant growth and overall development. Chemical fertilisers and pesticides can have harmful impacts on the health of the soil and plants, which can have a negative impact on the ecosystem. A critical option for establishing sustainable agriculture output is beneficial microbial riches of agricultural value. Metagenomics improves in the prediction of microbial community structure and, as a result, can address and handle major scientific issues pertaining to microorganisms used in agriculture. By focusing on nif, this strategy has been effectively tested for the evaluation of the diazotrophs found in the rhizosphere of native red kidney beans (RKB) of the Western Indian Himalaya. This metagenomic study investigated the diversity and community structure of N_2-fxing bacteria in a Himalayan RKB rhizosphere, which can be investigated to serve as the foundation for additional research.To better understand community development, interspecies coordination and competition for vital nutrients, and the distribution of metabolic activities among community members, metagenome information for a rhizosphere is starting to reveal detailed information about associated community structure, dynamics, and functional activities. Also known as "rhizosphere engineering," functional metagenomics can be investigated to change the makeup of the rhizospheric microbial community and to readdress microbial activity.

Conclusions

Although, it is commonly recognised that microorganisms play a crucial role in the establishment and maintenance of plant ecosystems, the vast majority of the rhizosphere's population remains uncharacterised and unknown. The evaluation of community structure and function using a combination of conventional and cutting-edge metagenomic approaches will open up new perspectives on the microbial life in the soil. Identifying the signals, exudates, and important components of the rhizosphere's microbial community will also yield chemical and microbial markers that can be used to explain how plants attract and promote beneficial microbes. Additionally, soil metagenomics has the potential to increase agricultural output and unearth numerous as-yet-undiscovered soil microbes, their roles, and genes for a variety of applications. The most diverse microbial communities can be found on Earth in soil habitats. The genomic, metabolic, and phylogenetic diversity that is stored in the soil metagenome has so far only been partially explored by metagenomic techniques. The development of techniques that capture the heterogeneity and dynamism of complex soil microbial communities, both over time and space, represents one of the main difficulties for soil metagenomics. Although there has been significant progress in the characterisation of microbial communities by random sequencing, it is still necessary to enhance sequencing technology, lower the cost of sequencing, and develop bioinformatics tools for analysing the massive amount of data collected.

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STRESS BREEDING FOR CLIMATE CHANGE

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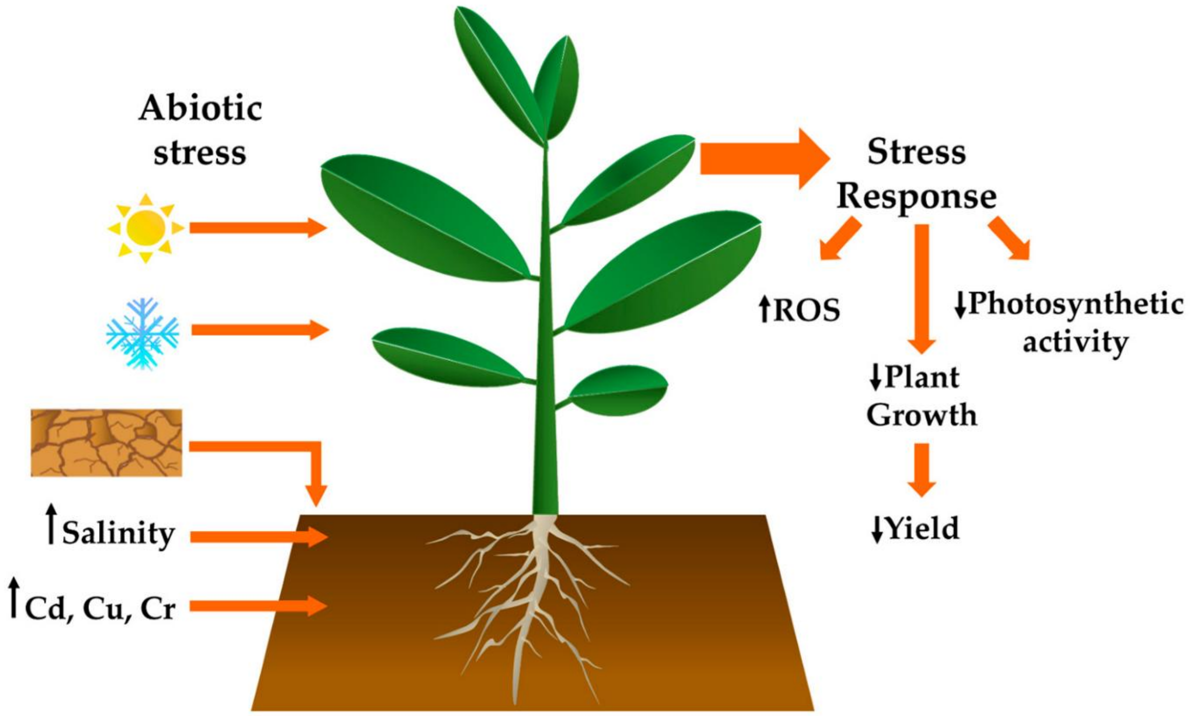
Stress Breeding is a term used to describe a process of plant breeding that involves exposing plants to stressful conditions in order to select for traits that enhance their ability to survive and thrive under those conditions. With climate change posing significant challenges to agricultural productivity and food security, stress breeding has become an increasingly important tool for developing crop varieties that can tolerate drought, extreme temperatures, and other environmental stresses.



(Source: Godoy *et al.*,2021)

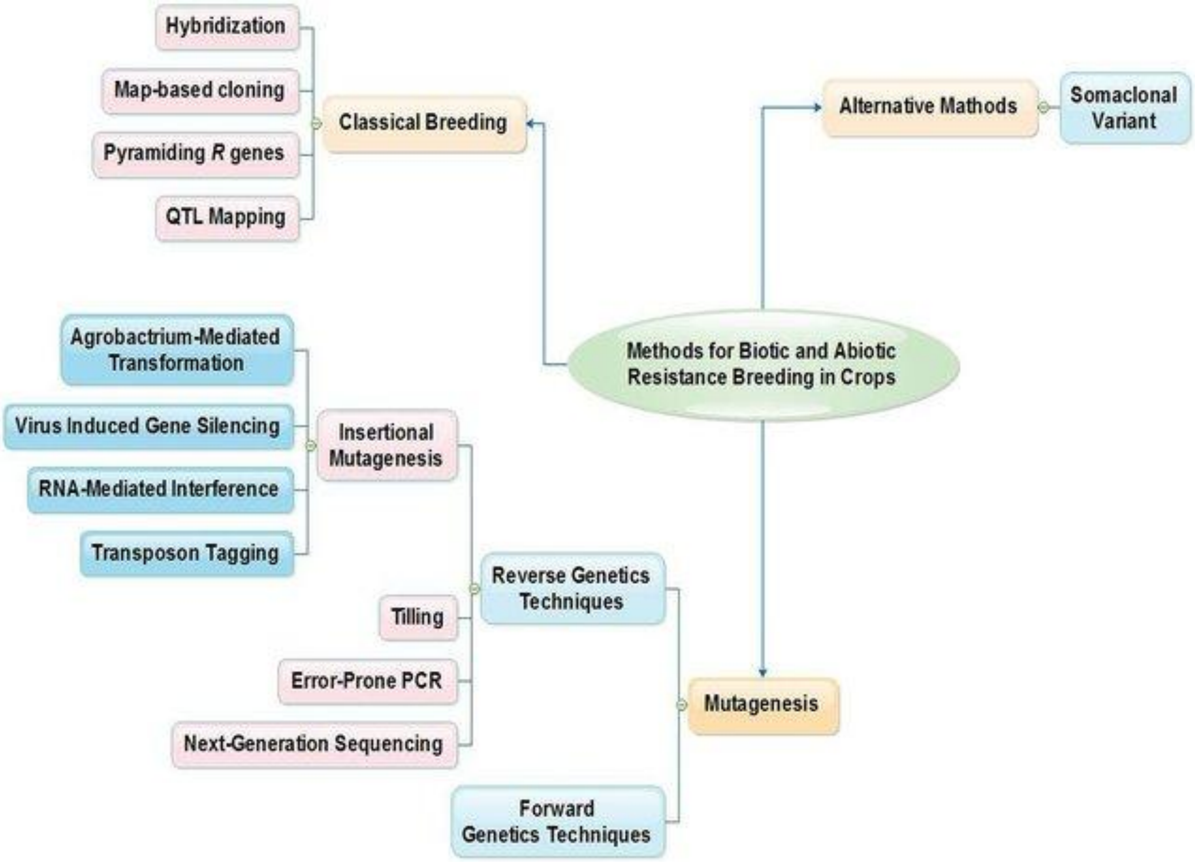
Stress breeding involves subjecting plants to different kinds of stress, such as drought, high temperature, or high salinity, and selecting the plants that perform best under those conditions. This process is repeated over several generations, with the goal of producing plants that have inherited the genetic traits that make them better adapted to those stresses.

Stress breeding can be done using traditional breeding methods, such as cross-breeding and selection, or through genetic engineering techniques that allow for more precise manipulation of plant genomes. In either case, the goal is to develop crops that can maintain high yields even in the face of challenging environmental conditions.

Some of the Commonly Used Breeding Methods for Abiotic Stress Include

1. **Conventional breeding:** This method involves crossing two or more plants with desirable traits to produce offspring that exhibit the desired traits. This method can be time-consuming and may require several generations to produce plants with the desired traits.
2. **Marker-assisted selection:** This method involves selecting plants based on specific genetic markers associated with the desired trait. This method allows for more precise selection and can reduce the time and resources needed for conventional breeding.
3. **Genomic selection:** This method involves using genomic data to predict the performance of offspring and select plants with the desired traits. This method can be useful for selecting plants with complex traits and can reduce the time needed for conventional breeding.
4. **Mutagenesis:** This method involves inducing mutations in the plant's genome using chemicals, radiation, or other methods. Mutagenesis can create novel genetic variation and can be used to select plants with improved abiotic stress tolerance.
5. **Genetic engineering:** This method involves introducing genes from other organisms into the plant's genome to confer desirable traits. Genetic engineering can be used to introduce genes that improve abiotic stress tolerance, such as genes for drought tolerance or salt tolerance.
6. **Recombinant DNA technology:** This method involves creating new combinations of genes by combining fragments of DNA from different sources. Recombinant DNA technology can be used to create new genetic variations that confer improved abiotic stress tolerance.
7. **Polyploidy breeding:** This method involves increasing the number of chromosomes in the plant's genome to create new genetic variation. Polyploidy breeding can be used

to select plants with improved abiotic stress tolerance, as polyploid plants often exhibit greater genetic diversity and higher tolerance to stress.



(Source: Ashkani *et al.*,2015)

Major Challenges Associated With Abiotic stress Breeding

Breeding for abiotic stress tolerance is a complex and challenging process that involves identifying, selecting, and developing plant varieties that can thrive under challenging environmental conditions, such as drought, salinity, extreme temperatures, and nutrient deficiency. Here are some of the major challenges associated with abiotic stress breeding:

- Complexity of abiotic stress: Abiotic stress is a complex phenomenon that can be caused by a range of environmental factors. Therefore, it is difficult to identify the specific genes or mechanisms that are responsible for conferring tolerance to a particular stress.
- Lack of genetic diversity: Many crops have narrow genetic diversity, which makes it difficult to breed for abiotic stress tolerance. This can limit the availability of useful traits to improve the crops' resilience to environmental stresses.

- Difficulty in phenotyping: Phenotyping plants for abiotic stress tolerance can be challenging, as it often requires growing plants under controlled conditions that mimic the environmental stress. This can be time-consuming and expensive, and it may also require specialized equipment and expertise.
- Time-consuming and costly: Developing abiotic stress-tolerant plant varieties is a time-consuming and expensive process. It can take many years to identify, select, and breed plants that are capable of withstanding challenging environmental conditions.
- Conflicting traits: Breeding for abiotic stress tolerance often requires trade-offs with other important traits, such as yield, quality, and disease resistance. This can make it difficult to balance the need for stress tolerance with the need for other desirable traits.
- Lack of effective screening methods: Screening large numbers of plants for abiotic stress tolerance can be a daunting task. There is a need for effective, high-throughput screening methods to identify plants with desirable traits quickly.
- Regulatory challenges: Developing new plant varieties can be challenging due to regulatory requirements for safety, efficacy, and environmental impact. These requirements can add time and cost to the development process.

Limitations

While stress breeding holds great promise for developing more resilient crops, there are also concerns about the potential negative impacts on biodiversity and ecological systems. Some experts have raised concerns that stress breeding could lead to the development of crop varieties that are highly specialized for specific environmental conditions, making them less adaptable to changing conditions in the future. Others worry that stress breeding could exacerbate existing inequalities by favouring large-scale agribusinesses that have the resources to invest in advanced breeding technologies.

Conclusion

Despite these concerns, stress breeding is likely to play an increasingly important role in the development of crops that can thrive in a changing climate. By selecting for traits that enhance stress tolerance and resilience, stress breeding offers a promising pathway for ensuring that food production can keep pace with growing demand while also mitigating the impacts of climate change.

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