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AGROCHEMICALS

Production, Consumption & their Impact

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From the Editor's Desk

Dear Readers,

The October issue of the **Times of Agriculture magazine** is going to be extremely important for you. In this issue, we have covered detailed article on the **Agrochemicals: Production, consumption, and their potential impact.** Agrochemicals are widely used in India as a significant input in farming, and many companies sell them under various names. With the increasing population in India, there is a continuous and extensive use of agrochemicals to boost production. While these chemicals do increase production, they also leave some adverse effects on crops, affecting the environment, soil, as well as human health. **India** is the **fourth largest producer** of agrochemicals in the world. In India, agrochemicals are primarily used in crops like cotton, rice, wheat and vegetables, with the main goal of increasing production.

Through ongoing research, it has been discovered that the continuous and indiscriminate use of agrochemicals is leading to the presence of toxic chemicals in fruits and vegetables, which can eventually pose serious health risks, including the development of life-threatening diseases like cancer in humans. Farmers are using these chemicals to increase crop production without adhering to specific dosage recommendations, impacting the **soil, environment, and human health.**

In this issue, we will discuss this topic in detail, and we hope you will enjoy reading it. If you have any suggestions or feedback, please feel free to send it to us via email. Your feedback motivates us to improve further.

Thank you and happy reading.....

Thank you!

Dr. Devraj Singh
Editor-In-Chief

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Previous Issues

Agriculture Updates

Northeast's Mithun Gets 'Food Animal' Tag

The **Food Safety and Standards Authority of India (FSSAI)** has recently recognized the mithun as a **'Food Animal', opening doors for its commercial use.** The recognition of Mithun as a **'Food Animal'** and the **efforts to promote its meat as a commercial product can indeed have significant economic and cultural implications for the region.** Mithun is a captivating and culturally significant bovine species found in Northeast India.

Odisha Scientist Swati Nayak wins Norman Borlaug Field Award 2023

Fondly called **"Bihana Didi" (Seed Lady)** by local communities in Odisha, Indian agricultural scientist **Swati Nayak became the third Indian agriculture scientist to win the prestigious Norman Borlaug Field Award 2023.**

The Norman Borlaug Field Award 2023 is presented by the **World Food Prize Foundation** in memory of the Nobel awardee **Dr. Norman Borlaug, for outstanding achievements in international agriculture and food production by individuals under 40.**

UP Declares Gangetic Dolphin as State Aquatic Animal

Uttar Pradesh Chief Minister Yogi Adityanath has made a significant announcement regarding the **Gangetic Dolphin, designating it as the state's aquatic animal.** This move highlights the importance of conserving these unique creatures and preserving the purity of the rivers and ponds they inhabit.

Uttar Pradesh's decision to declare the Gangetic Dolphin as the state aquatic animal and the launch of the **"Meri Ganga Meri Dolphin 2023" campaign.**

“Kisan Rin Portal” launched

On 19th September, 2023, **India’s Finance Minister and Agriculture Minister launched the 'Kisan Rin Portal'.** This portal **aims to provide subsidized loans to farmers under the Kisan Credit Card (KCC) scheme, bringing a revolutionary change to the country's agriculture sector.**

The Kisan Rin digital platform **offers comprehensive insights into farmer data, scheme utilization progress, loan disbursement details, and interest subvention claims.**

India Launches Unified Portal for Agricultural Statistics (UPAg)

On 15th September, 2023, India introduced the **Unified Portal for Agricultural Statistics (UPAg), an innovative online platform developed by the Ministry of Agriculture and Farmers' Welfare (DA & FW),** marking a significant milestone in agricultural data management.

The UPAg Portal is envisioned as a public good, reducing search costs and enhancing access to reliable, detailed, and unbiased agricultural data.

Odisha Government Bans Use of Paraquat

The Odisha government banned **Paraquat**, a highly toxic substance used as an herbicide. The herbicide is used to control undesired plants on farms, in commercial forests, and on lawns and managed landscapes.

The decision has been taken in view of public safety and to prevent adverse impact of the chemical on human health and animals.

Rajouri's Chikri Wood Craft, Anantnag's Mushqbudji Rice Receive GI Tag

In a significant recognition of local craftsmanship and agricultural heritage, the Geographical Indication (GI) Tags have been bestowed upon **Rajouri Chikri Wood Craft from Rajouri district and the prized Mushqbudji Rice variety from Anantnag district of Jammu and Kashmir.**

These labels signify the unique nature and exceptional qualities of these products, tracing their origins to specific regions. This achievement is a result of a collaborative effort involving NABARD, the Department of Handicrafts & Handloom, and the Department of Agriculture.

AGROCHEMICALS

Production, Consumption, and Impact

About the Author

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Heavy use of toxic pesticides in agriculture worldwide has raised serious concerns about health issues. **The World Health Organization (WHO) estimates that acute pesticide poisoning (APP) affects 3 million people and accounts for 20,000 unintentional deaths per year, with 99 percent of these fatalities believed to be in developing countries.** Continuous use of agrochemicals against agricultural pest and disease vectors poses serious threats upon both human health and environment. In developing country, it is very difficult to find out the impact on human health or on the environment due to lack of awareness, training and adequate knowledge for using agrochemicals.

Agrochemicals exposure periods and levels, types of agrochemicals used (regarding toxicity and persistence), and various environmental condition of the areas are also factors for acute and chronic poisoning on human health and environment.

Agrochemicals are the various chemical products that are used in agriculture. In most cases, the term agrochemical refers to the **broad range of pesticide chemicals, including insecticide chemicals, herbicide chemicals, fungicide chemicals, and nematicides chemicals (chemicals used to kill round worms).** The term may also include synthetic fertilizers, hormones, and other chemical growth agents, as well as concentrated stores of raw animal manure.

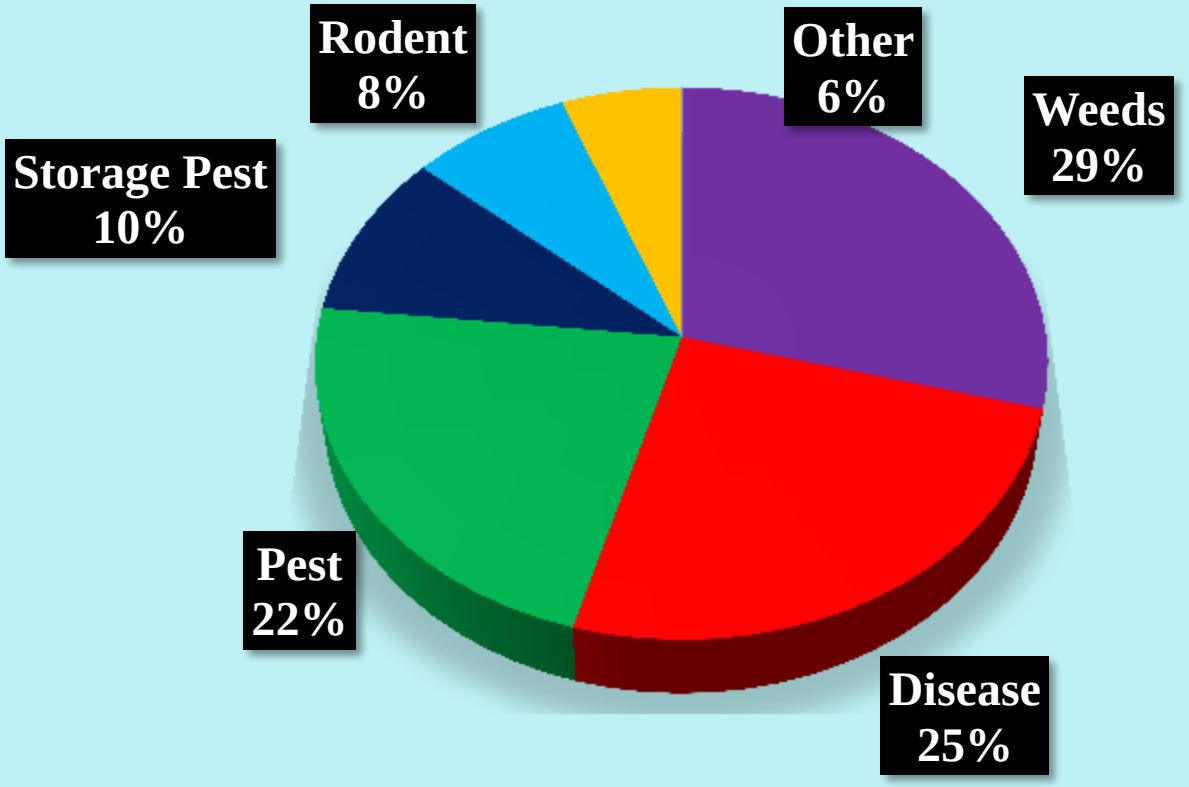
Key highlights of the Global Agrochemicals Industry

- Growing demand for food supply due to the rapid growth in the human population has triggered agricultural intensification during the last few decades
- While North America is the fastest growing market, **Asia Pacific is the largest market of agrochemicals**
- The industry highly competitive market with the presence of several multinational companies.
- The Agrochemicals Industry is valued at around **USD 208.6 Bn (2020)** and is projected to reach USD 246.1 Bn in 2025 growing at a CAGR of 3.4%

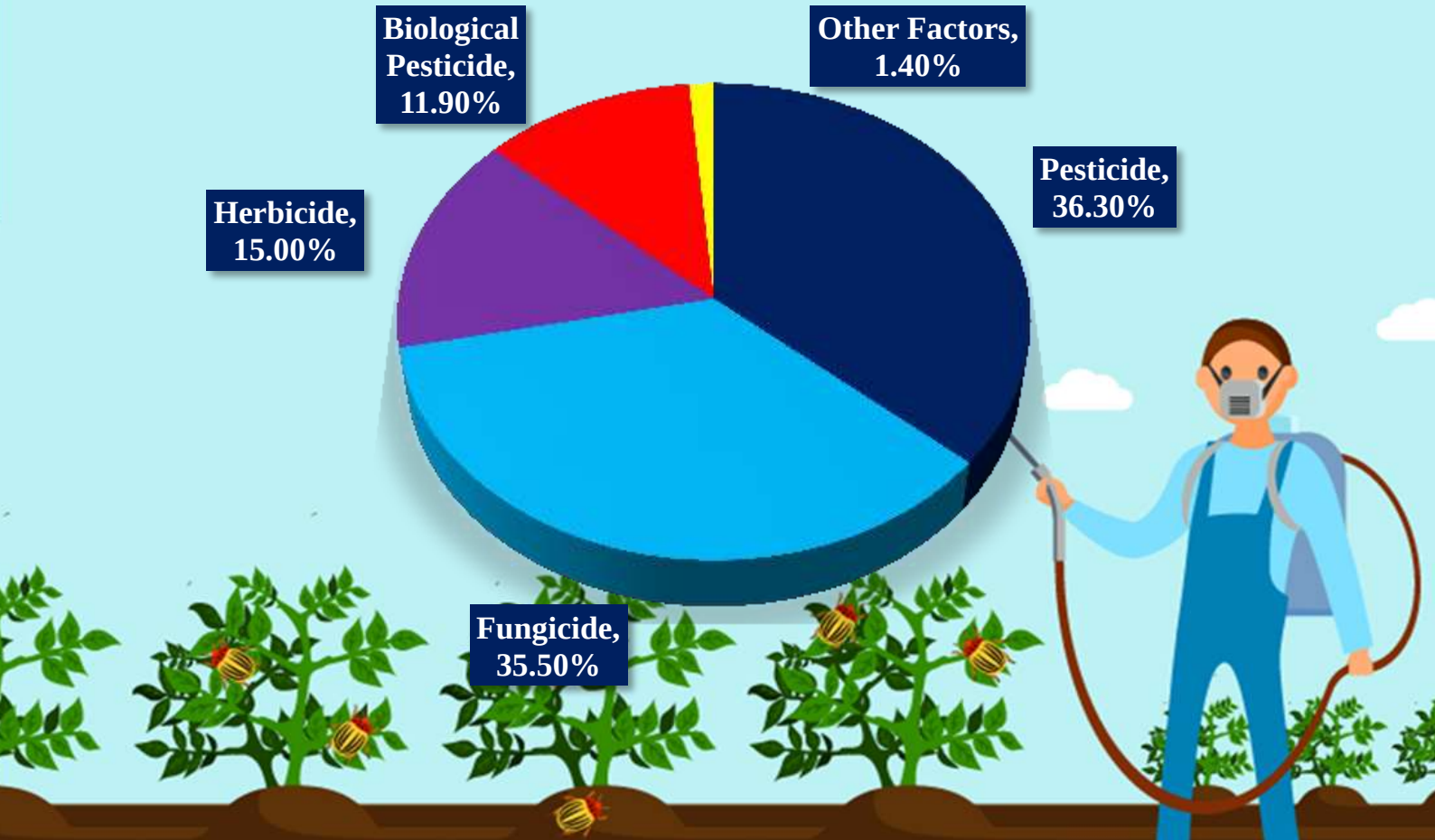
An Overview of Indian Agrochemicals Industry

- Indian Agrochemicals Industry was valued at around **Rs. 42,000 Crore (~6 Billion USD) in 2019-20 and is expected to grow at a CAGR of around 8% till 2025**
- Indian is the fifth largest producer and the fourth largest exporter of agrochemicals
- Inadequate use of agrochemicals can lead to **~25-30% yield losses** in medium to long term.
- Scientific, timely and sustainable use of agrochemicals is essential to ensure food security and enhance farmer income.

Damage caused by various Sources



Percentage of Various Agrochemical Usage in India



Source: Statistical database, Directorate of Plant Protection, Quarantine and Storage.

An Overview of Agrochemicals Manufacturing in India

- **India is 4th largest producer of agrochemicals globally,** and **50% of the growth** witnessed by the agrochemical companies in India (in last 5-6 years) has been driven by exports
- **India is net exporter of agrochemicals (13th largest) & exports stood at USD 1.8 Bn. in 2018-19 compared to USD 510 Mn. in 2010-11**
- **India has emerged as the fifth largest producer and the fourth largest exporter of agrochemicals after the United States, Japan, and China.**
- **India has the potential to become *"The Global Manufacturing Hub"* for agrochemicals** due to a number of favourable factors such as low manufacturing cost driven by availability of labor and tax benefits, technically trained manpower, underutilised production capacity, seasonal domestic demand, and low usage etc.

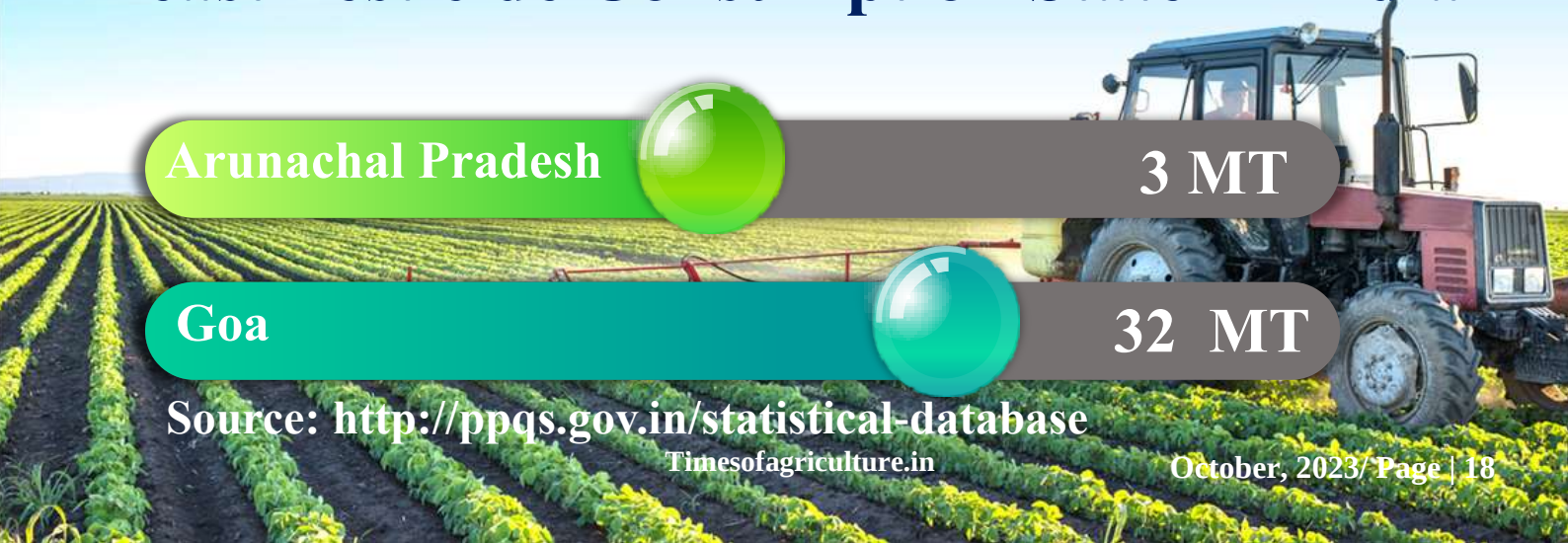
Top pesticide consumption states in India -54,140 MT

Source: http://ppqs.gov.in/statistical-database

Agricultural chemicals play a crucial role in farming practices, aiming to enhance production and safeguard crops. In India, there are **248 registered pesticides and 59 combination products for agricultural use. Among these, 63 are pesticides, 40 are fungicides, and 7 are growth regulators specifically registered for crop protection in vegetables. On average, India uses 381 grams of active substances per hectare for pesticides, which is lower than the global average of 500 grams per hectare.** In **vegetable farming, around 13-14% of pesticides and fungicides** are applied, with the highest use of active substances occurring in chili at 5.13 grams per hectare, followed by eggplant at 4.6 grams per hectare.

Crop damage in the country due to various diseases and pests ranges from 10 to 30 percent. The economic losses resulting from such damage can be mitigated through the proper use of pesticides and fungicides. However, it is imperative for farmers to have a thorough understanding of the right selection, dosage, and application methods for these chemicals. Unfortunately, a lack of adequate knowledge and indiscriminate use is not only detrimental to the environment but also poses health risks to humans.

Least Pesticide Consumption State In India



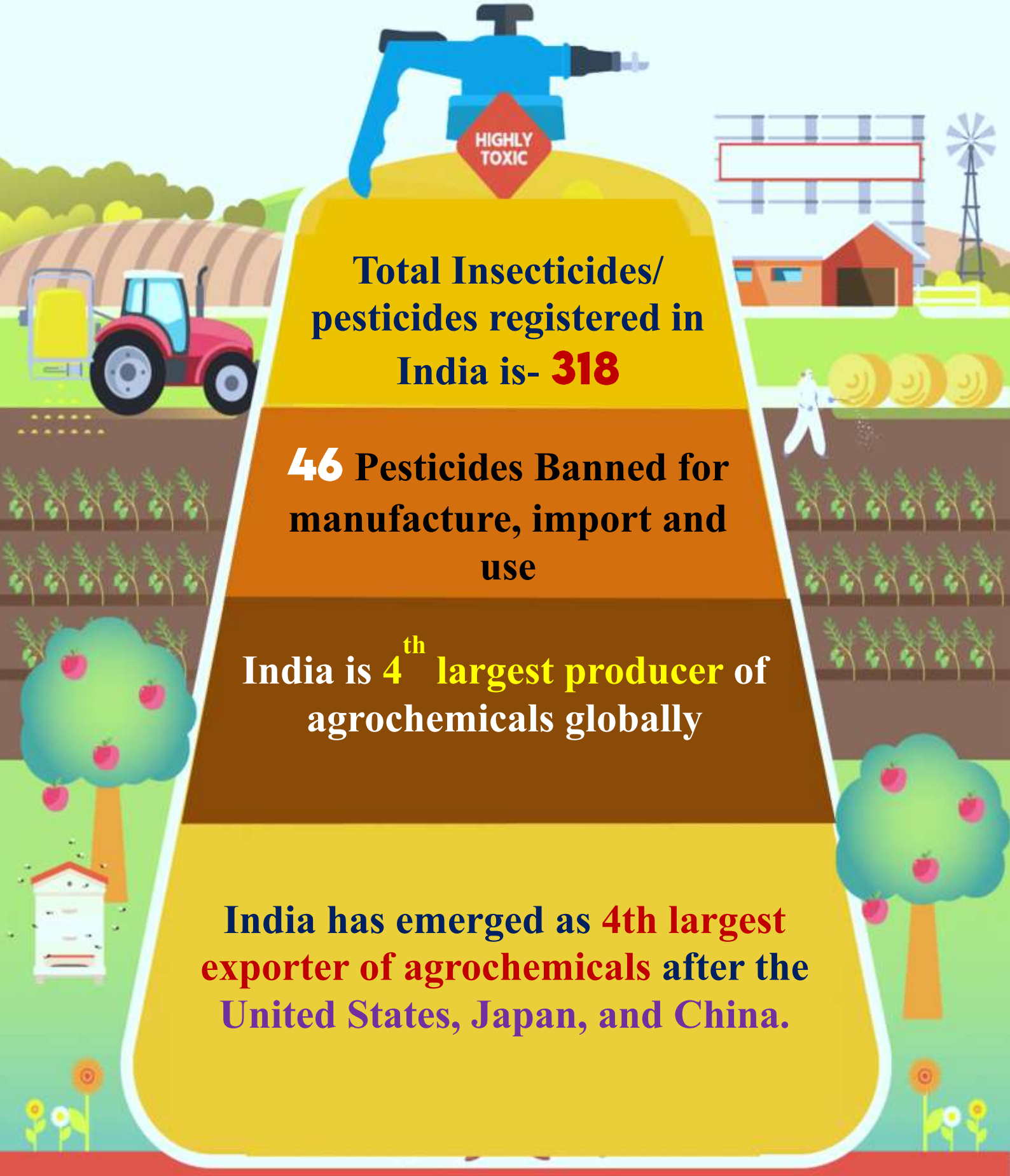
Source: http://ppqs.gov.in/statistical-database

The continued use of agricultural chemicals has had a profound impact on the environment, soil quality, and human health. As the saying goes, **"Necessity is the mother of invention."** The inception and success of the Green Revolution were primarily rooted in two key factors: the development of high-yielding seeds and the widespread use of agricultural chemicals. Consequently, the nation achieved self-sufficiency in food production.

However, indiscriminate usage poses a significant challenge to human well-being, soil health, and the environment. According to government data, alarmingly high levels of pesticides have been detected in various regions of the country, affecting vegetables, fruits, and other food products. **The most alarming fact is that out of the 234 pesticides in India, 24 have been identified as carcinogenic.** The continued application of pesticide agents in vegetables and fruits is elevating their presence in the final produce, leading to the accumulation of these chemicals in the human body and resulting in diseases such as cancer.

According to the National Institute of Cancer Prevention and Research in Noida, people in the country are daily ingesting 0.5 milligrams of pesticides through their food. The Rajiv Gandhi Cancer Institute and Research Center affirms that, after tobacco, pesticides are emerging as the second-largest cause of cancer in the country.

#PesticidesFact



Source: http://ppqs.gov.in/statistical-database

Effect of Various Agrochemicals on Human health, Environments and Ecosystems

Effect on Ecosystems:

- In a survey conducted in West Bengal, India, these pesticides were present in fish body parts such as the gills, brain, liver, skin, and fish. Organochlorine and Organophosphate can be causative agents in changing feeding behavior and reproduction, leading to a reduced population of raptorial birds. The high toxicity of organochlorine, organophosphate insecticides can have an impact on the bird's mortality.

Effect on soil:

- Carbamate and organophosphate is very toxic to the earthworm population, hence shown to reduce the population of earthworms.

Effect on Water:

- When fertilizers and pesticides are being applied to the field, it first contaminates the soil and then the underground water, the water polluted is both hazardous. Nitrate is accumulated and concentrated in water can immobilize hemoglobin, and caused "**Blue baby syndrome".**
- Drinking water containing nitrate (the dissolved nitrogen) above **50 mg/NO3 −/L** leads to various serious conditions like blue-baby syndrome, goiter, heart diseases, gastric cancer, and also birth defects.

Effect on human health

- **Neurological effects of (OP) and (OC):** Various types of pesticides are involved in the neurological effects, among these, organophosphate (OP) and organochlorine insecticide groups are described well, and it is a neurotoxin. A characterization of OP and OC poisoning in 1–4 days is intermediate causes is muscle weakness, and fatal. When the exposure prolongs to 2–5 weeks, it induces delayed poly-neuropathy-symptoms involving sensory abnormalities, muscle cramps, weakness, and paralysis occur primarily in the legs, and these symptoms are due to the OP inhibition of neuropathy target esterase-neural enzyme this may be irreversible causes the consequences of axonal death.
- **Perkinsons disease:** Exposure to any kind of pesticides has increased the risk of Parkinson's, especially for people with farming as their occupation. Studies also indicate that the herbicide paraquat also leads to degeneration of neurons that are involved in Parkinson's disease.
- Fungicides including maneb and dithiocarbamate increases the risk of Parkinson in individuals
- **Alzheimer's disease: Dithiocarbamate** fungicides are more severe to this disease. The relationship between the pesticide and Alzheimer's is quite different because the loss of cholinergic neurons is the basic neurochemical defect in **Alzheimer's** to increase the cholinergic tone, it is occasionally treated with OP-cholinesterase inhibitors.

FEEDING A CONTINENT AGAINST THE ODDS:

Addressing Challenges in Africa's Agriculture Sector

*According to a study done by McKinsey **agriculture in Africa** has a massive social and economic footprint. More than 60 percent of sub-Saharan Africa's population is smallholder farmers. Agriculture is the backbone of the economy in many African countries and can empower young people.*

About the Author

Ruvarashe Chirimuta

Agriculture Storyteller

Zimbabwe

Dr. Akinwumi Adesina, President of the Africa Development Bank, made the following remarks in 2018 at the Public Lecture of the Food and Agriculture Organization **(FAO)** of the United Nations, held at the FAO Head Office, Rome, Italy: ***"The future of food in the world will depend on what Africa does with agriculture. I am sure you must be saying did I hear right? Yes, you did. Africa holds 65% of the uncultivated arable land left to feed 9 billion by 2050. Its' vast savannas are the world's largest agriculture frontier, estimated at 400 million ha. But only 10% of this is cultivated. That's a mere 40 million hectares."***

Africa has so much arable land available to feed its people and create wealth on an individual and national level. While the **continent accounts for over 60% of the world's arable land, it only contributes around 4% to total output**. As lucrative as the sector is, farmers face several pressing challenges. In this article, some of the challenges contributing to Africa's low agricultural output are highlighted.

Demand for agricultural land is high. Africa has a lot of arable land. Farmers in Africa face challenges accessing essential resources such as land. Uncertainties around land ownership and tenure make it difficult for aspiring farmers to obtain land and financing for farming.

Africa has communal and traditional land tenure systems. As a result, land rights are unclear in some cases. Banks and financial institutions may be reluctant to provide loans to purchase land with uncertainties around land tenure and collateral. As a result, farmers struggle to access financing for land acquisition and development. Policymakers are encouraged to make a multilateral effort to address issues around land tenure systems. **To help aspiring farmers on the continent get the necessary financing from lending institutions to purchase land and jumpstart their agriculture dream.**

The sector needs a makeover to appeal to Africa's young population. With a growing population and an increased need for food production, young people need to join the sector to ensure food security in Africa. **Agriculture in Africa is generally perceived negatively and is regarded as a low-income, labour-intensive, and unprofitable practice by many Africans. Why? Because subsistence farming is the most widely used method of agricultural farming in sub-Saharan Africa**. Subsistence farming is when a farmer, family, or group produces only enough to feed themselves. Farmers grow crops and raise livestock that are sufficient only for themselves, without surpluses for trade or financial profit. The continent needs to shift from subsistence farming to income-generating farming.

continent accounts for over 60% of the world's arable land, it only contributes around 4% to total output.

More than 60 percent of sub-Saharan Africa's population is smallholder farmers.

Only 6% of the continent's farmland is irrigated. As a result, crops in Africa rely on rain—despite irregular and insufficient rainfall and frequent drought.

Africa holds only 10% of cultivated land, which amounts to a mere 40 million hectares.

Poor infrastructure is also a challenge at present. The agricultural value chain includes agro inputs manufacturers and suppliers, crop production and livestock farming, product aggregators, sales and marketing, manufacturing, logistics, and transportation, agro-processing, packaging and value addition, consultancy, technology, security, research, education, e-commerce, finance, construction, and many others. Several value chain players work together for an agricultural product to move from the beginning of the value chain to the final consumer. Sadly in Africa, we still find infrastructure challenges such as inadequate transportation networks and poor road networks that affect the ability of farmers to easily access their farms and transport their produce to markets efficiently. Rural areas in Africa still **lack proper cold storage facilities and warehouse storage infrastructure.** Farmers struggle to store produce safely for extended periods and sell it to any buyer to avoid spoilage. **Electricity is a vital input in the agricultural value chain.** In agriculture, electricity runs irrigation equipment, machinery, and equipment, lights the farm, and maintains the life of livestock, poultry, and plants. It is also a requirement across the entire agricultural value chain to prevent food spoilage, heating and cooling of buildings, processing and manufacturing, and refrigeration to preserve products.

Access to affordable credit and financial services remains a challenge for farmers. Without financing, farmers struggle to invest in agribusinesses.

Big financial lending institutions often have lending requirements that smallholder farmers cannot meet. Other lenders are available but farmers may fail to pay them back and become trapped in debt due to high interest rates

Smallholder farmers in Africa rely heavily on rain-fed agriculture, which limits their farming ability throughout the year. **Affordable irrigation systems** suitable for smallholder farmers will fast-track agricultural development in Africa and improve food security. African farm systems also remain the least mechanized across all continents. **Climate change remains a long-term challenge.** Farmers have lost crops and livestock due to climate change, and some have plunged into debt due to not paying back farm loans.

Wealthy nations process their produce. Africa continues to sell agricultural produce largely unprocessed without value addition**.** **Dr. Akinwumi Adesina** illustrated the disadvantages of selling unprocessed materials when he said: *"While demand for raw commodities is elastic, demand for processed and value-added commodities is relatively inelastic. Cotton prices may decline, but rarely for textiles and garments. Cocoa prices may drop, but not chocolate prices. The price of coffee beans may decrease, but never the price of brewed specialty coffee at Starbucks."* For this reason, African countries need to promote and create favourable agro-processing policies.

Farmers also continue to face challenges accessing profitable markets for their produce. Price volatility, limited market infrastructure, and middlemen affect farmers' ability to sell produce at fair prices.

William Arthur Ward once said ***"Opportunities are like sunrises. If you wait too long, you miss them."*** **Africa's agriculture sector is full of opportunities waiting to be exploited. Now is the right time to invest in Africa and its agriculture sector. Addressing these challenges will require a multi-faceted approach that includes several stakeholders.**

Improving gender equality in the sector, investing in smallholder farmers, improving access to finance, funding rural infrastructure, promoting climate-smart agriculture, and value addition are all pressing issues. Although many challenges still exist some of which were not mentioned in this article several positive steps are being taken by governments, private stakeholders, and non-profit organizations to address challenges in the sector. Albert Einstein famously said, ***"In the middle of difficulty lies opportunity."*** These challenges present opportunities for investors to invest in the continent and build a profitable, prosperous, and successful agriculture sector in Africa.

The New Trend of
PLANT-BASED MEAT

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In this modern era, with new technologies and mechanisms flourishing in every sector including agriculture and the food sector, the trend of meat production and processing out of live animals via butchering has also changed. Earlier consumers were divided into two categories concerning their choice of diet- Vegetarian, and Non-Vegetarian. In past times, non-vegetarians got the liberty to feed on both meat and plant-based food items, while vegetarians, missed out on the dishes of conventionally obtained meat, its flavor, aroma, and overall eating experience. However, now this situation has changed for vegetarians who wish not only to get some nutritional benefits of meat, but also to savor its taste on their palate without the harm of any animal, by means of plant-based meat technology in the food sector.

In this modern era, with new technologies and mechanisms flourishing in every sector including agriculture and the food sector, the trend of meat production and processing out of live animals via butchering has also changed. Earlier consumers were divided into two categories concerning their choice of diet- Vegetarian, and Non-Vegetarian. In past times, non-vegetarians got the liberty to feed on both meat and plant-based food items, while vegetarians, missed out on the dishes of conventionally obtained meat, its flavor, aroma, and overall eating experience. However, now this situation has changed for vegetarians who wish not only to get some nutritional benefits of meat, but also to savor its taste on their palate without the harm of any animal, by means of plant-based meat technology in the food sector.

What is plant-based meat?

Plant-based meat is a food product that is obtained out of plant products (plant source), and not by slaughtering of live animals. This meat has nothing to do with animal cells and has plant cells instead because of its plant-based attribute, therefore this food product can be eaten as a meat substitute. It is nearly identical to conventionally obtained meat in terms of taste, appearance, aroma, and somewhat nutritional availability. Thus, eating plant-based meat gives the vibe of feeding on animal meat. This food is also called Fake Meat or Mock Meat. Vegetarian products and ingredients that can be used to produce meat replacements include- soy, potato starch, lentils and beans, coconut oil, nuts and seeds, seitan or wheat gluten, pea protein, or other vegan raw materials. Few examples of plant-based meat products are- vegan meat pie, tofu, sausages, burgers, tuna, vegetarian bacon, vegan chicken nuggets, vegetarian patties, kebabs, and steaks.

Production of plant-based meat-

Production of plant-based meat products involves three general steps- Crop development, ingredients optimization, and finally product formulation and manufacturing.

- To manufacture meat substitutes, suitable crops (e.g. soybean, wheat) are cultivated as a source of raw materials and main ingredients.

- Then the harvested crops are processed (mechanically and chemically) to only keep the wanted parts (e.g. protein, fats, and fiber parts), while discarding the unwanted crop parts.
- In the last step, the desired parts are formulated into the desired mixture by adding meat-like flavors and aroma, and then through different manufacturing processes, fibrous structure is induced in the mixture to form plant-based meat alternatives.

Two types of manufacturing schemes that can be utilized to form muscle-like fibrous texture are-top-down, and bottom-up scheme. The former causes the formation of fibrous structure using the extrusion technique on the ingredients, while the latter scheme targets on forming individual fibers and assembling them together to form the larger meat alternative (cultured meat). After getting the fibrous texture, various chemical processes like mallard reaction, lipid oxidation, thiamine breakdown, and other reactions, are used to facilitate the meat-like aroma and various natural flavorings are used for getting meat taste. Yeast extracts, fermented foods, and hydrolyzed vegetable proteins, when used with the main ingredients, can induce the above-mentioned reactions and create richer meat aroma and flavors.

Advantages of Plant-based meat products-

To begin with, various researches show that feeding on plant-based meat products is a healthier option than consuming real meat. This is because they have desirable and better nutritional components like lesser saturated, trans fat, cholesterol, overall calories, and more antioxidants, and fibrous content. This quality makes it better for consumption and overall health.

Plant-based meat, according to studies, may help in the prevention of various health-related problems like high blood pressure, obesity, hypertension, heart attack, diabetes, and other related issues. Consuming real meat on a regular or frequent basis increases the risk of various above-mentioned health problems, and thus fake meat can reduce this risk without the compromise of a tasty meal.

Moreover, fake meat is more environment friendly than conventionally obtained meat. The older ways of slaughtering animals to obtain meat can be replaced by this new technology of manufacturing meat-like food products from plant sources. This reduces the butchering of animals on a higher scale for meeting the meat market demand as well as overall greenhouse gas emissions (30-90% less than in the case of real meat).

Plant-based meat trend also serves as a boon for pure non-vegetarians who never get to taste meat-based dishes either because of their religious, and cultural beliefs or due to their personal will to stand against animal killing. With new meat-like in the market made out of pure vegetarian ingredients, this section of the society also gets the chance to experience mock meat-inclusive diet.

Not only does this new trend satisfy the pure vegetarians, but also helps the non-vegetarians to easily switch to more vegan or herbivorous foods. Plant-based meat, therefore, can benefit consumers with both types of choices in food.

Disadvantages of Plant-based meat products-

One of the major demerits of fake meat can be the excessive processing of raw materials to form meat-like food items. This highly processed nature of fake meat with added sugar, refined oils, dextrose, or other such items can prove to be harmful to consumer's health. Mock meat manufacturers still have to find a way to make sure that their products are not highly processed.

Secondly, it might be difficult for lower or middle-class consumers to purchase this food category. Because of the high cost of production and processing, plant-based meat can be quite costly compared to the conventionally obtained meat in the market. This can be a problem for manufacturers in building fake meat's market and increasing its popularity. Due to the high price, consumers might not be able to include mock meat that frequently in their diet.

Plant-based meat products can contain higher amounts of sodium as compared to real meat. This can pose a risk to consumer's health.

Lack of nutrients can be another demerit of feeding on mock meat. Some research shows that plant-based meat, even after enough processing to make it similar to real animal-based meat, lacks some essential nutrients that are present in real meat.

Additionally, harmful chemicals can be found in plant-based meat products which can be added in small quantities to make them similar to real meat products in terms of taste, sense, appearance, and other factors. For instance, Titanium Dioxide, an additive to keep meat colour white, can be used to form fake white chicken.

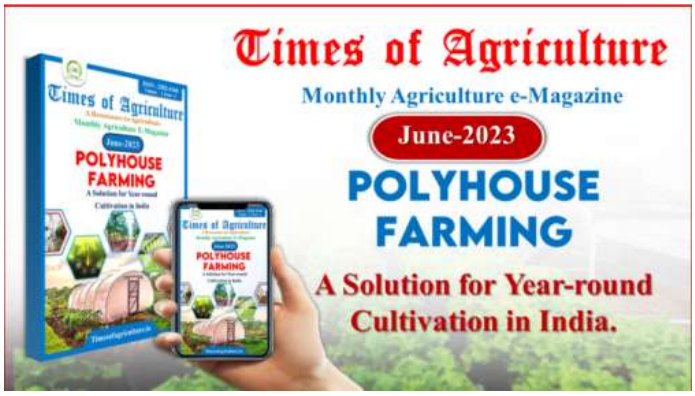
Conclusion

This innovative trend of fake meat comes with both its own merits and demerits which can either attract a huge proportion of masses or discourage them from opting for such meat products. The final call remains in the hands of consumers whether they welcome this technology or not. ■

Times of Agriculture

A Monthly Agriculture E-Magazine

Previous Issues



EMPOWERING INDIAN FARMERS

THE VITAL ROLE OF DIGITAL AND E-MARKETING IN AGRICULTURAL TRANSFORMATION

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Agriculture has been the backbone of India's economy for centuries, sustaining millions of livelihoods and providing the nation with a diverse range of food products. However, despite its significance, Indian farmers often grapple with numerous challenges, including low incomes, lack of access to information, and market inefficiencies. In this era of rapid digitalization, it's becoming increasingly clear that digital and e-marketing solutions are the need of the hour to uplift farmers economically and transform the agricultural landscape.

Digital marketing: A catalyst for farmer prosperity

Digital marketing encompasses a wide range of tools and strategies, including websites, mobile apps, social media, and e-commerce platforms, that facilitate the promotion and sale of products and services using digital channels. When applied to agriculture, it can revolutionize the way farmers connect with markets, access critical information, and improve their economic well-being.

Farmer empowerment through digital marketing

Farmer Producer Organizations (FPOs): A beacon of hope

Real-life examples illustrate the transformative power of digital marketing in Indian agriculture. Farmer Producer Organizations (FPOs) stand as beacons of hope, showcasing how technology can empower farmers economically.

Ninjacart, a Bengaluru-based startup, has harnessed digital marketing to connect farmers with retailers and restaurants through a tech-driven supply chain network. Farmers can now reach a broader market and secure fair prices for their produce. Similarly, DeHaat offers end-to-end solutions, linking farmers to buyers and allowing them to sell their products online. These platforms empower farmers to break free from

traditional middlemen and realize the full potential of their hard work.

Transparency, efficiency, and access to knowledge

The virtue of transparency

Transparency in the agricultural supply chain is another significant benefit of digital marketing. Platforms like Udaan are paving the way for consumers to trace the journey of their food from farm to table. This transparency fosters trust by allowing consumers to learn about farming practices and the origin of the produce. Ethical and sustainable sourcing becomes a reality, bolstering consumer confidence.

Ramalingappa Chhatragudi, a farmer from the rural Chaudapur village in Koppal district, Karnataka, has pioneered an innovative and profitable approach to agriculture that harnesses technology while eliminating middlemen. His success story centers around the use of QR codes, which provide consumers with comprehensive crop history information, including details such as the date of sowing and the application of organic fertilizers. This transparency has gained immense popularity and trust among consumers.

Rather than relying on traditional marketing methods, Ramalingappa has ingeniously integrated QR codes into his farming practices. Each papaya plant and fruit on his 15-acre farm is affixed with a QR code. When scanned, these QR codes reveal essential information about the product, such as its origins and the meticulous care taken during its cultivation, including sowing dates and the types and quantities of organic manure used. This level of transparency empowers consumers to make informed choices about the produce they wish to purchase.

What sets Ramalingappa's approach apart is his collaboration with the postal department for shipping products. When customers contact him via phone to place orders, they often make online payments through platforms like PhonePe and Google Pay. The produce is then shipped through the local post office, which serves as a reliable and efficient means of delivery. Notably, this innovative farming method has not only attracted customers from various parts of the state, including urban centers like Bengaluru and Hubballi, but it has also inspired other farmers to explore similar technological solutions, marking a welcome development in the agricultural sector.

Efficiency in supply chains

Efficiency in supply chains is paramount to reduce waste and ensure a consistent supply of fresh produce. Digital marketing platforms like BigHaat streamline the procurement of agricultural inputs, promoting efficiency throughout the supply chain. This not only benefits farmers but also guarantees consumers a steady and diverse supply of high-quality products.

Access to knowledge: An empowerment tool

Knowledge is power, and digital marketing is delivering this power directly to farmers' hands. Apps such as Krishi Jagran and the government's Kisan Suvidha app offer farmers access to valuable information, including weather forecasts, crop advisory services, and real-time market updates. This wealth of knowledge empowers farmers to make informed decisions, improve crop yields, and adapt to ever-changing market dynamics.

Financial inclusion and the promise of the future

Financial inclusion through digital payments

Financial inclusion is a critical aspect of empowering farmers economically. Digital payment platforms like Paytm and PhonePe are simplifying financial transactions for farmers, reducing their dependence on cash and promoting secure transactions with buyers. This not only enhances their financial stability but also ensures that they receive fair and timely payments for their products.

A bright future beckons

The amalgamation of digital marketing and agriculture in India holds the promise of a brighter future for farmers and consumers alike. It's not merely about economic empowerment; it's about transforming the way we cultivate, consume, and connect. As technology and tradition intertwine, the food on our plates gains a meaningful story to tell.

In this age of digital innovation, we must celebrate the profound transformation that empowers farmers and enriches the consumer experience. The time has come for digital and e-marketing to take center stage in Indian agriculture, bringing prosperity to the heartlands of our nation and securing a sustainable and thriving future for all.

Conclusion

Digital and e-marketing solutions are revolutionizing the agricultural landscape in India. They empower farmers economically by connecting them directly with markets, promoting transparency and efficiency, and providing access to valuable knowledge. The stories of real-life initiatives like FPOs, agritech startups and digital platforms demonstrate the tangible impact of digital marketing in transforming the lives of Indian farmers. As we embrace this digital revolution, we ensure not only the prosperity of our farmers but also the satisfaction of consumers who seek transparency and quality in their food. The future of Indian agriculture is digital, and it holds boundless promise for all stakeholders in the ecosystem.

■■■

FROM BLACKBOARD TO DIGITAL BOARD
A NEW ERA OF EDUCATION IN INDIA

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India has made significant strides in education in recent years, with a growing emphasis on quality and the use of technology. This is evident in the shift from blackboards to digital boards, which is taking place across the country. Digital boards offer a number of advantages over traditional blackboards. They are more engaging and interactive, and they can be used to display a wider range of content, including videos, images, and animations. This can help to improve student learning outcomes and make education more accessible to all.

A number of Indian states are leading the way in the adoption of digital boards. For example, the state of Gujarat has launched a program to provide all government schools with digital boards. The state of Karnataka has also made significant progress in this area, with over 70% of government schools now equipped with digital boards.

The Indian government is also supporting the adoption of digital boards through a number of schemes, such as the digital India initiative and the **Samagra Shiksha Scheme.** These schemes provide funding to schools to purchase digital boards and other educational technology.

The shift from blackboards to digital boards is a positive step for education in India. Digital boards offer a number of advantages over traditional blackboards, and they have the potential to improve student learning outcomes and make education more accessible to all.

Here are some examples of how digital boards are being used in Indian schools:

In the state of Gujarat, digital boards are being used to teach students about science and technology. Students are able to watch videos and animations of complex concepts, which help them to understand them better.

In the state of Karnataka, digital boards are being used to teach students about English and Hindi. Students are able to listen to stories and poems in these languages, and they can also practice speaking and writing.

In the state of Maharashtra, digital boards are being used to teach students about mathematics and science. Students are able to solve problems on the digital board, and they can also get feedback from their teacher in real time.

Government schemes of 2023 related to the shift to digital boards:

Digital India: The Digital India initiative is a flagship program of the Indian government that aims to transform India into a digitally empowered society. One of the key components of the Digital India initiative is the promotion of digital literacy and education. The initiative provides funding to schools to purchase digital boards and other educational technology.

Samagra Shiksha: The Samagra Shiksha scheme is a holistic scheme for school education that subsumes the erstwhile Sarva Shiksha Abhiyan (SSA) and Rashtriya Madhyamik Shiksha Abhiyan (RMSA). The scheme provides funding for a variety of educational initiatives, including the provision of digital boards to schools.

These government schemes are helping to accelerate the adoption of digital boards in schools across India. As a result, more and more students are benefiting from the advantages that digital boards offer. The shift from blackboards to digital boards is a welcome development for education in India. Digital boards have the potential to improve student learning outcomes and make education more accessible to all. With the support of the government and other stakeholders, the shift to digital boards is likely to continue in the years to come.

In addition to the benefits listed above, digital boards can also be used to:

Encourage collaborative learning: Digital boards allow students to work together on projects and assignments, and to share their work with the class.

Promote creativity: Digital boards can be used to create presentations, videos, and other creative projects.

Develop critical thinking skills: Digital boards can be used to access and analyse information from a variety of sources, and to develop and test hypotheses.

The future of education in India is digital. As more and more schools adopt digital boards, students will be better prepared for the challenges and opportunities of the 21st century. The government's recent budget announcement has signaled a shift in education policy, with an emphasis on quality and the use of technology. In addition, the government plans to develop a district-wise strategy for improving quality, based on the NAS results. This, along with enhanced teacher education and training, is expected to contribute to the improvement of quality in education.

Other notable mentions in the budget include the setting up of residential schools in tribal areas on the lines of the Navodaya Vidyalayas and investing in innovation and research by taking the funding up to Rs. 100 crore.

Overall, the government's budget announcement is a positive step towards improving the quality of education in India. The emphasis on technology and holistic education is particularly welcome. It remains to be seen how these announcements will be implemented, but they provide a promising roadmap for the future of education in India.

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REVOLUTIONIZING AGRICULTURE

HOW ROBOTICS IS TRANSFORMING FARMING

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Farming, one of the oldest professions in human history, is undergoing a remarkable transformation thanks to the integration of cutting-edge technology. Agricultural robotics, once a futuristic concept, is now a reality that promises to reshape the way we produce food. In this article, we will explore the fascinating world of agricultural robotics and how it is revolutionizing the agriculture industry.

The Growing Need for Agricultural Innovation

As the global population continues to expand, the pressure on agriculture to feed the world is increasing exponentially. To meet this challenge, farmers are turning to technology, and robots are playing a pivotal role in this transformation.

1. Precision farming

Agricultural robots are designed to perform tasks with exceptional precision. For example, they can plant seeds, apply fertilizers, and even harvest crops with minimal waste. This precision farming not only maximizes yields but also reduces the need for

Precision farming

Labor shortages

Sustainable agriculture

harmful chemicals and minimizes the environmental impact of agriculture.

2. Labor shortages

One of the most significant challenges facing the agriculture industry today is the shortage of labor. With fewer people willing to work in agriculture, robots are stepping in to fill the gap. They can work tirelessly around the clock, reducing the reliance on human labor and increasing overall productivity.

3. Sustainable agriculture

Agricultural robots are environmentally friendly. By accurately applying resources like water, fertilizer, and pesticides only where needed, they help reduce waste and minimize the negative effects of agriculture on the environment. This sustainable approach is critical in the face of climate change and growing concerns about food security.

Types of agricultural robots

Agricultural robots come in various shapes and sizes, each designed for specific tasks:

1. Harvesting robots: These robots can pick fruits and vegetables with unmatched speed and accuracy. They reduce crop damage and minimize the need for human pickers.

2. Autonomous tractors: These driverless vehicles can plow, sow, and cultivate fields with precision, following predetermined paths while making real-time adjustments for optimal planting.

Harvesting & Autonomous Tractors

Drone Technology

Weed Control Robots

3. Weed control robots: These robots use computer vision and artificial intelligence to identify and eliminate weeds, reducing the need for herbicides.

4. Drone technology: Drones equipped with sensors can monitor crops, assess plant health, and even deliver targeted treatments to specific areas of a field.

Challenges and future prospects

While agricultural robotics offers immense promise, there are still challenges to overcome. High initial costs and the need for specialized training are barriers for many farmers. Additionally, there are concerns about job displacement in rural communities as automation takes over.

However, the future of agricultural robotics looks bright. As technology advances, costs are likely to decrease, making these innovations more accessible to farmers of all sizes. Moreover, the data collected by robots can help farmers make data-driven decisions to optimize their operations further.

Conclusion

Agricultural robotics is transforming the way we farm, making it more efficient, sustainable, and productive. These innovative machines are not replacing farmers but rather empowering them to feed a growing world population while reducing environmental impacts. As we look to the future, the fusion of technology and agriculture will play a crucial role in addressing some of the most pressing challenges of our time. The era of smart farming is upon us, and it is an exciting time for the world of agriculture.

■■■

PRECISION AGRICULTURE

ENHANCING CROP YIELDS AND MINIMIZING AGRICULTURAL WASTE

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The goal of precision agriculture, sometimes referred to as precision farming or site-specific crop management, is to boost crop yields and decrease waste by utilizing data,analytics, and cutting-edge technologies to optimize farming practices. Farmers now have access to a potent tool that can help them run their enterprises more profitably, sustainably, and efficiently. We shall examine precision agriculture's function in boosting agricultural yields and decreasing waste in this post.

What is precision agriculture?

Precision agriculture is a technology-driven approach to farming that uses data, analytics, and advanced technologies to optimize farming

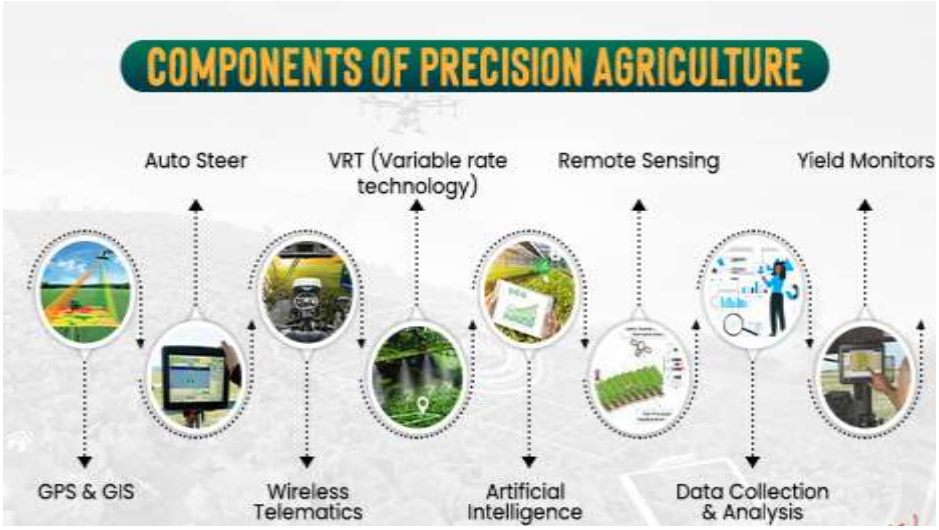
practices. The goal of precision agriculture is to maximize crop yields and reduce waste by using precise, site-specific information about soil conditions, weather patterns, crop growth, and other factors to make informed decisions about planting, fertilizing, watering, and harvesting crops.

Many different technologies, including as global positioning system (GPS), remote sensing, drones, machine learning, and big data analytics, are used in precision agriculture. These technologies allow farmers to collect information on a variety of elements, such as soil moisture, nutrient levels, temperature, humidity, and insect and disease outbreaks that affect crop growth and productivity. Farmers may optimize their use of resources and reduce waste by using this data to develop site-specific management strategies.

How does precision agriculture work?

Precision agriculture relies on a number of technologies and techniques to gather and analyze data about soil conditions, crop growth, and other factors that affect crop productivity. Here are some of the key components of a precision agriculture system:

1. **GPS and GIS mapping:** To map and analyze the spatial variability of soil and crop conditions across a farm, GPS and geographic information systems (GIS) are utilized. Precision farming techniques and site-specific management plans can be formulated using this information.
2. **Remote sensing:** Information on crop growth, soil moisture, and other environmental elements that affect crop yield is gathered using remote sensing technology, such as satellite imaging and aerial drones. To determine which parts of the farm need more or less water, fertilizer, or other inputs, this data can beused.
3. **Variable rate technology:** Using VRT, farmers can apply inputs like fertilizer and insecticides at different rates over a field depending on site-specific conditions. By applying inputs only where they are required rather than uniformly throughout the entire field, VRT can reduce waste.
4. **Data analytics:** Big data analytics and machine learning algorithms are used to analyze data gathered from sensors, drones, and other sources to identify patterns and make predictions about crop growth and productivity. This information can be used to optimize management decisions and improve crop yields.



Benefits of precision agriculture

Precision agriculture offers a number of benefits to farmers, including:

1. **Increased crop yields:** By optimizing inputs such as water, fertilizer, and pesticides, precision agriculture can increase crop yields and improve cropquality.
2. **Reduced waste:** Precision agriculture can reduce waste by minimizing the use of inputs that are not needed, such as water and fertilizer, and by reducing losses due to pests and diseases.
3. **Improved efficiency:** Precision agriculture can improve farm efficiency by reducing labor costs, optimizing the use of equipment, and improving the timing of management practices.
4. **Environmental sustainability:** Precision agriculture can reduce the environmental impact of farming by minimizing the use of inputs that can harm the environment, such as fertilizers and pesticides, and by reducing soil erosion and runoff.
5. **Economic benefits:** Precision agriculture can improve farm profitability by increasing yields and reducing waste, while also reducing the cost of inputs and improving the efficiency of farming operations.

Challenges of precision agriculture

Despite its many benefits, precision agriculture also faces a number of challenges, including:

1. **High cost:** The cost of implementing precision agriculture technologies can be prohibitively high for many farmers, particularly small-scale and resource- limited farmers in developing countries.
2. **Technical expertise:** Precision agriculture requires technical expertise in data analysis, GIS mapping, and the use of advanced technologies, which can be a barrier to adoption for some farmers.
3. **Data management:** Precision agriculture generates large amounts of data, which can be difficult to manage and analyze without the proper tools and resources.
4. **Connectivity:** Precision agriculture relies on high-speed internet and cellular networks to transmit data and control equipment, which can be a challenge in rural areas with limited connectivity.
5. **Privacy and security:** Precision

agriculture involves the collection and storage of sensitive data, such as cropyields and soil conditions, which must be protected from unauthorized access and use.

Despite these challenges, precision agriculture has the potential to transform agriculture by increasing crop yields, reducing waste, and improving environmental sustainability. With the continued development of new technologies and the adoption of best practices, precision agriculture is poised to become an increasingly important tool for farmers around the world.

Examples of precision agriculture in action

Precision agriculture is already being used in a variety of settings around the world. Here are a few examples of how precision agriculture is being used to increase crop yields and reduce waste:

1. **Digital green:** Digital Green is an Indian non-profit organization that uses video- based extension services to provide farmers with information on best practices in crop management. The organization has used precision agriculture technologies, such as soil sensors and GPS mapping, to help farmers optimize their use of water and fertilizer and increase their crop yields.
2. **The climate corporation:** The Climate Corporation is a US-based company that uses big data analytics and machine learning algorithms to provide farmers with real-time information on weather conditions and soil moisture levels. The company's precision agriculture tools enable farmers to optimize their use of resources and improve their crop yields.
3. **CABI:** The Centre for Agriculture and Bio science International (CABI) is a UK-based organization that provides farmers in developing countries with information on best practices in crop management. CABI has used precision agriculture technologies, such as GPS mapping and remote sensing, to help farmers improve their soil health and increase their crop yields.

Conclusion

Precision agriculture is a powerful approach for increasing crop yields, reducing waste, and improving the sustainability of agriculture. By using data, analytics and advanced technologies to optimize farming practices, farmers can maximize their use of resources and minimize their impact on the environment. Despite the challenges of implementing precision agriculture, the potential benefits make it a promising area of innovation in agriculture. As more farmers adopt precision agriculture practices and new technologies continue to be developed, we can expect to see significant improvements in the efficiency, sustainability, and profitability of agriculture around the world.

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GREENING THE CITYSCAPE
A REVOLUTION IN URBAN FARMING

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In an age where cities are expanding at an unprecedented rate and the global population continues to surge, Urban farming appears as a ray of light, providing solutions to some of our most pressing challenges. Urban farming is revolutionizing the way we engage with our urban environments, from barren lots turned into vibrant community gardens to the lush vegetation covering skyscraper rooftops.

As our cities grow vertically and horizontally, green spaces are shrinking. Urban sprawl often comes at the cost of agricultural land, leading to longer food supply chains and increased environmental pollution. This is where urban farming steps in to bridge the gap. This article explores the world of urban farming, its significance, benefits, and the promising future it holds.

Benefits of urban farming:

1. **Local food production:** Urban farming enables cities to produce a significant portion of their own food, reducing the need for long-distance transportation and mitigating carbon emissions. Fresher, healthier produce is now within arm's reach.
2. **Sustainable agriculture:** By incorporating innovative techniques such as vertical farming, hydroponics, and aquaponics, urban farming minimizes water usage, eliminates the need for harmful pesticides, and optimizes resource utilization.
3. **Community building:** Community gardens and urban farms are more than just sources of nourishment; they serve as hubs for social interaction, education, and empowerment. Neighbours come together, learn from each other, and cultivate a sense of belonging.
4. **Biodiversity and green spaces:** Urban farms act as green lungs in the heart of cities. They attract pollinators, provide habitat for wildlife, and combat the urban heat island effect.
5. **Food security:** Urban farming enhances food security by reducing cities' dependence on external sources of food. It empowers communities to have more control over their food supply, which is especially crucial during times of crisis.

Innovations in urban farming:

1. Rooftop gardens: The sky is the limit when it comes to utilizing rooftop spaces for farming. From herbs to fruits and vegetables, urban farmers are scaling new heights to make the most of available real estate.

2. Container farms: Shipping containers are repurposed into self-contained mini-farms, making it possible to grow crops year-round in a controlled environment.

3. Vertical farming: High-rise buildings are being transformed into vertical farms, where crops are grown in stacked layers with precise control over light, temperature, and nutrients.

4. Aquaponics: This sustainable system combines aquaculture (fish farming) and hydroponics (soilless plant cultivation), creating a mutually beneficial ecosystem where fish waste fertilizes the plants, and the plants purify the water for the fish.

Disadvantages of urban farming:

1. **Limited space:** Urban areas often have limited space available for agriculture. Finding suitable land or space for farming can be a significant challenge, especially in densely populated cities.
2. **Land contamination:** In many urban areas, the soil may be contaminated with pollutants, heavy metals, or other harmful substances. This can make it unsafe to grow food without remediation, which can be costly and time-consuming.
3. **Water availability:** Access to clean and reliable water sources can be a challenge in urban farming. Water scarcity and the cost of irrigation systems can make urban farming less economically viable.
4. **Pest and disease management:** Urban environments can provide a breeding ground for pests and diseases, which can be more challenging to control in close proximity to other buildings and people.
5. **Noise and pollution:** Urban farming locations may be exposed to noise pollution and air pollution, which can affect plant growth and the quality of produce.
6. **High start-up costs:** Setting up an urban farm, especially in a city with high land and property prices, can be expensive. Costs for infrastructure, soil improvement, and equipment can be prohibitive for some potential urban farmers.

Major urban farming crops

Major crops of urban farming are: Avocados, Strawberries, Carrots, Tomatoes, Cucumbers, Peppers, Green beans, leafy greens salad vegetables, Garlic greens, Peas, Jalapeno, peppers, Radishes, Strawberries, Herbs and many more.

How to start urban farming:

1. Choose your farm location, to practice urban farming your main

task is to find a place or choose your location of farming

2. Fertility of the soil. It might be challenging to locate fertile soil in densely populated places. You'll likely have to convert hard soil into rich, black humus unless you're moving your farm to the rooftop. This can require clearing away overgrown vegetation, ripping out old concrete from an abandoned lot, or getting rid of any detritus past owners left behind.
3. Choose your crop consider your temperature, how much sunlight your plot receives, and the needs of your neighborhood when deciding what to cultivate. The kind of plants you can cultivate mostly relies on the quantity of room you have. However, it's preferable to start small by only planting a few crops. Always remember to grow during the following growing season.

Conclusions

1. Urban horticulture has positive effects on social, economic, food, and ecological sustainability within cities.
2. It increases community livelihood, saves energy, sustains the environment, and improves health through fresh food supplies in urban environments.
3. It also offers recreational and aesthetic value to urban landscapes and individual homeowners. During the pandemic conditions of COVID-19, it offers a more consistent food supply, prevents markets disruptions, increases food scarcity, and helps with stabilizing food prices.
4. In addition, urban horticulture can help people become physically stronger and spiritually enriched; it can be considered a key component to promoting public health. However, there remains unexploited potential for urban green infrastructures for vegetable and fruit gardening, which needs to be explored and integrated into urban food production systems to provide sustainable food supply to urban dwellers, as well as provide environmental protection, and enhanced food security.

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THE FARMING FRONTIER

IMPACT OF ARTIFICIAL INTELLIGENCE ON AGRICULTURE

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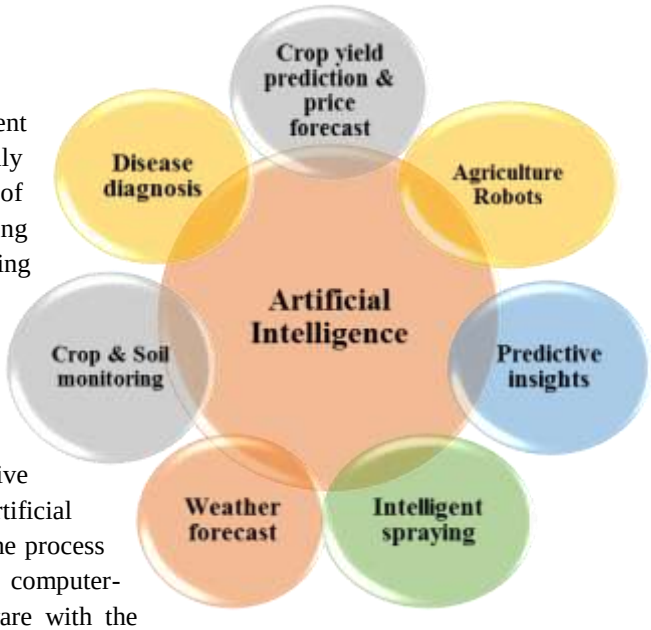
In recent years, the integration of Artificial Intelligence (AI) into agriculture has ushered in a new era of innovation and efficiency. The traditional image of farming, with manual laborers toiling in the fields, is evolving rapidly as AI technologies make their way onto farms. This transformation, often referred to as the "Farming Frontier," represents a seismic shift in the way we produce food and manage agricultural resources. AI, with its ability to process vast amounts of data and make intelligent decisions, is fundamentally changing the landscape of agriculture. From optimizing crop yields and reducing resource waste to automating labor-intensive tasks, AI is proving to be a powerful ally for farmers in the quest for sustainable and productive farming practices. Artificial Intelligence (AI) refers to the process of imbuing computers, computer-controlled robots, or software with the ability to think intelligently, akin to the human mind. This is achieved through the examination of human brain patterns and the analysis of cognitive processes. The result of these investigations leads to the creation of smart software and systems.



Components of artificial intelligence

It extends beyond the realm of computer science; it is a vast field that involves various interconnected factors. Developing AI necessitates an understanding of the composition of intelligence, which is an abstract aspect

of our brain encompassing reasoning, learning, problem-solving, perception, language comprehension, and more. To achieve these factors for a machine or software AI requires various disciplines *viz.* mathematics, biology, psychology, sociology, statistics, neural science and computer science.

Artificial intelligence in agriculture

Weather events account for 90% of crop losses, and predictive weather modeling can potentially prevent 25% of those losses. By leveraging AI, data from satellites, on-ground sensors, and weather stations can be combined to provide more accurate weather predictions. This information can then be used to advise farmers on optimal timings for planting and harvesting, enhancing agricultural productivity and reducing the impact of weather-related risks on crops. By analyzing soil samples, specialists can provide recommendations on the most suitable fertilizers to enhance soil quality and address any existing soil defects. The tractor is equipped with an onboard computer system and a camera that runs deep learning algorithms, enabling it to identify weeds accurately, which allows precise spraying of herbicides only where needed. By doing so, this method utilizes only 10% of the herbicides that would have been used in a conventional approach, which involves indiscriminate spraying of the entire field. This not only reduces herbicide usage but also promotes more efficient and eco-friendly weed control in agricultural practices.AI robots have the capability to harvest around 8 acres of crops within a span of 24 hours. This level of efficiency allows crop owners to significantly reduce their dependency on human laborers and overhead costs by replacing manual labor with AI robots for harvesting tasks. The use of AI robots in agriculture can lead to increased productivity, cost savings, and improved overall efficiency in crop harvesting operations.

Pros and cons of artificial intelligence

Pros	Cons
AI is highly accurate and its use reduces human error.	AI can contribute to an increased reliance on machines, potentially leading to a lack of motivation and decreased initiative in humans.
AI enables the automation of repetitive tasks across various industries.	The adoption of AI necessitates significant investments in advanced infrastructure and employee training, making AI implementation a costly endeavor for businesses.
AI excels in handling and processing vast amounts of Big Data efficiently.	AI implementation has the potential to lead to higher unemployment rates since AI systems can accomplish the tasks equivalent to multiple human workers simultaneously.
AI enables rapid extraction of insights from processed data, leading to expedited decision-making. Additionally, AI systems offer continuous availability without the need for breaks, unlike human counterparts.	AI systems rely on a set of algorithms for making predictions, making them highly practical for various tasks. However, in complex and challenging situations, these algorithms may limit their creativity and innovation capabilities.
AI indeed aids in risk mitigation, as AI systems can be deployed in environments that are hazardous to humans. By using AI, we can reduce the need for human presence in dangerous settings, thereby enhancing safety and minimizing potential harm.	Incorporating ethics into AI systems poses a significant challenge.

The utilization of artificial intelligence to ensure food security for the future is truly enlightening. AI's suitability and effectiveness in the agriculture sector lie in its ability to optimize resource utilization, enhance efficiency, and substantially address resource and labor shortages. Embracing AI in agriculture could spark a technological revolution, catering to the growing global human population's needs for sustenance. AI applications, systems, and devices will play a significant role in assisting farmers with tasks ranging from seed sowing and soil quality tracking to weed removal, crop harvesting, and enhancing supply chain visibility. This integration of AI is set to revolutionize and streamline farming practices in numerous ways.

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BIOFORTIFICATION IN VEGETABLE CROPS
A STEP TOWARDS MITIGATING HIDDEN HUNGER

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In a world grappling with malnutrition and dietary deficiencies, finding sustainable and effective solutions is of paramount importance. One such solution gaining momentum is biofortification, a process that enhances the nutrient content of crops to improve their nutritional value. In particular, biofortification has emerged as a promising approach to bolster the nutrient levels in vegetables, leading to a range of health benefits. This article delves into the concept of biofortification in vegetables, its methods, and its potential impact on global health.

Understanding biofortification

Biofortification involves using traditional breeding techniques or biotechnology to develop nutrient-rich varieties of crops. The process focuses on increasing the levels of essential vitamins, minerals, and other nutrients in the edible parts of plants, such as leaves, roots, and fruits. By fortifying vegetables at the genetic level, biofortification addresses the challenge of micronutrient deficiencies, or "hidden hunger," prevalent in many parts of the world.

Methods of biofortification

1. Agronomic biofortification: Supplementation of micronutrients like iodine, copper, iron, zinc, nickel, manganese, molybdenum, etc. in the form of mineral nutrition through foliar or soil application thereby enriching the economic produce with the needed deficient nutrient.

2. Conventional Breeding: Traditional breeding techniques are employed to develop vegetable varieties with improved nutritional profiles. This involves selecting and cross-breeding plants with higher nutrient content and favourable agronomic traits. Over several generations, breeders create new varieties that contain elevated levels of essential micronutrients, such as iron, zinc, vitamin A, and folate.

3. Genetic Engineering: Biotechnology plays a significant role in biofortification by enabling the insertion or modification of specific genes responsible for nutrient production within plants. Genetic engineering techniques allow for precise manipulation of plant DNA to enhance nutrient content. For example, scientists have successfully engineered vegetables

to produce higher levels of provitamin A, enabling improved vitamin A intake.

Biofortified crop varieties released in India

1. Carrot:

a.) **Pusa asita:** self-black coloured roots and late bolter. Rich source of anthocyanin

b.) **Pusa Rudhira:** Has higher level of Carotenoid (7.14mg) & Phenol (45.15mg/ 100g). Possess antioxidant property with self-core red coloured and delayed bolting.

2. Sweet potato:

a.) **Bhu Sona:** High β-carotene (14.0 mg/100g). Tuber yield: 19.8 t/ha with dry matter 27.0-29.0% and starch 20.0%.

b.) **Bhu Krishna:** High anthocyanin (90mg/100g). Tuber yield: 18.0 t/ha with dry matter 24.0- 25.5% and starch 19.5%.

c.) **Bhu Kanaka:** Early maturing (75-85 days). Cylindrical tubers with dark orange flesh colour having high beta-carotene.

3. Raddish:

a.) **Pusa Gulabi:** First Pink fleshed variety. High in total carotenoids, anthocyanin and ascorbic acid content. Grows exceptionally well in heat of summer. Medium root size and cylindrical shape.

b.) **Pusa Jamuni:** First purple fleshed nutritionally rich variety high in anthocyanin & ascorbic acid content.

4. Brinjal:

a.) **Pusa Safed Baigan 1:** White colored oval fruit rich in total phenol content and high antioxidant property.

5. Cauliflower:

a.) **Pusa Betakesari:** Contains high β-carotene (8.0-10.0 ppm) in comparison to negligible β-carotene content in popular varieties.

Impact on vegetable nutrition

Biofortified vegetables have the potential to revolutionize the way we combat malnutrition and its associated health issues. Here are some key impacts:

1. Improved Micronutrient Intake: Incorporating biofortified vegetables into diets can help address micronutrient deficiencies prevalent in vulnerable populations. By enhancing the nutrient content of commonly consumed vegetables, biofortification provides an accessible and sustainable solution to combat malnutrition.

2. Enhanced Health and Well-being: Biofortified vegetables, rich in essential vitamins and minerals, contribute to overall health and well-being. Increased consumption of these nutrient-dense vegetables can help prevent nutritional deficiencies and associated diseases, supporting immune function, growth, and development.

3. Sustainable Agriculture: Biofortification promotes agricultural sustainability by fortifying crops at their genetic level. Unlike other interventions, such as supplementation or food fortification, biofortified vegetables do not require additional processing or external sources of nutrients, reducing the need for costly interventions.

4. Economic Benefits: Biofortified vegetables offer economic advantages for farmers and communities. High-nutrient crops can be sold at premium prices, providing a lucrative market for farmers. Additionally, improved nutrition leads to a healthier workforce, reducing healthcare costs and increasing productivity.

Challenges and the way forward

While biofortification holds immense promise, it is not without challenges. Some key considerations include regulatory frameworks, acceptance among consumers, and ensuring equitable access to biofortified crops.

To overcome these challenges, concerted efforts are required from governments, research institutions, farmers, and consumers. Public awareness campaigns, farmer training programs, and public-private partnerships can play a vital role in driving the adoption of biofortified vegetables.

Conclusion

Biofortification in vegetables represents a ground breaking approach to address malnutrition and improve public health worldwide. By enhancing the nutritional composition of crops through conventional breeding and genetic engineering, biofortification holds the potential to combat hidden hunger and alleviate nutrient deficiencies. The adoption of biofortified vegetables can contribute to healthier populations, sustainable agriculture, and economic prosperity. With continued investment, research, and collaborative efforts, biofortification can pave the way toward a healthier and more nourished future for all.

25 Profitable Agriculture Business Ideas with low investment

Bharat Agri Startup: Unleashing Agricultural Innovation

ROLE OF
BANANA PLANT IN INCOME GENERATION

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One of the major fruits eaten worldwide is the banana. It has a wealth of nutrients that are good for human health, including carbohydrates, fiber, minerals, and bioactive substances like carotenoids, flavonoids, phenolics, amines, and vitamins C and E. For banana bunches or fruits to remain of high quality and obtain a competitive price on the market, they must reach their peak of ripeness. Due to the anticipated green life needed by the fruit before ripening, different countries have different standards for fruit ripening and maturity. Fruit quality characteristics can be categorized into sensory, hidden, or quantitative. Color, glossiness, size, shape, flaws, flavor, texture, and taste are examples of sensory qualities. The attributes that are hidden are nutritional values, the existence of harmful pollutants, and deadly substances. The quantitative factors are those that impact the general food quality.

Uses for banana plant parts

Banana plants make excellent compost and can be used to produce

energy through decomposition. Banana waste is a rich source of vitamins and minerals.

Banana peel

Starch, crude fat, crude protein, total dietary fiber, linoleic and -linolenic acids, pectin, essential amino acids (leucine, valine, phenylalanine, and threonine), and micronutrients (K, P, Ca, Mg) are all abundant in banana peel. Additionally, it can be used to make wine, ethanol, as a foundation material for the extraction of pectin, as a substrate for the generation of biogas, and for other purposes. Banana plants can benefit from the use of peel ash as fertilizer, and soap manufacture can use it as an alkali source.

Banana leaves and sheaths

The weaving of baskets, mats, food wrappers for marketing and cooking, coverings for food, tablecloths, plates for eating, and cups for soup all make great use of leaves. Banana bunches are wrapped in old leaves as "bunch covers" to keep birds and bats away. During the rainy season, rural people use the huge leaves of triploid bananas as umbrellas.

Dried banana leaves are both a fuel source and a growing medium for oyster mushrooms. Banana leaves are used in India (Orissa, West Bengal, and Kerala) for traditional rituals and rites as well as the roasting or steaming of ingredients for particular foods. People traditionally eat off of banana leaves in Sri Lanka and India's banana-growing regions. Banana leaves have a higher lignin content than banana pseudostem's. For improved digestibility, leaves can be fed to ruminants together with some protein extract. Due to their relatively high ash content, banana plant waste (leaf blade, flower stalk, leaf sheaths, and rachis) are not appropriate for pulping. Petiole, leaf blades, and leaf sheaths all contain significant amounts of pentosans. Leaf blades include a significant amount of protein, making them a potential feed source for cattle.

Banana pseudostem, pith and male bud

Male buds, immature fruit, and pseudo stems can be used to create a wide range of goods, including chips, ready-to-drink beverages, flour, jam, confections, dehydrated slices, and pickles. The pseudo stem of a banana can be used to make paper board, tissue paper, etc. When combined with paddy straw, banana fibers can be utilized as a natural sorbent, bio-remediation agent for bacteria in natural water purifiers, for the cultivation of mushrooms, and in the manufacturing of handicrafts and textiles. In addition, it's used to make nautical cordages, high-quality paper cardboards, tea bags, string thread, high-quality cloth, paper for currency notes, and good rope for tying.

To be utilized as bio-fertilizer, pseudo stem can be recycled. It has a large amount of cellulose and carbohydrates and can be used as cattle feed. Lectins, which are contained in the tissues of banana plants, are also useful for human consumption. In wastewater containing textile dyes, used banana pith can be used as a color absorber. In various regions of India, pith is consumed as food after being boiled and spiced. The pharmaceutical and food industries can utilise the considerable amount of starch found in floral stalks. Male buds are prepared like vegetables and eaten in India. Stomach issues can be treated with banana male bud juice.

The banana fruit has given rise to, popularized, and been used to make a number of value-added goods, including:

Flour, health drinks, baby food, sauces, pickles, and chips made from the pulp of an unripe banana and fig, juice, bars, jam, and sweet chutney made from the pulp of ripe bananas but some value-added products of banana described.

Chips

Banana slices that have been deep-fried or dried till crisp are called banana chips. Typically, they are manufactured from Nendran and Saba cultivars of starchier, firmer bananas (also known as "cooking bananas" or "plantains"). They come in both sweet and savory types and can be coated with sugar, honey, salt, or different spices.

Banana fig

It is a dried fruit that is made by maturing bananas that are either immature or mature and are both marketable and unmarketable. Figs are processed by peeling, sanitizing, and drying in a hot air oven or sun dryer; the finished product keeps for up to three months at room temperature.

Juice

It is a popular fruit juice among many people, especially those who produce juice at home or for a living, as it is a great way to consume overripe bananas. Given that the juice isn't always separated from the fibrous, starchy components of the banana, banana juice has a tendency to be thicker than most fruit juices.

Bar

It is a sweet treat made from any sort of ripe banana fruit. It is prepared by combining pectin, sugar, citric acid, and banana pulp in the proper amounts, then dehydrating the mixture sets to form a sheet.

Jam

The bananas that are overripe can be used in this simple recipe. Banana that is too ripe should be cut up and added to the bowl. Including sugar and lemon juice. Pour everything into a big pot after thoroughly mixing it. Cook the jam over a higher heat source until it comes to a vigorous rolling boil, then turn it down to a low setting and let it cook very slowly.

Flour

It is produced by gathering, peeling, cooking, and grinding green, unripe bananas into a fine powder. The nutrients in this organic flour are plentiful. Resistant starch, a prebiotic fiber that promotes digestive health and reduces blood sugar, is particularly abundant in it and is also high in potassium.

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CROP MODELLING
FROM THE EYES OF A COMMON MAN

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Recent shifts in markets, technology, and organization have led to intensified agricultural land use. Producers grapple with a wide array of technologies, from weed control to seed selection, aiming to enhance productivity, environmental sustainability, and profitability. Addressing these challenges demands a holistic understanding of plant growth factors. Future agricultural research will necessitate increased resources. Various models have emerged to aid in predictive processes. A model is a depiction of a system or a group of equations that captures the behavior of a system. Modelling entails using these equations to characterize a system. Crop models, a form of systems research, employ computer programs to simulate crop growth and development, aiding in production problem-solving.

Types of models

Models are divided into many sorts or groups according to the function for which they are intended. A few of them are:

- **Statistical models**: These models show the relationship between yield or yield elements and weather-related factors. Through the use of statistical techniques, these models evaluate systemic linkages. Example: Correlation, step-down regressions, etc.
- **Empirical models:** These are simple regression equations (with one or more components) that are used to directly describe the observed data and estimate the eventual yield.
- **Mechanistic models:** These models explain the mechanism of these models (explains the relationship of affecting dependent variables) in addition to the relationship between weather parameters and yield. The lowest levels therefore have a mechanism, understanding, or explanation (such as cell division).
- **Deterministic models**: The yield or value of the dependent variable is predicted by these models with accuracy. Moreover, the coefficients of these models are known. A deterministic model is one that produces constant forecasts for quantities (such agricultural yield or rainfall) without any matching probability distribution, variance, or random component.
- **Stochastic models:** Each output has a probability component associated to it. Different outputs are provided along with probability for each combination of inputs. At a specific rate, these models specify the yield or state of the dependant variable. However, stochastic models can easily become complex and have a tough time being handled technically.
- **Dynamic models:** Time is incorporated as a variable in dynamic models. Over a specific amount of time, both the dependent and independent variables' values remain constant.
- **Static models:** Time is not included in static models as a variable. Over a predetermined amount of time, dependent and independent variables with values remain constant.
- **Simulation models:** In general, computer models are mathematical representations of systems found in the actual world. Estimating agricultural productivity as a function of depending on the climate, soil, how crop is managed is one of the fundamental objectives of crop simulation models.

Applications of crop modeling

These three things; research, crop system management, and policy analysis- can all be put to use.

A. As research model:

- Correct understanding of research;
- Integration of information from several disciplines:
- Organization of data and experiment documentation improvements,
- Genetic advancements.

B. Yield analysis:

It is possible to extrapolate to other situations when a model with a strong physiological foundation is used. The evaluation of climatically determined yield in different crops through the application of diverse simulation models. In the South African sugar sector, the CANEGRO model has been applied in a similar manner.

C. As crop system management tools :

Managing cultural and input processes; assessing risks; and promoting investment.

D. Site-specific farming:

By managing farms as collections of smaller units and giving the essential inputs at the optimal rate to account for changes in soil quality of the farm, profit maximization can be achieved.

E. As policy analysis tool:

- Optimum management techniques,
- Forecasting yield,
- The beginning of a new crop,
- Crop production and the changing environment worldwide,
- Precision Farming.

Successfully developed and used models in agriculture:

1. **The de Wit School of models:** In the 1960s, initial efforts to model crop canopy photosynthesis led to estimates of food production potential. The Elementary CROp growth Simulator (ELCROS) and subsequent inclusion of micrometeorology and canopy resistance resulted in the BAsic CROp growth Simulator (BACROS), improving transpiration simulation.
2. **IBSNAT and DSSAT models:** Agriculture is the primary economic activity. The objective is to increase the yields of the crops they have been cultivating for a long period.

Conclusion

Crop modelling provides crucial agronomic insights on processes like sowing timing, irrigation, and fertilizer application, impacting soil-crop dynamics. It aids in pest and disease management, assessing management actions, and uplifts agriculture through predictions of plant-soil-atmosphere interactions, biomass, yield, and more. Additionally, it supports growers in supply control and decision-making, contributing to reduced pesticide and fertilizer use for enhanced environmental sustainability and crop quality.

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HUMBLING ARRIVAL OF INVASIVE PEST
SOUTH AMERICAN TOMATO LEAF MINER
(*Tuta absoluta* Meyrick) IN INDIA AND THEIR NATURAL ENEMIES

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Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) is an oligophagous pest causing serious damage to solanaceous crop plants, especially tomato (*Solanum lycopersicum* L.). *T. absoluta* is a recently invaded pest to India and causing damage to the both open field tomatoes and in protected crops. *Tuta absoluta* was recorded the first time on tomato field in India at the Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bengaluru, and originated in South America it is one of the most serious pests of tomatoes. It is also known to attack other solanaceous crops, including potato, eggplant, pepper, tobacco, and weedy species such as black nightshade, this pest spread rapidly throughout tomato growing areas and has become a major threat to tomato production worldwide.

The tomato belongs to the Solanaceae family and belong to botanical name the *Lycopersicon genus Solanum*. Tomato is one of the most important vegetable/fruit/flavor crops in India, is a premier vegetable crop round the year and one of the prominent eco-industrial crops of India generating sizeable employment and it serves as an important minerals which are useful for human body, is an important source of nourishment for the whole world's population indeed, tomato fruit consumption has been associated with a reduced risk of inflammatory processes,

Tomato crop damaged by American tomato leaf miner (*Tuta absoluta*)

cancer, and chronic noncommunicable diseases (CNCD) including cardiovascular diseases (CVD) such as coronary heart disease, hypertension, diabetes, and obesity. Antioxidant metabolites are a group of vitamins, carotenoids, phenolic compounds, and phenolic acid, with health-enhancing effects on our body. Now it is well known fact that the tomato leaf miner, *T. absoluta* is well established in south India. The pest is native to Peru, where it is a serious pest on solanaceous vegetables hence also called South American tomato moth. Tomato leaf miner or South American tomato leaf miner or tomato pin worm, *T. absoluta* (Lepidoptera: Gelechiidae) is a serious pest on tomato cultivation in several countries in Latin America and Mediterranean basin. The pest has been spreading fast and devastating tomato crop both in protected and open fields.

Nature of damage:

After hatching, young larvae of *T. absoluta* immediately mined into tomato leaves, apical buds, stalks or fruits. The larvae generally mining and feeding on leaves and boring into tomato fruits, with multiple larvae sometimes observed in a single fruit, Tunnels created by larvae while feeding on the leaf (mines) reduce the photosynthetic surface area of the leaves. In extreme cases, leaf mining caused early drying of leaves and eventual death of the plant. The third and fourth instar larvae were found to abandon the mines in the leaves to bore into stalks, apical buds and fruits. Pupation was observed in the mines of fresh leaves, fallen and dried leaves as well as in soil. The holes on the fruits were minute, bearing black spots with a small encircle of yellow line. Usually, there were 2-4 holes per fruit. The larvae was creamy-white in the early stage (early instar) that turned to green or pinkish with dark brown head in later. Feeding resulted inconspicuous mines (blotches) and galleries on leaves and pin sized holes on fruits from the stalk end generally covered with the frass. Larvae mainly attacked leaves, creating blotch/leaf mines visible from both sides of the leaf. The mines have dark frass (excrement) visible inside and the mined areas turned brown and dried over time. *T. absoluta* was recorded on two hosts viz., tomato as well as potato and the incidence was higher on tomato than potato. The main host plant of *T. absoluta* as tomato although the insect has also been reported on solanaceous weeds, including *Solanum nigrum* and *Datura stramonium*. Damage has also been reported on eggplant, pepper and potato, tomato leaf miner may multiply during summer months in outdoors but it is not expected to survive winter conditions because its development stops between 6 and 9°C, alternative host plants, especially *S. nigrum* may play important role in continuous spread of this pest.

Natural enemies

Nesidiocoris tenuis (Reuter) (Hemiptera: Miridae) was found predating on eggs and early instars of *T. absoluta* under field conditions. Presence of this natural enemy feeding on whitefly in tomato ecosystem in India was earlier reported, *Trichogramma achae* was also found to attack eggs of *Tuta absoluta*.

Management strategies

There is need to study the biology and ecology of known insect pests and their natural enemies. And should be known about ecology and genetic makeup of the Invasive insect pest. Tracking of geographical distribution of pest and growing Developing cultivars resistant to insect pests. as well as Judicious use of insecticides to prevent resistance and resurgence development. To identify, conserve and augment natural enemies of invaded insect pests. Modify crop management practices and Develop suitable integrated pest management programmes. With Phytosanitary regulations to prevent or limit the introduction of risky insect pests.■

[DeHaat: Sowing the seeds of Indian Agri-Revolution]

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FOOD SAFETY

HAZARD ANALYSIS AND CRITICAL CONTROL POINT

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Food play as significant role in determining population productivity, nutritional status and health. Therefore, it is crucial that the food we eat is healthy and secure. Numerous food borne illnesses can result from eating unsafe food. You may have read reports in the newspapers regarding health issue brought on by contaminated or adulterated foods. Food borne disease is a significant issue that affects public health on global scale.

Food safety

Food safety is the absence or present of small amount of hazards substances in food that do not threaten to the health of consumer, these include microbial, chemical and physical factors that or often not seen; such as bacteria, viruses and chemical residues. Food safety and quality have become important issue on a global scale since they can not only cause health but also harm to trade and tourism, earnings loss, unemployment and legal action which can impede economic progress. Food safety is a scientific discipline describing handling, preparation and storage of food in ways that can prevent foo borne illness. There is one is one more term which called food as food security, it's refers to the situation when the community has sufficient/ enough healthy food stuff for all its members, current definition of (FAO, 1996) food security is achieved when all people, all the times have physical, social and economic access to sufficient, safe an nutritious food to meet their dietary needs an food preference for an active an healthy life.

Hazard analysis and critical control point (HACCP)

HACCP (Hazard Analysis and Critical Control Point) is a systematic approach in identifying, evaluating and controlling food safety hazards. Hazard Analysis and Critical Control Point (HACCP) was developed in the 1960s in the United States to ensure food safety for the first manned National Aeronautics and Space Administration space missions (NASA). It is important to always remember that the establishment of effective HACCP programs involves primarily the application of good common sense and preventive considerations to address situations before they become problems. HACCP is a system which look for any prevents potential problems before they happen. It may be used by food

companies to make sure they do not break the law by putting consumers at risk when producing food. CCP (Critical Control Point) is an identification point in the production chain where a hazard may occur, action is taken to prevent the hazard from occurring.

Principles of HACCP implementation

(i) Hazard analysis
(ii) Determine the Critical Control Point
(iii) Establish critical limits
(iv) Establish a monitoring system
(v) Establish corrective actions
(vi) Establish verification procedures
(vii) Record keeping procedure.

Scope of HACCP

1. Aggressive competition required organization to reduce costs while maintaining quality.
2. Increasing consumer awareness and legal liability to produce safe food.
3. Changes in processed technology, increased automation, complex packaging solutions, new ingredients and improved formulations and
4. Greater emphasis on sensory evaluations and complex distribution networks leading to reduce delivery times.

Hazard

A hazard is a biological, chemical or physical agent that is reasonably likely to cause illness or injury in the absence of its control. In HACCP hazard refers to the condition or contaminants in foods that can cause illness or injury. There are three types of hazard like:

(a) Biological hazard: Food borne biological hazards includes microbiological organisms such as bacteria, viruses, fungi and parasites. These organisms are commonly associated with humans and with raw products entering the food establishment.

(b) Physical hazard: These physical hazards can result from contamination and/or poor practices at many points in the food chain from harvest to consumer, including those within the food establishment.

(c) Chemical hazard: Chemical contaminants in food may be naturally occurring or may be added during the processing of food. Harmful chemicals at high levels have been associated with acute cases of food borne illnesses and can be responsible for chronic illness at lower levels.

Measures to control hazards

1. Measure at the processing and packaging stages (Raw materials, packaging materials, processing steps, plant and machinery, storage and Distribution, premises and personnel).
2. Measures at post processing and packaging stages (Retail and Food service).
3. The consumer (Food preparation and Food usage).

Method	Control parameters
Heat treatment	Time, Temperature and Humidity
Filtration	Pore, size and filter integrity
Irradiation	Dosage and Density of load
Chemical	Concentration, pH and Temperature

Conclusion

HACCP program to be successful need proper implementation and management. This depends largely on regularly scheduled verification activities. The HACCP plan should be updated and revised as requirement. An important aspect of maintaining the HACCP system is to assure that all individuals involved are properly trained so they understand their role and can effectively fulfill their responsibilities. Today food industry standards play a major role in assisting food businesses to achieve compliance with legislation and in many cases exceed legislative requirements.

■■■

UNVEILING THE FUTURE OF OIL CONTENT AND QUALITY IN SEEDS
BREAKTHROUGHS IN UNDERSTANDING AND ENHANCEMENT

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In an ever-changing world where sustainable agriculture and renewable resources are of paramount importance, the quest to unlock the full potential of seeds has become a central focus of scientific research. Among the most valuable components of seeds is their oil content, which holds great promise for both food security and biofuel production. This article delves into the groundbreaking advancements in understanding and enhancing the oil content and quality of seeds, paving the way for a brighter and more sustainable future.

The significance of seed oils

Seed oils have played a pivotal role in human history, serving as a primary source of energy and nutrition. Over the years, they have evolved from being simply a dietary staple to a valuable resource with a myriad of applications. Today, seed oils are not

only used for culinary purposes but also as feedstock for biofuels, industrial lubricants, cosmetics, and pharmaceuticals. The demand for seed oils is ever-increasing, making it essential to explore ways to boost oil content and improve its quality in seeds.

Understanding the genetics

Advances in genomics have transformed seed oil enhancement by uncovering genes and regulatory elements governing oil biosynthesis. Scientists can now manipulate these genes, boosting oil content without harming the plant. Transcription factors, identified as master regulators, play a pivotal role. Overexpression of these factors has led to significant oil content increases in crops like canola and soybeans. Genetics also permits oil quality modification, yielding oils with improved nutrition and functionality. This innovation paves the way for healthier cooking oils and specialized industrial oils, marking a remarkable journey toward enhancing seed oil content and quality.

Advances in breeding

While genetic modification is a powerful tool, traditional breeding methods have also seen significant progress in enhancing seed oil content and quality. Plant breeders now have access to advanced techniques such as marker-assisted breeding, which allows for the selection of plants with desirable oil traits with greater precision and efficiency. The development of high-throughput phenotyping and genotyping technologies has accelerated the breeding process. These tools enable breeders to quickly assess the oil content and quality of a large number of seeds and identify the best candidates for further breeding efforts. This not only saves time but also conserves resources and reduces the environmental footprint of crop breeding programs.

Diversity in plant species

In the quest for higher seed oil content and quality, researchers have not limited their efforts to a single crop. Instead, they have explored a wide range of plant species, each with its unique set of characteristics and potential. This diversity is essential for ensuring a sustainable and resilient agricultural system. Oilseeds like sunflower, safflower, and flax have gained attention as alternative sources of high-quality oils. These crops have distinct oil profiles and can thrive in different climatic conditions, providing flexibility for farmers and reducing the risk of monoculture. Moreover, underutilized and wild plant species have been tapped into as genetic reservoirs for novel traits.

Sustainable agriculture practices

Enhancing seed oil content and quality goes hand in hand with sustainable agriculture practices. The use of environmentally friendly farming techniques can help ensure that the benefits of increased oil production do not come at the expense of the planet. Crop rotation, cover cropping, and reduced tillage are practices that promote healthy soil and reduce erosion, ultimately benefiting crop yield and quality. Precision agriculture, which involves the use of technology to optimize farming operations, can also contribute to more efficient and sustainable oilseed production. Furthermore, the development of pest-resistant and drought-tolerant varieties through breeding or genetic engineering can reduce the need for chemical inputs and minimize the environmental impact of oilseed cultivation.

The role of biotechnology

Biotechnology, specifically genetic engineering, has been instrumental in advancing seed oil content and quality. It allows precise genome modifications in oilseed crops, offering various benefits. Herbicide-tolerant varieties enhance weed control, boosting yields and crop quality. Insect-resistant crops reduce the need for chemical insecticides. Genetic engineering can also lower anti-nutrient levels in seeds, improving suitability for consumption. Additionally, it enables biofortification, enriching seed oils with essential nutrients to combat nutritional deficiencies in vulnerable populations, promising a bright future for seed oil production and quality

Future challenges and opportunities

Challenges and opportunities in seed oil enhancement include adapting to climate change, developing resilient crops; evolving regulatory frameworks for biotechnology; meeting changing consumer preferences for healthy and sustainable products; and fostering global collaboration to ensure food security and sustainable agriculture

Conclusion

The future of seed oil content and quality is bright, thanks to a combination of genetic understanding, advanced breeding techniques, and biotechnology. These breakthroughs not only offer the potential to meet the growing demand for seed oils but also to do so in an environmentally sustainable and socially responsible manner.■

PLASTIC PACKAGING

A REAL THREAT TO THE ENVIRONMENT ? EXPLORING BETTER ALTERNATIVES FOR SAFER FOOD PACKAGING

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In the modern world, plastic packaging has become an integral part of our daily lives. From the moment we wake up and brush our teeth, to the time we prepare meals and store leftovers, plastic packaging is everywhere. However, this convenience comes at a cost - a significant and alarming threat to the environment. The adverse impact of plastic packaging on ecosystems, wildlife, and human health has raised concerns globally, prompting a search for safer and more sustainable alternatives. In this article, we will delve into the environmental repercussions of plastic packaging and explore promising alternatives that can revolutionize the way we package our food.

The plastic predicament: A deepening crisis

Plastics were initially hailed as a revolutionary innovation, offering durability, versatility, and cost-effectiveness. However, the very characteristics that made plastics so popular have also contributed to their widespread misuse and accumulation in the environment. Plastic packaging, especially single-use plastics, has emerged as a pressing environmental challenge due to its non-biodegradable nature.

Plastic packaging poses several threats to the environment:

1. Persistent pollution

Plastics are designed to last for centuries, yet they are often used for products with a lifespan of minutes. This disconnection between use and durability leads to massive accumulation in landfills, oceans, and natural habitats. The Great Pacific Garbage Patch, a massive collection of plastic waste floating in the Pacific Ocean, is a testament to this alarming issue.

2. Wildlife endangerment

Marine animals and birds mistake plastic for food, leading to ingestion and entanglement. The ingestion of microplastics, tiny fragments that result from the breakdown of larger plastics, can also have dire consequences for marine life and the entire food chain.

3. Microplastics in food chain

Microplastics have infiltrated even the remotest corners of our planet, from the depths of the oceans to the peaks of mountains. They have been found in drinking water, seafood, and agricultural products, raising concerns about their potential impact on human health.

4. Carbon footprint

The production of plastics requires fossil fuels, contributing to greenhouse gas emissions. Additionally, the disposal of plastics through incineration releases harmful pollutants into the atmosphere.

Promising alternatives to plastic packaging

The urgency of addressing plastic packaging's environmental impact has spurred the development of alternative materials and packaging methods that are safer for both the environment and human health. Some of these alternatives include:

1. Biodegradable plastics

These plastics are designed to break down more quickly than traditional plastics. They can be made from a variety of sources, including cornstarch, sugarcane, and algae. While biodegradable plastics offer a reduced environmental footprint compared to conventional plastics, challenges remain, such as proper disposal infrastructure and potential issues with the speed and completeness of degradation.

2. Edible packaging

Edible packaging, often made from materials like seaweed or starch, is gaining traction as a sustainable alternative. These packaging materials can be consumed along with the food, eliminating waste entirely. However, their application is limited to certain types of products, and concerns exist regarding shelf life and taste transfer.

3. Compostable packaging

Compostable packaging materials are designed to break down into nutrient-rich compost under specific conditions. They offer a promising solution, especially for organic waste, as they can enrich the soil rather than burdening landfills. However, the effectiveness of compostable materials depends on appropriate disposal practices and industrial composting facilities.

4. Paper and cardboard

These traditional materials have made a comeback as eco-friendly alternatives to plastics. They are biodegradable, recyclable, and renewable resources. With advancements in coatings and treatments, paper and cardboard can now be made more resistant to moisture and grease, expanding their applications in food packaging.

5. Reusable packaging

The concept of reusability is gaining momentum. Consumers can bring their containers to stores and restaurants, reducing the need for single-use packaging. While this approach requires changes in consumer behavior and infrastructure, it has the potential to drastically reduce packaging waste.

The role of industry and innovation

The shift towards sustainable packaging is not solely the responsibility of consumers. Industries play a crucial role in driving change through innovation, collaboration, and responsible production practices. Companies are increasingly being held accountable for their environmental impact, leading to a growing interest in adopting greener packaging solutions. Innovations in packaging design, such as minimizing the use of plastic, optimizing packaging sizes, and reducing unnecessary layers, can significantly decrease waste generation. Additionally, exploring new business models that prioritize reusability and reduced packaging can drive positive change

Conclusion

The omnipresence of plastic packaging has undeniably contributed to a severe environmental crisis. However, the growing awareness of its detrimental impact has fuelled the search for alternatives that are safer for both the environment and human health. While challenges persist, the on-going innovation and commitment to change offer hope for a future where plastic packaging is no longer a threat, but a triumph of sustainable packaging solutions. The journey towards a plastic-free world is a complex one, but it is a journey we must collectively undertake for the well-being of our planet and generations to come.

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WHAT IF, AGRICULTURE GOES WRONG!!

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"If agriculture goes wrong, nothing else will have a chance to go right."

The statement was given by MS Swaminathan. The statement "If agriculture goes wrong, nothing else will have the chance to go right in the country" can be justified by understanding the fundamental role that agriculture plays in a country's overall development, economy, and well-being. Agriculture is a backbone of many nations, especially in developing economies, and its success or failure can significantly impact various aspects of a country's functioning:

- **Food security:** Agriculture is the primary source of food production. When agriculture goes wrong and there are food shortages or insufficient production, it directly affects the population's food security. Malnutrition and hunger can become prevalent, leading to adverse health outcomes and social unrest.
- **Economic impact:** Agriculture contributes significantly to a country's economy through the employment of a large portion of the population, export revenue, and raw material supply for various industries. If agriculture fails, it can lead to reduced income for farmers, increased unemployment, and decreased revenue for the government.
- **Trade imbalances:** Many countries depend on agricultural exports to maintain trade balances. If agricultural production falters, a nation may have to import more food, leading to trade deficits and economic challenges.
- **Rural development:** In many countries, agriculture forms the backbone of rural communities. If agriculture fails, it can lead to the decline of rural areas, pushing people toward urban centers in search of better opportunities. This can strain urban infrastructure and create social and economic challenges.
- **Environmental impact:** Agriculture has a direct impact on the environment, including soil health, water resources, and biodiversity. Unsustainable farming practices can lead to environmental degradation, affecting ecosystems and natural resources.
- **National stability:** Agricultural failures can lead to social unrest, protests, and political instability,

especially in countries where agriculture is a significant part of the economy and livelihoods.

- **Inflation and cost of living:** Food shortages due to agricultural failure can lead to inflation, as demand exceeds supply. This can increase the cost of living for the general population, particularly for vulnerable groups.
- **Dependency on aid:** If a country heavily relies on its agricultural sector, its failure may result in increased dependency on foreign aid and assistance, undermining national sovereignty and self-sufficiency.
- **Health impact:** Agriculture also impacts public health. For instance, when crops fail, farmers may resort to using harmful chemicals to protect their crops, leading to health risks for both farmers and consumers.
- **Social well-being:** Agriculture provides the foundation for social stability and well-being. When it goes wrong, the overall quality of life can decline, leading to various social challenges.

Happenings, if agriculture goes wrong

When agriculture goes wrong, it can lead to various negative consequences, impacting food production, environmental sustainability, and socio-economic factors. Here are some potential outcomes of agricultural failures:

- **Food shortages:** If agricultural practices fail to produce enough food to meet the demands of the growing population, food shortages can occur, leading to hunger and malnutrition.
- **Environmental degradation:** Unsustainable agricultural practices can cause soil erosion, depletion of natural resources, deforestation, water pollution, and loss of biodiversity. This harms ecosystems and disrupts the balance of the environment.
- **Soil depletion:** Continuous cultivation without proper soil management can deplete essential nutrients from the soil, making it less fertile over time. This reduces crop yields and can render land unproductive.
- **Pest and disease outbreaks:** Monoculture (growing a single crop over large areas) and improper pest management practices can lead to outbreaks of pests and diseases that devastate crops and reduce productivity.
- **Water scarcity:** Inefficient water usage, excessive irrigation, and lack of proper water management can lead to water scarcity, reducing the availability of water for both agriculture and other human needs.
- **Climate change impact:** Agriculture is both affected by and contributes to climate change. Extreme weather events, such as droughts, floods, and storms, can damage crops and disrupt farming activities, while agricultural practices like deforestation and methane emissions from livestock contribute to greenhouse gas emissions.
- **Economic losses:** Failed harvests and reduced agricultural productivity can lead to economic losses for farmers, agricultural industries, and entire communities that rely on agriculture for their livelihoods.
- **Food safety concerns:** Incorrect use of pesticides, fertilizers, and other chemicals can lead to contaminated food products, posing health risks to consumers.
- **Social disparities:** Agricultural failures can exacerbate social inequalities, as vulnerable populations may face difficulties accessing food and resources, leading to food insecurity and poverty.
- **Migration and conflict:** In some cases, agricultural failures can lead to rural-to-urban migration as people seek better opportunities, which can strain urban infrastructures. Moreover, disputes over scarce resources like land and water may escalate into conflicts.

Conclusion

In summary, agriculture's centrality in providing food, employment, and economic stability makes it a critical factor in a country's functioning. If agriculture goes wrong, it can have far-reaching consequences that ripple through various sectors of the country, impacting the economy, social fabric, and overall well-being of the population. Thus, agriculture's success and sustainability are vital for ensuring the overall development and stability of a nation. To address and mitigate these potential consequences, sustainable and responsible agricultural practices, research, technology, and policies are essential. Promoting agroecological approaches, supporting smallholder farmers, investing in research and innovation, and implementing conservation measures are some steps that can help create a more resilient and sustainable agricultural system.

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AGRO- METEOROLOGICAL TOOLS AND TECHNOLOGIES FOR

PRECISION AGRICULTURE

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Precision agriculture relies on a range of agro-meteorological instruments and technologies to improve farming practices by providing precise weather and climate data. These tools empower farmers to make informed decisions, increase crop yields, reduce resource usage, and minimize environmental impact. Below are key agro-meteorological tools and technologies commonly used in precision agriculture?

Weather monitoring stations:

Automated weather stations collect data on factors such as temperature, humidity, rainfall, wind speed, and wind direction. This information is vital for monitoring local weather conditions, estimating evapotranspiration rates, and forecasting weather patterns.

Remote sensing:

Satellite imagery and drones equipped with specialized sensors offer real-time insights into crop health, soil moisture levels, and pest infestations. These data help farmers assess crop conditions and identify areas that require specific interventions.

Soil moisture sensors:

These sensors measure soil moisture at varying depths. Farmers use this data to determine when and how much to irrigate, preventing both over- and under-watering.

GPS technology:

Global Positioning System (GPS) technology allows precise field mapping and enables variable-rate application (VRA) techniques. VRA enables farmers to apply fertilizers, pesticides, and water based on specific field conditions, optimizing resource utilization.

Weather prediction models:

Advanced weather prediction models and software provide farmers with short- and long-term weather forecasts. This information aids in planning planting, harvesting, and other farming activities to avoid adverse weather conditions.

Climate monitoring systems:

Climate monitoring systems track long-term climate patterns, helping farmers adapt to changing conditions and make informed decisions about crop selection and planting schedules.

Decision support systems (DSS):

DSS software integrates agro-meteorological data with agronomic knowledge to offer recommendations for crop management. These systems consider factors like weather forecasts, soil conditions, and crop needs to optimize farming practices.

Pest and disease prediction:

Agro-meteorological data can predict pest and disease outbreaks. Early warning systems help farmers take preventive measures, reducing the reliance on chemical treatments.

Mobile Apps and IoT devices:

Mobile applications and Internet of Things (IoT) devices allow farmers to access real-time weather and agro-meteorological data on their mobile devices. These tools facilitate quick decision-making in the field.

Automated irrigation systems:

Smart irrigation systems use weather data and soil moisture information to adjust water application rates. They can be programmed to optimize water usage and minimize waste.

Climate-resilient crop varieties:

Agro-meteorological data assists in selecting crop varieties better suited to prevailing weather conditions, helping farmers mitigate the effects of climate change.

Data analysis and machine learning:

Advanced data analytics and machine learning algorithms process large datasets to identify patterns and trends, resulting in more accurate predictions and recommendations for farm management.

These tools and technologies play a pivotal role in precision agriculture, enabling farmers to boost productivity, reduce resource inputs, and promote sustainable farming practices based on well-informed decisions.■

CLOUDS ARE A HELPFUL TOOL IN WEATHER FORECASTING

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Cloud is a water vapor which collects in the atmosphere and looks like smoke, it mainly evaporates from atmospheric water sources like ocean, river, lake, pond etc. and gets transferred into the atmosphere through transpiration of trees and plants. In the atmosphere, it remains in the state of water vapor, which condenses on dust and smoke particles in contact with cold air and gets converted into the form of micro-sized water drops or small crystal particles of ice whose size is 20to 60 microns. (0.024-0.008mm).

How are clouds formed?

- Clouds are an important part of the weather, formation of clouds is a physical phenomenon which increases the surface evaporation of aerial water sources and the transpiration rate of trees and plants as a result of increasing the temperature of the atmosphere due to solar radiation heat.
- Water vapor collects in the atmosphere and looks like smoke, which appears as a cloud when seen from the ground. Temperature is very important for all these incidents. The air in the place where the temperature is high gets heated and rises up due to which the air pressure of that area gets reduced and to fill its place, high pressure moist cold winds move in.
- At higher altitudes above the earth's surface, clouds form due to the accumulation of water particles and ice particles formed by the process of condensation of water vapor in the atmosphere. For this, the air gets cooled through Adiabatic Process and when its temperature falls below the dew point, clouds are formed.
- The size of cloud particles is 20-60 microns (0.008 to 0. 24 millimetres). A rain drop is made up of 10 lakh cloud particles.

Weather forecast by looking at clouds:

Clouds can be considered an important means for predicting the weather in the coming time, the type of clouds, cloud activity, cloud top temperature give advance indication of the atmospheric conditions that will occur in the future. The following discussion will help in understanding the type of weather in future as per the discussion given below.

A. High clouds (average height above ground level 6-13 kilometers)

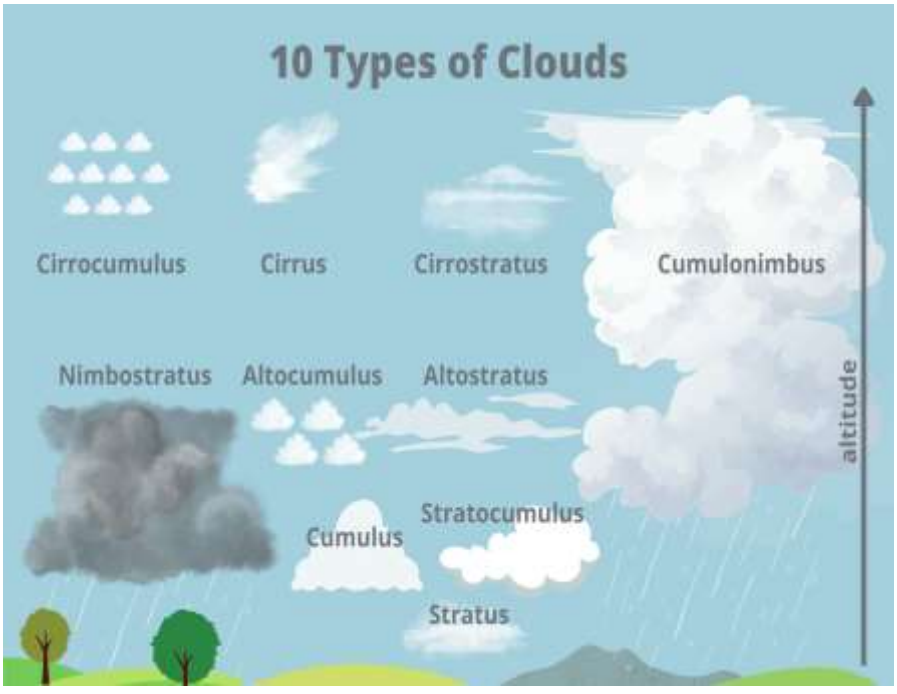
1 **Cirrus clouds:** These are soft and scattered clouds like white silk at the highest altitude in the sky. These are made of ice particles, hence they do not cause rain. They indicate clear weather, but when they appear sequentially with cirrus or stratus clouds, then there is a possibility of bad weather. These clouds are the first to appear during the arrival of the cyclone, hence these clouds are indicators of the arrival of the cyclone.

2 **Cirrocumulus clouds:** These clouds are formed as a result of convection in summer season in the latitudes where the temperature is high, its height is variable which depends on the relative humidity of the air. These are spread over large areas like a milky sheet. It is made of ice particles. Circumferolateral clouds form a halo around the Sun during the day and the Moon during the night. These clouds give information about cyclone.

3 **Cirrostratus clouds:** Such clouds which are found in rows or groups. These remain in the form of small spherical bodies which are made of ice particles. Covers the entire sky or part of it, producing holo phenomena around the Sun or Moon.

B. Middle cloud (average height 2-7 kilometres above ground level)

4 **Alto cumulus clouds:** These clouds are brown or somewhat white. Layers are found in these. They remain scattered in the form of waves. These clouds are shady.



Their development occurs upwards. Convection - Cumulus clouds are formed in the air currents due to waves or rising up the mountain slope. Such clouds are also called pennant clouds.

5 **Alto stratus clouds:** This cloud covers the entire sky in the form of a thick layer of brown or blue color. They are striped in appearance. They are not able to create aura. Due to these, the sky is partially or completely covered with clouds. There is a possibility of rain, drizzle and snow due to this cloud.

C. Low clouds (average height 0-2 kilometers above ground level)

6 **Cumulus clouds:** These clouds are made of spherical masses. These are placed in the lower brown layers of clouds. These appear as clusters or waves. Sometimes this cloud causes light rainfall, the average height of these clouds is 12500-3000 meters.

7 **Stratus clouds:** These clouds cover the sky like fog. They are formed due to the spread or upliftment of the lower layers of fog. Their development occurs from bottom to top. Due to their scattering the sky appears blue. These fragmented clouds are called Fractostratus. These clouds are usually formed during the winter season in the temperate zone due to the meeting of two winds of opposite nature.

8 **Nimbostratus clouds:** These clouds are low level clouds. These are brown and dark colored unbroken clouds. These cause continuous rain and snow. These form rain-layer clouds along the warm front in temperate cyclones. This cloud causes more rainfall in the monsoon season.

9 **Cumulus clouds:** These cumulus clouds are dense and widely spread. They appear like cotton washed in the entire sky. Due to their vertical growth, they appear dome-shaped or cauliflower-like in the sky. Their base is black in color and extends far horizontally. They appear bright in sunlight. Cumulus clouds are very dense in size. This gives the impression of clear weather.

10 **Cumulonimbus clouds:** The color of these clouds is dark and their shape is vertical, their top parts are domed like mountains. Their height in the sky is on average 18 kilometers. These clouds cause heavy shower of rain. Their main characteristics are heavy rains and strong thunderstorms. These clouds look like rain layers. These clouds cause rain accompanied by fierce thunder and lightning. After rain the weather becomes clear and clean.

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IMPACTS OF SOIL ON CLIMATE CHANGE

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In order to reduce global warming, soils are necessary. On the one hand, soils have a substantial capacity as carbon sinks and have the ability to increase it through the sequestration of soil organic carbon (SOC). However, soils are a source of GHG emissions as well. In the entire world, soils store two to three times as much carbon as the atmosphere contains. As a result, a small rise or decrease in carbon stock can have a big impact on climate mitigation. Due to the separation of arable and animal farming, peatland drainage, streamlined crop rotations, crop residue disposal, and losses from soil erosion, worldwide SOC stocks have historically fallen significantly. If the current methods of managing agricultural land are not modified, SOC stocks will keep declining. Additionally, it is thought that climate factors alone will result in substantial SOC losses. For peatlands, the size of predicted future losses is assessed, but research reveals relatively little insights into losses related to the sustainability of the dominant agricultural use of mineral soils at the present time. According to the Intergovernmental Panel on Climate Change, reaching that will most likely involve removing carbon dioxide from the atmosphere. However, methods like growing new trees to absorb carbon or capturing and storing the carbon emissions from power plants that use biofuels come with their own particular issues. They would either cost too much or the need too much land, water, or energy if they were implemented on a large enough scale to be effective.

However, sequestering carbon in soil is a very natural process that has fewer negative effects on land and water,

requires less energy, and is less expensive. The potential of soils to retain carbon might be enhanced through better land management and agricultural practices, which would help prevent global warming.

Carbon losses from soil

How consequential carbon soils can absorb and how long they can store it varies by emplacement and is effectively determined by how the land is managed. Because nearly half the land that can support factory life on Earth has been converted to spreads, ranges and rangelands, soils have actually lost 50 to 70 percent of the carbon they formerly held. This has contributed about a quarter of all the manmade global hothouse gas emigrations that are warming the earth. Tilling, monoculture planting, crop residue removal, excessive fertilizer and pesticide use, and overgrazing are examples of agricultural practices that disturb the soil and expose the soil's carbon to oxygen, causing it to burn off into the sky. Soils also release carbon when peatlands are drained, deforested, or permafrost thaws.

Soil organic carbon influences on climate change

More over one-third of all land is used for agriculture. With good land and soil management, such a significant portion of the world's land surface has the potential to improve SOC, which enhances the ability to store carbon dioxide from the atmosphere and contributes to reducing beings climate change. Unfortunately, the state of the soil is being harmed by current agricultural techniques. There are steps that can be implemented to mitigate the consequences of existing agricultural practices, boost SOC, and improve carbon sequestration. Such as less intensive tilling, cover crops, and perennial crops can all help achieve sustainability. In introducing the soil to microbial breakdown and increasing the quantity of carbon released back into the atmosphere, intensive tilling of soils reduces the amount of SOC being stored. After the main crop is harvested, cover crops like peas and clover are sown in order to enhance the absorption of carbon from soil. All-year-round crops known as perennials are capable of developing extensive root systems. These crops have the advantage of storing more carbon in the soil than annual crops due to their deeper root systems and throughout the year.

Conclusion

A crucial part of mitigating climate change will be realizing the potential of the natural environment and implementing good land and soil management strategies into consequence. To raise SOC, which is necessary to enhance soil health, lower atmospheric carbon dioxide levels, and enhance food security, agricultural practices such as less intensive soil tilling, the planting of cover crops and perennial crops, and others will be used. The mitigation of both soil fertility loss and global climate change has been linked to the sequestration of carbon as SOC in soils through agro-management strategies. Therefore, it is imperative to have a complete understanding of SOC dynamics and how they influence techniques of management. For the purpose of obtaining long-term advantages from the soil ecosystem, it would be beneficial to customize the agro-management methods in a site-specific way to potentially sequester SOC. Occasionally have long-term studies been conducted, both statistically and qualitatively, on the relationship between soil aggregate dynamics, soil N availability, and microbial characteristics with respect to SOC dynamics under sustainable nitrogen management strategies.

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GUARDIANS OF THE GREEN

CRISPR-Cas9 AND RNAi

TACKLE PLANT DISEASES

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The agricultural sector plays a critical role in meeting the ever-increasing global demand for food. However, it faces significant challenges posed by plant diseases caused by various pathogens like fungi, bacteria, and viruses. These diseases have consistently threatened crop yields, putting pressure on the agricultural industry to find effective solutions. Traditional breeding methods, which have been used to develop disease-resistant crops, have their limitations. They often involve lengthy breeding cycles and are constrained by the limited genetic diversity of existing crops. In recent years, a new era of bioengineering techniques has emerged as a revolutionary approach to address these challenges. Two prominent technologies, CRISPR-Cas9 genome editing and RNA interference (RNAi), have garnered attention for their potential to engineer crops with enhanced resistance to diseases. This article aims to delve into

these innovative techniques, explaining how they function, their practical applications, and the promising future they hold for sustainable agriculture.

What is CRISPR-Cas9 ?

CRISPR-Cas9, short for Clustered Regularly Interspaced Short Palindromic Repeats and CRISPR-associated protein 9, is a versatile and powerful genome editing tool employed in various organisms, including plants, animals, and humans. It leverages specialized DNA sequences found in bacteria and archaea genomes, which serve as a form of immune memory containing segments of DNA from past encounters with viruses. Cas9, often referred to as "molecular scissors," is an enzyme associated with CRISPR that can cut DNA at specific locations. To make precise DNA modifications, scientists design a short RNA molecule called guide RNA (gRNA) complementary to the target DNA sequence. The gRNA guides the Cas9 enzyme to the exact spot in the DNA where it should create a break. Subsequently, the cell's natural repair mechanisms come into play to mend the DNA break, allowing for specific and controlled genetic alterations.

CRISPR-Cas9 for disease-resistant crops:

In the context of agriculture, CRISPR-Cas9 has opened up remarkable avenues for enhancing disease resistance in crops. CRISPR-Cas9 enables scientists to target and disrupt specific susceptibility genes in plants, rendering them less vulnerable to pathogens. For example, in rice and wheat, CRISPR-Cas9 has been employed to knock out susceptibility genes, leading to increased resistance against fungal infections. CRISPR-Cas9 facilitates the precise integration of resistance genes from wild relatives or other sources into crop genomes. This enables the development of resistant varieties without introducing unwanted traits. By modifying key regulatory genes, CRISPR-Cas9 can enhance a plant's innate immune system, making it more effective against a broad spectrum of pathogens. This approach provides a proactive defense mechanism.

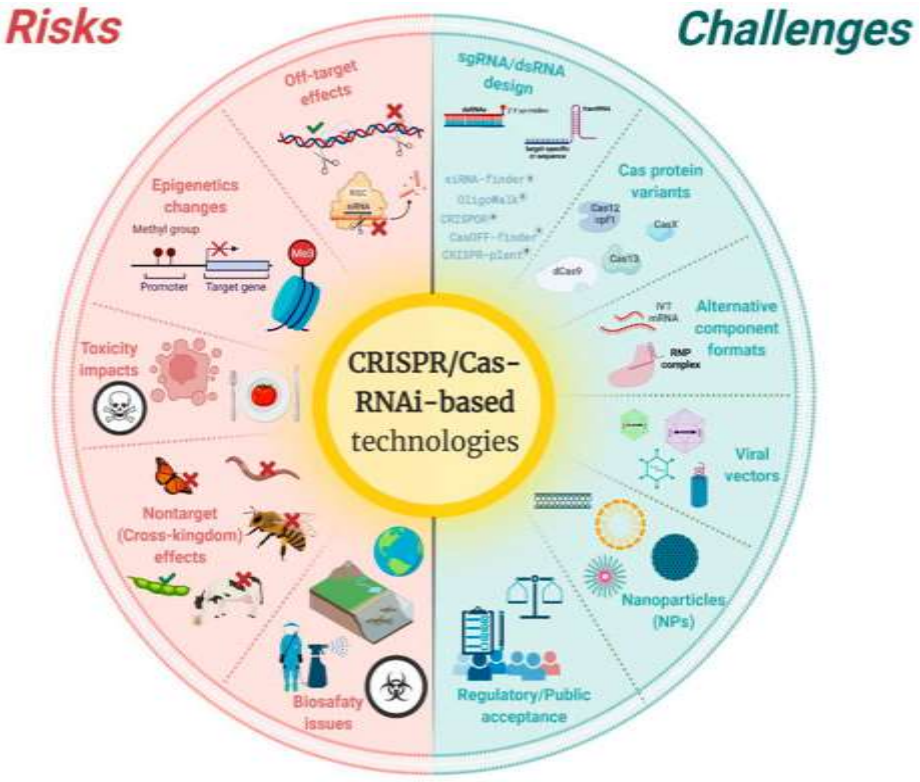
RNA Interference (RNAi) for crop disease resistance:

RNA interference (RNAi) is a powerful and naturally occurring mechanism that plays a significant role in plant pathology, particularly in the defense mechanisms of plants against pathogens. RNAi is a biological process through which small RNA molecules, specifically small interfering RNAs (siRNAs) and microRNAs (miRNAs), regulate gene expression by suppressing the translation of specific messenger RNAs (mRNAs) or by targeting the degradation of those mRNAs. In the context of plant pathology, RNAi has several key roles:

Host-Induced Gene Silencing (HIGS) and Plant-Induced Gene Silencing (PIGS) are RNA interference (RNAi) strategies employed in plant pathology. HIGS involves genetically engineering plants to produce specific small interfering RNAs (siRNAs) that target essential genes in invading pathogens, reducing their virulence and ability to infect the host plant. PIGS, on the other hand, utilizes RNAi to suppress the host plant's own genes that are exploited by pathogens for infection, enhancing the plant's innate immunity against various diseases. Additionally, RNAi plays a pivotal role in virus resistance, as plants detect viral RNA and trigger the production of siRNAs to degrade viral RNA, preventing viral replication. Moreover, RNAi can be employed to develop resistance against fungal pathogens and nematodes by targeting essential genes in these pathogens, impeding their capacity to infect and harm plants. These RNAi-based approaches offer promising strategies for developing disease-resistant crops, bolstering plant defenses, and ensuring global food security.

Practical applications and benefits:

- Both CRISPR-Cas9 and RNAi allow for precise and rapid modifications, reducing the time required to develop resistant crop varieties.
- Disease-resistant crops reduce the need for chemical pesticides, promoting environmentally friendly and sustainable agriculture.
- Disease-resistant crops have the potential to increase crop yields, contributing significantly to global food security.



Challenges and considerations:

Despite their immense potential, CRISPR-Cas9 and RNAi face challenges. CRISPR-Cas9 may unintentionally edit similar sequences elsewhere in the genome, necessitating rigorous testing and validation. The release of genome-edited crops into the environment raises regulatory questions, with various countries having differing approaches to their regulation. Ethical considerations include potential unintended ecological consequences and equitable access to these technologies for farmers, especially in developing regions.

Conclusion:

CRISPR-Cas9 and RNAi represent a new frontier in agricultural biotechnology, offering powerful tools for bioengineering disease-resistant crops. As global population growth continues, these technologies are poised to play a pivotal role in meeting the rising demand for food while promoting sustainable agriculture. Addressing the challenges and regulatory considerations will be crucial in harnessing the full potential of these bioengineering techniques, ensuring a future where crops are fortified against devastating diseases, and global food security is safeguarded. As we bioengineer the future of farming, CRISPR-Cas9 and RNAi stand as beacons of hope for a more resilient and sustainable agricultural landscape.■

BREEDING FOR RESISTANCE TO ABIOTIC STRESS

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Breeding for resistance to abiotic stress is a critical aspect of modern agriculture as it helps to increase crop yields in the face of environmental challenges such as drought, high temperatures, and soil salinity. Abiotic stress, which reduces average yields for most major agricultural plants by more than 50%, is the main factor in crop loss worldwide. Drought, high salinity, cold, and heat are the major abiotic stresses that negatively affect the survival, biomass production, and yields of staple food crops by up to 70%. This threatens global food security. However, the productivity of crops is not rising at the same rate as the demand for food. The main issues for agriculture worldwide are drought, salt stress, and low temperatures because these adverse environmental factors prevent plants from realizing their full genetic potential.

Drought stress

Drought stress is one of the abiotic stresses that is seen as posing the greatest risk to maintaining food security in the present and more so in the future climates. In India, almost 58% (80 M ha) of the net sown area is still rainfed, which provides to 40% of food grain output and feeds 2/3 of the animal population. Drought is a major threat to food security, as it can significantly reduce crop yields and cause widespread food shortages. As a result, plant breeders have been working to develop crops that are more resistant to drought, a process known as breeding for drought resistance.

Breeding for drought resistance is a multi-step process that involves identifying and selecting plants with desirable traits, such as increased root depth or improved water-use efficiency.

Mineral stress

Mineral stress, caused by a lack of essential minerals in soil, can have a significant impact on crop growth and productivity. To overcome this challenge, plant breeders have been developing new crop varieties that are more resistant to mineral stress, a process known as breeding for mineral stress resistance. Breeding for mineral stress resistance is a multi-step process that involves identifying and selecting plants with desirable traits, such as increased nutrient uptake or improved mineral use efficiency.

Heat and cold stress

Heat and cold stress can have a significant impact on crop growth and productivity, as extreme temperatures can cause damage to plant tissues and reduce yields. To overcome this challenge, plant breeders have been developing new crop varieties that are more resistant to heat and cold stress, a process known as breeding for heat and cold resistance.

Breeding for heat and cold resistance is a multi-step process that involves identifying and selecting plants with desirable traits, such as increased tolerance to high or low temperatures.

Sources of abiotic stress resistance

The sources of abiotic tolerance in crop plants are well documented. Land races, wild cousins, high-yielding variants, initial breeding materials, and advanced breeding materials can all contain tolerance. It has been effective to create open pollinated varieties or hybrids for water-scarce situations using landraces from dry habitats. We always considered potential sources of abiotic stress to be wild species and the ancestors of our farmed crops. The likelihood of discovering the necessary genes, along with the anticipated challenges and likelihood of success in introducing these genes into the selected recurrent cultivar, all play a role in the choice of genetic resource to be used as donor for abiotic stress tolerance. Genetic engineering can introduce biotic and abiotic stress.

Genetics of abiotic stress tolerance

Information on the genetic basis of abiotic stress tolerance, mode of inheritance, size of gene effects, heterosis, combining ability, and their mechanism of action are required to plan effective breeding programmes for creating abiotic stress tolerant cultivars.

Breeding methodology

The form of reproduction of the species, whether it be self-pollinating, cross-pollinating, or asexual, should be taken into consideration before choosing any breeding approach for any crops. The cultivar variety linked to the genetic regulation of characteristics. It can be challenging to breed a species for more than one robust characteristic at a time because individual plants respond to comparable abiotic stress sources so differently, but that is exactly what plant breeders are aiming for. The same breeding techniques used for yield and other economic features are used to breed for drought tolerance. For self-pollinated crops, pedigree and bulk methods could be utilized, and for cross-pollinated crops, recurrent selection. However, back cross is the recommended technique if the goal is to transmit a small number of features related to drought tolerance to a genotype that yields well. Contrarily, biparental mating (half-sibling and full-sibling combinations) preserves the wide genetic basis and offers the opportunity to generate the desired genotype of drought tolerance Crop cultivars resistant to drought can be created by selection, hybridization, introduction, and mutation. Salinity-tolerant varieties were created using pedigree, modified bulk pedigree, and a different culture-based method. Genetic modification for effective stress tolerance is challenging because of the intricate characteristics of abiotic stress occurrences in plants. Breeding under abiotic stress is a crucial strategy for preventing yield loss. Researchers from all around the world are working hard to create hybrids and cultivars with enhanced heterosis under stressful situations. The most promising, resource-efficient, economically viable, and politically correct strategy is to create crop types that are tolerant to heat, salt, and drought.

Another approach to breeding for abiotic stress resistance is the use of 'marker-assisted selection' (MAS). This involves using molecular markers to identify plants that carry genes for stress tolerance, and then using these markers to select for these plants in the breeding process. This helps to speed up the selection process and reduce the time it takes to develop new crop varieties. Other tools such as genetic engineering and gene editing have also been used to develop crops that are more resistant to abiotic stress. For example, scientists have successfully introduced stress-tolerant genes into crops, such as rice, to improve their tolerance to drought and high temperatures.

Conclusion

In conclusion, breeding for resistance to abiotic stress is an essential aspect of modern agriculture, as it helps to improve crop productivity in the face of environmental challenges. By combining conventional breeding techniques with modern biotechnology tools, plant breeders are developing new crop varieties that are more resistant to abiotic stress, helping to ensure food security for future generations.■

HARVESTING SUSTAINABILITY

REVOLUTIONIZED AGRICULTURE WITH CIRCULAR ECONOMY APPROACHES

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The foundation of human civilization involves the agricultural system, which supplies our demands for food. Nevertheless, due to the negative impact they have on the environment, traditional farming practices have come under scrutiny. Around 31% of the world's greenhouse gas emissions are linked to changes in agriculture and land use, making this sector of the economy an important factor in climate change. According to the IPCC, if current unsustainable food systems and consumption habits are not transformed, food-related CO_2 emissions could double by 2050. These encouraged the adoption of circular economy systems

used in farming, often known as circular agriculture. In contrast to the conventional linear economy, which has a "take-make-dispose" pattern, a circular economy reuses, recycles, or reprocesses the resources that were initially intended for disposal. By doing this, less resources are used, less waste is produced, and fewer CO_2 emissions are generated from products that were previously considered to be waste.

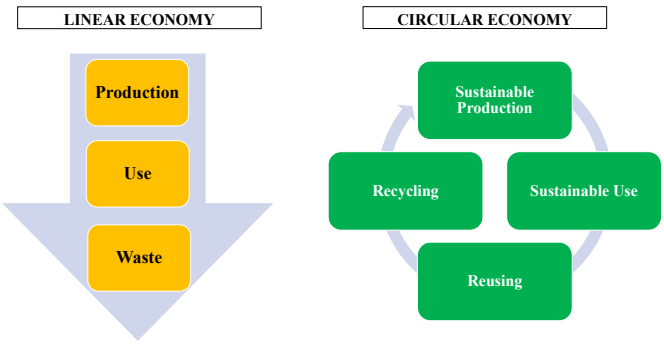
The principles and benefits

Circular agriculture is based on three core principles, *viz*. reduction of wastages, recycling of materials or products, and reusing of materials and the benefits of circular agriculture are:

- **Resource efficiency:** By maximizing the use of resources like water, fertilizers, and energy, circular agriculture minimizes the demand for external inputs.
- **Increases soil fertility:** Circular agriculture can assist boost soil fertility and lessen the need for chemical fertilizers by using natural inputs like animal manure, crop rotation, and cover crops.
- **Less environmental pollution and combat climate change:** By using fewer synthetic chemicals and reducing soil and water pollution, circular agriculture creates a healthier ecosystem. According to IPCC, circular agriculture could lower the food industry's greenhouse gas emissions by 20% in 2050.
- **Climate resilience:** The diversified and adaptable strategies used in circular agriculture make farms more resilient to the effects of climate change, assuring steady food production.
- **Economic viability:** While requiring initial investments, circular agriculture offers long-term economic benefits through reduced costs and increased yields.

Optimization of food chain from farm to fork- closing the loop

The term "circular agriculture" refers to a broad strategy for developing sustainable food systems. With a strong focus on promoting sustainable development, this strategy entails optimizing each stage of the food cycle, from production and harvest to packing, transportation, marketing, consumption, and disposal. Circular agriculture's fundamental principles include the integration of mixed crop-livestock and organic farming, precision farming, agroforestry, and the appropriate recycling and reuse of water and wastewater. These approaches are what give circular agriculture its fundamental strength. The combined objective of these strategies is to accomplish a number of goals, including minimizing carbon dioxide emissions, increasing the effective use of natural resources, and drastically reducing input consumption. Circular agriculture encourages improvements to on-farm grain storage, cold storage facilities for fresh produce, effective transportation systems, market connections, and thorough training in best practices for post-harvest management in order to reduce post-harvest losses. More emphasis is given in the use of recyclable paper or plastic, reusable packaging options, biodegradable materials obtained from sources like corn starch or sugarcane, and minimalist designs that lower overall production of waste. Circular agriculture places a focus on turning food waste and agricultural by-products into biofuels like ethanol or biodiesel through procedures like fermentation or trans esterification. These biofuels serve as renewable energy sources for transportation and heating. The Sustainable Development Goals (SDGs) of the United Nations, such as Zero Hunger (SDG 2), Clean Water and Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), Responsible Consumption and Production (SDG 12), and Climate Action (SDG 13), are all perfectly aligned with these circular agricultural practices. Circular agriculture reveals its potential to greatly contribute to a more sustainable and resilient future through its all-encompassing and deliberate approach.



A case study

In India, rice farming and fish farming are combined in a symbiotic system where the rice receives nutrients from the fish and the fish use the rice fields as ponds during the rainy season. Rice yields from the rice-fish farming integration system were increased to 10-26 % higher, lower 19-22 % labour input and 7 % material inputs. Additionally, it has been estimated that methane emission was 34.6 % less than that from a rice monoculture cultivation system.

Conclusion

Traditional farming faces environmental issues, but circular agriculture provides a sustainable solution by focusing on waste reduction, recycling, and resource efficiency. It promotes a healthier ecosystem and more climate resilience while increasing resource efficiency, lowering the demand for external inputs, and improving soil health. Its long-term economic potential is unquestionable, even though it could require initial investments.

Future prospects

Circular agriculture is gaining popularity as environmental issues become more widely recognized. It will be even more effective as a result of ongoing research and technological developments. Circular agriculture is positioned as a major tool for tackling global sustainability objectives because to its alignment with the UN's Sustainable Development Goals, opening the door to a peaceful and prosperous future.■

EXPORT PERFORMANCE OF TEA IN INDIA

PROBLEMS AND PROSPECTS

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Plantation sector plays an significant role in export to meet the domestic requirement in employment generation and poverty development, mainly in rural areas. The total production of tea in India is 1,208,780 million tonnes. India is the world's second-largest producer of tea and fourth-largest exporter, and Assam is the state with the most tea-growing land, accounting for half of the nation's total production. Tea (*Camellia sinensis)* is the second broadly consumed drink world-wide after water. This popularity of tea is most probably due to its pleasant flavor and supposed health benefits against cardiovascular disease and chronic pathologies such as cancer. Plantation sector pays to the employment both directly and indirectly to Indian people. More than two millions people are engaged in plantation sector directly. Tea is mainly cultivated in North-east and Southern part of India. The tender buds and leaves of the plant are used to produce tea.

Geographical Indication (GI) Tag: Darjeeling Tea is also known as "Champagne of teas", globally because of its flowery aroma was the first GI tag product.

INTERNATIONAL TEA DAY

IT IS OBSERVED ON 21ST MAY EVERY YEAR, IT WAS DESIGNATED BY THE UNITED NATIONS GENERAL ASSEMBLY IN DECEMBER 2019.

Other two variants of Darjeeling tea, are green and white tea also hold GI tags.

Health benefits of tea

- Tea contains abundant antioxidants.
- Tea has less caffeine as compared to coffee.
- Tea may help in reducing the risk of cardiovascular diseases and stroke.
- Tea may burn fat and improves physical performance.
- Improves dental health and helps to reduce hair loss.
- Lower the risk of various types of cancer.
- Helps to prevent HIV.

Risk factors for health-related to tea consumption

Green tea should not be taken by patients suffering from heart conditions or major cardiovascular problems, Pregnant and breast feeding women should not drink tea more than one or two cups per day, because caffeine can cause an increase in heart rhythm. It is also important to control the associated consumption of green tea and some drugs, due to caffeine's diuretic effects. Patients with kidney failure are also recommended to drink less green tea to avoid neurological diseases.

Tea board

It is a statutory body under the Ministry of Commerce that was set up in 1953 for the development of tea industry in India. Its vision is to make the country

a leading producer of tea across the world for which it established programme and schemes.

Indian's position in world tea exports

The performance of India's tea export comparing it with the tea export act of other major tea exporting countries. India is one of the top 5 exporters of tea in the world, accounting for 10 per cent of all exports. Black tea, regular tea, herbal tea, green tea, lemon tea and masala tea are among the varieties of tea exported through India. Out of these, Black tea, regular tea and green tea account for roughly 80 per cent, 16 per cent and 3.5 per cent of the total tea exported from India respectively.

In 2021-2022, India's total exports in quantity were 201 million kg and total exports were 65 million kg, the unit price of tea was US$ 3.62 per kg. In previous year, was US$ 3.52 per kg. From 2018-2019, the price per unit of tea exported out of India has increased by 17 per cent in 2021-2022. This has allowed the country to have better productivity out of the exported goods.

Incentives to exports

To help the Indian exporters to market tea of Indian origin in overseas market on a sustained basis, the Tea board of India started a scheme: Promotion of packaged tea of Indian origin.

- Tea Development and Promotion Scheme**:** This scheme was launched in November 2021 by the Tea Board of India for the period of 2021-2026. The main objective of this scheme is to increase the productivity and quality of the production in India.
- A systematic monitoring system was implemented to protect Darjeeling tea in major export markets.
- Remuneration for eligible exporter's participation and travel expenses at trade shows in overseas markets.

Problems of tea exports

At present China is the leading exporter of tea on the world. In 2022, China exported around 375 thousand metric tonnes of tea price nearly 2.1 billion US$, at least a quarter of the worldwide supply. Indian tea is being exported to different parts of the world, yet India's share in the world trade is less than 15 per cent. The export units are facing so many problems related to the purchase order, execution of the order, lack of information, modernization, delayed payments, transport, communication and nature of intermediaries abroad and also marketing strategies of the exporters.

Suggestions

- Improvement of Supply chain management inside the country and global tea marketing network has to be made.
- It has been observed that the actual producer of tea has no direct link with the final consumer. Tea producers sell their products to the wholesale purchaser through direct sale or through sale to big buyers. Therefore, the producers do not understand the market demand and choice of the customer, it is important in today's market economy for long term sustainability of the industry, with the withdrawal of sales restriction, the growers can directly go to the market by building their own brand.
- Reduction in cost of production, improving infrastructure, extensive research, Quality Enhancement and Improvement through training.■

AVOCADO | A SUPER-FRUIT FOR HUMAN HEALTH. WEALTH AND PROSPERITY

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People are becoming more conscious of their health today. Fruits high in phytonutrients are gaining popularity across the world as people become more aware of their value as nutraceuticals. Avocado is one of the wonderful fruit crops with several nutraceutical and health benefits. It contains fat-soluble vitamins that are uncommon in other fruits, as well as significant quantities of protein, minerals, and unsaturated fatty acids. The avocado pulp contains varying amounts of oil and is frequently used in the pharmaceutical and cosmetics industries. Fruit contributes to a healthy diet, particularly in lowering cholesterol, curing diabetes, and avoiding heart disease.

Avocado (*Persea americana* Mill.) is one of the important exotic super fruits belonging to the family Lauraceae. Due to its similarity to butter, its smooth pulp texture, and the absence of any pulp flavour, it is sometimes known as "butter fruit," "vegetable butter," or "butter pear." It is also referred to as Alligator Pear and Fruit of the New World. It is a quick-growing, beautiful tree with dark-green foliage that may grow to a height of 20 meters. The fruits are dark greenish to purplish black in colour, pear-shaped, egg-shaped, or spherical, with thin or thick skin and a smooth or rough surface. The fruit size varies from as small as 120 g to as large as 2.5 kg. The flesh is greenish

or yellowish with a buttery consistency, a rich, nutty flavour, and a single seed, depending on the variety. It is regarded as one of the tropical fruit crops that may grow in subtropical climates. Mexico is the largest producer, followed by Colombia, the Dominican Republic etc. It was introduced in India from Sri Lanka by an American missionary, who lived in Bangalore between the years 1906 and 1914. The avocado is one of the underutilized fruit crops in India with potential for commercialization. It is irregularly cultivated in the Kodaikanal, Ooty area of Tamil Nadu, Gundlupet and Kodagu region of Karnataka, Kerala and some part of Maharashtra, and a minor area in North Eastern India at elevations of 800-1,600 meters. These regions may produce roughly 5000 tonnes of avocados annually, and production increases quickly. Due to their high nutritional value, abundance of dietary vitamins and minerals, as well as their presence of important phytochemicals avocados are becoming more and more popular, both internationally and in India. It has the potential to become an export crop having international importance.

Nutritional and food value

Avocado's nutritional quality has been demonstrated to be remarkable, with various key constituents (Table 1). Avocado has four times more nutritional value than any other fruit except banana, which has the highest energy value (245 cal/100 g). It is well-known for its fat-soluble vitamins, including Vitamins A and B (thiamine, riboflavin, and niacin), median levels of Vitamins D and E, ascorbic acid, and folic acid, as well as its phytochemical components, which are absent in other fruits. The avocado fruit is also known to contain significant amounts of saturated fatty acids (palmitic and stearic acids), low levels of polyunsaturated fatty acids (linoleic acid), and high levels of monounsaturated fatty acids (oleic and palmitoleic acids) that are enhanced with polar lipids, such as glycolipids and phospholipids. Thus, it can efficiently raise the good high-density lipoprotein (HDL) cholesterol and lower the undesirable low-density lipoprotein (LDL). The pulp is a rich source of proteins (up to 4%) and, but low in carbohydrates. Avocados are rich in potassium, magnesium, calcium, and salt, as well as other minerals like iron, selenium, and zinc etc.

Avocado is frequently consumed in salads, as sandwich filler, and in soups. It is widely consumed across the world as fresh fruit. It can also be used in ice cream and milk-shakes, vinegar, and the pulp may be preserved by freezing. Some processed avocado products, including Arka avocado chutney, Arka avocado bread spread, and Spray dry avocado powder, were developed by the Indian Institute of Horticultural Research in Bengaluru. The oil extracted from avocado can be used for cooking, salads, marinades, skin care products, sunscreen lotions, moisturisers, makeup bases, etc.

Medicinal and therapeutic value

Avocado has become well known and respected for its medical and therapeutic benefits in addition to its nutritional value. It may help to prevent chronic conditions such as cardiovascular diseases, cancer, diabetes as well as aging, eye, and skin diseases, obesity, and osteoarthritis etc. Due to their high monounsaturated fat and folate content, avocados help to maintain a healthy heart and are linked to lower blood pressure. The β-sitosterol activity helps in weight loss by reducing compulsive eating binge and fat accumulation in the abdominal region. Avocado also contains lutein, a pigment that helps fight against prostate cancer and retinal disorders including cataracts and macular degeneration. It contains different oil levels in the pulp; thus, it is widely used in the pharmaceutical and cosmetic industries and for obtaining commercial oils similar to olive oil because of their similar fatty acid composition.

Conclusion

The demand for avocados is rising as a result of rising health awareness among the people and their very profitable nature. It is attracting a lot of people to consume it in their daily diet due to its high nutraceutical content, medicinal value, and utility of its high-quality fats in boosting the health of the heart and circulatory system. Avocados can be a gateway fruit for the future in India, which is a market for avocados with a lot of potential. There is tremendous potential for avocado cultivation in India since a sizable portion of the country is ideal for avocado farming.■

Table 1. Nutritional value of avocado fruit per 100-gram edible portion

Approximate composition (100 g of edible portion)		Mineral composition (100 g of edible Portion)		Vitamin content (100 g of edible Portion)	
Composition	**Value / 100g**	**Minerals**	**Value / 100g**	**Vitamin**	**Value / 100g**
Water (g)	72.3	Calcium (mg)	13.0	Vitamin A (µg)	7
Energy (kcal)	167	Potassium (mg)	507	Vitamin C (mg)	8.80
Protein (g)	1.96	Magnesium (mg)	29.0	Thiamin (mg)	0.08
Carbohydrate(g)	8.64	Phosphorus (mg)	54.0	Riboflavin (mg)	0.14
Fiber (g)	6.80	Sodium (mg)	8.0	Niacin (mg)	1.91
Total lipid (fat) (g)	15.4	Zinc (mg)	0.68	Vitamin B-6 (mg)	0.29
Saturated fats (g)	2.13	Selenium (ug)	0.40	Vitamin E (mg)	1.97
Monounsaturated fatty acids (g)	9.8	Iron (mg)	0.61	Vitamin K (µg)	21
Polyunsaturated fatty acids (g)	1.82	Copper (mg)	0.17	Folate (µg)	89

FARMERS' DECISION-MAKING PROCESSES

INSIGHTS FROM BEHAVIOURAL ECONOMICS

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The decision-making processes of farmers hold paramount significance, shaping not only their own livelihoods but also influencing the broader agricultural landscape. By applying the principles of this interdisciplinary field, it unveils a deeper understanding of the multifaceted factors that govern farmers' decisions, offering valuable insights into their behaviour and its implications for the agricultural sector. The foundation of this exploration lies in a primer on behavioural economics, a discipline that bridges the gap between psychology and economics. It illuminates how farmers' choices often deviate from the classical rational model, shedding light on the cognitive biases, heuristics, and psychological factors that sway their decision-making processes. With this foundational knowledge, the article embarks on a comprehensive analysis of the factors that exert influence over farmers' choices, both internal and external.

One crucial aspect that emerges is the role of framing and choice architecture in shaping farmers' decisions. The article explains how the presentation of information, as well as the structuring of choices, can significantly impact the outcomes of their choices. By dissecting these elements, it underscores the power of subtle cues and contextual factors in guiding agricultural decisions. Furthermore, the article discusses the omnipresent specter of risk and uncertainty in agriculture. It examines how farmers grapple with the inherent unpredictability of their profession and how behavioural economics provides a framework for understanding their risk preferences and strategies for risk management. This section also explores the emotional and cognitive dimensions of risk perception, shedding light on the interplay between psychology and economics in agricultural decision-making.

The insights garnered from behavioural economics are not confined to academia alone; they have tangible implications for agricultural policy. The article expounds on the potential applications of behavioural insights in crafting more effective and farmer-centric agricultural policies. By aligning policy interventions with the behavioural tendencies of farmers, governments and agricultural organizations can optimize their efforts to enhance productivity, sustainability, and overall well-being within the agricultural sector.

Behavioural economics:

a. Explanation of major concepts in Behavioural economics

Behavioural economics is a branch of economics that incorporates insights from psychology and other social sciences to understand how individuals make economic decisions. major concepts in Behavioural economics include:

- **Bounded rationality:** People have limited cognitive resources, and they make decisions within these constraints. They may not always make perfectly rational choices, as assumed in traditional economics.
- **Cognitive biases:** Cognitive biases are systematic errors in thinking that affect decision-making. Examples include confirmation bias (seeking information that confirms preexisting beliefs) and overconfidence (overestimating one's own abilities).
- **Prospect theory:** Developed by Daniel Kahneman and Amos Tversky, prospect theory suggests that people evaluate potential outcomes based on perceived gains and losses relative to a reference point, rather than in absolute terms.
- **Loss aversion:** This is a fundamental concept in Behavioural economics. People tend to place more weight on avoiding losses than on acquiring equivalent gains.
- **Anchoring:** Individuals often rely on the first piece of information they encounter (the "anchor") when making decisions, even if it's irrelevant to the decision at hand.

b. How behavioural economics differs from traditional economic models

Traditional economic models assume that individuals are perfectly rational and utility-maximizing. In contrast, behavioural economics recognizes that human decision-making is influenced by various psychological and social factors, leading to deviations from strict rationality. Here are some key differences:

- **Predictive power:** Behavioural economics offers a more accurate predictive framework for

understanding real-world decisions. It acknowledges that people often deviate from the rational actor model.

- **Policy implications:** Traditional economics assumes that individuals will always make choices that are in their best interest. Behavioural economics suggests that policies should consider these deviations and employ "nudging" strategies to guide individuals toward better decisions.
- **Complexity:** Behavioural economics acknowledges the complexity of human decision-making, integrating insights from psychology, sociology, and neuroscience into economic analysis.

Risk and uncertainty in agriculture

a. Farmer responses to risk and uncertainty

Farmers face inherent risks in agriculture, including weather-related uncertainties and market fluctuations. Their responses to these risks can be influenced by psychological factors like loss aversion and cognitive biases. These responses may include risk-averse behaviour, diversification of crops, or adopting insurance schemes.

b. Prospect theory and its application in farming decisions

Prospect theory's insights into how individuals evaluate gains and losses can be applied to understand how farmers respond to price volatility, weather shocks, and other uncertainties. Policymakers can use this knowledge to design risk management programs that align with farmers' decision-making tendencies.

Behavioural insights in agricultural policy

a. Examples of policies informed by behavioural economics

Several agricultural policies have integrated behavioural insights. For example, subsidies for sustainable farming practices, simplified enrolment procedures for agricultural insurance, and targeted information campaigns to encourage responsible pesticide use are all influenced by Behavioural economics principles.

The potential for improving policy effectiveness through behavioural insights

By understanding how farmers make decisions and the biases that influence them, policymakers can design more effective agricultural policies. Tailoring interventions to align with farmers' natural inclinations can lead to higher compliance and better outcomes in areas such as conservation, food safety, and land management.

Practical implications

How farmers can apply behavioural insights to their decision-making

Farmers can benefit from awareness of cognitive biases and Behavioural principles. They can seek unbiased information, consider the framing of decisions, and actively manage their emotional responses to make more informed and rational choices.

The role of agricultural advisors in facilitating better choices

Agricultural advisors can play a crucial role in helping farmers apply Behavioural insights. They can provide personalized advice, offer decision-making tools, and create educational programs that take into account farmers' psychological and social contexts.

Conclusion:

Behavioural economics provides a valuable framework for understanding the complexities of farmers' decision-making processes. By acknowledging the influence of psychological biases, social factors, and decision architecture, policymakers, farmers, and agricultural advisors can work together to develop more effective strategies and policies that promote sustainable and profitable agricultural practices while respecting the realities of human behaviour. This interdisciplinary approach has the potential to drive positive change in the agricultural sector, benefiting both farmers and society as a whole.

■■■

AUTO-IRRIGATION SYSTEM
A NEED OF MODERN FARMER

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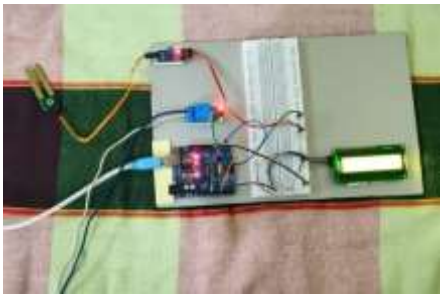
One of the various problems faced by farmers in their day to day farming activities is the constant need to watch over-irrigation. Many times, the farmer must travel several kilometres to reach their fields and irrigation pumps. Hence, a huge amount of time and effort is expended daily in a farmer's life to irrigate the field when this time could be made use by the farmer at other farms such as animal husbandries which requires much more continuous observation and care. Through this paper, a project is proposed where a system is created to completely automate the process of irrigation such that none to minimal human intervention is required. The aim is to set up a wireless sensor network in the field which will collect data about the moisture in the soil and send information to start the water pump.

In developing countries the economy is highly based on agriculture

but we lack in proper utilization of resources available to us. This is mainly because of the unplanned use of water for irrigation. Although there are many modern irrigation techniques like drip irrigation and sprinkler irrigation farmers have to visit the farms in person regularly in order to water their crops. i.e. it is manually controlled. All these problems results in wastage of human and agricultural resources as well as time. Hence, there is a need for making an automatic irrigation system. Literature reports different techniques implemented for automatic irrigation systems if the level goes below the threshold.



Purpose

The automatic irrigation system shows a well-established combination of Arduino Uno, Soil Moisture Sensor, Water Pump and their interconnection. This system has been designed to achieve the following properties:

- To increase the production by using better irrigation system.
- To manage the water supply for proper cultivation of plants.
- To reduce man power.
- To take proper action regarding the condition of the soil through the proposed system.

Components required for the automatic irrigation system

The project requires very few components and the connection is also very simple. The components are listed below:

- Arduino * 1
- Moisture sensor * 1
- 5v relay module * 1
- Water pump*1
- Connecting wires

Arduino

The Arduino uno is a microcontroller which is based on the ATmega328 datasheet. It has 14 digital inputs /output pins. It is an open source

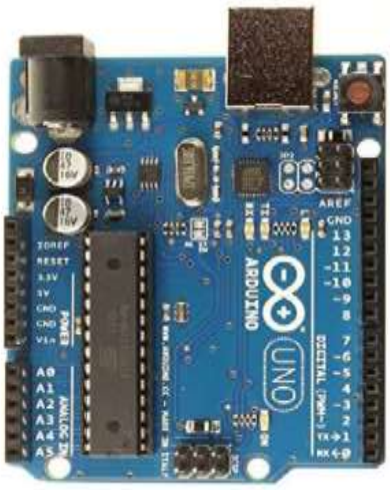


Fig 1 : Arduino Uno

microcontroller which is used to control relay, simply connect to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. It is large assortment of included libraries for interfacing to wide range of hardware. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip.

Relay

One-channel relay board which operates on 5-6V is used here. The relay board consists of three pins which are normally open (NO), normally closed (NC) and common (C). The common pin is connected to NC pin when the relay is off and to the NO pin when the relay is on. The input pin receives logic high from Arduino Uno and in turn switches on the relay, thus common are connected to NO which turns the device on till the relay is on. The “VCC” and “GND” pins of the relay are connected to 5V supply and ground respectively

Water pump

The water pump is used to artificially supply water for a particular task. It can be electronically controlled by interfacing it to a microcontroller. It can be triggered ON/OFF by sending signals as required. The process of artificially supplying water is known as pumping. There are many varieties of water pumps used. This project employs the use of a submersible water pump which is connected to power supply through relay.

Soil moisture

Sensors A soil moisture sensor measures the water content in soil by measuring the dielectric permittivity of the soil as a function of water content. The volumetric water content is measured by the soil moisture sensor indirectly by properties like electrical resistance and dielectric constant. Using this we can reduce manpower, save water to improve production and gravimetric method

Flow chart and working

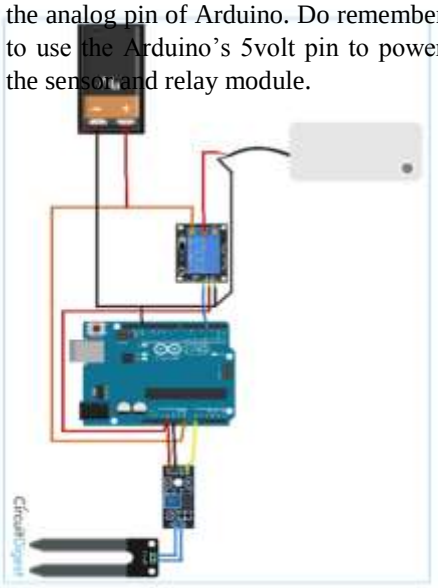
The depicts the flow chart of automatic water irrigation system. The Arduino Uno is a link between the soil moisture sensor and pumping motor. Arduino is supplied with a power of 7V to 12V. The pump motor is given a separate supply of 9V. The soil moisture sensor is used in this project because it has to check soil moisture to measure the electrical conductivity of soil. The moisture sensor provides an analogue output which can be easily interfaced with Arduino. In this project two sensors are connected to analogue pins A0 and A1 of the Arduino board. The system receives a signal from the soil moisture sensor and compares with the preset threshold value. If the value detected by the sensor is below the threshold value, the Arduino sends a message signal to the motor to fetch water. But when the value detected by the sensor is above the preset value, the motor doesn’t rotate. The Arduino always accepts the signal from the sensor and keeps updating its data.

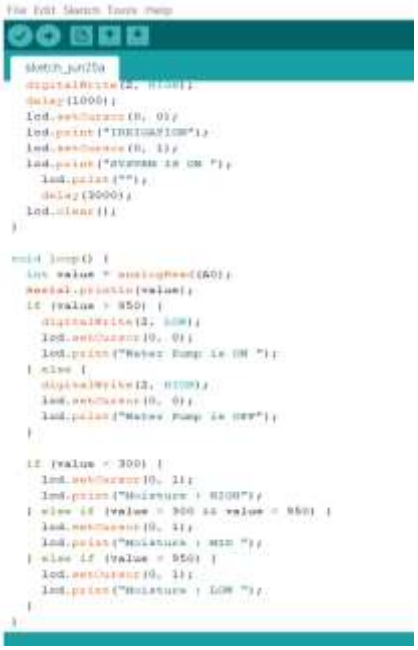
Circuit diagram of the arduino automatic irrigation system

In this section, I will explain all the details with the help of the schematic diagram. The **Arduino UNO** is the brain of this whole project. It controls the

motor pump according to the moisture in the soil which is given by the moisture sensor.

To power the circuit, I am using an external Battery. You can use any 9v or 12-volt battery. The battery is connected to the Vin and ground pins of Arduino and we can also connect the motor to this battery via a relay. Moisture sensor output is connected to the analog pin of Arduino. Do remember to use the Arduino's 5volt pin to power the sensor and relay module.





Results and discussions

The system was tested soil under the dry and wet conditions. Using these results a maximum value for the dryness of the soil is set that is 1023 and minimum value is 300. Maximum value is taken as 1023 since the soil moisture sensor can measure value up to this. So, if the measured value by the sensor is between 1023 to 300 the motor will turn on automatically and initiates supply of water to the crops. However, if the measured value is less than 300 it implies that the soil is wet and hence the motor remains off and no water is supplied to the crops.

Conclusions and future scope

The Arduino based automatic irrigation system is simple and precise way of irrigation. Hence, this system is very useful as it reduces manual work of the farmers and also helps in the proper utilization of resources. It eliminates the manual switching mechanism used by the farmers to ON/OFF the irrigation system. This project can be extended to greenhouses where manual supervision is less. Fully automated gardens and farm lands can be created using this principle in the right manner on large scale.

■■■

REMOTE SENSING IN AGRICULTURE

REVOLUTIONIZING FARMING THROUGH TECHNOLOGY

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Agriculture is the bedrock of civilization, feeding billions across the globe and shaping landscapes. But it comes with challenges, not the least of which are resource management, environmental sustainability, and maximizing yields. In recent years, an emerging technology is poised to transform the face of agriculture: remote sensing. This article

explores the multifaceted applications, the science behind it, and the potential it holds for a sustainable agricultural future.

Understanding remote sensing

At its core, remote sensing is the collection of data from a distance, often using satellites or drones. It's non-invasive, efficient, and immensely versatile. In agriculture, it provides a fresh perspective on how we manage our farms.

Applications of remote sensing in agriculture

- **Crop monitoring:** One of the most impactful uses of remote sensing is in crop monitoring. Satellites orbiting the Earth capture data about vegetation cover, helping farmers monitor crop health, growth, and potential threats. This real-time information allows for timely interventions to protect crops and optimize their yield.
- **Soil quality assessment:** Understanding the health of the soil is fundamental for any farming operation. Remote sensing techniques can analyze soil properties, from texture to moisture levels. It can even detect issues like erosion or nutrient deficiencies. By doing so, it empowers farmers to take precise actions to enhance soil health.
- **Precision agriculture:** Precision agriculture is all about fine-tuning the farming process. Remote sensing plays a pivotal role here. By analyzing data from satellites and drones, farmers can tailor their practices to specific areas within their fields. This approach boosts crop yields and minimizes resource wastage.
- **Water resource management:** Water is a precious resource in agriculture. Remote sensing technology helps manage irrigation efficiently by tracking moisture levels in soil. It also aids in assessing drought risk, allowing farmers to make informed decisions about water allocation.

How remote sensing works

Remote sensing technology involves a range of tools and technologies. Satellites are the primary data source for global-scale monitoring, capturing images in various wavelengths. Drones are a more localized but highly adaptable alternative, suitable for high-resolution imagery. Sensors, often equipped on these platforms, collect data by measuring reflected light, temperature, or other environmental factors.

The role of GIS in remote sensing

The utility of remote sensing data significantly expands when integrated with Geographic Information Systems (GIS). GIS software allows for the analysis, interpretation, and visualization of the vast amount of data collected through remote sensing. It transforms raw data into actionable information, enabling better decision-making in agriculture.

Benefits of remote sensing in agriculture

- **Increase in productivity:** With a data-driven approach, remote sensing empowers farmers to make precise decisions. By knowing where to allocate resources and when to intervene, it is possible to significantly increase productivity. More crops are grown on less land, reducing the pressure to clear forests for farming.
- **Environmental sustainability:** Sustainability is at the heart of modern agriculture. Remote sensing minimizes the environmental impact of farming. By optimizing resource use, from water to fertilizers, it helps reduce the carbon footprint of agriculture.
- **Early detection of issues:** Crop diseases, nutrient deficiencies, and soil erosion can spell disaster if not addressed promptly. Remote sensing can detect these issues early, offering a window for intervention before significant losses occur.
- **Data-driven decision making:** Data is the backbone of modern agriculture. Remote sensing delivers data that guides the decision-making process. Whether it's choosing when to plant or which areas need more water, farmers can rely on data to make informed choices.

Challenges and limitations:

While the potential of remote sensing in agriculture is immense, there are challenges. Initial implementation costs can be prohibitive for some farmers, and there's a need for training and awareness to make the most of this technology. Additionally, privacy and data security issues need to be addressed.

Future trends and development

The future of remote sensing in agriculture holds exciting possibilities. Emerging technologies, such as artificial intelligence and machine learning, are being integrated into remote sensing systems. This means more accurate predictions, more targeted interventions, and even greater resource efficiency.

Conclusion

Remote sensing has become a crucial tool for modern agriculture. It's no longer a luxury but a necessity for managing resources efficiently and sustainably. With its ability to monitor crops, assess soil, enable precision agriculture, and manage water resources, remote sensing is revolutionizing farming. The future of agriculture is one where data-driven decision-making and environmental sustainability are at the forefront, and remote sensing is leading the way. As the global population continues to grow, it's reassuring to know that we have this remarkable technology to support our efforts to feed the world while safeguarding the environment.■

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