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1. PATHOLOGY

Mushroom: A Fungi of Flavour, Nutrition, and Innovation

Hariharan Selvam

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Introduction

Fungi have long been cherished for their culinary delights and diverse applications in food production and biotechnology. Among them, mushrooms stand out for their unique flavours, textures, and nutritional richness. However, the world of mushrooms is not without its risks, as some species can be highly toxic. Proper identification is crucial to ensure safe consumption, especially considering mushrooms' ability to absorb environmental pollutants. Despite these challenges, the cultivation and utilization of edible fungi offer immense potential in various sectors.

Taxonomy and Cultivation

With an estimated 40,000 species, macrofungi, primarily belonging to the Basidiomycota and Ascomycota groups, dominate the fungal kingdom. Cultivated mushrooms such as button mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus sp.*), and Shiitake mushrooms (*Lentinula edodes*) are staples in many cuisines. Commercially harvested wild fungi like *Boletus* and *Chanterelles* are prized for their flavours and textures. The nutritional value of mushrooms, including proteins, fibres, minerals, and vitamins, contributes to their importance in human diets.

Biochemistry and Medicinal Properties

Beyond their culinary appeal, mushrooms offer a plethora of bioactive compounds with potential health benefits. Polysaccharides from mushrooms like *Macrolepiota procera* exhibit anti-inflammatory and probiotic effects, while various compounds have shown anti-aging and anti-cancer properties. Mushrooms are rich sources of proteins, amino acids, unsaturated fatty acids, carbohydrates, and B vitamins, making them comparable to animal products in nutritional value. Moreover, mushrooms contain antioxidants like β-glucans, phenolics, and selenium, which contribute to their medicinal properties.

Traditional and Ecological Importance

Mushrooms have deep-rooted cultural significance and have been used in traditional medicine for centuries. Their therapeutic properties, including immune-boosting and anti-tumor effects, have been well-documented. Furthermore, mushrooms play crucial ecological roles as decomposers and symbiotic partners with plants, aiding in nutrient cycling and soil health. Certain species have been utilized in bioremediation efforts to clean up environmental pollutants, showcasing their potential in environmental sustainability.

Innovations and Economic Opportunities

In recent years, mushrooms have garnered attention as sustainable alternatives to conventional meat products. Mushroom-based meat substitutes offer a rich source of protein with lower environmental impact. Additionally, mushrooms are being explored as biofuel sources due to their high cellulose content and efficient biomass conversion. The cultivation of mushrooms presents economic opportunities for rural communities, providing income generation and employment. Small-scale mushroom farming is accessible to smallholder farmers in developing regions, contributing to poverty alleviation and food security.

Conclusion

Research into the medicinal properties of mushrooms continues to expand, uncovering new therapeutic applications. Compounds isolated

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from mushrooms show promise in treating various ailments, including cancer, diabetes, and cardiovascular diseases. Furthermore, mushrooms are being investigated for their potential role in boosting cognitive function and improving mental health. The utilization of mushrooms offers innovative solutions to global challenges related to food security, environmental sustainability, and public health. Continued exploration and investment in mushroom research and cultivation hold the key to unlocking their full potential for the benefit of humanity and the planet.

References

Bilal, A. W 2010. Nutritional and medicinal importance of mushrooms, *Journal of Medicinal Plants Research*, 4(24): 2598-2604.

Valverde, M.E., Hernández-Pérez, T. and Paredes-López, O. 2015. Edible mushrooms: improving human health and promoting quality life. *International journal of microbiology*.

Zhu, F., Du, B., Bian, Z and Xu, B. 2015. Beta-glucans from edible and medicinal mushrooms: Characteristics, physicochemical and biological activities. *Journal of Food Composition and Analysis*, 41: 165-173.

2. ENTOMOLOGY

Bee Keeping: Conventional to Precision

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Abstract

The requirement for sensors and targeted software to optimise beekeeping management gave rise to precision beekeeping, which aims to provide beekeepers with insights into their hives' internal workings without requiring them to conduct physical inspections. By remotely providing real-time information about the hives, smart hives reduce stress in the colony and the costs associated with managing them. The health of the colonies, which under ideal circumstances are able to maintain consistent relative humidity and temperature, can be determined by keeping an eye on the hives' interior temperatures. In order to accurately assess the condition of bee colonies, it is also necessary to monitor the external environmental parameters.

Introduction

Precision agriculture (PA) is a farming management approach that enhances agricultural production sustainability by monitoring, measuring, and adapting to temporal and spatial variability. A variety of agricultural disciplines, including horticulture, viticulture, forestry, and animal husbandry, have developed techniques for precision agriculture, or PA. Furthermore, in recent times, Precision Beekeeping (PB) has emerged, initially delineated by Zacepins *et al*. (2012). Precision beekeeping compliments traditional beekeeping, which calls for the manual and periodic control of the apiaries, which are frequently located at great distances from one another and require a high cost to reach. Precision beekeeping is defined as an apiary management strategy based on monitoring individual bee colonies to minimise resource consumption and maximise bee productivity. On average, fifteen times a year, each hive is examined (Alleri *et al*., 2023).

How Precision Beekeeping (PB) works?

Beekeepers can select which hives to inspect directly by using PB's smart hives, which are fitted with sensors to identify parameters that describe the health of the colony and provide information through web-based systems that can be accessed via a smartphone. In order to remotely transmit the data gathered by the server, the sensors are connected to a battery-operated microcontroller that is often networked. The two primary microprocessor types in use today are Arduino and Raspberry Pi. The microprocessor gathers data at regular intervals and then transfers it to a server. The cloud receives the detected data and uses it for storage, processing, and alarm creation (Pejic *et al.*, 2022).

Wireless sensor networks (WSN) have been essential in the advancement of monitoring systems in recent years. A wireless sensor network (WSN) is made up of embedded devices that can gather data from various sensors, process it, and exchange it with a computer and a cloud database (Hadjur *et al.*, 2022 and Zacepins *et al.*, 2017). It keeps track of both internal and external hive metrics, including weight, relative humidity, internal temperature, flight activity, sounds, vibrations, and gasses (wind speed, rainfall, and ambient temperature and external parameters).

1. **Hive internal parameters:** Smart hives is to provide real-time information on the state of health of the colony and the quality of its internal environment important to control parameters inside the hive such as weight, temperature and relative humidity, sounds and vibrations.
    a. **Weight of the hive:** A hive's weight can reveal crucial details about the size and activity of the colony. Throughout the day, the hive's weight varies in a rather usual way. When the bees leave to forage in the morning, there is a reduction of roughly 300–500 g, and when they return with pollen and nectar, the weight progressively rises until well before dusk. This metric may fall by 200 g per night during the night as a result of bee consumption of honey. Most researches employ scales that measure the hive's overall weight and are externally positioned at the base of the colony. The mass sensor in Seritan *et al.* (2018) low-cost platform is made up of a single load cell with an accuracy of ±100 g and can detect up to 200 kg, whereas Ochoa *et al.* (2019) system makes use of four load cells positioned at each corner of the hive's base. However, the approach suggested by Sakanovic and Kevric (2020) uses twenty sensors two for each frame to determine the weight of every single frame in the hive.
    b. **Temperature:** A colony's internal temperature serves as the main health indicator.
    Temperature variations can occur in correspondence with natural events, such as swarming, or adverse events, such as a weakening of the colony, which is unable to keep the temperature stable. Andrijevic *et al.* (2022) approach involves the setup and transmission of a push message to notify of any hive changes, particularly when the interior temperature rises above 35 C. Conversely, in the model put out by Ochoa *et al.* (2019) an alert triggers the sending of an SMS, an email, and a voice call whenever the temperature near the brood falls below the 20 ◦C threshold.
    c. **Relative humidity**: Relative Humidity (RH) inside the hive can be considered as an indicator of health and optimal development of the bee colonies, which the bees are able to maintain a stable values of around 70%. For egg hatching, the optimal RH range goes from 90 to 95%, while values lower than 50% hinder this phase. RH can also influence the development of parasites and pathogens; specifically, values between 55% and 70% favour the reproduction of varroa (*Varroa destructor*), while higher values reduce its reproduction. DHT22 sensor is also used for RH measurement, having a 0–100% RH measurement range with 2% accuracy and 0.1% resolution (Abou-Shaara *et al.*, 2017 and Cecchi *et al.*, 2020).
    d. **Flight activity**: Bee flight activity measures how many bees come into and go out of the hive in a given amount of time. The number of bees that leave the hive to feed is positively correlated with increases in ambient temperature and sun radiation, but negatively correlated with increases in ambient relative humidity. There is information available about the flight activity of bees in relation to colony populations, foraging activity, pesticide impacts on bees, and bee-eaters (*Merops apiaster*) and other natural enemies (Bermig *et al.*, 2020 and Alleri *et al.*, 2023). The BeeCheck

counting system, which can distinguish between entering and outgoing bees, is comprised of 24 polyethylene entrance tubes, each containing seven capacitive sensors. As the bees pass through the tubes, an electrical capacity change is produced, which serves as a signal. The use of a camera does not disrupt the bees' typical behavior in any way and enables the collection of additional data, including hornet predation, parasite detection (such as varroa), and corbicular pollen loading.

e. **Sounds and vibrations:** Bees communicate within the colony through vibrations and sound signals. Continuous sound monitoring can provide important information on bee health. It can be used to detect the presence of the queen, predict swarming or pillaging, colony strength, the presence of parasites and predators (Alleri *et al.*, 2023). Upon emergence, queen bees produce sounds at different frequencies: 400 Hz on the first day and 500 Hz on the second and fourth days after birth. Prior to flickering, they release a series of brief pulses at a frequency of approximately 350 Hz. After a few days, they have about seven brief pulses, down from about seventeen at first. Bees emit a unique sound at a frequency of 1500 Hz that can be heard 5–6 meters away from the hive prior to swarming. In response to perceived threats from hornets (Vespa spp.) and bee-eaters (*M. apiaster*), they hiss at a frequency between 300 and 3600 Hz. Kulyukin *et al*. (2018) categorizing sound samples from microphones positioned around 10 cm above the landing pads of Langstroth beehives. They created audio classification systems that could distinguish between background noise, cricket chirping, and bee buzzing (Sharif *et al.*, 2020).

f. **Gases:** Measuring carbon dioxide (CO2) is a crucial step in examining bee behavior. It is connected to bee metabolism because a change in its respiratory emission is linked to a bee's normal metabolic heating during activity. Bees also start to ventilate to regulate and maintain CO2 at an acceptable level, which is between 0.1% and 4.3%, when the amount within the hive exceeds the ambient norm (Alleri *et al.*, 2023). The internal relative humidity and temperature of the hive as well as the volume of sound produced by the bees, which is correlated with gas exchange and respiration, are also related to this metric. The authors verified that low CO2 levels might signal bee deaths from disease, poisoning, animal attacks, or family queenlessness, necessitating quick intervention from the beekeeper. Valeric acid suggests that caprylic and isocaprylic acids could be markers for the presence of Paenibacillus larvae, the pathogen responsible for American foulbrood (AFB). They created a gadget with semiconductor gas sensors, and they positioned a sample probe in the center of the hive (Szczurek *et al.*, 2019).

2. **Hive external parameters:** Naturally, the weather outside has an impact on hives. Pollen collection is influenced by temperature, relative humidity, wind speed, rainfall, and light intensity. Thus, keeping an eye on weather patterns is crucial to maintaining bee health.

   a. **Wind speed:** Insect flying is an energy-intensive activity that is similarly impacted by wind speed and direction; in fact, bee populations decrease as wind speeds rise. In addition, bees avoid coming outside to forage during extended windy spells, and honey production ceases.The authors discovered that a mere 2.75 m/s wind speed causes a 37% drop in floral visits. Honey output was found to decrease at wind peaks exceeding 4 m/s. The bees' inability to leave and their honey consumption were the causes of the decrease in honey (Hennessy *et al.,* 2020).

b. **Rainfall:** According to the authors, on rainy days with an ambient relative humidity of more than 80%, bees are not active. Honey bees use their increased foraging activity to forecast forthcoming rainfall. Using Radio Frequency Identification (RFID) monitoring, He *et al.* (2016) showed that foragers are busier in the days before rain than they are in the days after a sunny day.

c. **Ambient temperature:** Bees are heterothermic insects; they must exert all of their energy to maintain a consistent body temperature within the hive. There is a broad temperature range in which foraging occurs, from 10 to 40 ◦C (Southwick*et al.*, 1987). The life of colonies is disrupted by fluctuations in temperature. Specifically, bees must expend considerable energy to regulate the temperature of the hive when it falls or rises above the optimal threshold of 35°C, which ensures consistent brood breeding. Bees experience severe stress as the outside temperature drops. To prevent heat loss from the colony, worker bees often stay relatively quiet and gather closely in what is known as the winter cluster. Individual workers, on the other hand, actively generate heat by shivering their flying muscles (Nurnberger *et al.*, 2018).

Geographic Information System (GIS) applications in apiculture

Apiary locations are often chosen by beekeepers using their experience, yet occasionally the site may not be ideal for bee colonies. In practical terms, an apiary should ideally have between 30 and 80 colonies; the quantity of accessible forage in a particular location is the primary factor in deciding the ideal number (Komasilova *et al.*, 2020). The authors created a model utilizing the Python computer language and used satellite and aerial photos of agricultural fields found via Google Maps to assist beekeepers in finding and choosing appropriate apiary locations (Halbich *et al.*, 2012).

Conclusion

The harmful effects of climate change on bee life can be mitigated through the use of precision beekeeping. The incorporation of information technologies into the beekeeping process and the adaptation of Precision Agriculture techniques and procedures into Apiculture can alter and enhance the beekeeper's comprehension of the characteristics of bee behaviour.

Reference

Alleri, M., Amoroso, S., Catania, P., Verde, G. L., Orlando, S., Ragusa, E and Vella, A. 2023. Recent developments on precision beekeeping: A systematic literature review. *Journal of Agriculture and Food Research*, 100726.

Pejic, J., Milovanovic, M., Bozilov, A and Pejic, P. 2022. Impact of the Precision Beekeeping on the Living Environment. *Facta Universitatis, Series: Working and Living Environmental Protection*, 049-061.

Hadjur, H., Ammar, D and Lefevre, L. 2022. Toward an intelligent and efficient beehive: A survey of precision beekeeping systems and services. *Computers and Electronics in Agriculture*, *192*, 106604.

Seritan, G. C., Enache, B. A., Argatau, F. C., Adochiei, F. C and Toader, S. (2018, May). Low cost platform for monitoring honey production and bees health. In *2018 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR)*. pp. 1-4.

Sakanovic, S and Kevric, J. 2020. Habeetat: A novel monitoring platform for more efficient honey production. In *CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering*. pp. 193-200.

Andrijevic, N., Urosevic, V., Arsic, B., Herceg, D and Savic, B. 2022. IoT monitoring and prediction modeling of honeybee activity with alarm. *Electronics*, *11*(5): 783.

Abou-Shaara, H. F., Owayss, A. A., Ibrahim, Y. Y and Basuny, N. K. 2017. A review of impacts of temperature and relative humidity on various activities of honey bees. *Insectes sociaux*, *64*: 455-463.

Cecchi, S., Spinsante, S., Terenzi, A and Orcioni, S. 2020. A smart sensor-based measurement system for advanced bee hive monitoring. *Sensors*, *20*(9): 2726.

Bermig, S., Odemer, R., Gombert, A. J., Frommberger, M., Rosenquist, R and Pistorius, J. 2020. Experimental validation of an electronic counting device to determine flight activity of honey bees (Apis mellifera L.). *Journal of Cultivated Plants/Journal für Kulturpflanzen*, *72*(5): 132-140.

Sharif, M. Z., Jiang, X and Puswal, S. M. 2020. Pests, parasitoids, and predators: Can they degrade the sociality of a honeybee colony, and be assessed via acoustically monitored systems. *Journal of Entomology and Zoology Studies*, *8*: 1248-1260.

Kulyukin, V., Mukherjee, S and Amlathe, P. 2018. Toward audio beehive monitoring: Deep learning vs. standard machine learning in classifying beehive audio samples. *Applied Sciences*, *8*(9): 1573.

Szczurek, A., Maciejewska, M., Bąk, B., Wilde, J and Siuda, M. 2019. Semiconductor gas sensor as a detector of Varroa destructor infestation of honey bee colonies–Statistical evaluation. *Computers and electronics in agriculture*, *162*: 405-411.

Hennessy, G., Harris, C., Eaton, C., Wright, P., Jackson, E., Goulson, D and Ratnieks, F. F. 2020. Gone with the wind: effects of wind on honey bee visit rate and foraging behaviour. *Animal Behaviour*, *161*: 23-31.

He, X. J., Tian, L. Q., Wu, X. B and Zeng, Z. J. 2016. RFID monitoring indicates honeybees work harder before a rainy day. *Insect science*, *23*(1): 157-159.

Southwick, E. E and Heldmaier, G. 1987. Temperature control in honey bee colonies. *Bioscience*, *37*(6): 395-399.

Nürnberger, F., Härtel, S and Steffan-Dewenter, I. 2018. The influence of temperature and photoperiod on the timing of brood onset in hibernating honey bee colonies. *PeerJ*, *6*, e4801.

Komasilova, O., Komasilovs, V., Kviesis, A., Bumanis, N., Mellmann, H and Zacepins, A. 2020. Model for the bee apiary location evaluation. Agronomy Research. 18: 1350–1358.

Halbich, C and Vostrovsky, V. 2012. Monitoring of infection pressure of American Foulbrood disease by means of Google Maps. *AGRIS on-line Papers in Economics and Informatics*, *4*(4): 19-26.

Zacepins, A., Stalidzans, E and Meitalovs, J. 2012. Application of information technologies in precision apiculture. In *Proceedings of the 13th International Conference on Precision Agriculture (ICPA 2012)*.

Zacepins, A., Kviesis, A., Pecka, A and Osadcuks, V. 2017. Development of internet of things concept for precision beekeeping. In *2017 18th international carpathian control conference (ICCC)*. pp 23-27

Ochoa, I. Z., Gutierrez, S and Rodríguez, F. 2019. Internet of things: Low-cost monitoring beehive system using wireless sensor network. In *2019 IEEE International Conference on Engineering Veracruz (ICEV)* 1:1-7.

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3. NEMATOLOGY

Guava Root Knot Nematode Infestation in MITCAT Farm, Musiri

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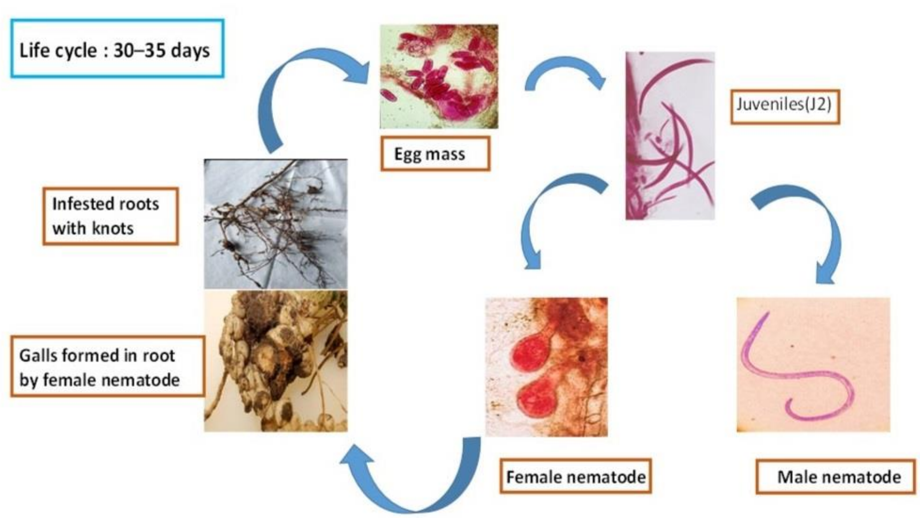
Introduction

Guava (*Psidium guajava*) ensures the India's nutritional security by satisfying the dietary needs of people and it is cultivated all over the world due to its hardiness and economic importance. In many cases, guava was found susceptible to various pests, diseases and nematodes. Overall damage of the plant parasitic nematode causes about 21.3% (Khan, 2020). The new outbreak of the extremely pathogenic and destructive nematode *M. enterolobii* threatens agriculture worldwide through its tremendous economic loss of 65% and the MITCAT Farm in Tamil Nadu is experiencing severe yield loss and tree death due to nematode infestations.

Life cycle

M. enterolobii is a polyphagus obligate biotrophic parasite with a lifecycle of 30-35 days. It differs from other species by having male, female, and juvenile morphometrics. Adult females lay eggs in a gelatinous layer (500-1000 eggs), and nematodes develop into juveniles and larvae. Infested root systems contain giant cells that nurture nematodes (Pulavarty *et al*., 2021). In non-favorable circumstances the *Meloidogyne* species only develops into males.

Life cycle of *Meloidogyne enterolobii*



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Diagnosis

Diagnosis of *M. enterolobii* infestation was daring due to its morphological similarities with other root-knot nematode species. Majority of the farmers are not aware of the infestation till the harvesting and would get to know only by witnessing the clumpy galled roots (Schwarz, 2019). This nematode dwells in soil often infecting the living plant roots, often causing severe root infestation which would end up with wilting, stunting, nutrient deficiency, decreased yield and on severity leads to death of the plant.

Control Measures

- Crop rotation with non-host crops such as mustard, marigold helps to decline the population level
- The Velum prime (Fluopyran 40% SC) applied at the recommended rate of 5ml/tree, the solution is drenched in the ring basin.
- Nimitz (Fluensulfone 2% G) applied at the suggested dose of 35g/tree at the depth of 15 to 20 cm.
- The fungal bio-control agent *Pochonia chlamydosporia* 1.15 % WP applied at the rate 20ml//tree.

Conclusion

PPNs are a major limiting factor for crop cultivation in India, with recent outbreaks of *M. enterolobii* posing serious threats. Despite being neglected pests, they are low priority for production and protection. Due to the ill effect of chemical pesticides the alternative strategies like botanicals, biopesticides, and integrating multiple options based on compatibility, economic viability, and availability are being explored.

Reference

Kumar, V., Khan, M. R., and Walia, R. K. (2020). Crop loss estimations due to plant-parasitic nematodes in major crops in India. National Academy Science Letters, 43, 409-412.

Pulavarty, A., Egan, A., Karpinska, A., Horgan, K., and Kakouli-Duarte, T. (2021). Plant parasitic nematodes: A review on their behaviour, host interaction, management approaches and their occurrence in two sites in the republic of Ireland. Plants, 10 (11), 2352.

Schwarz, T., Li, C., Ye, W., and Davis, E. (2020). Distribution of *Meloidogyne enterolobii* in eastern North Carolina and comparison of four isolates. Plant Health Progress. 21 (2), 91–96.

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4. GENETICS AND PLANT BREEDING

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

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Introduction

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

Meiotic recombination mechanisms

Meiotic recombination starts by creating breaks in the DNA double strands (DSBs) (Robert et al., 2016). This is then followed by the removal of the 5' ends of the damaged DNA strands, leading to the production of single-stranded DNAs (ssDNAs) with 3' ends (Paull and Deshpande, 2014). After the DNA strands are broken, they proceed to invade either a homologous chromosome or a sister chromatid, resulting in the formation of a stable intermediate with a single invading end (Da Ines et al., 2013). This invading strand from one chromosome extends into the corresponding double-stranded DNA (dsDNA) of the other chromosome, creating a structure known as a displacement loop (D-loop). The D-loop can be resolved into various joint molecules (JMs), leading to the formation of either a crossover (CO) or a non-crossover (NCO) duplex product. NCOs are predominantly generated through the synthesis-dependent strand annealing (SDSA) pathway using different mechanisms.

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

- Obligate CO
- CO interference
- CO homeostasis

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

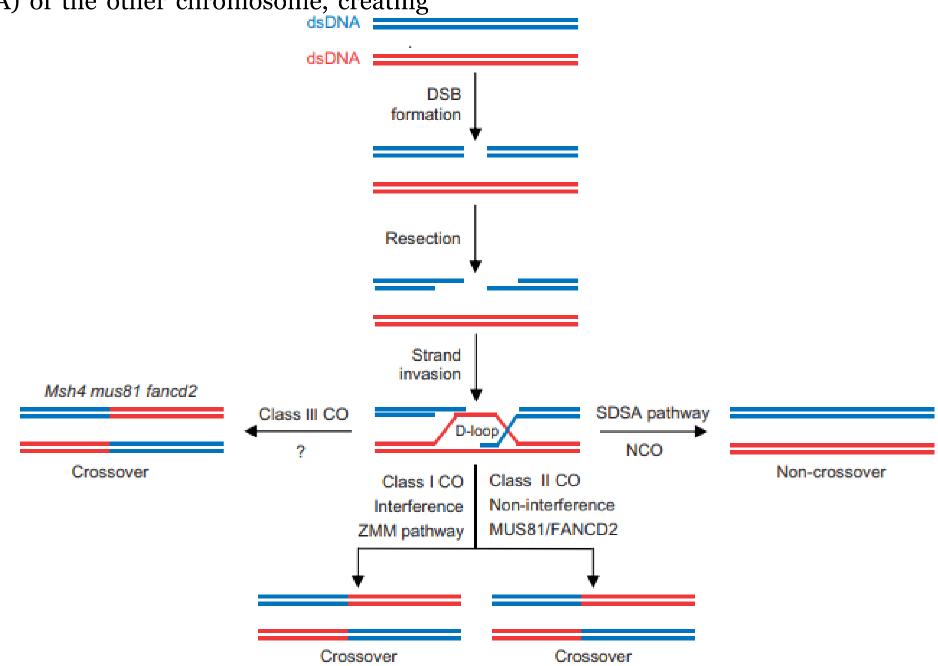

Fig. 1: Meiotic recombination pathway model in plants.

During meiotic recombination, there are typically two distinct pathways for crossover (CO) formation in most eukaryotes, known as class I and class II COs, which are differentiated based on their sensitivity to CO interference. Class I COs, comprising the majority (80-85%) of crossovers, are sensitive to interference and rely on conserved ZMM proteins such as MSH4 (MutS homolog 4), MSH5, MER3 (Meiotic recombination 3), ZIP4 (Zinc transporter 4 precursor), SHOC1 (Shortage of crossovers

1), HEI10 (Human enhancer of cell invasion No.10), RFC1 (Replication factor C1), PTD (Parting dancers), and POL2A (DNA polymerase 2A). On the other hand, the minority class II COs are insensitive to interference and require MUS81/FANCD2 for their formation (Kurzbauer et al., 2018). In most eukaryotes, including budding yeast, mammals, and plants, these two CO pathways coexist (Hunter, 2015). However, in fission yeast, only class II COs are formed during meiosis and in Caenorhabditis elegans, all COs exhibit interference (Hillers and Villeneuve, 2003). Notably, in Arabidopsis, a triple mutant lacking essential proteins required for both class I and II repair (msh4/mus81/fancd2) still exhibits some level of CO formation, suggesting the existence of an aberrant type of CO formation that operates in the absence of the normal class I and II CO pathways. This phenomenon has also been observed in Drosophila melanogaster (Yildiz et al., 2002) and yeast (Argueso et al., 2004), implying the presence of additional and alternative CO pathways (class III).

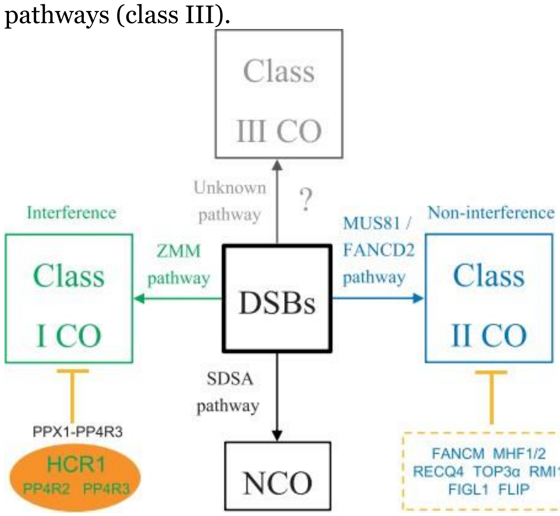

Fig. 2: Anti-crossover formation pathway model in plants

Mutating anti-CO factors can greatly enhance the recombination frequency in agricultural crops.

The presence of anti-CO genes naturally restricts the frequency of crossover events, which can limit genetic diversity during hybridization. Recent advancements in understanding the molecular mechanisms behind meiotic recombination suppression have led to the study of these anti-CO factors in important crop species. In Brassica species, specifically B. rapa and B. napus, the anti-CO gene FANCM was investigated using EMS-induced mutations, and several mutants with nonsense or missense mutations were identified using the TILLING technique (Blary et al., 2018). Interestingly, the enhanced CO frequency in fancm mutants was less pronounced in the heterozygous background (Col/Ler F1) compared to the homozygous background (Col/Col), suggesting that the effectiveness of FANCM mutation in promoting recombination frequency depends on the plant genome's heterozygosity. Recent research in lettuce demonstrated that LsFANCM, when replacing AtFANCM in transgenic Arabidopsis plants, retained its anti-CO function. However, unlike previous findings in Brassica, the fancm mutant of lettuce displayed abnormalities in chiasmata location among chromosomes, resulting in reduced pollen viability and seed set. Furthermore, the distribution of meiotic class I COs was altered, forming multiple foci on short chromosome stretches, indicating a divergent role of FANCM in meiotic bivalent formation.

Two other anti-CO genes, FIGL1 and RECQ4, were also studied in crops. FIGL1 mutations led to infertility in rice, pea, and tomato, limiting its application in crop breeding. In contrast, RECQ4 emerged as the most significant meiotic recombination suppressor. In Arabidopsis, RECQ4 mutation resulted in an almost six-fold increase in recombination frequency, and this effect was efficiently conserved in crops, as the recq4 single mutant exhibited over a three-fold increase in CO formation in rice, pea, and tomato. More recently, recombination frequency variation was examined in a biallelic recq4 mutant of an interspecific tomato hybrid created through CRISPR/Cas9 mutagenesis. RECQ4 knockout led to a 1.5-fold increase in recombination frequency in the F1 recq4 mutant and a 1.8-fold expansion of the genetic map in the F2 progeny, demonstrating that RECQ4 manipulation is not restricted by the plant genome's heterozygosity.

Thus, manipulating RECQ4 may serve as a universal and more reliable approach for generating hyper-recombinant plants

Hyper-recombinant ornamental plants offer a wide range of possibilities for utilizing anti- CO genes

In recent years, the genomics of ornamental plants has made significant progress thanks to the rapid advancements in sequencing technology. Ongoing genome projects involving ornamental plants like Gerbera hybrida, Tagetes erecta, and Gypsophila paniculata are currently underway (unpublished data). These projects offer the potential to identify meiotic recombination suppressors within ornamental plants. In fact, genomic data from these projects have already yielded the isolation of meiotic recombination suppressors, such as FANCM and RECQ4 (Li, Cheng, Sun, et al., 2021). Multiple species exhibit the presence of two or more copies of the RECQ4 gene, which can be traced back to whole genome duplications that occurred in various clades. Examples of these clades include Arabidopsis, Brassica, lettuce, soybean, and sunflower. Previous studies have reported the retention of multiple RECQ4 copies in these species, highlighting the impact of whole genome duplications (Mieulet et al., 2018). Further analysis of RECQ4 in eight ornamental plants has uncovered conserved functional domains, including DEAD, HELICc, RQC, and HRDC. This discovery suggests that RECQ4 may have a preserved function across ornamental plant species. These findings indicate that RECQ4 could serve as a key target gene for manipulating meiotic recombination in ornamental plants, offering potential opportunities for genetic manipulation in this context. With the advent of the CRISPR genome editing tool, there is now a potential to directly knock out anti-CO (anti-crossover) genes in F1 hybrids, enabling the rapid generation of hyper recombined populations (Gao, 2021). This presents an opportune moment to study the function and explore the application of anti-CO genes in the emerging field of enhancing current ornamental breeding practices. We are now in an era where we can manipulate the recombination rate of ornamental plants by leveraging the latest genetic information and advanced gene-editing technologies.

References

Argueso, J. L., Wanat, J., Gemici, Z., and Alani, E. 2004. Competing crossover pathways act during meiosis in Saccharomyces cerevisiae. Genetics. 168: 1805–1816.

Blary, A., Gonzalo, A., Eber, F., Berard, A., Berges, H., Bessoltane, N., Charif, D., Charpentier, C., Cromer, L., Fourment, J., Genevriez, C., Le Paslier, M.-C., Lode, M., Lucas, M.-O., Nesi, N., Lloyd, A., Chevre, A.-M., and Jenczewski, E. 2018. FANCM limits meiotic crossovers in brassica crops. Front. Plant Sci. 9: 368.

Chen, L., Li, W., Katin-Grazzini, L., Ding, J., Gu, X., Li, Y., Gu, T., Wang, R., Lin, X., Deng, Z., McAvoy,

R. J., Gmitter, F. G., Deng, Z., Zhao, Y., and Li, Y. 2018. A method for the production and expedient screening of CRISPR/Cas9-mediated non-transgenic mutant plants. Hortic. Res. 5: 13–12.

Da Ines, O., Degroote, F., Goubely, C., Amiard, S., Gallego, M. E., and White, C. I. 2013. Meiotic recombination in Arabidopsis is catalysed by DMC1, with RAD51 playing a supporting role. PLOS Genet. 9: e1003787.

Fan Li, Chunlian Jin, Liangsheng Zhang & Jihua Wang (2021): HyperRecombinant Plants: An Emerging Field for Plant Breeding, Critical Reviews in Plant Sciences, https://doi.org/10.1080/07352689.2021.1985819

Gao, C. 2021. Genome engineering for crop improvement and future agriculture. Cell. 184: 1621–1635.

Hillers, K. J., and Villeneuve, A. M. 2003. Chromosomewide control of meiotic crossing over in C. elegans.

Curr. Biol. 13: 1641–1647.

Kurzbauer, M.-T., Pradillo, M., Kerzendorfer, C., Sims, J., Ladurner, R., Oliver, C., Janisiw, M. P., Mosiolek, M., Schweizer, D., Copenhaver, G. P., and Schlogelhofer, P. € 2018. Arabidopsis thaliana FANCD2 promotes meiotic crossover formation. Plant Cell. 30: 415–428.

Li, S., Cheng, Y., Sun, D., Ma, L., Li, M., and Li, F. 2021. Identification and Expression of TOP3a in Gerbera hybrida. Hortic. Plant J. 7: 167–173.

Paull, T. T., and Deshpande, R. A. 2014. The Mre11/Rad50/ Nbs1 complex: recent insights into catalytic activities and ATP-driven conformational changes. Exp. Cell Res. 329: 139–147.

Robert, T., Nore, A., Brun, C., Maffre, C., Crimi, B., Guichard, V., Bourbon, H.-M., and de Massy, B. 2016. The TopoVIB-Like protein family is required for meiotic DNA double-strand break formation. Science. 351: 943–949.

Yildiz, O., Majumder, S., Kramer, B., and Sekelsky, J. J. € 2002. Drosophila MUS312 interacts with the nucleotide excision repair endonuclease MEI-9 to generate meiotic crossovers. Mol. Cell. 10: 1503–15

5. AGRICULTURAL BIOTECHNOLOGY

Biosensors – A Step towards Artificial Intelligence in Agriculture and Food Science

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Introduction

At the global level, nearly 1.3 billion tonnes/year of the edible parts of agricultural production for human consumption gets wasted. FAO asserted global Food Loss and waste per year are nearly 40 to 50% of horticultural crops. Food Corporation of India reported losses ranging from 10 to 15% of the total production of fruits and vegetables. Post-harvest losses mainly occur at different stage of post-harvest and processing level, due to the highly perishable nature of horticultural crops (Anonymous 2019). There are major constraints like lack of proper post-harvest management chain, less technological intervention and very poor packaging materials etc. For instance, packaging is a key point to reduce food loss. Furthermore, it can protect and preserve the quality of food and also facilitate transport and distribution. Therefore, to overcome this problem, novel, efficient and smart biodegradable packaging materials should be developed to retain the freshness, durability, and quality of food. This can also aid to enhance food availability to fight against hunger.

The quality of food is fundamentally based on the biochemical configuration of food (i.e. Fruits or Vegetables). Henceforth, recent advances in the fabrication of different types of Biosensors in smart food packaging materials or conjugating with films that have been designed for the assessment of various components in the highly perishable agricultural product. Needless to say, that it is timely demand of today's era. However, in the area of analytical chemistry, it plays a crucial role in food quality aspects because of almost each and individual sector associated with quality control.

Biosensor

A food quality biosensor is a nano-scale or micro-scale device, which can stimulus to some specific property or properties of food (or biological substances) and transforms the response(s) into a detectable signal, often an electric signal by conjunction with physicochemical transducers. This signal (i.e. bioluminescence and chemiluminescence) may provide direct details (selective/semi-quantitative) about the quality parameter(s) to be measured or may have a known relation to a specific analyte. An immobilized biological material which uses by a sensor could be an enzyme, antibody, nucleic acid, or hormone, in a self-contained device (Turner, 2013). Today, scientist are more interested in nanobiosensors due to very huge potentials of nonmaterial's like, carbon dot nanoparticle (fluorescence activity) and Carbon nanotubes (good electrical conductivity and light weight flexibility) reacted with specific enzymatic reaction (potential biomarkers i.e. protein, DNA, RNA, Biomolecules and Enzymes etc.,) which can be detected through detector and hence real time data can be obtain. To satisfy the consumer and regulatory requirements and to revive the production feasibility, standard sorting, automation, and demotion of production cost and time, eventually could be the vital intention of this technology. Nowadays, nanobiosensors also available in paper based printed forms in an international market.

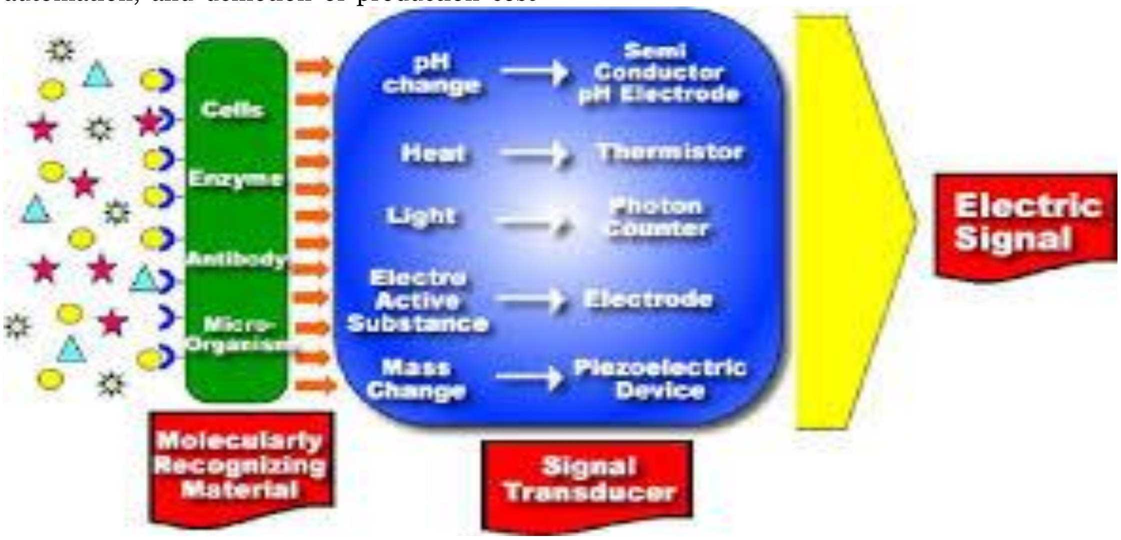

Fig. 1: Generalized mechanism of biosensor

A Perspective in near future:

Presently, Biosensors are widely used in medical field and engineering field (in machines, devices, technology, automobiles, medical instruments etc.). In near future, IoT (Internet of things) will become driven fully in worldwide and each entity will connected with each other by this technology. Furthermore, the remoteness between agricultural science and application of IoT could be filed by biosensors for real time monitoring and data observations. Hence, that era will be in near future when we can get notification from our food. For instance, an apple send message of starting of browning to our internet electronic devices (i.e. Smart phone) can be reality in our daily routine in near future. Presence of pesticides residues can also be monitored by real time. In refrigerator our stored food items will be in touch with us by real time notification.

This technology could also be become milestone for all farmers to consumer in supply chains of distant market. For example, Smart phone based colorimetric portable sensor can be detected pH, Color change and gaseous proportion (Huang *et. al.*, 2018). Similarly, tourism sector like hotels which having large segment of food delivery and serving to consumers, needs real time detection of their commodity for that they don't required to check food quality often by physically testing of samples. Also, this could be having immense potential in Data Science and Machine Learning like emerging filed which having very vast scope in corporate sectors.

References

Anonymous (2019) NAAS-Saving the Harvest: Reducing the Food Loss and Waste, Policy Brief No. **5**.

Huang, X., Xu, D., Chen, J., Liu, J., Li, Y., Song, J., Ma, X. and Guo, J. (2018). Smartphone-based analytical biosensors. *Analyst*, **143**(22), 5339-5351.

Naik, K. M., Srinivas, D., Sasi, B., and Basha, S. J. (2017). Biosensors in food processing—a review. *Int J Pure Appl Biosci*, **5**(4), 1219-1227.

Turner, A. P. (2013). Biosensors: sense and sensibility. *Chemical Society Reviews*, **42**(8), 3184-3196.

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6. ENTOMOLOGY

Types of Pheromones and its Exploitation in Pest Management

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Pheromone

The word Pheromone is derived from Greek word, pherein- to transfer and hormone- to excite. Used for intraspecific communication. It is a chemical or mixture of chemicals released by an insect that causes specific reaction in a receiving insect of the same species (Baker, 2009).

Types of Pheromones

Pheromones are classified based on the purpose for which it is released

1. Sex pheromone, 2. Aggreration pheromone, 3. Alarm pheromone, 4. Trial pheromones, 5. Host marking pheromones

1. Sex pheromone

Used to attract the opposite sex for mating and reproduction. Mostly females release the sex pheromone to attract males. It is produced by eversible glands at the tip of the abdomen and recieved by sensory sensillae on male antenna. Volatile, species specific and related only to smaller number of species-depends on distance. Have high compatibility with other control strategies. It has wide adoption, Example: Helilure – *Helicoverpa armigera,* Litlure and spodolure – *Spodoptera litura*, Gossyplure – Cotton pink bollworm

2. Aggregation pheromone

Produced by one or both sexes to bring both sexes together for feeding and reproduction, Cause insects to aggregate at food sites, reproductive habitats, hibernation sites (Ridgway et al., 1990). Prominent in some species of beetles like bark beetles, *Ips spp., Dendroctonus spp. are involved in tree attacks.* Operates over a long range. Example: Rhinolure – Coconut rhinoceros beetle, Ferrolure – Coconut red palm weevil, Cosmolure – Banana rhizome weevil.

3. Alarm pheromone

Alarm pheromone is produced by an insect species to repel and disperse other insects of same species. It is used to raise alert in conspecifics, to raise a defence response and to initiate response. Highly volatile and having low molecular weight. Common in social insects-Ants, Bees, Aphids. Example: E – Beta Farnesene (EBF) – aphid alarm pheromone

4. Trial pheromones

Used to indicate source of requisites to other members of the colony. Example: Ants- associated with walking. Bees - During foraging for making attractive foraging sites and for scent marking of unproductive food sources. Bumble bees- to increase efficiency in their use for pollination.

5. Host marking/ Epidietic/ Spacing pheromones

These pheromones elicit dispersal away from potentially crowded food sources and thereby reducing numbers. Reduce intraspecific competitions by disrupting landing, feeding or oviposition of pests on their host plants. Results in repelling. Example: Fruit flies- marks the surface on fruits after oviposition. Apple maggot, *Rhagoletis sp*.- Oviposition marking pheromone. House flies and other Diptera- Mating deterrent Pheromones. Parasitoids- to find their host species.

Strategies for exploitation of pheromones in pest management

Discovery, isolation and chemical identification of sex pheromone (bombykol) in 1959 - impetus for the exploitation of pheromones in pest management. 1970's – for 200 insects, 1980 - > 2000 insects.

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•Pheromones can be exploited in three ways- A. Monitoring, B. Mass trapping and C. Mating disruption

A. Monitoring

It is a highly sensitive means of detecting both the presence and relative density of pest population at a specific site. Insect infestation can be detected and estimated at a very early stage. Can forewarn regarding outbreaks of important pests. The appropriate control actions can then be carried out. Used to detect presence of invasive pests. One example of a successful use of pheromone traps in detecting invasive species is the pink bollworm (*Pectinophora gossypiella*).

Monitoring helps in detection of pest, measurement of pest density, assessment of density of natural enemies, assessment of pest phenology, assessment of effectiveness of mating disruption, monitoring of insecticide resistance. The most widespread use of pheromones has been for monitoring endemic pest species' adult populations. Monitoring of leafroller pests coupled with computer assisted degree-day models (Riedl & Croft, 1974) allowed sprays to be timed for optimum efficacy against eggs and first instars on such key pests as the codling moth (*Cydia pomonella*) and oriental fruit moth (*Grapholita molesta*). During the mid-1970s to late 1980s, insecticide applications were reduced by more than 50% - Apple codling moth- New York State, Michigan and the Pacific North west due to monitoring programs that improved decision making about the need to spray insecticides (Madsen, 1981) as well as their timing. On other crops in the USA as well as around the world, pheromone monitoring traps have asserted themselves in IPM programs as essential elements to the success of these programs.

B. Mass Trapping

Catching substantial proportion of a pest population before mating, oviposition or feeding -prevents damage to the crops. Effective results will obtain with combination of lure and trap (Franca et al., 2020). Effective for pests which are geographically isolated and at low densities. Two approaches are used, 1. Lure and kill, 2. Lure and Infect

1. Lure and kill: Insect come in contact with the toxicant and get killed. Example: Methyl eugenol + malathion - oriental fruit fly, PBW- 12 traps/ acre

2. Lure and Infect : Combines attractive lure with an entomopathogen. Also known as auto-dissemination. Example: Use of entomopathogenic nematodes, bacteria, fungi, viruses.

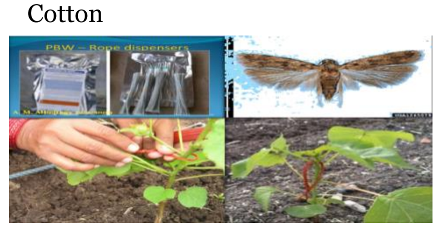
Recommended pheromone traps for mass trapping of pests

Crop	Pest	No.of traps (per ha)
Rice	Yellow stem borer	5
Sorghum	Stem borer	-
Groundnut	*Spodoptera* and *Helicoverpa*	10
	Leafminer	25
Sugarcane	borers	10
Cotton	Bollworms and *Spodoptera*	5
Pigeon pea	*Helicoverpa*	5
Brinjal	Shoot and fruitborer	10
Okra	*Earias spp.*	10
Cabbage, cauliflower	*Spodoptera* and DBM	10

C. Mating disruption

It is also called confusion or Decoy method. To permeate the air with sex pheromones. Insect entering the area cannot locate mates emitting natural pheromone because synthetic pheromone permeates the whole environment (Mazzoni and Anfora, 1990). Cause a reduction of reproductive rates and achieve crop protection without use of insecticides. Mating disruption involves dispensing relatively large amounts of sex pheromone over crop hectarage and suppressing males' abilities to locate females for mating. Since the introduction of the first commercial pheromone mating disruptant in the world in 1976 against the pink boll worm. Example of successful mating disruption programs are:

- In the early 1990s, apple and pear growers in California and the Pacific Northwest adopted a Codling Moth Areawide Management Program (CAMP) that relied on mating disruption for controlling the codling moth (*Cydia pomonella*). One overall goal of this study was to achieve an 80% or greater reduction of the use of broad-spectrum conventional insecticides by the end of the five-year program
- Against bollworm on cotton, use of the mating disruption technique has grown slowly but steadily.
- Worldwide, over the past several years nearly 400 000 ha of various agricultural crops and forests have been under commercial mating disruption targeting a wide variety of insect pests.
- Mating disruption using PB Rope L: for pink bollworm management in Cotton



- Contol of yellow stem borer by mating disruption with a PVC resin formulation- pheromone - Z9-16: ALD, Z11-16:ALD and Z13-18:ALD = 1:10:1, Seliberate CS Strips - 4.1%

References

Baker, T.C. (2009). Use of pheromones in IPM. Integrated pest management, pp.273-285.

De França, S.M., M.O. Breda, C.A. Badji and J.V.D.Oliveira. (2020).The Use of Behavioral Manipulation Techniques On Synthetic Insecticides Optimization In: Insecticides - Development of Safer and More Effective Technologies. IntechOpen: 177-196

Madsen, H. F. (1981). Monitoring codling moth populations in British Columbia apple orchards. In Management of Insect Pests with Semiochemicals, ed. E. R. Mitchell, pp. 57–62. New York: Plenum Press

Mazzoni, V and G.Anfora. (2021). Behavioural Manipulation for Pest Control. Insects, 12: 287

Riedl, H. & Croft, B. A. (1974). A study of pheromone trap catches in relation to codling moth (Lepidoptera: Olethreutidae) damage. Canadian Entomologist, 112,655–663

Ridgway, R.L., Inscoe, M.N. and Dickerson, W.A. (1990). Role of the boll weevil pheromone in pest management. *Behavior-modifying chemicals for insect management*, pp.437-471.

7. HORTICULTURE

Bio-Fortification in Horticultural Crops

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Bio-fortification refers to increasing the bio-availability of mineral content in food cropsgenetically. Biofortification is one time investment to develop seeds that fortify themselves, recurrent costs are low and germplasm can be shared internationally. Biofortification help in overcoming malnutrition problems especially in rural areas. Application of biofortified crops would benefit farmers by increasing their income in the long term. Biofortification differs from other fortification because it focuses on making plant foods more nutritious as the plants are growing, rather than having nutrients added to the foods when they are being processed.

Biofortification Techniques

1. **Agronomic Biofortification** - Agronomic practices starting right from field preparation to the harvesting of crops at right time and right stage of the crop. Fortification is done mainly through fertilizer application alone. Fertilizer application is done eitheras foliar spraynor as soil application by increasing nutrition in food and thereby improvingthe quality of food.
2. **Conventional plant breeding** - In this method there are so much breeding techniques like Introduction, Selection, Hybridization, Pureline, Polyploidy, Mutagenesis, SSD (Single Seed Decent), Pedigree method, Bulk method *etc*. that through which it increases nutrient or improves quality of food.Examples for biofortification through conventional plant breeding methods includesincreasing zinc in wheat, rice, maize; iron in beans and pearl millet and pro-vitamin A in sweet potato and maize.
3. **Genetic engineering**
   a. Vector gene transfer
      i. ***Agrobacterium* mediated transfer:** Thismethod is thought to induce less rearrangement of the transgene. Lower transgene tries to copy the number that direct DNA delivery methods.
      ii. **Viral vector:** They are tools commonly used by molecular biologists to deliver genetic material into cells. This process can be performed inside a living organism (in vivo) or in cell culture (in vitro). Viruses have evolved specialized molecular

mechanisms to efficiently transport their genomes inside the cells they infect.

b. Direct gene transfer

i. **Micro-injection:** By the use of a glass micropipette to inject a liquid substance at a microscopic or borderline macroscopic level. The target is often a living cell but may also include intercellular space. In this way the process can be used to introduce a vector into a single cell.

ii. **Particle bombardment:** The Particlebombardmentdevice, also known as the gene gun, was developed to enable penetration of the cell wall so that genetic material containing a gene of interest can be transferred into the cell.

List of Biofortified Horticultural Crops

Crop	Developed variety	Biofortification was done for
Sweet Potato	BHU Sona, BHU Krishna	Beta carotene
Pomegranate	Solapur Lal	Iron, Zinc and Vitamin C
Cauliflower	Pusa Betakesari	Beta carotene
Cowpea	Pant Lobia -1 Pant Lobia - 2	Iron, Zinc
Tomato	Pusa Uphar, Pusa Rohini Pusa Hybrid 2	High ascorbic acid
Carrot	Pusa Asita Pusa Rudhira	Anthocyanin Lycopene
Cassava	Sree Visakam	Beta carotene
Pumpkin	Arka Chandan	Beta carotene

Importance of Bio-Fortification

- Improves the plant or crop quality.
- Increase the nutritional quality in daily diets.
- Overcome malnutrition in human beings.
- Promote nations food security.
- It is especially important for poor rural community with finite access to a varied diet, fortified foods or supplements.

Conclusion

Biofortified crops, either by conventional breeding methods orby modern biotechnological tools, are not a solution formalnourishment. The ultimate aim in global nutrition remains asufficient and diverse diet for the world's population.However, biofortified crops can complement existingmicronutrients interventions; can have a significant impact onthe lives and health of millions of people, especially thosemost in need.

References

Barsha T, Pradyumna T, Priyanka S, Sandeep R and M. Sai Sindhu. (2020).Biofortification of Vegetable Crops - A New Tool to Alleviate Micronutrient Malnutrition,Agriculture and Rural Development: Spatial Issues, Challenges and Approaches, 14(83-97).

Gomathi, M.; Irene Vethamoni, P.; Vethamoni, I. and P. Gopinath. (2017). Biofortification in Vegetable Crops: A Review. *Chemical Science Review and Letters,* **6**(22): 1227-1237

Bouis, H.E. (2000). Enrichment of food staples through plant breeding: a new strategy for fightingmicronutrient malnutrition. Nutrition 16:701–704.

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8. HORTICULTURE

Methods of Seed Production in Cabbage

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- Cabbage is one of the important vegetables.
- Formed by the development of densely overlapped leaves around the growing point.
- Popular in the south and South Eastern parts on India.
- Under cultivation since 2000 BC to 2500 BC.
- It is a biennial in nature having 2 specific periods of growth i.e. vegetative and reproductive phases.

Seed production areas in India

1. 1. Srinagar valley (J&K)
2. 2. Upper Kullu valley (Himachal Pradesh)
3. 3. Lahaus valley (Himachal Pradesh)
4. 4. Kalpa valley, Kinnaur (Himachal Pradesh)
5. 5. Saproon valley, Solan (Himachal Pradesh)
6. 6. Kumaon hills (Uttar Pradesh)
7. 7. Kalimpong – Darjeeling hills (West Bengal)
8. 8. Nilgiris (South India)

History

In 1942-43 for the first time imperial Government encouraged the seed production of European type of vegetable at Quetta in Baluchistan. At about the same time initial trials on seed production were also initiated in Kashmir, Katrain.

Seed production

For seed multiplication of cabbage the following three methods (singh et al.,1959) can be followed depending on the suitability, type of the seed and stage of multiplication.

1. Seed to seed method
2. Head to seed method
3. Late planting

Seed to seed method

- Also known as In-situ method.
- Commonly followed for Foundation and Certified seed production.
- It is the commercial method of cabbage of seed production.
- In this method, labour is not needed for uprooting, storage and replanting of heads.
- Obtain early seed yield.

There are 3 methods of seed to seed methods

1. Head intact method
2. Stump method
3. Stump method with central core intact

Head intact method

- Most common method.
- Head formation in mid-Dec.& is kept intact.
- Earthing up is done.
- 2 vertical cross cuts is given and care is taken not to injure the central growing point.
- Cross cuts may be given twice or thrice in the varieties, having compact heads.
- Merits
- The heads are allowed to over winter in the field and no wastage of labour for shifting.
- No direct injury of snow/frost.
- Get higher seed yield.

- Selection and rouging of heads can be delayed.

Demerits

- No extra income.
- Earthing up is needed.
- Careless cross cuts may injure the terminal buds.
- Flowering and maturity is delayed.

Stump method

- Decapitate the fully mature heads.
- The stumps will develop the flowering shoots from the axillary buds.
- Useful when selection of heads is based on internal characters like core size.

Merits

- Extra income.
- Flowering and maturity is advanced.
- Seed yield is more.
- Suitable for regions with little frost / snowfall.

Demerits

- Flowering shoots arising from the stumps are decumbent.
- Rotting of stumps from the cut ends after a frost/snowfall.

Stump method with central core intact

- Heads are chopped off on all sides with downward perpendicular cuts.
- The flowering shoots arise from the terminal and axillary buds.

Merits

- Higher seed yields.
- Flowering branches are not decumbent.
- Early seed maturity.

Demerits

- The cut portion of heads are un-marketable.
- Require additional labour.

Head to seed method

- Mostly followed for nucleus seed production.
- True to type heads are selected, uprooted and replanted in a separate plot during Nov-Dec.
- Before replanting, the outer leaves are removed and the plants are set in the field ssuch a way that the whole stem below the head is buried in the ground with the head resting just above the surface of the soil which prevents tilting of plants due to weight of the heads.
- The soil around the base of the plant is made firm by pressing and leveled uniformly. There should not be no depression otherwise water will stagnate and may injure the root system.
- The loosely set plants get tilted immediately after the irrigation.
- Selection of true to type heads is possible only in the compact stage.
- Hence selection in the loose headed quality point of view is risky unless there is certainity of the highest quality of the seed stock used.

Modified Head to Seed Method

- Used for heavy snowfall areas during winter and the land remains covered with the snow for fairly long time.
- The compact true to type heads are selected uprooted and stored in trenches.
- In this method trenches of size 300cm long, 90 cm wide and 75cm deep are made being convenient for storage.
- Heads are stored in a layer in single slanting position and the roots are buried 5-7cm deep in the soil.
- The trenches are covered with wooden planks and about 15cm layer of earth is spread over them and on both the sides of trenches small holes are made for vernalization.
- Due to extreme low temperature, the heads get vernalized in the trenches.
- As soon as the danger of frost is over the head is taken out and replanted in well prepared field during march-april.
- Cross cuts is given to the heads before they start bursting.

- Flowering in June-July and Harvesting of the heads in August-September.
- Generally suitable for Nucleus seed and Breeder seed production.
- Provides better scope for inspection of heads and rouging.

Late planting

- Modification of In-situ method.
- Followed only under certain specific circumstances.
- Followed when early varieties are planted in late.
- Formation of head occur in May-June.
- Seed yield is very high, but the quality of seed may not be up to the prescribed standards.

Constraints of Seed Production

- Problems of satisfactory isolation due to cross-pollination by insects.
- Crops have to be carried over in to the second season
- Plant attains morphological shape and size during the additional growing period, which is not known to majority of the seed growers.

Bolting, Flowering and Seed Setting

- Exposure of plants to low temperature results in transformation of leaf – primordia into floral primordia.
- The size of the plants are exposed to low temperature.
- Optimum temperature for flowering is 4.4°c to 10.2°c
- The larger the plants at the vernalization, greater its tendency to shoot to seed.

Curing, Threshing and Seed Grading

- The ultimate seed quality is depend upon the handling of the harvested crop and care is taken during threshing, curing and storage conditions.
- Curing with branches helps the unripened seed to ripen slowly as under normal conditions in the field.
- Curing improves the colour of the seed and also reduces the shattering lossed in the field.

Threshing

- Threshing should be done on a clear day for once – over operation.
- In the morning the crop is spread on a tarpauline or concrete floor for drying and in the afternoon the seed is extracted by beating with the sticks.
- Seeds can be separated from chaff or broken twigs by winnowing or passing through coarse mesh sieve.
- Drying of seeds to a safe moisture level of 7%

Grading and Seed Yield

- Hand grading of seeds is laborious and takes lot of time.
- Seed grading machines have overcome the difficulty.
- after grading should contain minimum of 98% of pure seed. With 7% moisture.
- Final graded seed weight will determine the quality.

Seed Certification Standards

1. Field Inspection
2. Field Standards
3. Seed Standards

Field Standards

General requirements

Isolation Distance

Contaminants	Minimum distance (m)	
	Foundation	Certified
Fields of other varieties	1600	1000
Fields of same variety not confirming to varietal purity	1600	1000

Rouging

- The First rouging is done at the time of handling the mature heads.
- The Second rouging is done before the heads start bursting.

Specific requirements

Factor	Maximum permitted percentage	
	Foundation	Certified
Off-type	0.10	0.20
Plants affected by seed borne diseases	0.10	0.20

Factors	Standards for each class	
	Foundation	Certified
Pure Seed (minimum) %	98	98
Inert matter (maximum) %	2.0	2.0
Other Crop seeds (maximum) number/kg	5	10
Weed seeds (maximum) number/kg	5	10
Germination (minimum) %	65	65
Moisture (maximum) %	7.0	7.0
For vapour-proof containers (maximum) %	5.0	5.0

9. ENTOMOLOGY

Predatory Mites: A Tool for Biological Control

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Introduction

Pest management in agricultural systems is an ongoing challenge worldwide, with detrimental impacts on crop yield and quality. The reliance on chemical pesticides has raised concerns about environmental sustainability and human health. To address these challenges, there has been a growing interest in adopting alternative pest management strategies, with biological control emerging as a promising approach. In particular, predatory mites from the Phytoseiidae family have garnered attention for their effectiveness in controlling pest populations, such as spider mites and thrips, while minimizing the use of chemical inputs. This article explores the biology, behaviour, mass rearing, releasing strategies, and compatibility of phytoseiid predatory mites with other biocontrol agents and chemical pesticides, highlighting their potential for sustainable pest management in agriculture.

Biology and Behaviour of Phytoseiid Predatory Mites

Phytoseiid mites are renowned for their role as natural enemies of plant-feeding arthropods, making them valuable assets in biological pest control programs. Their life cycle comprises distinct stages, including egg, larva, protonymph, deutonymph, and adult, with variations in feeding patterns and food sources. These mites exhibit a broad dietary range, consuming prey, pollen, fungal spores, and plant exudates, allowing them to adapt to diverse environments. Understanding their biology, including life table parameters and foraging behaviour, is crucial for selecting effective predators for pest management programs. Life table characteristics, such as the intrinsic rate of increase (r), provide insights into population growth potential, while foraging behaviour, including functional and numerical responses, influences prey consumption and population dynamics. Some important phytoseiid mites employed in biological control are *Phytoseiulus persimilis*, *Neoseiulus cucumeris*, *Neoseiulus barkeri*, and *Amblyseius swirskii* against tetranychid mites, thrips, whitefly, and eriophyid mites respectively.

Mass Rearing of Phytoseiid Predatory Mites

The successful implementation of biological control relies on the mass production and release of natural enemies in agricultural systems. Mass rearing methods for phytoseiid predatory mites vary depending on species-specific dietary requirements and environmental conditions. Open rearing systems, conducted within greenhouse environments, offer advantages such as large-scale production and relatively low labour requirements. However, challenges such as environmental risks and predator loss necessitate careful management. In contrast, closed rearing systems, characterized by climate-controlled rooms, provide precise environmental control and continuous production but require intensive labour and investment. Moreover, natural prey production, particularly spider mites, is essential to sustain predatory mite populations, emphasizing the interconnectedness of predator and prey dynamics in biological control systems.

Releasing Strategies and Compatibility Assessment

Effective releasing strategies are vital for optimizing the impact of predatory mites on pest populations. Various methods, including bulk material in tubes, hand sprinkling, sachet method, and mechanical release, offer flexibility in deployment, catering to different crop types and pest densities. Achieving the optimal predator-prey ratio is critical for successful pest control, necessitating careful monitoring and adjustment based on environmental conditions and pest dynamics. Compatibility assessments between phytoseiid predatory mites and other biocontrol agents or chemical pesticides are essential to ensure synergistic interactions and minimize unintended consequences. While some studies suggest compatibility between predatory mites and certain biocontrol agents, such as predatory thrips, challenges remain in assessing their compatibility with chemical pesticides due to potential sublethal effects and species-specific vulnerabilities.

Conclusion

Phytoseiid predatory mites represent a promising solution for sustainable pest management in agriculture, offering effective control of key pest species while reducing reliance on chemical pesticides. Their biology, behaviour, mass rearing, releasing strategies, and compatibility with other biocontrol agents and chemical pesticides are essential considerations for successful integration into pest management programs. Future research efforts should focus on optimizing mass rearing techniques, refining releasing strategies, and further elucidating interactions with other biocontrol agents and pesticides. By harnessing the potential of phytoseiid predatory mites, agriculture can transition towards more environmentally friendly and sustainable pest management practices, promoting ecosystem health and food security.

References

McMurtry, J. A., De Moraes, G. J and Sourassou, N. F. 2013. Revision of the lifestyles of phytoseiid mites (Acari: Phytoseiidae) and implications for biological control strategies. *Systematic and Applied Acarology*, 18(4), 297-320.

McMurtry, J. A and Croft, B. A. 1997. Life-styles of phytoseiid mites and their roles in biological control, *Annual review of entomology*, 42(1), 291-321.

Rao, K. S., Padmanabhan, A and Vishnupriya, R. 2018. Recent update on the role of predatory mites in biological control programmes. *Research Journal of Agricultural Sciences*, 9(3), 473-479.

10. ENTOMOLOGY

Robots Used in Agriculture

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Abstract

Precision agriculture technology have revolutionised the agricultural production system in the previous few decades. The growing global population and decreasing amount of land available for cultivation have compelled researchers to focus on the application of IoT, Artificial intelligence, machine learning and robots for sustainable, environmentally sound, and commercially successful agriculture. Applications for robots in agriculture are numerous and include simple jobs like harvesting and packing fruits and vegetables and sowing seeds, as well as more complicated ones like monitoring crops and determining the pH of the soil. It is evident that technology will play a major role in successful agriculture in the future when you take into account automation for air management and ventilation systems, milk production, and arable irrigation.

Introduction

Robotic technology has recently found application in the agricultural sector. Technological sustainability can improve the cultivation of crops with high yield and quality. Controlling pest infestations more effectively is important. The management of insect infestation presents major challenges for farmers. Avoiding and detecting pests early on is crucial to crop management. Understanding pests and their habitats is necessary for effective pest management. Currently, farmers are dousing their fields in insecticides (Chaitanya *et al*., 2020).

Mechanised farming systems are the primary integration of steady and precise automation in agriculture. To address the aforementioned issues, an automated robotic system that can spray pesticides in limited amounts only in the event that pests are found is needed. Because of the limited use of pesticides, the farmer not only avoids physically and medically dangerous diseases but also saves money. For this reason, it promotes the economic growth of farmers and the country as a whole. Employing these kinds of robots It takes less time to spray liquid pesticides, which will help farmers labour less and complete their tasks in any weather or season (Ahmed *et al*., 2016).

Robotics is an intelligent machine created by engineering marvel of computing, electronics and mechanical engineering which resembles the work pattern of human being. Robotic technology in agriculture has for various operations like seeding, planting, spraying, weeding, harvesting and post-harvest operations. Robotic technology not only removes the drudgery in farm operations, but also protects the farmers from work under harsh environmental conditions.

History of development in robotics

- Al-Jazari - developed a robot - 1206. In his book titled 'Book of Knowledge of Ingenious Mechanical devices' he described how he had built devises such as Elephant clock, candle clock (David *et al*., 2011).
- Leonardo da Vinci (1495) designed the first humanoid robot (Mechanical knight)
- 1839- Horse-drawn reaper
- 1890- Machine power
- 1930- Farm machinery
- 1945- George Devol – first Industrial robots

Timeline – Robotics In India

- 2013-2014: Agricultural robots
- 2013-2017: Robots that care for the elderly
- 2013-2020: Nano robot

- 2017: Medical robots
- 2017-2019: Household robots
- 2035: First completely autonomous robot soldiers on the battlefield.

AGROBOT: a mobile, autonomous, decision-making, mechatronic device that accomplishes crop production tasks (e.g. soil preparation, seeding, transplanting, weeding, pest control and harvesting) under human supervision, but without direct human labour.

Components of agricultural robots

Accordingly, these four parts exert their own influence on agricultural production.

- **First**, the vision system can transform captured data into images using various cameras, such as thermal, RGBD, TOF, and multi-spectral cameras.
- **Second**, the control system is the brain of the robot, playing an instrumental role decision-making and motion planning.
- **Third**, advanced mechanical actuators are a prerequisite for precise operation, especially for tender fruits and vegetables.
- **Lastly**, mobile platforms enable robots to navigate, avoid obstacles, perform detection, and carry out tasks.

Core technologies involved in agricultural robotic applications

Different agriculture robots are characterized by their respective application scenarios, they bear a number of similarities in core technologies. For example, a stable mobile platform, multi-sensor collaboration, advanced visual image processing technology, sophisticated algorithms, and flexible locomotion control are usually indispensable in constitute an agricultural robot.

CURRENT STATUS OF AGRICULTURAL ROBOTS

MF-Scamp Robots Designed by Blackmore

MF-Scamp robots are designed for scouting, weeding and harvesting. Now this intelligent hoe tools uses vision sensor to locate and identify the crops in rows and column and steers itself accurately, to a larger extend reducing the usage of herbicides. This robot designed not only reduce the labour time but also the economic feasible with slight reductions in prices of navigation systems (Kushwaha *et al*., 2016).

Autonomous Plant Inspection (API) Research Platform designed by Danish institute of Agriculturalscience (DIAS)

The API Platform was initially developed by Madsen and Jakobsen in the year 2001. Further it was developed by Aalborg University in Denmark. The robot has 60cm height clearance, and a track width of 1m. It is also equipped with Real Time Kinematic Global Positioning system (RTK-GPS) and there is an operating unit over the head of the frame which implement for agricultural operations like spraying devices, sensors or weeding tools (Billingsley *et al*., 2008).

Sub canopy robot ISAAC 2 from Hohenheim University, Germany

This prototype is designed to collect timely and accurate information in the crop carrying range of sensors to assess crop health and status. This high clearance platform carries instruments above the crop canopy and utilizes GPS (Bak and Jakobsen *et al*., 2004).

BoniRob farming robot developed by Deepfield robotics funded by Bosch, Germany

BoniRob is a multi-purpose robotic platform for applications in agriculture. It has four independently steerable drive wheels that has the ability to adjust its track width and makes it highly manoeuvrable. The robot can navigate autonomously along plant rows (e.g., dams) in the field, carrying the application module (plantation) as it goes.

Lettuce Bot, California

The bot design is more of robotics, computer vision and machine learning algorithm to advance the growing fields. The Bot has a database of more than a million images that it uses to identify the plants (Tang *et al*., 2000).

CROPS, European union

The CROPS research project, “Clever Robots for Crops”, which is sponsored by the EU Commission, could provide a solution for an automated harvesting procedure. The aim is a configurable, modular and intelligent robot platform, which reliably recognizes both the fruit as well as obstacles and other objects. In this way it can navigate and harvest on its own on plantations and in greenhouses (Godwin *et al.*, 2001).

HortiBot, Denmark

Hortibot is a commercially produced and robust tool carrier designed for high tech plant nursing for e.g., organic grown vegetables. The HortiBot navigate on the basis of computer vision recognition of the topography of the tracks between beds (Chi and Ling *et al.*, 2004).

AgBot II, Austrila

AgBot II is a robot designed to help farmers to take decisions on the use of herbicides, pesticides, fertilizers and watering. It is developed at the Queensland University of Technology (QUT) in Australia, using sensor networks, drones, weather, satellite and historical data to help "farmers" run mathematical models and statistical programs to help and guide them in farm management decisions such as whether to use herbicides, pesticides, fertilizers and how much water plants.

Vitirover solar Robots, New Zealand

A French company designed a smart autonomous robot called Vitirover. This little autonomous robot uses thesolar power for the electrical motors which could work for hours without any pause and are used for cutting grass & weeds in vines.

ROBOTIC APPLICATION IN INDIAN AGRICULTURE

- Indian researchers have has also tried to develop various kind of robots for agricultural operations. Tamil Nadu agricultural university (TNAU) has developed a pneumatic actuated gripper for grasping and releasing the plug type seedling. The transplanting rate of developed mechanism was set as 20 – 25 seedlings/minut. TNAU has also developed a robotic rice pellet seeder. The control of the seeder is done remotely from the telemetry controller.
- IARI New Delhi has developed a robotic precision planter with wireless control through microprocessor using Wi-Fi module. There are Traction wheel controls, steering control, seeding mechanism control in three Cartesian coordinates.
- IIT Kharagpur has developed a robotic arm for cotton picking based on 3D machine vision techniques.

Advantages

1. It possesses vision systems and an intelligent hoe that enable it identify the rows of crops and steer accurately between them hence considerably reducing the need for herbicides.
2. Robots gantry can operate as both fertilizer or liquid sprays, and importantly an automatic self-control system that responds to the weather change conditions.
3. They can be small in size and hence enable it to accumulate data close to crops and perform mechanical weeding, mowing, spray pesticide and fertilizer.
4. Robotics cameras and sensors can detect weeds, identify pest, diseases or parasites and other forms of stress. The sensors are usually selective and used to spray only on the area affected.
5. Robots provide opportunity of replacing human operators aside providing effective solutions with good investment return.
6. The Robot does not get sick or tired and does not need time off.
7. It can operate with closer tolerances (so every round is at full field capacity) with fewer errors and at higher speeds.

Disadvantages

1. It promotes unemployment.
2. Liability.
3. Limited access to the technology.
4. A periodic human presence in the field.
5. Energy cost and maintenance.
6. In future it could change emotional appeal to agriculture.
7. Not currently scale neutral.
8. High cost of research and development.
9. Lack of access for poor farmers ((Shwetal and Bhophe, 2015).

Conclusion

The adoption of robotics for pest control in agriculture is a significant step towards sustainable and precision farming. While challenges such as high initial costs, the need for technical skills, and regulatory issues remain, the potential benefits make it an exciting area for development and research. By merging the precision and efficiency of robotics, we can address the global challenge of pest control. This integration will not only safeguard our agricultural productivity but also contribute to the health of our environment.

References

Ahmed, H., Juraimi, A. S and Hamdani, S. M. 2016. Introduction to robotics agriculture in pest control: a review. *Pertanika journal of scholarly research reviews*, 2(2): 80-93.

Bak, T. and Jakobsen, H. 2004. Agricultural Robotic Platform with Four Wheelsteering for Weed Detection. Biosystems Engineering 87(2): 125-136.

Billingsley, J., Visala, A., Dunn, A., 2008. Robotics in Agriculture and Forestry. Springer Handbook of Robotics, pp. 1065-1078..

11. SOIL SCIENCE

Comprehensive Insights into Carbon Footprint: Importance and Calculation Methods

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Introduction to carbon footprint

The carbon footprint refers to the release of greenhouse gases (GHGs) from every aspect and stage associated with a specific product, individual, or system, spanning from manufacturing to disposal. Initially, only carbon dioxide (CO_2) was considered in estimating the carbon footprint. However, contemporary assessments include all significant GHGs, such as CO_2, CH_4, and N_2O, expressed in terms of CO_2 equivalent (CO_2-e).

Importance of carbon foot printing

The carbon footprint, as a quantitative expression of greenhouse gas (GHG) emissions resulting from an activity, plays a crucial role in managing emissions and assessing mitigation strategies (Carbon Trust, 2007). By quantifying emissions, it becomes possible to pinpoint significant emission sources and prioritize areas for emission reduction and efficiency enhancement. This opens avenues for environmental efficiencies and cost savings.

Greenhouse gas accounting

- 1. Selection of GHGs
- 2. Setting boundary
- 3. Collection of GHG emission data

Selection of GHGs

The choice of greenhouse gases (GHGs) considered in calculations relies on the adopted guidelines, the purpose of carbon footprint assessment, and the specific activity being analyzed. For instance, in the case of a thermal power plant where CO_2 emissions are predominant and other gases are minimal, measuring only CO_2 emissions may be practical. On the other hand, for activities like a cattle farm, where CH_4, CO_2, and N_2O emissions could be substantial, including all three gases in the calculation might be necessary.

Setting boundary

The term "boundary" denotes an imaginary demarcation around the activities considered in carbon footprint calculations, and its selection depends on the specific objectives and characteristics of the entity being assessed. Once the organizational boundary is established, the operational boundary must be defined. The operational boundary involves selecting the direct and indirect emissions to be accounted for in the assessment. In the context of natural systems and land uses, the determination of boundaries and tiers is often unclear.

Collection of GHG data

Direct measurements encompass various sensors such as optical, chemical, and biological sensors, including photoacoustic infrared sensors. These instruments are used in techniques like collecting gases in specialized chambers and analyzing them through infrared spectroscopy for CO2 and gas chromatography for all greenhouse gases (GHGs). These methods are applied in ground-based measurements, whether static, mobile, or aerial. Eddy covariance or flux towers are utilized to measure flux across the entire landscape, while cavity ring-down spectrometers are used in aerial measurements. Additionally, secondary data sources and global-level databases are now available alongside onsite measurements.

Footprint calculation

Greenhouse gas (GHG) data are converted into CO2-equivalents (CO2-e) using conversion factors provided by the Intergovernmental Panel on Climate Change (IPCC). While some organizations report carbon footprints in carbon equivalents (Wiedmann and Minx, 2007), CO2-e is generally more widely accepted.

Carbon Footprint = Agricultural Input × Emission factor

$CF_t = CF_F + CF_N + CF_P + CF_{IR} + CF_D + CF_M$,

Where, CF_F = carbon footprint from fertilizers, CF_N = direct N_2O from N fertilizer application, CF_P = carbon footprint from pesticides , CF_{IR} = carbon footprint from irrigation, CF_D = mechanical operations involved in crop production, CF_M = an additional factor used in the case of rice to account for methane emission.

For the estimation of methane emissions from rice cultivation, the following equation is used:

$$CF_M = \delta M \times \frac{16}{12} \times 23 \times \frac{12}{44}$$

Where, CF_M = carbon footprint of methane, dM = methane emission factor,

CF_N is estimated by using the below equation:

$$CFN = FN \times \partial N \times \frac{44}{28} \times 298 \times \frac{12}{44}$$

CF_N = direct N_2O emissions from applied inorganic N fertilizer (in t CE), FN = quantity of inorganic N fertilizer applied, dN = emission factor of N_2O induced by inorganic N fertilizer application

Conclusions

understanding and quantifying carbon footprints provide a valuable tool for identifying emission sources, prioritizing reduction measures, and enhancing environmental efficiency. Standardized guidelines and methodologies, such as those from GHG Protocol, ISO, and country-specific agencies, ensure consistency and comparability in carbon footprint assessments. The selection of GHGs, establishment of boundaries, and accurate data collection remain critical aspects, with ongoing efforts to address complexities in natural systems and land uses. As organizations increasingly report their carbon footprints for legal compliance, carbon trading, and corporate social responsibility, ongoing research and refinement of methodologies are essential.

References

Carbon Trust (2007). Carbon footprinting. An introduction for organizations.

IPCC (2006) National Greenhouse gas inventories: Land use, land use change and forestry. Hayama, Japan: Institute of Global Environmental Strategies.

Pandey D, Agrawal M, Pandey JS (2011) Carbon footprint: current methods of estimation. Environmental monitoring and assessment, 178:135-60.

Wiedmann, T and Minx, J (2007) A definition of carbon footprint. ISAUK Research Report 07-01, Durham, ISAUK Research & Consulting.

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12. SOIL SCIENCE

Revolutionizing Soil Testing: Sensor-Based Approaches for Enhanced Agricultural Productivity and Sustainability

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Introduction

Analyzing soil is a crucial measure to enhance agricultural productivity and boost farm revenue. Conventional soil testing relies on chemical procedures conducted in controlled laboratory settings, which are typically time-consuming, tedious, and involve intricate sample preparations. Timely analysis of collected soil samples from diverse agricultural fields becomes impractical, leading to delayed test results that often do not reach farmers promptly. Therefore, the introduction of innovative technologies is imperative to make soil testing-based nutrient management a practical and efficient reality.

Concept of Soil Sensors

Sensor-based soil nutrient estimation is an innovative approach that offers significant potential for improving agricultural productivity and sustainability. Sensor technology has revolutionized the field of soil nutrient estimation, offering efficient and precise monitoring techniques. Various types of sensors are employed to assess soil nutrient levels, providing real-time data that can guide nutrient management decisions.

Different Types of Soil Sensors

1. **Electrochemical Sensing Methods:** An electrochemical sensor comprises an ion-selective membrane designed to specifically react to a particular ion, and a transducer that converts these reactions into measurable electrical signals.
   a. **Ion Selective Electrode (ISE)**: The operational principle of the Ion-Selective Electrode (ISE) method can be succinctly explained through the Nernst equation. The alteration in the potential of an ISE, when compared to a reference electrode, exhibits a linear relationship with the logarithmic change in ionic activity of the targeted ion. Ion-selective electrodes are capable of detecting nutrients such as nitrates, ammonium, potassium, and phosphorus. However, a drawback of using ISEs lies in their potential unsuitability for real-time sensing applications due to the delayed response, which can take several minutes.
   b. **Ion Selective Field Effect Transistor**: The ISFET, or Ion-Sensitive Field Effect Transistor, combines an Ion-Selective Electrode (ISE) with a field-effect transistor (FET). In this integration, the ion-selective membrane is positioned atop the insulator layer of the FET structure. This arrangement allows for the chemical modulation of the ISFET's threshold voltage, with the measured voltage directly correlated to the concentrations of the target ion. Nutrients like nitrates, ammonium, and potassium can be effectively detected using these sensors, albeit at a generally higher cost.
2. **Vis–IR Spectroscopy**: Vis–IR spectroscopy stands out as a physical, nondestructive, swift, and cost-effective technique for characterizing materials based on the energy absorption within the wavelength range of 700 nm to 1 nm. Noteworthy advantages include its rapid application, low cost, and the absence of

sample preparation requirements. Vis–IR spectroscopy proves highly advantageous and user-friendly, making it an efficient method for detecting nutrients such as carbon, nitrogen, phosphorus, and potassium.

3. **Reflectance Spectroscopy:** Soil nutrient detection is predominantly carried out through diffuse reflectance spectroscopy, primarily based on near-infrared reflection spectroscopy. In the context of portable nitrogen detection, a compact Fourier transform infrared (FTIR) coupled spectroscope is employed, featuring a small, portable design and accompanied by software for data acquisition and spectral analysis. Mukherjee and Laskar (2019) introduced a Vis–NIR diffuse reflectance spectroscopy-based sensor. The absorbance values pertinent to nitrogen are observed at 850 nm, for phosphorus at 620-630 nm, and for potassium at 460-470 nm. This methodology provides an efficient means of analyzing soil nutrient content through non-destructive spectroscopic techniques.
4. **Raman Spectroscopy:** Raman spectroscopy stands out as a rapid and effective tool for soil nutrient testing. This technique involves the use of a powerful beam of visible or ultraviolet light to illuminate the sample and collect the scattered Raman spectra. Relying on the vibrations and rotations of radiation-excited molecules, the Raman spectra's signature provides structural information crucial for sample identification. Notably, Raman spectroscopy exhibits exceptional capacity for detecting phosphorus, with the ability to identify phosphorus in the wavenumber range of 200 to 4000 cm^{-1}. In addition, Dong et al. (2018) reported water-soluble nitrogen detection using Surface Enhanced Raman Spectroscopy (SERS). The characteristic peaks of nitrogen were identified at 1028, 1370, 1436, and 1636 cm^{-1} utilizing SERS based on Opto trace Raman (OTR) 202.
5. **Colorimetric:** Soil testing kits offer a rapid, on-the-spot, and approximate assessment of the nutrient content in soil, employing the colorimetric technique for analysis. In this method, the colorimetric principle involves comparing the color change of a solution with calibrated reference color charts. The varying shades on the color chart correspond to different concentration ranges. By correlating the color of the solution with nutrient concentration, the colorimetric approach gauges the fertility level of nutrients (NPK) in the soil. The observed color change in the soil sample indicates whether the nutrient concentration is low, medium, or high.

Conclusions

The detection accuracy of soil nutrients is hindered by variations in soil and environmental factors. This challenge can be addressed by employing pretreatment methods and different calibration techniques. While spectroscopic methods face limitations due to the bulkiness and cost of typical spectrometers, along with the need for site-specific calibration, colorimetric methods offer a viable solution for developing a portable and cost-effective optical sensor for soil macronutrient detection. Generally, colorimetric techniques do not require expensive equipment, perfect measurement conditions, extensive databases, or sophisticated analysis techniques.

References

Dong T, Xiao S, He Y, Tang Y, Nie P, Lin L, Qu F, Luo S (2018) Rapid and quantitative determination of soil water-soluble nitrogen based on surface-enhanced Raman spectroscopy analysis. Applied Sciences, 8(5):701.

Masrie M, Rosli AZ, Sam R, Janin Z, Nordin MK (2018) Integrated optical sensor for NPK Nutrient of Soil detection. In2018 IEEE 5th international conference on smart instrumentation, measurement and application (ICSIMA), 1-4.

Mukherjee S, Laskar S (2019) Vis–NIR-based optical sensor system for estimation of primary nutrients in soil. Journal of Optics, 48(1):87-103.

Potdar RP, Shirolkar MM, Verma AJ, More PS, Kulkarni A (2021) Determination of soil nutrients (NPK) using optical methods: a mini review. Journal of Plant Nutrition, 44(12):1826-39.

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