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The Great Hunger

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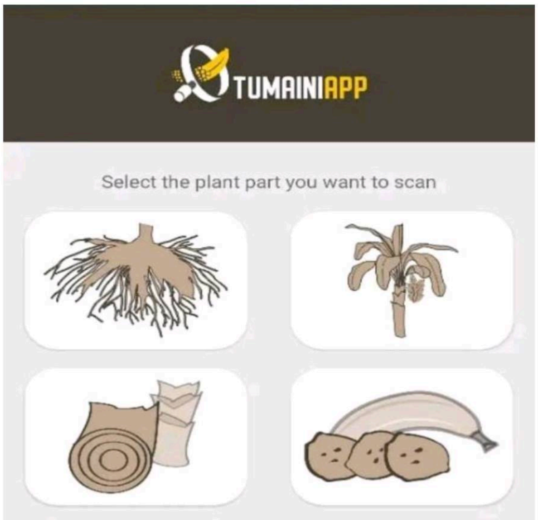

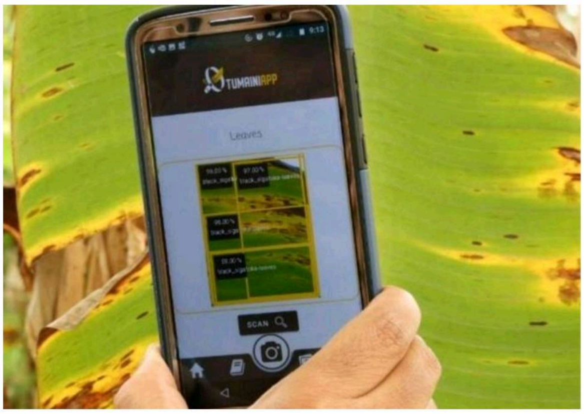

Issue No : 01 Year : 2021

Message from the Editor

With profound pleasure, humility, and anticipation, we celebrate AgriGate Magazine-An International Magazine's launch with this inaugural issue. On behalf of the AgriGate Editorial Team, I would like to extend a very warm welcome to the readership of AgriGate Magazine. I take this opportunity to thank our authors, editors and anonymous reviewers. All of them have volunteered to contribute to the success of the Magazine.

The magazine aims to provide a forum for the scientific community to publish their research findings and open new vistas for further research. AgriGate magazine is primarily focused on research and technical activities related to agriculture, agriculture engineering, Agribusiness Management, Agricultural engineering and Precision Farming, Agriculture & Horticulture, Bio-Sciences / Life-Sciences, Biotechnology & Biochemistry, Environmental Science & Forestry, Fisheries & Animal Sciences, Food & Dairy Technology, Genetics & Breeding, Organic Farming and Sericulture, Plant Pathology & Entomology and Soil Sciences.

The area covered in the journal also include Abiotic stress management in crops, Adaption potential of various crop and veg., Agriculture e-commerce and agri-business, Agro-forestry, forestry and fodder research, Agronomic Research, CO_2 sequestration, Dairy, poultry and fisheries research, Doubling the Farmer's Income ideas, Food security and development, Germ-plasm conversation and development of allied variety related research, Identification of agricultural Insect/Pests, Identification of diseases and their suitable treatment, Impact of Climate change on Agriculture, Integrated Pest Management, Livelihood improvement of farmer, Olericulture, floriculture and pomology based research, Plant physiology and biochemistry, Post-harvest management, Recent trends in agriculture communication and extension, Recent trends of other allied sciences of agriculture, Role of plant growth regulators, Soil and Nutrient Management, Sustainable agriculture, Weed, Water and Nutrient management related research, Zero Budget Natural Farming

We welcome contributions that can demonstrate near-term practical usefulness, particularly contributions that take a multidisciplinary/convergent approach because many real-world problems are complex.

I close this message by inviting everyone to submit their exciting articles to AgriGate magazine. All articles receiving a high degree of enthusiasm in the peer-review process will find a home in AgriGate magazine.

Once again, I welcome you to this Magazine – your magazine! With your support as authors, reviewers, and editors, I see very bright prospects for AgriGate magazine to serve science and the scientific community even better in the future. Ultimately, we will improve more lives and, consequently, our communities.

We hope to hear from you soon, and we welcome your feedback!

If you have any questions, suggestions, or concerns, please address them to sramakrishnan@jnkvv.org.

Thank you. We hope you will find AgriGate magazine informative.

R. Shiv Ramakrishnan

Editor in Chief

Issue No : 01 Year : 2021

Addressing Irish Famine Pathogen *Phytophthora infestans* using molecular tools

Article ID: AG-I1-01

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Abstract

Phytophthora infestans remain to be a devastating pathogen since its discovery. Starting from the Irish famine, it continues to threaten both plants and humans. It becomes obvious to reduce its movement into other places to manage great losses. Hence, numerous diagnostic tools have been devised to identify this pathogen and eliminate its deliberate entry. Though traditional methods help to understand this pathogen and identify them, the recent increase in commerce demands modern tools to diagnose this pathogen in no time. The answer being molecular tools, diploid nature, sexual and asexual reproducing ability and unique mating types of *P.infestans* keep pathologists challenged, putting them in the state of a red queen.

Keywords: *Phytophthora infestans,* Irish famine, molecular tools, plant protection, disease diagnostics

Introduction

Phytophthora infestans is a heterothallic oomycete pathogen which causes late blight of many solanaceous crops especially targeting on potato and tomato. This pathogen is infamous for the devastating loss of acres of potato farms which is also the reason behind the Irish famine of 1840. It is claimed to be a costly potato pathogen worldwide because of the cost incurred to manage this disease (Goss et al. 2014). The annual loss due to this pathogen alone was estimated to be $6.7 billion annually (Wu et al. 2016). Its epidemiological success is a result of its mode of reproduction i.e. sexual and asexual which aid in the development of new strains and rapid spread (Ristaino 2002). Also, the rapid evolution of new virulent strains to novel R genes and fungicides exacerbates its effective management (Grünwald et al. 2006). In this globalized world, the movement of harvested produce to every nook and corner is made possible, trading off the biosecurity of a country. These being the harbingers for a potential epidemic, the need for a rapid and quick diagnostic kit becomes the need of the hour.

Traditional methods of isolation of a pathogen, culturing in-vivo, and confirming the causal organism with the available literature would be a poor approach in this commercialized agriculture world. It's not just laborious and non-specific but the pathogen would have devastated the entire field by the time the causal agent is confirmed. The advent of molecular techniques such as PCR-based methods, DNA/RNA probe-based methods, post amplification technique, isothermal amplification-based methods, and RNA-Seq based Next generation sequencing provide powerful tools for the quick and accurate identification of the pathogen. To identify *P.infestans,* enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR) remain the widely adopted methods because of their efficiency and high specificity (Harrison et al. 1990; Appel et al. 2001). However, the downsides such as time consumption, labor-intensiveness and multi-step process demand the need for a new reliable diagnostic tool.The aim of this report is to discuss the diagnostic methods traditionally used to identify *Phytophthora infestans*, controversies and dilemma in disease diagnostics, and how molecular tools help settle the issues. Further, the report briefed the futuristic molecular tools for disease identification and the problems with present molecular tools.

Deciphering the mysteries and controversies

P. infestans continues to remain a threat to production agriculture. Since its discovery, many controversies pertaining to its biology and pathogenicity persist. The first controversy being whether the pathogen is a result or a cause of the late blight puzzled pathologists until it was resolved by de Bary's critical work on this pathogen (Bourke 1991). Improvements in molecular biology and genomics provide promising and powerful tools to address various other dilemmas.

Evolutionary position

P. infestans is considered a model organism for oomycetes. But to deem this status, one of the important controversies that has been resolved using the power of molecular tool is that the oomycetes are unrelated to the phylum fungi (Fry 2008). As a matter of fact, oomycetes share some characters with fungi such as extension via hyphal tips, absorption as the mode of nutrition, and reproduction via spore formation (Money 1998). However, some of the distinguishing characteristics such as the cell wall compound, diploid mycelial compartment, tinsel and whiplash flagellum and antheridia and oogonia production as gametangia have provided enough evidence to treat and appreciate the evolutionary distance between oomycetes and fungi (Money 1998). These clear separations arise after series of molecular genetic analysis that confirmed the polyphyletic nature of the fungi.

Contribution of oospore

The contribution of oospores in overwintering and the geographic distribution of A2 mating types remained a topic of debate in the late 19th and early 20th century (Fry 2008). de Bary described that the mycelium overwintering in the diseased potato tuber is the cause of late blight (de Bary, cited in Fry 2008) leaving no information about oospores. Some scientists who believed that oospores may have remained in the field could not accept de Bary's claim (De Bruyn 1926). However, in a production agriculture, diseased tuber is of utmost importance and this by no means prevent the production of oospores and its survival in non-cultivated field (Fry 2008). This rare oospores' contribution is minimal in places where asexual reproduction is the primary mode of reproduction (Fry 2008). Ko (1994) reported this due to the changes and shifts in mating type as a result of self-fertilization which again led to controversies in the late 20th century (Fry 2008). Goodwin and Drenth (1997) used DNA fingerprinting to reconfirm that A2 mating types were different from those old A1 mating population.

Centre of origin

Understanding the center of origin of a pathogen is to understand its global occurrence and spread. Two theories revolve around the possible center of origin of *Phytophthora infestans* namely central Mexico or South America. Traditionally, these theories arise from the fact that central Mexico has genetically diverse and sexual population of *P.infestans* whereas South American Andes remained the center of origin of potato (Grünwald & Flier 2005; Gómez-Alpizar et al. 2007). Goss et al. (2014) used powerful tools such as Bayesian phylogenetics and Approximate Bayesian Computation (ABC) to resolve the dilemma on the origin of *P. infestans*. Findings of Goss and his team showed that the appearance of new strains worldwide may be attributed to the diverse population of pathogen in the central Mexico whereas Europe being the reason behind the migration of the virulent pathogens via seed potatoes.

Migrations

Due to migrations, there was a considerable change in the global population structure of *P. infestans.* The first migration happened from Mexico to Europe and the subsequent migrations from Europe to other parts of the world (Fry 2008). First report on the change in mating type due to migration of the population becomes evident when Hohl and Iselin (1984) observed a *P. infestans* strain obtained from Switzerland exhibiting A2 mating type behaviour. The likely route of migration is the shipment of 25,000 metric tonnes of fresh potatoes from Mexico to Europe in 1976-1977 because the cargo contained infected tubers increasing the chances of diverse population of *P. infestans* (Niederhauser 1991). The diverseness in mating type, allozyme genotype, DNA fingerprinting, and mitochondrial haplotype of this containment was proved through retrospective inspection (Fry et al. cited in Fry 2008).

Detecting *Phytophthora*

There is no single holistic approach to diagnose the pathogen. Like screwdrivers of different shapes and sizes dealing with various screws, molecular tools should be wielded properly according to the need and purpose.

Isolation

Traditionally, *Phytophthora* is identified by placing the tissues excised from diseased parts onto a selective agar medium, allowing them to grow and confirm by morphological characters (Hüberli et al. 2000). But this method may lead to false negatives due to various factors (O'Brien et al. 2009). Hüberli et al. (2000) observed that false negatives turned positive when the samples were thoroughly washed before isolation. On another occasion, symptomless plants provided positives. Further studies using PCR showed there were more number of positives than it was noted using isolation technique (O'Brien et al. 2009). The reason for growth failure in selective medium may be due to other micro-organisms (Malaczjuk, cited in O'Brien et al. 2009), inhibition by plant phenolic compounds (Hüberli et al. 2000) and intervention by oospores or chlamydospores (Tsao, cited in O'Brien et al. 2009).

Immunological studies

Immunological assays remain to be a widely used tool owing to their quick and easy diagnosis of *Phytophthora*. Commercially available ELISA test kits for the detection of *Phytophthora* identify up to genus level by binding antibodies to generic *Phytophthora* antigens (O'Brien et al. 2009). But problems such as failure to detect pathogens, cross-reactivity with *Pythium* spp., and vagaries in the sensitivity between different species and within the isolates of the same species are the major downsides in ELISA. Another antibody-based testing device called Lateral Flow Device (LSD) is highly specific in on-site detection of *Phytophthora* species and tested to be more accurate than ELISA (Lane et al. 2007). Besides a considerable amount of research showing the fallacious results produced by ELISA, USDA has recommended ELISA as a preliminary testing tool to reduce the number of test samples (Bulluck et al. 2006). This questions the safety of the cropping in a particular place as this pathogen once introduced is hard to manage.

DNA based detection tests

DNA based diagnosis becomes a norm in this commercial and fast-moving world because of its rapidity, specificity, and sensitivity (O'Brien et al. 2009). Any region of the DNA can be amplified using PCR and can be detected through gel electrophoresis. Further, the sensitivity and detection of the pathogen can be increased by nested-PCR where a second round of primers are used which bind between the primer sites used in the first round of PCR (O'Brien et al. 2009). Another innovation in PCR is the real-time PCR where the amplified product can be measured after each cycle and multiplexing can be done (O'Brien et al. 2009). These advantages eliminate the use of gel electrophoresis and have occupied modern diagnostic laboratories. PCR results, however, sometimes are of no value because they cannot distinguish between a viable and non-viable pathogen, erroneous results due to mutations in primer binding sites and false results due to poor DNA extractions.

Conclusion

Commercialization in agriculture and globalization has promoted the mobilization of plant materials and so the spread of pathogens. Moreover, it results in devastating consequences because of the new strains forming hybrid species in new regions. The modern tools such as MALDI-TOF mass spectroscopy (MALDI-TOF MS) to detect multiple species of a pathogen in a single time (O'Brien et al. 2009) and a gold nanoparticle-based lateral flow biosensor for visual detection of late blight pathogen (Zhan et al. 2018) are in the pipeline to server the current diagnostic approaches. With all these powerful tools made working round the clock for us we are still stumbling to tackle the intelligent prowess of the pests and pathogens with their rapid evolution, cross country spread, passing resistance down the lineage, etc. A quintessential example for this ineptitude would be better understood by our current struggle against the new variant of corona virus. A simple change in its protein coat has knocked all the silver bullets shot against it. Similarly, *P. infestans* being a versatile pathogen in detecting arms against it and evolving through sexual reproduction, utmost care should be taken in diagnostic approaches.

To devise a powerful diagnostic tool, understanding the pathogen biology, taxonomy, and population change is highly important. One of the major threats that challenges the modern tools is the sampling the shipment from different countries. It is nearly impossible to sample such large volumes of produce. Consistent with this, biosecurity offices should be provided with data regarding the very recent outbreak of the pathogen in each part of the world, more accurate and rapid diagnosing tools that don't require sampling and investigation reports from the exporting country for the presence of pathogen should be made available. In a nutshell, along with all cutting-edge technologies strict policies, appropriate selection of tools, and responsibility of every individual will alone make us stand against this arms race against pathogens and humans.

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Tumaini: an AI-Powered Mobile App for Pests and Diseases

Article ID: AG-I1-02

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Banana crops are prone to damage by several types of pests and diseases. Once the pest or disease afflicting a crop is identified, swift and targeted action can reduce the extent of outbreaks and potentially save entire harvests.

Fig : 1 Banana disease (Xanthomonas wilt, Leaf spot, Fusarium wilt, Banana Bunchy Top Disease) and Pest (Banana weevil).

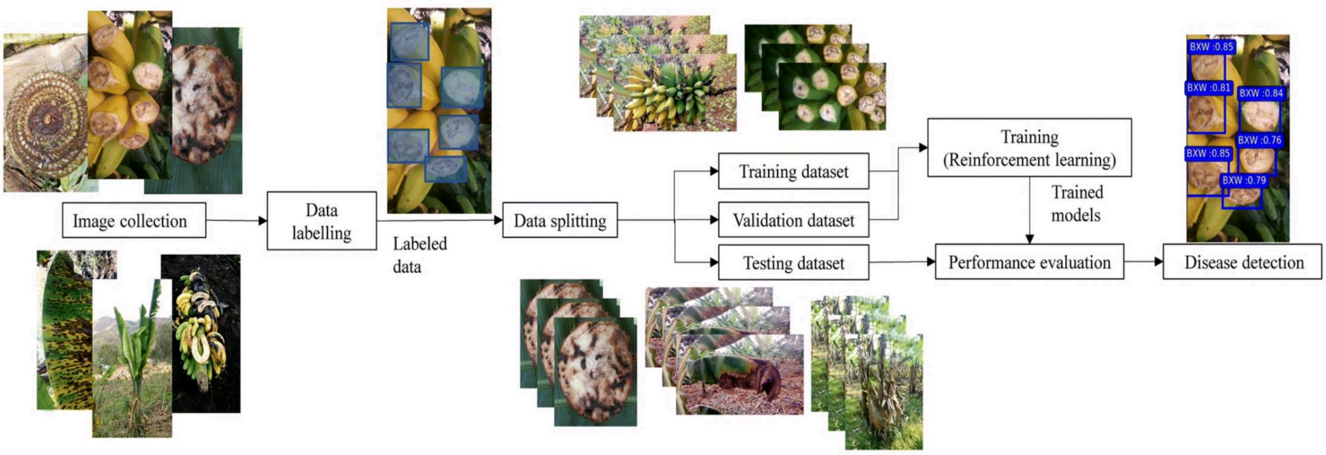

Fig.2. Testing and validation of the Tumaini smartphone App in Southern India.

CGIAR researchers at the Alliance of Bioversity International and CIAT, Imayam Institute of Agriculture and Technology (IIAT) have developed a digital tool to help farmers better protect their banana crops. The device is a mobile application that merges expertise on banana pest and diseases with artificial intelligence to quickly identify common afflictions that threaten bananas, allowing farmers and extension workers to act quickly and save their crops.

The smartphone app, called Tumaini – which means “hope” in Swahili – helps banana farmers identify symptoms of five major diseases and one common pest. Farmers use the app to screen photos of pest or disease symptoms. The app uses image-recognition technology, drawing on a dataset of more than 30,000 raw images. Tumaini records the image, including the geographic location, and feeds it into a central database. The app then provides a diagnosis and recommends steps to address the affliction

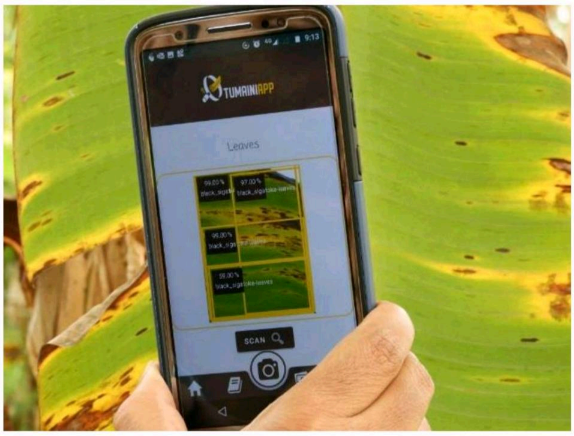

Fig 3. The Tumaini app has so far demonstrated a 90% success rate in detecting pests and diseases.

Other existing crop disease detection methods focus primarily on the leaf symptoms and can accurately function only when pictures contain detached leaves on a plain background. The novelty of Tumaini is that it can detect symptoms on any part of the crop – including the fruit, bunch or plant – and can read low-quality images, even those containing background noise, like other plants or leaves, to maximize accuracy.

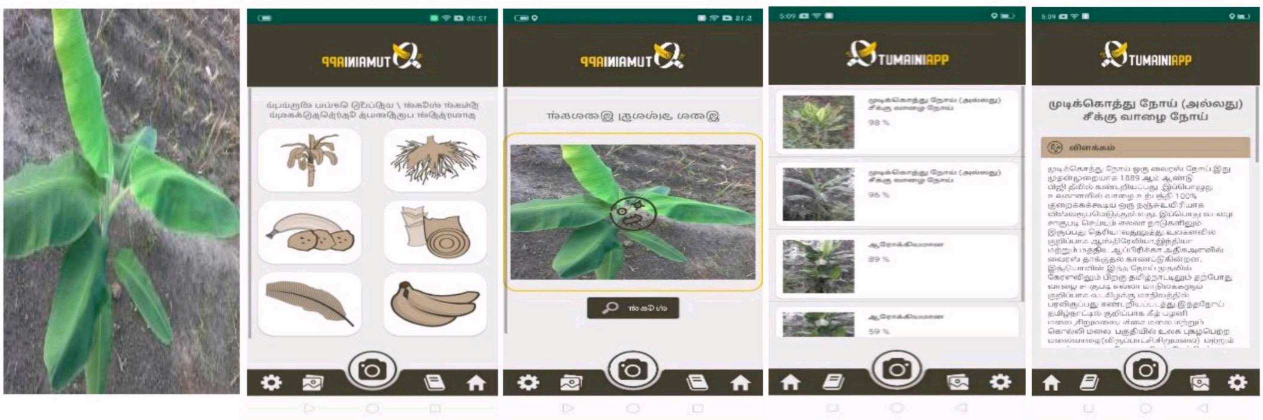

Fig 4. Detection of the health status of banana

Tested in Colombia, the Democratic Republic of the Congo, India, Benin, China, and Uganda, the Tumaini app has so far demonstrated a 90% success rate in detecting pests and diseases. This work is a step towards creating a satellite-powered, globally connected network to control disease and pest outbreaks, say the researchers who developed the technology

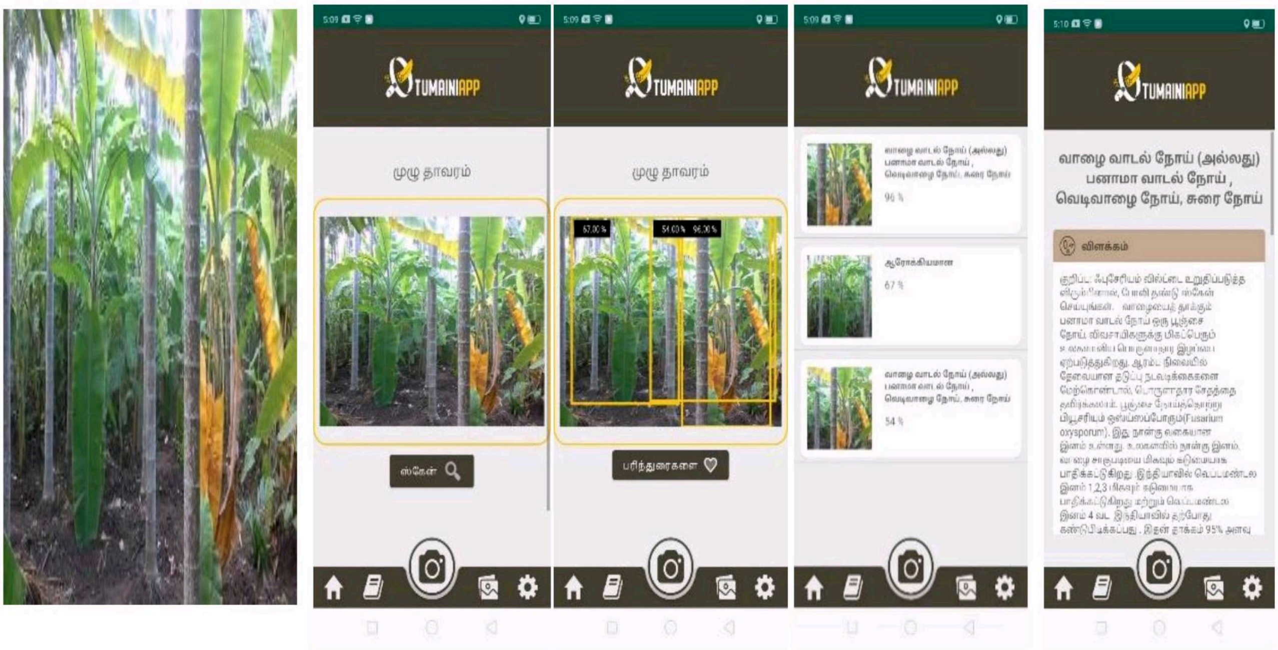

Fig 5. Detection of fusarium wilt in banana

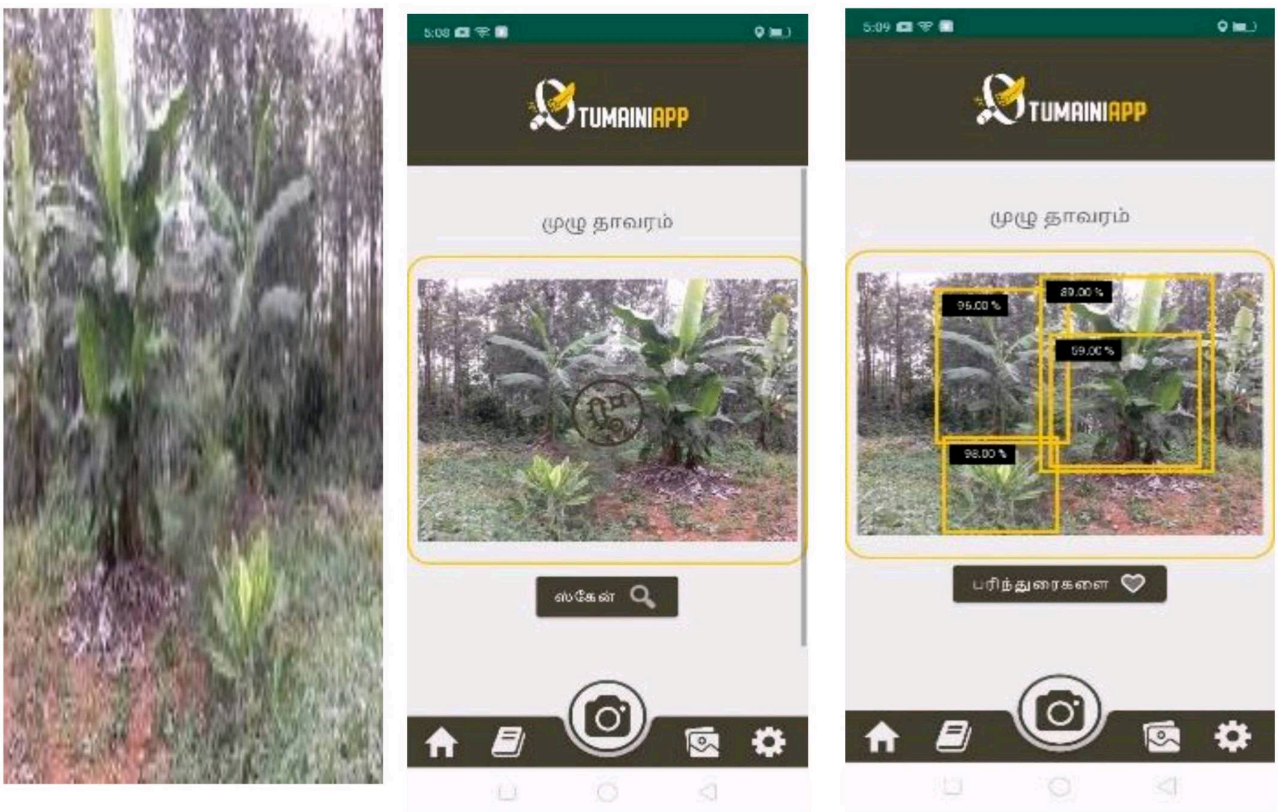

Fig 6. Detection of Banana Bunchy Top Virus in banana.

Research on the app was published in 2019 in the journal *Plant Methods* and became one of the year's most successful research papers for Bioversity International and CIAT. It also generated significant media attention and sparked inquiries from industry stakeholders regarding possibilities to expand the use of the app. To date, some 3,000 farmers are using the app in the field. A second version, released in 2020, allows for offline use, and researchers expect uptake of the app to increase as a result.

Reference:

M.G. Selvaraj, A. Vergara, H. Ruiz, N. Safari, S. Elayabalan, W. Ocimati, G. Blomme

AI-powered banana diseases and pest detection. Plant Methods, 15 (2019), p. 92.

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IMPORTANCE OF SILICON NUTRITION TO RICE IN CAUVERY DELTA ZONE

Article ID: AG-I1-03

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Introduction

From the start of Indian agriculture, rice cultivation has had a tremendous position and has always played an important part in our food and civilization. Rice is cultivated in Tamil Nadu in about 18.3 lakh hectares with 79.14 lakh mt of production and 4325 kg ha^{-1} productivity. However, certain limitations, such as water scarcity, pest infestation, insufficient use of fertilizers, and low-yielding traditional varieties, lead to a reduction in potential. Consequently, increasing productivity and keeping pace with rising food demand with minimal environmental disruption has become a challenge for farmers and researchers.

Importance of rice as food

Rice (*Oryza sativa L.*) is one of the world's most common field crops, grown in various agroecosystems, among other cereals. Rice is the staple food for half of the population worldwide and ranks second after maize in terms of production. It is the cornerstone of our nation's food security and plays a critical role in guaranteeing it . Overall, 23 % of the total calorie (35 % in Asia and 31 % in India) and 16 % of the complete protein is derived from rice. Sustainable production of rice is therefore essential to overcome food scarcity worldwide.

Essentiality of Silicon (Si) to present day agriculture

Si is the second most abundant component in the crust and soil after oxygen. The average lithosphere content of elemental Si is about 28 percent. Total Si content in soil usually varies from 25 % to 35 %, with an average of 30 %, depending largely on soil types. There is now recognition of many advantages of silicon (Si) to crops. As the eighth most abundant element in the universe and the second most abundant element in the crust of the Earth, Si does not lack in amount (Epstein, 1999a); however, Si's plant-available forms may be restrictive (Savant *et al.*, 1997).

Silicon essentiality to rice

Rice is a high silicon accumulating plant, and the plant is benefited from Si nutrition. The silicon uptake by rice crop is in the range of 230 - 470 kg ha^{-1}. Si is a beneficial element for plant growth and is agronomically essential for improving and sustaining rice productivity. Besides rice yield increase, Si has many fold advantages of increasing nutrient availability (N, P, K, Ca, Mg, S, Zn), decreasing nutrient toxicity (Fe, P, Al), and minimizing biotic, abiotic stress in plants. Hence, the application of Si to soil or plant is practically useful in laterite-derived paddy soils, not only to increase yield but also to alleviate the Fe toxicity problems. Si increases the culm's mechanical strength, thus reducing crop lodging (Savant *et al.*, 1997). Si in the soil is not a much mobile element to plants. Therefore, a continuous supply of this element would be required, particularly for healthy and productive plant development during all growth stages. Consequently, there is a definite need to consider Si as an essential element to increase sustained rice productivity.

Demand of silicon to rice

Rice advantages from Si nutrition as an accumulator of Si. Si usage increases rice production and yield. Savant *et al.* (1997) noted that Si depletion might happen from the constant monoculture of high-yielding cultivars with intensive cultivation methods in traditional rice soils, particularly if farmers do not replace Si removed by rice. Consequently, it appears necessary in temperate and tropical countries to properly manage Si to boost yield and maintain crop output. As the synergistic impact, Si implementation can increase the optimum level of nitrogen (N), resulting in increased productivity of rice. N fertilization tends to cause drooping of rice leaves, while Si keeps them erect, which could readily account for a rise of 10 percent in photosynthesis with comparable yield increases.

Chemistry of Silicon

Until recently, the chemical dynamics of silicon in soils have been understudied. The chemical interactions between Si and many soil components influence the quantity of plant-available Si released into the soil solution. Plant absorption of silicon as mono silicic acid (H_4SiO_4) is proportional to Si's soil solution concentration. Si's solubility (both crystalline and amorphous) is constant between 2 and 8.5 pH levels but is rapidly rising above 9. The rapid rise in solubility above 9 is due to the ionization of mono silicic acid, as illustrated below:

$$Si(OH)_4 + OH^- \text{-------} Si(OH)_3^- + H_2O$$

$$H_4SiO_4 + OH^- \text{----------} H_3SiO_4^- + H_2O$$

Silicon plays a significant role in alleviating biotic and abiotic stress in different crops. There is a wide range of evidence from scientists worldwide on the usefulness of this factor in improving yields of crops such as rice (*Oryza sativa*), especially under stressful growing conditions such as drought, salinity, pests, and diseases. Various functions have been attributed to silicon, such as enhancing nutrient imbalance, decreasing mineral toxicity, enhancing the mechanical properties of plant tissue, and enhancing resistance to other abiotic and biotic stresses (Ma and Yamaji, 2006).

Benefits of Si to rice

Si amended rice plants have different degrees of capacity to withstand or tolerate biotic stresses such as insect attacks, pests and fungal diseases, and abiotic stresses such as soil toxicity Al, Fe, Mn, and excessive salts. Its supply also helps to decrease cuticular transpiration and crop accommodation due to excessive N supply to some extent (Savant *et al.*, 1997). The beneficial impacts of Si on yield have been suggested by research. It also improves the nutrient translocation within the plant and the effectiveness of water use by decreasing transpiration. For development, rice needs greater quantities of nitrogen and silicon. Applied Si appears to communicate positively with other nutrients used in fertilizers *viz.*, N, P, and K and provides the ability to enhance their agronomic performance and yield.

Rice is a proven silicon accumulator and benefits from Si nutrition. Therefore, there is a definite need to recognize Si as an essential element for sustained rice productivity. Silicon depletion may occur in traditional rice-growing soils from continuous production of rice from and using high-yielding varieties with thorough cultural practice, particularly if farmers do not substitute Si removed by rice. The supply of nutrients by fertilization or alteration of the soil structure influences the soil's amount of nutrients. The presence of Si in the soil does not negate the occurrence of its deficiency as a nutrient. Therefore, the use of exogenous Si fertilizer may be appropriate for a cost-effective and sustainable rice production system (Ning *et al*., 2016).

Silicon demand in Cauvery Delta Zone (CDZ)

Rice-growing Cauvery delta zone (CDZ) soils become deficient in Si due to intensive cultivation without the addition of Si fertilizers, especially if the rice straw is not incorporated into the field. Consequently, there was Si depletion, which was highlighted as one of the factors for rice output stagnation.

Plant available Si is generally low in tropical and subtropical soils (Meena and Singh Shivay, 2010). Liang *et al.* (2007) recorded that, due to enormous active desilification and fertilization processes, Si content in red soils (highly weathered soil) in the tropical zone may be less than 1 %. Tubana *et al.* (2016) pointed to soils belonging to the weakly formed Entisols and Inceptisols that are also thought to have low levels of plant-available Si, while Entisols have strong quartz (SiO_2) content in the sand. Still, the Si is only marginally soluble and unavailable to plants (Datnoff *et al.*, 1997). Silicon ranges between 200 and 300 g Si kg^{-1} in clay soil and 450 g Si kg^{-1} in sandy soil (Matichenkov and Bocharnikova, 2001).

Matichenkov and Bocharnikova (2001) determined that 210 – 224 million tons of Si were extracted from cultivated soil each year. Nonetheless, suppose the silicon is not reincorporated into the field, plant-available Si may be depleted in soils with decreasing cereal yields. Guntzer *et al.* (2012) has recorded that Si fertilizer has been used in many countries to increase rice yield.

Conclusion

Thus, it is the right time to turn our vision towards silicon nutrition in Cauvery delta zone (CDZ) soils, especially where rice is the major crop that may tremendously increase its yield.

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Integrated Crop and Livestock System and its Advantages

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Background

Poverty and hunger must be eliminated in our generation and should therefore be a prominent stand-alone goal. The majority of the world's poor people live in rural areas, and agriculture development has proven effective in lifting rural families out of poverty and hunger(Dobermann et al., 2013). Managing the linkages between agriculture, poverty and nutrition is critical as we look towards providing children with an opportunity to reach their full potential(Cleaver et al., 2006; Hawkes and Ruel, 2006).To ensure**a** sustainable development path for agriculture and food systems, preserving the environment through systems management principles is essential. These principles increase resource use efficiency, reduce net carbon emissions and other pollutants associated with agriculture, improve soils, conserve natural resources, and increase net profit of the farmers(Bennett and Franzel, 2013; Dobermann et al., 2013).Sustainable agricultural practices and food systems, including both production and consumption, must be pursued from a holistic and integrated perspective. Land, healthy soils, water, livestock, and plant genetic resources are key inputs into food production, and their growing scarcity in many parts of the world makes it imperative to use and manage them sustainably. Diversifying production on marginally productive croplands could contribute to increased crop production and can feed the increasing global population thereby enhancing food security. Introducing livestock into annual and perennial farming systems can improve crop productivity, various ecosystem services and provide economic benefits(Lemaire et al., 2014).Within this framework, an integrated crop-livestock farming system represents a key pathway for addressing food security through eco-efficient agricultural system.

What is Integrated Crop Livestock System (ICLS)?

The increasing pressure on land and the growing demand for livestock products make ICLS more essential to guarantee the effective use of feed resources, including crop residues(Thornton, 2010). Integrated crop and livestock systems (ICLS) are agricultural management systems where land is rotated over space and time among crop, pasture, and livestock uses. A key characteristic of these systems is that the outputs of one land use are used as inputs into another. For example, manure from ruminant livestock is used as a fertilizer source for cropland and the crop residues are used as feed for the livestock(Herrero et al., 2010; Powell et al., 2004).An integrated farming system consists of a range of resource-saving practices that target to achieve satisfactory profits, and high and sustained production levelswhile curtailing the negative effects of intensive farming,hence preserving the environment.

Advantages of integration of crop-livestock

In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of the available resources efficiently. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying the nutrients that improve soil fertility, reducing the use of chemical fertilizers. It occurs not only in the mixed ecological farms of temperate countries, but also in the mixed, relatively low input farms of southern and south-western Australia with grain-legume-sheep mixtures. Integration occurs most often, however, in low external input agriculture (LEIA) farming systems that exist in many tropical countries where products or by-products of one component serve as a resource for the other - dung goes to the crops and straw to the animals. In this case, the integration serves to make maximum use of the resources. Unfortunately, these systems tend to become more vulnerable to disturbance because the mixing of resource flows makes the system internally more complex and interdependent.

In Asia, the integration of livestock, fish, and crops has proved to be a sustainable system through centuries of experience. In China, for example, the integration of fishpond production with ducks, geese, chickens, sheep, cattle, or pigs increased fish production by 2 to 3.9 times (Chen, 1996), while there were added ecological and economic benefits of fish utilizing animal wastes. Environmentally sound integration is ensured where livestock droppings and feed waste can be poured directly into the pond to constitute feed for fish and zooplankton. Livestock manure can be used to fertilize grass or other plants that can also constitute feed for fish. Vegetables can be irrigated from the fishponds, and their residues and by-products can be used for feeding livestock.

The best-known type of integrated mixed farming is probably the case of mixed crop-livestock systems. Cropping in this case provides animals with fodder from grass and nitrogen-binding legumes, leys (improved fallow with sown legumes, grassesor trees), weeds and crop residues. Animals graze under trees or on stubble,provide draught and manure for crops, while they also serve as a savings account.Grazing of livestock under plantation trees such as rubber, oil palm or coconut is a form of crop-livestock integration that is often found in Southeast Asia. Experiments in Malaysia with cattle and goats under oil palm showed better oil palm bunch harvest and comparable results were found where goats fed under rubber trees. In rubber and oil palm plantations in Malaysia, the integration of livestock to utilize the vegetative ground cover under the tree canopy increased overall production and saved up to 40 percent of the cost of weed control. Similarly, sheep helped control weeds in sugar cane fields in Colombia. This suppressed the costs of herbicides, reduced the cost of weed control by half, and provided additional income from meat production.

Based on the principle of enhancing natural biological processes above and below the ground, the integrated system represents a winning combination that (a) reduces erosion(Schroder et al., 2011); (b) increases crop yields, soil biological activity and nutrient recycling; (c) producesdiverse foods, augments pollinator populations, aids in pest management(Bale et al., 2008) (c) intensifies land use, improves land-use efficiency improving profits(Lemaire et al., 2014); and (d) can therefore help reduce poverty and malnutrition and can strengthen the environmental sustainability (Hilimire, 2011).

Conclusion

Integration of livestock with cropping system enhances farmers' opportunities to improve soil health, food grain production, environmental safety, and diversified marketing system that can reduce risks, increase farm output and make flexible for weather extremes. Before introducing livestock into a regular farming system, it's important to know about the financial, infrastructure, adaptability, and marketing demands involved in producing livestock. The farmers with poor financial status can begin to integrate livestock with a cropping system under contract grazing which might be a good option to start ICLS.

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RAWE: A Flagship Activity for Final Year Agricultural Students

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Introduction:

The Rural Agricultural Work Experience (RAWE) which is a part of **Student READY Programme** provides exposure to agricultural students to the natural setting of the village situations, work with the farm families, identify their problems and make use of various extension tools for transferring the latest agricultural technologies. The students also get opportunity to study the various on-going schemes related to agriculture and rural development and participate in their implementation. The students were given rigorous orientation and familiarization on various issues and problems expected on farmers' field and hence gain competence and confidence for solving problems related to agriculture and allied sciences. It has been implemented in adopted villages under the supervision of scientists. Activities focused on intensive observations/ analysis of socio-economic and technological profile of the farm families in rural areas, participatory extension approach and acquaintance with farming situations, farm practices and interaction with progressive farmers. This helps orient our agricultural graduates for participation in various rural developmental programme. The students also gain first-hand information on industries during attachment with identified Agro-based industries.

(Image Source: ICAR Agricultural Education Portal**)**

History:

Agricultural Education is an important tool in ensuring increased agricultural productivity, sustainability, environmental and ecological security, profitability, job security & equity. In India, **Randhawa Committee (1992)** recommended the **Rural Agriculture Work Experience (RAWE)** programme for imparting quality,practical and production-oriented education for agriculture degree programme. **The World Bank (1975)** statedthat there was little emphasis on curricula on preparing the agricultural graduates for better career in agriculture or agribusiness outside govt. jobs. Therefore, the agenda for the 21st century in agricultural education should be drawn on the basis of the challenges it has to meet in the near future. RAWE programme provides significant hands-on experience in acquiring knowledge and skill.

Main Objectives Of RAWE:

- To building self-confidence in the agricultural graduates by honing their professional skills.
- To provide opportunities to the students for studying the rural situations.
- To bestow occasions for gaining direct farm experience.
- To study and document the activities of rural artisans / entrepreneurs / Self Help Groups (SHGs).
- To document the Indigenous Technical Knowledge of farmers.
- To gain experience about the preparation of farm and village development plans.
- To develop communication and organizational skills of students in transfer of technology.

Implications Of RAWE Programme: -

- Sensitization towards field agriculture.
- Hands-on experience in village condition.
- Development of favourable and required skill and attitude among agricultural graduates.
- Development of human resource in agriculture education.

Conclusion:

From the immemorial, human being are carrying out agricultural operation as their primal operation. This primitive business of human civilization is going on unabated triumphing over all catastrophic events. But farmers of our country are habituated with indigenous technology. They are sometimes reluctant to adopt new technology innovated at the research station. This is due to lack of communication gap between farmers and researchers. All round development of farming community is possible through effective dissemination of agricultural technology to the farmer's field. Agricultural graduates can play a vital role in transfer of technology.

Naturally, the formal education, which is imparted to agricultural graduates within the four walls of University campus, is not enough. Mere acquisition of knowledge will be futile if it is not applied in practical field situation. An old Chinese proverb conveys us **"If I hear I forget, if I see I remember, if I do I know"**. So, it is evident that we will be practically strong and competent by working in the village, by interacting with the farmers to gather some idea about indigenous technology of the farmers which is why Rural Agricultural Work Experience (RAWE) has become an integral part of the course curriculum in undergraduate programme in agricultural education.

It gives us the opportunity to analyse the rural social situation, farm situation, standard of living of age-old tillers of soil, socio-economic standard of farmers, their joy and sorrow. All such analyses will provide a 'bench mark' about farmers need. Need based field oriented technology will be evolved in collaboration with farmers indigenous technology, which will be beneficial for them.

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❖ https://education.icar.gov.in/student_ready.aspx

RAWE Yethapur Group Students

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