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CONTENTS

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KUNAPAJALA: AN ITK FOR SUSTAINABLE CROP PRODUCTION

Mahendra Choudhary[1]*, D K Shukla[1], Sanjeev Kumar[2], Jyoti Choudhary[3], and Raghuveer Choudhary[4]

[1]Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar (UK)- 263145

[2]ICAR-National Dairy Research Institute, Karnal 132001

[3]Department of Soil Science, Rajasthan College of Agriculture, MPUA&T, Udaipur-313001

[4]Department of Agronomy, Junagarh Agricultural University, Junagadh-362001

*Corresponding author email: mcrchoudhary99@gmail.com

ABSTRACT

Due to the decline in agricultural productivity from the careless use of chemicals and unscientific intensive farming, a shift towards eco-friendly organic methods is necessary. Organic inputs like Kunapajala can enhance soil health and protect plants, boosting productivity. Kunapajala, an ancient organic manure from India, decomposes animal feces and recycles bio-waste into nutrients. It includes dairy excreta, products, natural resources, and non-edible by-products. This traditional formulation, adapted over time, contains essential vitamins, enzymes, growth hormones, and bio-pesticidal compounds. Kunapajala can be used alone or with other nutrients, promoting sustainable crop production.

KEYWORDS: Bio-enhancer, Organic farming, Plant nutrients, sustainable crop production

INTRODUCTION

The population on the earth is increasing day by day which urges more food. To fulfill the demand of food, chemical-based agriculture is dominant. Although chemical use has played a crucial role in fulfilling our stomachs and according to the FAO, if such chemicals (fertilizers, pesticides, etc.) hadn't been employed, almost 40% of the world's population would not exist today. But nowadays due to the use of chemicals in an unregulated manner, we are facing lots of second-generation problems such as degrading soil health and quality, contaminating waters, declining water table, nutritional imbalances, salinity, environmental pollution etc. and a reduction in net profit.

On the other hand, the net cultivated crop area is shrinking due to rising population pressure and that's why we need to increase crop productivity. Before the green revolution, agriculture in India was exclusively based on with organic inputs and techniques. In the past, organic farming produced enough food on its own to feed the whole population. Population increase proved organic farming unsustainable over time, and the green revolution replaced it with chemical-based agriculture. However, since 1990, agricultural productivity losses brought on by persistent chemical use have gained attention, and Indian agriculture is once again exhibiting a paradigm shift towards organic farming to some degree (Biswas, 2020).

Organic farming is chemical-free farming that maintains a biological cycle, and biodiversity and it is well-known that it is an eco-friendly approach. It offers a variety of nutrients and speeds up the activity of microorganisms and other organic processes linked to crop production. The use of eco-friendly techniques and the use of organic manures, biopesticides, organic mulching, etc. are the mainstays of organic agriculture. Organic agriculture is the oddest farming system that is also related to a variety of conventional organic formulations in the form of indigenous technical knowledge (ITK), in addition to these organic goods and activities. These formulations vary with the location and availability of raw material but these are good sources of macro, and micronutrients, PGRs, and also a good source of microorganisms and *have bio-pesticidal activity* (Ram et al., 2018). Among these formulations, one traditional organic formulation is Kunapajala.

Kunapajala – Kunapajala is one of the oldest documented organic formulations that is produced from plant and animal products by the procedure of fermentation. Kunapajala is made up of two Sanskrit words, Kunapa which means ‘smelling like a dead body’ or ‘filthy’ and jala means ‘water’ or ‘fluid’. Kunapajala is mentioned in two probably contemporaneous texts: the Vrikshayurveda by Surapala, who lived in eastern India in 1000, AD. and Lokopakara, which was produced in 1025, AD in southern India's Karnataka state by poet Chavundaraya.

THE PREPARATION METHOD OF *KUNAPAJALA*

Kunapajala words are mentioned in two works of literature Vrikshayurveda i.e. written by Surapala and Lokopakara by Chavundaraya. However, the procedure of preparing *Kunapajala* is missing in Lokopakara. Vrikshayurveda (verses 101-106) mentioned the preparation procedure.

Surapala's Vrikshayurveda mentions varieties of *Kunapajala* and in verse 101 mentions that the marrow of the bones, excreta, flesh, brain, and blood of a pig is mixed with water and stored underground is called *Kunapa*. In the following verses, it is quoted that animal wastes are gathered and stored whenever they become available. Even though dead boar wastes were initially described. Surapala enlarged the scope of wastes to include other animals, particularly horned ones. After that, boiling the wastes and then they mixed with husk and stored. Subsequently, the formulation is cooked with the sesame oil cake, soaked black gram and honey, and finally, ghee pored. Verse 101 suggests burying animal waste to prevent unpleasant odors and to keep goods safe from wandering animals like dogs. Surapala has described animal waste from cows, porpoises, cats, birds, deer, elephants, and other creatures in the lines that come after the ones that were previously cited.

Late Dr. Nene created a vegetarian version of the original method in 2012 known as herbal *Kunapajala*. Thus, utilizing cow pee and dung while keeping the other elements used by Surpala. In the herbal version of *Kunapajala*, the main ingredients are cow urine and dung, black gram seed, jaggery neem or mustard oil, rice huck, finely sliced weeds, and water in prescribed proportions.

Table 1: Ingredients and procedure to make herbal kunapajala

SN.	Materials	Quantity
1.	Cow Dung	15-20 kg
2.	Cow Urine	15-20 Litres
3.	Jaggery (Spoiled)	2 Kg
4.	Sprouted Black Gram	2 Kg
5.	Mustard or Neem Cake	2 Kg
6.	Local Farm weeds	20 Kg
7.	Water	10-12 Liters

BENEFITS OF *KUNAPAJALA* APPLICATION

Kunapajala is a traditional Vrikshayurvedic plant nutrient, fertilizer, and bio-enhancer that offers several remarkable advantages. Using this doesn't necessitate the use of any additional fertilizer. It can play a crucial role in enhancing crop quality and productivity by supplying varieties of nutrients for the plant's uptake from soil or foliar absorption. Valmiki Sreenivasa Ayangarya was the first one who experiment with herbal *Kunapajala* and documented the beneficial role of herbal *Kunapajala* on coconut and mango (Ayangarya, 2004).

Kunapajala is a rich source of plant growth-promoting bacteria (PGPB) and has the potential to help host plants in several ways, including encouraging plant growth, increasing nutrient availability, and controlling pests and diseases (Chakraborty et al., 2019). As a result, it has been extensively advised for use as a soil soaking or foliar spray for many crops, including black gram (*Vigna mungo*), mustard (*Brassica campestris*), and rice (*Oryza sativa*). According to Chakraborty *et al*. (2019), *Kunapajala* is a rich source of plant nutrients and majorly provides major plant nutrients which are N, P, and K.

Chakraborty *et al* ., (2019) also found that *Kunapajala* has pesticidal properties that overcome the attack of insects and diseases and help in quality crop production. Additionally, *Kunapajala* is a great technology for the waste management of plants and animal waste sustainably (Sorathiya *et al*., 2014). Intensified crop production with livestock farming has been contributing to generating huge amounts of residue. India, as an example, produces about 683 million tones of crop residues per year from 10 major Indian crops (Bhattacharjya *et al*., 2019), while rice and wheat alone contributed around 300 million tones of residue generation recorded in the year 2017–2018. It can be the best option to convert waste into wealth. (Venkatramanan *et al*., 2021)

CONCLUSION

Kunapajala is an organic source of plant nutrients that plays a significant role in improving soil and plant health. It is made from agricultural waste and provides all essential nutrients by creating a supportive ecology for crop production. Some studies suggest that *kunapajala* helps to control pests and diseases. Therefore, through the application of Kunapajala, farmers can achieve the good quantity of crop yield with waste management and better soil health.

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ENDOPHYTES AS AN ECOFRIENDLY BOOSTER FOR PLANT DISEASE MANAGEMENT

Reena Kumari, Karuna Dhiman and Aditi Thakur

College of Horticulture and Forestry, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Neri-Hamirpur (177001) HP, India

**Corresponding author email: reenarattan@gmail.com*

ABSTRACT

Changing climatic conditions increase biotic stress on agricultural crops, caused by bacteria, viruses, fungi, nematodes, weeds, and insects, negatively impacting plant growth and development. These factors elevate reactive oxygen species levels, reducing crop productivity. Typically, synthetic chemicals are used as plant protection products to manage this issue, interfering with cellular functions and targeting organisms' life cycles. Applied as aqueous sprays, these chemicals have limited efficacy and stability, especially on aerial parts. Soil application offers better stability and efficacy. The focus should now shift to reducing agrochemical use and promoting eco-friendly alternatives like beneficial plant-bacterial and fungal interactions to sustain the environment and health.

KEYWORDS: Antimicrobial compounds, Biological control, Endophytes, Plant growth promotion, Plant pathogens

INTRODUCTION

In recent years, the use of biological agents to control pests or diseases has become much more fascinating. .Biological control are the organisms and their products which minimize the adverse effects of plant pathogens and act as positive stimulator to promote plant health. Biological controls include natural substances, biochemicals, macroorganisms and microorganisms. The microbes are categorized into three different groups on the basis of their interaction with host plants, viz., symbionts, epiphytes and endophytes. The plant tissues are reported to be colonize with microbial commodities known as endophytes which is made up of two words endo (within) and phyte(plants). .Endophytes colonized all parts of plants, which includes inter space in between the cell walls and vascular bundle of plant roots, leaves,stems,flowers, fruit and seeds (Wilson,1995) . It is reported that the maximum proportion of endophytes are present in below ground parts as compared to above ground parts. Roots are the entry point of endophytes to the host plants due to the their abundance in rhizosphere. De Bary in 1866 first time used this term endophyte i.e non-pathogenic organism which resides inside the plants.These endophytes are also reported to combat injury caused by pathogens through enzyme production, volatile organic compounds, secondary metabolites, competition for food, parasitism and activation of harmones. Besides this, they also improve the soil and plant health. Scientists across the globe reported approximately 200 genera from the 16 phyla of bacterial species to be associated with endophytes with dominance of Proteobacteria, Actinobacteria and Firmicutes (Golinska et al., 2015). The multifariousness of endophytic bacteria reported to be ranged from gram-positive to gram-negative, such as Achromobacter, Acinetobacter, Agrobacterium, Bacillus, Brevibacterium, Microbacterium, Pseudomonas, Xanthomonas etc. The diverseness of these endophytes are far famed to produce broadspectrum bioactive metabolites that act as antimicrobial,antiviral and antifungal compounds.In this article main emphasis will be given on the explotation of endophytes as biological control.

ENDOPHYTES FOR DISEASE MANAGEMENT

Several strains of plant growth promoting bacteria are reported to activate the defence mechanism of plants. Most of the endophytes reported to directly inhibit the growth of pathogen or either through the establishment of plant systemic resistance. These are also reported to produce antibiotics and lytic enzymes responsible for degradation of pathogens cell wall and some may regulate the quorum sensing of pathogens.Most of the fungus genera are reported to produce enzymes like cellulases, amylase, glutaminase and 1,3- glucanases which facilitate cell wall degradation, thus reduce disease severity caused by different phytopathogens. The uncountable reports proved that the endophytes have effective role to control numerous devastating phytopathogens, insects and nematodes.

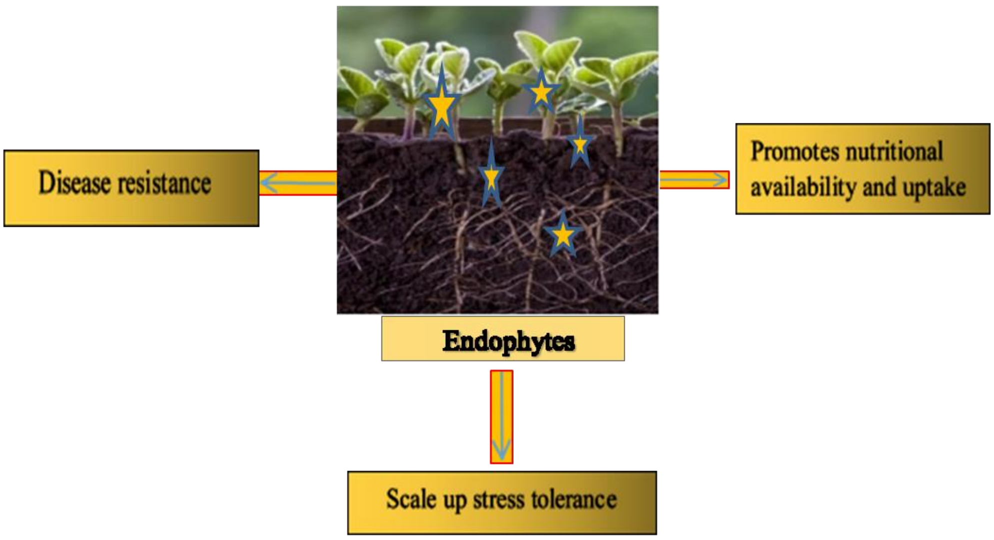

Fig 1. Endophytes as plant defence regulator

These are also reported to activate plant resistance by upregulating of various defence related genes such as pathogenesis related genes, phenyl propanoid pathway related genes,and also elevate the production of antioxidant enzymes. There are several reports on applications of endophytes to various plant diseases (Table 1)

Table 1: Endophyte mediated plant disease management

Endophytes	**Effective against target pathogens**
Pseudomonas denitrificans	Control Oak wilt caused by fungus *Ceratocystis fagacearum* in oak
Alcaligenes sp.(EIL-2)	Control abnormal leaf fall caused by Phytophthora meadii in rubber tree
Bacillus pumilus (JK-SX001)	Control canker caused by *Cytospora chrysosperma*, *Phamopsis macrospora* and *Fusicoccum aeseuli* in cutting of poplar
Trichoderma harzianum (B100) and *Trichoderma aureoviride* UASWS	Necrotic area of oak tree caused by *Phytophthora plurivora*
Bacillus strain YC7010	Rice bacterial blight
Azospirillum sp. B510	Rice blast disease and bacterial blight
Beauveria bassiana or *Purpureocillium lilacinum*,	Cotton aphid (Aphis gossypii)
Diaporthe phaseolorum, *Aspergillus fumigatus* and *A. versicolor*,	Effective against bacterial spot of tomato (*Xanthomonas vesicatoria*)

COMMERCIAL PRODUCTS

Numerous bacteria and fungi used as biocontrol agents are available as commercial products. Bacteria as biocontrol agents are Agrobacterium radiobacter K84, Enterobacter spp. , Bacillus spp., Pseudomonas spp. (Pseudomonas chlororaphis, Pseudomonas aureofaciens), Pantoea spp., Streptomyces sp. and Paenibacillus spp. Examples of fungi as biocontrol agents are Trichoderma spp. (eg: Trichoderma asperellum, Trichoderma atroviride, Trichoderma gamsii, Trichoderma polysporum), Aureobasidium pullulans, Ampelomyces spp. (Ampelomyces quisqualis), Beauveria bassiana, Colletotrichum spp., Candida spp. (Candida oleophila), Coniothyrium spp., (Coniothyrium minitans), Metarhizium anisopliae,Gliocladium spp. (Gliocladium catenulatum), Phlebiopsis gigantean, Paecilomyces lilacinus, Purpureocilium lilacinum, and Verticillium spp. (Verticillium lecanii).

CONCLUSION

In order to secure global agricultural productivity the use of endophytes as biological control agent is an attractive approach to knock down the use of chemical based pesticides. Considerably limited number of endophytes are commercialized till date. Therefore the more focus will be insisted on identification, characterization and evaluation of endophytes with wider stability under different environmental conditions.

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*********XXXXX**********

UTILIZATION OF PINEAPPLE WASTE IN SILAGE PREPARATION FOR LIVESTOCK FEED

K.Sudha Rani[1]* and M.Ravi Kumar[2]

[1]*Assistant Professor, Department of Animal Nutrition, Sri Venkateswara Veterinary University, College of veterinary Science, C.V.Sc Garividi, Vizianagaram, Andhra Pradesh-535101

[2]Associate Professor, Department of Animal Nutrition, Sri Venkateswara Veterinary University, College of veterinary Science, C.V.Sc Garividi, Vizianagaram, Andhra Pradesh-535101

*Corresponding author email: drsudha0606@gmail.com

ABSTRACT

The growing need for sustainable livestock feed has driven the exploration of agricultural by-products like pineapple waste, consisting of peels, cores, and crowns. This nutrient-rich by-product shows promise for silage production. This review covers the process of making silage from pineapple waste, highlighting its benefits and the considerations necessary for its effective use in livestock diets. By utilizing this waste, farmers can create an economical and environmentally friendly feed source, enhancing both livestock nutrition and sustainable farming practices.

KEYWORDS: Livestock feed, Nutritional value, Pineapple waste, Sustainable farming, Silage production

INTRODUCTION

Pineapple cultivation in India is significant, with major producing states including West Bengal, Assam, Karnataka, Kerala, Tripura, and Andhra Pradesh. The crop thrives in tropical climates with temperatures between 22°C and 32°C, annual rainfall of 1000-1500 mm, and well-drained sandy loam soils. India produces approximately 1.2 to 1.5 million metric tons of pineapples annually. Andhra Pradesh has about 2,000 to 3,000 hectares under pineapple cultivation, primarily in the Visakhapatnam district. The yield in Andhra Pradesh is comparable to the national average, around 15-20 metric tons per hectare. Pineapple waste, a significant by-product of the pineapple processing industry, often poses disposal challenges. The efficient use of agricultural by-products is essential for sustainable farming practices. Utilizing this waste for silage preparation offers an economical and environmentally friendly solution while providing nutritious feed for livestock. This article explores the methods, benefits, and challenges associated with using pineapple waste in silage production.

COLLECTION AND PREPARATION OF PINEAPPLE WASTE

Pineapple waste, including peels, cores, and crowns, is collected from processing plants, markets, or farms. The waste is chopped into small pieces (1-2 inches) to facilitate fermentation and improve packing density.

MIXING WITH FORAGE

Pineapple waste is mixed with forage crops (e.g., corn, grass, alfalfa) or dry materials (e.g., hay, straw) to balance moisture content and enhance nutritional value. A typical ratio of 70% pineapple waste to 30% forage is recommended.

PACKING AND SEALING:

The mixture is packed into silos, trenches, or plastic bags, ensuring tight packing to eliminate air and promote anaerobic conditions. The silage is then sealed with plastic sheets, weighed down to prevent air ingress.

FERMENTATION PERIOD:

The packed silage is left to ferment for at least 3 weeks, allowing beneficial bacteria to produce lactic acid, which preserves the silage.

BENEFITS OF PINEAPPLE WASTE SILAGE:

Nutritional Value: Over a 20-day period, high-quality silage was prepared, achieving an average pH of 4.2 and a lactic acid content of 6–7%. On a dry matter basis, the nutritive value of the Pineapple Waste silage was superior to conventional maize green fodder. This silage contained 52.0% total sugars, 7.50% crude protein, 56.04% neutral detergent fiber, 19.76% acid detergent fiber, 72% total digestible nutrients, 0.61% calcium, and 0.30% phosphorus. This enhanced nutritional profile makes the silage a more beneficial option for livestock feed compared to traditional maize fodder. Pineapple waste is rich in fiber and certain vitamins, contributing to a balanced diet for livestock. The fermentation process enhances the palatability and digestibility of the silage.

Considerations for Livestock Usage: Pineapple waste has high moisture content, which can lead to spoilage if not properly balanced with dry forage. Ensuring the right mixture is crucial for quality silage. Regular monitoring of the silage is essential to detect any signs of spoilage, such as mould or foul odour. Proper storage conditions must be maintained to preserve the nutritional value of the silage.

Introduction to Livestock Diet: Silage should be introduced gradually into the livestock diet to avoid digestive issues. A gradual transition helps animals adapt to the new feed and maximizes nutritional benefits. Feeding pineapple silage at 25% of diet improved the nutrient intake, energy balance, and body weight gain of growing Myanmar local cattle.

CONCLUSION

Using pineapple waste reduces feed costs by recycling agricultural byproducts that would otherwise be discarded. The utilization of pineapple waste in silage preparation presents a viable option for sustainable livestock feeding. The process not only offers a cost-effective and nutritious feed source but also contributes to waste management and environmental sustainability. Further research and practical implementation can enhance the efficiency and effectiveness of this approach, benefiting both the livestock industry and the environment.

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X-RAY SPECTROSCOPY AND ITS AGRICULTURAL APPLICATION

Ayantika Ghosh*

Division of Biochemistry, Indian Agricultural Research Institute, Pusa, New Delhi-110012

*Corresponding author email: ayantika.ghosh1997@gmail.com

ABSTRACT

Owing to its exceptional elemental analysis capabilities, X-ray spectroscopy is a potent analytical instrument that has transformed biological research. This method is essential for comprehending intricate biological processes and is used in the analysis of biological specimens. Applications include identifying trace elements in tissues, deciphering biomolecules' structural features, and learning about the workings of enzymes. Through comprehensive insights into the elemental composition and structural characteristics of biological samples, X-ray spectroscopy advances our understanding of nutrient physiology, phytotoxicity, heavy metal buildup, and adulterations in the field of agriculture.

KEYWORDS: Elemental analysis, Nutrient physiology, X- ray spectroscopy

INTRODUCTION

X-ray is a part of electromagnetic spectrum. X-rays have a wavelength in range of 10-5Å to 100 Å; conventional X-Ray spectroscopy is largely confined to approximately 0.1 Å to 25 Å. X-Ray spectroscopy is based upon measurement of emission, absorption, scattering, fluorescence and diffraction of electromagnetic radiation by atoms. It can be defined as short wavelength electromagnetic radiation produced by deceleration of high-energy or electronic transition of electrons in the inner orbitals of atoms. Transitions are used in X-ray spectroscopy for both absorption (XAS, X-ray absorption spectroscopy) and emission (XES, X-ray emission spectroscopy), where the former studies the transitions from the ground state to the excited state while the latter studies the decay process from the excited state. Synchrotron sources offer a spectrum of X-ray energies that are appropriate to most elements in the periodic table, especially those found in redox-active metallo-enzymes. Both techniques describe the chemical makeup and surroundings of atoms in molecules. The particular element being investigated is typically determined by the energy of the X-rays employed (Yano and Yachandra, 2009).

BRIEF HISTORY

In 1912, a pair of British physicists named William Henry and William Lawrence Bragg actually started using X-ray spectroscopy. They investigated the interactions between X-ray radiation and crystallographic atoms using spectroscopy. By the next year, their method known as X-ray crystallography had become the industry standard, and in 1915 they were awarded the Nobel Prize in Physics.

PRINCIPLE OF X-RAY SPECTROSCOPY

Materials can become ionised when they are exposed to high-energy, short-wavelength radiation, such as X-rays. An atom's inner shell electron jumps to a higher energy level when it is activated by a photon's energy. The energy it previously received from the excitation is released as a photon with a characteristic wavelength for the element when it returns to the low energy level (each element may have multiple characteristic wavelengths). Therefore, in modestly atomic number atoms, atomic X-rays released during electronic transitions to the inner shell states. Since each element has a distinct X-ray spectrum that may be used to identify it, these X-rays have distinctive energies linked to the atomic number.

X-Ray Spectroscopy is also based on Braggs law (1912) which states that The X-Rays appear to be reflected from the crystal only if the angle of incidence ϴ satisfies the condition that

$$\sin\Theta = n\lambda / 2d$$

where where d is the inter planar distance of the crystal

n is an integer

λ is wavelength of X-radiation.

At all other angles, destructive interference occurs.

WORKING PRINCIPLE

The basic idea behind X-ray spectroscopy is that materials that are subjected to X-rays either produce or absorb secondary, or distinctive, X-rays. The elemental composition of the substance may be identified and analysed thanks to these secondary X-rays, which are specific to each element. This is a thorough breakdown of the operational principle:

Source: Primary X-rays are produced by an X-ray source, such as a synchrotron or X-ray tube. The substance under research is exposed to high-energy X-rays, which interact with its atoms.

Interaction with Atoms: Photoionization is a process by which the atoms can lose inner-shell electrons to the primary X-rays, which leaves vacancies in the inner shells of the atoms.

Emission of Characteristic X-rays: Electrons from higher energy levels (outer shells) descend to lower energy levels by releasing energy in the form of secondary X-rays, which helps fill the voids left by the ejected electrons. The energy difference between the two shells engaged in the transition is equivalent to the energy of these X-rays that are released.

Detection and Analysis: A suitable detector, such as a semiconductor detector, gas-filled detector, or crystal spectrometer, is used to detect the X-rays that are released. The distinctive X-rays' energy and intensity are measured by the detector. A spectrum is created when X-rays are detected; this is a visualization of the X-ray intensity vs energy. The typical X-ray energies of each element are distinct and show up as peaks in the spectrum. The spectral plot is later analysed using various softwares.

APPLICATION IN AGRICULTURE

X Ray spectroscopy has wide spectrum of uses in agriculture. Some of them are listed below:

- Elemental analysis of plants using X Ray spectrometry: Plant tissues can be analysed using X-ray spectroscopy in order to quantify the elements (As, Al, Co, Na, Sr, and Pb), micronutrients (Mn, Fe, and Zn), and macronutrients (P, K, Ca, Mg, and S) in plant samples using calibration curve methods. It can also be applied in the detection of heavy metals and trace elements. The physiology of nutrients and the toxicity of heavy metals in soil and plants are better understood as a result of these findings, which also present a chance to develop phytoremediation techniques (Margui et al., 2005).
- Elemental imaging and mapping of Plant tissues: The nondestructive nature of Micro-X Ray Fluoroscence (μ-XRF), a specialist X-ray spectroscopy technique, makes it useful for determining the spatial distribution of elements in a variety of biological samples.
- Plant physiology has utilised μ-XRF in particular to examine the distribution of elements in various plant components, including leaves, stems, roots, and seeds. The spatial distribution of zinc in primed common bean seeds and the chemical imaging of P, S, and Ca in soybean leaves infected with anthracnose were studied by Rodrigues et al., (2018).
- Real-time Monitoring: Farmers may now analyse plant health in the field in real-time, receiving rapid feedback on nutrient status and aiding in the optimisation of fertiliser application thanks to the development of portable XRF instruments.
- Detection of adulterations: Food product adulterants and pollutants are found using X-ray spectroscopy. To ensure that foods fulfil safety regulations before being consumed by consumers, it can, for example, detect the presence of heavy metals in grains, fruits, and vegetables.

- Verification of Nutrient Content: To make sure that food items meet quality standards and nutritional labelling requirements, X-ray absorption spectroscopy, or XAS, can be used to confirm the nutrients contained in the product (McLaughlin et al., 2011).
- Structure of insecticide can be determined via this technique.
- X Ray Spectroscopy can be used to detect DNA radiation damage.
- Structure of an element or a compound can be effectively determined.
- X-ray fluorescence (XRF) spectroscopy has been used to study tomato plant vigor, develop automatic weed control system and count the number of tiller in rice.

CONCLUSION

With the ability to precisely analyse the elements of soils, plants, and fertilisers, X-ray spectroscopy is a potent analytical tool in the agricultural industry. It improves knowledge of pollutant presence, soil composition, and nutrient distribution, which helps to maximise fertilisation techniques and raise crop yields. X-ray spectroscopy is essential to current farming and agricultural research because it supports increased agricultural output and environmental stewardship by enabling focused interventions and sustainable practices.

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INDIA'S YOUTH: REVOLUTIONIZING THE FIELDS OF TOMORROW

Amrit Warshini[1]* and Swapnil Srivastava[2]

[1]Research Scholar, Acharya Narendra Deva University of Agriculture and Technology, Ayodhya, India

[2]Research Scholar, Sardar Vallabhbhai Patel University of Agriculture Technology and Sciences, Meerut, India

*Corresponding author: amritwarshini1312@gmail.com

ABSTRACT

As India faces food security challenges and climate change, a new wave of young farmers is transforming agriculture with innovation and technology. The increase in the youth population from 30.6% in 1971 to 34.8% in 2011 presents both challenges and opportunities for the sector. Today's young farmers are tech-savvy entrepreneurs using drones, AI, and blockchain to revolutionize traditional farming. Empowering these innovators requires strategies such as agripreneurship incubators, tech-integrated training, and sustainable farming incentives. Despite hurdles like limited capital and climate unpredictability, solutions like crowdfunding and climate-resilient crops are emerging. India's youth are redefining agriculture, ensuring a sustainable and prosperous future.

KEYWORDS: Agricultural innovation, Climate-resilient farming, Sustainable agriculture, Tech-integrated farming

INTRODUCTION

In the heart of India's vast agricultural lands, a quiet revolution is taking root. As the nation grapples with evolving food security challenges and climate change, a new generation of young farmers is stepping up, armed with innovation, technology, and a fresh perspective on what it means to cultivate the land. The demographic shift in India's youth population is striking. From 30.6% in 1971 to 34.8% in 2011, the proportion of young people has steadily increased, presenting both a challenge and an unprecedented opportunity for the agricultural sector. This surge in youthful energy comes at a crucial time when farming needs reinvention to attract fresh talent and ideas.

BREAKING THE MOLD: FARMING'S NEW FACE

Agriculture was once considered a last resort for those with no other options. Today's young farmers are tech-savvy entrepreneurs, environmental stewards, and innovators. They're transforming traditional farming practices with drones for crop monitoring, AI-powered irrigation systems, and blockchain technology for supply chain transparency.

STRATEGIES FOR EMPOWERMENT

To harness this youthful potential, a multi-pronged approach is essential.

- ✓ Agripreneurship Incubators: Establishing hubs where young agri-innovators can access mentorship, funding, and resources to turn their ideas into viable businesses.
- ✓ Tech-Integrated Training: Offering vocational programs that blend traditional agricultural knowledge with cutting-edge technology skills.
- ✓ Land Leasing Reforms: Implementing policies that make it easier for young farmers to access land without the burden of ownership.
- ✓ Digital Marketplaces: Creating platforms that connect young farmers directly with consumers, cutting out middlemen, and increasing profitability.
- ✓ Sustainable Farming Incentives: Offering financial incentives for adopting eco-friendly farming practices appeals to environmentally conscious youth.

INNOVATIONS RESHAPING THE FIELD

The integration of technology in agriculture is not just enhancing efficiency; it's revolutionizing the entire farming ecosystem.

- ✓ Precision Agriculture: Using satellites and IoT devices to optimize resource use and maximize yields.
- ✓ Vertical Farming: Utilizing urban spaces to grow crops in stacked layers, conserving water and land.
- ✓ Agri-Fintech: Developing mobile apps that provide simple access to micro-loans and crop insurance for small-scale farmers.
- ✓ Smart Greenhouses: Employing AI to create ideal growing conditions, enabling year-round cultivation of non-native crops.

CHALLENGES AND SOLUTIONS

Despite the enthusiasm, young farmers face significant hurdles. Limited access to capital, fragmented landholdings, and climate unpredictability pose serious challenges. However, innovative solutions are emerging:

- ✓ Crowdfunding platforms allow urban investors to financially support young farmers and share in the harvest.
- ✓ Community Farming Models: Encourage collective farming practices in which young farmers pool resources and share risks.
- ✓ Climate-Resilient Crop Varieties: Developing and promoting seeds that can withstand extreme weather conditions.

THE GLOBAL PERSPECTIVE AND FUTURE OUTLOOK

The youth agricultural movement in India is part of a global trend. From vertical farms in Singapore to tech-driven greenhouses in the Netherlands, young farmers worldwide are reimagining agriculture. This global network of innovation is creating a knowledge-sharing ecosystem that transcends borders.

Looking ahead, the future of Indian agriculture is intrinsically tied to its youth. As climate change and population growth intensify food security concerns, the adaptive capacity and innovative spirit of young farmers will be crucial. Their ability to blend traditional wisdom with modern technology may well be the key to ensuring a sustainable and food-secure future for India and beyond.

CONCLUSION

India's fields are transforming, not just in crops but also in the hands that tend them. As young farmers take the reins, they're not just cultivating land; they're growing ideas, nurturing innovation, and harvesting hope for a sustainable future. The agricultural sector, once seen as a vestige of the past, is rapidly becoming a frontier of innovation, thanks to the vision and vigor of India's youth. In this new era of farming, every seed planted is a step towards a more resilient, technologically advanced, and sustainable agricultural ecosystem. The youth of India are not just participating in agriculture; they're redefining it, ensuring that the nation's fields remain fertile ground for innovation, sustainability, and prosperity for generations to come.

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THE DISEASES OF WHITE BUTTON MUSHROOM: A CLOSER LOOK

Kishor Sharma*, Adikshita Sharma and Monica Sharma

College of Horticulture and Forestry Thunag, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP), INDIA

*Corresponding author: ks4141173@gmail.com

ABSTRACT

The white button mushroom (Agaricus bisporus) constitutes 31% of global mushroom production, with India contributing 85% of its total mushroom yield. Despite its industrial significance, the productivity of A. bisporus in India is hindered by various diseases and environmental factors. Key fungal diseases such as Wet Bubble, Dry Bubble, Cobweb, Green Mould, Brown Plaster Mould, and Bacterial Blotch significantly impact yield. Effective disease management practices include maintaining hygiene, proper composting and pasteurization, and targeted chemical treatments. Genetic diversity within A. bisporus strains remains limited, increasing susceptibility to pathogens and posing challenges for disease resistance.

KEYWORDS: Bacterial diseases, Disease management, Genetic diversity, Fungal diseases

INTRODUCTION

As per current estimates, 1.5 million types of fungi are considered to exist on Earth.16000 species of mushroom were found globally under natural habitat. However, about 31 genera of mushrooms were known to us based on their edibility. Among the various types of well-known mushrooms, the cultivation of Button mushroom (Agaricus bisporus), Oyster mushrooms (Pleurotus spp.), Paddy Straw mushroom (Volvariella volvaceae), Milky mushroom (Calocybe indica), Shiitake mushroom (Lentinula edodes) etc. reached to a enthusiastic industrial status. According to data, about 48.3 million tonnes of grown mushrooms will be produced worldwide (FAO Stat, 2022). In connection with mushroom production, China is the global principle producer subsequently succeeded by the US, Netherlands, Poland, and Spain. As per the estimate given by FAO in 2023, India ranks 5th in terms of global mushroom production 2.0 million tonnes. In comparison to developed nations like the US, Netherlands, Poland, Spain and other European countries, India's response to the rise in mushroom productivity in recent years has been trailing behind on several parameters.

The white button mushroom (Agaricus bisporus), overall contributes 31 percent of global production while, India's share of white button mushrooms comprised of 85 per cent of total mushroom production. Amongst the main reason for significantly less yield and productivity of button mushrooms in India, is insect infestation, disease, and environmental fluctuations such as PH, CO2 accumulation, excessively hot as well as low temperature, low moisture etc. Although, among the different diseases of mushrooms, at the core mainly fungal, bacterial and viral pathogens caused a devastating losses. The most prevalent and important disease of A. bisporus includes Dry Bubble, Wet Bubble, Cobweb, Green Mould, False truffle, Olive green mould, Brown plaster mould and Bacterial blotch. Furthermore, the aggressiveness of all these disease-inciting agents generally lies on healthiness of the compost, casing and spawns. Moreover, A. bisporus strains lack genetic diversity that is underlying challenge supports limited parent strain crossing and increases susceptibility of mushrooms toward various pathogenic diseases (Savoie et al., 2013).

FUNGAL DISEASE OF WHITE BUTTON MUSHROOM

WET BUBBLE (*Mycogone perniciosa*)

Wet bubble disease of white button mushrooms is also recognized as La mole, white mould, bubble, or Mycogone disease.

Symptoms: Malformed mushrooms have swollen stipes. The cap of mushroom loose its original shape and size due to formation of white and fluffy cottony growth of fungal mycelium on emerging young pinheads well as primordia and mature fruiting flush. The yellowish droplets appear on unpleasant odour stinking infected tissue which have a size sometimes similar to grapefruit (Sharma et al., 2007).

Disease spread and transmission: The dissemination of fungus spores to surrounding environment take place by factors including mechanical means, soil, water, flies as mites etc. The fungus survives even for long durations inside spent mushroom debris as well as soil in form of resting structures such as chlymdosopres. However, unhygienic conditions maintained in growing room, use of contaminated water at time of irrigation and spores mixed with casing attributed to infection in fruiting bodies.

Management: The infection of wet bubble during cropping period will be minimized by following using directions of good agriculture practice. Broadly, these practices include firstly maintenance of proper hygiene inside crop growing room. The infection aggravated due to mechanical means should be restricted by implementing complete checks on entry as well as exits of growing room. However, if disease persists in form of patches, have to be isolated and simultaneously treat the patches with (2.0 %)

formalin swab. The pasteurization of casing soil for 4-6 hours at 65 °C also attributed to neutralizes the inoculum completely. As important, spray of benomyl at rate of 0.1 per cent after application of casing on compost minimizes the inoculum. The regular spray of benzimedazole fungicides viz. Carbendazim and Thiabendazole at the rate of 0.62 g/m2 also proved effective in control of disease.

DRY BUBBLE (*Verticillium fungicola* / *Lecanicillium fungicola*)

Symptoms: This disease is recognized by its peculiar symptoms like appearance of irregular mass of undifferentiated tissues as well as wart like growth of soft tissues during early stage of infection on emerging young pin heads. Which is followed by drying as well as breaking stipes. While, during advancement of disease in fully formed mushrooms leads to formation slight brown sunken lesion leading to dryness of and browning of cap (Sharma et al., 2007).

Disease spread and transmission: The fungus requires high humidity, poor ventilation and temperature of 28°C for its optimum growth. The spores of Verticillium spp. are generally sticky in nature which disseminated by mean of anemochory, hydrochory as well as improper hygienic conditions maintained in growing room. The spores of fungus also move and infects the casing through dust as well as sciarid and phorid flies.

Management of Dry Bubble: The disease is managed by implementing proper sanitation practices at growing room. The bubble or wart like structures on infected pinheads should be isolated and removed as early followed by treatment with 2.0 percent formalin and salt. The casing material have to be completely pasteurized for 4-6 hours at 65 °C. However, the infestation of flies/insect in the cropping room to be controlled by spray application of insecticides. The spray of preventive fungicide like chlorothalonil or zineb at the rate of 0.5 g/m2 also proved effective in control of disease.

COBWEB (*Cladobotryum dendroides*)

Symptoms: The irregular cottony ball of mycelium in form of cobweb appeared over casing soil. The mycelium covers the fruiting pin heads, which leads to discoloration of mushroom fruiting bodies as well as and causes soft rot. However, often development of brown irregular spots also becomes visible on fruiting structures. Moreover, with the advancement of infection cob web produce granular irregular structure of mycelium having powdery masses of spores (Sharma et al., 2007).

Disease spread and transmission: The main source of infection is infected casing soil. At time of maturity of cobweb, white powdery mass of spores were dislodged by windblown through vents, water splashes as well as spore carried through dust and debris inside the growing room. High humidity maintained inside the growing room also favours the cob web development over casing soil.

Management of Cobweb: The casing soil should be completely pasteurized for 4-6 hours at 65 °C. The identification of early symptoms like formation of spots of cobweb are very important. Such infections spot to be immiditltly treated with alcohol. Treat the infected patch by covering with salt. Avoid to use casing soil that is embedded with heavy peat. The control strategies include lowering humidity and increasing air circulation. Increase hygiene of the harvesting and watering department. The spray of preventive fungicide like chlorothalonil or zineb at the rate of 0.5 g/m2 also proved effective in control of disease

GREEN MOULD (*Trichoderma viride, Penicillium cyclopium, Aspergillus* spp.)

Initially dense growth of white mycelia mat becomes visible over the casing soil and sometimes on compost also. The green colour of sporulation also found on the casing as the name indicates green mould. In case of heavy infestation, the symptoms are similar to dry bubble disease. Later the fungus creeps at the casing layer and infect the young mushroom primordia. This disease leads to formation of malformed and distorted cap as well as stipes.

Epidemiology: Disease spread and transmission Green mould most appears over compost which were rich in carbohydrate and having deficiency of nitrogen. The compactness of compost during its preparation also leads induce the disease due to improper pasteurization. Excessive level of humidity, low pH in the casing soil and regular use of 2.0 per cent formalin are the factors leads to disease development. The dispersal of pathogen spores were takes place by dust particles, contaminated clothing’s, and animal vectors especially the mite.

Management: Maintain of good hygienic conditions at growing room will minimize the disease outbreak. The use of completely pasteurized compost is necessary. Sterilization of equipment’s inside cropping room is important. The sprays of mancozeb (0.2%) or bavistin (0.1%) or treatment with zineb dust at weekly interval gives effective control of the disease.

BROWN PLASTER MOULD (*Papulaspora byssina*)

*Symptoms:*The disease is attributed due to formation of white mycelial growth in form of patches on the compost, casing soil as well as on the side of polybags due to accumulation of water due to process of condensation. However, with the advancement of disease the size of patches increases and changes colour to tan brown colour. This disease lead to no production of mycelium of mushroom (Sharma et al., 2007).

Epidemiology: The poorly prepared compost and casing soil cause primary infection. Highly wet compost prepared from poor quality of straw as well as addition of poor quality of gypsum and high temperature ranges between 28 -32 0C at the time of spawning induce the disease development.

*Management:*Composting should be done thoroughly, using adequate gypsum without adding excessive water. The compost ought not to become extremely wet prior or following optimum heating/pasteurization. Localized treatment of affected patches with 2 percent formalin treatment.

INK CAPS (*Coprinus* spp.)

Symptoms: This disease is usually encountered on mushroom beds throughout the spawn flow, that appears especially in North India. It mainly appears on compost bed during spawn run and even on newly cased beds, even outside the manure piles during fermentation. Ink caps are generally conical bell-shaped mushrooms. The fruiting structure of ink caps are initially appearing creamy white in colour which later turns blue to blackish in colour even covered with dry white scales. The stem of such fruiting structures becomes strong and rigid usually grows in clusters which grows deep inside the compost layer. However, this disease leads to decaying of ink caps and formation of slimy black mass on the beds due to process of auto digestion (Sharma et al., 2007).

Epidemiology: The disease usually spreads through unpasteurized or poorly pasteurized manure or casing soil. The abundance of a high level of nitrogen in compost, in addition to the usage of an excessive quantity of chicken manure throughout the process of composting, leads to the development of ink caps. Appearance of ink caps are meant as general indicator of accumulation of ammonia in manure. Use of poor quantity of gypsum as well as maintaining of too low temperature during composting even excessive wetness in compost favours the disease spread. The large mass of spores is usually released from such cluster of fruiting structures and infects fresh beds of compost.

Management: Use correctly pasteurized compost and casing soil. Avoid overwatering. To prevent the undesirable mushroom from spreading further, eradicate its young fruit bodies. Prepare compost with fresh straw. During spawning, the level of ammonia in the compost need to be less than 10 ppm, indicating that there is no ammonia smell.

BACTERIAL DISEASE OF WHITE BUTTON MUSHROOM

BACTERIAL BLOTCH AND BACTERIAL OF WHITE BUTTON MUSHROOM (*Pseudomonas tolaasii*)

This disease is also named as brown blotch and bacterial spot.

Symptoms: This disease is identified by appearance of circular to irregular pale yellow spots develops on the surface of the piles later coalesce to form sunken chocolate brown blotches. The most conspicuous symptoms appear as formation of dark area of blotches on the surface of caps which later turns dark brown in colour. The disease in severe instances leads to splitting of caps as well as misshapen of mushroom fruiting bodies. The tissue comprises the fruiting structures generally appear water soaked and grey. Blotches appear in early button stage, appear on any age - even on harvested refrigerated mushrooms. Sometimes covering entire cap (Sharma et al., 2007).

*Epidemiology:*Casing material mixture and air-borne dust are primary source of infection of bacterial blotch. Besides gram negative bacterial population found to be more in caps in comparison to casing. The pathogen mostly survives in mushroom spent or debris under the presence of moisture. However, the secondary spread of disease took place by contaminated farm tools, cloths, water splashes, sciarids and mites.

Management: Lowering of temperature not more than 20 C and humidity not more than 85 per cent will be helpful in minimizing the disease incidence. Additionally, spraying of Pseudomonas fluorescens over the casing also lowers the infection. Under the chemical application, spraying of terramycin, streptomycin at the dose of 200 ppm and oxytetracycline at the dose of 300 ppm fond effective in managing of disease.

MUMMY DISEASE OF MUSHROOM (Pseudomonas spp)

Symptoms: The name of disease resembles with visible symptoms appeared on fruiting body of button mushroom. In this disease, early symptoms appeared as swollen base of stipe which usually covered with fibrous mat of white mycelial growth. However, structure of stipes becomes leathery brown in texture as well as colour. The advancement of infection leads to curving of caps to one side while, inner tissue of fruiting structure becomes spongy in nature sometime even caused breaking of veils. Whenever, such mushroom cut in to two parts longitudinally inner tissues appeared reddish brown in colour (Sharma et al., 2007).

Epidemology: The disease mostly spreads to healthy one due to dispersal of contaminated causing as well as compost. The bacteria usually colonize and invade the hyphae of Agricus by means of entry through cell wall. The disease is mostly aggravated due to presence of high humidity, warm temperature, poor ventilation inside growing room

Management: Isolation of infected mushroom is important and disinfect the infected patch from where disease portion have been removed to be treat with 2.0 % formalin or salt solution. Infectivity of inoculum is rendered to extent by steaming of compost at the temperature of 70C for one hour. The use of streptocycline and oxytetracycline is proved effective to reduce disease.

COMMON VIRAL DISEASE OF WHITE BUTTON MUSHROOM

La France disease was known as one of important disease which is caused by dsRNA virus particle. The disease derived its name because it was first identified and diagnosed by La France brothers of America in 1948. This disease also known to its one more name as X disease because for long period the cause of disease was unknown to us.

Symptoms: The symptoms of diseases attributed by opening of veils before maturity of fruiting structures, brownish colour of mushroom caps which gradually accompanied by reduction in yield of crop. Symptoms of disease mostly appeared after casing the compost then the symptoms appeared on fruiting bodies. The sporophore inhibition also takes place due to infestation of disease. However sometimes after application of casing mycelia fails to convert in to reproductive structures or appears in close dense clusters. Development of musty smell in addition to dwarfing are common structures.

Epidemology: The transmission of viral disease commonly took place by movement of spores as well as viable mycelium to healthy mushroom beds. Additionally, vectors like phorid fly and mites also helps in transmission of disease.

Management: Maintain of proper hygienic condition in cropping room will reduce movement of viable mycelium or spores will reduce disease spreads. the use of heat therapy will be helpful to check the disease. The use of high yielding resistant and immune strains of mushroom will be helpful. The control of virus vectors should be done through using spray of dimethoate or malathion

CONCLUSION

The cultivation of white button mushrooms in India is critically affected by a range of diseases, predominantly fungal and bacterial in origin. The industry's growth is hampered by the susceptibility of A. bisporus to pathogens due to limited genetic diversity. Effective disease management strategies, including stringent hygiene practices, proper composting, pasteurization, and the use of fungicides and bactericides, are essential. Addressing these challenges is vital for enhancing productivity and sustaining the growth of the mushroom industry in India. Increased research into developing disease-resistant strains and improving cultivation practices will be crucial for the future.

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