ISSN : 0019 - 4336

INDIAN AGRICULTURIST

VOL. 68

NO. 1 & 2

2024

OFFICIAL PUBLICATION OF

THE AGRICULTURAL SOCIETY OF INDIA

KOLKATA

THE AGRICULTURAL SOCIETY OF INDIA

Registered under the Society Act No. XVI of 1860

No. S/2871 of 1957–58

OBJECTS

1. To advance the cause of Agriculture in all its bearing on life.
2. To disseminate knowledge of Agriculture.
3. To provide facilities for association and conference among research workers in the various fields of agricultural sciences and agricultural extension.

INDIAN AGRICULTURIST is the official publication of the Agricultural Society of India. It is published four times a year for the present in March, June, September and December. The subscription rate is, with effect from January, 2019 for non-members Rs.4000.00 (under certificate of posting/Book seller's discount : @15%) per year in India and US $ 450.00 (air mail posting) for other countries. Membership fee is Rs.3000.00 per annum or Rs.4000.00 for the whole life and student member Rs.2000.00 per annum. The journal is supplied free to members of the Society.

All communications regarding business matters should be addressed to Secretary, The Agricultural Society of India, 51/2 Hazra Road, Kolkata- 700019 (India). Phone : (033) 2442 2700, Mob. : 94331 57988 e-mail : agsocietyin_50@rediffmail.com / agsociety.india@gmail.com, Website : www.indianagriculturist.in.

NAAS rating : 3.76

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 1-5, 2024

A Comprehensive Review on Production and Nutritional Aspects of Foxnut (Makhana)

[1]Atanu Mahanty*, [1]Subham Chakraborty, [1]Gurupada Saren, [1]Shubhadip Kar, [1]Souvan Kumar Patra and [2]Ashim Kumar Dolai

[1]Ph.D. Research Scholar, Department of Agronomy, Institute of Agricultural Science, University of Calcutta, Kolkata
[2]Assistant Professor, Department of Agronomy, Institute of Agricultural Science, University of Calcutta, Kolkata
** Corresponding author email id : atanumahanty1997.agri@gmail.com*

Abstract

Foxnut (*Euryale ferox*), commonly known as Makhana, is an aquatic crop predominantly cultivated in the eastern parts of India. This review delves into the production techniques, agronomic practices, and nutritional benefits of Foxnut. The cultivation of Foxnut is eco-friendly, requiring low external inputs and offering sustainable livelihood opportunities for marginalized farmers. The crop is resilient to environmental stress and can thrive in waterlogged and semi-aquatic conditions. Traditional harvesting methods, though labor-intensive, are being improved through mechanization and innovative agricultural practices to enhance yield.

Nutritionally, Foxnut is a rich source of protein, dietary fiber, and essential micronutrients like potassium, magnesium, and phosphorus, making it a valuable functional food. Its low glycemic index and gluten-free nature also make it suitable for individuals with diabetes and celiac disease. The review also highlights the potential of Foxnut in addressing nutritional deficiencies, particularly in rural populations, and its growing demand in the health food industry.

The paper underscores the need for further research into optimizing cultivation techniques, improving post-harvest processing, and exploring the potential of Foxnut in global markets.

Keywords : *Cultivation, eco-friendly, foxnut, protein, post-harvest, resilient*

1. Introduction

Foxnut is commonly known as Makhana is an important aquatic crop. The scientific name of Makhana is *Euryale ferox Salisb*. The Makhana seed of an aquatic herb is a monotypic genus of the family Nymphaeaceae and is characterized by its hard seed coat (shell), black in colour and round shape with a diameter ranging from about 5 mm to 15 mm. Its seed is also called as Black Diamond. It is commonly known as Gorgon nut, Fox nut and Makhana in India. It is mainly cultivated as source of starch and protein (Puste, 2004). Makhana, Euryleferox salisb is considered an important aquatic cash crop in India (Jha *et al*., 1998). The plant is native to south East Asia with prevalence to tropics to sub tropics accomplished with humid to sub humid environment. It occurs in wild form in Japan, Korea, Bangladesh and Russia. It is grown during warmer part of the year, particularly in hot sub humid seasons in wetlands having water depth 0.5-3.0 m or even more. Makhana plant is considered as native of South-East Asia and China, but distributed to almost every part of the world. Its distribution is extremely limited to tropical to sub-tropical regions i.e. South-East and East Asia and is known to exist in Japan, Korea, Russia, North America, Nepal, Bangladesh and India. India and China are the only countries where Makhana is cultivated as crop. In India it is mainly distributed in the states of Bihar, West Bengal, Manipur, Tripura, Assam, Jammu & Kashmir, Odisha, Rajasthan, Madhya Pradesh and Uttar Pradesh but commercially produced in few states only. In West Bengal major Makhana producing districts limited to Malda & Uttar Dinajpur. The plant grows in fallow wetlands of standing shallow water of about 2.5 m depth and has rhizomatous stem. It prefers tropical and subtropical climate, temperature between 20^0C-35^0C, humidity between 50-90%, and rainfall between 100-250 cm. it falls under one of the superior food qualities, which is reflected in its high amino acid index (89- 93%) and arginine+ lysine/proline ratio (4.74- 7.6) (Mishra *et al*., 1995). It has prominent place in Indian dietary chart with medicinal values for respiratory, circulatory, digestive, renal and reproductive diseases (Jha *et al*., 2003). Makhana is used as tonic and treatment of leucorrhoea and good immunostimulant (Kumar *et al*., 2011). Makhana cultivation is one of the new adoptions among farmers in West Bengal as a possibility of providing them with good profitability.

2. Nutritional Aspects of Makhana

Makhana is an aquatic cash crop with high carbohydrate, protein, and low-fat content. The raw makhana contains 76.9% carbohydrates, 12.8% moisture, 9.7% protein, 0.9% phosphorus, 0.5% minerals, 0.1% fat, 0.02% calcium and 0.0014% iron. In popped makhana 84.9% carbohydrate, 4% moisture, 9.5% protein, and 0.5% fat. Makhana had high medicinal value and it support the cotton industry highly. Makhana supported good treatment for respiratory, circulatory, digestive, and reproductive systems. Biochemical analysis of makhana seed had a high protein content of 15.6% and 1.36% fat. The calorie value of 100g of raw and puffed makhana gives 362 kcal and 328 kcal. Due to its high protein and fat content, the makhana is similar to almonds, walnut, cashew nut, and coconut. Makhana reported 16 types of amino acids in the kernel. The essential amino acid index (EAAI), chemical score (CS), and biological value (BV) of Makhana are similar to fish. Compared to eggs, the higher content of arginine, alanine, and tyrosine in protein and amino acid composition (g/16 g N) in Makhana. Net protein utilization (NPU), true digestibility (TU), and apparent digestibility (CE) of makhana are given as 49.3, 89.3, and 69.1. These NPU, TU, and CE of makhana were lower than the soybean, egg, and cow milk (Khadatkar *et al*., 2020). The makhana is rich in macro as well as micronutrients as well as a good source of minerals. Cu, Na, Ca, Fe, and Mg these trace metals have been reported by different researchers. The vegetative part of the makhana contains a good amount of N, P, and K. The high content of the P, Fe, and Zn is due to the muddy field condition. The makhana also contains a high amount of vitamins such as vitamin A and vitamin C ranging from 62.23 to 63.84 IU/g and 0.18% to 0.20% respectively (Khadatkar *et al*., 2020). The makhana has high content of carbohydrate of 78%, the carbohydrate is in the form of starchy dimension in makhana. The makhana has only 0.1% fat and contain high amount of minerals. Makhana has a calorie content of 362 Kcal in 100g of makhana in popped makhana it gives only 328 Kcal in 100g. Biological value of makhana is very low it contribute high leucine to isoleucine ratio in makhana seed (Kumari *et al*., 2019). Fox nut has higher nutritional value compared to other dry fruits such as walnut, cashew nut and almond (Tehseen *et al*., 2020). Despite having a lower percentage level (10–12%) than other cereals, Jha *et al*., (1991) discovered that makhana protein was nutritionally superior to several plantand animal-based diets.

3. Uses of makhana

Makhana is stored in two forms via seeds and Makhana pop. In India it is mainly consumed in popped form and in China it is consumed medicinally or for food. Makhana is the popped expanded kernel of the foxnut or gorgon nut. The nuts are collected from water and popped to remove the edible starchy kernel. The expanded kernel of the nut obtained through this process is called popped kernel and is known as Makhana in India.

Makhana pop has several uses. It is a highly relished food consumed as namkeen, kheer, curry, and so forth. Makhana pop is traditionally consumed as a snack, high-protein, low-fat food, sweet component and it has been used in traditional medicine. Popped Makhana is used in the preparation of a number of delicious and rich sweet dishes like Makhana kheer, vermicelli, halwa, flour, puddings and various other sweet dishes. The Flour produced from Makhana is used as substitute of Arrow Root. The flour is also used to make delicious dishes like sweet meat, soups, Makhana kheer and as thickener in different foods preparations.

Makhana is consumed as a non-cereal food by devotees during their fasts. Hence it solves the religious purpose. In every religion, Makhana is considered as the pious and divine food item. In Hindu religion, it is used in all the worshiping ceremonies, Hawan, Pooja etc. In addition to this, due to his heavenly nature, it is considered as the best offering to god and goddesses in temples. Even the Muslim Communities consume lot of Makhana during their festival of Eid. Makhana seeds are very rich in carbohydrate content.

3. Methods of makhana production

Makhana cultivation is practiced either in perennial water bodies with a depth of 4-6 feet or in specially prepared agricultural fields. In the traditional pond system, Makhana plants germinate from leftover seeds from the previous season. For new ponds, the recommended seed rate is 80 kg per hectare, while for annual sowing, 35 kg per hectare of water-spread area is sufficient. The cultivation process can be carried out using two primary methods: the pond system and the field system.

In the pond system, Makhana is traditionally grown with seeds left in the water body acting as planting material for subsequent crops. Additionally, air-breathing wild fish often enter these ponds with floodwaters, providing farmers with an additional source of income. On the other hand, the field system, a more recent innovation standardized by research institutes, allows Makhana cultivation in agricultural fields with water depths of about 1 foot. This system simplifies the process and enables the fields to be used for cereals and other crops in the same year. In this method, Makhana seedlings are first raised in a nursery and then transplanted to the main field between February and April. This system reduces the crop duration to about four months, enhancing land utilization.

Harvesting of Makhana involves manually collecting the scattered seeds from the bottom of ponds or shallow water fields, typically from August to October. This process is labor-intensive, requiring divers to sweep the bottom thoroughly, gather seeds into heaps, and retrieve them in multiple dives. Despite the strenuous nature of the task, the yield from traditional water bodies ranges between 1200 to 1500 kg per hectare. However, in water bodies with shallower depths, the yield can be higher, ranging from 1800 to 2200 kg per hectare.

4. Processing and machineries

The post-harvest processing of Makhana involves a series of steps, starting with cleaning and washing the matured seeds to remove foreign materials, dirt, and mud. The cleaned seeds are then sun-dried for 2-3 hours on a mat or cemented floor under bright sunlight to reduce moisture content to around 31%, making them suitable for temporary storage and transportation. These seeds are typically stored under ambient conditions for 20-25 days, during which water is sprinkled at intervals to maintain their freshness and quality.

After storage, the seeds are graded into 5 to 7 sizes using a set of sieves, ensuring uniform heating during roasting and improving processing efficiency. The size-graded seeds undergo pre-heating in an earthen or cast iron pan placed over fire, where they are continuously stirred at surface temperatures ranging from 250°C to 300°C for 5-6 minutes, reducing their moisture content to approximately 20%. Following this, the seeds are tempered by storing them under ambient conditions for 48-72 hours to loosen the kernels within the hard seed coat.

The most critical and labor-intensive stage is roasting and popping. Pre-heated and tempered nuts, approximately 300 grams at a time, are roasted in a single layer over a fire in a cast iron pan at surface temperatures of 290°C to 340°C with continuous stirring. After 1.5 to 2.2 minutes, a cracking sound indicates that the seeds are ready. These are quickly scooped and subjected to impact force using a wooden hammer to break the hard shell, allowing the kernel to pop out in an expanded form, known as Makhana pop or lawa. Depending on the quality of raw seeds, the yield typically ranges from 35% to 40% of the raw seed weight.

Polishing is done by rubbing the Makhana pops against each other in bamboo baskets, enhancing their whiteness and luster. Grading follows, where the popped Makhana is categorized into three grades: lawa, which is swollen and white with reddish spots, and thurri, which is semi-popped, hard, and reddish. Finally, packaging is carried out using ordinary gunny bags for local markets and gunny bags with polythene lining for distant markets. These bags, typically with a capacity of one quintal of sugar, can hold about 8 to 9 kilograms of good-quality Makhana.

5.1 Traditional tools and equipments

Traditional tools and equipment play a crucial role in the processing of Makhana. One such tool is the *Khonnghi* or *Deli*, a small cylindrical bamboo bucket used for storing raw and popped seeds and also during the polishing operation. Another essential tool is the sieve, which is typically made of iron sheets with wooden frames. These sieves, usually numbering seven to ten with varying mesh sizes, are used to grade raw Makhana seeds. For sun-drying the seeds before roasting, mats are employed as a convenient surface.

The iron pan, a cooking utensil, is used for both pre-heating and roasting the seeds, ensuring even heat distribution. Wooden appliances like the *Aphara*, *Batna*, and *Thaapi* are made from hardwood such as shisum or mango. The *Aphara* serves as a platform where roasted seeds are struck with a flat wooden hammer called *Thaapi*. Earthen pans, or *Chula's*, are specifically used for roasting sun-dried seeds or *guris* without mixing sand, maintaining the traditional flavor. Bamboo sticks are also utilized for stirring the Makhana seeds during the roasting process, ensuring uniform exposure to heat. These traditional tools collectively contribute to the effective processing of Makhana while preserving its authenticity.

4.2 Latest machineries and equipments

The latest machinery and equipment for Makhana processing have significantly improved efficiency and product quality. The *Raw Makhana Seed Washer* is designed for washing and cleaning raw seeds collected from ponds, effectively removing impurities such as seed membranes, snails, dead fish pieces, mud, stones, and other debris. For size grading, the *Makhana Seed Grader* is used, capable of categorizing seeds into seven sizes ranging from 3-5 mm to greater than 15 mm.

To reduce the moisture content of graded seeds, the *Makhana Seed Dryer* is employed, which dries seeds from 35-40% to 28-30% moisture content. It is designed to optimize time and temperature for various seed grades. The initial roasting process, which gelatinizes starch and denatures protein, is carried out using the *Seeds Roasting Machine*. This step is crucial for achieving high-quality popped Makhana, as minor changes in roasting conditions can impact the final product.

For the critical popping process, the *Roasting and Popping Machine* developed by ICAR-CIPHET, Ludhiana, is utilized. This machine has a capacity of 25-30 kg/h for conditioned nuts and boasts a popping efficiency of over 90%. Post-popping, the *Popped Makhana Grader* separates husks, unpopped seeds, decorticated kernels, partially popped Makhana, and fully popped Makhana. Any unpopped kernels can be finely ground using the *Un-popped Makhana Grinder* to produce Makhana flour, which serves as a base for value-added products.

The entire processing plant can be managed through a *Control Panel*, an electronic and electrical system that regulates operations from a single location. It allows for either individual or simultaneous operation of all machines, with features such as a main switch, power breaker, indicators, on/off switches, safety devices, and separate indicators for each machine. This centralized control system ensures smooth, safe, and efficient functioning of the plant.

5. Storage of makhana

Makhana when properly stored may last more than a year under room temperature and air tight conditions. Following cares need to be taken for achieving the shelf-life.

1. Packages should be kept away from sun, rain and moist conditions in covered premises.

2. The room where the Makhana is to be stored should have dry atmosphere, free from unwanted odour as well as proofed against insects and vermin entry.

3. The room should have controllable ventilation where it could be able to give good ventilation in dry conditions and should have fully closed ventilation in damp conditions. Fumigation facilities should also be there.

6. Conclusion

Makhana cultivation holds substantial promise for India, both economically and environmentally. By leveraging its unique advantages and addressing challenges through research and supportive policies, India can enhance its makhana production, ensuring benefits for farmers and contributing to sustainable agricultural practices. As the global demand for nutritious and health-oriented foods grows, makhana is poised to become a key player in India's agricultural and economic landscape.

Literature Cited

Jha, V., Kargupta, A. N., Dutta, R. N., Jha, U. N., Mishra, R. K., & Saraswati, K. C. 1991. Utilization and conservation of Euryale ferox Salisbury in Mathila (North Bihar), India. *Aquatic Botany* ***39***(3-4): 295-314.

Jha, S. N., & Prasad, S. 2003. Post–harvest technology of gorgon nut. *Makhana, ICAR, New Delhi* 194-214.

Jha, V., Verma, A.M., Jha, A.K. and Banerjee, L.K. 1998. Rural technology for harvesting makhana seeds (Euryale ferox Salisb.) in Bihar. Botanical Survey of India ENVIS News Letters ***5***: 7-8.

Khadatkar, A., Mehta, C. R., & Gite, L. P. 2020. Makhana (Euryle ferox Salisb.): A high-valued aquatic food crop with emphasis on its agronomic management–A review. *Scientia Horticulturae* ***261***: 108995.

Kumar, L., Gupta, V. K., Khan, M. A., Singh, S. S., Jee, J., & Kumar, A. 2011. Field based makhana cultivation for improving cropping intensity of rice fields. *Bihar Journal of Horticulture* ***1***(1): 71-72.

Kumari, R., Jakhar, D. S., & Kumar, P. 2019. Nutritional, and medicinal importance of makhana (Euryale ferox Salisb.). *Marumegh* ***4***: 53-55.

Mishra, R. K., Jha, B. P., Jha, V., Singh, S. K., & Mahato, A. 1992. Insect associations of Euryale ferox Salisb. in the ponds of Darbhanga, North Bihar. *Journal of Freshwater Biology* ***4***(3): 199-208.

Puste, A. M. 2004. Agronomic practices and cultivation techniques of Euryale ferox (Fox nut/ Makhana) in India.

Tehseen, S., Sarfraz, F., Muntaham, S., Ateeq, N., Ashfaq, F., Yasmin, I., & Mehmood, T. 2020. Foxnut (Euryale ferox Salisb.): A health promising fruit. *Acta Scientific Agriculture* ***4***(12): 68-72.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 7-13, 2024

Conservation Agricultural Practices Enhance Soil Carbon Storage and Leading to Mitigate Climate Change Problems

Sanjukta Chakraborty, Neepa Dey, Tanushree Adhikary, Shri Jib Kumar Kar Souran Bhukta and Sanjib Kar

Department of Agricultural Chemistry and Soil Science, Institute of Agricultural Science, University of Calcutta. E-mail: sanjib_cu@yahoo.co.in

Abstract

Conservation agriculture might have the potential to increase soil organic C content compared to conventional tillage-based systems. The conventional method of intensive tillage alters the soil environment, destroys soil aggregates, depletes soil organic carbon (SOC), emits more carbon, requires higher energy, alters microbial activities and ultimately degrades the soil health. To minimize these negative effects of conventional tillage (CT), conservation agricultural (CA) practices such as reduced tillage (RT) and no-till (NT) with crop residue retentions are advocated as sustainable practices that can improve the soil health. The objective of this study was to investigate the effects of different tillage and cropping systems on SOC stocks and soil aggregation under different tillage and cropping systems in a Inceptisol .A field experiment was conducted for eight years in Agricultural farm of University of Calcutta with four scenarios namely scenario 1(CT) where conventional tillage practice and all residue removal were done with transplanted rice followed by wheat, scenario 2(partial CA) where transplanted rice-zero till pea-zero till wheat were cultivated with partial residue removal, scenario 3(full CA) where rice-pea-wheat were cultivated with zero tillage and all residue retention, scenario 4(fallow) where land was kept fallow after 2 years of farmers practices. Some key soil properties were subjected to calculating soil quality indices in each tillage systems. The proportion of large macro-aggregates was the highest under NT than CT whereas that of micro-aggregates was highest under CT. The aggregate associated organic C tended to decrease with the decrease of aggregate size. This study quantified soil organic carbon (SOC) and soil C derived from four scenario. Soil organic matter (SOM), total organic carbon (TOC) and humic substances were extracted from soils collected from 0 to 15 cm depth of each scenario. Results showed that Scenario-3 recorded significantly highest HA content. Lower E4/E6 ratio revealed higher stability and humification of humic acid carbon under CA based scenarios. The gross SOC turnover was lower in soil with residue retention than without residues. It was found that the ZT system with residue retention is a practice with a potential to retain organic carbon in soil. CA improves SOC stocks by addition of more C inputs through greater biomass production and reduction in SOC losses due to surface soil cover and locking SOC in soil aggregates. This causes net sequestration of atmospheric C into the soil, leading to climate change mitigation.

Keywords : Conservation agriculture, Humic acid, E4/E6 ratio, Carbon storage and climate change.

Introduction

Conservation Agriculture (CA) is a farming system that can prevent losses of arable land while regenerating degraded lands. It promotes minimum soil disturbance, maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production" (FAO, Retrieved 26,2020). In CA is practicing minimum soil disturbance which is essential to maintaining minerals within the soil, stopping erosion, and preventing water loss from occurring within the soil. In the past agriculture has looked at soil tillage as a main process in the introduction of new crops to an area. It was believed that tilling the soil would increase fertility within the soil through mineralization that takes place in the soil. Also tilling of soil can cause severe erosion and crusting which leads to a decrease in soil fertility. Today tillage is seen as destroying organic matter that can be found within the soil cover. No-till farming has caught on as a process that can save soil organic levels for a longer period and still allow the soil to be productive for longer periods (FAO, 2007). Additionally, the process of tilling can increase time and labor for producing that crop. Minimum soil disturbance also reduces destruction of soil micro and macro-organism habitats that is common in conventional ploughing practices. (FAO, retrieved 24, 2020) When no-till practices are followed, the producer sees a reduction in production cost for a certain crop. Tillage of the ground requires more money in order to fuel tractors or to provide feed for the animals pulling the plough. The producer sees a reduction in labour because he or she does not have to be in the fields as long as a conventional farmer.

The second key principle in CA is much like the first in dealing with protecting the soil. The principle of managing the top soil to create a permanent organic soil cover can allow for growth of organisms within the soil structure. The presence of mulching also reduces the velocity of runoff and the impact of rain drops thus reducing soil erosion and runoff. (FAO Retrieved 26,2020) The third principle is the practicing diverse crop rotation or crop interactions. Establishing crops in a rotation allows for an extensive build up7 of rooting zones which will allow for better water infiltration (Hobbs *et al*. 2007) (FAO Retrieved 26,2020). Organic molecules in the soil break down into phosphates, nitrates and other beneficial elements which are thus better absorbed by plants. Ploughing increases the amount of oxygen in the soil and increases the aerobic processes, hastening the breakdown of organic material. Thus, more nutrients are available for the next crop but, at the same time, the soil is depleted more quickly of its nutrient reserves.

An excessive loss of soil organic carbon (SOC), alterations in microbiological activities, and breakdown of soil aggregates coupled with the increasing climate change have threatened the sustainable food production under intensive cultivation. Loss of SOC occurs upon conversion of perennial vegetation into agricultural land involving intensive tillage. Such conventional tillage practices can degrade soil quality (the soil's inherent capacity to function to sustain crop productivity) and soil health (the balance among the soil organisms within the soil system and between the soil organisms and their environment. The adoption of conservation agriculture (CA) is promoted by FAO as a response to sustainable land management, environmental protection and climate change adaptation and mitigation (Pisante *et al*. 2012; 2015). According to the FAO definition, CA is a farming system that promotes maintenance of (1) minimum soil disturbance avoiding soil inversion (i.e. no-tillage or minimum tillage), (2) a permanent soil cover with crop residues and/or cover crops, and (3) diversification of plant species through varied crop sequences and associations involving at least three different crops (FAO, 2017). The utilization of CA-based technologies has become an official state policy for agriculture in Kazakhstan. In fact, since 2008, the government of Kazakhstan has been subsidizing farmers who adopt CA-based technologies.

Italy is one of the European countries where the adoption of no-tillage and minimum tillage has been growing recently (Kassam *et al*., 2019). Beyond the no-tillage practice, further information about the CA practices they implement is not available. Finland is the most northern country adopting no-tillage with the highest application rate of 10% (200,000 ha) in Europe (González-Sánchez *et al*., 2017). Conservation agriculture provides many benefits, such as enhanced biodiversity and natural biological processes above and below the soil surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production. Moreover, increases in SOC could increase crop yield (Zhao *et al*., 2017) and reduce yield variability since the SOC accumulation not only sequestrates atmospheric CO2, but also increases soil fertility and soil water holding capacity (Franzluebbers, 2002). Healthy soils are key to developing sustainable crop production systems that are resilient to the effects of climate change. High-residue producing crops may sequester more C than crops with low residue input. Intensification of cropping systems, such as increased numbers of crops per year, double cropping, and the addition of cover crops can result in increased soil C storage under NT (West and Post, 2002).

Cover crops can increase C concentration and stocks, potentially offsetting residue removal-induced losses to SOC and harm to other soil properties (Ruis and Blanco-Canqui, 2017). Thus, CA involves complex and interactive processes that ultimately determine soil C storage making it difficult to identify clear patterns, particularly when the results originate from a large number of independent studies. To solve these problems, a model approach can be useful to assess the contribution of each principle of CA in soil C sequestration. The three sites are very contrasting for soil texture and organic C contents, climates, crops used and management intensity. To assess the feasibility of options, allowing for C sequestration in soils in future years, and simulations under a short-term future climate scenario were carried out.

The main objective of this study was to investigate the effects of different tillage and cropping systems on SOC stocks, soil aggregation and GHG emissions under different tillage and cropping systems in an inceptisol. This paper will provide a comprehensive summary of our knowledge regarding the effect of CA.

Materials and methods

Study area and treatment details

Samples were collected in March, 2024, at location 88 °4355'E, 22 °3744'N, University of Calcutta agricultural farm, Baruipur, Kolkata, India. Average rainfall of the area 1700mm, 70% of which occurred during monsoon, soil is silty-loamy alluvial and soil order is Inceptisol. The area was split up into fully randomized experimental units of 40m2 (5m*8m) with three replicates per treatment. A field experiment was conducted for eight years in Agricultural farm of University of Calcutta with four scenarios namely scenario 1 (CT) where conventional tillage practice and all residue removal were done with transplanted rice followed by wheat, scenario 2 (partial CA) where transplanted rice-zero till pea-zero till wheat were cultivated with partial residue removal, scenario 3 (full CA) where rice-pea-wheat were cultivated with zero tillage and all residue retention, scenario 4(fallow) where land was kept fallow after 2 years of farmers practices. Recommended doses of fertilizers 120-60-60 kg ha-1 of N-P2O5-K2O for both rice and wheat varieties were applied in all CA based scenarios.

Sampling

Each plot was flat and uniform and soil sampling was done using a grid. The field was divided into cells by means of a coarse grid. A horizontal coarse cell was selected in the top row and kept the X coordinate the same but randomly select a new Y coordinate. The soil samples were placed in cold boxes and transported to the laboratory for analysis. Soil moisture

To determine the soil moisture, 10 g of the soil samples was dried in an oven at 60°C, and then sieved with 2 mm mesh size and weight of the evaporated water from oven drying was calculated.

Soil texture

Texture also affects water permeability, and heavier finer soil can suffer from drainage problems, if soil structure is poor. Soil texture is determined by international pipette methods in order to characterise the particle size composition of the soil.

Bulk density

Bulk density is the weight of the soil in a given volume. In the laboratory, samples were weighed. To calculate the water content of the soils, two sub-samples (20 g) were oven-dried at 105°C, and water content was calculated.

Soil organic matter concentration

The determination of soil organic carbon is based on the Walkley-Black chromic acid wet oxidation method. Oxidisable matter in the soil is oxidised by 1 N $K_2Cr_2O_7$ solution. The reaction is assisted by the heat generated when two volumes of H2SO4 are mixed with one volume of the dichromate. The remaining dichromate is titrated with ferrous sulphate. The titre is inversely related to the amount of C present in the soil sample (Anonymous, 1992).

Isolation and purification of humic Acid

The HA was extracted using a 0.5 mol L-1 238 NaOH solution in a proportion 1:10 (soil: solution), followed by shaking for 3h @ 150 rpm (de Souza and Bragança, 2018). For the removal of inorganic contaminants from the HA, purification was carried out by parchment paper then repeatedly washed with deionized water. The purified HA was dried at 40°C (de Souza and Bragança, 2018).

E4/E6 index measurement

E4/E6 ratio was determined by dissolving 1 mg of HA in 5 ml of 0.05 M NaHCO3 and pH was adjusted to 8.3 with NaOH. The absorbance at 465 and 665 nm was measured on a UV3000 spectrophotometer (Chen *et al.* 1977).

Results and discussion

Soils in the study area are well drained and acidic to neutral in PH, brown in colour, silty clay in texture, sub angular blocky in structure, low in organic matter and possess moderate cation exchange capacity. The soils have high amount of silt and clay fraction which do not shows any trend in different depth. Based on morphological, physical and chemical characteristics, soils were classified as Inceptisols. the better the aggregate stability against water erosion. After 8 years ZT plots had a greater proportion of large macroaggregates than CT plots. In contrast to CT, ZT promoted macro-aggregation, especially within the surface soil layer (Table-2). Favourable effects of ZT on soil structural properties may also be partly due to higher activity of earthworms and more microbial

Table 1. Physico-chemical analysis of soil

scenario	pH	Δ pH	EC(mSm^-1)	CEC	%OC	OM%	Texture
Initial	6.10	-0.36	0.06	28.5	1.32	2.297	33,48,19
After 8 years of conservation agriculture	6.00	0.42	0.05	29.10	1.52	2.645	33,48,19

Table 2. Effect of Different tillage on aggregate associated carbon concentration (%)

Tillage Practices	LM-C(0-15cm)	SM-C(0-15cm)	M1-C(0-15cm)	S-C(0-15cm)
CT	0.62	0.36	0.30	0.24
RT	0.68	0.38	0.34	0.32
NT	0.71	0.42	0.39	0.37

Table 3. Yield of Humic acid (g/100g soil) and E4/E6

Scenarios	Yield of HA(g/100g)	E4/E6
Initial	0.92	4.8
Scenario 1	1.21	5.1
Scenario 2	1.71	4.5
Scenario 3	2.97	4..2
Scenario 4	0.98	4.7

biomass than in CT plots (Nyamadzawo *et al.* 2009). Bulk density greatly depends on inherent soil qualities and management practices. Bulk density can be used as a measure of a soil's compaction and indicates the effect a soil is likely to have on seedling emergence, root growth and thus crop production. NT with residue retention, decreased bulk density by 1.4% (2.4 to 2.11). Tillage had greater impacts on soil bulk density than residue retention and all plots that received residues had lower bulk densities. The changes in soil bulk density values under different tillage practices were significant in the surface layers. After 8 years conservation practices PH and EC decreases to some extent, but CEC increases due to the formation of more humic substances under CA practices (Table-1).

Total organic carbon (TOC) in different soil management

Many studies on the influences of reduced tillage and no-till on SOC build-up have been made. Significant variation in TOC content was observed among the scenarios. At 0-15 cm soil depth, Scenario-3 showed 44% higher TOC compared to conventional agriculture practices (Scenario1) (Table 1). Zero tillage with minimum soil disturbance further slows down the decomposition of organic matter in CA based practices. Higher TOC 2 in CA based management practices was due to long term crop residue retention at soil surface which upon decomposition released carbon to soil. In addition, carbon inputs through roots, rhizodeposition might also have significantly contributed in TOC build up in soil. Higher SOC concentrations at surface soil under CA based systems due to higher quantities of above and below ground residue additions and zero tillage mediated slower SOC decomposition. Higher population of microflora and fauna might have resulted higher C content in CA based systems through greater conversion of crop residue carbon to soil organic carbon (Choudhary *et al.*, 2018a, b).

E4/E6 ratio of HA under different CA managements

The E4/E6 ratio (ratio of the absorbance at 465 and 665 nm) has been widely used to study the characteristics of HA fraction. The E4/E6 ratio is considered to be inversely related to the degree of condensation and aromaticity of the humic substances and to their degree of humification (Chen et al., 1977). The absorbance at 465 nm represents the organic material at the initial stages of humification, whereas the absorbance at 665 nm indicates the highly condense humified material with prevalence of aromatic constituents. HA extracted from Scenario-1 showed highest E4/E6 value (5.1), whereas it decreased significantly in different CA based system. Lower E4/E6 ratio indicated higher degree of humification and aromaticity of HA's. More condensed and aromatic humic molecule was formed in soil under CA based scenarios as evidenced from lower values of E4/E6 ratio (Table. 3). Highest yield of HA recorded in scenario -3 (Table-3). Higher carbon input through crop residues as well as zero tillage and inclusion of legumes further facilitated the conversion of crop residue carbon to soil organic carbon and subsequent formation of more condensed humic acid under CA based scenarios as also evidenced by higher soil organic carbon and soil aggregation (Jat et al., 2019a,).

Crop yield

Table 4 presents a clearer picture of the impact of CA practices on crop yield. As shown in the table, the impacts of CA practices on grain yield of crops were negative, but CA practices restore soil health and mitigate some part of climate change problem compare to conventional tillage. The main reason for the negative yield impact of grass strips is due to the fact that it occupies cultivable land for hedge formation.

Literature Cited

Anonymous, 1992. Soils. Methods for determination of organic matter. GOST 26213-91. State Committee for Standardization and Metrology of the USSA. Moscow, p.8 http:/ / docs.cntd.ru/document/1200023481 (In Russia.

Chen, Y., Senesi, N., Schnitzer, M., 1977. Information provided on humic substances by 544 E4/ E6 ratios. Soil Sci. Soc. Am. J. 41, 352-358. 545 https://doi.org/10.2136/ sssaj1977.03615995004100020037x

TABLE 4. Comparison of the yield of conventional agriculture and conservation agriculture

Scenario	Crop	conventional agriculture yield (ton/ha)	conservation agriculture yield (ton/ha)
Scenario 1	Rice	3.2	2.3
Scenario 2	Wheat	2.9	2.6
Scenario 3	Pigeon Pea	1.3	2.5

Choudhary, M., Datta, A., Jat, H. S., Yadav, A. K., Gathala, M. K.,Sapkota, T. B., Das, A. 547 K., Sharma, P. C., Jat, M. L., Singh, R., Ladha, J. K., 2018a. Changes in soil biology under conservation agriculture based sustainable intensification of cereal systems in Indo-Gangetic plains. Geoderma 313, 193-204. https://doi.org/10.1016/j.geoderma.2017. 10.041 551

Choudhary, M., Jat, H. S., Datta, A., Yadav, A. K., Sapkota, T. B.,Mondal, S., Meena, R. P., Sharma, P. C., Jat, M. L., 2018b. Sustainable intensification influences soil quality, biota, and productivity in cereal-based agroecosystems. Appl. Soil Ecol. 126,189– 554 198. https://doi.org/10.1016/j.apsoil.2018.02.027

de Souza, F., Braganca, S.R., 2018. Extraction and characterization of humic acid from coal for the application as dispersant of ceramic powders. J. mater. Res Technol. 7, 254-260.

Franzluebbers, A.J., 2002. Water infiltration and soil structure related to organic matter and its stratification with depth. Soil Till. Res. 66, 197–205. https://doi.org/10.1016/ S0167-1987(02)00027-2.

FAO, Retrieved 26 October 2020. "Conservation Agriculture". Food and Agriculture Organization of the United Nations. Retrieved 26 October 2020.

FAO, Retrieved 24 October 2020. "Conservation Agriculture". Food and Agriculture Organization of the United Nations. Retrieved 26 October 2020.

FAO (2017), What is Conservation Agricutlure? FAO CA website (http://www.fao.org/ag/ca/1a.html), FAO, Rome.

FAO (2007), Investing in Sustainable Crop Intensification: The Case for Soil Health. Report of the International Technical Workshop, FAO, Rome, July. Integrated Crop Management, Vol. 6. Rome: FAO. Online at: http:// www.fao.org/ag/ca/.

González-Sánchez, E.J., Moreno-García, M., Kassam, A., Holgado-Cabrera, A., Triviño- Tarradas, P., Carbonell-Bojollo, R., Pisante, M., Veroz-González, O., Basch, G., 2017. Conservation Agriculture: Making Climate Change Mitigation and Adaptation Real in Europe, ed. European Conservation Agriculture Federation (ECAF), 154p. doi: 10.13140/ RG.2.2.13611.13604.

Hobbs P.R, Singh Y, Giri G.S, Lauren J.G, Duxbury J.M. Direct seeding and reduced tillage options in the rice–wheat systems of the Indo-Gangetic Plains of South Asia. In: Pandey S, Mortimer M, Wade L, Tuong T.P, Lopez K, Hardy B, editors. *Direct seeding: research strategies and opportunities. Proc. Int. Workshop on Direct Seeding in Asian Rice Systems: strategic research issues and opportunities, Bangkok, Thailand, 25–28 January 2000.* International Rice Research Institute; Los Banos, Philippines: 2002. pp. 201–215.

Jat, H.S., Datta, A., Choudhary, M., Sharma, P.C., Yadav, A.K., Choudhary, V., Gathala, M.K., Sharma, D.K., Jat, M.L., McDonald, A., 2019a. Climate Smart Agriculture practices improve soil organic carbon pools, biological properties and crop productivity in cereal-based systems of North- West India. Catena, 611 https://doi.org/10.1016/ j.catena.2019.05.005

Kassam, A., Friedrich, T., Derpsch, R., 2019. Global spread of conservation agriculture. Int. J. Environ. Studies 76, 29–51. https://doi.org/10.1080/ 00207233.2018.1494927.

Nyamadzawo G, Nyamangara J, Nyamugafata P, Muzulu A (2009) Soil microbial biomass and mineralization of aggregate protected carbon in fallow–maize systems under conventional and no-tillage in central Zimbabwe. Soil Till Res 102:151–157

Pisante M., Stagnari F., Acutis M., Bindi M. Brilli L., Di Stefano V., Carozzi M., 2015. Conservation Agriculture and Climate Change, in.:Farooq, M., Siddique, K.H.M. (Eds.), Conservation Agriculture. Springer, Cham, pp. 579-620. DOI 10.1007/ 978-3-319-11620-4_22.

Pisante, M., Stagnari, F., Grant, C.A., 2012. Agricultural innovations for sustainable crop production intensification. Ital. J. Agron. 7, 300–311. Poeplau, C., Don, A., 2015. Carbon sequestration in agricultural soils via cultivation of cover crops – a meta-analysis. Agr. Ecosys. Environ. 200, 33–41. https://doi.org/10. 1016/j.agee.2014.10.024.

Ruis, S.J., Blanco-Canqui, H., 2017. Cover crops could offset crop residue removal effects on soil carbon and other properties: a review. Agron. J. 109, 1785–1805. https://doi. org/10.2134/agronj 2016.12.0735.

West, T.O., Post, W.M., 2002. Soil organic carbon sequestration rates by tillage and crop rotation: a global data analysis. Soil Sci. Soc. Am. J. 66, 1930–1946. Yli-Viikari, A. (Ed.). 2019. Maaseutuohjelman (2014–2020) ympäristöarviointi. Luonnonvara- ja biotalouden tutkimus 63/2019. Luonnonvarakeskus, Helsinki (In Finnish with English abstract). https://jukuri.luke.fi/handle/10024/544713.

Zhao, X., Liu, S.L., Pu, C., Zhang, X.Q., Xue, J.F., Ren, Y.X., Zhao, X.L., Chen, F., Lal, R., Zhang, H.L., 2017. Crop yields under no-till farming in China: a meta-analysis. Eur. J. Agron. 84, 67–75. https://doi.org/10.1016/j.eja. 2016.11. 009.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 15-19, 2024

Effect of Weather and Population Dynamics of Gundhi Bug Infestation Under Staggered Planting

[1]Debashree Sarkar, [2]Anupama Baliarsingh, [3]Satyamaya Satapathy*

[1]Subject matter Specialist, Agrometeorology, KVK Bolangir[2] Professor Department of Agronomy
[3]Senior Scientist and Head, KVK Bolangir
Orissa University of Agriculture and Technology, Bhubaneswar- 751003, Odisha, India
Corresponding author email id : satyamayasatapathy@gmail.com

Abstract

An experiment was conducted in Agrometeorology field, Central Research Farm, Orissa University of Agriculture and TechnologyBhubaneswar during 2017-2018, to study the population dynamics of Gundhi bug and its correlation with weather parameters under staggered planting with 12 dates starting from 16th July 2017 to 1st January 2018 at 15 days interval and three varieties such as Geetanjali, PoornaBhog and Pusasugandh –II.The population of GB was built up from September to April, but the highest occurrence was observed during last week of November in 1st September planting date and second peak occurrence was observed during 2nd week of September in 16th July date.

The GB population was highest when maximum temperature was 30-34^{0}c, minimum temperature (18-20^{0}c), morning relative humidity 85-88% and afternoon relative humidity 50-55%, ample sunshine hours of (9-10hr), under dry conditions found favorable for pest population.

Introduction

Rice is a crucial cereal crop globally, and the rising demand for aromatic varieties in both local and international markets has highlighted their vulnerability to insect pests, leading many farmers to discard affected crops. Key climatic factors such as rainfall, temperature, and humidity play significant roles in the development and proliferation of rice insect pests.

While paddy crops are attacked by a wide range of insect pest guilds, only a few are responsible for substantial yield losses. These pests pose a major constraint to achieving optimal rice yields, making effective pest management essential for farmers aiming to meet market demand and maintain crop health. Addressing these challenges is vital for sustaining rice production and ensuring food security.

The Gundhi bug, measuring around 19 mm in length, is characterized by its slender body, long legs, and antennae, typically exhibiting green or brown coloration. It lays oval, dark reddish-brown eggs in clusters of 10-20 on leaves, arranged in straight rows. The nymphs are slender and wingless, initially brownish-green, with their color deepening as they mature; fully grown nymphs reach about 14-16 mm.

Both adults and nymphs feed on the sap of young shoots, leaves, florets, and soft grains using their piercing, sucking mouthparts. This feeding causes white spots at the feeding sites and can lead to black or brown marks around the punctures, where sooty mold may develop. Infestation can also compromise grain quality, causing them to break easily during milling. Infested rice fields often emit a foul odor, contributing to the bug's name.

Materials and Methods

Odisha, located at an elevation of 25.9 meters above sea level and positioned at 20°15' N latitude and 85°52' E longitude, features a hot and humid climate, particularly in Bhubaneswar. In 2017, the annual mean maximum temperature reached 35.3 °C, while the mean minimum was 22.6 °C. The summer season, from March to June, is characterized by temperatures ranging from 26.4 to 35.7 °C, with May being the hottest month (32–42 °C). In contrast, the winter months of December and January are cooler and drier, with temperatures between 15 and 28 °C.

The present study was conducted during the kharif (monsoon) season of 2017 and the rabi (winter) season of 2017-2018 at the Research Farm of the College of Agriculture, Orissa University of Agriculture and Technology in Bhubaneswar. The focus was on the infestation of the Gundhi bug in aromatic rice under varying weather conditions. The research involved staggered planting across 12 dates, from July 16, 2017, to January 1, 2018, at 15-day intervals. Three rice varieties were studied: Geetanjali, PoornaBhog, and Pusasugandh-II. However, the planting dates of October 1 and October 16 were excluded due to high sterility caused by low temperatures.

Normal agronomic practices were followed in both the experimental plots and those adopted by local farmers. To assess the population dynamics of the Gundhi bug, damaged leaves with white or transparent patches were counted, enabling the study of its correlation with weather parameters. Throughout the investigation, key weather factorsmaximum and minimum temperatures, rainfall, relative humidity, and sunshine hourswere recorded and analyzed to identify the peak periods of Gundhi bug incidence during the growth of aromatic rice. The data aimed to establish correlations between the bug population and abiotic factors, contributing to better pest management strategies in rice cultivation.

Results and Discussion

1. Population built up of Gundhi Bug

The Gundhi bug occurrence was found most of the planting date starting from 1st date (16th July) to 12th date of planting (1st January), except 16th August, 1st November, 16th November, 16th December date of planting. The number of pest per hill varied from 0.1 to 1.8 (Table 1). However, the infestation of GB was first found from 3rd week of September (SMW 38) and was continued up to 2nd week of April (SMW 45). Though the population of GB was built up from September to April, but the highest occurrence was observed during last week of November in 1st September date of transplanting, and gundhi bug was not found in November and December dates of planting.

Table 1. 4.13 Weekly GB Population Per Hill

Week after planting	16-Jul	1-Aug	16-Aug	1-Sep	16-Sep	1-Nov	16-Nov	1-Dec	16-Dec	1-Jan
WK1	0	0	0	0	0	0	0	0	0	0
WK2	0	0	0	0	0	0	0	0	0	0
WK3	0	0	0	0	0	0	0	0	0	0
WK4	0	0	0	0	0	0	0	0	0	0
WK5	0	0	0	0	0	0	0	0	0	0.2
WK6	0	0	0	0	0	0	0	0	0	0
WK7	0	0	0	0	0	0	0	0	0	0
WK8	0	0.1	0	0	0	0	0	0	0	0
WK9	0.2	0.2	0	0	0.3	0	0	0	0	0
WK10	0.5	0	0	0	0.1	0	0	0	0	0
WK11	0.1	0	0	0	0	0	0	0	0	0
WK12	0	0.1	0	1.8	0	0	0	0	0	0
WK13	0	0	0	0	0	0	0	0	0	0.4
WK14	0	0	0	0	0	0	0	0	0	0.3

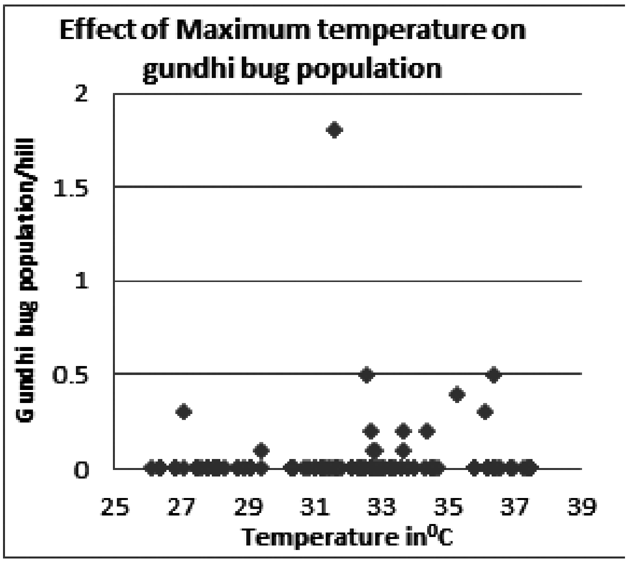
2. Favorable weather parameters for Gundhi Bug Population

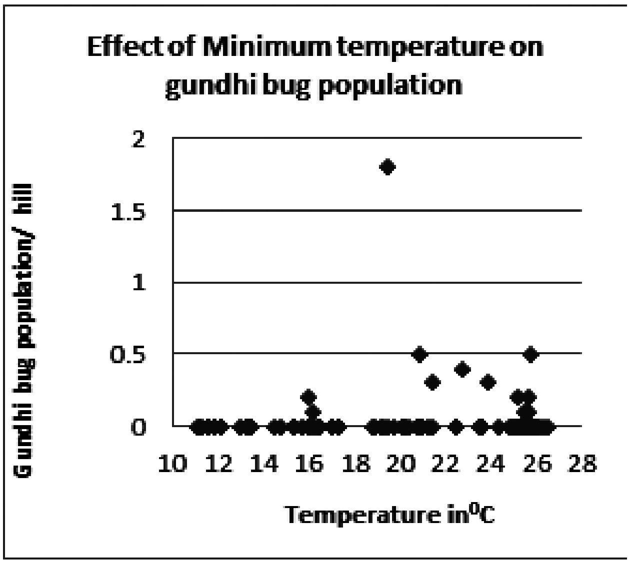
The GB population was highest when the following conditions were prevailed as maximum temperature ($30-34^0$c), minimum temperature ($18-20^0$c), morning relative humidity 85-88% and evening relative humidity 50-55%, ample sunshine hours of (9-10hr), with dry conditions found favourable for pest population, while the GB population was found at a range of maximum temperature from(26- 37°C), minimum temperature (11- 26°C), relative humidity at morning (82-96%), relative humidity at afternoon of (20-85%),rain fall (0-160mm),with 1-10hours of sunshine (Fig 1).

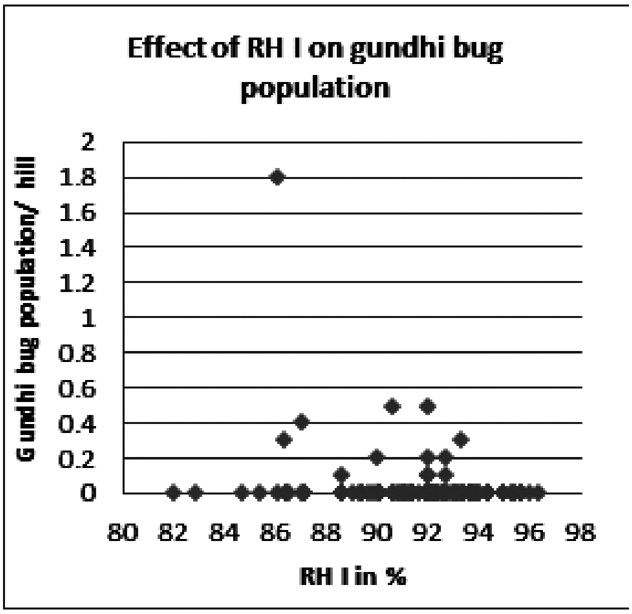
3. Correlation studies of Gundhi Bug with weather parameters

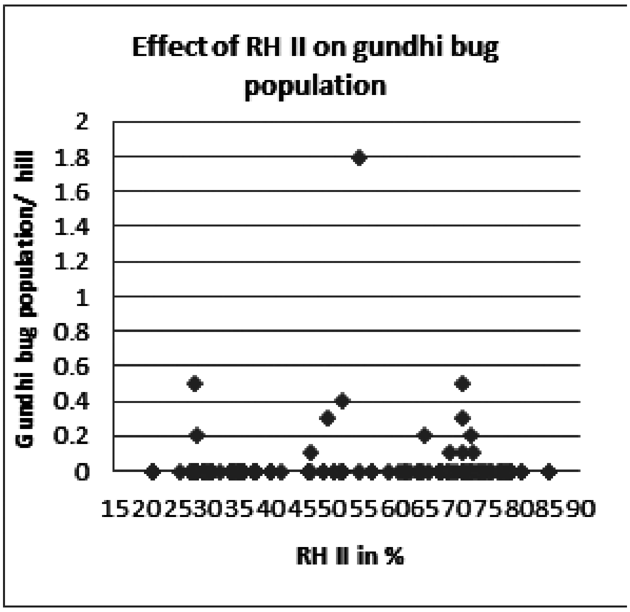
The correlation between GB Population and different weather parameters revealed significant correlation only in two dates of planting viz., 1st September and 1st January out of 12 planting dates (Table 2).

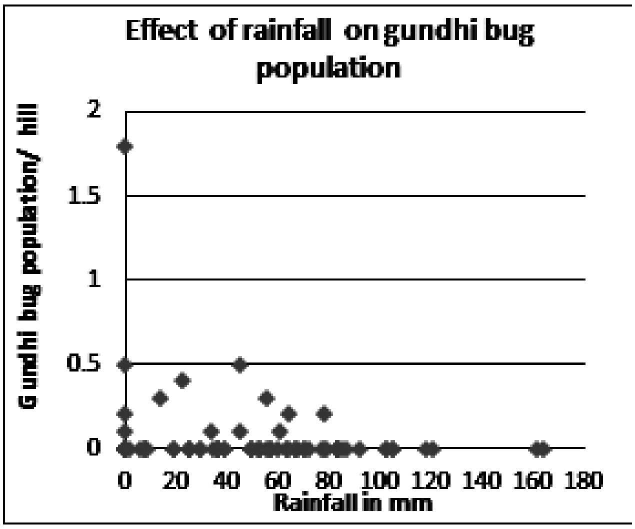
The GB was negatively correlated with afternoon relative humidity with r value (-0.57) in 1st











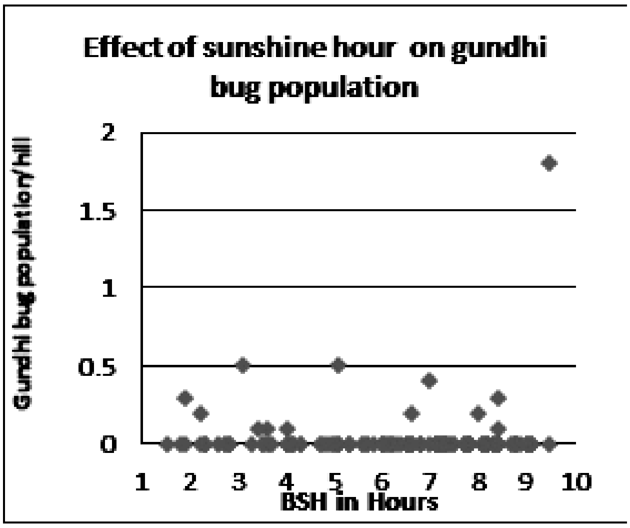


Fig. 1 Favourable weather parameters for gundhi bug population

September date of planting. In 1st January date of planting GB was negatively correlated with morning relative humidity with r value (-0.66) and positively correlated with evening relative humidity and rainfall with r value (0.67) and (0.91).

Summary and Conclusion

Gundhi bug was attacked the crop at reproductive stage and was at maximum occurrence during (SMW 47) followed by (SMW 37) and was aggravated by weather condition of (30-34^{0}c) maximum temperature of minimum temperature 18-20^{0}C, RH1(85-88%), RH 2(0-55%) under long hours of sunshine, GB was mostly correlated with relative humidity and rainfall.

Literature Cited

Dogra I and Choudhary A. 2005. Some insect pests of rice, *Oryza sativa* Linn. In Kangra Valley of Himachal Pradesh, *Insect-Environment*, **11**(1): 21-22.

Table 2. Correlation studies of population density of GB with weather parameters

WP	16th Jul	1st Aug	1st Sep	16th Sep	1st Dec	1st Jan
TX	0.18548	-0.0652	-0.0723	-0.407	0.28376	0.22418
0.5255	0.8247	0.8059	0.1322	0.2697	0.441	
TN	0.06107	-0.311	-0.4939	0.02275	0.25541	0.39285
0.8357	0.2791	0.0726	0.9359	0.3225	0.1647	
RH1	-0.0871	0.04231	-0.4638	0.07737	-0.1332	**-0.6683**
0.7672	0.8858	0.0948	0.784	0.6101	0.009	
RH2	-0.33983	-0.1599	**-0.5778**	0.19442	-0.21	**0.67656**
0.2345	0.5849	0.0304	0.4875	0.4174	0.0079	
RF	-0.21128	-0.1433	-0.4174	0.22076	-0.0742	**0.91329**
0.4684	0.625	0.1375	0.4291	0.7771	<.0001	
SS	-0.10939	-0.4671	0.52641	-0.4147	-0.2841	0.10269
0.7097	0.0921	0.0531	0.1243	0.269	0.7268	

Gangarade GA, Kaushik UK, Patidar DG, Shukla BC, Shrivastava SK, Deshmukh PD and Pophaly DJ. 1978. Insect pests of summer paddy in M.P, **3**(6):16.

Ghose RLM, Ghatge MB and Subramanyan V. 1960. Pests of Rice, ICAR, New Delhi, pp. 248- 257.

Kalita H, Avasthe RK and Ramesh K. 2015. Effect of Weather Parameters on Population Build-up of Different Insect Pests of Rice and Their Natural Enemies, *Indian Journal of Hill Farming*, **28** (1): 69-72.

Karuppaiah V and Sujayanad G K. 2012. Impact of Climate Change on Population Dynamics of Insect Pests, *World Journal of Agricultural Sciences*, **8** (3): 240-246.

MadhuriG, Dash P.C, and Rout K.K.2017.Effect of Weather Parameters on Population Dynamics of Paddy Pests*Int. J. Curr. Microbiol. App. Sci*, **6**(10): 2049-2053

Israel P and Rao. 1961. The Incidence of Gundhi bug and steps for its control. Proc. Rice Conf., Cuttack, pp. 297-99.

Yasumatsu K, Wongsiri T, S Navavichit and C Tirawat. 1975. Approachestoward an integrated control of rice pests. Part 1: Survey of natural enemiesof important rice pests in Thailand, *Plant Prot.*, pp .8-9.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 21-26, 2024

Effect of Zero Tillage and Seed Rate on Growth and Yield of Wheat (*Triticum aestivum)*

Snehasish Das, Debasis Sahoo and R.K. Sarkar*

Department of Agronomy, Institute of Agricultural Science, University of Calcutta, 51/2, Hazra Road, Kolkata-700019

**Corresponding author email id : sarkarrk1@rediffmail.com*

Abstract

Field experiments were conducted during winter season of 2020-21 and 2021-22 at the Water Management Research Station, Ranaghat, District Nadia, West Bengal to study the effect of zero tillage and seed rate on growth and yield of wheat. Results reveled that both the factors of tillage method and seed rate had profound influence on vegetative growth parameters like plant height and dry matter production. Zero tillage system produced maximum dry matter 1m^2 in wheat.Zero tillage system improved the physiological growth parameters like LAI, CGR, RGR and NAR over conventional method of sowing. Among the seed rates 125 kg/ha showed contain improvement in these growth parameters.Zero tillage system improved number of earhead /m², number of filled grain/ earhead, 1000 grain weight. Successive increase in seed rate upto 150 kg/ha improved most of the yield contributing characters in wheat.Zero tillage system recorded 9041 and 45.88% higher grain yield over conventional tillage and line sowing and conventional tillage and broadcasting respectively in pooled basis. Both the seed rate of 125 and 150 kg/ha showed similar yield potential of wheat.

Introduction

Tillage in wheat assumes great importance due to disrupt soil structure caused by puddled condition created in previous rice crop and availability of limited time for preparation of land for wheat sowing. Zero tillage technology could be a valid option to reduce the turnaround time cost and establishment of good crop stand of wheat without loss in productivity and sustainability of natural resources. The sowing with zero-till drill facilitates timely sowing of wheat on residual moisture. Zero tillage also advances sowing of wheat then conventional tillage. Optimum seed rate is one of the most important factors for higher grain yield of wheat. Seed rate influences the capacity of plans to utilise the environmental factors in building plant tissues through regulating the absorption capacity of plants. Hence there is need of ascertaining the effect of zero tillage and seed rate on growth and productivity of wheat crop in Gangetic alluvial land.

Materials and Methods

The experiment comprising three types of tillage system viz. (i) Zero tillage followed by line sowing and (ii) Conventional tillage followed by line sowing and (iii) Conventional tillage followed by broadcasting in main plots and four seed rates viz. (i) 75 kg/ha (ii) 100 kg/ha (iii) 125 kg/ha and (iv) 150kg/ha in subplots were tested in a split – plot design replicated thrice at Water management Research Station, Ranaghat, district Nadia, West Bengal during winter season of 2020-21and 2021-22. The experiment way conducted in Gangetic alluvial soil (Inceptisol) type with clay loam in texture with moderate water holding capacity and mediumfertility status. The wheat cultivarUP-262 was grown as test crop. The crop way sown during third week of November during both years with spacing of 20cm row distance with continuing sowing. Standard fertilizer doseof 120g N, 60 kg P^2O^5 and 60 kg K^2O/ ha was applied after final Land Preparation in all five irrigations were given based on critical growth stags. Recommended agronomic practices were adopted while growing the crop. Computation of growth analysis was doneas par Watson (1955).The crop was harvested during second week of March during both the years.

Results and Discussion

Increased plant height in in zero tillage with line sowing was probably owing to advantages of sowing dates, proper placement of seeds in the narrow slit and early emergence of wheat seedlings (Kumar and Yadav, 2005). The effect of send rate proved ineffective on shoot elongation of wheat particularly at higher seed rate.

Moredry matter accumulation in zerotilled wheat plants might be due to more plant height, more leaf area and due to more number of tillers (Parihar, 2004) as compared to other systems of tillage. Greater amount of dry matter under seed rate of 125 kg and 150 ug per ha wasdue to more numbers of plant Per unit area compared with lower seed rate.

More LAI in conventional tillage and sowing treatments might be due to move plant height, more number of tillers and higher leaf production. Higher seed rate of 150kg/ha resulted in increased LAI due to increase in leaf number and size in cell number under conductive plant geometry and plant population.,

Higher CGR with zero tilled wheat might be due to higher LAI whichaccumulated higher dry matter.Higher CGR recorded with 150 kg seed /ha might be accounted for higher effective tiller accompanied with high leaf area which led to increase in CGR in wheat.

In general,better manifestation of RGR under zero tillage might be attributed to more accumulation of dry matter and crop growth rate. More RGR at lower seed rate of 125kg/ha over 150kg/ha was due to less competition among the plants for light, moisture and nutrient compared with those of higher seed rate.

Zero tilled wheat exhibited higher NAR which could be possible due to higher CGR. Hence NAR expressed plants capacity to increase dry weight in terms of its assimilation surface (Reddy, 2000) and reflects the photosynthetic efficiency of crop. Significant and appreciable improvement in NAR with 100 and 125 kg seed/ha could be ascribed for the effectiveness to modify growth environment of plants by proper distribution of plants over ground area owing to better interception and absorption and utilization of radiant energy, there by resulting in higher photosynthesis and finally dry matter accumulation by the crop per unit area (Singh *et al,* 1993).

Tillage system and seed rates had shown pronounced effect on yield attributing characters of wheat. Zero tillage system exhibited higher number of spikes/m^2, maximum test weight of grains, conventional tillage with line sowing showed the highest filled grains/ spike owing to better seed bed for wheat sowing available after rice which resulted in better growth and yield attributes of wheat (Sharma*et al.*2002). The effect of filled grains / spike was also similar of zero tillage and conventional tillage with line sowing. Maximum yield attributes had been recorded with higher seed rate of 125 and 150 kg/ha. Probably because of proper spatial distribution of plants which had resulted in increased supply of natural resources. The results on test weight of seeds proved ineffective due to variation in seed rate.Increased grain yield by zero tillage could be due to various favorable factors under zero tillage like advancing of sowing date, properplacement of seeds in narrow slits made by zero till drill, early enhancement of wheatseedlings and availability of higher moisture content which might have helped to compete the crop sown where conventional tillage (Gupta, 2007). The improvement in yield attributes under zero tillage might have occurred owing to better establishment of plants asa resultof less weed competition under zero tillage incomparison to conventionaltillage (Yadav *et al*, 2002). Zero tillage system outyielded by 9.41 and 45.88% higher grain yield over conventional tillage and line sowing and 45.88% over conventional tillage and broadcasting respectively on pooled basis.

Increase in grain yield at 125kg seed/ha was mainly owing to moderately higher spikes/m^2, test weight of grains over its higher send rate, indicating perhaps the higher intra plant competition among plants at higher seed rate. The increase in yield at 125 kg seed rate/ha might be dueto higher plant population which might have resulted in more utilization of natural resources particularly soil moisture nutrients, carbon dioxide and radiant energy (Azad *et al,* 1988)

Zero tillage system had given appreciably and significantly higher straw yield over other systemsprobably due to more dry matter production in vegetative parts and increased morphological

Table 1. Effect of tillage systems and seed rate on growth parameters of wheat

Treatments	Plant height (cm)		Dry matter /m^2(g)		Crop growth rate CGR g/m^2/day mean at maximum of 75-90 days
	2020-21	2021-22	2020-21	2021-22	
Zero tillage followed by line sowing	114.36	116.65	1290.00	1374.18	26.11
Conventional tillage followed by line sowing	115.36	116.76	1162.25	1236.06	22.06
Conventional tillage followed by broadcasting	95.16	96.84	842.50	888.93	11.10
S.Em (+)	3.23	3.29	36.66	39.19	0.78
CD (P=0.05)	2.37	2.39	143.89	153.84	3.05
Seed 75 kg/ha	109.06	111.24	943.00	1014.47	15.29
Seed 100 kg/ha	105.21	107.02	1111.67	1195.25	21.86
Seed 125 kg/ha	110.34	I 11.34	1186.67	1229.68	22.25
Seed 150 kg/ha	108.55	110.72	I 151.66	1226.16	19.63
S.Em (+)	2.37	2.39	25.96	27.26	0.51
CD (P=0.05)	NS	NS	77.11	80.98	1.51

Table 2. Effect of tillage systems and seed rate on growth parameters of wheat

Treatments	Relative growth rate RGR maximum during 45-60 days gm^2/day)		Net assimilation rate (NAR maximum at 60-75 days		Spikelets m^2/day)	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Zero tillage followed by line sowing	0.078	0.078	5.56	5.58	284.88	320.70
Conventional tillage followed by line sowing	0.077	0.077	4.63	4.65	**283.50**	315.88
Conventional tillage followed by broadcasting	0.075	0.075	6.36	6.39	251.25	267.74
S.Em (+)	0.002	0.002	0.14	0.14	8.04	8.24
CD (P=0.05)	NS	NS	0.54	0.54	NS	32.34
Seed 75 kg/ha	0.077	0.077	5.86	5.86	**232.33**	252.07
Seed 100 kg/ha	0.077	0.077	5.74	5.77	279.00	**322.56**
Seed 125 kg/ha	0.077	0.077	5.48	5.51	**286.33**	**319.10**
Seed 150 kg/ha	0.076	0.076	4.99	5.01	295.17	**312.03**
S.Em (+)	0.002	0.002	0.11	0.11	6.1	6.23
CD (P=0.05)	NS	NS	0.32	0.32	18.17	18.51

TABLE 3. Effect of tillage systems and seed rate on yield components and grain yield and harvest index of wheat

Treatments	Filled grain/ spike weight(g)		Test weight 1000 grain (t/ha)ha)		Grain yield (%) (HI)		Starw yield (t/		Harvest Index	
	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22	2020-21	2021-22
Zero tillage followed by line sowing	38.98	37.37	35.77	37.21	3.75	4.36	9.19	10.54	28.99	29.27
Conventional tillage followed by line sowing	39.20	38.42	31.65	33.27	3.45	3.97	8.25	9.65	29.46	29.14
Conventional tillage followed by broadcasting	37.46	37.08	29.03	30.55	2.60	2.96	5.87	7.62	30.74	28.48
S.Em (+)	1.06	1.93	0.96	1.01	0.1	0.11	0.26	0.30	0.78	0.78
CD (P=0.05)	NS	NS	3.78	3.95	0.28	0.35	1.03	1.19	NS	NS
Seed 75 kg/ha	39.59	38.38	31.75	31.75	2.81	3.20	6.69	8.16	29.51	17.89
Seed 100 kg/ha	37.77	35.47	32.30	32.30	3.31	3.83	7.87	9.10	30.74	30.36
Seed 125 kg/ha	38.32	37.56	32.69	32.69	3.46	4.03	8.44	10.48	29.11	27.65
Seed 150 kg/ha	38.50	39.08	31.86	31.86	3.48	4.00	8.08	9.34	30.47	30.05
S.Em (+)	-	1.03	0.69	0.72	0.08	0.09	0.19	0.22	6.60	0.68
CD (P=0.05)	NS	NS	NS	NS	0.22	0.26	0.55	0.64	NS	NS

parameters like dry matter, LAI and number of tillers/ m^2. Increased biomass production at seed rate of 125kg/ ha could be attributed to the cumulative effect of growth parameters viz.tillers/ m^2, LAI which might have increased the photosynthetic area and thereby the quantum of dry matter production at maturity. Significantly lowest biomass yield under the lowest seed rate of 75kg/ha in pooled data was attributed to mainly lower plant population which in turn gave lower straw yield in wheat.

Tillage systems and seed rates exerted in significant effect on harvest index (HI). Higher harvest index was an indication of increasedphysiological capacity to metabolize the photosynthates towards economic yield. Use of moderate seed rate of 100kg/ hacaused proportionally greater increase in economic part than in non-economic part which might have resulted in higher harvest index. However, under this treatment, increase in biological yieldcorresponding to increasing economic yieldindicated hardly that the economic yield was proportional to harvest index (Donald and Hamblin, 1976).

Literature Cited

Azad, BS., Bhagat, BD., Bali, S.V., Kachroo, D. and Gupta, S.C. 1998. Response of late sown wheat (*Triticum aestivum*) to seed rate and fertilizers level. Indian journal of agronomy. 43(I): 633-655

Donald, C.M. and Hamblin, J., 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. *Advances in agronomy*, *28*, pp. 361-405.

Gupta, R. and Sayre, K., 2007. Conservation agriculture in south Asia. *Journal of Agricultural Science-Cambridge*, *145*(3), p.207.

Kumar, R. and Yadav, D.S., 2005. Effect of zero and minimum tillage in conjunction with nitrogen management in wheat (Triticum aestivum) after rice (Oryza sativa). *Indian journal of Agronomy*, *50*(1), pp. 54-57.

Parihar, S.S., 2004. Effect of crop-establishment method, tillage, irrigation and nitrogen on production potential of rice (Oryza sativa)-wheat (Triticum aestivum) cropping system. *Indian Journal of Agronomy*, *49*(1), pp.1-5.

Reddy, S.R. 2000. Principals of Agronomy: *Kalyani Publisher,* New Delhi.

Sharma, S.N., Bohra, J.S., Singh, P.K. and Srivastava, R.K., 2002. Effect of tillage and mechanization on production potential of rice (Oryza sativa)-wheat (Triticum aestivum) cropping system. *Indian Journal of Agronomy*, *47*(3), pp.305-310.

SNGH, G., SINGH, O., YADAVA, R. and SINGH, R., 1993. Response of wheat (Triticum aestivum) to planting method, seed rate and fertility in late-sown condition. *Indian Journal of Agronomy*, *38*(2) : 193-199

Yadav, D.S. & Shukla, R.P. & Sushant, & KUMAR, BIRENDRA. (2005). Effect of zero tillage and nitrogen level on wheat (*Triticum aestivum*) after rice (Oryza sativa). Indian Journal of Agronomy. 50. 52-53. 10.59797/ija.v50i1. 5060.

Watson, D.J., 1958. The dependence of net assimilation rate on leaf-area index. *Annals of Botany*, *22*(1), pp. 37-54.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 27-33, 2024

Estimation of Energy & Carbon Footprints of Alternate Agri-inputs Focusing Sustainable / Regenerative Farming Approach

R. Bera[a*], S. Saha[a], A. Datta[a], K. Mukhopadhyay[b], A. K. Barik[c], P. Bhattacharya[d], R. Mallick[e], M. Ganguli[f], V. L. Narasimhan[g] and E. Quah[g]

[a]*Inhana Organic Research Foundation, 168, Jodhpur Park, Kolkata – 700068, India.*
[b]*Nadia Krishi Vigyan Kendra, BCKV, ICAR, Nadia, West Bengal -741234, India.*
[c]*Department of Agronomy, Visva Bharati University, Sriniketan, Bolpur-731235, India.*
[d]*Agricultural and Ecological Research Unit, Indian Statistical Institute, Giridih- 815301, India*
[e]*Institute of Agricultural Science, Calcutta University, Kolkata- 700019, India.*
[f]*Ex-Energy Transition Commission, London, UK.*
[g]*i-NoCarbon Limited, 59 Harfield Road, Sunbury-on-Thames, UK.*
**Corresponding author email id : bera.ranjan@gmail.com*

Abstract

Development of energy and carbon footprint database of alternate agricultural inputs is an important criteria towards the measurement of energy and carbon footprint of any sustainable / regenerative farming approach. To develop an agriculture carbon calculation standard for Indian Ecosystem –" Agriculture Carbon Footprint Accessor (ACFA)'- a study has been initiated in 2020 towards the development of respective database maintaining the protocols of all major standards like GHG Protocol Agricultural Guidance; ISO 14044 : 2006 , ISO 14064 (1, 2 &3) : 2018 -2019 and PAS 2060:2014; following IPCC methodology. Carbon footprint of these inputs were evaluated based on both conventional and multi basket approaches and the developed database can be a useful resource for energy and carbon footprint assessment in Indian Agri-Eco-system in future.

Key words : Regenerative agriculture, alternate agricultural inputs, carbon footprint, energy footprint, multi basket approach, ACFA

Introduction

Greenhouse gas abatement, the utilisation of renewable energy sources, and energy efficiency represent the main pillars of Sustainable Agriculture (Al-Mansour and Jejcic, 2017). Agriculture is both a victim as well as a contributor to climate change. On one hand, agricultural activities contribute approximately 30 per cent of total greenhouse gas emissions (IAEA, 2024), mainly due to the use of chemical fertilizers, pesticides and animal wastes. On the other hand, these greenhouse gases include nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4), which all contribute to climate change and global warming and thereby have a profound impact on the sustainability of agricultural production systems. Agriculture covers approximately 35% of the land area and accounts for nearly 13.5% of the total global anthropogenic GHG emissions, contributing about 25%, 50%, and 70% of CO_2, CH_4, and N_2O, respectively (Al-Mansour and Jejcic, 2017).

Determination of energy and carbon footprint of inputs used to produce food is of great interest to evaluate the net carbon and energy footprint of the agriculture produce. Determination of the carbon footprint of agricultural products requires a detailed analysis of energy consumption in the various processes used for crop production. Total input energy in agricultural production is the sum of all the components of the energy used in the different processes for the production of outputs. Now there is a dearth of study which documented a structural methodology towards estimation of energy and carbon footprint of different agro-inputs specially different alternate agro-inputs used under sustainable/ regenerative agriculture. This paper describes the structure of the model calculation of the carbon and energy footprint of agricultural inputs and the establishment of a database for Indian Ecosystem in future.

Materials and method

Developing the database related to the inputs specially the alternate organic inputs have been initiated as early as 2020, when the concept of development of an agriculture carbon calculation standard for Indian Ecosystem – "Agriculture Carbon Footprint Accessor (ACFA)' has been conceptualized. For the proposed study we have reviewed number of cultivation practices in different agro-ecosystem and documented variety of agricultural inputs used for cultivation specially sustainable/ regenerative cultivation practices

To evaluate the energy and carbon footprint of different alternate agro-inputs are important to access the impact of any sustainable / regenerative farming practice. As per standard protocol, literature review from standard pear reviewed articles or established energy & carbon footprint database specially in the same ecosystem/ country is the primary steps to findout the database. However absence of any suitable database, calculation of energy & carbon footprint have to be done in a systemic way. To evaluate that, careful development of a system boundary from cradle to grave is the most important work for every individual inputs. However, establishing appropriate and consistent system boundary and calculation processes for the calculation of carbon emissions remains challenging especially at the regional level (Liu et al, 2015) due to non-centralized or lacking statistics and discrepancies among economic development levels can lead to uncertainty with regard to carbon emissions (Sovacool and Brown, 2010).

Thus to develop a robust calculation methodology, standards like GHG Protocol Agricultural Guidance (WRI/WBCSD 2004, ; ISO 14044 : 2006 , ISO 14064 (1, 2 & 3) : 2018 -2019 and PAS 2060:2014; Carbon Footprint Measurement Methodology (Carbon Trust, 2007) and methodology from IPCC guideline (2006 & 2019) were taken as reference. The basic formula for calculation of energy & carbon footprints was as follows

For sourcing of materials we have categorized the sourced area as local, zonal and regional level and assumed 100km, 500 km and 1000 km as average distance for respective area specially when specific area is not well defined.

Concept of conventional and muti-basket carbon footprint calculation

A two-basket approach (multi – basket) for interim milestones—as opposed to a one-basket (conventional) interim milestone—is critical because reducing short- and long-lived GHGs benefit the climate over different timescales, and there is a possibility of missing out better outcomes in both the near- and long-term, if the gases are combined into one target (Jackson, 2009; Smith et al, 2012).In the latest IPCC report (2021), it has been clearly mentioned that, IPCC does not recommend an emissions metric because the appropriateness of the choice depends on the purposes for which gases or forcing agents are being compared (Bera *et al*, 2023). Most importantly, this multi basket approach for carbon computing as also proposed in Montreal Protocol for Climate Policy would encourage leapfrogging of technologies (UNEP, 2016) in agriculture towards encouraging Regenerative farming initiatives for long term sustainability. Conventional Reporting with $GWP_{100\ years}$ value of CO_2 (GWP : 1), N_2O (GWP: 273) and CH_4 (GWP= 27.2 for non fossil source and 29.8 for fossil source) as per AR6 of IPCC (2021). Where as under multi basket approach : $GWP_{100\ years}$ value for long-lived Green House gases (CO_2 : 1 ; N_2O : 273) and GWP_{24} years for short-lived greenhouse gas viz. CH_4 : 75.0) (as per AR6 of IPCC, 2021; Abernethy and Jackson, 2022)

Results and discussion

Alternate Inputs were classified into two major groups, one Alternate Soil Management and another Alternate Plant/Pest Management. Under Alternate Soil Management different type of compost, cowdung, oil cake, mulching materials were considered. Value of biochar has been taken from IPCC (2019). In some cases where energy footprint of a particular component is difficult to evaluate with risk of higher unforced error, we used conversion factor from GHG to Energy

$$\textbf{Energy Footprint of Input (MJ/kg)} = \sum_{i=1}^{n} F_{V1} \times EU_{F1} + F_{V2} \times EU_{F2} + \text{-----} + F_{Vn} \times EU_{Fn} + \sum_{i=1}^{n} EI_{V1} \times EU_{EI1} + EI_{V2} \times EU_{EI2} + \text{-----} + EI_{Vn} \times EU_{EIn} + \sum_{i=1}^{n} M_{V1} \times EU_{M1} + M_{V2} \times EU_{M2} + \text{----} + M_{Vn} \times EU_{Mn} \quad \text{----} \ \textbf{(i)}$$

Where,

F_v= Energy or fuel use like diesel, petrol, coal, electricity etc

EU_F = Energy unit of respective Energy or Fuel components

EI_v = Embodied energy of components used like machinery, vehicles, instruments used

EU_{EI} = Energy unit of respective components

M_v = Man /Animal energy used

EU_M = Energy unit of respective components

$$\textbf{Carbon Footprint of Input (KgCO}_2\textbf{e/kg)} = \sum_{i=1}^{n} F_{V1} \times CF_{F1} + F_{V2} \times CF_{F2} + \text{-----} + F_{Vn} \times CF_{Fn} + \sum_{i=1}^{n} EI_{V1} \times CF_{EI1} + EI_{V2} \times CF_{EI2} + \text{-----} + EI_{Vn} \times CF_{EIn} + \sum_{i=1}^{n} AI_{V1} \times EF_{AI1} + AI_{V2} \times EF_{AI2} + \text{----} + AI_{Vn} \times EF_{AIn} \quad \text{---} \ \textbf{(ii)}$$

Where,

F_v= Energy or fuel use like diesel, petrol, coal, electricity etc

EU_F = Carbon footprint of respective Energy or Fuel components

EI_v = Embodied GHG of components used like machinery, vehicles, instruments used

EU_{EI} = Carbon footprint of respective components

AI_v = Alternate inputs

EF_S = Emission factor of respective components

Table 1. Alternate Soil Management

Sl No	Alternate Soil Management	Conventional GHG (Kg CO_2e/ kg)	Multi-basket GHG (Kg CO_2e/kg)	Energy (MJ/ kg)
1.	Cow Dung (old) (kg)	-0.07931	-0.07931	3.2794
2.	Cow Dung (fresh) (kg)	-0.01725	-0.01725	1.064
3.	Mustard cake (kg)	-0.09117	-0.09117	18.92
4	Castor cake (kg)	-0.1224	-0.1224	20.25
5	Elemental Sulphur (kg)	0.27	0.27	5
6	Lime (kg)	0.59	0.59	0.53
7	Guatemala grass Mulch (kg)	-0.1105	-0.1105	0.25
8	Green biomass Mulch (kg)	-0.0521	-0.0521	0.25
9	Water Hyacinth Mulch (kg)	-0.0691	-0.0691	0.25
10	Biochar (wood) (kg)	-2.259	-2.259	8.55
11	Biochar (grass, twigs, etc.) (kg)	-1.907	-1.907	8.55
12	Biochar (animal manure) (kg)	-1.115	-1.115	8.55

Table 2 : Organic and organic concoction based alternate plant/pest management inputs

Sl No	Alternate Plant/ Pest Management	Conventional GHG(Kg CO_2e/ kg)	Multi-busket GHG(Kg CO_2e/kg)	Energy (MJ/ kg)
1.	Amritpani (Ltr.)	0.004	0.007	1.0
2.	Cow dung slurry (CDS) / Sanjivak (Ltr.)	0.055	0.055	0.92
3.	Cow Urine (Ltrs)	0.1995	0.1995	0.16
4.	Cowpat pit (kg)	0.036	0.036	0.6
5.	Inhana Cow dung slurry (Ltr.)	0.062	0.062	1.0
6.	Inhana Plant Management Solutions (Ltrs)	0.118	0.118	2
7.	ITK concoctions (Ltr.)	0.08	0.087	1.5
8.	Jivamrit (Ltr.)	0.038	0.038	0.6
9.	P5 concoction (Ltr.)	0.303	0.67	5.1
10.	Panchgavya (kg)	0.47	1.24	3.6
11.	Vermi wash (Ltr.)	0.0014	0.0014	0.2

as stated by Wells, 2001. Estimation of GHG emission post soil application was done as per the methodology of IPCC (2006 & 2019).

Alternate inputs for Plant/pest management was further subdivided in to 3 major groups viz (i) Organic inputs and organic concoctions, (ii) Oil and sulphur based inputs and (iii) Growth promoters and bio-fertilizers. We have reviewed no of published literature

Table 3 : Oil and sulphur based alternate plant/pest management inputs

Sl No	Alternate Plant/ Pest Management	Conventional GHG (Kg CO_2e/ kg)	Multi-basket GHG (Kg CO_2e/kg)	Energy (MJ/ kg)
1.	Azadirachtin 0.15 EC (Ltr.)	0.265	0.265	4.4
2.	Azadirachtin 1 EC (Ltr.)	0.521	0.521	8.7
3.	Azadirachtin 5 EC (Ltr.)	1.727	1.727	28.8
4.	Karanj Oil (Crude) (Ltr.)	0.3427	0.3427	5.7
5.	Lime sulphur (Ltr.)	0.145	0.145	2.4
6.	Micronized sulphur (Ltr.)	0.41	0.41	6.9
7.	Neem Oil (Crude) (Ltr.)	0.3247	0.3247	5.4
8.	Neem & Karanj Combination (Ltr)	0.302	0.302	5
9.	Sesame oil (Ltr)	2.6	2.6	43.3
10.	Sulphur 40 % WP (Ltr.)	0.12	0.12	2
11.	Sulphur 52 % SC (Ltr.)	0.16	0.16	2.6
12.	Sulphur 80 % WP (Ltr.)	0.24	0.24	4
13.	Petroleum based horticulture oil (Ltr)	5.64	5.64	43.2

Table 4 : Growth promoters and bio-fertilizers based alternate plant/pest management inputs

Sl No	Alternate Plant/Pest Management	Conventional GHG(Kg CO_2e/ kg)	Multi-basket GHG(Kg CO_2e/kg)	Energy (MJ/ kg)
1.	Biofertilizer (Ltr.)	5.1	5.1	2.98
2.	Biofungicide (Ltr.)	3.9	3.9	10.1
3.	Biopesticide (Ltr.)	5.1	5.1	21.6
4.	Copper sulphate	3.9	3.9	65
5.	Growth Promoter	0.047	0.047	0.78
6.	Plant growth-promoting rhizobacteria (PGPR)	0.047	0.047	0.78
7.	Adjuvant /spreader/ surfactant	0.6	0.6	10

viz Singh and Mittal 1992; Ram and Verma, 2017; Wells 2001; Mihov et al, 2012; Yadav et al, 2015 for peer-reviewed carbon / energy footprint values of specific inputs. Here also in some cases, where energy/carbon footprint estimation was difficult, we used the conversion factor from GHG to Energy as stated by Wells, 2001.

Conclusion

Development of Carbon and Energy footprint of alternate agro-inputs is crucial for measuring the carbon and energy footprint of any sustainable/ regenerative agricultural practice. As system boundaries of these inputs in most cases are difficult to draw, chances of unforced error will be high and values may vary from region to region based on the availability of resources. Thus the development of standard methodology based on the referenced protocol is a dire need and the present study aims to fulfill the objectives and the database developed in the present study can be useful for energy and carbon audit of any sustainable/ regenerative farming practice.

Literature Cited

Abernethy S and Jackson RB (2022). Global temperature goals should determine the time horizons for greenhouse gas emission metrics, Environ. Res. Lett. 17: 024019.

Al-Mansour F. and Jejcic V. (2017). A model calculation of the carbon footprint of agricultural products: The case of Slovenia, Energy, 136 : 7-15, ISSN 0360-5442,

Bera R., Datta A., Bose S., Barik A. K. , Mallick R. , Ganguli M., Narasimhan V. L. , Quah E. , Mukherjee K., Bhattacharya P. and Seal A. (2023). Technological Breakthrough for Large Scale Bioconversion of Coir Pith towards Sustainable Soil Health Management and Development of Source Point Methane Abatement Model, International Journal of Environment and Climate Change, 13(7):75-102.

Carbon Trust (2007) Carbon Footprint Measurement Methodology, Version 1.3. The Carbon Trust, London, UK. Available at https:// semspub.epa.gov/work/09/1142519.pdf

Hoekstra, A.Y. (2008) Water neutral: reducing and offsetting the impacts of water footprints, Value of Water Research Report Series No. 28, UNESCO-IHE, Delft, the Netherlands.

IAEA (2020). Green House gas reduction, International Atomic Energy Agency, Available at https:/ /www.iaea.org/topics/greenhouse-gas-reduction.

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IPCC (2019). IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

ISO (2018). ISO 14064-1: Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals, Available at https://carbon.land leaf-tech.com/wp-content/uploads/2022/04/ ISO14064-1-2018.pdf

Jackson, S. C. Parallel pursuit of near-term and long-term climate mitigation. Science 326, 526–527 (2009).

Mihov M. , Antonova G., Masheva S. and Yankova V. (2012). energy assessment of conventional and organic production of head cabbage, Bulgarian Journal of Agricultural Science, 18 (No 3) 2012, 320-324

Ram RA and Verma AK (2017). Yield, energy and economic analysis of organic guava (Psidium guajava) production under various organic farming treatments, *Indian Journal of Agricultural Sciences* **87** (12): 1645–9.

Singh S and Mittal JP.(1992). Energy in production agriculture. New Delhi: Mittal Pub.;Page 166

Smith, S. M. et al. Equivalence of greenhouse-gas emissions for peak temperature limits. Nat. Clim. Change 2, 535–538 (2012).

Sovacool, B.K., Brown, M.A., 2010. Twelve metropolitan carbon footprints: a preliminary comparative global assessment. Energy Policy 38, 4856–4869.

UNEP (2016). Report of the Twenty-Eighth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, Available at https://ozone.unep.org/sites/ default/files/2019-08/MOP-28-12E.pdf

Wells (2001). Total Energy Indicators of Agricultural Sustainability: Dairy Farming Case Study, Technical Paper 2001/3, ISBN: 0-478-07968-0

WRI/WBCSD (2004) The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard Revised Edition. World Business Council for Sustainable Development and World Resource Institute, Geneva

Yadav A, Singh O, and Kumar N (2015). Evaluation of Energy Ratios for Karanja and Neem Biodiesel Life Cycles, S-JPSET, 1(1):55-59

Zhu Liu, Kuishuang Feng, Klaus Hubacek, Sai Liang, Laura Diaz Anadon, Chao Zhang, Dabo Guan (2015). Four system boundaries for carbon accounts, Ecological Modelling, 318: 118-125.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 35-44, 2024

Farmers Producer Organizations in Western India: Status, Constraints and Implications

S.K. Roy*, Rajesh T and Tushar Athare

ICAR-Agricultural Technology Application Research Institute, Pune, Zone-VIII
**Corresponding author email id : skr12kolkata@gmail.com*

Abstract

After the co-operatives movements in Indian agriculture, Government of India formulated another Central Sector Scheme "Formation and Promotion of Farmer Producer Organizations" to strengthen the bargaining power of small holders and to enable them to capture the positive effects of economies of scale. The Scheme was launched by Department of Agriculture, Cooperation & Farmers' Welfare, Government of India for formation and promotion of 10,000 FPOs over a period of 5 years. In the present study, an attempt has been made to study the status, area of operation, employment generation, feedback and way forward from selected FPOs in Maharashtra and Gujarat that are under technical guidance of KVKs. A total of 364 FPOs from Maharashtra and Gujarat were selected purposively as these FPOs operated and supervised by KVKs. Among them, 298 FPOs are from Maharashtra and 66 FPOs from Gujarat state. A total of 46 districts were covered by these 364 FPOs. Well-structured questionnaire was developed for the collection of primary data. The data on status, employment, area of operation and constraints were collected in a prescribed questionnaire. Results indicated that 257 and 56 FPOs formed during 2011-2023 in Maharashtra and Gujarat, respectively. In Maharashtra,majority of FPOs (41.95 %) has less than 100 shareholders whereas 40.60 per cent FPOs had in the range of 101-500 shareholders. In Maharashtra and Gujarat, 289 FPOs (96.98%) and 66 FPOs (100 %) have provided employment to less than 50 youths each, respectively. Analysis on area of operation revealed that FPOs in Maharashtra have focused more towards value addition and post-harvest management aspects, whereas FPOs in Gujarat have focused majorly on marketing and horticulture aspects. During initial stage, unavailability of funds, lack of proper knowledge, unavailability of proper training institute and low farmers participation were the major constraints faced by FPOs.

Key Words : Farmers Producer Organizations, KVK, Employment, Area of Operation, Constraints

Introduction

Indian agriculture has made a significant progress over last several decades, mainly due to improvement in technologies (seeds, fertilizer, plant protection chemicals, etc.), practices (line sowing, mono-cropping, mechanization, etc.) and policy environment (price support, input subsidy, market infrastructure, credit, etc.). Consequently, the total production of food grains has increased by 5.6 times, fruits by 16 times, vegetables by 11 times, oilseeds by 6 times, milk by 10 times and so on in last 70 years. During the same period, the number of farm households has also increased significantly, leading to fragmentation of land holdings and declining size of average land holding. Currently, more than 85 per cent of the farmers are smallholders cultivating on an average about 1.01 hectare of land. They own only 47% of total cultivated area.Small holders do not have enough bargaining power to negotiate in input or output market in their favour. Small landholdings also increase the transaction costs for the producers as well as for the bulk buyers, like processors, retailers, traders, etc. (Kumar *et. al.,* 2022).

Earlier, farmers were brought together in co-operatives to counter some of the above challenges due to aggregation/ collectivization of inputs. These co-operatives mainly focussed on providing easy credit and/or inputs like fertilizers and seeds to the farmer-members. Moreover, over the years due to in-built governance structure, these cooperatives provided

[1] *Director, ICAR- Agricultural Technology Application Research Institute, Pune, Zone-VIII*
[2&3] *Scientist, ICAR-Agricultural Technology Application Research Institute, Pune, Zone-VIII*

significantly more management control and power to local influential persons without contributing to the business of the co-operatives. Over time, they used their influence for self-serving interests, leading to in general disenchantment among the farmer-members. Consequently, except for dairy sector cooperatives and to some extent in sugar sector which became highly successful at grass root level, by-and-large cooperatives in agriculture sector have failed(Chauhan *et al.*, 2021).At this situation, the concept of Farmer Producer Organization (FPO) came into picture. The role of FPO is to act as an aggregator for member farmers which will enhance the economy of scale and bargaining power of member farmers.With this background, Government of India formulated a Central Sector Scheme (CSS) viz., "Formation and Promotion of Farmer Producer Organizations (FPOs)". The Scheme has been launched by Department of Agriculture, Cooperation & Farmers' Welfare (DAC&FW), Ministry of Agriculture & Farmers Welfare (MoA& FW), Government of India for formation and promotion of 10,000 FPOs over a period of 5 years. In the present study, an attempt has been made to study the status, area of operation, feedback and way forward from selected FPOs in Maharashtra and Gujarat that are under technical guidance of KVKs.

Methodology

A total of 364 FPOs from Maharashtra and Gujarat were selected purposively as these FPOs operated and supervised by KVKs. Among them, 298 and 66 FPOs are from Maharashtra and Gujarat states, respectively. A total of 46 districts were covered by these 364 FPOs. Well-structured questionnaire was developed for the collection of primary data. The data on status, area of operation and constraints were collected in a prescribed questionnaire. Using descriptive statistics, including tabular and percentage analysis was done to draw meaningful and logical inferences from the study.

Results and Discussion

FPOs registered by different agencies

In Maharashtra and Gujarat, number of FPOs were registered by different agencies such as Small Farmers' Agri-Business Consortium (SFAC), NABARD andother Implementing Agencies (IAs) under CSS for formation & promotion of 10,000 FPOs. In Maharashtra, 569 FPOs were registered out of which 291 (51 per cent) FPOs under NABARD, 173 (30 per cent) registered by Implementing Agencies under CSS for formation & Promotion of 10,000 FPOs and 105 (18 per cent) by Small Farmers' Agri-Business Consortium (SFAC). In Gujarat out of 355 FPOs,Small Farmers' Agri-Business Consortium (SFAC) registered 25 FPOs (7 per cent), 190 by NABARD (54 per cent) and 140 by IAs under CSS for formation & Promotion of 10,000 FPOs (39 per cent) (Figure 1).

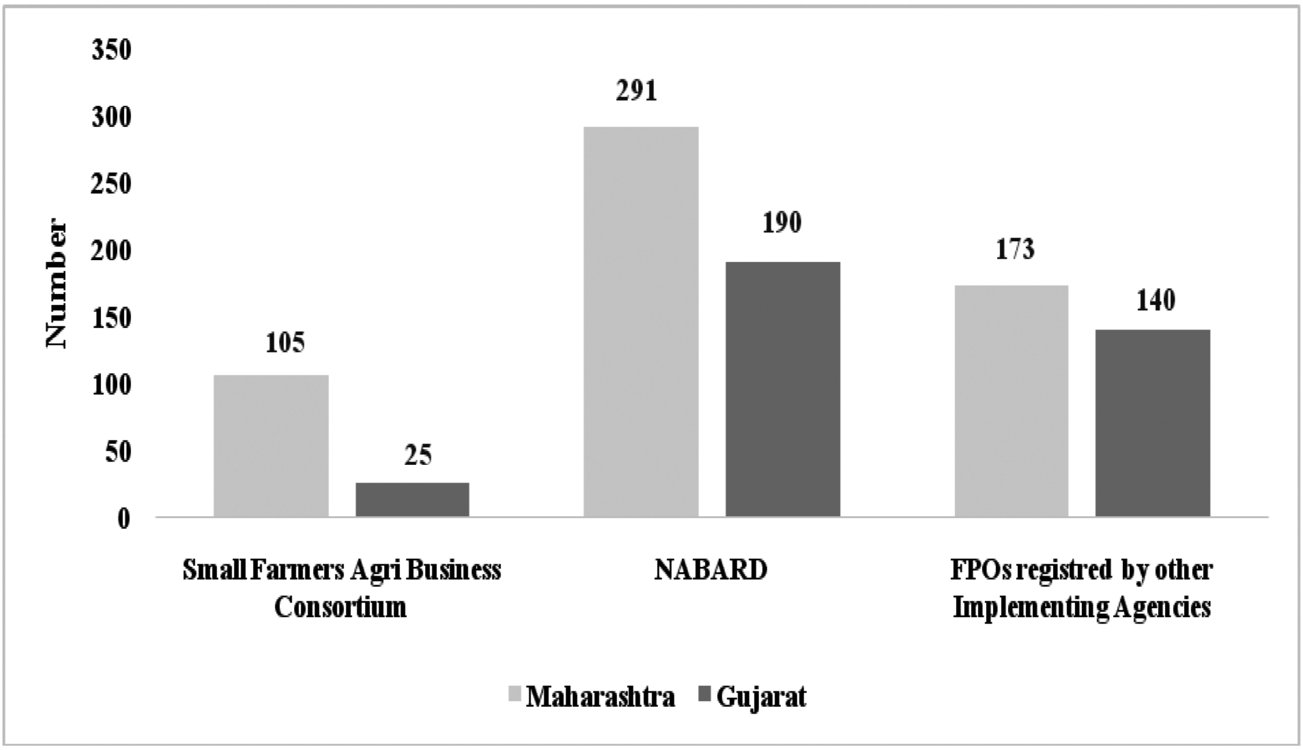
Aggregation of small, marginal and landless farmers into FPOs will help enhance economic strength & market linkages of farmers for enhancing their income. Keeping this in mind, Government of India has launched a "Formation and Promotion of 10,000 Farmer Produce Organizations (FPOs)" with a clear strategy and committed resources to form and promote 10,000 new FPOs in the country(PIB, Govt. of India, Ministry of Agriculture & Farmers Welfare).

Table 1 shows the Promotion and Development of FPOs under CSS for formation & Promotion of 10,000 FPOs. Data revealed that, 5029 FPOs were registered with2029000 shareholder members. 1363FPOs credit linked, whereas 2917 FPOs were market linked. Also 110 Producers' Organization Promoting Institutes,110 number of Cluster Based Business Organizations and 22Resource Support Agency are involved. 4290 FPOs and 1867252 members were digitised under this program.

FPOs registered under CSS for Formation & Promotion of 10,000 FPOs by SFAC in Western India

SFAC is implementing the central schemes of Government of India for economic inclusion of small and marginal farmers in agribusiness activities. It provides a platform for increased accessibility and cheaper availability of agricultural inputs to small and marginal farmers and in establishing forward and backward linkages in supply chain management. This

Fig. 1 Number of FPOs registered by respective agencies



Source : sfacindia.com

Status of FPOs registered under the program 'Promotion and Development of FPOs under CSS for formation & Promotion of 10,000 FPOs' in India

initiative has triggered mobilization of farmers for aggregation across the country with ultimate aim of sustainable business model and augmented incomes(http://sfacindia.com).

FPOs registered under CSS for Formation & Promotion of 10,000 FPOs by SFAC in Western India is shown in Table 2. Maharashtra targeted 222 FPOs, out of which 82 FPOs were registered and 41 under process of registration. In Gujarat, 123 FPOs targeted, out of which 159 FPOs were registered and 63 FPOs under the process of registration.

State of art of FPOs guided by KVKs in Western India

Supportto FPOs by KVKs over time in Western India

The state of art of FPOs guided by KVKs across the Western India presented in Table 3. Data indicated that 257 and 56 FPOs formed during 2011-2023 in Maharashtra and Gujarat, respectively. In Maharashtra, 75 FPOs were formed during 2011–2015 (29.18 per cent), 110 FPOs during 2016-2020 (42.80 per cent) and 72 FPOs during 2021-2023 (28.02 per cent). In Gujarat, 5 FPOs were formed during 2011–2015 (8.93 per cent), 11 FPOs during 2016-2020 (19.64 per cent) and 40 during 2021-2023 (71.43per cent).

Distribution of FPOs based on their shareholders

Distribution of FPOs based on their shareholders is presented in Table 4.In Maharashtra, data regarding shareholders indicated that majority of FPOs (41.95 %) hasin range of less than 100 shareholders followed by 40.60 per cent FPOs had in the range of 101-500 shareholders and 16.11 per cent FPOs has more than 501-1000 shareholders. However, lowest shareholders (1.34 per cent) FPO has in the

Table 1. Promotion and Development of FPOs under CSS for formation & Promotion of 10,000 FPOs' in India

Particulars	Numbers
No. of FPOs registered	5029
No. of total Shareholder Members	2029000
No. of FPOs credit Linked	1363
No. of FPOs market linked	2917
No. of Producers' Organization Promoting Institute (POPIs)	1350
No. of Cluster Based Business Organisations (CBBOs)	110
No. of Resource Support Agencies (RSA)	22
No. of FPOs digitised	4290
No. of members digitised	1867252

Source:www.nabard.org

Table 2. FPOs registered under CSS for Formation & Promotion of 10,000 FPOs by SFAC in Western India

State Name	Targeted FPO	Registered FPO	Under Process of Registration
Gujarat	123	82	41
Maharashtra	222	159	63
Total	**345**	**241**	**104**

Source: sfacindia.com

Table 3. State of art of FPOs guided by KVKs in Western India

Year	Number of FPOs	Percentage
	Maharashtra	
2011-2015	75	29.18
2016-2020	110	42.80
2021-2023	72	28.02
Total	**257**	**100**
	Gujarat	
2011-2015	5	8.93
2016-2020	11	19.64
2021-2023	40	71.43
Total	**56**	**100**

Source:Author's compilation based on primary survey by KVKs

TABLE 4. Distribution of FPOs based on their shareholders

Number of members	Number of FPOs	Distribution of FPOs %
Maharashtra		
1-100	125	41.95
101-500	121	40.60
501-1000	48	16.11
More than 1000	4	1.34
Total	**298**	**100**
Gujarat		
1-100	11	16.92
101-500	39	58.46
501-1000	8	12.31
More than 1000	8	12.31
Total	**66**	**100.00**

Source: Author's compilation based on primary survey by KVKs

range of more than 1000 shareholders. In Gujarat, Data regarding shareholders indicated that majority of FPOs (58.46 %) hasin range of 101-500 shareholders followed by 16.92 per cent FPOs has in the range of 1-100 shareholders and 12.31 per cent FPOs has more than 501 and above 1000 shareholders.

Distribution of FPOs based on employment generation

Distribution of FPOs based on employment generation is presented in Table 5. In Maharashtra,data regarding distribution of FPOs based on employment generationindicated that, 289 FPOs (96.98%) hasprovided employment to less than 50 youths and 5 FPOs (1.68 %) hasprovided employment to range of 51-100 and 2 FPOs has provided employment to more than 500 youths. In Gujarat, data indicated that 66 FPOs (100%) hasprovided employment to the youth in range of less than 50.

Area of Operation of FPOs in Western India

Maharashtra

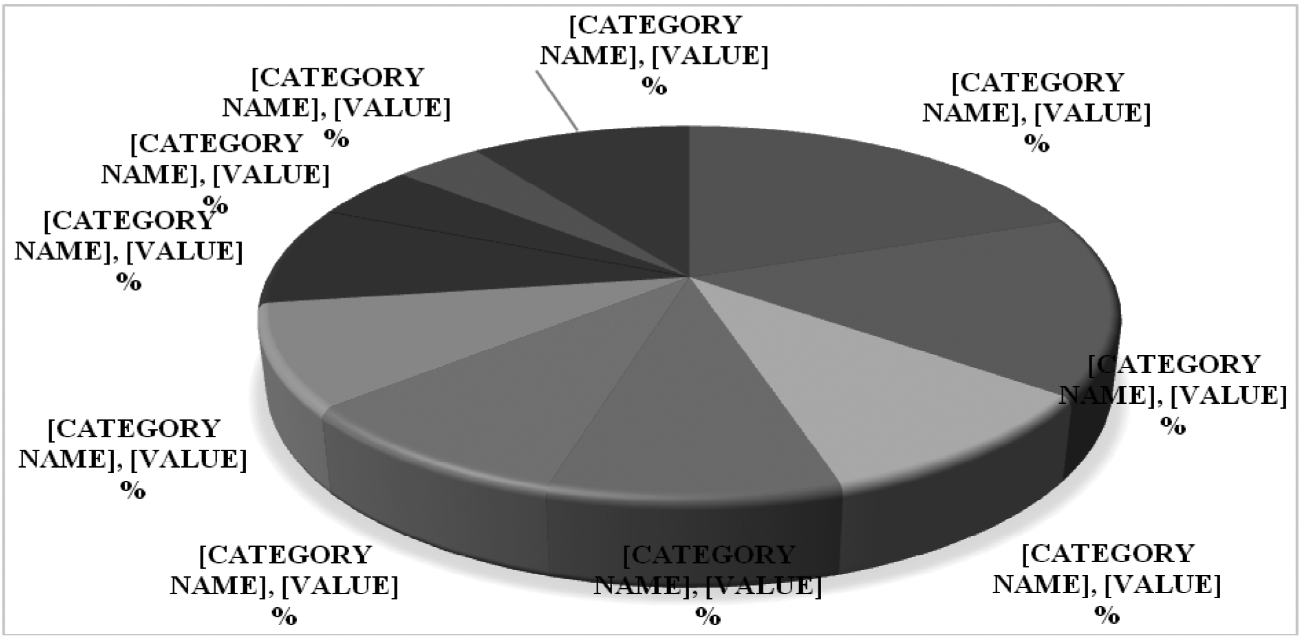
KVKs in Maharashtra are providing support to 298 FPOs from different districts and Blocks. These FPOs produce different types of output and work on different aspects of agriculture. Majority of the FPOs (19.80 %) is working on value addition aspect whereas 15.77 percent FPOs are working on Post-Harvest Management aspect in Maharashtra and both of these aspects has a huge market at national as well as international level. 10. 07 percent FPOs deals with seed production and seed processing as it also has a vast market in Maharashtra. 9.4 percent FPOs are engaged in production of horticulture commodities; and input distribution and agro input centre each, whereas 9.06 percent FPOs are engaged as procurement centres for the benefit of farming community. 8.72 percent FPOs are engaged in marketing of

Table 5. Distribution of FPOs based on employment generation

Employment Provided to Youth	Number of FPOs	Distribution of FPOs %
	Maharashtra	
Less than 50	289	96.98
51-100	2	0.67
101-500	5	1.68
More than 500	2	0.67
Total	**298**	**100.00**
	Gujarat	
Less than 50	66	100.00
Total	66	100.00

Source: Author's compilation based on primary survey by KVKs

Fig. 2 Distribution of FPOs based on Area of Operation in Maharashtra



Source: Author's compilation based on primary survey by KVKs

agriculture products like Onion and Grapes. 4.07 percent FPOs deals with production of agricultural commodities including organic farming. FPOs (4.03 %) also deals with compost, fertilizers likevermi-compost and pesticides that are both chemical and organic origin. 10.07 percent FPOs are engaged in other areas like oilseeds (cotton, soybean, groundnut), agronomical crops (millets, rice, moong), livestock (poultry, goatery and fishery), agriculture commodity, feed unit, service centre, forestry and custom hiring centre (Table 5 and Figure 2).

Gujarat

66 FPOs have been formed and promoted by KVKs of Gujarat. Out of 66, majority (39.39 %) of the FPOs are engaged in marketing of agricultural commodities like cumin, chickpea, cotton, castor, fresh & processed organic products. 19.70 percent FPOs is working in horticultural aspects (Datepalm, potato, cumin and vegetables). 18.18 percent FPOs works as procurement centre. 16.67 percent FPOs are engaged in seed production and processing of seeds. 15.15 percent FPOs are producing oilseeds and also involved in production of agricultural commodities. 10.61 percent FPOs are dealing with agronomical crops like Cotton, Castor, Cumin, Wheat, Jowar, Bajra&Moong. Value addition of agricultural commodities (Cumin, Banana, Cotton); and Input distribution is being done by 9.09 percent FPOs each. Some of the FPOs also carry out other activities like Agriculture commodity, Compost/ fertilizers/pesticides, Livestock, Feed Unit, Forestry, Post-Harvest Management, Service center, Custom Hiring Center and such FPOs share a portion of 15.15 % in the overall total (Table 6 and Figure 3).

Constraints/ Challenges faced by FPOs

It has been observed that the FPOs perform better when its management systems, governance and capital structure are strong. Other factors like market and financial accessibility, farmer-members' engagement plan, infrastructure development, better than existing market pricing mechanism, etc. should also be strengthened to scale up the business of the FPOs for its long term growth and viability.

The constraints experienced by the members of the FPO were related to personal, infrastructural, operational, economic and marketing aspects. At initial phase, it is observed that unavailability of funds is major problem faced by FPOs (53 per cent) followed by lack of proper knowledge (16 per cent), unavailability of proper training institute (14 per cent) and low farmers participation (7 per cent). At post-establishment phase, issues related to funds availability (49 per cent), marketing and branding (23 per cent), unavailability of certified or trained CEOs (11) and unavailability of godown (6 per cent) were the major constraints as opined by FPOs in Western parts of India i.e.

Table 5. Status of FPOs based on Area of Operation in Maharashtra

Area of Operation	Number of FPOs
Value Addition	59
Post-Harvest Management	47
Seed Production/processing	30
Horticulture	28
Input distribution/ agro-input centre	28
Procurement centre	27
Marketing	26
Production	14
Compost/ fertilizers/pesticides	12
Others *	30
Total	**298**

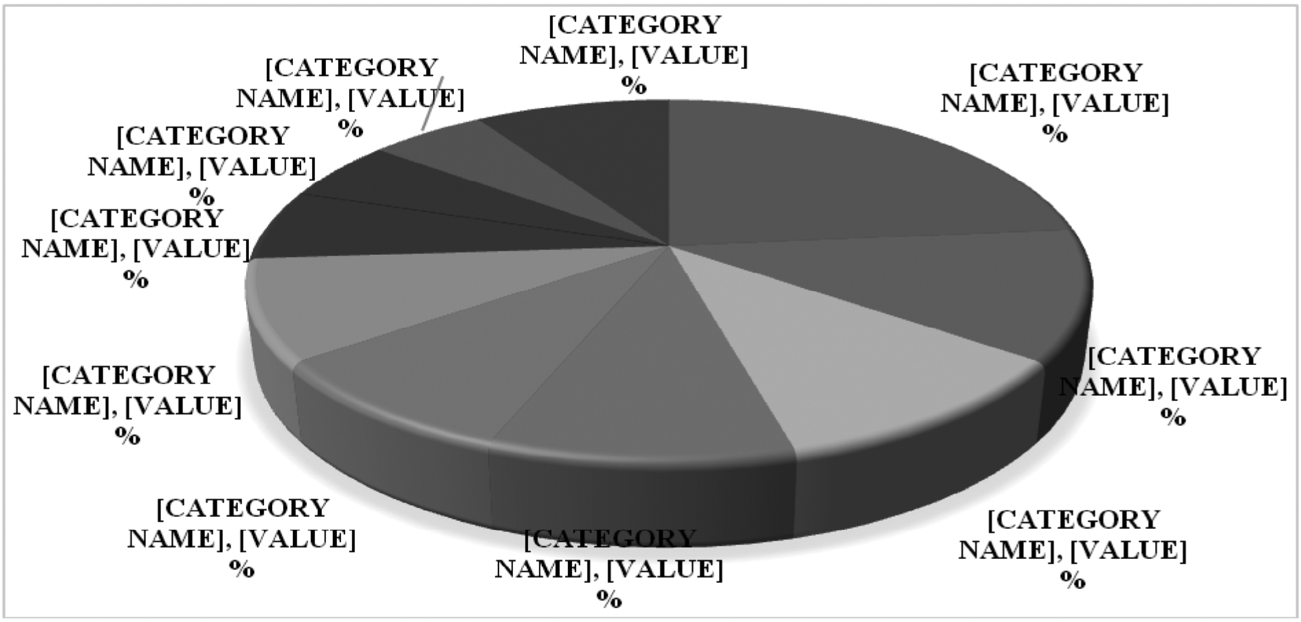
Source: Author's compilation based on primary survey by KVKs
Others *: Oilseeds, Agronomical crops, Livestock, Agriculture commodity, Feed Unit, Service centre, Forestry, Custom Hiring Centre.

Table 6. Status of FPOs based on Area of Operation in Gujarat

Area of Operation	Number of FPOs
Marketing	26
Horticulture	13
Procurement center	12
Seed Production/processing	11
Oilseed	10
Production of agricultural commodities	10
Agronomical crops	7
Value Addition	6
Input distribution/ agro-input center	6
Others *	10
Total	**66**

Source: Author's compilation based on primary survey by KVKs
Others *: Agriculture commodity, Compost/ fertilizers/pesticides, Livestock, Feed Unit, Forestry, Post-Harvest Management, Service Center, Custom Hiring Center.

Fig. 3 Distribution of FPOs based on Area of Operation in Gujarat



Source : Author's compilation based on primary survey

Maharashtra and Gujarat (Table 7). This result agrees with the study, which indicated that undeveloped storage facilities is that most of the FPO's are formed recently and it is very challenging for any new organization to build all the infrastructure so quickly (Bishnoiand Kumari, 2020).

from any promoting organisations like NABARD, SFAC, NCDC, etc. As a result, all registered FPOs must be provided with a minimum seed fund as a one-time grant with previously established requirements, such as the number of farmer-members, board diversity, a business plan for the following three years, etc.

Table 7. Constraints/ Challenges faced by FPOs in Western India

	Constraints/Challenges			
Sr. No	**Initial Stage**	**Percentage**	**Post –Establishment Stage**	**Percentage**
1	Funds	53	Marketing and branding	23
2	Low active participation	7	Funds	49
3	Lack of proper knowledge	16	Unavailability of certified or trained CEOs	11
4	Unavailability of proper training institute	14	Godown	6
5	Others	10	Others	11

Source: Author's compilation based on primary survey by KVKs

Way Forward

According to the study of the Doubling Farmers Income (DFI) Committee, the FPO is one of the most crucial tools for addressing a variety of farmer difficulties and concerns about the expansion of agriculture. As a result, the Government of India has also introduced a number of supporting programmes to aid in the growth and promotion of these farmers' organisations under various legal frameworks (Kumar *et. al*., 2022). The following strategies may be taken into consideration for scaling up and scaling out of FPOs:

- **Setting up of National Board of FPO (NBFPO):** On the model of MSME (Micro, Small and Medium Enterprises) and other commodity boards, a national board for the promotion of FPOs is required. This board will be able to track the growth of all FPOs and offer the same level of support to them all, regardless of the promoting agency.
- **Minimum assured seed funding support as grant:** Due to their remote locations or for other reasons, many FPOs do not receive help
- **Special provision for working capital finance for FPO:** At first, all FPOs need working cash to run their operations for their members, whether it is buying supplies in bulk or buying products from them to create market connections. Due to their initial lack of cash, these FPOs have a very difficult time obtaining institutional credit at an affordable rate to cover operating costs. However, they require initial support for the development of managerial competence as well as simple access to operating capital in order to realise that objective.
- Strengthening the FPOs with adequate knowledge, infrastructure, technical backstopping of agriculture and agri-preneurship should be accommodated
- Appropriate capacity building method should be adopted to make FPO members and office bearers capable of making appropriate and timely decisions

- Appropriate linkage with the financial institutions and FPO should be strengthened to promote agri-enterprises establishment at a large scale.
- Adequate skill embedded knowledge related to processing, value addition, storage of agricultural products and application of Information Communication Technology in marketing of produce should be provided.
- Adequate market intelligence, market infrastructure and supply chain should be promoted for getting optimum
- Policy should be developed to establish the FPOs as the grass root organisation of extension delivery mechanism for scaling out the agricultural and agri entrepreneurial knowledge to the common farmers.

Literature Cited

Bishnoi, R.K. and Kumari, S. (2020) Challenges faced by FPOs & strategies to overcome: a review, *International Journal of Advances in Agricultural Science and Technology*, Vol. **7** Issue. **6**, June-2020, pp. 25-33

Chauhan, J. K., Adhikary, A. and Pradhan, K. (2021) Identification of Constraints Associated with Farmers' Producer Organisations (FPOs), *International Journal of Current Microbiology and Applied Sciences,* **10 (01)**: 1859-1864

Kumar, R., Kumar, S., Pundir, R.S., Surjit,V. and Rao, S. (2022). FPOs in India: Creating Enabling Ecosystem for their Sustainability. ICAR-National Academy of Agricultural Research Management, Hyderabad, India. Pp. 22.

Policy & Process Guidelines for Farmer Producer Organisations (2013). Dept. of agriculture and cooperation, Ministry of Agriculture, Govt. of India.

http://sfacindia.com

www.nabard.org

Acknowledgement

Authors are thankful to all the KVKs of Maharashtra and Gujarat for associating themselves in the study and providing information.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 45-50, 2024

Integrated Nutrient Management of French Beans *(Phaseolus vulgaris)* in Rice-Fallow System Under Red Laterite Zone of West Bengal

Dhiman Mukherjee*, Golam Moinuddin and Subhendu Jash

Regional Research Station (Red &Laterite Zone)
Bidhan Chandra Krishi Viswavidyalaya
Jhargram-721507 (West Bengal)
**Corresponding author email id : dhiman_mukherjee@yahoo.co.in*

Abstract

French bean is one of the most precious and highly relished widely grown short duration legume vegetable. This study is intended to assess the integrated manner of nutrient management for higher productivity of french bean under acidic soil condition in red-latertic zone of west bengal. The experiment was carried out during two consecutive years (2021-2022 and 2022-2023) of *rabi* season at Regional Research Station, Jhargram, Bidhan Chandra Krishi Viswavidayalaya. The combination of twelve different treatments were tested to know the effective nutrient management option for higher productivity of frenchbeans in Jhargram district of west bengal. The experiment was laid out in randomized block design with three replications. Yield-attributing characters like pods/plant, seeds/pod, pod length, 100-seed weight were significantly influenced due to different integrated nutrient management. With different treatments significantly higher yield of pod seen with application of 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha (23.51 t/ha) and was closely followed by 100% NPK (22.05 t/ha) and 75% NPK + vermicompost @ 1 t/ha (21.82 t/ha). They were at par with each other and statistically superior to other integrated nutrient measures. This registered 126.9,112.7 and 110.6 percent more pod yield over control, respectively. This also registered 54.5, 44.9 and 43.5 percent more yield over farmer's practice, respectively. It is noted that as per availability of the source *i.e.,* vermicompost and FYM in a given area or location, 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and 75% NPK + vermicompost @ 1 t/ha may be recommended which will indirectly beneficial for good soil health and improvised sustainable production of french bean in tribal belt to Jhargram and adjoining rainfed zone in winter season.

Key words : French bean, growth, integrated nutrient management, red-laterite, yield

Introduction

French bean (*Phaseolus vulgaris* L.; 2n=22) is an important leguminous vegetable crop in India because of its short growing duration and good nutritional value. This is grown popularly for its green pods and dry seeds. French bean is known by various names; kidney bean, snap bean, tepary bean, haricot bean etc. (Sharma *et al*., 2013) and also referred as "the meat of the poor" (Kandula *et al*., 2022). This is a herbaceous annual of the plant family "Fabaceae". It is a good source of different essential amino acids and the crop has the potential to prevent different diseases including diabetes and cardiac breakdowns. There are about 2.97 lakh hectares of land under cultivation of beans in India currently with production tune of about 25.69 lakh tonnes. However, most of the commercial growing pockets of our country utilize different chemical fertilizers and pesticides for growing the crop. Thereby, the quality of produce is deteriorating day by day due to presence of toxic residues of different banned pesticides or other agrochemicals. In beans such evidence has recently been exposed through the study conducted by the Society for Promotion of Wastelands Development. Besides, the gradual rise of input costs in conventional chemical farming makes it nearly impossible to grow this crop by the small and marginal farmers of our country. On the other hand, organic farming is relying on low cost involving production. This become very popular home shade garden among tribal people of red latertic zone due to it's high nutritive and market value (Mukherjee, 2023). French bean is consumed in various forms in this area mainly as green vegetable, green shelled, or dry as pulses. It is an excellent source of protein and is cooked fresh or processed as frozen . Hundred grams of green pods contain approximately 1.7 g protein, 4.5 g carbohydrates, 221 I.U. vitamin A, 11 mg vitamin C and 50 mg of calcium (Datta *et al*., 2023). In uplands, this can be grown after maize. In lowlands, a rice-french bean cropping sequence become popular. In Jhargram block farmer's usually kept their land fallow after rice due to poor availability of irrigation facility (Mukherjee *et al*., 2024). French bean become good option perticularly in rice-fallow system in this area. Cultivation of french bean become challenging under current scenario due to heavy use of inappropriate amount of chemical inputs, which deteriorate its quality and texture also. The modern agriculture technology emphasizes wide spread of use of chemical fertilizer (off farm inputs) as a source of nutrients. In-fact, fertilizer use is considered as a barometer of agricultural production but use of chemical fertilizer is limited in many areas due to high cost and lack of availability. In order to reduce dependence on commercial fertilizer, there much interest to use local available manure as alternative source (Mukherjee, 2013). Supplementation of farm yard manure/compost as well as application of vermicompost along with chemical fertilizer is the most potentially option for agronomic effectiveness of the component crops. Integrated nutrient management methods, mineral and organic nutrient combining source, offer better results than reliance on one source alone. In red-latertic zone of west bengal, practically there are no research work has been conducted with reference to application of different levels of fertilizer with different dose of organic sources in French bean. Hence this experiment was undertaken to observe the integration of different inorganic and organic source of nutrients on vegetative growth and economic yield of French bean.

Materials and Methods

A field experiment was conducted at Research Farm of Regional Research Station, Jhargram under the aegies of Bidhan Chandra Krishi Viswavidayalaya during rabi season of 2021-22 and 2022-23. The soil of experimental site was sandy loam in texture. Soil pH was found to be acidic (5.63) with EC of 0.1 dS/m. Soil available N 132.7 kg/ha, P 12.9 kg/ha, K 153.6 kg/ha and organic carbon content was low (0.39%). The experiment consisting of twelve treatments viz, 100% NPK @ 50:80:80 kg /ha (RDF), 75% NPK + FYM @ 2.5 t/ha, 75% NPK + vermicompost @ 1 t/ha, 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha, 50% NPK + FYM @ 5.0 t/ha, 50% NPK + vermicompost @ 2t/ha, 50% NPK + FYM @ 2.5 t/ha + vermicompost @ 1 t/ha , 25% NPK + FYM @ 7.5 t/ha, 25% NPK + vermicompost @ 3 t/ha , 25% NPK + FYM @ 3.75 t/ha + vermicompost @ 3 t/ha, farmers practice (@ 30 : 30 : 30 NPK kg/ha) and control. The experiment was laid out in Randomized Block Design (R.B.D.) with three replications on sandy loam having low organic carbon (0.32%), nitrogen (164.4 kg/ha), phosphorus (16.11 kg/ha) and potassium (279 kg/ha). French bean seeds Arka Komal, were used for sowing. Seeds were sown singly at 2-3 cm depth, @ 60-70 kg/ha, maintaining a spacing of 15 cm plant to plant and 50 cm row to row. Recommended dose of N, P, K and other organic sources were apply as per treatments. Nitrogen, phosphorus and potassium fertilizers were applied in the form of urea, diammonium phosphate and muriate of potash, respectively, as per the treatments. FYM and vermicompost should be applied 25 days before sowing. Full dose of P, K and half dose of N were applied at the final land preparation. The other half dose of N was applied 30 days after sowing. To raise the crop, other recommended package of practices was followed. The treatments were evaluated on the basis of growth, yield and yield attributes, quality, soil nutrients and economics. Five plants selected randomly were tagged from the net plot area of each treatment for recording various biometric observations and the data collected were analyzed statistically following the procedure described by Gomez and Gomez (1984).

Results and discussion

The findings of the experiment regarding growth and yield attributes have been categorically represented as per the followings:

Growth parameters

The results illustrated that almost all the growth and yield attributes taken into account in this investigation were greatly influenced by the intervention of different organically designed treatments with statistically significant (P d” 0.05) differences among different treatments (Table 1 & 2). The NPK fertilizers with

TABLE 1. Effect of integrated nutrient management on growth attributing character of the French bean crop at 60 days after sowing (Pooled data of two year)

Treatments	Plant height (cm)	Branches/ plant (No.)	Leaves / plant (No.)	Dry matter accumulation/ plant (g)
100% NPK (RDF)	47.93	7.12	29.63	26.25
75% NPK + FYM @ 2.5 t/ha	45.00	5.96	27.11	24.36
75% NPK + vermicompost @ 1 t/ha	47.66	6.78	21.54	24.25
75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha	45.32	6.41	30.25	27.55
50% NPK + FYM @ 5.0 t/ha	43.17	5.11	37.32	24.35
50% NPK + vermicompost @ 2t/ha	43.98	6.06	25.39	20.14
50% NPK + FYM @ 2.5 t/ha + vermicompost @ 1 t/ha	42.66	6.66	31.06	23.35
25% NPK + FYM @ 7.5 t/ha	42.64	5.23	34.98	20.14
25% NPK + vermicompost @ 3 t/ha	40.00	5.66	25.01	25.13
25% NPK + FYM @ 3.75 t/ha + vermicompost @ 1.5 t/ha	40.33	5.11	32.25	21.33
Control	40.48	5.07	31.96	16.25
Farmers practice	44.25	5.66	33.67	21.25
SEm±	1.14	0.21	1.27	0.81
CD (p=0.05)	3.33	0.70	4.05	2.19

organic manures along with vermicompost alone or in combination were found to have significant effect on growth characters as compared to control. It is evident from Table 1 that among all the twelve treatments, plant height at 60 DAS, significantly more observed with 100% NPK (RDF) and very close to 75% NPK + vermicompost @ 1 t/ha, 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and 75% NPK + FYM @ 2.5 t/ha. They showed parity with each others and statistically superior to other treatments. Number of branches per plant more observed with 100 % NPK and was statistically similar with 75% NPK + vermicompost @ 1 t/ha , and significantly better to other treatments. Further, number of leaves per plant importantly more seen with 50% NPK + FYM @ 5.0 t/ha and showed parity with 25% NPK + FYM @ 7.5 t/ha and farmers practice. Dry matter accumulation much registered with 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and was at par only with 100% NPK (RDF) and notably better to other nutrient management treatments. The reason might be due to higher availability of nutrients as a result of integration of organic and inorganic sources. This is in line with the findings of researchers Mukherjee (2024a), Longmatula *et al.* (2021)and Kumar *et al.* (2009).

Yield attributes and yield

Integrated use of fertilizers and organic manures significantly increased yield and yield attributing characters of French bean compared to control (Table 2). With various treatments pods/plant significantly more observed with 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and was at par with full recommended doses of NPK. The integrated

Table 2. Effect of integrated nutrient management on yield and yield attributing character of the French bean crop (Pooled data of two year)

Treatments	Pods/plant (No.)	Pod length (cm)	Seeds/ pod (No.)	Seed length (cm)	Hundred seed weight (g)	Fresh weight of one pod (g)	Yield of pod/plant (kg)	Yield of pod(t/ha)
100% NPK (RDF)	70.22	10.11	7.31	1.63	45.32	11.41	8.97	22.05
75% NPK + FYM @ 2.5 t/ha	37.08	10.45	5.86	1.67	44.15	13.36	6.06	20.25
75% NPK + vermicompost @ 1 t/ha	66.19	11.98	7.13	1.71	45.92	12.18	8.51	21.82
75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha	72.66	11.13	6.33	1.63	46.11	12.06	9.65	23.51
50% NPK + FYM @ 5.0 t/ha	56.33	9.17	5.96	1.69	42.28	9.06	7.31	18.40
50% NPK + vermicompost @ 2t/ha	64.66	11.12	7.09	1.78	43.19	10.86	9.44	21.25
50% NPK + FYM @ 2.5 t/ha + vermicompost @ 1 t/ha	55.24	11.01	6.33	1.71	44.32	12.54	8.07	20.11
25% NPK + FYM @ 7.5 t/ha	25.33	9.01	5.66	1.48	41.05	10.16	4.63	14.95
25% NPK + vermicompost @ 3 t/ha	36.95	10.07	5.33	1.55	40.71	11.54	6.44	17.15
25% NPK + FYM @ 3.75 t/ha + vermicompost @ 1.5 t/ha	33.66	10.74	5.28	1.61	40.25	12.05	5.01	16.25
Control	23.65	9.21	5.66	1.59	40.98	9.01	4.04	10.36
Farmers practice	44.71	10.83	6.66	1.61	43.47	10.75	5.35	15.21
SEm±	0.87	0.26	0.21	0.35	0.47	0.59	0.37	0.67
CD (p=0.05)	2.51	0.74	0.64	NS	1.49	1.61	1.17	1.81

use of chemical fertilizers, FYM and vermicompost increased the physical properties of soil (water and nutrient holding capacity). Availability of nutrient helps the plant to bear more number of flowers and reduce the chance of flower and fruit drop; as a result, more number of pods per plant. This is in conformity with Longmatula *et al*. (2021). However, pod length more registered with 75% NPK + vermicompost @ 1 t/ha and closely followed by 75% NPK + FYM @ 1.25 t/ ha + vermicompost @ 0.5 t/ha, 50% NPK + vermicompost @ 2t/ha and 50% NPK + FYM @ 2.5 t/ha + vermicompost @ 1 t/ha. They were at par with each other and statistically superior to other treatment measures. The increased pod length with substitution of vermicompost might be due to the fact that organic manures release nutrients slowly, increases nutrient use efficiency, biological fixation and availability of micro-nutrients. Similar results were documented by Gupta *et al.* (2017) and Mukherjee (2023). Number of seeds/ plant significantly more seen with 100 % NPK and was closely followed by 75% NPK + vermicompost @ 1 t/ha and 50% NPK + vermicompost @ 2t/ha. They were at par with each other. Kamble *et al*. (2016) also reported that seed per plant varies with different nutrient management practices. Seed length failed to gave any statistical difference, however among various treatments more seed length observed with 50% NPK + vermicompost @ 2t/ha and was followed by 50% NPK + FYM @ 2.5 t/ha + vermicompost @ 1 t/ha . Significantly more test weight observed with 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and showed parity with 75% NPK + vermicompost @ 1 t/ha , 100% NPK (RDF) and 50% NPK + vermicompost @ 2t/ha. Increase in yield attributing characters in these treatments might be the combined effect of effective nutrients and and micronutrients available from FYM and vermicompost for better yield of french bean. Fresh weight of pod more seen with 75% NPK + FYM @ 2.5 t/ha and was significantly at par with other treatments except control, farmer practice, 25% NPK + FYM @ 7.5 t/ha and 25% NPK + FYM @ 7.5 t/ha. This is probably due to presence of different micro-nutrients along essential plant growth promoting nutrients in organic manures (vermicompost) and NPK formulations as well. This corroborate with the earlier finding of Mukherjee (2016) and Rai *et al.* (2021).

Yield of pod per plant more observed with 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and showed parity with75% NPK + vermicompost @ 1 t/ha and 50% NPK + vermicompost @ 2t/ha and full dose of NPK, and significantly better to other treatments. More yield of pod as a whole observed with 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha (23.51 t/ha) and was closely followed by 100% NPK (22.05 t/ha) and 75% NPK + vermicompost @ 1 t/ha (21.82 t/ha). They were at par with each other and statistically superior to other integrated nutrient measures. This registered 126.9, 112.7 and 110.6 percent more grain yield over control, respectively. This also registered 54.5, 44.9 and 43.5 percent more grain yield over farmer's practice, respectively in red-latertic zone of west bengal. The increase in the yield could be due to the greater availability of nutrient in soil due to integration of different source of nutrients resulting in the better growth and development which might be attributed to better mobilization of different nutrients and increased allocation of photosynthetes towards the economic parts and also hormonal balance on the plant system.

Conclusion

From the study, it may be concluded that French bean is highly responsive to application of of different ogranic source of nutrient application instead of sole dependent on chemical sources of nutrients. It is noted that as per availability of the source *i.e.,* vermicompost and FYM in a given area or location, 75% NPK + FYM @ 1.25 t/ha + vermicompost @ 0.5 t/ha and 75% NPK + vermicompost @ 1 t/ha may be recommended which will indirectly beneficial for good soil health and improvised sustainable production of french bean in tribal belt to Jhargram and adjoining rainfed zone in winter season.

Literature Cited

Datta, S., Sarkar, R.K and Rai, U. 2023. Effect of sowing dates on growth, yield and quality components of bush type vegetable French bean varieties. I*nternational Journal of Bio-resource and Stress Management,* 14(4): 611-616.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedure for agricultural research, 2nd edn. John Willey & Sons. New York, U.S.A. pp 241-271.

Gupta, S., Singh, D.P., Kasera, S. and Kumar, S.M.2017. Effect of integrated nutrient management on growth and yield attributes of table pea (*Pisum sativum* L.) cv. AP-3. *International Journal of Chemical Studies,* 5(6): 906-908.

Kamble, M.Y., Kalalbandi, B.M., Kadam, A.R. and Rohidas, S.B., 2016. Effect of organic and inorganic fertilizers on growth, green pod yield and economics of French bean (*Phaseolus vulgaris* L.). *Legume Research,* 39(1) : 110–113

Kandula, V., Prasad, K.R., Kumara, K.U., Babu, M.R. and Krishna, U., 2022. Evaluation of bush type French bean (Phaseolus vulgaris) genotypes for growth, yield and quality traits. *The Pharma Innovation Journal,* 11(9) : 1361–1363.

Kumar, R.P., Singh, O.N., Singh, Y., Dwivedi, S. and Singh, J.P. 2009. Effect of integrated nutrient management on growth, yield, nutrient uptake and economics of french bean (*Phaseolus vulgaris* L.). *Indian Journal of Agricultural Sciences,* 79(2): 122-128.

Longmatula, Kanaujia, S.P. and Changkiri, M. 2021. Response of French bean (*Phaseolus vulgaris* L.) to integrated nutrient management on acid alfisol of Nagaland. *Annals of Plant and Soil Research,* 23(1): 61-65.

Mukherjee, D. 2013. Organic agriculture. *In* **:** *Advances in Agro-Technology: A Text Book* (eds. Rodriguez, H., Ramanjaneyulu, R., Sarkar, N.C. and Maity, R). Compilation of international research work. Puspa Publishing House, Kolkata, India. Pp 43-81.

Mukherjee, D. (2016). Integrated nutrient management practices on growth and yield of field pea (*Pisum sativum* L.) under mid hill condition. *Journal of Agricultural Sciences,* .12(2): 309-313.

Mukherjee, D. 2023. Cropping system for sustainable agriculture under Red-Laterite Zone . *Agri Tech Today*, 1 (8) : 166-173.

Mukherjee, D. 2024a. Agriculture potential crops under red-lateritc zone of Jhargram district of west bengal: A Case Analysis. *Agri Tech Today*, 2 (7) : 129-131.

Mukherjee, D., Jash, S., Poduval, M. and Moinuddin, G. 2024. Challenges and remedial measure for sustainable crop production in Jhargram red-latertic belt of west bengal-A case study. *International Journal of Bioresource Science,* 11(01): 89-96.

Rai, U., Datta, S., Chatterjee, R. and Thapa A., 2021. Effect of organic sources of nutrients, humic acid and sea weed extracts on growth and yield of french bean varieties. *Legume Research-An International Journal,* 44(7) : 824–825.

Sharma, B.K., Kushwah, S.S.,Verma, K.S. and Singh, O.P. 2013. Studies on french bean (*Phaseolus vulgaris*) varieties under different N, P, K and S levels for growth, yield and economics. *Journal of Horticultural Sciences*, 8(2) : 268–270.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 51-55, 2024

Field Performance of Various Seed Treatments Under Direct Seeded Condition in Rice (*Oryza sativa* L.):

Manish Bhattacharya*[1], Soumen Panda[1], Anindya Kumar Hembram[1], Sabyasachi Kundagrami[2]

[1]*Department of Seed Science & Technology, Institute of Agricultural Science, University of Calcutta*

[2]*Department of Genetics & Plant Breeding, Institute of Agricultural Science, University of Calcutta*

**Corresponding author email: manishb060899@gmail.com*

Abstract

Seed treatment in enhancing the quality of seeds and having positive impact in productivity is a well established fact & direct seeded rice is gaining popularity due to low cost over transplanting method in recent times. So, with the view of making an assured production of good quality seeds in apparently low cost a field experiment was conducted to investigate the influences of the various dry and wet seed treatments in direct seeded method. Seeds of a high yielding variety IET-4786 were treated with some dry crude plant materials & pharmaceutical for a particular time period. In case of wet seed treatments distilled water, growth regulators & some vitamins were employed. Data was collected for yield & yield attributing characters. Study revealed that most of the seed treatments can effectively enhance the desired parameters in case of direct seeded method as well. Considering all the characters ascorbic acid, aspirin & red chilli powder were found be the most effective ones. Ascorbic acid performed as best treatment in terms of yield per square meter, harvest index & also produced the most effective no of tillers. So, we can conclude that seed treatments can be done for enhancing the yield & quality of the seeds in direct seeded method as well.

Introduction

Rice (*Oryza sativa* L. 2n=2x=24) belongs to the family of grasses, Gramineae (Poaceae). Rice is one of the three major food crops over the world and consumed as a staple diet of about half of the world's population. About 90% of the rice production is from the Asian countries and over 75% of the world supply is consumed by people in Asian countries. As the population is increasing the demand for rice is also increasing gradually. Rice is a nutritious cereal crop, used specially for human intake. It is the main supply of energy and is a critical supply of protein imparting giant quantities of the recommended nutrient intake of zinc and niacin. Farmers usually face problems in the case of transplanted rice due to standing water as well as alleviating the cost of production.

Direct Seeded Rice has some superiority over transplanted rice in some certain aspects. Joshi *et al.* (2013) revealed that, DSR technique was becoming popular now a day because of its low-input demand nature. The development of short duration, early maturing cultivars and efficient nutrient management techniques along with increased adoption of weed management methods have encouraged many farmers to switch from transplanted to DSR culture.

It is a well established fact that good quality high vigorous seed provides better seed germination, uniform crop stand & a sustainable productivity (Roberts and Osei-Bonsu, 1988; Powell, 2009; Ghassemi-Golezani *et al.*, 2011).

Seed treatments has been found to be a very effective tool in providing quality seeds, enhancing the vigour, viability, germination, productivity as well as it helps to cope up with different stresses (Yang *et al.*,2018; Bhateshwar *et al.*,2020; Patra, 2017; Biswajit *et al.*,2015).

Therefore the present investigation was carried out with the objective of finding out the influences of the various seed treatments on Direct seeded rice in terms of productivity & yield attributing characters.

Materials and Methods:

For dry seed treatment, seeds of high yielding rice variety IET-4786 were used for the investigation. Seeds of rice (250g) were dry dressed in finely powdered pharmaceutical viz., Aspirin @ 2g/kg of seed and crude plant materials viz., Red chilli powder, Ginger powder, Garlic powder, Turmeric powder, Cardamom powder, Black pepper, Catharanthus leaf powder @ 2g/kg of seed in HD Amber bottles at room temperature (28 ± 1^0C). After treatment, bottles containing treated seeds were kept at room temperature (28 ± 1^0C) for one month. The bottles were shaken once a day for up to 7 days for the thorough mixing of powdered pharmaceutical and crude plant materials with the seeds. The methods of seed treatments were the same in pre-storage and mid-storage seed invigoration treatments.

In case of wet seed treatments, seeds (cv. IET-4786) were soaked in double volume of distilled water and some growth hormones solutions viz., Gibberellic Acid, Indole Acetic Acid, Salicylic Acid @ 100ppm and Osmo protectant solutions of Ascorbic acid, Alpha Tocopherol having 1% concentrations for duration of 3 hours followed by light air-drying under the fan prior to germination. After treatment, bottles containing treated seeds were kept at room temperature (28 ± 1^0C). Details of all the treatments are furnished in the Table 1.

The field experiment was conducted at the Agricultural Experimental Farm, University of Calcutta, Baruipur, 24- Parganas (South), West Bengal (latitude 22^0'N and 88^0-28'E longitude), during rabi season using randomized block design with 3 replications for each treatment. Five plants were taken randomly in each replication and data were taken for plant height, number of tillers/hills, number of effective tillers/hills, number of panicles/plants, number of grains/panicles, length

Table 1. Details of Seed Treatments used in the experiment

Treatment	Materials used	Dose
	DRY SEED TREATMENTS	
T_1	Control	-
T_2	Red Chilli Powder	2g/kg
T_3	Ginger Powder	2g/kg
T_4	Garlic Powder	2g/kg
T_5	Turmeric Powder	2g/kg
T_6	Cardamom Powder	2g/kg
T_7	Black Pepper Powder	2g/kg
T_8	Catharanthus Leaf Powder	2g/kg
T_9	Aspirin	2g/kg
	WET SEED TREATMENTS	
T_{10}	Distilled Water	
T_{11}	Gibberelic Acid	100ppm
T_{12}	Indole Acetic Acid	100ppm
T_{13}	Salicylic Acid	100ppm
T_{14}	Ascorbic Acid	100ppm
T_{15}	Alpha Tocopherol	1%

of the panicle, 1000 seed weight and their mean were computed. Data of seed yield per square meter, biological yield per square meter were also taken and Harvest Index was calculated (Grain yield/Biological yield).

Results and Discussion:

The data on plant height as influenced by plant extracts, chemicals and growth regulators are presented through Table 2. The average tallest plant was recognized for T12 (i.e. 108cm, IAA @ 100ppm) followed by T2 (i.e. 105cm, Red chilli powder) and T4 (i.e. 105cm, Garlic powder) as a response towards wet and dry seed treatments respectively. Among the different treatments, maximum influence was observed to be exerted by IAA @ 100 ppm and it could also be noted due to auxins promoting cell growth and expansion, cell division, lateral root formation, apical dominance, and the development of fruit (Pospýsilova, 2003).

A significantly highest number of tillers per hill was observed for T9 (i.e. 28 tillers/hill, Aspirin treatment) followed by T10 (i.e. 27 tillers/hill, Distilled water) and T2 (i.e. 27 tillers/hill, redchilli powder). It is also recorded that all the treatments (except T7 & T4) have a good impact in this parameter over control.

TABLE 2. Effect of seed treatments on field performances of Rice seeds (cv. IET-4786)

Treat-ment	Plant Height (cm)	No. of Tillers	Effective Tillers	Panicle Length (cm)	Grains no. / Panicle	Grain yield / m² (g/ m²)	Biological yield / m² (g/ m²)	Harvest index	Days of maturation	Test weight (g)
T1	96.667	19.000	12.333	19.617	79.000	267.000	546.667	0.434	120.667	17.893
T2	105.000	27.000	21.000	26.103	102.333	297.333	563.333	0.528	115.000	19.873
T3	98.333	21.333	15.333	20.660	89.667	282.667	572.663	0.494	116.667	18.150
T4	105.000	18.667	13.000	22.080	82.333	269.333	588.000	0.458	120.000	19.293
T5	102.333	24.000	16.000	23.047	98.667	275.333	555.556	0.498	118.000	19.490
T6	102.667	20.000	14.000	23.933	83.667	242.333	575.667	0.421	119.667	18.090
T7	95.333	19.000	12.000	19.820	79.667	278.333	585.111	0.476	118.000	18.083
T8	99.000	20.667	16.333	20.930	78.333	251.333	578.889	0.489	120.667	19.127
T9	93.667	28.333	20.333	20.927	90.000	293.333	567.222	0.517	120.000	19.033
T10	100.667	27.667	21.667	24.513	105.333	289.667	570.000	0.508	115.000	20.663
T11	102.667	21.333	17.667	24.097	94.000	284.333	594.333	0.478	114.000	21.017
T12	108.000	23.000	16.333	26.803	95.667	276.667	596.667	0.464	116.000	19.940
T13	100.333	24.333	17.000	26.320	99.667	286.333	589.111	0.486	119.000	21.177
T14	103.667	26.000	21.667	24.457	101.000	308.000	563.333	0.547	120.000	21.687
T15	104.000	21.000	16.000	21.493	91.667	282.000	584.667	0.482	120.000	18.587
C.D.	1.796	2.583	1.680	1.068	3.254	19.604	29.012	0.044	1.559	0.716
SE(m)	0.617	0.887	0.577	0.367	1.118	6.733	9.964	0.015	0.536	0.246
SE(d)	0.872	1.254	0.816	0.519	1.581	9.521	14.091	0.021	0.757	0.348
C.V.	1.056	6.751	5.979	2.763	2.118	4.181	2.999	5.343	0.785	2.187

Note: C.D.- Critical Difference, SE(m)- Standard error of mean, SE(d)- Standard error of difference, C.V.- Coefficient of Variance; T1= Control, T2= Chilli powder @2g/kg, T3= Ginger powder @2g/kg, T4= Garlic powder @2g/kg, T5= Turmeric powder @2g/kg, T6= Cardamom powder @2g/kg, T7= Black pepper powder @2g/kg, T8= Catharanthus leaf powder @2g/kg, T9= Aspirin @2g/kg, T10= Distilled water, T11= GA3 @100ppm, T12= IAA @100ppm, T13= SA @100ppm, T14= AsA @1%, T15= Alpha tocopherol @1%

The maximum number of effective tillers per hill was produced by Ascorbic acid @ 1% though statistically similar performance could be noticed for Hydropriming and Red chilli powder. Significantly lowest value for this parameter was recorded in T7 when seed treatment was done with Black pepper powder. Amin *et al*. (2008) and Jafar *et al*. (2012) have been reported exogenous Ascorbic acid can be benefitted to wheat tiller number and increase yield respectively.

All the treatment's influence and interaction effect were found to be significant for the number of grains per panicle at marketable stage. However, significantly maximum value for this parameter was observed for T10 (Hydropriming) followed by T2 (Red chilli powder). Mahajan *et al.* (2011) also recorded highest panicle/m² with hydropriming among all the treatments.

that regarding priming treatments, Ascorbic acid primed seeds gave higher grain yield as compared to other treatments.

GA3 @ 100 ppm exhibited the best result in maturity as it took least number of days to mature than other treatments. Noticeable responses were also found statistically similar for T10 (Hydropriming) & T2 (Red chilli powder).

It is evident from the collected data that significantly highest magnitude of test weight could be noted for T14 (Ascorbic acid @ 1%) over all the treatments and influence of most of the treatments was recorded to be significantly better than control.

T14 (Ascorbic acid @ 1%) produced highest value for harvest index over all the treatments and better influence of some other treatments could also be noted over control except T6 (Cardamom powder treatment).

TABLE 2. Selection and characterization of treatments on the basis of field parameters

Treatment	Plant Height (cm)	No. of Tillers	Effective Tillers	Panicle Length (cm)	Grains no. / Panicle	Grain yield / m² (g/ m²)	Biological yield / m² (g/ m²)	Harvest index	Days of maturation	Test Weight (g)
T1	96.667	19.000	12.333	19.617	79.000	267.000	546.667	0.434	120.667	17.893
T2	105.000	27.000	21.000	26.103	102.333	297.333	563.333	0.528	115.000	19.873
T9	93.667	28.333	20.333	20.927	90.000	293.333	567.222	0.517	120.000	19.033
T10	100.667	27.667	21.667	24.513	105.333	289.667	570.000	0.508	115.000	20.663
T11	102.667	21.333	17.667	24.097	94.000	284.333	594.333	0.478	114.000	21.017
T12	108.000	23.000	16.333	26.803	95.667	276.667	596.667	0.464	116.000	19.940
T14	103.667	26.000	21.667	24.457	101.000	308.000	563.333	0.547	120.000	21.687

Note: T1= Control (Highlighted with yellow colour), Other colours signify the best results among all the treatments, T2= Chilli powder @2g/kg, T9= Aspirin @2g/kg (Orange), T10= Distilled water (Light orange), T11= GA3 @100ppm (Green), T12= IAA @100ppm (Blue), T13= SA @100ppm (Grey), T14= AsA @1% (Violet)

Similar to grains per panicle, the influence of all the treatments on grain yield per unit area at marketable stage was recorded as significant. Significantly maximum grain yield per unit area was exhibited by T14 (Ascorbic acid @ 1%) although T2 (Red chilli powder) & T9 (Aspirin) had statistically similar performances. Shah *et al.* (2019) also recorded

Conclusion:

On a conclusion note we can state that dry seed treatments with ecological non-toxic plant products and pharmaceuticals can be utilized for maintaining the vigour and viability of the harvest-fresh (high vigour) seeds in the longer-run in an easy and sustainable way very effectively. The products like Red

Chilli Powder and Aspirin are found to be very much superior over other products in terms of both seed quality parameters & yield attributing characters. In case of pre-sowing hydration treatments, soaking in dilute solution of ascorbic acid (1%) for 3hours and then lightly air-drying may be practiced for improved germination, early seedling growth, field performance and productivity of rice seeds.

Literature Cited

Amin, A.A., Rashad, E.S.M., Gharib, F.A.E. (2008). Changes in morphological, physiological and reproductive characters of wheat plants as affected by foliar application with salicylic acid and ascorbic acid. *Aust. J. Basic Appl. Sci.*, **2**: 252–61.

Bhateshwar, D. C., Prabha, D., Jangid, D., & Salman, M. (2020). Effect of seed priming with botanicals on plant growth and seed yield of lentil (Lens culinaris M.). *International Journal of Current Microbiology and Applied Sciences*, **9**(7): 3484-3499.

Biswajit, P., Sritama, K., & Sabyasachi, K. (2015). Role of seed treatment with herbal plant products and management practices with growth nutrients by decreasing chlorophyll reduction rate for overcoming submergence stress in rice (*Oryza sativa* L.). *International Research Journal of Biological Sciences*, **4**(5): 38-43.

Ghassemi-Golezani, K., Dalil, B., Moghaddam, M., Raey, Y. (2011). Field performance of differentially deteriorated seed lots of maize (*Zea mays*) under different irrigation treatments. *Not. Bot. Horti. Agrobo*., **39**: 160-163.

Jafar, M.Z., Farooq, M., Cheema, M.A., Afzal, I., Basra, S.M.A., Wahid, M.A. (2012). Improving the performance of wheat by seed priming under saline conditions. *J. Agron. Crop Sci.,* **198**: 38–45.

Joshi, E., Kumar, D., Lal, B., Nepalia, V., Gautam, P., & Vyas, A. K. (2013). Management of direct seeded rice for enhanced resource-use efficiency. *Plant Knowledge Journal*, **2**(3): 119-134.

Mahajan, G., Sarlach, R. S., Japinder, S., & Gill, M. S. (2011). Seed priming effects on germination, growth and yield of dry direct-seeded rice. *Journal of Crop Improvement*, **25**(4): 409-417.

Patra, Sabyasachi. 2017. Response of various seed invigoration treatments in high and medium vigour rice (*Oryza sativa* L. cv. IET-4094) seeds for improved germinability. *Crop Research*, 1-3.

Pospýsilova, J.(2003). Participation of phytohormones in the stomatal regulation of gas exchange during water stress. *Biol. Plant.,* **46**: 491-506.

Powell, A. (2009). What is seed quality and how to measure it? In: Second World Seed Conference; 8 -10 September; Rome, Italy. Food and Agriculture Organization (FAO), pp. 142-149.

Roberts, E.H., Osei-Bonsu, K. (1988). Seed and seedling vigour. In: World crops: cool season food legumes (Summerfield RJ. Ed.). *Kluwer Academic Publishers*, London, pp. 897-910.

Shah, T., Latif, S., Khan, H., Munsif, F., & Nie, L. (2019). Ascorbic acid priming enhances seed germination and seedling growth of winter wheat under low temperature due to late sowing in Pakistan. *Agronomy*, **9**(11): 757.

Yang, A., Akhtar, S.S., Iqbal, S., Qi, Z., Alandia, G., Saddiq, M.S., Jacobsen, S.E. (2018) Saponin seed priming improves salt tolerance in quinoa. *J. Agron. Crop Sci.,* **204**(1): 31–39.

Indian Agriculturist, Vol. 68, No. 1 & 2, pp. 57-62, 2024

Studies on the Potency of Different Bio-Pesticides on Insect Pests of Aman Paddy

A. Ghosal*, A. Mukherjee, I. Mukherjee, P. Kundu and A. K. Dolai[1]

Sasya Shyamala Krishi Vigyan Kendra, RKMVERI, Arapanch, South 24 Pgs, Kolkata-700150

[1]Department of Agronomy, Institute of Agricultural Science, Calcutta University, Kolkata-700019

**Corresponding author email: abhijit.rkmveri@gmail.com*

Abstract

Bio-pesticides have persuasive role in the present day agriculture as an alternative of chemical insecticides. The present study was oriented to find out the potency of different technologies against different pest of rice in farmer's field through participatory research. Findings of the present study showed that bio-pesticides application in combination are at par with the potency of Flufenoxuron 10 DC and superior over Profenofos 40%+Cypermethrin 4% in terms of reducing the infestation of leaf folder, stem borer and hopper complex. Highest B:C was achieved in combine application of NPV @ 5 g/lt at 30 DAT and Neem oil 10000 ppm @ 3 ml/lt at 45 DAT.

Keywords: Bio-pesticide, hopper, leaf folder, rice, stem borer.

Introduction

Rice (*Oryza sativa* L.) is an important staple food for more than three billion people, especially in South and South East Asia (Sharif *et al.* 2014). Rice provides more than one-fifth of the calories consumed by humans across the globe predominantly in Vietnam, Cambodia, Laos, Myanmar, and Bangladesh and 20-44% in Thailand, Philippines, Malaysia, India, Nepal and Sri Lanka as well as rice is the major crop cultivated by the farmers of South and South East Asia countries and still continues the main source of income from farming. As natural phenomenon a sympatric association of different species of insect pests and natural enemies has co-evolved in rice agro-ecosystems. In most of the Asian countries, average yield of rice is 3-4 t/ha (Gianessi 2014). An array of insect pest is found to infest rice and thereby act as one of the main reasons in increasing the gap between actual yield and potential yield. Approximately 300 insect species attack rice crops in India of which 20 species are the major pests (Arora and Dhaliwal 1996); categorized as borer, sap sucking, defoliator, and foliar pests, they are found to infest at different stages of crop growth (Akhtar *et al.* 2010). Extensive outbreaks of yellow rice stem borer (*Scirpophaga incertulas* L.), leaf folder (*Cnaphalocrocis medinalis* Guenee), brown plant hopper (*Nilaparvata lugens*) and white-backed plant hopper (*Sogatella furcifera* Horvath) makes the situations more aggravated in those areas particularly having more exposure of insecticides (Chakravarthy *et al.* 2013; Heong *et al.* 2013; Bottrell *et al.* 2012). In South and South East Asia rice is grown in warm, humid environments advantageous to the endurance and propagation of key insect pests: the yellow rice stem borer, leaf folders, brown plant hoppers and green leafhoppers. Stem borers are pervasive throughout rice fields in Asia and cause severe damage in every rice field every year. Losses from borer and leaf folder damage may reach up to 95% and 63 to 80% respectively (Gianessi 2014). The introduction of high yield technology in the 1960s involving rice varieties with high tillering ability, denser plant spacing, high fertilizer application and irrigation where farmers planted 2 or 3 rice crops a year provided abundant habitat for leaf hoppers and leaf folders that enabled the populations to reproduce nearly year round (Gianessi 2014). Further, the increased use of nitrogen fertilizers increased the insects' reproductive potential. Insecticides are used to combat the incidence of different insect pests at varying degrees in Asian rice fields (% hectares treated to total rice cultivated area): Cambodia (38%), Indonesia (75%), Malaysia (70%), Philippines (95%), Thailand (58%), Vietnam (99%), Bangladesh (50%), and India (50%) (Gianessi 2014). These injudicious exposures may affect biology of the exposed insects (Castro et al., 2012), which may undergo a significant selection pressure and develop resistance to insecticides. The development of insecticide resistance often leads to increase the insecticide dosage to manage resistant insects, which ultimately affects public health and pollute the environment (Khan, 2019). Bio-pesticides have potential role in this particular aspect and are the best fit for agrarian eco-system. In the above backdrop the present study was oriented to evaluate the potency of different bio-pesticides against the insect pest of aman paddy through participatory research.

Materials and methods:

The experiment was conducted to assess the impact of different bio-pesticides on insect pests of aman paddy (var: sabita patnai) in farmers' field as participatory mode of research during 2022 & 2023 at different location of South 24 Parganas district of West Bengal with three technology option (TO) along with farmers practice (FP). The land situation was rainfed medium to low land having cropping system of rice-fallow-greengram. The study was repeated in 7 different farmers field as replication. The tested technology details are as follows: TO-1: 2 round sprays of new generation bio-rational pesticide spray (Flufenoxuron 10 DC @ 1 ml/l) at 30 and 45 dates after transplanting (DAT), TO-2: Spraying of *Verticillium lecanii* @5 g/lt at 30 DAT and *Beauveria bassiana* @ 5 g/l at 45 DAT, TO-3: Spraying of NPV @ 5 g/lt at 30 DAT, Neem oil 10000 ppm @ 3 ml/lt at 45 DAT; application of chemical pesticides (Profenofos 40%+Cypermethrin 4%) @ 2 ml/ l was followed in FP. The experiment was set after group meetings and necessary training and personal interview as a mode of participatory research. The other agronomic parameters are followed at par in all the replication under the trial. Data of insect pest incidence was recorded at different intervals based on the insect damaging stage, 60 & 75 DAT for leaf folder, 21 & 45 DAT for stem borer & 45 & 60 DAT for hopper complex; besides yield and yield attributing characters, percent infestation of insect pests, cost analysis and Farmers' Assessment was recorded after the trial. Recorded data were analyzed in DMRT using SPSS software.

Results and discussions:

The experimental results showed that there was no such difference in efficacy level between the broad

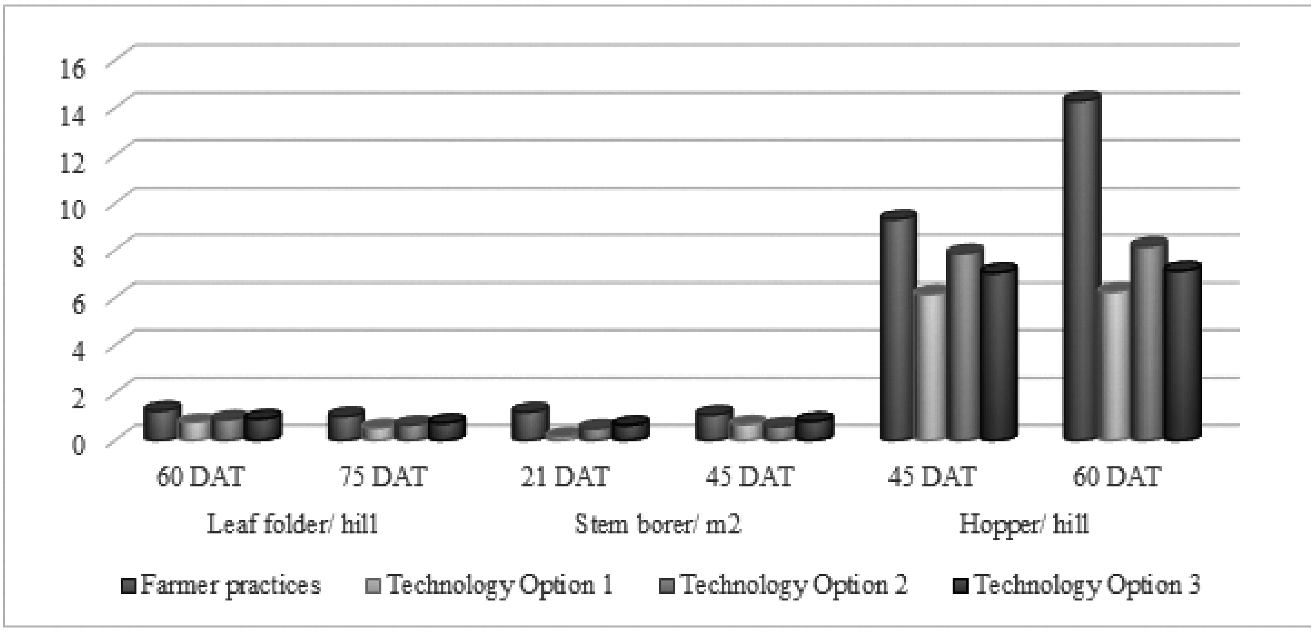


Fig. 1 Effect of different technologies on the major insects of paddy (2022)

Table 1. Impact of different technology options on the yield parameters (2022)

Technology option	No. of effective tillers/hill	Yield component No. of spikelet per panicle	Test wt. (g)	Disease/ pest insect incidence (%)	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs/ha)	BC ratio
Farmer practices	32.01±1.06a	99±2.34a	18.25±0.45b	7.54±0.35b	50.21	52450	90378	37928	1.72
Technology Option 1	31.05±1.02a	102±2.16a	20.1±0.32a	4.25±0.21a	50.49	53600	90882	37281	1.69
Technology Option 2	32.45±1.01a	104±2.02a	19.56±0.24ab	5.26±0.41ab	50.42	51250	90756	39506	1.77
Technology Option 3	32.80±1.16a	103±2.19a	20.20±0.48a	5.10±0.32ab	50.54	50600	90972	40372	1.79

Table 2. Impact of different technology options on the yield parameters (2023)

Technology option	No. of effective tillers/hill	Yield component No. of spikelet per panicle	Test wt. (g)	Disease/ pest insect incidence (%)	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs/ha)	BC ratio
Farmer practices	28.01±0.6a	103±2.43a	18.05±0.47b	19.08±0.75c	49.17	52350	88506	36156	1.69
Technology Option 1	29.02±0.22a	106±2.21a	19.1±0.42a	9.07±0.14ab	50.94	53420	91692	38272	1.71
Technology Option 2	28.25±0.41a	103±2.38a	19.06±0.39ab	9.16±0.33b	50.49	51450	90882	39432	1.77
Technology Option 3	29.0.8±0.56a	104±2.64a	20.17±0.34a	6.12±0.42a	51.04	50780	91872	41092	1.80

Selling Price: Rs. 18/- per kg; data presented are means ± standard error, Mean followed by a different letter are significantly different at pd”0.05 by Duncan’s multiple range test (DMRT)

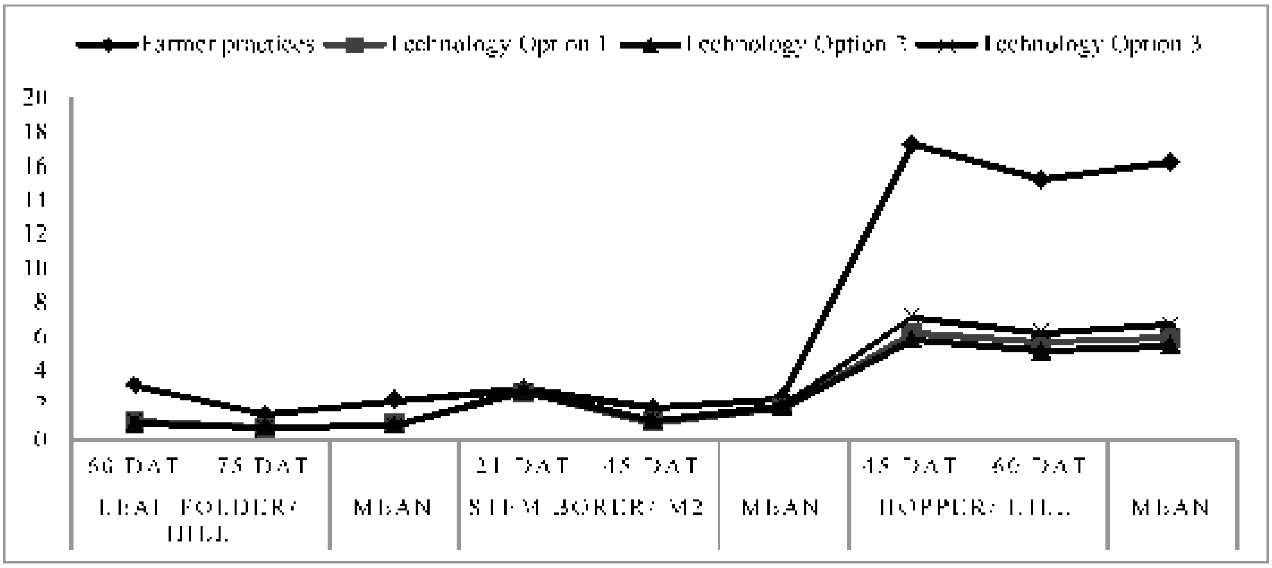


Fig. 1 Effect of different technologies on the major insects of paddy (2023)

Table 3. Influence of bio-pesticides on the incidence of different major insects of aman paddy (2022)

Technology option	Leaf folder/ hill		Mean	Stem borer/ m^2		Mean	Hopper/ hill		Mean
	60 DAT	75 DAT		21 DAT	45 DAT		45 DAT	60 DAT	
Farmer practices	1.26±0.19b	1.02±0.08b	1.14	1.21±0.03c	1.09±0.04b	1.15	9.30±0.41c	14.30±0.32c	11.8
Technology Option 1	0.75±0.10a	0.52±0.11a	0.63	0.15±0.02a	0.67±0.11a	0.41	6.15±0.36a	6.25±0.41a	6.20
Technology Option 2	0.88±0.09a	0.65±0.08a	0.76	0.49±0.04b	0.58±0.08a	0.53	7.85±0.49b	8.15±0.25b	8.00
Technology Option 3	0.91±0.16ab	0.73±0.06ab	0.82	0.64±0.06b	0.80±0.07a	0.72	7.05±0.27b	7.13±0.21b	7.09

spectrum insecticide like Profenofos 40%+ Cypermethrin 4%, biorational pesticides like Flufenoxuron 10 DC and the bio-pesticides of different origin like *Verticillium lecanii*, *Beauveria bassiana or* Spraying of NPV, Neem oil in combination in both the experimental years. It is apparent from the data recorded in both the year that there were no significance differences between the technology options and the farmers own practices in respect of yield attributing parameters, but significant difference was noted in test weight of the seeds. Maximum effective tillers, numbers of spikelet were 32.80 & 29.08, 104 & 106, respectively in both the years. The test weight was varied from 18.25 to 20.20 & 18.05 to 20.17, respectively. Incidence of disease (%) was recorded to the tune of 4.25 to 7.54 & 6.12 to 19.08 during first year and second year of the experiment. Maximum yield (q/ha) was noted in TO-3 (50.54) during first year and 50.94 in TO-2 during second year (Table 1, 2). Lowest yield was observed in farmers' practices because of maximum infestation of pests. In respect of infestation of different insect pests like leaf folder, stem borer and hopper technology option 1 (2 spray of new generation biorational pesticide spray (Flufenoxuron 10 DC @ 1 ml/l) at 30 and 45 DAT) performed well though nearly at par result was obtained in TO-3 and TO-2 respectively in both experimental years. The lowest mean population of leaf folder/ hill was recorded in TO-1 (0.63) & TO-3 (0.83); stem borer/ m^2 in TO-1 (0.41 & 1.87); hopper complex/ hill in TO-1 (6.20) & TO-2 (5.51), correspondingly (Table 3, 4). Highest numbers of insect population were recorded in farmers' practices though the difference in terms of leaf folder

TABLE 4. Influence of bio-pesticides on the incidence of different major insects of aman paddy (2023)

Technology option	Leaf folder/ hill 60 DAT	Leaf folder/ hill 75 DAT	Mean	Stem borer/ m^2 21 DAT	Stem borer/ m^2 45 DAT	Mean	Hopper/ hill 45 DAT	Hopper/ hill 60 DAT	Mean
Farmer practices	3.15±0.23b	1.44±0.47b	2.29	2.97±0.11a	1.86±0.21b	2.41	17.29±0.32b	15.23±0.18b	16.26
Technology Option 1	1.09±0.08a	0.69±0.17a	0.89	2.72±0.19a	1.02±0.18a	1.87	6.21±0.14a	5.75±0.23a	5.98
Technology Option 2	0.96±0.10a	0.72±0.13a	0.84	2.79±0.25a	1.09±0.08a	1.90	5.85±0.35a	5.18±0.9a	5.51
Technology Option 3	0.98±0.08a	0.69±0.11a	0.83	2.88±0.17a	1.13±0.14a	2.01	7.21±0.23a	6.30±0.17a	6.75

and stem borer is not very pronounced over the technology options; while the hopper population was comparatively higher than that of the different technology options adopted.

In respect of B:C, TO-3 (Spraying of NPV @ 5 g/lt at 30 DAT, Neem oil 10000 ppm @ 3 ml/lt at 45 DAT) recorded superior over others for both the years (Table 1, 2). Bio-pesticides being biological in origin exerted less hazard to ecosystem, now a day's management strategies are oriented in eco-friendly manner that to reduce the unnecessary chemical pesticide spray. Bio-pesticides like Verticillium, Beauveria, NPV, Metarrhizium, Bt etc are very effective in reducing an array of insects to the same tune of chemical insecticides, if not spurious. Microbial pesticides comprehend a microorganism (bacterium, fungus, virus, protozoan or alga) as the active ingredient which is relatively specific for its target pest(s), thus very crucial tactics for IPM strategies. All India Coordinated Rice Improvement Programme (AICRIP) findings showed that commercially available formulations of Bt is very potent insecticides against leaf folder besides their concomitant effectiveness against stem borer. Singh and Sarao (2023) reported that neem based formulations azadirachtin 5%; 50,000 ppm exerted good potency against leaf folder and yellow rice stem borer; the reduction in the pest incidence might be due to repellency, oviposition deterrence and antifeedant effects of azadirachtin. Rice plant hopper complex are one of the most emerged protuberant pests of rice, and very critical to manage because of high resistance development potentiality to insecticides; thus bio-pesticides have potential role in managing the pests very specifically. Abdullah *et al.* (2020) portrayed that entomopathogenic fungi *B. bassiana* was able to cause mortality to green leafhoppers. Bahadur *et al.* (2015) also pointed out the efficacy of entomopathogenic fungi *B. bassiana* against varied pest of rice. NPV is a potential bio-pesticides for controlling of varied lepidopteran pests, thus it can be assumed that the potency of NPV against leaf folder and neonates of rice stem borer of our present findings. On the other hand, Flufenoxuron 10% DC is a novel acyl urea insecticide and acaricide is basically a chitin synthesis inhibitor, acting only on young forms of arthropods showed very good potency against leaf folder, stem borer and hopper complex of rice; the findings of present research are comparable with the findings of Reshma and Manogem (2024).

Conclusion:

It is prominent from the present findings that bio-pesticides are potent alternative of chemical pesticides for the management of rice insect pest as both the technology tested are comparatively at par with the efficacy of new generation pesticides like Flufenoxuron 10% DC. The efficiency of microbial pesticides application by spraying on plants may be influenced due to the stimulus of high temperatures, low humidity if not spurious.

Literature Cited

Abdullah, T.; Kuswinanti, T.; Nurariaty, A.; Daud, I. D.; Nasruddin, A.; Risal, R.; Utami, S. and Tuwo, M. (2020). Application of *Beauveria bassiana* (Bals.) Vuil. (Hypocreales: Cordycipitaceae) in rice seed and its effect on mortality of green leaf hopper, *Nephotettix virescens* (Distant) (Homoptera: Cicadellidae). IOP Conference Series: Earth and Environmental Science, Volume 486, 2nd

International Conference on Food Security and Sustainable Agriculture in the Tropics 2 September 2019, Makassar, Indonesia, pp. 486.

Akhtar, M. W.; Sengupta D. and Chowdhury A. (2010). Impact of pesticides use in agriculture: their benefits and hazards, *Interdisciplinary Toxicology*, **2**: 1–12.

Arora, R. and Dhaliwal, G. S. (1996). Agro-ecological changes and insect pest problems in Indian agriculture, *Indian Journal of Ecology*, **23**: 109–122.

Bahadur, S. A. P.; Ashwani, K. and Singh D. V. (2015). Field evaluation of *Beauveria bassiana* and *Metarhizium anisopliae* against major insect pest on paddy (*Oryza sativa* L.). *Indian Journal of Entomology*, 15(1): 62-65.

Bottrell, D. G. and Schoenly, K. G. (2012). Resurrecting the ghost of green revolutions past: the brown planthopper as a recurring threat to high-yielding rice production in tropical Asia. *Journal of Asia-Pacific Entomology,* **15**(1), 122–140.

Castro, A. A.; Lacerda, M. C.; Zanuncio, T. V.; Ramalho, F. S.; Polanczyk, R. A.; Serrao, J. E. and Zanuncio, J. C. (2012). Effect of the insect growth regulator diflubenzuron on the predator *Podisus nigrispinus* (Heteroptera: Pentatomidae). *Ecotoxicology,* **21**: 96–103.

Chakravarthy, A. K.; Doddabasappa B. & Shashank P. R. (2013). The potential impacts of climate change on insect pests in cultivated ecosystems: an indian perspective. In: Nautiyal, S., Rao, K.; Kaechele, H.; Raju, K. & Schaldach, R. (Eds.); Knowledge Systems of Societies for Adaptation and Mitigation of Impacts of Climate Change.

Gianessi, L. (2014). Importance of Pesticides for Growing Rice in South and South East Asia. International Pesticide Benefits Case Study No. 108.

Heong, K. L.; Wong, L.; Hasmin, J. and Reyes, D. L. (2013). Addressing planthopper threats to Asian rice farming and food security: fixing insecticide misuse. Asian Development Bank, 6 ADB Avenue, Mandaluyong City 1550 Metro Manila, Philippines.

Khan, H. A. A. (2019). Realized heritability of resistance to deltamethrin in a field strain of *Musca domestica* Linnaeus (Diptera: Muscidae), *Chemosphere*, 215: 678-680

Reshma, V. and Manogem, E. M. (2024). Effects of flufenoxuron on the male reproductive development of *Spodoptera mauritia* Boisduval (Lepidoptera: Noctuidae). Phytoparasitica, 52(4): 74.

Sharif, M. K.; Butt, M. S.; Anjum, F. M. & Khan, S. H. (2014). Rice bran: a novel functional ingredient. *Critical Reviews in Food Science and Nutrition.* **54**(6), 807–816.

Singh, S. and Sarao, P. S. (2023). Field Evaluation of Biopesticides against Rice Insect Pests under Organic Farming. *Indian Journal of Entomology*, **85**(4): 1030–1034.

INDIAN AGRICULTURIST

GOLDEN JUBILEE NUMBER

2008

CONTENTS

Edited by : Prof. M. K. Sadhu

Page : 200 Price : Rs. 500/-

Discount : 50%

COMMEMORATION VOLUMES PUBLISHED BY THE SOCIETY

(50% Discount)

01. Professor P. K. Sen Commemoration Volume (Indian Agriculturist/ Vol. 15, No. 1 & 2, 1971)	**700.00**
02. Professor N. R. Dhar Felicitation Volume (Indian Agriculturist/ Vol. 17, No. 1, 1973)	**500.00**
03. Professor J. N. Mukherjee Commemoration Volume (Indian Agriculturist/ Vol. 19, No. 1, 1975)	**500.00**

SPECIAL PUBLICATIONS OF THE SOCIETY

(50% Discount)

01. Weed Flora of The District of 24-Parganas, West Bengal *by* Radha Benode Majumder	**20.00**
02. Spices of India *by* H.L. Chakraborty and D. P. Chakraborty	**20.00**
03. Proceedings of the National Seminar on Maximisation of Crop Production held at Varanasi in 1968 *Edited by :* P. K. Sen	**30.00**
04. Proceedings of the Seminar on Possibility of Growing a Second Crops after Rice in West Bengal 1973 *Edited by :* Dr. D. K. Das Gupta	**20.00**
05. Aphids of Economic Importance in India *by* A. K. Ghosh	**30.00**
06. Proceedings of the National Symposium on Higher Productivity in Agriculture held in Kolkata on May 19-20, 1978 *Edited by :* D. K. Das Gupta and N. C. Chattopadhyay	**45.00**
07. Ion Exchange Phenomenon A Special volume of Indian Agriculturist, 1982	**80.00**
08. Proceedings of the Workshop on Betelvine, 1982 *Edited by* : S. K. Roy, A. K. Sarkar, N. Samajpati and N. C. Chattopadhyay	**80.00**
09. The World of Palms (a Review) *by* A. K. Sarkar	**20.00**
10. Advances in Capsicum Science, 2005 *Edited by* : R. K. Maiti, N. C. Chattopadhyay and N. Samajpati	**600.00**
11. Advances in Flax Sciences, 2006 *Edited by* : R. K. Maiti, N. C. Chattopadhyay and N. Samajpati	**150.00**

INSTRUCTIONS TO CONTRIBUTORS

The page of Indian Agriculturist shall be open ordinarily only to members of the Society.

Manuscript should be sent in duplicate, type with double spacing on one side of the paper, leaving 4 cm spacing on the top and left along with a **CD**. Author will have to pay printing cost @ Rs. 300.00 per typed page of A 4 size and will have to bear 100 per cent of the block making charges. Short communications are also considered for publication. The accepted paper will be sent to the press after receiving payment in full. Authors will receive 20 reprints without cover, free. The cost of each extra reprint is Rs.10.00 per page multiplied by the number of pages per copy. The number of extra copies required should be stated while sending the manuscript. Manuscripts of the articles will not be returned, so the authors are requested to keep copies before sending for publication.

Paper should start with an Abstract which should be a concise summation of the findings being reported, followed by ***Introduction, Materials*** *and* ***Methods, Results, Discussion*** *and* ***Literature Cited.***

In short communications there should not be any subdivision of the text except *Abstract* (approximately 100 words) and *Literature Cited*.

Literature Cited should be prepared by quoting the name of the author(s), the year of publication, title of the paper, the volume and page numbers. Abbreviation of journals should be according to the World List of Scientific Periodicals. A specimen for quoting literature cited in the text is given below.

Datta. R. M. and Basak, S. L. 1959. Complex chromosome mosaic in two wild jute species, Corchorus trilocularis Linn. and *C. siliquisis* Linn. *Indian Agric.*, **3**, 37-42.

Review articles are published only when invited.

Illustrations in line should be drawn boldly in India ink on Bristol board or smooth white card. All necessary shading must be done by well defined dots or lines. Colour, either in lines or wash, should be avoided. Due allowance for reduction must be made in the size of lettering, thickness of lines and closeness of shading. Photographs should be glossy print on black and white. The tables should be typed on separate sheets.

Manuscript submission

One soft copy including text, tables and figures / photographs (black & white) etc. in word file through e-mail to editorindianagriculturist@gmail.com / indianagriculturist@gmail.com / agsocietyin_50@rediffmail.com.

For **online submission** of the Manuscript, please visit the following website: **www.indianagriculturist.co.in**

All correspondence should be made with the Editor, The Agricultural Society of India 51/2, Hazra Road, Kolkata – 700 019 (India).

Full address with pin no., phone no. and E-mail number of the corresponding author, if available, should be given in a footnote on the first page of the manuscript.

NAAS rating : 3.76

Contents