INNOVATIVE METHODOLOGY FOR PEST CONTROL IN INDIAN ARCHITECTURE - INTEGRATED PEST MANAGEMENT

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Abstract:
Pesticides are often used in agricultural settings to control pests and diseases, guarantee a high crop yield, and protect the crop's market value. However, there are dangers to human and environmental health from agricultural land that gets a lot of chemical inputs. In addition, consumers seek for products that haven't been subjected to any chemical processing or pesticides. The majority of people throughout the world eat rice, which is grown with the use of artificial pesticides. Natural predators can help decrease the need for chemical pesticides in rice farming. Predators and parasitoids have an almost zero chance of survival in rice-growing environments due to the absence of cover and sustenance. This research work eco-engineered the rice landscape to boost crop protection biocontrol agents. Blooming plants that produce nectar on top of rice bunds offer shelter and food for biocontrol agents, which in turn serves to decrease insect numbers and sustain grain output. The variety of predators, parasitoids, and parasites was higher in ecoengineered plots compared to pesticide-treated and control plots. Bund-grown flowering plants attracted fewer significant insect pests and suffered less damage than neighbouring plots. Pest populations can be reduced and crop yields maintained without the use of pesticides, as shown in this research, just by altering the habitat of natural enemies in rice landscapes.

Keywords: Agricultural, Pest control, Management, Crop protection and Environment.

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1. INTRODUCTION

It was crucial that high-yield rice technology [1] be developed and implemented during the Green Revolution between 1965 and 1975 to prevent famines in Asia throughout the 1980s, as rice is the most important source of energy in the world and is used to feed half of the population. Irrigated rice accounts for more than 92% of global output; almost all of it comes from Asia (91%). There is little difference between the environmental impacts of irrigated rice and rainfed lowland rice. Many nation's economies rely on rice production, therefore any crisis that reduces that output might have a significant impact on those nation's economy. Insect pests and plant diseases are major obstacles to rice production in almost all rice-producing nations..

Unfortunately, the rising cost of insecticides [2] and the advent of irrigated rice contributed to a worsening insect issue. Biologic and abiotic variables account for around 200 million metric tons per year in lost rice production. Several severe diseases, such as tungro and yellow dwarf, are carried by insects and can affect rice crops. Due to the destructive habits of Lepidopteran stem borers and rice leaf folders, ten million metric tons of rice are destroyed annually. Rare epidemics can wipe off 60-95% of a harvest.

Nilaparvata lugens brown planthopper[3]was not a concern until it was exposed to pesticides, which contributed to the formation of secondary pests. Several large-scale rice production programs in areas like the Solomon Islands failed because of the usage of pesticides to battle more widespread secondary pest outbreaks, which led to the development of pest resistance. Moreover, agricultural workers were exposed to rice pesticides, which contributed to the evolution of insecticide resistance in human disease vectors. In flooded areas, these vectors quickly proliferate. The goal of pest management is to increase the efficiency of natural, non-chemical controls in order to reduce reliance on expensive pesticides, which can exacerbate pest problems, damage ecosystems, and generate intractable dilemmas for farmers who misuse insecticides. As a means of resolving issues with the long-term sustainability of traditional agriculture, we must work to expand IPM over the world. Integrated Pest Management (IPM) is a method that uses both chemical and biological methods to eliminate pests.

Predators can eat a wide variety of prey without harming vegetation [4]. In this way, they guarantee that pest control is fair and effective. Due to a lack of knowledge, predators are frequently overlooked as potential biological control agents. Kim *et al.,* reported that 40-45 days after rice is transplanted, in the middle of July, predators begin to multiply in the fields. Similar farmable conditions can be found in Japan. Spiders control unwanted insect populartions. Evidence suggests that rice field spiders can help reduce insect pest populations by preying on them.

The natural enemies of pest insects might be harmed by pesticides [5]. To maximize the efficacy of natural control agents, minimal pesticide application is recommended.

Understanding that even a negligible number of insect pests can help feed beneficial species and avoid outbreaks of other pests is crucial. Predator breeding for use in rice fields is an expensive endeavor. This research work helps to preserve agricultural crops by using bio-control agents and avoiding or minimizing the use of broad-spectrum pesticides and instead making use of insecticides that kill pests but leave beneficial insects unharmed.

Increased crop intensity complicates the use of tried-and-true strategies for reducing insect pest damage [6]. For the last several years, pest management that is grounded on an elementary knowledge of pest ecology has received a lot of attention. Pathogens including viruses, fungus, bacteria, protozoa, and nematodes are used to control insect pest populations biologically. Short-term chemical control and long-term biological control are both options for invitro pathogens. This article discusses the significance of ecologically oriented Integrated Pest Management in agriculture, focusing on the most modern biological control approaches used within an ecological framework in rice crop. The research investigates how farmers might best take use of natural controls in order to cut down on their usage of synthetic pesticides.

2. REVIEW OF LITERATURE

Soon after World War II, when synthetic organic insecticides became widely available, a few, far-sighted scientists documented that haphazard use of the new synthetic organic insecticides would verify to be problematic. According to Smith [3] reported that Californian entomologists developed the concept of “supervised insect control” in which insect control was to be supervised by qualified entomologists, and insecticide applications were based on conclusions reached from periodic monitoring of pest and naturalenemy populations. This was viewed as an alternative to calendar-based insecticide programs. The first program was initiated 60 years ago in supervised control and targeted alfalfa caterpillar, After a period of decade, the troubles with haphazard use of insecticides were becoming clear, including pest resistance, target pest resurgence, secondary pest outbreaks and environmental contamination. It was in this setting that four entomologists at University of California presented the concept of ‘integrated control,’ which was stated as ‘to identify the best mix of chemical and biological controls for a given insect pest’ [4]. This was one of the first understandable definitions of Integrated Pest Management (IPM). The concepts of economic threshold and economic injury level were also introduced by these authors. For managing spotted alfalfa aphid, Therioaphis maculata [5], on alfalfa grown for hay purposes, first integrated control program was devised. However, integrated control as originally formulated had a relatively slight center of attention. However, the challenging thought of ‘pest management’ gained support in some quarters of 1960s; it was wider and included large numbers of suppressive strategies such as host plant resistance, cultural control and semio-chemicals. Though, integrated control and pest management steadily became synonymous, even if each remained largely insect oriented. Early 1970s until the incorporation of all classes of pests, modern concept of IPM was born [6]. Overall Integrated Pest Management has been a valuable model for organizing research and extension efforts worldwide over the past 30 years.

3. METHODOLOGY

Twenty-five years after its first implementation, the concept of integrated pest control is widely regarded as one of the most beneficial agricultural scientific undertakings of the 20th century. Integrated Pest Management (IPM) uses cultural, genetic, mechanical, and biological methods, as well as chemical pesticides as a last resort, to keep insect populations below economic damage thresholds. Synergistic use of these methods and chemical insecticides is used. Community coexistence is promoted via integrated pest control. Many people believe that IPM is the greenest method of pest control available. Increases in international travel and trade have facilitated the spread of invasive species to new regions [7]. Responses against pests need to be created and put into action. To be effective, the plan must include all of the techniques used in IPM while posing as little risks as feasible. In the past three decades, IPM (Integrated Pest Management) has gained popularity as a green method of pest control in agriculture [8]. Integrated pest control strategies might save farmers money by reducing economic product loss from insect pests [9] without harming any other animals.

3.1. Integrated Pest Management and Principles

The following guidelines serve as the foundation for integrated production and pest management initiatives in Africa and Latin America:

- To cultivate a healthy soil and crop;
- To protect natural enemies;
- To monitor the field on a regular basis, including the soil, the water, the plant, pests, and natural enemies.
- That farmers should make an honest attempt to educate themselves and become specialists.

In the context of agricultural output, effective pest control, efficient agricultural practices, and sound economic judgment are essential components of rice Integrated Pest Management.

3.2 Biological Control Methods in Rice Crop

Food crops from the grass family, of which rice is one, are essential to human survival. Wheat and maize are the other two. Since rice is used as a staple meal in the majority of nations and is expected to remain so for the foreseeable future, it is one of the most significant crops farmed worldwide. More than 100 million families in Asia and Africa rely on revenue from the crop for subsistence and economic stability, according the Food and Agriculture Organization of the United Nations [10]. China, India, and Indonesia own more than half of the world's rice fields and eat almost all of the own country rice .

For emerging nations, where rice production has lagged behind population growth, the prospect of a food catastrophe has become more urgent. Several of the most influential rice farmers in the developing world have united to prevent rice exports [11]. A rise in the use of fertilizer and an increase in cropping are both results of the confluence of a scarcity of farmland and a strong demand for production. Increased insect populations were identified by Heong [12] as a risk to rice harvests as a result of these efforts [13]. Due to pest infestations, agricultural output is reduced in tropical Asia [14]. There are 128 distinct types of insects found in rice fields. Kalode claims that only around 20% of the 128 known insect species are commercially significant [15]. Nilaparvata lugens, more commonly known as brown planthoppers, are a destructive secondary pest of rice. Because of pesticide subsidies and government incompetence, this little but powerful insect has historically caused enormous losses [16]. However, even in areas where pesticides are often used incorrectly or excessively, the brown planthopper is still only a small threat. This bug is yet just a moderate concern, but it has the potential to act as a "hub" in the ecological sense, making ecological understanding and control essential for sustainable rice production. Brown planthopper is the major focus of IPM education initiatives because to the ongoing importance of preventing crop damage from outbreaks. (Figures 1 and 2).

Natural predators keep brown planthopper numbers under control. When pesticides were first widely used, they triggered tropical epidemics in the 1970s. The brown planthopper returns after being treated with pesticides, leading to "hopper burn" and the dehydration and death of rice plants. Insecticides can be used to get rid of brown planthoppers and other pests that threaten plant life. On the other hand, the eggs they deposit inside the stem are safe from injury and can develop into nymphs without being eaten. There is proof of biological control when the population of brown planthoppers does not increase in unsprayed regions. The rice stem borer is another major pest. We can find the yellow stem borer, or *Scirpophaga incertulas* Walker [17], all across India. It is the most harmful borer species known today [18]. Almost all of Northern West Bengal is plagued by yellow stem borer infestations [19]. In the northern parts of West Bengal, paddy is cultivated by choosing high-yielding cultivars, preserving temporal and geographical continuity, using large quantities of fertilizers and pesticides, and without engaging in rigorous management owing to a lack of scientific knowledge. The efficacy of the pest control technique as a whole, as it is promoted and defined on a national scale, has to be assessed on a more, micro, or local scale [20]. (Figures 3, 4 and 5).

Fig. 1 Brown plant hopper present on paddy rice leaf [5]

Fig. 2 During heavy infestation, brown plant hopper (BPH) sucking drains plant fluid and nutrients, causing rice plants to yellow and die [6]

Fig. 3 Stem borers on paddy rice leaf [7]

Figs. 4 and 5 Rice panicle neck rot. At the base of the panicle, signs of rotted neck occur. This assault almost always results in the panicle's demise. Infected panicles are white and hollow within [8]

3.3 Integrated Pest Management against Pests

Rats, snails, and birds are just a few examples of the pests that can cause harm to crops and thus need community planning and response. Rice fields are especially vulnerable to destruction by rats. Its ramblings can be heard across the rice fields. Following the panicle, its favorite food was rice. Farmers utilized insecticides and other measures to manage the rat population in their fields. Strategies for rat management have included things like determining the most common rat species in the area to ensure the effectiveness of the baits, using community-level mapping methods to plan and carry out continuous trapping along feeding routes, fumigating rats or digging holes in the ground, modifying appropriate habitat, and setting up bait stations in the early season with second-generation anticoagulant baits [10]. Some farmers, however, made use of very harmful pesticides like zinc phosphide and unlabeled aldicarb [11]. Almost all countries now prohibit the use of pesticides due to the deaths of children and small animals [12].

FAO [13] suggested increasing both the number of techniques developed and the number of individuals engaging in the program via community events that teach rat biology and behavior. One prerequisite for booting is year-round rat population control at the neighborhood level [14]. With the help of creative owl habitat management, the rat population in rice and plantation crops has reduced in Malaysia. Plastic trap-and-barrier devices might be useful in rice fields [15].

Birds could do the same damage to rice that rats do. They are dangerous when they join forces. The red-billed quelea [16] and other species are detrimental to the rice environment throughout Asia and sub-Saharan Africa. Most of Asia uses rice and other crops as "bird netting" to capture large numbers of birds for human consumption. There are various species of animals that are notorious for destroying nests. Using these strategies, the population of pest birds in Asia has been drastically reduced. Although the trapping approach has provided residents in Africa with a new revenue or protein source, it has had little effect on the continent's invading bird populations

[17]. Crops in northeast Asia are protected from birds using nets during the ripening stage.

The deployment of nets in the fields is essential for protecting the seed harvest. Several methods of frightening birds away from agricultural land in Asia and Africa ensure their safety. People in Asia employ films, cassette recordings, or reflective ribbons to frighten the birds away, while those in Africa yell at the birds or throw dry mud at them [18]. Damage to non-target aquatic creatures can result from the use of poisoned baits and the elimination of nesting sites. The whole city needs to have its rodent and bird populations reduced [19]-[20].

3.4. Materials and Methodology

The research was carried out at the regional rice field research center in Tamil Nadu, which is located in the city of Chennai in the Indian state of Tamil Nadu. Both of the research locations have nationwide rice-growing infrastructures. With 90% of the land at each site being used for rice cultivation, they provide a visual picture of the region's rice producing landscapes.

Two years and many rice growing seasons were devoted to the project. We can sow rice during the Aus, Aman (T. Aman), or Boro tree seasons. The Boro and T. Aman seasons were analyzed. Looking into the effectiveness of tree remedies. Instead of using pesticides on the rice, the initial treatment included flowering plant borders atop earthen bunds. (Figure 1). (hereafter T1). The second treatment consisted of applying insecticides to the rice as usual while leaving the bund unworked. (i.e., prophylactically at 15-day intervals) (T2). A fallow bund served as a control in the third treatment, which did not include the application of any kind of pesticides (T3). Boro's rice bunds were planted with a variety of crops, including sesame (*Sesamum indicum*), cosmos (Cosmos Sp.), marigolds (Tagetes Sp.), and sunflowers (*Helianthus annus*). T. Aman was the location where the first sesame seeds were planted. Fifteen thousand sunflowers and thirty thousand marigolds were planted each acre. The bund dispersed 2 tons of sesame seed per acre. The three blocks at each site had a total of 12 bunded plots, all of which were managed using a randomized full block design (n=3).

In the 2019-2020growing season in Boro and in 2020 in T. Aman, the giant rice varieties BRRI dhan28, 58, and 52 were grown. Manually transplanting rice seedlings aged 30–40 days into the fields was performed per the cultivar production package. Two or three seedlings were planted on a mound that was 20 cm × 20 cm in size. Fertilizers and irrigation were used after the therapy was done. The first application of Virtako 40WG (thiamethoxam 20%+chlorantraniliprole 20%) was made 15 days after transplanting, and further applications were made every 15 days (three times) throughout the duration of the growth season. This pesticide is used by farmers to treat their crops for rice stem borer infestations. During the 2019–2020 and 2020–2021 T. Aman seasons, BRRI dhan63 and dhan52 were tested and analyzed. Flowers with high nectar production were planted on the bunds of each T1 plot; they included cosmos in the T. Aman plot and marigolds in the Boro plot. Carbofuran 5G (10.0 kg/ha) was applied four times to T2 at 15-day intervals after the first top dressing with urea.

Sampling insect pests

At the peak of rice tillering, samples of insects were taken from each treatment. The plots were swept with a net 40 cm in width to gather the samples. The canopies of twenty plants were selected at random for this study. Bags were used to transfer the insects to the lab, where they could be processed, recognized, and counted.

Insect pests and their natural enemies were documented in the experimental plots using yellow sticky traps made by Zhangzhou Enjoy Agriculture Technology Co., Ltd. in Fujian. Sticky boards were set up over the canopies of rice fields, and individual traps were then attached to bamboo poles and set up there. The sticky traps were retrieved after forty-eight hours, transported to the lab, and kept at four degrees Celsius until the insects were counted and identified. Due to a lack of sticky traps in other areas, it was only used in one.

Essential pest parasitism rates were monitored by monitoring Brown Planthopper(BPH) eggs, White-Backed Planthopper (WBPH) eggs, rice hispa eggs, and yellow stem borer eggs. Laboratory exposure of 45-day-old rice plants in pots to several bugs produced sentinel egg baits. Each container with six plants was caged with five pregnant female planthoppers for 48 hours during both the BPH and the WBPH. Plants were grown in greenhouses for a certain amount of time before being transferred to experimental plots and adult planthoppers removed. Six-plant tree pots were placed at random in the center of each plot. In order to harvest moths for YSB, they were imprisoned above rice plants grown in pots. The YSBs were taken out after 24 hours, and the plants were sent out in the field in a manner similar to that in which planthopper eggs are laid. In addition, traps with rice hispa egg bait were strategically placed across the farm. The plants were left outdoors for 48 hours before being taken back inside, where they spent the next four days in a greenhouse at room temperature. Then, a microscopic check was made to see whether any parasitized eggs had been laid on the plants.

Assessment: We used 57 Tea hill countings to keep track of the various insect pests, damage symptoms, and natural enemies that were present on each hill. White head damage caused by YSB during rice crop reproduction was measured and reported as a percentage of the white head. A white-head percentage formula is presented.

$$\text{White head (\%)} = \frac{\text{No. of damaged hills (of 20 hills)}}{\text{Hills sampled (20 hills)}} \times \frac{\text{damaged panicles (of 20 hills)}}{\text{Totle panicles (of 20 hills)}} \times 100$$

Stats: The purpose of this research was to learn more about how natural enemies of rice field pests interact with rice bund plants in bloom. An One-Way Analysis of variance (ANOVA) and Tukey's post hoc Honestly Significant Difference (HSD) test were used to examine the effects of the treatments on predators, parasitoids, insect pests, parasitism, and rice yields. Log or arc sine conversions were applied to the data before checking for consistency. When the information in question was 0, the change took place on iteration (n+1). All data was analyzed using SPSS 16.0.

4. RESULTS

Insect pests and their natural enemies are shown in Fig. 6 for the Boro seasons 2019–20, 2020–21, and 2021–2022. During the Boro2019–2020 season, T3 had the highest number of grasshoppers (GHs) and yellow stem borers (YSBs). (Fig. 6A). T1 was able to lower GHs ($P<0.05$). There were no further reports of insect concerns. The green mirid bug (GMB) is the most important predator of the brown planthopper in rice fields. GMB populations were only found in T1. (Fig. 6A). T1 had a significantly higher number of spiders, damsel flies, and lady bird beetles in subsequent years compared to the other treatments (Fig. 6B, C, $P<0.05$). Rice insect pests and parasitoids were collected using yellow sticky traps. During the Boro season that took place in 2020–2021, T1 treatment plots had the highest amount of parasitoids, and traps facing east and west in each patch collected an equal number of individuals (Fig. 6D).

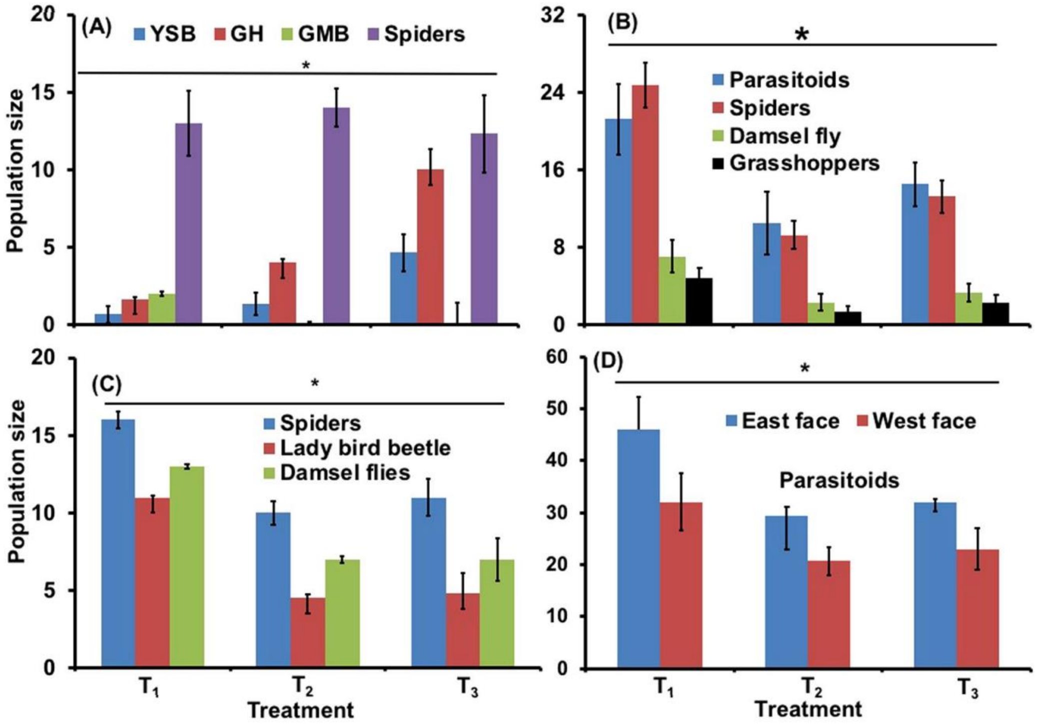

Figure 6: The impact of the treatment on insect pests and their natural enemies on a rice field. Yellow sticky traps were used to capture Boro parasitoids in the 2019–2020, 2020–2021, 2021–2022, seasons. T1 = flowering plants grown on rice bunds; T2 = preventative pesticide use; T3 = control; *denotes statistical significance (p.05). Standard mistake shown by an error bar. Grasshoppers are GH while green mirids are GMB.

Parasitism of important pests such the Brown Plant Hopper (BPH), White-Backed Plan Thopper (WBPH), Rice Hispa (RH), and Yellow Stem Borer (YSB) varied between treatments during T. Aman 2020 and 2021, and Boro 2019-2020 and 2021-2022 (Fig. 7). When compared to the other treatments, T1 had the highest percentage of parasitism of pest eggs.(Fig. 7, $P<0.01$). During the T. Aman season, parasitism of planthopper eggs peaked at 80% (Fig. 7A), whereas it never went over 60% during the Boro season. (Fig. 7C, D).

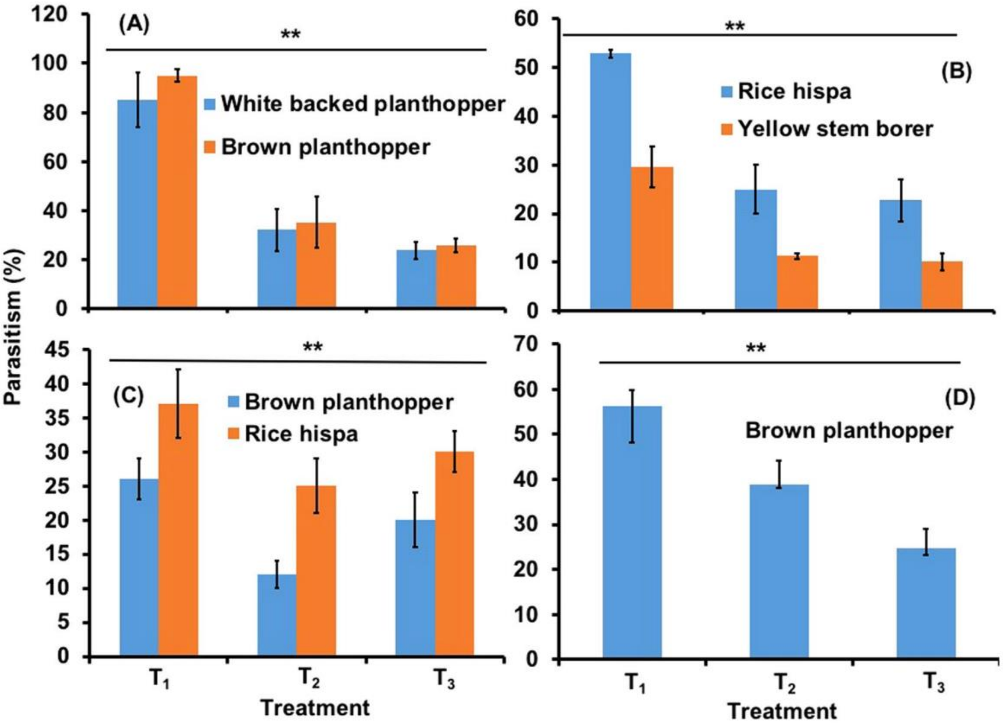

Fig. 7: The effects of treatments on rice fields and the parasitism of sentinel insect pest eggs. T1 is for the cultivation of flowers on rice bunds; T2 is for the application of prophylactic insecticides; and T3 is for regulation. (no insecticide and no flowering plants used). Egg parasitism in BPH (A), Boro (B) in 2019–2020, T. Aman (C) in 2020–2021, and D) in 2021–2022. The asterisk denotes a significant (5%) treatment difference. Error bars depict the standard deviation of the data.

5. CONCLUSION

The presence of natural enemies and the rate at which parasitoids and other parasites consumed eggs from insect pests were both highest in rice fields that were in close proximity to nectar-producing flowers. However, in rice fields that had been presumptively treated with pesticides, both the number of natural enemies and the proportion of egg parasitism were much lower. Additionally, a contrast was drawn between insecticide-sprayed rice fields and untreated ones bordered by flowering plants. That group's output fell dramatically. This suggests that farmers can be able to reduce their reliance on potentially harmful pesticides by growing nectar-rich flowering plants on the bunds around rice fields. An alternate strategy for eradicating annoying insects. It's possible that using this method could help to restore rice ecosystems, keep natural enemies around to cut down on production costs and chemical inputs, improve environmental safeguards, cut down on insect infestations, and reduce the time and effort required to spray for pests, all of which could increase profits. The land has been partitioned up into several smaller plots delimited by boundaries, all of which are suitable for the cultivation of flowering plants. This creates new opportunities for using this technology in the rice business; the remaining challenge is getting the world out to farmers.

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