Demonstration of Ecological Engineering and Eco-friendly Pest and Disease Management Strategies in Paddy

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A B S T R A C T

Ecological Engineering and ecofriendly pest and disease management strategies in paddy is the need of the hour because of reduction in natural enemies population in rice ecosystem due to indiscriminate use of pesticides. Ecological Engineering and ecofriendly pest and disease management strategies in paddy was demonstrated in the farmers' field as Front Line Demonstration in Nagapattinam district of Tamil Nadu. In the demonstration plot the dead heart symptoms was 3.63% and white ear was 0.86% compared to 13.29% and 2.90% dead heart and white ears respectively in the farmers practices adopted plot. In the same manner the leaf folder damage was also low in the demonstration plots. The pest defender ratio was 0.75:8 in the demonstration plot and it was 4:1in the farmers practices adopted field. The per cent Disease Index (PDI) for blast was 0.73%, PDI for Bacterial Leaf Blight (BLB) was 2.47% compared to 5.12% and 9.51% respectively in farmers practices adopted field. The PDI of false smut was 0.33% in the demo plot and it was 3.33% in the farmers practices adopted plot. In the demonstration plot the highest yield of 56.57 Q/Ha was recorded when compared to only 34.73 Q/Ha in the farmers practices adopted plot. The net return was Rs. 35,540/Ha whereas, in the farmers practices adopted plot the net return was only Rs.9,458/Ha. The benefit cost ratio was 1:1.82 in the demonstration plot and it was 1:1.24 in the non-demo plot.

Introduction

Paddy (*Oryza sativa* L.) is the stable food crop for 50 per cent of world population. About 90 per cent of paddy area is in Asia. Around 1373 insect pests are known to attack paddy crop. Among these, 20 to 30 insect pests are causing economic damage and causes reduction in yield up to 25 to 30%.

Pest problems have increased tremendously due to monoculture, overlapping of crops, dense cropping and availability of preferred host. Intensive rice production with the primary goal of achieving high yield is often characterized by the excessive application of fertilizers and pesticides. It has led to many negative environmental effects, such as the reduction of biodiversity and natural

biological control, high pesticide residues in rivers, drinking water and agricultural products, rapid and high insecticide resistance in pests, secondary pest outbreaks, environmental pollution and ecological imbalance. These severe negative effects will damage the ecosystem, lead to frequent pest outbreaks and in turn require an increased pesticide dosage, which form a vicious circle (Conway and Pretty, 1991).

Ecological engineering is a relatively new concept of habitat manipulation for the benefit of man and the environment. Habitat manipulation is growing nectar producing flowering plants combined with trap plants on the rice bounds, reducing the intensity of pesticide use and nitrogenous fertilizers, and managing the vegetation in non-rice habitats including the rice-free season (Sree Latha and Jesu Rajan, 2018).

The purpose of ecological engineering for pest management was to exploit the cultural practices, usually based on vegetation management, to enhance biological control. Alternative to chemical method is biological control and in ecological engineering concept, growing flowering plants is key component to provide resources such as nectar and pollen to natural enemies to promote biological control. It includes attractant plants to attract the natural enemies, repellent plants to repel the pests, trap plants to attract and trap the crop pests, barrier/guard plants to prevent the entry of pests. It also includes trap crops that divert pests away from crops and changing monocultures to polycultures in agroecosystem.

Keeping this in view the demonstration of Ecological engineering and ecofriendly pest and disease management strategies in paddy was demonstrated as Front Line Demonstration in the farmers field at Nagapattinam district of Tamil Nadu, India

during Rabi season (October to January) 2016-17.

Materials and Methods

Front line demonstration was conducted at Nagapattinam district of Tamil Nadu during Rabi season (October to January) 2017-18. Nagapattinam district is located in Cauvery delta zone of Tamil Nadu and paddy is the major crop and cultivated in 1,60,440 hectares during Rabi season. The prioritized problems observed were reduction in natural enemies due to indiscriminate use of pesticides in rice ecosystem and lack of knowledge on eco friendly pest and disease management strategies among the rice growing farmers in the Nagapattinam district. There were 10 demonstrations one acre each. In the demonstration plot the following technologies were demonstrated. In the bunds of rice field the farmers were instructed to grow the sunflower, marigold, sesame and black gram for nectar and pollen sources for parasitoids and predators.

Neem cake was applied @ 250kg/Ha during last ploughing. The paddy seeds were treated with talc formulation of TNAU *Pseudomonas fluorescens* (pf1) @ 10 gm/Kg seeds. For the management of rice yellow stem borer, egg parasitoid, *Trichogramma japonicum* @ 5cc/Ha were released at 30 and 37th days after planting and yellow stem borer pheromone traps were installed 12 numbers/Ha. For the management of rice leaf folder, *T. chilonis* were released @ 5cc/Ha at 37, 44 and 51 days after planting. For the management of bacterial leaf blight and false smut - foliar spray of *P. fluorescens* @ 2.5 kg/Ha and spray of fresh cow dung extract 20%.

For the management of sucking pests - Azadirachtin (10,000 ppm) @ 1250 ml/Ha were sprayed at the time of early infestation. *Lecanicillium lecanii* and *Beuvaria bassiana*

were applied @ 5 kg/acre during active tillering stage and panicle initiation stage for the management of sucking pests and larval pests. The were about 250 bird perches were erected to attract the predatory birds and one light trap was installed (TNAU, 2012). The per cent pest and disease incidence, predator and parasitoid population were recorded in all the demonstration and farmers practices adopted plots during active tillering stage, panicle initiation stage, flowering and harvesting stage. Farmers were instructed to adopt all other recommended package of practices. The farmers were motivated about the ecological engineering and ecofriendly pest and disease management strategies through trainings, mass media and conducting field day for vertical spread of the technologies to the other farmers. The farmers were insisted to adopt these strategies on community basis and avoiding use of insecticides for building up of the beneficial insects for effective management of the pests. In the demonstration plot no inorganic pesticide were applied. The cost of the critical inputs was Rs.7500/Ha. The cost of cultivation and yield parameter were collected from the farmer at the end of the season and economic analyses were done using the prevailing input and output costs.

The extension gap, technology gap and technology index were worked out. To estimate the technology gap, extension gap and technology index, following formulae given by Samui *et al.,* (2000) was used.

Technology gap = Potential yield (q/ha) - Demonstration yield (q/ha)

Extension gap = Demonstration yield (q/ha) - farmer's practice yield (q/ha).

Technology Index = (Potential yield - Demonstration yield) / Potential yield) x100

Results and Discussion

The results from table 1 revealed that in the demonstration plot the dead heart was 3.63% and white ear was 0.86% compared to 13.29% and 2.90% dead heart and white ears respectively in the farmers practices adopted plot. In the same manner the leaf folder damage was also low in the demonstration plot. The pest defender ratio was 0.75:8 in the demonstration plot and it was 4:1in the farmers practices adopted field.

The Per cent Disease Index (PDI) for blast was 0.73 and PDI for Bacterial Leaf Blight (BLB) was 2.47 compared to 5.12 and 9.51 respectively in farmers practices. The PDI of false smut infestation was 0.33% in the demonstration plot and it was 3.33% in the farmers practices adopted plot (Figure 1). In the demonstration plot the highest yield of 56.57 Q/Ha was recorded as compared to only 34.73 Q/Ha. The net return was Rs. 35,540/ha whereas, in the farmers practices adopted plot the net return was Rs.9,458/Ha. The benefit cost ratio was 1:1.82 in the demonstration plot and it was 1:1.24 in the non-demo plot (Table 2). The results in table 3 revealed that the technology gap was 5.98 Q./ha, the extension gap was 21.84 Q/ha and the technology index was 9.56%.

In the present study the pests and diseases incidence was significantly low in the demonstration plots when compare to farmers practices adopted plot. It might be due to the pest defender ratio was more in the demonstration plot *i.e.* natural enemies population was more compared to pest load. It might kept the pests under control. The border or bund crops like sesame, marigold, black gram and sunflowers might supported the multiplication and survival of natural enemies. The bund crops might provided pollen and nectar for natural enemies. Earlier studies also supported this finding. Nectar

food management can not only increase the longevity and improve the reproduction of natural enemies, but also plays a role in enhancing the biological control ability of natural enemies (Wackers *et al.,* 2005).

In China, growing the flowering plant sesame (*Sesamum indicum*) on rice field bund and road side to improve biological control has been listed as a main component of the nationally recommended sustainable management of rice insect pests by ecological engineering (Lu and Guo, 2015). Y-tube olfactometer assays indicated that the egg parasitoids *Anagrus optabilis* and *Anagrus nilaparvatae* are significantly attracted by the volatiles from sesame. Similarly, both of these two parasitoids significantly parasitize more BPH eggs in the presence of sesame flowers (Zhu *et al.,* 2012).

The predatory bug *Cyrtorhinus lividipennis* is an important natural enemy of rice planthopper eggs and young nymphs (Katti *et al.,* 2007; Sigsgaard, 2007). The adult longevity of *C. lividipennis* with access to sesame flowers can be extend, along with significantly increased egg consumption and strongly promoted predation (Zhu *et al.,* 2014). Meanwhile, the real fecundity of *Trichogramma chilonis*, a common egg parasitoid of *Lepidoptera* pests, is significantly increased by sesame flowers.

Non-rice habitats, as refuges and pools of arthropods in rice ecosystem, play important roles in the reconstruction and development of arthropod community in rice fields (Yu *et al.,* 1996; Zhang *et al.,* 1997; Gu *et al.*, 1999). Bunds and other non-rice habitats are rich in natural control resources and can effectively regulate the pest populations in rice fields (Li *et al.,* 2002). An arthropod investigation in rice fields and adjacent non-rice habitats showed that parasitoid species in rice fields and non-rice habitats accounted for 45.89% and 46.60% of the total natural enemy species, respectively (Xu *et al.,* 2004). There are huge populations of *Oligosita* spp. on gramineous flora, such as *Digitaria anguinalis* and *Eleusine indica*, and there are abundant of *Anagrus* spp. Field studies conducted with different flowering plants suggested that growing of sesame, bhendi, sunflower and sunhemp attracts large number of predators and parasitoids like coccinellids, ground beetles, *Anagrus* species, *Bracon* species etc., which attack the pests (Sree Latha and Jesu Rajan, 2018). Habitat manipulation aims to provide resources such as pollen (Hickman and Wratten 1996), nectar (Baggen and Gurr, 1998), alternative prey, physical refugia (Halaji *et al.,* 2000), alternative hosts, lekking sites (Sutherland *et al.,* 2001) and (Viggiani, 2003) to the natural enemies.

Table.1 Comparative analysis of Pests incidence and natural enemies in the demonstration and in farmers practice plot

Parameters	Demonstration plot*	Farmers practice plot *
% dead heart	3.63	13.29
% white ear	0.86	2.90
% leaf folder damage (vegetative)	2.79	11.92
% leaf folder damage (flowering)	1.14	7.28
Pest Defender Ratio	0.75:8	4:1

* Mean of ten demonstrations

Table.2 Economic analysis of cost and returns in the demonstration and in check plot

| Parameters	Demonstration plot*	Farmers practice plot **
Gross cost of cultivation (Rs./Ha.)	43,658	39,167
Yield (Q/Ha.)	56.57	34.73
Gross income (Rs./Ha.)	79,198	48,625
Net return (Rs./Ha.)	35,540	9,458
Benefit Cost Ratio	1.82	1.24

* Mean of ten demonstrations

Table.3 Technology gap, extension gap and technology Index of Ecological Engineering IPM paddy

Potential yield (Q./Ha.)	Demonstration yield (Q./Ha.)	Farmers practice yield (Q./Ha.)	Technology gap (Q./Ha.)	Extension gap (Q./Ha.)	Technology index (%)
65.53	56.57	34.73	5.98	21.84	9.56

* Mean of ten demonstrations

Figure.1 Comparative analysis of Per cent Disease Index (PDI) in the demonstration and check plot
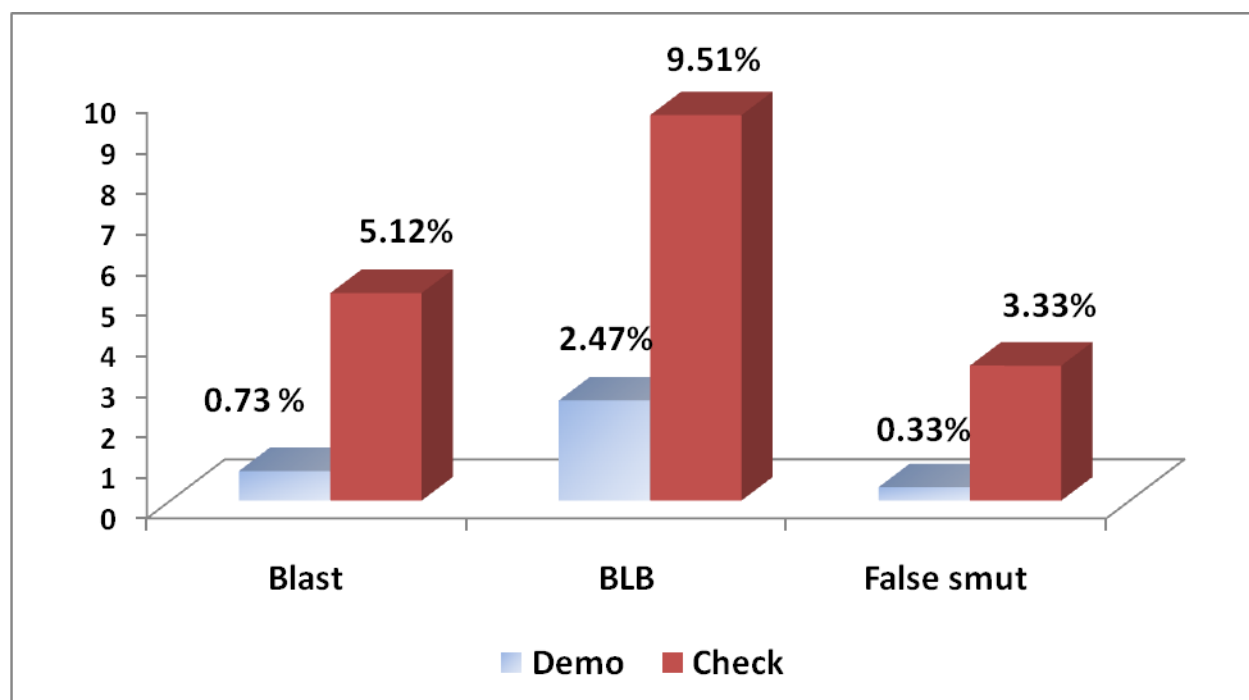
The technology gap in the demonstration yield over potential yield were 5.98 Q/ha. The technological gap may be attributed to the dissimilarity in the soil fertility status. The latest technologies will eventually lead the farmers to discontinue the traditional technology and to adopt new technology. The extension gap was 21.84 Q/ha during the period of study which emphasized the need to educate the farmers through various means for the adoption of improved agricultural production to reverse the trend of wide extension gap. The technology index was 9.56 percent which showed the feasibility of the evolved technology at the farmer's field. Tiwari *et al.,* (2015) reported that the lower the value of technology index, the more is the feasibility of the technology.

In conclusion, experimentation with ecological engineering is revealed that it offers immense opportunities to rice pest management using non-chemical methods leading to economic and environmental benefits. Ecological engineering is not a "high-tech" approach so simple and practical for rice farmers to implement. For the successful implementation of this technology motivating the farmers to follow these eco-friendly approaches on community basis is essential. A collective approach by the farming community will not only suppress the pest population but also enhances the soil micro flora and enrich the soil with organic matter.

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