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RESEARCH ARTICLE :

Aromatic variety as a trap crop for stem borer management in rice

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SUMMARY : Yellow stem borer (YSB) is a key pest affecting all the growth stages of the rice plant from nursery to harvest. In India, we observe 4-5 generations of this pest in a cropping season. The YSB larvae emerge out from the egg masses laid on the leaf laminae, reach to the base of the tillers with the help of silken threads, enter the stem by making a tiny hole just above the water level and feed on the growing stem primordia. Once the larva gains entry into the tillers, the damage is reflected either as dead heart or white ear head or the grain filling is affected in the panicle, depending on the stage of the crop. Economic yield loss particularly due to white ear damage has been estimated to range from 38 to 80 %. During the search for an eco-friendly alternative to insecticide use, studies were carried out to explore the possibility of using a susceptible variety as a trap crop to wean way the pest from damaging the main crop. Initial efforts made at ICAR-IIRR revealed the utility of aromatic varieties of rice in trapping the larvae of yellow stem borer which were attracted to these varieties more than the non aromatic lines. Of the many varieties tested, Pusa Basmati-1 was found to be the most susceptible aromatic variety which when planted in the main field can help in minimizing the damage to the main crop. The duration of the main crop and the trap crop were considered based on which the date of sowing was adjusted so that the trap crop would come to booting a week earlier than the main crop. However, planting of main crop and trap crop was done at the same time. Planting of one row of Pusa Basmati- 1 as trap crop, preferably in east– west direction, for every 2.5- 3m of main crop, resulted in effectively managing the pest in the main field planted with popular variety. The stem borer damage observed in the main crop was half of the damage that was recorded in the trap crop. By adopting this practice in a stem borer endemic area, impulsive spraying of chemical pesticides against yellow stem borer could be avoided at the vegetative stage. The yield was higher in the main crop where trap crop was grown compared to the fields without the trap crop. Also, though the yield in trap crop was affected due to higher pest damage the resulting yield from the trap crop would still be of added advantage as aromatic rice fetches premium price. The loss in yield was offset by the higher returns for the farmer due to higher price of the produce. The strategy has been tested across various locations under both FLDs in the Telangana districts as well as different locations across different states under All India coordinated Rice Improvement Project (AICRP) with locally recommended and popular main crop varieties such as Prakash (RP4-14), Swarna, BPT 5204, MTU1010, Krishna hamsa, Tellahamsa etc. resulting in a favourable B: C ratio. The eco-friendly tactic has thus, been included as one of the integral components of recommended rice IPM modules, particularly in stem borer endemic areas. It can also be integrated along with alley ways and sex pheromones. Theres a dire need to create awareness among the farmers to adopt such eco-friendly practices of pest management to reap the benefits.

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BACKGROUND AND OBJECTIVES

Yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) is the most dominant species among stem borers on rice in India. It is a monophagous pest which feeds and survives only on rice host. YSB is a regular and key pest affecting all the growth stages of the plant from nursery to harvest. In India there are reports of 4-5 generations of the pest in a year. The YSB larvae emerge out from the egg masses laid on the leaf laminae, slide down to the base of the tillers with the help of silky strings, invade the stem by making tiny hole just above the water level and feed on the growing stem primordia. Once the larva gains entry into the tillers, invariably the damage is reflected either as dead heart or white ear head or the grain filling in the panicle is affected depending on the stage of the crop. The yield loss has been estimated to range from 38 to 80 %.

Farmers usually resort to chemical control measures for managing the pest. However, indiscriminate use of insecticides nullifies economic, environmental as well as health benefits. Sex pheromones were found to be effective and safer options in monitoring and mass trapping of the yellow stem borer moths, thus, minimizing the damage but non-availability of the pheromone lures is the major constraint in adoption of this technology. During further search for environment friendly alternatives, the concept of adopting an age old practice of planting inter crop as trap crops for yellow stem borer management was found to be a promising one.

Trap crops have been defined as " plant stands that are; per se or *via* manipulation, deployed to attract, divert, intercept, and/or retain targeted insects or the pathogens they vector in order to reduce damage to the main crop. " Insects and their host plants interact and become influenced by size, fragmentation and connectivity of host patches (Tscharntke and Brandl, 2004). In some instances, the trap crop and the main crop are the same crop, but the trap crop is planted earlier than the main crop (Smith and Liburd, 2015).

Enhancing the effectiveness of the trap crop is vital to minimize the land sacrificed to production commonly known as "land equivalent ratio" when using trap cropping as pest management strategy. General guidelines for trap cropping recommend that about 10% of the total crop area be planted with the trap crop, although the percentage of trap crop needed for a particular system has to be determined for each case. Ultimately, the combination of insect behavious and trap crop characteristics, value of the trap crop and practical considerations determines the success of a trap cropping system (Shelton and Badenez-Perez, 2006).

Varma et al. (2002) demonstrated that synergizing pheromone blends with extracts of Pusa basmati1 increased the trap catch of yellow stem borer (YSB) in rice. Pusa Basmati 1, an aromatic fine grained rice variety exhibited more stem borer damage than other varieties. Based on the basic principles of trap cropping a strategy was developed at ICAR-IIRR (formerly Directorate of Rice Research) to trap the YSB insects on the susceptible Pusa Basmati1 variety (Padmakumari, unpublished) and minimize the damage on the main crop. A proper understanding of the insect biology, behaviour and dynamics is very important in successful adoption of this strategy. Keeping in view the above principles of trap cropping, research studies on planting pattern of trap crop at ICAR-IIRR (Padmakumari and Pasalu, 2003) identified that transplanting one row of Pusa basmati 1 as a trap crop for every 9 rows of main crop (2.5-3 m) in east-west direction would minimize stem borer damage in the main crop. The sowing time of the trap crop (Pusa Basmati 1) should be adjusted such that the trap crop flowers one week before flowering of the main crop. Here we report the results of the on farm trials taken up in the farmers fields through Front line demonstrations.

RESOURCES AND METHODS

The demonstrations were carried out in farmers fields of Medchal and Mahboobnagar districts of Telangana region on 25 acres of land. The main crop variety was a local popular variety of farmers choice. To facilitate easy adoption by the farmers the technology was modified to reap the optimum benefits. The duration of Pusa basmati 1 is 135 days and for a trap crop to be effective, the trap crop should reach booting stage 6-7 days before the main

crop. The duration of the main crop and the trap crop were considered based on which the date of sowing was adjusted so that the trap crop would come to booting a week earlier than the main crop (Table A). For every 2.5- 3m of main crop one row of trap crop (Pusa Basmati-1) was planted preferably in east – west direction. The experiment was laid out in farmers fields of Medchal and Mahboobnagar districts of Telangana region on 25 acres of land. The main crop varieties which is of farmers choice included, Prakash, MTU1010, BPT5204, Krishna hamsa, Tellahamsa and private hybrids.There were two main treatments 1) main crop alone 2) main crop with trap crop with 4 replications in each treatment and all the recommended agronomic practices were followed for raising the crop. The duration of these varieties varied from 120-150 days. An insecticide spray was advocated to protect the main crop when the damage in the trap crop exceeded more than 25%. Observations were recorded on total tillers and number of dead hearts were recorded at 30 and 50 DAT; panicle bearing tillers, and number of white ears at pre harvest from 25 hills per replication. In each of the fields, observations were also recorded on egg mass number in 50 hills each of main crop and trap crop to observe the ovipositional preference of the insect. Three pheromone traps were also placed in each of the farmers field to record the adult moth catches of YSB. Grain yields (main crop yield and trap crop yield) were recorded from a uniform area of 9×3 sq m^2 at two places in each replication separately and the yield is calculated per hectare basis. Based on the land equivalent ratio of the trap crop, benefit cost ratios were worked out from the obtained yields and the cost of cultivation involved in each case.

Alley ways and trap crop: In brown planthopper endemic areas where taking up alley ways are recommended, the trial in farmer's field included planting of one row of PB1 along the alley way and one row of trap crop on either side of the main crop along the alley way(which equals to two rows). Private hybrids such as 303, 6666 and 2222 were cultivated in these areas.

At the time of planting precautions were taken to – keep the nursery free from any stem borer infestation and ensuring no carry over from nursery to the main field. ii. ensure that the trap crop seedlings were well established in the field after transplanting. At the time of harvest, in case of use of combines for harvesting, the trap crop rows were harvested manually a day earlier to the normal harvest. All the other agronomic practices were taken up as per the recommended package of practices.

Table A: Sowing schedule of the trap crop

duration of the main crop is	Sowing of Pusa Basmati 1 done
120 days	10 days before the main crop
135 days	6 days before the main crop
150 days	10-13days after the main crop

OBSERVATIONS AND ANALYSIS

The incidence of stem borer was monitored through the pheromone trap catches. The catches varied from 2-30 moths per trap.The incidence of stem borer at vegetative stage varied from 3.9-10.5% dead hearts(DH), while the white ear (WE) damage ranged from 3.97-8.8 % in fields with main crop grown alone but when the main crop was grown along with the trap crop, the white ear damage was reduced to half of that in the main crop though in some situations there was no significant difference in dead heart damage. In three locations stem borer incidence was not observed at vegetative phase. The damage in trap crop of Pusa basmati was always high and recorded upto 13.7% farmers fields (Table 1). The time of sowing for various durations of the main crop ensured effective minimization of the damage. This has also been reflected in other main crop varieties like Swarna, Jalpriya, Karjat 3,TPS3, ADT3, Rajendra kasturi. (DRR, 2009-2011; Padmakumari *et al.*, 2008a,b; Padmakumari, 2012). Considering the grain yield, the main crop yields were comparable between the treatments where it was grown along with trap crop and where it was raised alone. PB1 being a premium crop the yield from trap crop was an additional advantage. It was observed that the damage did not reach the economic threshold level (less than 10% in all the fields), saving cost of insecticidal application. Hokkanen (1991) opined that the main crop seldom needs to be treated with an insecticide and thus, the natural control of pests is unaffected. Since the yield from trap crop is of high value, the benefit cost ratio was favourable (>1.5:1)in fields planted with trap crop.

Trap crop with alley ways :

The stem borer damage at vegetative stage ranged from 6.2 to 11.9% in main crop and 12.1 to 14.9% in trap crop (Table 2). There were no discernible differences in damage between main crop alone and main crop along

with trap crop as well as trap crop alone. However, at harvest, the fields with trap crop showed significantly less damage (2.4 to 5.5% WE) compared to fields with main crop grown sole (8.6 to 10.6% WE). The trap crop also showed significantly higher damage range of 10.3 to 16.1% WE). Results also suggest that the trap crop can be planted on one side of the alley way without any affect on the yield. Though the reduction in damage is more when two rows of trap crop are grown, it is not economical to raise the trap crop on either side of the alley ways. However, it was observed that trap crop can be planted along the alley way helping in integration of both cultural practices.

Table 1: Effect of trap crop on stem borer damage in the main crop

Farmer	Variety	Dead hearts (%)		White ears (%)		Total yield (main crop + trap crop)	B:C
		MC	TC	MC	TC	Kg/ha	
1.	MTU1010+TC	9.8	13.7	4.3	9.2	7150.6	1.86:1
	MTU1010(sole Crop)	10.5	-	8.8	-	6111.1	
2.	BPT 5204+TC	3.8	7.6	4.9	8.7	7015.3	2.53.1
	BPT 5204(sole crop)	7.13	-	5.2	-	6111.1	
3.	BPT 5204+TC	1.6	8.6	3.0	12	4038.5	2.6:1
	BPT 5204(sole crop)	7.1	_	7.3	-	3999	
4.	BPT 5204+Tc	No incidence		3.2	4.6	6708.9	1.52:1
	BPT5204(sole crop)	-		3.97		5740.7	
5.	Var 303	No incidence		5.3	7.5	4365.8	1.52:1
				7.0		4000.0	
6.	MTU1010+ trap crop	5.0	8.0	2.8	8.6	6166.7	
	MTU1000	5.6	-	5.8		6111	
7.	BPT 5204+TC	1.9	7.6	1.7	13.6	4267.2	3.1:1
	BPT5204(sole crop)	8.6		5.6		4000.5	
8.	Tellahamsa+Tc	3.6	4.2	1.7	12.3	4915.6	4.3:1
	Tella hamsa(sole crop)	8.8		5		4600.0	
9.	Var.6666+TC	6	11.8	3.3	7.86	7400.0	03:01
	Var.6666	9.2	-	4.95	-	6600.0	
10.	var6666+TC	4	11.5	2	11.7	7150.0	2.8:1
	6666	7.5	-	4	-	6600.0	
11.	Swarna+TC	5.4	7.8	1.4	6.7	4716.0	
	Swarna(sole crop)	3.9		1.7		4665.0	
12.	Prakash+TC	No incidence		1.9	5.1	4861.0	2:1
	Prakash+TC			2.5		4081.0	

MC- main crop:TC-Trap crop: Sc – sole crop

Table 2: Effect of trap crop along the alley ways on stem borer damage

Variety	Dead hearts (%DH)		White ears (%WE)		Total yield (TY) (kg/ha) (MC+TC)
Single row of trap crop along the alley ways a					
Main crop	MC	TC	MC	TC	
Var. 303	11.7	-	10.6	-	5318
Var.303+PB1 one row	11.9	14.9	5.4	10.3	5555
Two rows of trap crop (on either side of alley way)					
Var.303	11.7	-	10.6	-	5318
Var.303+two rows TC	10.3	12.1	5.5	16.0	4537
Var.2222	8.5		8.61	-	6111
Var.2222+TC (one row)	6.2	14.2	2.39	14.1	7800

MC- main crop:TC-Trap crop: Sc – sole crop

Effect of trap crop on oviposition :

Data on egg mass numbers collected in the treatments with trap crop and without trap crop across the different main crop varieties over years revealed no significant difference in the number of egg mass laid on the trap crop and the main crop. Earlier studies also suggested that yellow stem borer does not have any ovipositional preference (Khan *et al.,* 1991). In our study we observed that the egg mass were laid on both the leaf blade and stems of the plants. The phenomenon is more prominent in the *rabi* season and there's no significant difference in the number of egg laid between leaf blade and stems. Pimentel, (1961) suggested that the relative 'trapping effect' depends upon the size and purity of the plant stand.

Overall, the studies revealed that stem borer damage observed in the main crop was half of the damage that was recorded in the trap crop. It can protect the main crop without much economic loss and by adopting this methodology in a stem borer endemic area, one impulsive spraying of chemical pesticides can be avoided at the vegetative stage. This would also help in conserving the natural enemies. The yields in both the main crops (grown sole and with trap crop) would be almost same or at times higher in the main crop where trap crop is grown, but in the latter situation yield from the trap crop would be of an added advantage. Pusa Basmati 1 being a premier scented variety, fetches more price in the market. Hence, the cost benefit ratio was found favourable (> 1.5) for the different combination of varieties. Hence the cost benefit ratio has always been favourable and is > 1.5 for the combination of varieties test. Similarly trap crop as a perimeter was advocated for management of *Nephotettix virescens* by Saxena *et al.* (1988) and for rat management (Lam, 1998). Companion crops were advocated in a climate adapted push –pull strategy to minimize the damage by striga and stemborer in maize crop thereby increasing grain yields (Midega *et al.,* 2015).

Conclusion :

This method of pest management utilises the concept of exploitation of host plant susceptibility for management of yellow stem borer. Through this technique of raising one row of susceptible aromatic variety as intercrop, within a main crop, the stem borer damage in the main crop could be reduced by half of that recorded in the trap crop, thereby lowering the damage below ETL. Hence, this is a technology is suitable for small farmer as the cost incurred on one spray application could be avoided with additional yield from trap crop. Here it's a companion crop where we can harvest the yield from both the main crop and trap crop (Vandermeer, 1989). The favourable cost benefit ratio along with low insecticide use is the hidden ecosystem service whose cost is invaluable. This technology can also be integrated with alley ways, sex pheromone traps etc. and can be advocated as a component of IPM. Pest management benefits can also be realized from intercropping due to increased diversity. However, awareness needs to be created among the farmers to adopt such ecofriendly practices of pest management to reap the benefits. Further studies are being carried out to identify more suitable aromatic lines for use as trap crop to protect the main crop from much economic loss due to yellow stem borer. Understanding the chemical ecology interactions between trap crop and the pest will be the key focus area for future research.

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