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Enhancement of spiders' population through habitat management in rice (*Oryza sativa*) fields

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ABSTRACT

Spiders constitute over 90% of the natural enemy population in rice fields which play important role to contain the insect pests. Due to indiscriminate use of insecticides their population is adversely affected. Hence, there is a need to develop technology for conservation of spiders. In the present study, field trials were conducted in rice for two consecutive years, 2006 and 2007 at Atterna (Sonipat-Haryana) with 'Pusa Sugandh 4' ('Pusa 1121') for conservation of spiders using straw bundles and planting of other suitable crop on border to increase crop diversity. The experiment included five treatments, ie straw bundles+maize (T_1), straw bundles+sunn hemp (T_2), straw bundles+*Sesbania* (T_3), only straw bundles (T_4) and control (T_5) without any interventions. Each plot was of 0.5 acre in size. The straw bundles were placed in sorghum field for 15 days for charging with spiders before use in rice. In rice, these bundles were fixed vertically with bamboo sticks after 15 days of rice transplanting @ 20 bundles/ha so that the lower portion of the bundle remained 15 cm above the water level. The observation made on charging of the straw bundle indicated that each bundle contained 30–40 spider adults, 8–10 spider egg masses, 500–600 spiderlings and 20–30 earwigs. All the treatments (T_1 to T_4) had significantly lower stem borer and leaf folder as compared to control in both the years. The progressive populations build-up of spiders during the entire crop season indicated only one peak, ie the maximum spider population in September. Spider population on paddy plants remained significantly higher in T_1 to T_4 as compared to control. On the plant, the maximum spiders remained confined to lower part of the plant (up to 25 cm above the ground). Species composition of different spiders prevailing in paddy crop has also been discussed in the paper.

Key words: Leaf folder, Rice, Spiders, Straw bundles, Stem borer

In rice (*Oryza sativa* L.) fields, spiders have been reported to represent more than 90% of the natural enemies of brown plant hoppers in Korea (Lee *et al*. 1997) and their population is significantly reduced by the application of insecticides, especially by carbofuran (Bae *et al*. 1994), which is widely used in rice fields. During the recent past, promoting generalist predators in agriculture via habitat manipulation has gained much interest in biocontrol research. Straw shelters have been used by Chinese farmers for >2 000 years to provide temporary spider refugia during cyclic farming disturbances (NAS 1977, USDA 1982). Large-scale uses of this technique in China have presumably contributed to significant reduction in pesticide use (50–80%), pest control costs (80%) and enhanced crop production (NAS 1977, Wang 1982). However, the technology has never been systematically evaluated in India. Some other methods documented in the literature for conservation of natural enemies also require field evaluation. The present study was aimed to device habitat management tactics for conservation of spiders in rice through intercropping or artificial contrivances.

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MATERIALS AND METHODS

Field trials were conducted for two consecutive years during 2006 at Atterna village (Sonipat-Haryana) on evaluation of habitat management tactics through artificial structures, ie straw bundle and border cropping with maize, sunn hemp, *Sesbania* for augmentation and conservation of spiders in rice. The straw bundles were prepared with wheat straw placed in plastic nets. Each bundle was about 90 cm in length and 25 cm in diameter (Tanwar *et al*. 2008). Both the ends of these bundles were tied with plastic rope (Fig 1). These bundles were placed in sorghum fields (more than 90 days old crop) for charging with spiders and other natural enemies. After 15 days these bundles were transferred in rice

field. The bundles were fixed vertically with bamboo sticks @ 20 bundles/ha in rice fields having 20 days transplanted seedlings in such a way that the lower portion of the bundle remained 15 cm above the water level. In both the years, the experiments were conducted with 'Pusa Sugandh 4' ('Pusa 1121') involving five treatments, ie straw bundles+maize (T_1), straw bundles +sunn hemp (T_2), straw bundles+ Dhaincha (*Sesbania)* (T_3), only straw bundles (T_4) and control (T_5) without any additional structure or border crop, replicated thrice. Each plot was of 0.5 acre in size. Pheromone traps were also installed @ 5 traps/ha in all the experimental fields to monitor stem borer population. Pest management tactics in all the treatments included one release of *Trichogramma japonicum* @100 000 adults/ha against stem borer and one spray of carbendazim in first week of September against blast.

The observations on the infestation of stem borer (*Scirpophaga incertulas* Walker) and leaf folder (*Cnaphalocrosis medinalis* (Guenee)) and population of spiders in all the treatments were recorded from twenty hills selected randomly from each plot at 10 days interval. The distribution of spiders on the ground and vertically on the plants (< 25cm, from 25–50 cm and >50 cm above the ground) was also observed at 10 days interval. The spider samples were collected from fields and transferred in 70% alcohol. These samples were identified under Stereo zoom Binocular microscope and were compared with Tikader (1987) for identification.

Statistical analysis was carried out using SAS software. Usual Analysis of Variance (ANOVA) and Fisher's Least Significant Difference (LSD) were carried out to find any significant differences between different treatments. Pooled analysis was carried out using Proc Mixed of SAS software. The pair-wise differences were calculated using Tukey-Kramer adjustments (Littell *et al*. 2006).

RESULTS AND DISCUSSION

The results on the infestation of stem borer and leaf folder indicated that the infestation of both the insect pests, in general, remained low in all the treatments but the differences among treatments were statistically significant even at low level of infestation. All the treatments (T_1 to T_4) had significantly lower stem borer as compared to control in both the years. The pooled analysis indicated that the T_1 and T_2 had significantly low stem borer infestation as compared to T_4 but at par with T_3 in both 2006 as well as 2007 crop seasons. Treatment T_3 was at par with T_1, T_2 as well as with T_4 (Table 1). In case of leaf folder the treatments T_1 to T_4 showed significantly lower levels of leaf folder infestation as compared to control during both the years but were at par with each other.

The observation made on charging of the straw bundle for 15 days in sorghum fields indicated that each charged bundle contained 30–40 spider adults, 8–10 spider egg masses, 500–600 spiderlings and 20–30 earwigs.

Table 1 Infestation of insect pests in different treatments in rice

Treatment	Stem borer			Leaf folder		
	2006	2007	Pooled	2006	2007	Pooled
T1 (M+B)	1.82^{C}	2.88^{C}	2.35^{C}	2.88^{B}	1.68^{B}	1.57^{B}
T2 (S+B)	2.10^{C}	3.20^{BC}	2.65^{C}	1.60^{B}	1.89^{B}	1.74^{B}
T3 (D+B)	$2.35B^{C}$	3.19^{BC}	2.77^{BC}	1.68^{B}	1.95^{B}	1.82^{B}
T4 (B)	2.83^{B}	3.85^{B}	3.34^{B}	1.65^{B}	2.17^{B}	1.91^{B}
T5 -C	4.05^{A}	5.17^{A}	4.61^{A}	2.45^{A}	3.39^{A}	2.92^{B}
Significant	0.01	0.01	0.01	0.01	0.01	0.01
CD	0.63	0.76		0.52	0.86	

Means with same letter do not differ significantly at 5%
(M, Maize; B, straw bundle; S, sunn hemp; D, dhaincha (*Sesbania*); C, control)

The results on the population dynamics of spiders indicated that the spider population on rice plants in both the crop seasons remained significantly higher in T_1 to T_4 treatments as compared to control (T_5) but were at par with each other (Table 2). The same trend holds well for both the years as indicated by the pooled analysis. There were no significant changes in spider population on the ground (in between rice plants) during 2006 among different treatments. However, in 2007, the treatments T_1 to T_4 were having significantly higher populations of spiders on ground as compared to control treatments but the treatments were at par with each other. The pooled analysis indicated that only T_3 and T_4 had significantly higher population of spiders as compared to control but were at par with T_1 and T_2. The treatments T_1 and T_2 were at par with control.

The progressive population builds-up of spiders during the entire crop season in the present study indicated only one peak of highest spider population in September, whereas in Korea, during the rice growing period, spiders had shown two peaks-one when spiders which had over wintered nearby migrated into the rice and the other was when the second generation of the year appeared (Lee and Kim 2001). The different time taken by various spider species to immigrate from levees into rice fields is the cause of the low initial population densities (Lee *et al.* 1997). Most of the dominant

Table 2 Population of spiders on plants (per hill) and on the ground ($1m^2$), in between rice plants, in different treatments

Treatment	Spiders on plants			Spiders on ground		
	2006	2007	Pooled	2006	2007	Pooled
T1 (M+B)	1.68^{A}	1.70^{A}	1.69^{B}	1.07	1.15^{A}	1.11^{AB}
T2 (S+B)	1.55^{A}	1.49^{A}	1.52^{B}	0.74	1.14^{A}	0.94^{AB}
T3 (D+B)	1.37^{A}	1.32^{A}	1.35^{B}	1.27	1.18^{A}	1.22^{A}
T4 (B)	1.73^{A}	1.69^{A}	1.71^{B}	1.35	1.51^{A}	1.43^{A}
T5 -C	0.18^{B}	0.39^{B}	0.28^{B}	0.65	0.53^{B}	0.59^{B}
Significant	0.05	0.01	0.01	NS	0.05	0.01
CD	0.90	0.71			0.58	

Means with same letter do not differ significantly at 5%; NS, Not significant
(M, Maize; B, straw bundle; S, Sunn hemp; D, Dhaincha (*Sesbania*); C, control)

Fig 1 Straw bundle in paddy fields to enhance spider population (*left*); spider egg mass in straw bundle (*right*)

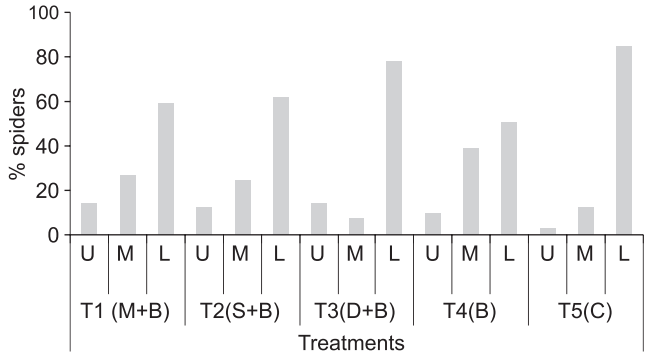

Fig 2 Distribution of spiders on rice plant in different treatments (L, Lower part up to 25 cm above the ground; M, middle 25–50 cm above the ground; U, upper >50 cm above the ground)

spider species immigrated from outside areas into the rice fields by ballooning (habit of young spiders of sailing through the air borne by silk strands on wind currents).

While studying the inter- and intra-plant distribution and species composition of spiders, it was found that the maximum spiders on the rice plant during their peak period (September) remained confined to lower part of the plant (up to 25 cm above the ground) as compared to middle (25–50 cm above the ground) and upper (>50 cm above the ground) part of the rice plant (Fig 2). Among different spiders, *Oxyopes javanus* Thorell (Oxyopidae), *Tetragnatha javana* (Thorell 1890), *T. mandibulata* Walckenaer 1842, *Tetragnatha* sp. (Tetragnathidae), *Neoscona theis* (Walckenaer) and *Neoscona sinhagadensis* (Tikader 1975) *(*Araneidae) were the predominant species on the middle and upper part of the rice plants which generally appeared in the later part of the crop. Other species comparatively less abundant in rice plants were *Thomisus* sp. (Thomisidae) on lower part, *Araneus inustus* (L Koch 1871) (Araneidae) and *Leucauga decorate* (Blackwall 1864) (Tetragnathidae) on upper part. *Theridula angula* Tikader 1970 (Theridiidae) represented only a smaller proportion of the population on the lower part of the plant. In the present study the predominant spiders on the ground (in between the rice plants) were *Paradosa* sp., *Lycosa pseudoannulata* (Boes. Et Str.) (Lycosidae) and *Hippasa* sp. *L. pseudoannulata* was available in the field throughout the season on the ground as well as on the lower part of the plant holding egg sac. Kumar and Shiva Kumar (2004) in Gujarat recorded 33 species of spiders in rice under 10 families. The most dominant species recorded by them were *L. pseudoannulata* and *Oxyopes shweta* from hunter group and *Tetragnatha* sp., *Argiope aemula*, *Cytrophora cicatrosa*, *N. theis* and *N. sinhagadensis* from weaver group. Their report indicated that *L. pseudoannulata* remained high throughout the cropping season, whereas *O. shweta* increased during grain-filling stage.

It is evident from the present study that the spiders in rice crop can be successfully augmented by simple devices either by straw bundles alone or in combination with other border crops. The technology has now been recommended by NCIPM as an important component of IPM in rice.

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