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# Effect of chemical *vis-a-vis* non-chemical pest management on predatory spiders in paddy-ecosystem

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**Abstract:** Spiders act as one of the most important defenders in paddy ecosystem and there are several families of those with different habits. The question on the effect of chemical application in comparison to the non chemical option on different spider families in the zone under study was attempted for getting answer. For that purpose, the field experiment was conducted during *kharif,* 2014 for studying spider abundance in chemical versus non-chemical treatments. Chemical based treatment consisted of the application of Phorate 10G at 10 days after transplanting (DAT), followed by spraying with Imidacloprid 17.8 SL at 45 DAT, and dusting of Methyl Parathion 2D at 80 DAT. Transplanting of rice following skip row technique, sowing of okra, cowpea, sesame & balsam on the surrounding bunds, retention of weeds on the bunds, single inoculative release of *Trichogramma chilonis* @ 1,00,000 at 35 DAT, and use of pheromone (*Scirpophaga incertulus* lure)-cum -light trap @ 10 traps $ha^{-1}$ were integrated together in non-chemical based treatment. The results revealed that the population of wolf spiders and long jawed spiders were statistically higher during all the seven dates of observation in non-chemical based approach. Amongst Araneid spiders, non-chemical based approach recorded significantly higher population at 60, 75 and 90 DAT. On the basis of overall mean, the non-chemical treatment had significantly higher population of spiders belonging to most of the families except Thomisidae. The mean population of spiders across the families varied from 1.06 to 12.0 and 0.54 to 6.66 per double sweep per sub plot in non-chemical based and chemical based treatment, respectively. Thus, the study confirms the safety of the non-chemical based approach in maintaining significantly higher level of spider population.

**Keywords:** Non-chemical, Pest management, Paddy, Spiders

## INTRODUCTION

The spiders, belong to order Araneae, are among the most diverse groups on Earth which rank seventh in global diversity of animals, after the five largest insect orders (Coleoptera, Hymenoptera, Lepidoptera, Diptera, Hemiptera) and Acari among the Arachnids (Parker, 1982) in terms of species described or anticipated. They are exceptional for their complete dependence on predation, thus are of economic value to man in order to suppress pest abundance in agro-ecosystems. Amongst agro-ecosystem, paddy is one of the three leading food crops in many countries and it is grown over an acreage of 162.31 million hectares globally with a production of 738.18 million tonnes. India stands for second position after China with a total production of 106.54 million tonnes over acreage of 43.59 million hectares during 2013-14 (Directorate of Economics and Statistics, 2015).

Over 800 species of pests and numerous species of natural enemies occupy the paddy during vegetative and reproductive stages (Hafeez *et al.,* 2010). Amongst natural enemies, the spiders are considered quite important (Satpathi, 2004; Sudhikumar *et al.,* 2005; Sebastian *et al.,* 2005; Motobayashi *et al.,* 2006) as they influence pest abundance, tractable to manipulation and convenient model organism to accelerate biological control. The over reliance on pesticides has not only generated the problem of insecticides resistance in insects, insect resurgence, residue in food and feed and environmental contamination but it has also reduced natural enemies population, thus resulting in impaired biological control in paddy-ecosystem (Heong, 2009). Further, the 21st century demands the development of non-chemical options for managing insect-pest attacking various crops without negotiating the health of the environment, farmers and consumers. It is quite clear that spiders are important natural regulator in many crop ecosystems including the major one i.e., rice ecosystem. It is utmost essential to know the exact effects of conventional pest management strategies on different spider families prevalent in different zones of the country. Such work is still rare or scanty in zone IIIA of Bihar. Therefore, the present study was attempted to investigate the effect of conventional chemical *vs* non-chemical based pest management approach on the abundance of different groups of the spiders in paddy-ecosystem.

## MATERIALS AND METHODS

The field experiment was conducted by growing paddy crop at Experimental Farm, Bihar Agricultural University, Sabour (Bhagalpur), Bihar (25°15'40" N, 82° 2'42" E and 46 m above sea level) during last *kharif* season. MTU 7029 (Swarna), the popular rice variety, was transplanted on July 26, 2014 in two different fields, each with 900 $m^2$ area. The distance between these two fields was kept 200 m and the crop was raised as per the recommended package and practices except pest management practices.

For pest management, chemical and non-chemical based pest management treatments were given separately for both the fields. The chemical based treatment were adopted from farmer's practice in Bihar for pest management in paddy and it included the application of Phorate 10G @ 10 kg $ha^{-1}$ at 10 days after transplanting (DAT) followed by spraying of Imidacloprid 17.8 SL @ 22.25 g a.i. $ha^{-1}$ at 45 DAT and dusting of Methyl parathion 2D @ 25 kg ha $^{-1}$ at 80 DAT. The non-chemical based treatment was comprised of ecologically sound interventions, namely, transplanting of rice following skip row technique, sowing of okra, cowpea, sesame (Gurr, 2004) and balsam on the surrounding bunds, retention of weeds on the bunds, use of self-made pheromone (*Scirpophaga incertulus*)-*cum* -light trap @ 10 traps $ha^{-1}$ and single inoculative release of *Trichogramma chilonis* @ 1,00,000 $ha^{-1}$ at 35 DAT.

Samplings for spiders were done using insect collection net (Make: Rescholar) from both the fields at 15, 30, 45, 60, 75, 90 and 105 DAT following sweep net technique (Pathak *et al*, 2011). For sampling, ten double sweeps were performed for each sampling site and it was replicated quintuple. These samples were collected in plastic container filled with 70 per cent alcohol, labeled properly and brought to the laboratory for identification at family level. Consequent upon identification, the counting was done accordingly. The data were transformed using square root transformation for analysis (following 't' test, two-samples assuming equal variances) for each spider family population at different observation period (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

The perusal of data presented in table 1 clearly shows that the population of wolf spiders (Lycosidae) and long jawed spiders (Tetragnathidae) were statistically higher throughout the observation period in non-chemical pest management based treatment. Similarly, the population of lynx spider (Oxyopidae) was significantly higher during 30 to 90 DAT except for 15 and 105 DAT. However, the population of Araneid spiders was recorded significantly higher specifically during 60 to 90 DAT in non-chemical treatment. More interestingly, the population of jumping spider (Salticidae) was significantly higher only at 90 and 105 DAT, whereas the population of crab spider (Thomisidae) was significantly higher during 90 DAT alone in non-chemical over chemical based pest management treatment. Kun *et al.,* (2015) observed that insect-selective insecticides like imidacloprid showed hypotoxicity against *P. pseudoannulata* (Lycosidae) which corroborates the present findings. Similarly, Hui and Liu (2014) also concluded from their study that the insecticide had a strong toxic effect on the main natural enemies and should not be applied in rice fields.

In chemical based treatment, the population of spiders belonging to different families also showed that insecticide application in general affected the population of spiders in the chemical treated field except in the cases discussed below. During vegetative stage of paddy, the population of spiders belonging to the family Araneidae remained at very low level. The spiders belonging to this family are categorized under Orb Weaver as they form web generally at the top of the crop canopy and wait for their prey (Sudhikumar *et al,* 2005). This habit might be the reason for getting non-significant differences in population at 15, 30 and 45 DAT followed soil application of Phorate at 10 DAT. Further, the prey population declined at maturity stage (105 DAT) which probably resulted in decline the population of Araneid spiders, thus no significant effect of Methyl Parathion application could be observed. Further, the families namely, Salticidae and Thomisidae were having comparatively very low level of population throughout the period of observation which is substantiated with the findings of Pathak *et al.* (2011). Salticidae and Thomisidae belong to the spider guild-Stalkers (jumping habit) and Ambushers (hidden nature of prey hunting), respectively. The typical habits of these families probably helped in escaping from the direct application of insecticides in chemical based treatment thus, no significant effect were recorded throughout the observation period except during 90 DAT. Overall mean indicates that the significant differences in spiders population belonging to different families except Thomisidae were obtained among the treatments which clearly indicates the bad effect of chemical based treatment on spiders.

However, there were no insecticide application in non-chemical based treatment and it was comprised of the maintenance of okra, cowpea, sesame and balsam along with grassy weeds on the surrounding bunds. Such kind of modification in ecological surrounding may probably provided refugia for predators and ultimately helped in maintaining higher level of spider population. Sigsgaard *et al.* (1999) studied directional movement of predators between the paddy field and the bund. During the field experiment, *Pardosa pseudoannulata* being an early colonizer of newly established paddy had the higher relative abundance in the bund which substantiates the present findings.

**Table 1.** Comparison of non chemical *vs* chemical pest management strategies on their effect on population of spiders belonging to different families.

| Treatments | Spider families | Average population (per double sweeps per sub plot) at different days after transplanting | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 15 DAT | 30 DAT | 45 DAT | 60 DAT | 75 DAT | 90 DAT | 105 DAT | Mean |
| $T_1$ (Non chemical based) | Lycosidae | 2.00(1.57) | 3.40(1.96) | 5.00(2.31) | 3.00(1.86) | 6.60(2.65) | 7.60(2.84) | 4.20(2.16) | 4.54(2.25) |
| $T_2$ (Chemical based) | | 0.80(1.12) | 1.60(1.44) | 2.40(1.67) | 1.80(1.51) | 3.20(1.91) | 2.60(1.75) | 1.40(1.37) | 1.97(1.57) |
| Significance | P(T<=t) one-tail value | 0.008* | 0.005* | 0.007* | 0.007* | 0.001* | 6.69E-05* | 0.0001* | 0.003* |
| $T_1$ (Non chemical based) | Tetragnathidae | 3.40(1.96) | 9.40(3.14) | 14.80(3.90) | 12.00(3.51) | 16.60(4.12) | 19.00(4.41) | 9.00(3.07) | 12.03(3.54) |
| $T_2$ (Chemical based) | | 1.80(1.51) | 4.80(2.28) | 10.60(2.10) | 5.20(2.38) | 9.60(3.17) | 9.20(3.11) | 5.40(2.42) | 6.66(2.68) |
| Significance | P(T<=t) one-tail value | 0.008* | 0.001* | 1.13E-06* | 0.0008* | 0.0006* | 2.77E-05* | 0.002* | 0.03* |
| $T_1$ (Non chemical based) | Araneidae | 0.40(0.91) | 1.40(1.32) | 2.20(1.60) | 3.40(1.96) | 7.20(2.76) | 9.00(3.08) | 2.00(1.55) | 3.66(2.04) |
| $T_2$ (Chemical based) | | 0.00(0.71) | 0.80(1.12) | 1.40(1.45) | 0.80(1.12) | 3.40(1.96) | 2.00(1.57) | 1.00(1.19) | 1.34(1.36) |
| Significance | P(T<=t) one-tail value | 0.071 | 0.196 | 0.210 | 0.0005* | 0.002* | 5.18E-07* | 0.05 | 0.04* |
| $T_1$ (Non chemical based) | Oxyopidae | 1.00(1.19) | 3.40(1.96) | 5.80(2.48) | 4.20(2.16) | 9.40(3.13) | 11.60(3.46) | 1.60(1.43) | 5.29(2.41) |
| $T_2$ (Chemical based) | | 0.80(1.09) | 1.80(1.50) | 3.20(1.72) | 1.60(1.44) | 3.00(1.86) | 2.40(1.70) | 1.40(1.37) | 2.03(1.59) |
| Significance | P(T<=t) one-tail value | 0.325 | 0.016* | 0.003* | 0.0006* | 3.62E-05* | 1.42E-05* | 0.361 | 0.03* |
| $T_1$ (Non chemical based) | Salticidae | 0.40(0.91) | 0.80(1.09) | 1.80(1.48) | 0.60(1.02) | 2.20(1.61) | 3.80(2.06) | 1.00(1.19) | 1.51(1.42) |
| $T_2$ (Chemical based) | | 0.20(0.81) | 0.40(0.91) | 0.60(1.40) | 0.40(0.91) | 1.20(1.30) | 0.80(1.09) | 0.20(0.81) | 0.54(1.02) |
| Significance | P(T<=t) one-tail value | 0.272 | 0.216 | 0.324 | 0.290 | 0.053 | 0.0009* | 0.030* | 0.02* |
| $T_1$ (Non chemical based) | Thomisidae | 0.20(0.81) | 0.60(1.02) | 1.20(1.30) | 0.40(0.91) | 1.80(1.50) | 2.60(1.75) | 0.60(1.02) | 1.06(1.25) |
| $T_2$ (Chemical based) | | 0.00(0.71) | 0.40(0.91) | 0.60(1.34) | 0.40(0.91) | 1.40(1.37) | 0.80(1.12) | 0.20(0.81) | 0.54(1.03) |
| Significance | P(T<=t) one-tail value | 0.173 | 0.290 | 0.293 | 0.50 | 0.208 | 0.0005* | 0.121 | 0.10 |

Figures in the parentheses indicate the square root transformed values (√x+0.5), *Significant at 5% level of significance, DAT=Days After Transplanting

## Conclusion

The spiders act as one of the most important defender and there are several families of those with different habits in rice ecosystem where our pest management is entirely based on the chemical pesticides. Keeping in mind the health of the environment, farmers and consumers without compromising the yield, the comparative effect of chemical and non-chemical pest management approaches on the spider families was first time attempted in the zone under study. The overall mean indicated that spider population ranged only from 0.54-6.66 per double sweep per sub plot in the chemical based treatment whereas it was as high as 1.06-12.03 in the non-chemical based treatment. Thus, it can be inferred from present study that the conventional chemical based treatment comparatively affected the population abundance of spider fauna in paddy-ecosystem. The non-chemical based pest management approach is environmentally safe besides maintaining abundant natural enemy population for sustainable crop production.

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