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Impact of Natural Enemies on Pest Population in Cotton Monocrop and Cotton Intercropped with Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted to study the impact of natural enemies on pests of cotton, when it was grown as monocrop and as intercrop with soybean. A comparison of diversity and abundance of pests and natural enemies of cotton monocrop in Rajendranagar (unprotected) and Adilabad (protected) was also made. Observations on pests and natural enemies were taken by using various sampling methods and correlation between pest and natural enemy population were estimated. Results revealed that in intercropped cotton, Coccinellidae, Spiders, Staphylinidae and Anthocoridae were the major predator taxa which have impacted the population levels of sucking pest's taxa such as Cicadellidae, Aleyrodidae Aphididae, Miridae and Thripidae. However, in mono-cropped cotton, Spiders found to have little or no impact on pest population, suggesting plant

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diversification is playing crucial in predators' activity. Further, the diversity of predators in un-sprayed Rajendranagar fields were comparatively higher (1.66) than the sprayed Adilabad cotton fields (1.62). Similarly, the evenness of predators in un-sprayed Rajendranagar fields were comparatively higher (1.37) than the sprayed Adilabad cotton fields (1.12). These results suggest that, intra crop diversification without or minimal use of insecticides allows the natural enemies to perform their part of job as natural regulates of pest populations which minimizes the cost of cultivation with added benefit from the intercrop.

Keywords: Cotton; intercropping; natural enemies; diversity indices; monocrop; plant diversification.

1. INTRODUCTION

"Cotton makes up about 2.5 % of the world's arable land. It is popularly known as "white gold" in India and is one of the important cash crops. The yield loss due to sucking pests in cotton was estimated to be 35.61 %" [1]. "As per the International Cotton Advisory Committee, globally, cotton covered 2.4 % of the world's cultivated land but used 4.7 % of the world's pesticides (and 10 % of insecticides). In India, cotton holds 6.5 % of the gross cropped area while consuming 50 % of the total pesticides" [2]. "An over reliance on synthetic insecticides and its associated environmental impact have resulted in the evolution of resistance in insects, secondary pest outbreaks, and resurgences" [3]. The introduction of *Bt* cotton has helped to minimise pesticidal sprays to some extent, however, an integrated approach is required to gain control of the devastating pests attacking the crop. Out of the many pest management practices feasible at the farmers' level, increasing plant diversity in the field can achieve increased population of various natural enemies, which subsequently enhance natural pest control.

"Plant diversification increases the population of various natural enemies, which subsequently enhance natural pest control. For many species, natural enemies are the primary regulating force in the dynamics of their populations" [4]. "Enhancement of natural enemy population in cotton by habitat manipulation has been extensively studied in the past. Creating conditions that increase biodiversity, especially the abundance of resident populations of natural enemies in agroecosystems, is an effective approach for the biological control of pests and diseases [5], increase variety and abundance of natural enemies" [6], thus, most ecologists support intercropping for Integrated Pest Management (IPM) to control pest insects. In cotton intercropping system, egg parasitism increases by *Trichogramma chilonis*, and increased in predatory insects' diversity have been proven [7]. "Cotton-cowpea intercropping may increase ladybird beetle's population and cotton-legumes intercropping might decrease the damages caused by *B. tabaci"* [8]. Much work has been done on agronomic and soil aspects of cotton-soybean intercropping methods but little is known about the composition and nature of predatory and parasitic guilds and the impact they create on pest abundance and diversity. Hence the present study was taken up to estimate the effect of natural enemies in cotton-soybean intercropped system in comparison with the mono cropped system to comprehend the impact of increased diversity of natural enemies on pest's incidence in cotton.

2. MATERIALS AND METHODS

The study on 'Impact of natural enemies on pests in monocrop cotton and cotton intercropped with soybean' was carried out during kharif 2020 in college farm, Rajendranagar, Hyderabad, India. Diversity and abundance of pets and natural enemies of cotton at Rajendranagar (Unsprayed) and Adilabad (Insecticide sprayed) was also compared. The experimental field was divided into two modules *viz*., module M-I and module M-II. In M-II, cotton was intercropped with soybean in 1:2 ratio and the M-I was cotton mono cropping. Observations on insect fauna were taken once in a fortnight in the modules from ten days after sowing till harvest during the morning between 7.00 a.m. and 9.00 a.m. when they were inactive. Various sampling methods such as yellow pan trap, pitfall traps, sweep nets, yellow sticky traps and visual counting were used to collect and count insects. After collection and separation of the insects into the families, the specimens were sent to taxonomy experts for identification. Populations of pests and natural enemies were correlated to obtain Pearson's correlation coefficient to know the extent of impact of the natural enemies on pest populations. Analysis was done using OPSTAT software [9]. To understand the impact of insecticide sprays on pest and natural enemy

population, a survey of pests and natural enemies of cotton at Agricultural Research Station, Adilabad was conducted three times at 15 days intervals. Population of pests and natural enemies were compared with that of cotton monocrop at Rajendranagar. Relative abundance of insects was calculated using the formula

Relative abundance (%) = ni × 100 / N

Where, N = total number of individuals of all taxa, and ni = number of individuals in the i^{th} taxa. The following diversity indices were also calculated manually for comparison of diversity at two places using the formulae:

A) Shannon- Wiener index (H) [10].

$$H' = \sum_{i=1}^{s} (pi)\,[Ln(pi)]$$

Where,

pi = Proportion of i^{th} taxa in the total sample, i.e., pi = fi/n
n = Total number of specimens in the sample
fi = Number of specimens of the ith taxa
s = Total number of taxa
Ln = Natural logarithm

B) Margelef diversity index (M) [11]:

$$M = (S - 1)/Ln(N)$$

Where,

S = Total number of taxa, N = Total number of individuals in the sample.

C) Pielou's Evenness Index (E) [12]

$$E = (H' / Ln\ S)$$

Where, H' = Shannon – Wiener diversity index, S = Total number of taxa in the sample

D) Simpson's Index of Diversity (D) [13]

$$D = \Sigma\ ((n_i - 1) / N * (N-1))$$

Where, n_i = Number of individuals in the *i*-th taxa; N = Total number of individuals in the community

E) Jaccard's index of similarity:

= (Number of taxa common in both the places/Total number of taxa)100

3. RESULTS AND DISCUSSION

3.1 Impact of Natural Enemies on the Pests in Intercropped Cotton and Cotton Monocrop

The correlation of insect pests and natural enemies in intercropped cotton showed that, there was significant and positive association of Coccinellidae with Aphididae (r=0.81), Staphylinidae with Aleyrodidae (r=0.88) and Anthocoridae with Miridae (r=0.98) and Thripidae (r=0.89). Further, the spider population in the intercropped cotton showed significant and positive association with Cicadellidae(r=0.76), Aleyrodidae (r=0.65), Aphididae (r=0.77) and Miridae (r=0.74). Furthermore, the hymenopteran parasitoid family Mymaridae was significantly and positively correlated with Aleyrodidae (r=0.79), while Braconidae with Aphididae (r=0.92) (Table 1). The correlation of insect pests and natural enemies in cotton monocrop showed that, Coccinellidae was significantly and positively associated with Cicadellidae(r=0.73), Aleyrodidae (r=0.80), Miridae (r=0.89) and Thripidae (r=78). Similarly, Staphylinidae was significantly and positively associated with Aphididae (r=0.80). Further, Anthocoridae was significantly and positively associated with Cicadellidae(r=0.80), Aleyrodidae (r=0.94), Miridae (r=0.82) and Thripidae (r=99). Furthermore, Spiders were significantly and positively associated with Aleyrodidae (r=70) (Table 2).

Planting maize, mung beans or sunflowers as bait crops around the cotton field can increase the protection and reproduction of ladybeetles and green lacewings and subsequently higher predation of sucking pests [14]. Several earlier studies had also reported similar results. There was a positive correlation between the insect predators and sucking pest population [15]. Association of leafhoppers and predators was significantly positive on Kriti (r=0.93), H6 (r=0.86) and Savita (r=0.86) cultivars, while it was negative on PKV Hy 2 (r= -0.66). The Coccinellids exhibited a high degree of prey density-dependent population build up (r = 0.83) in *Bt* cotton; whereas, in non-Bt cotton, syrphid larvae showed a high degree of prey dependence for population build up (r=0.72) [16].

There was significantly lowest infestation of whitefly in cotton + soybean (1.07 whiteflies per leaf), followed by cotton + green gram (1.48

whiteflies per leaf), cotton + black gram (5.31 whiteflies per leaf) and highest population (8.66 whiteflies per leaf) was in sole cotton [17]. The cotton intercropped with cowpea, sorghum and okra derived benefit in lowering the population of aphids (13.87, 14.80 and 35.15/leaf) and leaf hoppers (0.6, 1.20 and 0.67/ leaf) in cotton. Okra and cowpea as intercrops of cotton influenced favourably to lower thrips activity (3.1 to 3.14 thrips/leaf), while whitefly population was extremely low (0.24 to 0.39/leaf) in intercropped cotton and in sole cotton [18]. Cotton–rapeseed intercropping increased natural enemy populations by 15-fold, effectively controlling the aphids on cotton seedlings, and reducing the number of cotton aphids in summer [19].

3.2 Comparison of Diversity and Abundance of Pests and Natural Enemies of Cotton in Rajendranagar and Adilabad

Results of visual observations on pests of cotton monocrop in Rajendranagar and Adilabad revealed that mean population of Cicadellidae, Pentatomidae, Thripidae and Gelechiidae were more in Rajendranagar with an incidence level of 293.50, 2.50, 1339.50 and 67.00 numbers per count respectively, while incidence in Adilabad was 139.50, 1.00, 824.50 and 17.00 numbers per count respectively. In contrast, mean population of Aphididae and Aleyrodidae were more in Adilabad (543.67 and 1012.67 numbers per count respectively) while their incidence in Rajendranagar was 313.00 and 105.00 numbers per count respectively. Pests in the families Miridae, Pyrrhocoridae, Oxycarenidae and Membracidae were found only in Rajendranagar while pests in the families Noctuidae and Curculionidae were found only in Adilabad. Among the pest taxa of cotton in Rajendranagar, nearly 90% pest individuals were recorded in three families. The Relative abundance of Thripidae was highest (55.8%) followed by Aphididae (19.5%) and Cicadellidae (12.2%). However, among the pest taxa of cotton in Adilabad, the relative abundance of Aleyrodidae was highest (45.6%) followed by Thripidae and Aphididae (24.5%) (Table 3).

Observations on predator population showed that mean population of Coccinellid beetles, Syrphidae and Araneidae were more in Rajendranagar (32.00, 3.00 and 21.50 insects per count respectively) than in Adilabad (4.50, 1.50 and 14.50 insects per count respectively) while mean population of Staphylinidae, Chrysopidae and Oxyopidae were more in Adilabad (5.50, 8.50 and 8.50 numbers per count respectively) than in Rajendranagar (2.00, 6.00 and 4.50 insects per count respectively). Thomisidae and Salticidae were observed only in Rajendranagar. Coccinellidae and Araneidae dominated the predator taxa of cotton in Rajendranagar with relative abundances of 39.8% and 26.7%. However, in Adilabad, relative abundance of Araneidae was found highest (33.7%) (Table 3).

Table 1. Association of pests and natural enemies in intercropped cotton

Family	Cicadellidae	Aleyrodidae	Aphididae	Miridae	Thripidae
Coccinellidae	-0.33	-0.24	0.81*	0.29	0.30
Staphylinidae	0.24	0.88*	-0.44	0.33	-0.22
Anthocoridae	0.17	0.37	-0.14	0.98*	0.89*
Spiders	0.76*	0.65*	-0.77*	0.74*	0.53
Platygastridae	0.04	0.65	-0.50	0.37	-
Mymaridae	0.22	0.79*	-0.28	0.50	0.36
Braconidae	-0.18	-0.48	0.92*	-	-

Table 2. Association of pests and natural enemies in cotton monocrop

Family	Cicadellidae	Aleyrodidae	Aphididae	Miridae	Thripidae
Coccinellidae	0.73*	0.80*	0.35	0.89*	0.78*
Staphylinidae	-0.53	-0.28	0.80*	-0.29	0.01
Anthocoridae	0.80*	0.94*	0.20	0.82*	0.99*
Spiders	0.49	0.70*	-0.21	0.50	0.54
Platygastridae	0.46	0.49	-0.31	0.70	-
Mymaridae	0.24	0.21	-0.26	0.44	-0.005
Braconidae	-0.33	-0.13	0.64	-	-

Table 3. Comparison of abundance of pests and Predators of cotton monocrop in Rajendranagar and Adilabad

Pest abundance (Mean of three counts)					Predator abundance (Mean of three counts)				
Family	**RJNR**	**RA (%)**	**ADB**	**RA (%)**	**Family**	**RJNR**	**RA (%)**	**ADB**	**RA (%)**
Cicadellidae	293.5	12.2	139.5	4.2	Coccinellidae	32.00	39.8	4.50	10.5
Aphididae	469.5	19.5	815.5	24.5	Staphylinidae	2.00	2.5	5.50	12.8
Aleyrodidae	157.5	6.6	1519	45.6	Chrysopidae	6.00	7.5	8.50	19.8
Miridae	14.0	0.58	0.0	0.0	Syrphidae	3.00	3.7	1.50	3.5
Pentatomidae	2.5	0.1	1.0	0.0	Aranidae	21.50	26.7	14.50	33.7
Pyrrhocoridae	45.0	1.9	0.0	0.0	Thompsidae	7.50	9.3	0.00	0.0
Oxycarenidae	9.0	0.4	0.0	0.0	Oxyopidae	4.50	5.6	8.50	19.8
Membracidae	3.5	0.2	0.0	0.0	Salticidae	4.00	5.0	0.00	0.0
Thripidae	1339.5	55.8	824.5	24.7					
Gelechiidae	67.0	2.8	17.0	0.5					
Noctuidae	0.0	0.0	7.0	0.2					
Curculionidae	0.0	0.0	9.5	0.3					

RJNR = Rajendranagar, ADB = Adilabad, RA = Relative abundance

Table 4. Diversity indices and density of pets and predators of cotton monocrop in Rajendranagar and Adilabad

Diversity indices	Pests		Predators	
	RJNR	ADB	RJNR	ADB
Shannon Wiener (H')	1.32	1.24	1.66	1.62
Margelef species richness index	1.06	0.79	1.37	1.12
Pielou's evenness index	0.57	0.59	0.80	0.90
Simpson diversity (D)	0.37	0.33	0.24	0.21
Jaccard index of similarity	50%		75%	

RJNR = Rajendranagar, ADB = Adilabad

Studies on diversity indices of pests indicated that Shannon-Wiener index (H') was 1.32 and 1.24 and Margelef's species richness index was 1.06 and 0.79 in Rajendranagar and Adilabad respectively indicating a very unstable population, which may perish in the event of any natural calamity or an unfavourable agronomic practice. Pielou's evenness index (E) was 0.57 and 0.59 in Rajendranagar and Adilabad respectively indicating an evenly distributed population in the field. Simpson's Diversity Index (D) which was 0.37 and 0.33 in Rajendranagar and Adilabad respectively again demonstrating an unstable pest population. Jaccard's index was found to be 50 % which indicated that 50 % of families were common in both places since pest scenario was different between Rajendranagar and Adilabad. This was because fields in Adilabad Research Station were sprayed frequently with chemicals (Table 4).

Studies on diversity indices of predators indicated that Shannon-Wiener index (H') was 1.66 and 1.62 and Margelef's species richness index was 1.37 and 1.12 in Rajendranagar and Adilabad respectively indicating a moderately stable population which can contribute to natural control of pests. Predators were found to be evenly distributed in the field as was indicated by higher values Pielou's evenness index (E) was 0.80 and 0.90 in Rajendranagar and Adilabad respectively. Simpson's Diversity Index (D) which was 0.24 and 0.21 in Rajendranagar and Adilabad respectively which again showed that predator community was stable and ensured good natural control in the field. Jaccard's index was found to be 75% which indicated that 75% of families were common in both places (Table 4).

A total of 38 species, 9 orders and 25 families from cotton crop in Punjab, Pakistan using hand nets, bow traps and sweep nets [20]. Shannon Wiener diversity index value (H') and Evenness (E) of arthropods on cotton crop of Multan were H'=1.3, and E=0.99 and of Faisalabad it was H'=1.33 and E=0.96. Order Hemiptera had highest relative abundance of 10.34%, with 58 specimens, belonged to 4 families and 6 species followed by Lepidoptera 10.8% with 4 families with 5 species and 37 specimens [20]. The relative density values (RD) among sucking insect pests were maximum for aphids on *Bt c*otton (48.26%) and non-*Bt* cotton (39.28%) and the minimum for mealybugs (0.26 and 0.51%). Shannon-Wiener and Simpson's diversity indices values were relatively higher for non-*Bt* cotton being 1.64 and 4.28 respectively and for *Bt* cotton they were 1.50 and 3.40, respectively [16]. "The Margelef's index of species richness varied between 1.520 and 1.951 in conventional cotton for the different evaluation dates, and from 0.937 to 1.925 in *Bt* cotton, but was not significantly different between the cotton types. Shannon-Weiner index of species diversity varied from 0.718 to 1.430 in conventional, and 0.370 to 1.427 in *Bt* cotton, which was not significantly different between the cotton types" [21].

4. CONCLUSION

The population levels of insect pests in both intercropped and mono-cropped cotton was impacted to a greater extent by predators. Spiders, Coccinellids and Anthocorids were the major predator taxa whose population levels varied as per the population of insect pests. In a comparison way, in intercropped cotton, the spider population has contributed significantly more to the natural pest control than in cotton monocrop. It could be concluded that pest's and predator's situation on cotton in Adilabad and Rajendranagar was quite different. Population of pink bollworm, thrips, mirids, leafhoppers and red cotton bugs was higher in Rajendranagar, while whitefly, aphids and weevils were high in Adilabad. This was because fields in Adilabad were sprayed which suppressed the bollworms, thrips and Hemipterans, however, aphids and whiteflies were unaffected by the sprays. Similarly, predator's density in unsprayed

Rajendranagar cotton filed was more compared to the insecticide sprayed Adilabad cotton fields.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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