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POPULATION DYNAMICS AND DIVERSITY OF INSECT PESTS OF COTTON AND THEIR NATURAL ENEMIES IN SOLE CROP AND INTERCROP SYSTEMS

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ABSTRACT

A field study was conducted to appraise the population dynamics and diversity of cotton pests and their natural enemies at three different phenological stages of the crop. The study was conducted during *Kharif* 2020 at the experimental fields of College Farm, Rajendranagar, Hyderabad. Two crop modules *viz*; sole cotton and cotton as intercrop with soybean were analysed and compared. Sampling was done at fortnight intervals for 4 consecutive months. Visual counting, pitfall traps, yellow sticky traps, yellow pan traps and sweep netting methods were used to collectinsects. Shannon-Wiener, Pielou's and Margalef indices were used to calculate diversity, evenness and richness respectively. Population peaks of insect pests, predators and parasitosis were observed at vegetative stage of the crop in both modules, followed by boll maturity stage and lowest at flowering stage. Whereas, population peak of spiders was observed during boll maturity stage followed by vegetative and flowering stage. At vegetative stage, only few taxa were dominant and contributed majority individuals to the total abundance, hence the diversity was relatively less at this stage. The highest diversity of insect predators (1.80 and 1.78), spiders (1.83 and 1.59) and parasitoids (1.90 and 1.44) were recorded during the flowering stage of the crop and it was higher in intercropped module than in sole cotton. Diversity of insect pests (1.73 and 1.65) however, was more at boll maturity stage owing to more evenness and richness at this stage.

Key words : Population dynamics, Diversity, Intercropping, *Gossypium hirsutum* L., *Glycine max* L.

Introduction

Cotton (*Gossypium hirsutum* L.) is an important commercial crop cultivated in India which accounts for about 25% of the total world cotton production. India is the largest producer of cotton in the world, with an area of 12.07million hectares and production of 362.18 lakh bales, leading the globe in both cotton area and production (COCPC, 2021). However, productivity in India is 510 kg per hectare, which is far less than the world average of 808 kg per hectare. This is due to the various biotic and abiotic factors imposing stress on plants. Cotton crop is infested by a wide variety of insect pests at different phenological stages and acts as main factors restricting productivity (Sahito *et al*., 2017). Cotton forms 6.5% of the gross cropped area in India while consuming 50% of the total pesticides (Department of Agriculture, Cooperation & Farmers' Welfare, Annual Report 2020-21; Nayak and Solanki 2021). Insect resistance has evolved as a result of an over dependence on synthetic pesticides and the environmental damage they cause, leading to secondary pest breakouts and resurgences (Razaq *et al*., 2019). The introduction of *Bt* cotton has helped minimise pesticidal sprays to some extent, however, an integrated approach is required to gain control of the devastating pests attacking the crop and to minimise yield losses.

Plant diversification is one of the many integrated pest management strategies that boosts the population of different natural enemies, which in turn improves natural pest control. For many pest species, natural enemies are

the main factors governing the dynamics of their populations (Pedigo and Rice, 2009). Prevention of colonisation is one of the most promising ways of managing insect pests through creating diversity within the field, because only a small additional diversity in the crop field may have a significant effect on colonization by insects (Cromartrie Jr, 1993). Cultivating early maturing intercrops like soybean in cotton helps to safeguard the economy of the farmer through additional returns from the intercrop, improves soil fertility through biological nitrogen fixation and protects from adverse climatic risk. 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 current study was taken up as an objective to analyse dynamics of cotton pests and their natural enemies in soybean intercropped cotton relative to sole cotton at three growth stages of the crop.

Materials and Methods

The experiment was conducted at College Farm, Rajendranagar, Hyderabad during *kharif* 2019. A plot of 1200 sq m area was divided into two modules *viz*., module M-I and module M-II of 600 sq m each. Module M-I was raised as sole cotton while in Module M-II cotton was intercropped with soybean in 1:2 ratio. Spacing of 90 × 60 cm for cotton and 30 × 10 cm for soybean in the inter row space of cotton was adopted. *Bt* cotton variety Jadoo was sown in the second week of July and soybean variety, JS 335 was sown ten days after germination of cotton. Observations on insect fauna were recorded from 10 days after germination to the second harvest of crop *i.e.* from the last week of August to the second week of December. Various insect collection methods such as hand collection, yellow pan traps, pitfall traps, yellow sticky traps and sweep nets were employed. After setting up traps in the field for twenty-four hours, captured insects were gathered and segregated into respective families under each order and their abundance was worked out. After compiling data, following indices were calculated.

A) Shannon diversity index (H) (Shannon-Weaver, 1949)

B) Pielou's Evenness Index (E) (Pielou, 1966) and

C) Margalef diversity index (D_{mi}) (Margalef, 1958).

Results and Discussion

Dynamics of insect pests at different growth stages in intercropped and sole cotton ecosystems is shown in Fig. 1A. Density peaks of insect pests were recorded during the vegetative stage of the crop in both the modules. However, the average population size of pests was relatively more in sole cotton module (622.31) compared to intercrop (475.66) and this trend was observed throughout the cropping season. This demonstrates the impact of intercropping on pest abundance. Lowest population density was recorded during flowering and boll formation stage in both the modules and the second lowest was during maturity stage.

A comparative representation of the diversity, total abundance, evenness and richness indices of pests computed for intercropped and sole cotton modules across three growth stages is shown in Table 1. The total catch of insect pests was higher in sole cotton throughout the cropping season. The catch was 4275, 683 and 886 respectively during vegetative, flowering and boll maturity stage in intercropped module and 5602, 1070 and 919, respectively in sole cotton module. Shannon-Weiner index values for diversity were slightly more in sole cotton during vegetative and flowering stage (1.24 and 1.76) compared to intercrop (1.15 and 1.44). However, at maturity stage the intercrop showed more diversity (1.73) than sole cotton (1.62). Similarly, the value of evenness index was a bit higher in sole cotton during first two stages of crop (0.56 and 0.76) compared to intercrop (0.52 and 0.62).

The cotton crop's early and middle growth phases are the most vulnerable to aphid infestation because of the potential for abrupt increases in their density (Ali *et al*., 2016). Thrips and whiteflies are the other important sucking pests of the crop which invade during the early stage (Nadeem *et al*., 2023).

Insect predators were in their maximum abundant at vegetative stage of the crop during which intercropped cotton harboured a greater number of insect predators than sole cotton. In the flowering and maturity stages of the crop however, their population was more or the less constant and further intercropped cotton supported relatively higher number of predators than sole cotton (Fig. 1B).

A total of ten insect predator families were recorded and their total abundance, diversity, evenness, and richness indices are given in Table 2. A total of 184, 82 and 76 insect predators during vegetative, flowering and maturity stage, respectively were recorded in intercropped module and 142, 46 and 54, respectively in sole cotton. Predators are relatively more evenly distributed in intercropped cotton than in sole cotton throughout the cropping season and the same trend can be seen in the diversity of the predators. Among different growth stages

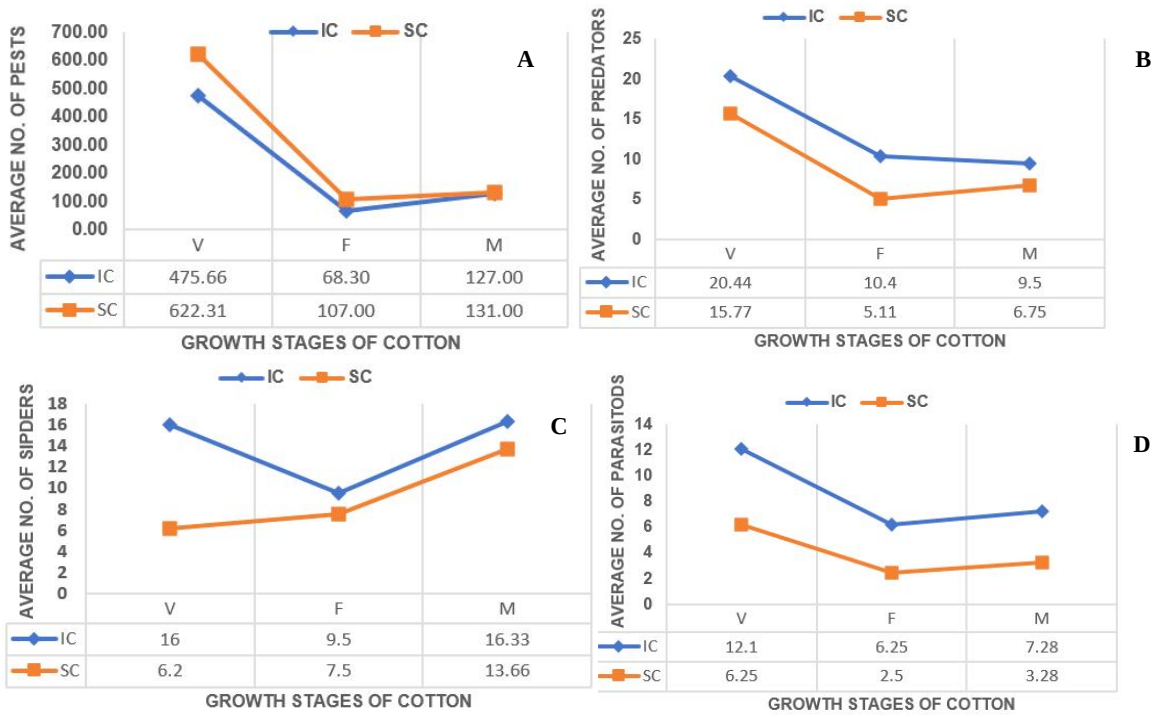

Fig. 1 : Population dynamics of insect and spider taxa in different growth stages of intercropped (IC) and sole cotton (SC). A. Insects pests; B. Insect predators; C. Spiders; D. Parasitoids. (V = Vegetative stage, F = Flowering and boll formation stage, M = Maturity stage).

Table 1 : Abundance of various insect pest families in different growth stages of intercropped and sole cotton.

Pest families	Vegetative Stage(V)		Flowering and boll formation (F)		Boll maturity stage (M)	
	IC	SC	IC	SC	IC	SC
Aphididae	750.00	794.00	12.00	58.00	175.00	257.00
Cicadellidae	353.00	499.00	270.00	314.00	162.00	147.00
Aleyrodidae	281.00	542.00	251.00	342.00	249.00	268.00
Thripidae	2705.00	3432.00	5.00	5.00	0.00	0.00
Gelechidae	9.00	14.00	6.00	8.00	133.00	145.00
Phyrrocoridae	0.00	0.00	1.00	30.00	122.00	77.00
Pentatomidae	10.00	5.00	53.00	132.00	12.00	8.00
Miridae	146.00	236.00	14.00	36.00	0.00	0.00
Oxycarinidae	0.00	0.00	0.00	0.00	33.00	17.00
Chrysomelidae	10.00	54.00	58.00	110.00	0.00	0.00
Noctuidae	11.00	26.00	13.00	35.00	0.00	0.00
Total abundance	4275	5602	683	1070	886	919
H	1.15	1.24	1.44	1.66	1.73	1.65
E	0.52	0.56	0.62	0.76	0.88	0.83
D_{mg}	0.95	0.92	1.4	1.3	0.88	0.87

IC = Intercropped cotton, SC= Sole cotton, H = Shannon diversity index, E = Pielou's Evenness Index, D_{mg} = Margelef's richness index

for both the modules however, flowering stage had higher diversity (1.80 and 1.78), since total population was more evenly distributed among the eight families (0.87 and 0.85). Whereas at vegetative stage, the diversity was bit lesser (1.60 and 1.40) owing to their less even distribution among nine (intercrop) and eight (sole crop) observed families (Table 2).

Unlike insect pests and predators, average population of the spiders were highest at the maturity stage of the crop in both the modules (16.33 and 13.66). During the

Table 2 : Abundance of various insect predator families in different growth stages of intercropped and sole cotton.

Predator families	Vegetative Stage(V)		Flowering and boll formation (F)		Boll maturity stage (M)	
	IC	SC	IC	SC	IC	SC
Coccinellidae	99.00	86.00	26.00	11.00	19.00	18.00
Carabidae	19.00	14.00	15.00	8.00	2.00	0.00
Staphylinidae	11.00	9.00	14.00	5.00	15.00	10.00
Anthocoridae	12.00	6.00	1.00	0.00	0.00	0.00
Geocoridae	3.00	0.00	6.00	8.00	7.00	3.00
Nabidae	2.00	2.00	2.00	1.00	1.00	1.00
Reduvidae	0.00	0.00	3.00	1.00	0.00	1.00
Syrphidae	14.00	6.00	0.00	1.00	0.00	0.00
Dolicopodidae	11.00	8.00	15.00	11.00	30.00	21.00
Chrysopidae	13.00	11.00	0.00	0.00	2.00	0.00
Total abundance	184	142	82	46	76	54
H	1.60	1.40	1.80	1.78	1.50	1.35
E	0.72	0.67	0.87	0.85	0.77	0.75
D_{mg}	1.53	1.01	1.6	1.83	1.38	1.43

IC = Intercropped cotton, SC= Sole cotton, H = Shannon diversity index, E = Pielou's Evenness Index, D_{mg} = Margelef's richness index.

Table 3 : Abundance of various spider families in different growth stages of intercropped and sole cotton.

Spider families	Vegetative Stage (V)		Flowering and boll formation (F)		Boll maturity stage (M)	
	IC	SC	IC	SC	IC	SC
Lycosidae	55.00	25.00	13.00	23.00	17.00	17.00
Araniedae	16.00	5.00	26.00	14.00	37.00	27.00
Thomicidae	1.00	1.00	9.00	3.00	9.00	8.00
Theridiidae	6.00	0.00	7.00	4.00	6.00	2.00
Oxyopidae	0.00	0.00	7.00	12.00	14.00	12.00
Salticidae	0.00	0.00	9.00	2.00	15.00	13.00
Pisauridae	2.00	0.00	4.00	2.00	0.00	0.00
Clubionidae	0.00	0.00	1.00	0.00	0.00	0.00
Total abundance	80	31	76	60	98	79
H	0.92	0.58	1.83	1.59	1.63	1.61
E	0.57	0.52	0.89	0.81	0.90	0.90
D_{mg}	0.91	0.58	1.61	1.22	1.09	1.14

IC = Intercropped cotton, SC= Sole cotton, H = Shannon diversity index, E = Pielou's Evenness Index, D_{mg} = Margelef's richness index.

first two stages however, different population trends were observed for sole and intercropped cotton. Second highest population peak for intercropped module was at vegetative stage (16.0) and lowest was at flowering (9.5). Whereas in sole cotton there was gradual increase in spider population from first stage (6.2) through second (7.5) and third (13.66) (Fig. 1C).

Coccinellids and spiders were the most prevalent taxa in the predatory complex, followed by dolicopodidae, staphylinidae, and carabidae. In our study, diversity of natural enemies was higher during middle growth stage followed by last and early stage. Same results were also reported by Ali *et al*. (2016). Coccinellids are the crucial natural enemies of several aphid species (Sharma and Joshi, 2010), presence of the a coccinellid species plays a pivotal role in the repression of cotton aphids (Lu *et al*., 2012). In the present study intercropped cotton harboured relatively more natural enemies which kept the population of insect pests at lower numbers than the sole cotton. Similar results were recorded by various researchers.

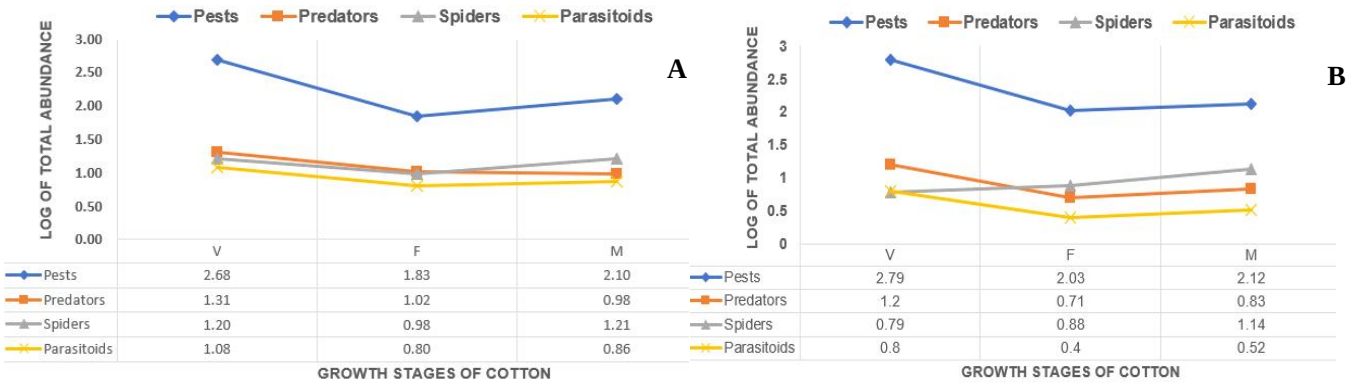

Fig. 2 : Correlation of insect pests, predators, spiders and parasitoids across different growth stages of cotton. A. Intercropped cotton; B. Sole cotton (V = Vegetative stage, F = Flowering and boll formation stage, M = Maturity stage).

Rao (2011) recorded significantly lowest infestation of whitefly in cotton-soybean, followed by cotton-green gram, cotton-black gram and highest population was in sole cotton. Population of leaf hoppers, aphids, thrips and whiteflies are less in intercropped cotton than sole cotton whereas the population of natural enemies was more in intercropped cotton than sole cotton (Godhani, 2006; Kadam *et al*., 2014; Rao, 2011; Devi, 2018).

Spiders belonging to eight families were recorded. Owing to the single taxon contributing majority of the individuals to the total population (Lycosidae, 68.75%), the diversity of the spiders in intercropped cotton was less during vegetative stage (0.92) even though their total abundance was higher (80). Whereas at flowering stage, the total population (76) was more evenly distributed (0.89) among eight families (maximum richness) hence the diversity was also maximum (1.83). Further, at the boll maturity stage, total population (98) was more evenly distributed (0.90) among only six families of spiders hence the diversity is relatively lesser than flowering stage (1.63) (Table 3). On the other hand, in the sole cotton module, the values of all the indices were relatively lesser than the intercropped module.

In the cotton agroecosystem, spiders are the natural control agents that significantly affect the dynamics of pest populations. They are among the first inhabitants of cotton fields as predators of insect pests, and their population steadily grows as the number of insect pests in the field rises. A higher Shannon Wiener index indicated a more diversity of spiders and this meant lesser competition between the species for the food resources as spider genera vary with each other in terms of food preferences (Anitha *et al*., 2019). In this study, we found a group of eight spider families as mentioned earlier and their abundance was observed to increase with time and more or less same trend was observed in the case of insect pests. Similar observations were made by many researchers that the population of predators or beneficial insects in the crop can be altered by population of insect pests or any change in environmental conditions (Nasir *et al*., 2021).

Population dynamics of the parasitoids followed the same trend as of the insect pests and predators as shown in Fig 1D. Maximum average population was during vegetative stage of the crop for both intercropped (12.10) and sole cotton (6.25) modules followed by maturity stage (7.28 and 3.28) and lowest at flowering stage (6.25 and 2.50).

A total of eight parasitoid families were recorded. At the vegetative stage of the crop, even though there was huge difference in the total abundance of parasitoids between intercropped (86) and sole cotton (41), diversity (1.78 and 1.77) and evenness (0.91 and 0.91) values remained same (Table 4). This same trend was also seen during the maturity stage of the crop and during this stage, diversity and evenness were maximum compared to other two stages. However, much difference was in flowering stage between sole and intercropped module with respect to total abundance (50 and 20), diversity (1.83 and 1.44) and evenness (0.88 and 0.81).

Correlation of insect pests, predators, spiders and parasitoids across different growth stages of cotton in sole and intercropped cotton is shown in Fig 2 A-B. The population of insect predators and parasitoids followed the same trends as pest population in both the modules. However, spider population in sole cotton was different as the population of spiders gradually increased towards the later stage of the crop.

It became clear from the results that the total abundance of the natural enemies was more during the vegetative stage but the diversity was relatively less. This was because, during this stage, only few taxa contributed maximum share to the total abundance, whereas during the flowering stage the of the crop the distribution of the

Table 4 : Abundance of various Parasitoid families in different growth stages of intercropped and sole cotton.

Parasitoid families	Vegetative Stage (V)		Flowering and boll formation (F)		Boll maturity stage (M)	
	IC	SC	IC	SC	IC	SC
Platygasteridae	23	11	16	9	13	5
Diapridae	18	8	8	5	5	3
Eupelmidae	14	2	10	3	10	1
Mymaridae	13	9	3	1	8	5
Braconidae	11	6	6	1	6	4
Aphelinidae	5	3	2	0	4	2
Ceraphronidae	0	0	2	0	0	0
Eulophidae	2	2	3	1	5	3
Total abundance	86	41	50	20	51	23
H	1.78	1.77	1.83	1.44	1.85	1.85
E	0.91	0.91	0.88	0.81	0.95	0.95
D_{mg}	1.34	1.61	1.80	1.67	1.53	1.91

IC = Intercropped cotton, SC= Sole cotton, H = Shannon diversity index, E = Pielou's Evenness Index, D_{mg} = Margelef's richness index.

individuals (evenness) among the observed taxa was more even, hence diversity was also higher. And further during this stage, richness was higher compared to other stages of crop. A higher richness and evenness contributed to higher diversity.

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