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Intensity of Insect Pests in *Gossypium hirsutum* Cultivars under High Density Planting System (HDPS) in India

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A B S T R A C T

A field experiment was conducted to study the mean incidence of major cotton insect pests during two consecutive seasons *i.e*. during *kharif*, 2010-11 and 2011-12 at CICR, Nagpur under high density planting system (HDPS) using different genotypes of *G. hirsutum* with different spacings. The main objectives of the work was to identify lines of *G. hirsutum* which have less infestation of major insect pests under HDPS system and to investigate whether the incidence is influenced by plant density. In 2010-11 the minimum mean population of leafhopper was on NISC-50 (1.82 nymphs/3 leaves/plant) with spacing of 45x13.5 cm followed by PKV-0811 (1.91 nymphs/3 leaves/plant) with spacing of 45x13.5 cm and these genotypes are significantly superior over the others. The injury grade was I on both NISC-50 and PKV-081. The mean per cent square damage was low in CNH-120 MB (2.76 %) followed by PKV-081 (3.82%) both were statistically on par with each other and significantly superior over other genotypes. The mean pink bollworm population was low on PKV-081 (2.53 larvae/25 green bolls). The lowest per cent locule damage due to pink boll worm was noticed on PKV-081 (8.48 %). However the performance of genotypes and geometry against the all insect pests in 2011-12 was not significantly different. Pest incidence was not altered by closer spacing.

Introduction

Adoption of High density Planting System (HDPS), compact and early maturing cotton varieties offer an alternate to sustainable production at decreased production cost under Indian condition. The productivity of cotton in Indian condition has not shown any remarkable improvement in the last 10 years and yields have stagnated. Increasing plant density in cotton is a potential alternate route to increase cotton yield and net profits (Venugopalan *et al.*, 2014) Considerable research efforts have been going on for over a century to determine the optimum plant population for maximum yield and quality in upland cotton. However, availability of more determinate cultivars, more efficient options of weed control and insect pest management (including transgenic), growth regulations to modify morphoframe, planting and harvesting equipments *etc.*, has made high density cotton planting system popular in several countries. The concept on high density cotton planting,

more popularly called Ultra Narrow Row (UNR) cotton was initiated by (Briggs *et al.*, 1967), and this concept has been one of the most researched topics during the last 15 years. Availability of early maturing, compact sympodial plant types with more fruiting bodies closer to the main stem is a pre-requisite for successful HDPS. Theoretically, higher planting density ensures earlier crop canopy cover, higher sunlight interception leading to higher and earlier yields at reduced cost. The obvious advantage of this system is earliness (Rossi *et al.,* 2004) since UNR needs less bolls/plant to achieve the same yield as conventional cotton and the crop does not have to maintain the late formed bolls to mature. In general, it was observed that lower plant densities produces high values of growth and yield attributes per plant, but yield per unit area was higher with higher plant densities (Namdeo *et al.,* 1991; Dhoble *et al.,* 1992; Sharma *et al.,* 2001). Several researches have concluded that seed cotton yield and plant density are either unrelated. Others have observed reduced yields at sub or supra-optimal plant densities. Fertilizer and pest management are important consideration for increased yields under high density planting system. Changes in plant density modify the microclimate and this may alter the incidence of pests and diseases (Venugopalan *et al.,* 2014). Keeping in view and above consideration, intensity of pest load on different genotypes with different spacing's was studied to identify lines of *hirsutum* which have less infestation of major insect pests under HDPS system and to observe whether the pest incidence was modified by plant density.

Materials and Methods

A field experiment was conducted to study the mean incidence of major cotton insect pests during two consecutive seasons *i.e*. *kharif*, 2010-11 and 2011-12 at CICR, Nagpur under high density planting system (HDPS) using different genotypes of *hirsutum* with three different spacings under rainfed conditions on a deep black soil. In 2010-11 we evaluated 5 *G. hirsutum* cultivars (Anjali, CNH-120MB, PKV-081, NISC-50, CCH-724) at 5 crop geometries (60 x 30 cm, 45 x 20 cm, 45 x 13.5 cm, 30 x 30 cm, 30 x 20 cm). In 2011-12 we evaluated 10 different genotypes (LH900, Suraj, PKV-081, NH-630, CNH2, CNH1109, CNH281, CNH1108, ADB-39 and DSC-115) at 3 crop geometries (60 x 30 with 100% RDF, 45x15 with 100% RDF and 45x15 with vermicompost @ 2 tonnes/ ha +125% RDF.

The experiment was replicated thrice with split plot design. Incidence of sucking pests *viz*., aphids, leafhoppers, whiteflies and thrips, bollworms *viz*., American bollworm, pink bollworm, spotted bollworm and tobacco caterpillar and that of natural enemies such as lady bird beetles and spiders were recorded from 6 randomly selected plants from each plot at 15 days interval throughout the cropping season.

The population of nymphs for leafhoppers, aphids and thrips, while adult count for whiteflies were recorded from three leaves, one each from top, middle and bottom canopies of the plant. The larval count of *H. armigera* was taken by observing squares, flowers and bolls of the plant. Similarly the intensity of damage by *H. armigera* was recorded in squares and green bolls from the whole plant.

The incidence of pink bollworm larvae was recorded by destructive sampling of the green bolls. From each of the test cultivars in all the treatments, 20-25 (25 green bolls 2010-11) and 20 green bolls 2011-12) were collected randomly and were cut open to observe the number of larvae per boll and locule damage. The population of *S. litura* larvae and natural enemies were recorded on whole plant basis.

Statistical analysis

The data obtained for various pests were analyzed by adopting appropriate transformation before statistical analysis following Gomez and Gomez (1984). Data analysis was performed by using ANOVA and means were separated using Lsd test at 5% level of significance.

Results and Discussion

2010-11

Population of sucking pests on *G. hirsutum*

Thrips, *Thrips tabaci* Lind: The mean thrips population during *kharif* 2010-11 indicated that there was no significance difference in the population level on all genotypes and spacing under HDPS (Table 1).

Leafhopper, *Amrasca biguttula biguttula* (Ishida): The minimum mean population of leafhopper was on NISC-50 (1.82 nymphs/3 leaves/plant) followed by PKV-081 (1.91 nymphs/3 leaves/plant) and these genotypes are significantly superior over the others. The injury grade was I on both NISC-50 and PKV-081 (Table 2). PKV 081 at 30x20 cm spacing harbored significantly lower jassid nymphs at 75 DAS as compared to other genotypes at different spacing (Table 2). The mean leafhopper nymphs population was maximum on CCH-724 with spacing of 60x30 cm (2.80 nymphs /3 leaves/plant) followed by CNH-120 MB with spacing of 45x20 cm (2.54 nymphs /3 leaves/plant). These genotypes are statistically on par and significantly different from other genotypes.

Whiteflies, *Bemisia tabaci* (Gennadius): The data showed that the mean population of whiteflies during *kharif* 2010-11 under HDPS did not differ significantly with respect to genotype and spacing (Table 1).

Incidence of bollworms: Per cent square and boll damage by boll worms

The mean per cent square damage was low in CNH-120 MB (2.76 %) followed by PKV-081 (3.82%) both were statistically on par with each other and significantly superior over other genotypes. The minimum per cent boll damage was recorded on PKV-081 (1.80%) but it spacing did not influence per cent square damage of the genotypes tested under HDPS (Table 4).

Pink boll worm, *Pectinophora gossypiella* (Saunders): The mean Pink bollworm population was low on PKV-081 with (2.53 larvae/25 green bolls). Spacing that showed less incidence was 45 x13.5 cm but on the whole all the genotypes and spacing were statistically non-significant for the incidence of pink boll worm under HDPS.

Locule damage by pink boll worm: The lowest per cent locule damage due to pink boll worm was noticed on PKV-081 with (8.48 %). All the genotypes were statistically non-significant for the incidence of PBW under HDPS. The spacing that showed less per cent of locule damage was 45x20 cm and 45x13.5 cm and is statistically at par with each other (Table 4). Number of spider webs: The data showed the spiders webs was maximum on CNH-120 MB with 8.91 webs/plot) followed by LRK-516 (8.87 webs/plot) and are superior to other genotypes but are statistically on par at each other. The spider webs at the on spacing 30x15 cm (11.8 webs /plot) were maximum (Table 3).

2011-12

Jassids: The mean incidence of jassid population (number of nymphs /3 leaves/pants) on the 10 *hirsutum* genotypes under 3 different spacing's was not significantly different.

Table.1 Incidence of sucking pests under HDPS during *kharif*, 2010-11

Treatment	Thrips/3 leaves	Whiteflies/3 leaves
Genotypes (G)		
LRK-516	2.26	1.99
CNH-120 MB	2.34	1.96
PKV 081	2.26	1.92
NISC-50	2.61	1.50
CCH-724	2.59	1.50
SEm	0.10	0.10
CD (P=0.05)	NS	NS
Spacings (cm) (S)		
60x30	2.98	1.81
45x20	2.54	1.49
45x13.5	1.79	1.93
30x30	2.18	2.01
30x20	2.64	1.59
SEm	0.18	0.13
CD (P=0.05)	NS	NS
Interaction (SxG)		
SEm	0.51	0.51
CD (P=0.05)	NS	NS

Table.2 Mean incidence of jassids under HDPS during *kharif*, 2010-11

Treatments	Number of jassids /3 leaves/plant					
	60x30 cm	45x20 cm	45x13.5 cm	30x30 cm	30x20 cm	Mean(G)
LRK-516	2.10 (1.43)	2.32 (1.51)	2.62 (1.51)	1.87 (1.36)	1.82 (1.34)	2.15^{b} (1.45)
CNH-120 MB	2.98 (1.73)	2.87 (1.67)	1.82 (1.67)	2.44 (1.56)	2.58 (1.60)	2.54 $(1.58)^{c}$
PKV 081	2.72 (1.61)	1.97 (1.39)	1.37 (1.39)	1.88 (1.37)	1.62 (1.27)	1.91^{ab} (1.36)
NISC-50	1.74 (1.31)	1.92 (1.38)	1.76 (1.38)	2.08 (1.43)	1.58 (1.25)	1.82^{a} (1.33)
CCH-724	3.13 (1.76)	2.97 (1.71)	2.30 (1.71)	3.35 (1.82)	2.25 (1.49)	2.80^{c} (1.67)
Mean (S)	2.53^{c} (1.57)	2.41^{c} (1.53)	1.97^{a} (1.39)	2.32^{abc} (1.51)	1.97^{ab} (1.39)	--
	Spacing (S)		**Genotype (G)**		**Interaction (SxG)**	
SEm	0.06		0.06		0.30	
CD (P=0.05)	0.13		0.11		NS	

Figures in parenthesis are square root transformed values; Treatment means with the letter(s) in common are not significant by Lsd at 5 % level of significance

Table.3 No. of spider webs under HDPS during *kharif*, 2010-11

Treatments	Number of spider webs/ 5 meter row					
	60x15 cm	45x13.5 cm	45x10 cm	30x20 cm	30x15 cm	Mean (G)
LRK-516	4.00 (1.93)	6.67 (2.51)	6.67 (2.63)	12.67 (3.47)	14.33 (3.78)	8.87^{ab} (2.87)
CNH-120 MB	5.55 (2.12)	6.67 (2.64)	11.00 (3.31)	10.00 (3.21)	11.33 (3.41)	8.91^{b} (2.94)
PKV 081	2.67 (1.65)	5.67 (2.33)	5.00 (2.35)	4.67 (2.25)	13.00 (3.39)	6.20^{a} (2.40)
NISC-50	3.33 (1.95)	6.33 (2.46)	13.67 (3.64)	11.33 (3.38)	8.67 (3.01)	8.67^{ab} (2.89)
CCH-724	4.33 (2.16)	9.33 (3.08)	6.67 (2.58)	5.00 (2.26)	11.67 (3.47)	7.39^{ab} (2.71)
Mean (S)	3.98^{a} (1.96)	6.93^{ab} (2.61)	8.60^{bc} (2.90)	8.73^{bc} (2.91)	11.8^{c} (3.41)	--
	Spacing (S)		**Genotype (G)**		**Interaction (SxG)**	
SEm	0.30		0.26		1.39	
CD (P=0.05)	0.68		0.53		NS	

Figures in parenthesis are square root transformed values; Treatment means with the letter(s) in common are not significant by Lsd at 5 % level of significance

Table.4 Incidence of bollworms under HDPS during *kharif*, 2010-11

Treatment	American bollworm	Pink boll worm damage indices		
	Per cent square damage	Per cent boll damage	No. of larva/ 20 green bolls	Per cent locule damage
Genotypes (G)				
LRK-516	4.68	5.37	3.51	11.13
CNH-120 MB	2.76	1.88	4.43	12.52
PKV 081	3.82	1.80	2.53	8.48
NISC-50	4.04	5.71	4.72	10.12
CCH-724	9.65	4.29	3.35	12.16
SEm	0.33	0.26	0.27	0.32
CD (P=0.05)	0.66	0.53	NS	NS
Spacings (cm) (S)				
60x30	5.59	6.65	6.02	14.27
45x20	3.57	1.58	2.93	8.76
45x13.5	5.56	4.64	2.36	9.11
30x30	4.62	2.94	3.67	11.87
30x20	5.60	3.90	3.56	10.39
SEm	0.56	0.36	0.34	0.37
CD (P=0.05)	NS	0.83	NS	NS
Interaction (SxG)				
SEm	1.73	1.40	1.44	1.69
CD (P=0.05)	NS	NS	NS	NS

Table.5 Incidence of pests and natural enemies under HDPS during *kharif*, 2011-12

Treatment	Sucking pest population					Defoliator	Natural enemies	
	Jassids /3 leaves (Nymph)	Aphids /3 leaves	Thrips /3 leaves	Whiteflies /3 leaves		Semi looper	No. of Lady bird beetle grubs /Plant	No. of spiders/ Plant
Genotypes (G)								
LH900	2.46	3.59	1.42	0.84		0.00	0.01	0.09
Suraj	2.75	3.19	1.77	1.17		0.01	0.05	0.09
PKV081	2.80	4.17	1.14	1.07		0.04	0.02	0.12
NH630	3.17	3.50	1.82	1.03		0.02	0.01	0.08
CNH 2	3.11	5.28	1.36	1.04		0.02	0.02	0.09
CNH 1109	2.80	3.82	1.40	0.74		0.07	0.03	0.09
CNH 281	2.78	4.18	1.25	1.27		0.02	0.03	0.10
CNH 1108	2.58	3.89	1.40	0.78		0.04	0.05	0.10
ADB 39	2.98	3.67	1.59	0.98		0.00	0.03	0.06
DSC 115	2.98	4.03	1.59	1.12		0.00	0.07	0.08
SEm	0.08	0.16	0.11	0.09		0.01	0.01	0.02
CD (P=0.05)	NS	NS	NS	NS		0.02	NS	NS
Spacings (cm) (S)								
60x30(100% RDF)	2.83	4.12	1.46	1.03		0.02	0.03	0.87
45x15(100%RDF)	2.70	4.34	1.45	1.06		0.03	0.03	0.89
45x15 (Vermi+125% RDF)	3.01	3.43	1.45	0.93		0.02	0.05	1.10
SEm	0.04	0.12	0.05	0.04		0.00	0.00	0.01
CD (P=0.05)	NS	NS	NS	NS		NS	NS	NS
Interaction (SxG)								
SEm	0.14	0.28	0.19	0.15		0.02	0.02	0.04
CD (P=0.05)	NS	0.60	NS	NS		NS	NS	NS

Table.6 Incidence of pink bollworm and American bollworm under HDPS during *kharif*, 2011-12

Treatment	Pink boll worm damage indices		American bollworm
	% locule damage	No. of larvae/20 green bolls	No. of larvae/plant
Genotypes (G)			
LH900	13.10	2.37	0.27
Suraj	16.86	3.40	0.22
PKV081	13.88	2.41	0.50
NH630	16.38	2.89	0.33
CNH 2	15.72	2.66	0.44
CNH 1109	15.72	3.31	0.27
CNH 281	9.83	2.58	0.03
CNH 1108	13.25	1.95	0.05
ADB 39	14.03	1.50	0.70
DSC 115	12.24	1.84	0.05
SEm	2.25	0.26	0.12
CD (P=0.05)	NS	NS	NS
Spacings (cm) (S)			
60x30 (100% RDF)	12.38	0.77	0.29
45x15 (100%RDF)	16.66	2.83	0.40
45x15 (Vermi+125%RD)	13.22	2.89	0.28
SEm	1.64	0.18	0.04
CD (P=0.05)	NS	NS	NS
Interaction (SxG)			
SEm	4.06	0.47	0.20
CD (P=0.05)	NS	NS	NS

The mean population was well below the economic threshold level (6 nymphs/3 leaves /plant). However the least jassid population was observed on LH-900 and CNH-1108 (Table 5).

Aphids: The observation on aphids revealed that the genotypes namely Suraj, NH-630 and ADB-39 recorded lower mean population, 3.19, 3.50 and 3.67 respectively, as compared to CNH-2, CNH-281 and PKV-081 whose mean population was more than four under 3 different spacing's. The overall mean aphid population on all genotypes tested at three different spacing was lower than ETL (Table 5).

Thrips: There was no significant difference in the thrips population observed on 10 genotypes of *hirsuum* in all three different spacing's tested. The genotype PKV-081 and CNH-1108 recorded lower incidence of thrips (1.14 and 1.25) as compared to NH-630 and Suraj (1.82 and 1.77) (Table 5).

Whiteflies: The incidence of whiteflies population was not significantly at three different spacing as well as across 10 genotypes tested under HDPS. The observed whiteflies population on all the genotypes in three different spacing's been insignificant ranging from 0.74 to 1.27/3 leaves /plant. Which was for below ETL (30/3 leaves

/plant) (Table 5). Semilooper: The semilooper larvae observed on all the treatments of different spacing and genotypes was lower than 1 larvae/plant. The performance of all genotypes against semilooper larval incidence was similar (Table 5).

American bollworm: The genotypes CNH-281, CNH-1108 and DSC-115 showed least incidence 0.03, 0.05 and 0.05 of larvae per plant, respectively. The genotypes ADB-39 (0.70) and PKV-081 (0.50) showed slightly more than the above genotypes. The *Helicoverpa* incidence is relatively more in plants spaced at 45x15 cm 100 % RDF than other two spacing's was observed. However statistically there was no significant difference in population density of *Helicoverpa* in 10 genotypes at three different spacing's (Table 6).

Pink bollworm (PBW): The mean incidence of pink bollworm larvae observed on 20 green bolls was relatively higher (2.83) on plants spaced at 45x15 cm than 60x30 (0.77 larvae/20 green bolls). This indicates wide spacing may harbor lower incidences of pink bollworm larvae. The genotypes Suraj and CNH-1109 harbor more incidences of pink bollworm larvae while ADB-39 and DSC-115 showed less incidence ranging from 1.50 to 1.84. However the performance of genotypes against the survival of pink boll worm was not significantly different. The mean per cent locule damage was not significantly different (Table 6).

Ladybird beetles: The lady bird population was observed as number of grubs per plant and it was found that the mean population ranging from 0.03 to 0.05 at three different spacing's while the grub population range was 0.01 to 0.07 on 10 genotypes of *hirsutum* studied. The ladybird beetle population was statistically non-significant among various spacing's and genotypes tested (Table 5).

Spiders: The number of spider population was also similar in all genotypes tested at three different spacing's and were not significantly different (Table 5).

It was indicative from the literature that scanty information is available on the intensity of insect pests in cotton under high density planting system; moreover few workers suggested that it will enhance the predator fauna in crop ecosystem. (Harshana *et al.*, 2017) results revealed that, irrespective of the genotypes, non-significant difference was observed with respect to pest's population among higher plant densities compared to normal spaced crops. Further, HDPS blocks registered higher seed cotton yield of 26.12 and 23.95 q/ha as compared to 20.35 and 21.20 q/ha under normal spaced crop (Sohi *et al.*, 1995) reported that incidence of jassid was less significant with different spacing's. The higher incidence of spiders and coccinellids was recorded under closer spacing of 90×45 cm than wider spaced crop (120×60 cm) (Kalaichelvi, 2008). Though, the non-significant results were observed in interactions. The similar results were found in the spacing's by recording 8.60 and 11.80 spider webs in 45x13.5 and 30x20 cm, respectively during 2010-11 and during 2011-12, 1.10 spiders per plant 0.05 lady bird beetle grubs per plant was noticed in the 45x15 cm spacing with vermin+ 125% RDF. It may be due to more congenial to make webs by spiders and increase the shelter for natural enemies for predating the pest population. In the same line the ideal conditions suits to pest build up but it may take care by natural enemies in the field henceforth, in general low population of pests was observed under HDPS. Natural pest control is an important ecosystem function that often depends on colonization of arable crops by natural enemies. Natural enemies have been reported to invade arable fields, and reduce pest densities, thereby reducing

damage levels and mitigating yield loss (Cardinale *et al.*, 2003; Ostman *et al.*, 2003). Therefore, an abundant complex of natural enemies in crops may provide sustainable crop protection, reducing the need to use chemical pesticides. Many predators considered to be important within agro ecosystems, such as carabid beetles and spiders, are generalists that use resources provided by natural habitats (Landis *et al.*, 2000; Symondon *et al.*, 2002). In cotton under different plant spacing of 15×75 cm, 22.5×75 cm and 30×75 cm, number of bolls per plant increased significantly as plant spacing increased i.e., 21.89, 25.33 and 28.67 bolls per plant, respectively, while number of plants per unit area decreased significantly as plant spacing increased, 8.61, 5.71 and 4.26 plants per meter square, respectively and seed cotton yield was 22.01, 25.12 and 22.84 q ha^{-1}, respectively (Ali *et al.*, 2009). Genotype AKH 081 popularly called PKV 081 was found most suitable for HDPS based on yield, morphological features, earliness, tolerance to sucking pests and boll weight[15] is in accordance with present findings that generally less number of sucking pests and pink bollworm damage indices during both the years and highest number of spiders plant (0.12) during 2011-12 was recorded. Incidentally PKV-081 was determinant and was earliest in maturity. These characters would have helped to escape pink bollworm compared to other genotypes.

In 2010-11 pest population under HDPS, the minimum mean population of leafhopper was recorded on NISC-50 with spacing of 45x13.5 cm followed by PKV-081 with spacing of 45x13.5 cm. The mean per cent square damage was low in CNH-120 MB followed by PKV-081. Mean pink bollworm population was low on PKV-081 and the lowest per cent locule damage due to pink boll worm was noticed on PKV-081. However the performance of genotypes and geometry against the all insect pests in 2011-12 was statistically non-significant but mathematically less population sucking pests, lepidopteron pests and maximum number of natural enemies was observed in decreased spacing's. In general PKV 081, CNH 1108 and CNH 281 performed better under HDPS with respect to pest tolerance. Thus pest population was not altered by closure spacing. For best performance under HDPS, early maturity, sucking pest tolerant genotypes are recommended.

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