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MANAGEMENT OF *BEMISIA TABACI, AMRASCA BIGUTTULA BIGUTTULA* AND *HELICOVERPA ARMIGERA* ON FIELD GROWN COTTON USING DIFFERENT ECOFRIENDLY INSECTICIDES

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ABSTRACT
Pest resurgence and development of resistance by the pest against the insecticides is the major issue to be enlightened with the use of hazardous chemical pesticides. Pod borer (*Helicoverpa armigera*), cotton jassid (*Amrasca biguttula biguttula*) and white fly (*Bemisia tabaci*) causes significant damage to the cotton crop. Field trial was conducted at Aligarh district, Uttar Pradesh during 2009 and 2010, to management of *B. tabaci, A. biguttula biguttula* and *H. armigera* by using different ecofriendly insecticides (*viz.*, neemgold, achook, biolep and endosulfan). All these four insecticides were applied at three different concentrations as well as different combinations. Three varieties of cotton selected for this purpose i.e. R.S.-875, F-1378 and H-1098. First spray was done by achook 0.5% on 2rd week (60 DAS), second spay i.e. 0.05% of neemgold on 25th week (75 DAS), third spray was of 0.08% of endosulfan on 29th week (90 DAS) then fourth spray was applied on 31st week (105 DAS) after that the combination of these insecticides were used for spraying purpose. Fifth spray was of 0.05 + 0.06 (neemgold + endosulfan), sixth spray was of 0.05 + 0.05 (biolep + neemgold) last spray was of 0.07 + 0.05 (endosulfan + achook). Results revealed that all the treated plots gave significant results and the production was higher than the control ones. The total cotton production in different three varieties was as 2.57, 2.92, 2.24 (Q/acare) during 2009-10 and 2010-11 it was 3.01, 2.85, 2.15 (Q/acare) in Var. "R.S.-875", Var. "F-1378" and Var. "H-1098" respectively in case of control. Where as in case of treated it was recorded as 4.04, 3.60, 3.64 (Q/acare) was 5.12, 3.32, 3.95 (Q/acare) in Var. "R.S.-875", Var. "F-1378" and Var. "H-1098" respectively. In case of treated one Var. "R.S.-875" showed much affected result whereas Var. "F-1098" showed least effective result of these tested insecticides. The total mean production of cotton recorded in control as 2.58, 2.67 Q/acre whereas it gave more production in treated one i.e., 3.76, 4.13 (Q/acare) during both cropping years. These insecticides were more effective in case of *A. biguttula biguttula* than the other two insects *i.e., B. tabaci* and *H. armigera*. These insecticides were least effective on the *H. armigera*.

KEY WORDS: *B. tabaci, A. bigutulla bigutulla*, *H. armigera*, Management

INTRODUCTION

Cotton the most important cash and commercial crop of India is subjected to the ravages of a number of insect pest (Sontakke *et al*., 2007). Cotton (*Gossypium hirsutum*) being a friendly fibre grown in 111 countries all along the world. In India it is cultivated in 9 million hectare with a production of 21.3 bales of seed cotton (Anonymous, 2005). Insect pests are well known as the major constraint to crop production. One of the problems in addressing pest management is inadequate knowledge about the factors influencing pest population dynamics. To understand pest dynamics, scientists collect pest surveillance data and related agricultural operations regarding crops, farming practices and other weather parameters.

Cotton whitefly (*Bemisia tabaci* Gen.) was described over 100 years ago as a pest of tobacco in Greece (Anonymous, 1989). Since then, it has become one of the most important sucking pests of world's industrial and food crops like cotton, sunflower, melon, tomato, brinjal etc. Over 500 plant species from Asia, Africa, America, Europe, Russia, Australia and the Pacific Islands confirms its polyphagous nature (Anonymous, 1986; Greathead, 1986). From cotton growing areas of central Punjab, Pakistan, it has been reported from 164 plant species (Attique *et al*., 2003). In 16 out of 27 cotton producing countries, whitefly has been reported as a major pest during mid to late cotton growing season (Anonymous, 1989). In the subcontinent region of Punjab, American cotton varieties failed completely during 1919 and 1926 and partially in 1921, 1923 and 1927, because of whitefly attacks (Hussain and Trehan, 1933). Heavy infestation may reduce plant vigor and growth, cause chlorosis and uneven ripening of bolls. Its direct feeding induces physiological disorders resulting in shedding of immature fruiting parts. Its nymphs produce honeydew, on which black sooty mold grows, reducing the photosynthetic capabilities of plants. It acts as a sole vector of more than 100 plant viruses, which cause diseases to many commercial crops in different parts of the world (Jones, 2003). Role of different crops in the winter survival, population build up and carry-over of whitefly to cotton has been recognized by various workers like Hussain and Trehan (1933) and Hussain et al. (1936) from India and Mohyuddin et al. (1989) from Pakistan. Similar role of crops and vegetables in the carry-over and population build up of whitefly has also been signified by Butler et al. (1986) and Johnson et al. (1982) from Southern California, Melamed Madjar et al. (1979) and Gerling (1984) from Israel, Mabbit (1978) and Nachapong

and Mabbit (1979) from Thailand. B. tabaci *responsible for transmission of yellow mosaic virus (YMV), which is a major* constraint for cultivation of the crop.

The leaf hopper, *Amrasca biguttula biguttula* (Ishida) is a major sucking insect pest and its incidence not only results in the loss of plant vigour, but also spreads the mosaic virus diseases affecting fruit yield perceptibility (Samal and Patnaik, 2008). The nymphs and adults suck the sap from leaves and cause phytotoxic symptoms known as hopper burn which results in complete desiccation of plants and has become one of the limiting factors in economic productivity of the crop (Shivanna et al., 2009). Adults and nymphs suck the sap from the leaves and also injecting toxic saliva in to the tissue which causes toxemia .The hopper generally feeds from the lower side of the leaves. The attacked leaves become crinkle and show the characteristic of browning and the other symptom of hopper burn. The attacked plants become stunted and fail to grow and bear no fruits.

A. biguttula biguttula appear with the onset of cloudy weather and their population is adversely affected by heavy rain. Eggs are laid singly within leaf veins in the parenchymatous layer between the vascular bundles and the epidermis on the upper leaf surface. Averages of 15 eggs (with a maximum of 29) are laid /female. Mature leaves (35 to 45 days old) are preferred for egg deposition. Incubation and nymphal periods last for 4 to 11 and 7 to 21 days respectively. Longevity of the adults varies from 5 to 8 weeks and there are 10 to 12 overlapping generations in a year. Nangpal (1948) has reported that mating takes place 2 to 16 days after emergence and oviposition begins 2 to 7 days after copulation. Life cycle is completed in 15 to 46 days in the different seasons.

Pod borer, *Helicoverpa armigera* (Hubner) is one of the most destructive pests and one of the major constraints for low yield of the crops right from vegetative to podding stage (Devi *et al*., 2002; Dhingra *et al*., 2003) and found on a large number of cultivated and wild plants throughout India (Pandey and Kanujia, 2004). The pest has been reported resistant to many commonly used insecticides (Jaysawal, 1990; Phokela *et al.*, 1990 and Lande, 1992). Ecological and physiological features like high fecundity, multi-voltinism, and ability to migrate long distances and diapauses during unfavorable conditions contribute for its severity in different situations. The *H. armigera* incidences, on other hand show a certain pattern in term of population dynamics. In this an effort has been made to understand the *H. armigera* population dynamics on cotton crop.

MATERIALS AND METHODS

The population dynamics of whitefly (*B. tabaci*), leafhopper (*A. biguttula biguttula*) and Pod borer, (*H. armigera*) on cotton varieties i.e. R.S.-875, F-1378 and H-1098. Improved agronomic practices recommended for the region at Aligarh, were adopted for raising the commercial crop for fibre purpose. Manure and fertilizers were applied: compost @200 Q/ha and half quantity of N_2 (45 kg/ha), P_2O_5 (50 kg/ha) and K_2O 60 kg/ha was given as basal dose at the time of sowing and half of the N_2 (45 kg/ha) was given 20 and 40 days after sowing. Nymphal counts of the *B. tabaci* and *A. biguttula biguttula* were made at biweekly interval from 20 random plants in the field taking three fully formed leaves in the upper canopy of each plant. Data on pest population as well as weather variables were averaged for different standard meteorological weeks. Mean temperature of around 30^0 C and mean relative humidity above 70% were found to be highly conducive for population build-up of these pests.

Four different ecofriendly insecticides were selected for the treatment i.e. neemgold, achook, endosulfan and biolep. These insecticides were applied at three different concentrations as well as different combinations. Three varieties of cotton have used in this experiment i.e. R.S.-875, F-1378 and H-1098. First spray was done by achook 0.5% on 23rd week (60 DAS), second spay i.e. 0.05% of neemgold on 25th week (75 DAS), third spray was of 0.08% of endosulfan on 27th week (90 DAS) then fourth spray was of biolep (0.05%) applied on 29th week (105 DAS) after that the combination of these insecticides were used for spraying purpose. Fifth spray was of 0.05 + 0.06% of neemgold + endosulfan on 31st week (120 DAS), sixth spray was of 0.05 + 0.05% of biolep + neemgold on 33rd week (135 DAS) and last spray was of 0.07 + 0.05% of endosulfan + achook on 35th week (150 DAS). The data were subjected to analysis of variance (ANOVA) for the significance of study at 1 and 5% level.

RESULTS & DISCUSSION

The present study a field trial was conducted to determine the population dynamics of *B. tabaci, A. biguttula biguttula* and *H. armigera* and their management by using different eco friendly insecticides (*viz.*, neemgold, achook, biolep and endosulfan). The insecticides were applied alone and in combination form. Three varieties of cotton i.e. R.S.-875, F-1378 and H-1098 were selected for this purpose. These treatments gave significantly superior as compared to untreated control throughout the period of experimentation during 2009-10 and 2010-2011 and the production was higher than the control ones. These insecticides were more effective against *A. biguttula biguttula* than the other two insects *i.e., B. tabaci* and *H. armigera*. The attack of *H. armigera* was more on the selected varieties of cotton and its mean population went upto 51.0 larvae/plant. These insecticides were least effective on the *H. armigera*.

The average population density of *B. tabaci* was recorded on before and after spray of different insecticides. Before 1st, 2nd, 3rd, 4th, 5th, 6th, and 7th spray the average population density of *B. tabaci* ranged from 0.15-0.30, 0.40-0.70, 0.48-1.25, upto 2.5, 1.45-2.0, 2.80-3.10 and 2.10-3.64 nymphs/adult/leaf was recorded in three different varieties of *Gossypium* spp. during 2009-10 and 2010-2011. After 1st day treatment of earlier mentioned insecticides from 1st to 7th spray, the mean population of *B. tabaci* decreased significantly ranged from 0.00-0.10, 0.15-0.61, 0.21-1.00, 0.40-2.10, 2.00-2.60, 2.10-2.80 and last 2.60-4.85 nymphs/adult/leaf were found during 2009-10 and 2010-2011 (Table-1).

Table: 1. Average population buildup of *B. tabaci, A. biguttula biguttula, H. armigera* on cotton under field conditions, 2009-10 and 2010-2011

B. tabaci

Varieties	Average number of nymph/adult per leaf during standard weeks																	
	23 week (60DAS)		25 week (75 DAS)		27 week (90 DAS)		29 week (105 DAS)		31 week (120 DAS)		33 week (135 DAS)		35 week (150 DAS)		Control		Treated	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	C.D. at 5%	C.D. at 1%	C.D. at 5%	C.D. at 1%
R.S.-875	0.15 (1.07)	0.0 (1.00)	0.70 (1.30)	0.40 (1.18)	1.25 (1.50)	1.00 (1.41)	2.50 (1.87)	2.10 (1.76)	2.60 (1.90)	2.00 (1.73)	3.10 (2.02)	2.80 (1.95)	2.60 (1.90)	2.40 (1.84)	0.501	0.405	0.542	0.403
F-1378	0.30 (1.14)	0.00 (1.00)	0.64 (1.28)	0.61 (1.27)	0.90 (1.38)	0.40 (1.18)	1.50 (1.58)	1.10 (1.45)	2.10 (1.76)	1.80 (1.67)	3.10 (2.02)	2.10 (1.76)	4.85 (2.42)	3.64 (2.15)	0.632	0.451	0.472	0.513
H-1098	0.15 (1.07)	0.10 (1.05)	0.40 (1.18)	0.15 (1.07)	0.48 (1.22)	0.21 (1.10)	0.90 (1.38)	0.40 (1.18)	2.00 (1.73)	1.45 (1.57)	2.80 (1.95)	2.10 (1.76)	3.95 (2.22)	2.10 (1.76)	0.584	0.425	0.351	0.476

A. biguttula biguttula

Varieties	Average number of nymph/adult per leaf during standard weeks																	
	23 week (60DAS)		25 week (75 DAS)		27 week (90 DAS)		29 week (105 DAS)		31 week (120 DAS)		33 week (135 DAS)		35 week (150 DAS)		Control		Treated	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	C.D. at 5%	C.D. at 1%	C.D. at 5%	C.D. at 1%
R.S.-875	0.15 (1.07)	0.08 (1.04)	0.75 (1.32)	0.58 (1.26)	0.95 (1.40)	0.60 (1.26)	1.20 (1.48)	0.25 (1.12)	2.80 (1.95)	1.50 (1.58)	3.20 (2.05)	2.50 (1.87)	3.40 (2.10)	2.70 (1.92)	0.482	0.421	0.392	0.293
F-1378	0.15 (1.07)	0.05 (1.02)	0.80 (1.34)	0.35 (1.16)	0.95 (1.40)	0.54 (1.24)	1.35 (1.53)	1.20 (1.48)	2.50 (1.87)	1.40 (1.55)	3.40 (2.10)	2.45 (1.86)	3.50 (2.12)	2.92 (1.98)	0.342	0.228	0.502	0.401
H-1098	0.15 (1.07)	0.05 (1.02)	0.50 (1.22)	0.31 (1.14)	0.62 (1.27)	0.041 (1.02)	1.35 (1.53)	1.02 (1.42)	2.85 (1.96)	1.85 (1.69)	3.85 (2.20)	2.45 (1.86)	2.85 (1.96)	2.10 (1.76)	0.431	0.321	0.347	0.253

H. armigera

Varieties	Average number of larvae per plant during standard weeks																	
	23 week (60DAS)		25 week (75 DAS)		27 week (90 DAS)		29 week (105 DAS)		31 week (120 DAS)		33 week (135 DAS)		35 week (150 DAS)		Control		Treated	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated	C.D. at 5%	C.D. at 1%	C.D. at 5%	C.D. at 1%
R.S.-875	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	1.00 (1.41)	3.00 (2.00)	4.00 (2.24)	10.00 (3.32)	11.00 (3.46)	20.00 (4.58)	18.00 (4.36)	35.00 (6.00)	26.00 (5.20)	4.206	3.053	4.178	3.034
F-1378	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	2.00 (1.73)	5.00 (2.45)	12.00 (3.61)	7.00 (2.83)	21.00 (4.69)	14.00 (3.87)	34.00 (5.92)	19.00 (4.47)	38.00 (6.24)	24.00 (5.00)	3.859	2.802	5.242	3.805
H-1098	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	2.50 (1.87)	4.00 (2.24)	8.00 (3.00)	9.00 (3.16)	11.00 (3.46)	16.00 (4.12)	21.00 (4.69)	27.00 (5.29)	26.00 (5.20)	31.00 (5.66)	4.647	3.373	4.915	3.568

Figure in parentheses are √(n+1) transform value

TABLE: 2. Correlation co-efficient between the populations of *B. tabaci, A. biguttula biguttula, H. armigera* and weather parameters on cotton during 2009-10 and 2010-2011

B. tabaci

Varieties	Temperature (^{0}C)				Relative Humidity				Wind Velocity (Km/h)	
	Maximum		Minimum		0712 A.M.		1412 P.M.			
	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated
R.S.-875	-0.788*	-0.752*	-0.398 ^{NS}	-0.245*	0.742*	0.645*	0.846^{NS}	0.715*	-0.598 ^{NS}	0.542*
F-1378	-0.698*	-0.721*	-0.382*	- 2.68^{NS}	0.641^{NS}	0.651*	0.845**	0.825*	- 0.543^{NS}	0.412*
H-1098	-0.809*	-0.782**	-0.398*	-0.342*	0.723*	0.721**	0.835*	0.850*	-0.594*	-0.591^{NS}

A. biguttula biguttula

Varieties	Temperature (^{0}C)				Relative Humidity				Wind Velocity (Km/h)	
	Maximum		Minimum		0712 A.M.		1412 P.M.			
	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated
R.S.-875	-0.690*	-0.689*	-0.598*	-0.621^{NS}	0.715*	0.638*	0.826*	0.815**	-0.812**	-0.715*
F-1378	-0.681*	-0.725**	-0.582^{NS}	-0.602^{NS}	0.638*	0.689*	0.815**	0.845*	-0.671*	-0.625*
H-1098	-0.812*	-0.891*	-0.539^{NS}	-0.482*	0.715*	0.710*	0.814**	0.849**	-0.703*	-0.642*

H. armigera

Varieties	Temperature (^{0}C)				Relative Humidity				Wind Velocity (Km/h)	
	Maximum		Minimum		0712 A.M.		1412 P.M.			
	Control	Treated	Control	Treated	Control	Treated	Control	Treated	Control	Treated
R.S.-875	-0.521^{NS}	-0.364*	-0.652^{NS}	-0.675*	0.710*	0.672*	0.451*	0.387*	-0.845*	0.834*
F-1378	-0.654*	-0.324^{NS}	-0.764^{NS}	-0.652*	0.782^{NS}	0.736*	0.541^{NS}	0.386*	-0.875^{NS}	0.825*
H-1098	-0.415**	-0.423*	-0.682*	-0.698**	0.715*	0.715*	0.421*	0.325*	-0.812*	-0.841*

* = Significant, ^{NS} = Non-significant

Mean population of *A. biguttula bigutulla* on before spray (1st to 7th spray) was observed (Table-1) ranged from 0.10-0.20, 0.50-0.80, upto 0.95, 1.20-1.35, 1.40-1.85, 2.44-2.50 and 2.10-2.92 nymphs/adult/leaf on cotton varieties, but after 1st day spray on all varieties of cotton and insecticides the average population of *A. biguttula biguttula* was significantly decreased and further reduction was monitored upto 3rd day and then mean population began to increase after 7th day in all treated plots during 2009-10 and 2010-2011. Maximum and minimum reduction in population was found in the combination of biolep and neemgold (0.05+0.05%) and achook (0.05%) treated plots at 135 and 60 DAS.

The average of two season's data also evinced the superiority of both the above treatments, with a record of low incidence of *A. biguttula biguttula* as compared to untreated control Samal and Patnaik (2008). Among the insecticides tested single spray with endosulfan on need basis also recorded less hopper population irrespective of seasons studied as compared to the untreated control Samal and Patnaik (2008). The efficacy of endosulfan against leaf hoppers corroborates with the findings of Mishra (2003). Gupta and Lal (1998); Amutha and Manisegaram (2006) revealed that three sprays of NSKE and a spray of imidacloprid significantly reduced the leaf hopper population. Mumtaz *et al.* (2006) indicate that three sprays of NSKE at 15 days interval could effectively control of *Chilo auricilius.*

In case of *H. armigera* the mean population density was recorded before the treatment at 60, 75, 90, 105, 120, 135, and 150 DAS ranged from 0.15, 0.50-0.80, upto 0.95, upto 1.35, 2.50-2.85, 3.2-3.85 and 3.5 larvae/plant during 2009-10 and 2010-2011(Table-1) while, 1st day after treatment of all insecticides on three varieties of cotton. The mean population of *H. armigera* was significantly decreased. Maximum and minimum reduction in mean population was observed at 135 and 60 DAS found in the combination of biolep and neemgold (0.05+0.05%) and achook (0.05%) treated plots found in the combination of biolepand neemgold (0.05+0.05%) and achook (0.05%) treated plots.

In view of environment safety the use of biopesticides providing effective, ecofriendly and economic management of the pod borer, *H. armigera* under field condition on the hand chemical pesticides exhibited ill effect in plant and human (Rao and Reddy, 2003; Mandal *et al.* 2003). Recently study made by Shayraj and Amalraj (2005), was complete corroboration with the present findings, who reported that the use of combination neem oil and monocrotophos were significantly superior for managing defoliator population in groundnut and the same results also made by Nazrussalam *et al.* (2008) who reported that the use of combination of achook and endosulfan were significantly superior for the management of *H. armigera* population in cotton. Neem products and dimethoate were equally effective in reducing the aphid infestation and increasing the yield of mustard (Singh *et al.*, 2003; Gupta and Rai, 2006; Ali and Ansari, 2008). Similar finding also made by Balikai (2005), who reported that the use of combination of cypermethrin at 50% flowering followed be acephate after 15 days were gave the best result against *H. armigera* in chickpea and combination, whereas, Singh *et al.* (2000) suggested the use of biopesticides also provide significant control in IPM of chickpea. However, Rawale *et al.* (2002) advocated that the use of neem oil also gave satisfactory result against cotton bollworm in cotton field.

The overall study revealed that among all schedule of insecticides and biopesticides, the schedule of biolep+neemgold (0.05+0.05%) and endosulfan+achook (0.07+0.05%) was significantly superior against the *B. tabaci*, *A. biguttula biguttula* and *H. armigera* and the least effective achook biopesticides against those insect pest of selected cotton varieties, during both cropping years.

Correlation coefficient (Table-2) of *B. tabaci* population with temperature and wind velocity was negative. In case of minimum temperature it was nonsignificant in variety F-1378 (-2.68) and significant in other two varieties i.e. R.S.-875 (-0.245) and H-1098(-0.342). Whereas in case of maximum temperature it was significant and ranges from -0.721 to -0.782 during 2009-10 and 2010-2011, respectively. The correlation coefficient with relative humidity was significant and positive in H-1098 (0.721 and 0.850). Wind velocity exhibited negative correlation and non significant in one variety i.e. H-1098 (-0.59), and R.S.-875 and F-1378 (0.542 and 0.412) where as significant in during 2009-10 and 2010-2011, respectively.

Correlation coefficient (Table-2) of *A. biguttula bigutulla* with different weather variables exhibited negative correlation with respect to the temperature, wind velocity and positive correlation with the humidity. The correlation coefficient between leafhopper population and temperature was negative as well as significant in case of maximum it ranges from -0.689 to -0.891 and in case of minimum it was non significant in varieties R.S.-875 (-0.621) and in F-1378 (-0.602) although it was significant in H-1098 (-0.482). The correlation coefficient of pest population with relative humidity was positive and significant, its ranged (0.638 to 0.710 min.) and (0.815to 0.849 max.). Wind velocity showed negative correlation coefficient as well as significant it ranged (-0.625 to -0.715) during 2009-10 and 2010-2011, respectively.

The correlation coefficient of *H. armigera* population with different parameter showed negative in case of temperature and wind velocity whereas it was positive in case of humidity. (Table-2) the correlation with population of *H. armigera* and maximum temperature recorded as negative and non significant in F-1378 (-0.324) where as in it was significant and in case of R.S.-875 and H-1098 it was highly significant. Whereas minimum temperature it was significant in R.S.-875 (-0.675), F-1378 (-0.652) and H-1098 (-0.698) varieties and during 2009-10 and 2010-2011, respectively. The minimum relative humidity showed positive and significant correlation in R.S.-875 (0.672), F-1378 (0.736) and H-1098 (0.715).

TABLE: 3 Regression relationship between the population of *B. tabaci, A. biguttula biguttula, H. armigera* and weather parameters on cotton in 2009-10 and 2010-2011

B. tabaci

Varieties		Regression equation	R^2
R.S.-875	Control	$Y=1.098+0.421\ X_1 +0.314X_2 +0.312X_3 -0.351X_4 +0.828X_5$	0.912
	Treated	$Y=2.145+0.525\ X_1 +0.241X_2 +0.425X_3 -0.680X_4 +0.214X_5$	0.908
F-1378	Control	$Y=2.104+0.214X_1 +0.105X_2 +0.124X_3 -0.231X_4 +0.111X_5$	0.915
	Treated	$Y=1.451+0.672\ X_1 +0.265X_2 +0.412X_3 -0.234X_4 +0.219X_5$	0.945
H-1098	Control	$Y=2.012+0.864\ X_1 +0.524X_2 +0.454X_3 -0.544X_4 +0.097X_5$	0.925
	Treated	$Y=1.315+0.416\ X_1 +0.510X_2 +0.231X_3 -0.247X_4+0.453X_5$	0.942

A. biguttula biguttula

Varieties		Regression equation	R^2
R.S.-875	Control	$Y=2.025-0.625\ X_1 +0.291X_2 +0.548X_3 -0.123X_4 +0.205X_5$	0.901
	Treated	$Y=1.920-1.015\ X_1 +0.208X_2 +0.393X_3 -0.241X_4 +0.151X_5$	0.908
F-1378	Control	$Y=2.141-0.185\ X_1 +0.398X_2 +0.589X_3 -0.209X_4 +0.114X_5$	0.903
	Treated	$Y=2.827+0.122\ X_1 +0.308X_2 +0.708X_3 -0.125X_4 +0.105X_5$	0.925
H-1098	Control	$Y=2.2431-0.345\ X_1 +0.204X_2 +0.542X_3 -0.241X_4 +0.181X_5$	0.934
	Treated	$Y=2.712-0.210\ X_1 +0.378X_2 +0.678X_3 -0.149X_4 +0.281X_5$	0.891

H. armigera

Varieties		Regression equation	R^2
R.S.-875	Control	$Y=2.056-0.245X_1 +0.561X_2 -0.435X_3 -0.145X_4 -0.234X_5$	0.915
	Treated	$Y=1.029-0.145X_1 +0.352X_2 -0.113X_3 +0.025X_4 -0.047X_5$	0.921
F-1378	Control	$Y=1.415-0.241X_1 +0.541X_2 -0.210X_3 +0.215X_4 -0.120X_5$	0.935
	Treated	$Y=1.262-0.124X_1 +0.325X_2 +0.641X_3 +0.565X_4 -0.325X_5$	0.945
H-1098	Control	$Y=1.264-0.245X_1 +0.542X_2 -0.245X_3 +0.235X_4 -0.456X_5$	0.901
	Treated	$Y=1.245-0.235X_1 +0.412X_2 -0.235X_3 +0.415X_4 -0.205X_5$	0.891

TABLE 4: Average yield of cotton in different varieties (Q./acare) in 2009-10 and 2010-2011

Varieties	R.S.-875	F-1378	H-1098	Mean
Control	3.01	2.85	2.15	2.67
	(2.00)	(1.96)	(1.77)	(1.92)
Treated	5.12	3.32	3.95	4.13
	(2.47)	(2.08)	(2.22)	(2.26)
Mean	4.06	3.08	3.05	3.39
	(2.25)	(2.02)	(2.01)	(2.10)
	Treatment	Varieties	Treatment x Varieties	
C.D. at 5%	0.682	0.592	0.976	
C.D. at 1%	0.435	0.561	0.765	

Figure in parentheses are √(n+1) transform value

Whereas maximum relative humidity showed positive and significant on R.S.-875 (0.387), F-1378 (0.386) and H-1098 (0.325). Wind velocity showed negative and significant correlation coefficient on H-1098 (-0.841) and significant correlation coefficient on R.S.-875 and F-1378.

The values (Table-3) of coefficient of determination (R^2) were high (0.89 to 0.94), indicated that the mean population of *B. tabaci, A. biguttula biguttula* and *H. armigera* governed significantly with the weather parameters. It concluded that the population of *L. erysimi* exhibited negative correlation with maximum and minimum temperature, wind velocity and positive with afternoon and morning relative humidity.

The total cotton production (Table-4) in different three varieties was as 3.01 Q/acare in Var. "R.S.-875", 2.85 Q/acare in Var. "F-1378" and 2.15 Q/acare in Var. "H-1098" in case of untreated (control) plots during 2009-10 and 2010-2011, respectively, whereas in treated plots was recorded as 5.12, 3.32 and 3.95 Q/acare respectively. The mean production of cotton (control + treated) was 4.06 Q/acare in Var. "R.S.-875", 3.08 Q/acare in Var. "F-1378" and 3.04 Q/acare in Var. "H-1098". In case of treated one Var. "R.S.-875" showed much affected result whereas Var. "H-1098" showed least effective result of these tested insecticides during 2009-10 and 2010-2011, respectively.

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