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Insect Pests of Black Gram (*Vigna mungo* L.) and Their Management in Vindhya Region

Indrajeet Singh Rajawat, Akhilesh Kumar, M.A. Alam, R.K. Tiwari, A.K. Pandey

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ABSTRACT

A study was conducted during the *Kharif* season of 2016-17 divulged the beginning of white fly infestation was recorded in the 5th week of July and reached a peak level 10.93 N and A /plant in the 4th week of August and aphid infestation was recorded in the 2nd week of August and reached a peak level 12.40 N and A /plant in the 2nd week of September. Correlation coefficient values for white fly and aphid population incidence and weather parameters showed that maximum and minimum temperature had positive influence while maximum and minimum relative humidity besides rainfall had negative influence on both the pest population. The incidence of ten species of insect pests and six species of natural enemies on the crop from germination to harvesting stages. Out of these insect pests six sap feeder; two defoliator; one stem feeder and one flower feeder were observed to infest in the urdbean. Therewith, six species of natural enemies were observed in the black gram variety T-9 under the agro-climatic condition of district Rewa. Evaluate the efficacy of Flubendiamide 24% + Thiacloprid 24% SC 200 ml/ha, Flubendiamide 39.35% SC 125 ml/ha, Thiacloprid 21.7% SC 250 ml/ha, Chlorantraniliprole18.5% SC 160 ml/ha, Flubendiamide 24% + Thiacloprid 24% SC 250 ml/ha, Quinalphos 25% EC 1500 ml/ha, Thiomethoxam 25% WG 125 g/ha and Emamectin benzoate 5% SG 220 g/ha against the *Bemisia tabaci* and *Aphis craccivora.* Thiacloprid 21.7% SC was found significantly most effective against white fly while, Thiomethoxam 25% WG was found significantly most effective against aphid.

Key words: Efficacy, Insect-pests, Natural enemies, Population, *Vigna mungo.*

INTRODUCTION

Black gram is a rich source of protein (20.8 to 30.5%) and carbohydrates (56.5 to 63.7%). It is scientifically known as *Vigna mungo* L and commonly known as urdbean in India. Its primary origin is India (Ali and Gupta, 2012). Black gram contributes about 10% in national pulse production. The annual yield loss due to the insect pests has been estimated at about 30 per cent in black gram and mung bean (Gailce Leo Justin *et al.*, 2015). The poor productivity of the crop in Rewa district has been attributed to many factors but among them insect pests infestation is a major limiting factor. Among the insects pest Whitefly (*Bemisia tabac*i Gennadius), Aphid (*Aphis craccivora* Koch), Jassid (*Empoasca spp*.) and Green leaf hopper (*Nephotettix spp*. Stal.) are recognised as an important sucking pests; while Grasshopper (*Atractomorpha spp*. Saussure), Leaf webber (*Grapholita critica* Meyr.), Grey weevil (*Myllocerus spp*. Marshall) Tobacco caterpillar (*Spodoptera litura* Fabricius), Bihar hairy caterpillar (*Spilosoma obliqua* Walker), Leaf miner (*Chromatomyia horticola* Goureau) and Epilachna beetle (*Epilachna spp*. Mulsant) as foliage feeders. The present research undertaken to study their effects of abiotic and biotic stress influenced the infestation and stabilization of various insect pests in black gram management. Therefore, attempts were made to find out the relationships between pests population natural enemies and the abiotic factors.

MATERIALS AND METHODS

A field experiment was carried out at Entomology Instructional Farm, JNKVV, College of Agriculture, Rewa, (M.P.), during *Kharif* 2016-17. Popular black gram variety T-9, was sown in 200 sq. meter area followed the standard package and practices of the crop. The observations on the population of white fly and aphid was recorded at a weekly interval, starting from germination till harvesting of the crop. The number of pests was counted at three locations. At each location five plants were selected at randomly and tagged for observation. Populations of each insect were recorded on top, middle and lower leaves of tagged plants. The qualitative composition of insect pests and their natural enemies were carried out in the trial, laid out for population dynamics study. The incidence of the various pests of black gram and presence of natural enemies therein were recorded at weekly interval in one square meter area from three locations of the experimental plot. Therewith, the experiment was laid out in randomized block design with nine treatments including control having three replications. First spraying was done at 40 DAG and second spraying

College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Rewa-486,001, Madhya Pradesh, India.

Corresponding Author: Akhilesh Kumar, Jawaharlal Nehru Krishi Vishwa Vidyalaya-Krishi Vigyan Kendra, Rewa-486 001, Madhya Pradesh, India. Email: akhiliivr@gmail.com

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was done 15 days after 1st spray. Population of white fly and aphid were counted one day before and one, 3,7,10 and 15 days after the insecticide application. The population of the pests were counted on top, middle and lower leaves of five randomly selected plants in each plot.

RESULTS AND DISCUSSION

The data related to the population dynamics of white fly *Bemisia tabaci,* (Gennadius) and aphid, *Aphis craccivora* (Koch) in black gram under the climate change condition of Rewa district were studied during *Kharif* 2016-17 (Table 1). The findings on the beginning of white fly infestation were recorded in the 5th week of July with an average population of 2.13 N&A /plant. However, during the month of July the average weekly population of the pest varied from 0 to 2.13 N&A /plant. The higher numbers of white fly population was observed in the month of August, with a record of peak population of 10.93 N&A /plant in the 4th week of August. Of course, during the entire month of August the average weekly population of the pest was found changing between 4.20 to 10.93 N&A /plant. The white fly population the present climatic condition of Rewa district had indicated a decline in pest number from 1st week of September and completely disappeared in the 1st week of October (Table 1). The findings of (Nitharwal *et al*, 2013) has indicated it's appearance from first week of August and reported peak population 11.20 N&A /plant of the pest in the month of September of *Kharif* 2006 and 2007. The correlation study of white fly population with the meteorological parameter *viz*., Temperature, relative humidity and rainfall had indicated a negative correlation (r = -0.322, -0.183, -0.001) with the maximum and minimum relative humidity and rainfall while a weak positive correlation (r = 0.101, 0.314) with maximum and minimum temperature. The temperature and sunshine hours also favourable for white fly population with positive correlation. These findings are in accordance with the findings of Yadav *et al*. (2015). In the present investigation peak of white fly population occurred in the 4th week of August which indicate a changing pattern in its appearance and peaks, which in presently show the effect of climate change. While, the beginning of aphid infestation was recorded in the 2nd week of August with an average population of 2.40 N&A /plant. However, during the month of August the average weekly population of the pest varied from 0 to 7.46 N&A / plant. The higher numbers of aphid population was observed in the month of September with a record of peak population of 12.40 N&A /plant in the 2nd week of September. Of course, during the entire month of September the average weekly population of the insect was found changing between 2.93 to 12.40 N&A /plant. The aphid population in present climatic condition of Rewa district had indicated a decline in pest number from 3rd week of September and completely disappeared in the 1st week of October (Table 2). Similarly

Table 1: Population of white fly and aphid in relation to temperature, relative humidity and rainfall in various standard weeks during *Kharif* 2016-17.

Standard weeks / name week of month	Population of white fly (N&A/plant)	Population of aphid (N&A/plant)	Max. temp.(°C)	Min. temp. (°C)	Max RH. (%)	Min RH (%)	Rainfall (mm)
29 (July 3rd week)	0.00	0.00	31.4	24.2	83.1	58.2	17.4
30 (July 4th week)	0.00	0.00	32.7	25	82.1	63.2	48.8
31 (July 5th week)	2.13	0.00	32.5	24.6	84.7	59.9	27
Average	0.71	0.00	32.2	24.6	83.3	60.43	Total 93.2
32 (Aug. 1st week)	6.26	0.00	31.2	24.5	89.7	52.1	96
33 (Aug. 2nd week)	4.20	2.40	27.2	23.3	98.1	89.2	470
34 (Aug. 3rd week)	8.40	4.26	31	22.9	80.4	77.4	52.4
35 (Aug. 4th week)	10.93	7.46	34	25.4	79.42	45.4	14.4
Average	7.44	3.53	30.85	24.02	86.90	66.02	Total 632.8
36 (Sept. 1st week)	8.13	10.80	32.5	24.7	81.4	53.6	10.4
37 (Sept. 2nd week)	5.20	12.40	32.9	24.3	79.9	63.4	89.4
38 (Sept. 3rd week)	2.73	8.80	32.6	24.1	91.1	71.1	70.2
39 (Sept. 4th week)	1.20	2.93	29.5	23.7	93.9	69.4	196
Average	4.31	8.73	31.87	24.2	86.57	64.37	Total 366
40 (Oct. 1st week)	0.00	0.00	33	24.1	85	59.1	0.00
41 (Oct. 2nd week)	0.00	0.00	32.5	20.5	86.7	60.4	20.2
Average	0.00	0.00	32.75	22.3	85.85	59.75	Total 20.2
Total							1112.2
Correlation coefficient of white fly (r value)	1		0.101	0.314	-0.322	-0.183	-0.001
Correlation coefficient of aphid (r value)		1	0.256	0.266	-0.287	-0.042	-0.063

(Jat *et al*, 2017) also reported that the aphid infestation began in the 3rd week of August (33rd SMW) during the years 2013 and 2014 with peak population in the 1st week of September (36th SMW) during 2013 and 2nd week of September (37th SMW) during 2014 in Udaipur district of Rajasthan state. The correlation study of aphid population with the above mentioned meteorological parameter had indicated a negative correlation (r = -0.287, - 0.042, - 0.062) between the maximum and minimum relative humidity and rainfall while a weak positive correlation (r = 0.256, 0.266) with maximum and minimum temperature. Jat *et al* (2017) also reported that the aphid population decreased due to excessive rainfall (94.80 mm/week) and relative humidity (87.60%). The present finding also show an excessive rain (94.80 mm/week) during the 2nd week of September. Abiotic factors like temperature, relative humidity, extent and distribution of rainfall, sunshine hour *etc*. influenced the infestation and stabilization of various insect pests in cowpea (Kumar and Kumar, 2015).

Diversity of insect pests on Black gram in Rewa district

The incidence of ten insect pests on the crop from germination to harvesting stages (Table 2). The insects which appeared on the crop were from Lepidoptera, Hemiptera, Coleoptera Diptera and Thysanoptera order and their incidence were noted from 5th week of July to harvesting of crop. White fly incidence was recorded earliest i.e. 5th week of July and its infestation continued up to 4th week of September. Jassid was recorded on the crop from 5th week of July to 4th week of September. Aphid infestation on black gram in district Rewa were recorded in 2nd week of August and continued up to 4th week of September. The Bihar hairy caterpillar as a defoliating pest recorded its first appearance on the crop in the existing 4th week of August and continued up to 1st week of October. Among the defoliating insects Tobacco caterpillar appearance was recorded from 1st week of August to 1st week of October. Stem fly was recorded as borer insect in the crop and its 1st appearance was recorded in the 3rd week of August at seedling stage of the crop and continued the infestation up to growth stage of the crop during *Kharif* 2016-17. At the pod stage of the crop *Riptortus* bug appearance was recorded from 4th week of August to 4th week of September and Green stink bug appearance was recorded from 1st week of August to 4th week of September. At the flowering stage of the Blister beetle incidence was recorded in high number from 3rd week of August to 2nd week of September. Flower thrips incidence was recorded on the crop from 3rd week of August to 2nd week of September. The composition of black gram insect pests has also been studied by various workers in different parts of country. (Chandra *et al*, 2010) reported sixteen insect pests population associated with urd bean [*Vigna mungo* (L.) Hepper] at different stages of crop grown from Faizabad Uttar Pradesh, India.

Diversity of natural enemies of insect pests in Black gram crop field

This study indicated (Table 2) the presence of six natural enemies in the crop ecosystem under the climate condition of Rewa district on black gram variety T-9. This arthropod was found belonging to class arachnids (*i.e*. spider) and class Insecta. The dominating species from the class Insecta were lacewing, lady bird beetle, dragon fly, damsel fly and preying mantid during *Kharif* 2016-17.

The studies conducted earlier in the country also indicated the presence of the predatory coccinellids in Black gram [*V. mungo*] feeding on *Aphis craccivora* in pulses (Parasuraman, 1989 and Routray *et al.*, 2016). (Kedar *et al.*, 2014) reported *Cheilomenes sexmaculata* (Fabricius) and *Brumoides suturalis* (Fabricius) as the most common predator of whitefly, *Bemisia tabaci* (Gennadius) on urdbean from Hisar, Haryana.

Efficacy of eight insecticides was evaluated against white fly after one day, 3,7,10 and 15th day of the insecticide spray.

White fly

The post treatment effect indicates (Table 3) that one day after the treatment a significant reduction in the population of insect pests was noted in the insecticide treated plots than control. The average number of insects varied from 4.03 to 6.3 Nymph and Adult/plant in insecticide treated plots as against 12.93 Nymph and Adult/plant of untreated control. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment with a ranging population between 1.97 to 4.43 and 0.97 to 3.3 Nymph and Adult/ plant, respectively. Among the tested insecticides, Thiacloprid @ 60 g a.i./ha was found superior over the rest of the insecticides with a percent reduction of 88.07 % in insect population after 7th day which was followed by Thiomethoxam @ 25 g a.i./ha with a reduction of insects population of 87.70 %. After 15th day of insecticide treatment a slight increase in the pest population were seen in all the insecticide treated plots including untreated control. Sunil *et al.*, 2015 also found similar result in their studied.

After second spray of insecticide, no doubt, further reduction in white fly population was observed in various treatments with a record of 2.57 to 4.07 Nymph and Adult/ plant in comparison to untreated control (10.97 Nymph and Adult/plant), one day after the second spray. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment. At this stage the population varied between 1.37 to 3.2 and 0.73 to 2.4 Nymph and Adult/plant, respectively. However, the populations in untreated control were found consequently higher. Among the tested insecticides Thiacloprid @ 60g a.i./ha was found superior over the rest of the insecticides with a percent reduction of 89.86% in insect's population after 7 days which was followed by Thiomethoxam @ 25g a.i./ha with a reduction of 88.33%. All insecticide were found effective and significantly superior over control after fifteen day of the

Table 2: Qualitative composition of insect pests and natural enemies of black gram during *Kharif* 2016-17.

Common name of insect pests	Scientific name	Crop stage	Period of activity	Common name of natural enemies	Scientific name	Duration of occurrence
White fly	*Bemisia tabaci* Gennadius	Vegetative	5th August to 29th September	Lacewing	*Chrysoperla carnea* Stephen	30th July to 15th September
Jassid	*Empoasca kerri* Pruthi	Vegetative	30th July to 25th September	(a) Common lady bird beetle	*Cheilomenes sexmaculata*	28th August to harvesting
Aphid	*Aphis craccivora* Koch	Vegetative	13th August to 28th September	(b) European beetle	*Coccinella septempunctata*	——— do ———
Bihar hairy caterpillar	*Spilosoma obliqua* Walk.	Vegetative	30th August to 7th October	(c) Transverse ladybird	*Coccinella transversalis*	——— do ———
Tobacco caterpillar	*Spodoptera litura* Fab.	Vegetative	6th August to 7th October	Praying mantid	*Mentis religiosa*	24th July to harvesting
Stem fly	*Ophiomyia phaseoli* Tryon	Vegetative and Flowering	24th August to 15th September	Dragon fly	*Crocothemis servilia*	30th July to harvesting
Riptortus bug	*Riptortus pedestris* Fab.	Flowering and Podding	1st September to 27th September	Damsel fly	*Agriocnemis femina*	1st August to 7th October
Green stink bug	*Nezara viridula* L.	Vegetative Flowering and Podding	2nd August to 30th September	(a) Spotted orbweaver spider	*Neoscona domiciliorum*	30th July to 15th October
Blister beetle	*Myalbris pustulata* Thurnburg	Flowering and Podding	24th August to 16th September	(b) Tarantula wolf spider	*Lycosa tarantula*	——— do ———
Flower thrips	*Caliothrips spp.* Bagnl.	Flowering and Podding	23rd August to 14th September	(c) Banded crab spider	*Misumenoids formosipes*	——— do ———
				(d) Striped lynx spider	*Oxyopes salticus*	——— do ———

Table 3: Efficacy of new molecules of insecticides against White fly and economics in black gram, during *Kharif* season 2016-17.

Treatment	Doses g a.i. /ha	Average population of White fly Nymph and Adult / plant										Average Yield (Kg/ha)	C:B ratio
			First spray					Second spray					
		Before treatment	After Treatment					After Treatment					
			1 DAT	3 DAT	7 DAT	10 DAT	15 DAT	1 DAT	3 DAT	7 DAT	10 DAT	15 DAT	
Flubendiamide 24% +Thiacloprid 24% SC	48 +48	11.4(3.45)	5.57 (2.46)	2.83 (1.82)	1.77 (1.50)	3.77 (2.07)	5.57 (2.46)	3.3 (1.95)	2.37 (1.69)	1.44 (1.39)	1.07 (1.25)	0 (0.71)	880.0	1:3.6
Flubendiamide 39.35% SC	60	11.3(3.44)	6.3 (2.61)	4.43 (2.22)	3.3 (1.95)	5.4 (2.43)	6.77 (2.70)	4.07 (2.14)	3.2 (1.92)	2.4 (1.70)	1.87 (1.54)	0 (0.71)	768.0	1:5.7
Thiacloprid 21.7% SC	60	11.63(3.48)	4.03 (2.12)	1.97 (1.57)	0.97 (1.21)	2.57 (1.75)	4.7 (2.28)	2.57 (1.75)	1.37 (1.37)	0.73 (1.11)	0.4 (0.94)	0 (0.71)	1008.0	1:13.3
Chlorantraniliprole 18.5% SC	30	11.5(3.46)	5.6 (2.47)	3.53 (2.01)	2.2 (1.63)	4.4 (2.21)	5.67 (2.48)	3.73 (2.06)	2.53 (1.74)	1.66 (1.47)	1.33 (1.35)	0 (0.71)	848.0	1:3.4
Flubendiamide 24%+ Thiacloprid 24% SC	60+60	11.3(3.44)	4.8 (2.30)	2.8 (1.81)	1.32 (1.35)	3.24 (1.93)	5.24 (2.39)	3.14 (1.90)	2.1 (1.61)	1.24 (1.31)	0.67 (1.08)	0 (0.71)	904.0	1:3.2
Quinalphos 25% EC	375	11.4(3.45)	6.03 (2.55)	3.96 (2.11)	3.16 (1.91)	5.06 (2.36)	6.36 (2.62)	3.83 (2.08)	2.63 (1.76)	2.03 (1.58)	1.8 (1.50)	0 (0.71)	824.0	1:5.1
Thiomethoxam 25% WG	25	11.6(3.48)	4.6 (2.26)	2.27 (1.66)	1 (1.22)	2.7 (1.79)	4.67 (2.27)	2.61 (1.76)	1.48 (1.41)	0.84 (1.15)	0.54 (1.01)	0 (0.71)	984.0	1:16.7
Emamectin benzoate 5% SG	11	11.53(3.47)	4.77 (2.29)	2.7 (1.78)	1.23 (1.30)	3.03 (1.87)	4.77 (2.29)	3.04 (1.88)	1.94 (1.56)	1.17 (1.29)	0.81 (1.13)	0 (0.71)	960.0	1:8.3
Untreated control		11.5(3.46)	12.93 (3.66)	10.47 (3.31)	8.13 (2.94)	9.64 (3.18)	10.27 (3.28)	10.97 (3.39)	7.17 (2.76)	7.2 (2.77)	6.9 (2.72)	2.5 (1.73)	560.0	1:3.6
SEm±		0.026	0.080	0.082	0.097	0.066	0.058	0.073	0.085	0.099	0.107	0.120	0.030	
CD at 5 %		NS	0.174	0.179	0.211	0.144	0.126	0.159	0.186	0.215	0.233	0.261	0.065	

*Figure in parenthesis are $\sqrt{X + 0.5}$ values

DAT = Day after treatment, NS = Non Significant

Table 4: Efficacy of new molecules of insecticides against Aphid and economics in black gram, during *Kharif* season 2016-17.

Treatment	Doses g a.i. /ha	Before treatment	Average population of Aphid Nymph and Adult /plant										Average Yield (Kg/ha)	C:B ratio
			First spray					Second spray						
			After Treatment					After Treatment						
			1 DAT	3 DAT	7 DAT	10 DAT	15 DAT	1 DAT	3 DAT	7 DAT	10 DAT	15 DAT		
Flubendiamide 24%	48+48	13.63(3.76)	7.5	6.2	5.73	6.7	8	6.23	4.23	2.21	1.04	0	880.0	1:3.6
+ Thiacloprid 24% SC			(2.83)	(2.59)	(2.49)	(2.48)	(2.92)	(2.59)	(2.17)	(1.65)	(1.24)	(0.71)		
Flubendiamide	60	13.87(3.79)	8.53	7.03	6.76	7.8	8.9	7.2	5.1	3	1.6	0	768.0	1:5.7
39.35% SC			(3)	(2.74)	(2.69)	(2.64)	(3.07)	(2.77)	(2.35)	(1.83)	(1.44)	(0.71)		
Thiacloprid	60	13.9(3.79)	6.73	5.43	4.93	6	7.1	5.76	3.76	1.8	0.9	0	1008.0	1:13.3
21.7% SC			(2.69)	(2.43)	(2.33)	(2.32)	(2.76)	(2.5)	(2.06)	(1.51)	(1.18)	(0.71)		
Chlorantraniliprole	30	13.83(3.79)	7.7	6.33	5.83	6.86	7.9	6.47	4.57	2.6	1.3	0	848.0	1:3.4
18.5% SC			(2.86)	(2.61)	(2.51)	(2.49)	(2.9)	(2.64)	(2.25)	(1.76)	(1.28)	(0.71)		
Flubendiamide 24 %+	60+60	13.6(3.75)	6.93	5.63	5.17	6.2	7.2	5.8	3.9	1.85	0.95	0	904.0	1:3.2
Thiacloprid 24% SC			(2.73)	(2.47)	(2.38)	(2.35)	(2.77)	(2.51)	(2.09)	(1.53)	(1.2)	(0.71)		
Quinalphos	375	13.53(3.75)	8.23	7.06	6.8	7.77	8.8	7.1	5.2	3.3	1.86	0	824.0	1:5.1
25% EC			(2.95)	(2.75)	(2.7)	(2.71)	(3.05)	(2.76)	(2.39)	(1.92)	(1.51)	(0.71)		
Thiomethoxam	25	13.73(3.77)	6.3	4.8	4.37	5.4	6.5	4.8	3	1.2	0.5	0	984.0	1:16.7
25% WG			(2.61)	(2.30)	(2.21)	(2.18)	(2.64)	(2.3)	(1.87)	(1.3)	(1)	(0.71)		
Emamectin	11	13.8(3.78)	6.8	5.3	4.83	5.83	6.9	5.5	3.6	1.6	0.75	0	960.0	1:8.3
benzoate 5% SG			(2.70)	(2.41)	(2.31)	(2.29)	(2.72)	(2.45)	(2.02)	(1.44)	(1.11)	(0.71)		
Untreated control		13.5(3.74)	13.7	10.2	10.7	11.3	11.5	11.98	12.19	10.3	7.1	3.2	560.0	1:3.6
			(3.77)	(3.27)	(3.35)	(3.44)	(3.46)	(3.49)	(3.52)	(3.29)	(2.76)	(0.91)		
SEm±		0.029	0.050	0.086	0.088	0.086	0.042	0.206	0.234	0.196	0.117	0.074	0.030	
CD at 5 %		NS	0.109	0.188	0.088	0.191	0.092	0.448	0.509	0.426	0.254	0.161	0.065	

* Figure in parenthesis are $\sqrt{X + 0.5}$ values

DAT = Day after treatment, NS = Non Significant

second treatments. Similar results were observed by several workers in the past. The following order of the efficacy of the insecticides, in the descending order, was observed T_3 (Thiacloprid @ 60 g a.i./ha) >T_7 (Thiomethoxam @ 25 g a.i./ha) > T_8 (Emamectin benzoate @ 11g a.i./ha) > T_5 (Flubendiamide + Thiacloprid @ 60+60 g a.i/ha) > T_1 (Flubendiamide + Thiacloprid @ 48+48 g a.i/ha) > T_4 (Chlorantraniliprole @ 30 g a.i /ha) >T_6 (Quinalphos @ 375 g a.i./ha) > T_2 (Flubendiamide @ 60 g a.i./ha). (Rajawat *et al.*, 2017) also reported Thiacloprid 21.7% SC was found significantly very effective against white fly.

Aphid

Efficacy of above mentioned insecticides against aphid indicated (Table 4) effectiveness of all insecticide over the untreated control. The post treatment effect, after one day, indicated a significant reduction in the population of insect in the insecticide treated plot than untreated control. The average number of insects varied from 6.3 to 8.53 Nymph and Adult/plant in insecticide treated plot as against (13.7 Nymph and Adult/plant) of untreated control. A significance reduction in the pest population due to insecticide treatment was further seen after 3rd and 7th day of the application with a record of 4.8 to 7.06 and 4.37 to 6.8 Nymph and Adult/ plant, respectively. However, the populations of untreated control consequently, were found at 10.2 Nymph and Adult/ plant and 10.7 Nymph and Adult/plant. Among the tested insecticides Thiomethoxam @ 25 g a.i./ha was found superior over the rest of the insecticides with a percent reduction of 59.16 % in pest population after 7th day; followed by Emamectin benzoate @ 11 g a.i./ha 54.86 %. However, after 15th day of insecticide application a further increase in the pest population was seen in all the insecticide treated plots.

After second spray of insecticide further reduction in aphid population was seen in various treatments in comparison to untreated control. In the insecticide treated plots population of aphid was observed between 4.8 to 7.2 Nymph and Adult/plant as against 11.98 Nymph and Adult/ plant in untreated control one day after the second spray. A significance influence of the insecticide was further seen after 3rd and 7th day of the treatment, with a record of 3 to 5.1 and 1.2 to 3 Nymph and Adult/plant population, respectively. However, the population in untreated control, consequently, was found 12.19 and 10.3 Nymph and Adult/ plant. Among the insecticides, Thiomethoxam @ 25g a.i./ ha was found superior over other insecticides with a record of 88.24 % reduction in population followed by Emamectin benzoate @ 11g a.i. /ha 84.43% after 7th day of spraying. Similar results were finding by (Parmar *et al.*, 2015) and (Yadav *et al*. 2015). The following order of the efficacy of the insecticides, in the descending order, was observed T_7 (Thiomethoxam @ 25 g a.i./ha) > T_8 (Emamectin benzoate @ 11g a.i./ha) > T_3 (Thiacloprid @ 60 g a.i. /ha) > T_5 (Flubendiamide + Thiacloprid @ 60+60 g a.i. /ha) > T_1 (Flubendiamide + Thiacloprid @ 48+48 g a.i. /ha) > T_4 (Chlorantraniliprole @ 30 g a.i /ha) > T_2 (Flubendiamide @ 60 g a.i. /ha) > T_6 (Quinalphos @ 375 g a.i. / ha).

Effect on grain yield and cost benefit ratio

The highest yield of 1008.0 kg/ha,was recorded in the plot treated with Thiacloprid @ 60 g a.i. /ha followed by Thiomethoxam @ 25 g a.i. /ha (984.0 kg/ha) as against the yield of 560 kg/ha in untreated control.

An increase in yield due to insecticide treatment has been reported by various scientists at national and global level. (Sharma and Singh, 2015) found that significantly higher yield in 2012 due to Imidacloprid treatment (11.33 q/ha) followed by Thiomethoxam (10.88 q/ha). In the year 2013, Thiomethoxam gave better results in increasing the yield 11.93 q/ha than other tested insecticides. The maximum C:B ratio (1:16.7) was recorded from Thiomethoxam treatment followed by Thiacloprid (1:13.3).

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