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Management of Whitefly, *Bemisia tabaci* (Genn.) and Yellow Mosaic Virus Disease Infesting Blackgram, *Vigna mungo* (Linn)

D.K. Jain, H. Swami[1], Hasmukh Kumar, Bahadur Singh,
Bhagwat Singh Chouhan, Gaurang Chhangani[2]

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ABSTRACT

Background: Pulse crops have a unique position in sustainable crop production as they provide highly nutritive food and keep the soil alive as well as productive. They play an important role in the Indian agriculture economy being the major source of protein in Indian dietary. Due to its more luxurious growth and more vegetative canopy, number of insect pests and diseases attack from seedling to maturity stage especially sucking pests like whitefly (*Bemisia tabaci* Genn.), which is the vector of the drastic disease, yellow mosaic virus disease (YMD) and cause losses ranging from 30-80% per cent.

Methods: The field experiment on the management of whitefly and yellow mosaic disease (YMD), was conducted by integrating different combination of insecticides and yellow sticky trap during *Kharif*, 2018 and 2019 at instructional farm of VBKVK, Udaipur. Seven treatments comprising of different combinations of seed treatments at the time of sowing, foliar spray at 30 and 45 DAG and yellow sticky traps were evaluated.

Result: Among the different treatments, seed treatment with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50 WP @ 0.1% and second foliar spray with Acetamiprid 20 SP @ 0.5 g/l at 30 and 45 DAS respectively + yellow sticky trap resulted in significantly less YMD incidence (18.91%) and the minimum mean whitefly population and highest seed yield of blackgram. The above treatment was followed by seed treatment with Imidacloprid 600 FS @ 5 ml/kg and two foliar spray of Acetamiprid 20 SP @ 0.5 g/l at 30 and 45 DAS + yellow sticky trap, which recorded 20.31% disease incidence of YMD and mean whitefly population of (3.77 and 1.44/plant, respectively after first and second spray) and black gram yield of 10.01 q/ha.

Key words: Imidacloprid, Thiamethoxam, Urdbean, yellow sticky traps, YVM virus.

INTRODUCTION

Pulse crops have a unique position in sustainable crop production as they provide highly nutritive food and keep the soil alive as well as productive. They play an important role in the economy of Indian agriculture by virtue of being the major source of protein in Indian dietary. The General assembly of the United nations has recognized pulses as an essential source of protein and a part of improving nutrition globally and declared 2016 as “The International Year of Pulses” (Anonymous 2016a). India is the world’s largest producer (18.5 million tonnes), largest importer (3.5 million tonnes) and largest consumer (22.0 million tonnes) of pulses (Anonymous 2016b). Blackgram [*Vigna mungo* (Linn)], also known as urdbean in India, is second one of the most important legume pulse crop in our country in terms of area and production next to pigeonpea. The main reason for low productivity is the susceptibility of the crop to insects, weeds and diseases caused by fungus, virus and bacteria. Due to its more luxurious growth and more vegetative canopy, number of insect pests and diseases attack from seedling to maturity stage especially sucking pests like whitefly (*Bemisia tabaci* Genn.) (Biswas *et al*., 2008) which is the vector of the yellow mosaic virus disease (YMD) and cause losses ranging from 30-80% (Swaminathan *et al.*, 2012; Sastry and Singh, 1973 and Khattak *et.al.,* 2004). This disease is popularly known as “Yellow plague of *Kharif* pulses” and currently spread over different agriculture zones of India including southern dry zone of Rajasthan. More than 20 viruses are reported from various mungbean growing areas worldwide. Among them, Mungbean yellow mosaic virus (MYMV) is the most serious disease (Williams, 1977). Whiteflies suck the cell sap from the leaves and also secretes honeydew which causes sooty mould and hampers the photosynthetic activity. To control the vector, insecticides have been commonly used. Previously many research workers have evaluated synthetic chemicals against sucking pest of mungbean (Gopal and Srivastava 1997). A drastic

Krishi Vigyan Kendra, Badgaon, Udaipur-313 011, Rajasthan India.
[1]Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur-313 001, Rajasthan, India.
[2]Department of Entomology, College of Agriculture, Agriculture University, Jodhpur-342 304, Rajasthan, India.

Corresponding Author: Gaurang Chhangani, Department of Entomology, College of Agriculture, Agriculture University, Jodhpur-342 304, Rajasthan, India. Email: gaurangchhangani@gmail.com

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reduction in the incidence of YMV was recorded where whitefly population was reasonably controlled by using chemical insecticides. But indiscriminate and continuous use of synthetic pesticides resulted in the development of resistance in the target pest species, resurgence of whiteflies and environment pollution. Current management of YMD includes planting of resistance varieties, vector management and alternate host of blackgram and modifying the cultural practices of the crop, which are not effective in managing the diseases remarkably. So, there is a need to investigate the tools for managing the sucking pest especially whiteflies in blackgram *i.e.* integrated approaches like seed treatment, yellow trap, neem oil and other chemical to develop an effective management strategy. Therefore, in this context, the present study was conducted using neem based pesticides and yellow sticky traps for the management of YMD.

MATERIALS AND METHODS

Experimental design and treatments

A field experiment was conducted at Instructional farm of Vidya Bhawan Krishi Vigyan Kendra, Udaipur, Rajasthan during *Kharif* 2018 and 2019 to evaluate the effectiveness of different insecticides as seed treatment and foliar sprays for the management of whitefly and YMD in blackgram. The experiment was laid out in Randomized block design with seven treatments replicated thrice in plot size of 4×3 m^2. The five systemic insecticides and one botanicalwere applied as per the treatment schedule. The variety of blackgram-PU-31 was sown at 30 cm $\times$ 10 cm spacing in thesecond week of July and all the recommended agronomic practices were followed to raise the crop, except plant protection measures. The details of spray schedule and treatment details are as follows:

T_1: Seed treatment (ST) with Imidacloprid 600 FS @ 5 ml/kg and two foliar spray of Acetamiprid 20SP @ 0.5 g/l at 30 and 45 DAS + yellow sticky trap @ 20/ha.

T_2: Two foliar spray of Imidacloprid 17.8 SL @ 0.03 % at 30 and 45 DAS + yellow sticky trap @ 20/ha.

T_3: Two foliar spray of Thiametoxam 25WG@ 0.01% at 30 and 45 DAS + yellow sticky trap @ 20/ha.

T_4: ST with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50 WP @ 0.1% at 30 DAS and second foliar spray with Acetamiprid 20SP @ 0.5g/l at 45 DAS respectively + yellow sticky trap @ 20/ha.

T_5: Two foliar spray of Dimethoate 30 EC @ 1 ml/l at 30 and 45 DAS + yellow sticky trap @ 20/ha.

T_6: Two foliar spray of Neem oil @ 3 ml/l at 30 and 45 DAS + yellow sticky trap @ 20/ha.

T_7: Untreated control (Without insecticide application).

Vector population and Per cent disease incidence

Three trifoliate leaves each from top, middle and bottom canopies were taken into a polythene cover from five plants from each plot. The samples were taken to the laboratory and the nymph/ adult of whitefly population count was taken using microscope. Data on pest population was recorded one day before spraying as pre-treatment count and post treatment counts were taken at 1, 3, 7, 10 and 15 days after the insecticide application. The observations were recorded from five randomly selected plants in each plot leaving the border rows. The disease incidence of YMV was recorded from the whole plot at 60 days after sowing from all the treatments. Disease incidence (%) was calculated by counting the number of plants infected and total number of plants in an experimental plot (for each treatment).

Disease incidence (PDI) % =

$$\frac{\text{Number of infected plants in a plot}}{\text{Total number of plants in plot}} \times 100$$

Growth and yield parameters

Randomly five plants from each treatment were collected (at harvesting stage) for assessing plant growth and yield parameters. The effect of YMD on plant height, number of pods/plants, pod length, number of seeds/pods, dry matter accumulation, straw yield (haulm), biological yield, harvest index, test weight, yield per ha was recorded and average data obtained from sample plants was analyzed statistically. The height of each plant was measured from base of the plant to the tip of the main shoot. Dry matter production was recorded at harvest stage, for this, plants from one meter row length were uprooted randomly from sample row of each plot. After removal of root portion, the samples were first air dried for some days. The numbers of branches of the five tagged plants of mungbean from each plot were counted at harvest. The crop was harvested after leaving two border rows on each side of plot along the length on both sides. The straw yield (kg/plot) was obtained by subtracting the grain yield from biological yield. Harvest index was computed by using the formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

RESULTS AND DISCUSSION

The findings of the present research study as well as relevant discussion have been conferred under following points.

Whitefly population and percent of disease incidence

The results of present investigation indicated that all the treatments were found comparatively effective in reducing disease incidence and whitefly population compared to untreated control (Table 1).

The population of whiteflies per three leaves (nymph and adult) before treatments ranged from 11.34-12.97. The post treatment effect indicated that one day after the treatment a significant reduction in the population of insect pests. The average number of insects varied from 4.04 to 10.34 per plant in insecticide treated plots as against 13.12 per plant of untreated control after first day of application. A significant influence of the insecticide was further seen after

Table 1: Efficacy of different treatments on whitefly population and disease incidence on black gram, during *Kharif*, 2018 and 2019 (pooled data).

Treat-ments	Average population of White fly Nymph and Audit/ three leaves													YMD incidence (%)	% yield reduction over control
	Before treat.	After first spray					Mean	After second spray					Mean		
		1 DAT	3 DAT	7 DAT	10 DAT	15 DAT		1 DAT	3 DAT	7 DAT	10 DAT	15 DAT			
T_1	11.17	5.23	2.96	1.48	3.07	5.77	3.70	3.27	1.86	0.99	0.98	0.00	1.42	19.93	67.59
	(3.41)*	(2.39)	(1.86)	(1.41)	(1.89)	(2.50)	(2.01)	(1.94)	(1.54)	(1.22)	(1.22)	(0.71)	(1.32)	(26.51)	(55.31)
T_2	11.45	6.85	4.67	2.83	4.81	6.86	5.20	3.83	2.72	2.83	1.65	0.00	2.21	25.32	58.83
	(3.46)	(2.71)	(2.27)	(1.82)	(2.30)	(2.71)	(2.36)	(2.08)	(1.79)	(1.82)	(1.47)	(0.71)	(1.57)	(30.21)	(55.09)
T_3	11.67	6.54	3.96	2.30	4.48	6.65	4.79	3.69	2.41	2.60	1.52	0.00	2.04	22.07	64.14
	(3.49)	(2.65)	(2.11)	(1.67)	(2.23)	(2.67)	(2.27)	(2.05)	(1.70)	(1.76)	(1.42)	(0.71)	(1.53)	(28.01)	(53.22)
T_4	11.87	3.96	1.99	1.09	2.62	4.72	2.88	2.90	1.30	0.87	0.45	0.00	1.10	18.81	69.40
	(3.52)	(2.11)	(1.58)	(1.26)	(1.77)	(2.28)	(1.80)	(1.84)	(1.34)	(1.17)	(0.97)	(0.71)	(1.21)	(25.71)	(56.42)
T_5	11.67	7.10	5.45	3.82	5.74	7.10	5.84	3.98	3.49	3.82	2.08	0.16	2.71	28.31	53.99
	(3.48)	(2.76)	(2.44)	(2.08)	(2.50)	(2.75)	(2.50)	(2.12)	(2.00)	(2.08)	(1.61)	(0.80)	(1.72)	(32.14)	(47.29)
T_6	12.00	10.15	9.80	6.22	7.63	7.89	8.33	5.56	4.37	5.57	4.62	1.78	4.38	46.03	25.16
	(3.54)	(3.26)	(3.21)	(2.59)	(2.85)	(2.89)	(2.96)	(2.46)	(2.21)	(2.46)	(2.26)	(1.51)	(2.18)	(42.72)	(30.09)
T_7	12.73	13.05	10.49	8.72	9.71	11.68	10.73	9.90	8.51	7.97	7.00	3.76	7.43	61.53	0.0
	(3.64)	(3.68)	(3.31)	(3.04)	(3.19)	(3.49)	(3.34)	(3.22)	(3.0)	(2.91)	(2.74)	(2.06)	(2.79)	(51.67)	(0.0)
SEm±	0.32	0.19	0.13	0.08	0.13	0.21	0.05	0.08	0.07	0.08	0.06	0.04	0.05	0.40	0.59
	(0.046)	(0.030)	(0.022)	(0.017)	(0.024)	(0.033)	(0.009)	(0.015)	(0.016)	(0.018)	(0.013)	(0.021)	(0.010)	(0.252)	(0.364)
CD at 5%	0.93	0.56	0.38	0.24	0.37	0.62	0.15	0.23	0.21	0.24	0.17	0.12	0.14	1.16	1.72
	(0.135)	(0.087)	(0.066)	(0.051)	(0.071)	(0.096)	(0.027)	(0.045)	(0.045)	(0.052)	(0.039)	(0.062)	(0.028)	(0.743)	(1.074)
CV (%)	15.07	14.10	13.06	12.36	13.16	16.50	4.71	9.37	11.57	13.33	12.19	29.36	8.83	7.02	6.82
	(7.407)	(5.959)	(5.244)	(4.937)	(5.682)	(6.678)	(2.090)	(3.862)	(4.490)	(5.235)	(4.447)	(11.606)	(3.100)	(3.005)	(3.521)

*Figure in parenthesis indicates square root transformed values. **Figures in parenthesis indicate arc sine transformed values.

DAT=Day after treatment, NS=Non Significant.

3th and 7th day of the treatment that ranged between 2.03 to 9.99 and 1.11 to 6.34 per plant, respectively. Among the tested insecticides, seed treatment (ST) with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50 WP@ 0.1% at 30 DAS and second foliar spray with Acetamiprid 20SP @ 0.5 g/l 45 DAS respectively + yellow sticky trap was found superior over the rest of the insecticides with a reduction of 87.50 % insect population after 7th day which was followed by treatment (T_1) ST with Imidacloprid 600 FS @ 5 ml/kg and two foliar spray of Acetamiprid 20SP @ 0.5g/l at 30 and 45 DAS + yellow sticky with a reduction of insects population of 82.99% (Table 1). 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) and Rajawat *et al* (2017) also found similar result in their studies. After second spray further reduction in whitefly population was observed in various treatments with a record of 2.95 to 5.67 nymphs or adult/plant in comparison to untreated control (11.45 nymph or adult/ plant), one day after the second spray. A significant influence of the insecticide was seen after 3rd and 7th day of the treatment. At this stage the insect population varied between 1.32 to 4.45 and 0.89 to 5.67 nymph or adult/plant, respectively. However, the populations in untreated control were found consequently higher. Among the tested insecticides, treatment (T_4) ST with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50 WP @ 0.1% at 30 DAS and second foliar spray with Acetamiprid 20 SP @ 0.5 g/l at 45 DAS respectively + yellow sticky trap was found superior over the rest of the insecticides with a reduction of 89.03% in insect's population after 7 days which was followed by treatment (T_1) ST with Imidacloprid 600 FS @ 5 ml/kg and foliar spray of Acetamiprid 20SP @ 0.5 g/l at 45 DAS + yellow sticky with a reduction of 87.56%. All insecticides were found effective and significantly superior over control after fifteen day of the second treatments. Similar results were also found by (Sharma and Singh , 2015 and Mahalakshmi *et al*., 2015). The following order of the efficacy of the insecticides, in the descending order, was observed.

$$T_4 > T_1 > T_3 > T_2 > T_5 > T_6 > T_7$$

Among the treatments imposed, treatment (T_4) ST with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50 WP@0.1% 30 DAS and second foliar spray with Acetamiprid 20SP @ 0.5 g/l at 45 DAS respectively + yellow sticky trap had significantly lowest mean YMD incidence (18.91%) with highest 69.15 percent reduction of YMD over control followed by treatment (T_1) ST with Imidacloprid 600 FS @ 5 ml/kg and two foliar spray of Acetamiprid 20 SP @ 0.5 g/l at 30 and 45 DAS + yellow sticky trap. The systemic effect of imidacloprid on the insect vector at initial stages might be the reason for low disease incidence (Wang *et al*. 2009). As compared to control plot the highest mean disease incidence was observed with the treatment involving treatment (T_5), two foliar spray of Dimethoate 30 EC @ 1 ml/l at 30 and 45 DAS + yellow sticky trap @ 20/ha *i.e*. (28.45%) followed by treatment (T_6), two foliar spray of Neem oil @ 3 ml/l at 30 and 45 DAS + yellow sticky trap @ 20/ha *i.e*. (46.23%). While in control plots, the disease incidence was 61.31%. Our results are in confirmity with Archana *et al*. (2018) where in they have reported that seed treatment and spraying with imidacloprid contributed to relatively low incidence of YMV on blackgram. Similarly, Jayappa (2017) observed that Seed treatment with imidacloprid @ 5 ml/kg of seeds and two spray of imidacloprid @ 0.5 ml/l recorded significantly lowest mean disease incidence. Also Kharel *et al*. (2016) reported that spraying with Diafenthuron50 WP @ 0.1% contributed to relatively low disease incidence on blackgram. Since, the chemical was systemic in nature, the insecticide could be effective in the plant up to 45 days after sowing.

Growth and yield parameters

The effect of Yellow Vein Mosaic Virus on various growth and yield parameters *viz*., Plant height, pods per plant, pod length, number of seeds per pod, dry matter accumulation, Haulm(straw) yield, biological yield, seed yield per plant and yield/ ha in different treatments were recorded (Table 2). It is evident from the results that the treatments which recorded least disease incidence and whitefly population have shown

Table 2: Effect of different treatments on the growth and yield parameters of blackgram-PU-31 (observation taken during *Kharif*, 2018 and 2019) [pooled data].

Treatment	Mean plant height at harvest (cm)	No. of pods/ plant	Pod length (cm)	No .of seeds/ pods	DMA (g/ plant) at harvest	Haulm yield (q/ ha)	Biological yield (q/ ha)	Harvest index (%)	Test wt (g)
T_1	32.73	24.02	4.49	5.46	16.78	12.09	22.42	46.08	20.63
T_2	30.55	22.46	4.32	5.23	16.12	10.71	20.08	46.63	19.89
T_3	30.04	21.67	4.12	5.09	15.35	11.50	21.51	46.55	19.34
T_4	35.74	25.83	4.90	6.22	18.36	14.23	25.15	43.56	23.23
T_5	27.34	18.80	3.79	4.85	14.08	10.14	18.69	45.62	18.40
T_6	24.58	16.24	3.68	4.78	13.66	7.63	13.75	44.51	18.16
T_7	23.47	11.57	3.46	4.01	12.81	5.79	10.64	45.28	16.43
SEm ±	0.39	0.44	0.11	0.10	0.30	0.34	0.49	0.92	0.34
CD at 5%	1.13	1.28	0.31	0.29	0.88	0.99	1.44	2.69	0.99
CV %	7.43	12.18	14.37	10.77	11.07	18.50	14.63	11.35	9.80

Table 3: Cost of cultivation and economics of Blackgram during *Kharif*, 2018 and 2019 (pooled data).

Treatments	Yield (q/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Cost benefit ratio
T_1	10.33	22730	77459	54729	2.41
T_2	9.36	21900	70234	48334	2.21
T_3	10.01	22500	75111	52611	2.34
T_4	10.92	23890	81867	57977	2.43
T_5	8.54	20800	64081	43281	2.08
T_6	6.12	19700	45922	26222	1.33
T_7	4.85	19000	36339	17339	0.91

a significant positive impact on all the growth and yield parameters evaluated.

There was no significant difference between various treatments with respect to plant height, pod length and number of seeds per pod. The plant height, pod length and number of seeds per pod varied from 23.12 to 35.45 cm, 3.12 to 4.56 cm and 3.67 to 5.88 respectively. Whereas, the significant difference was recorded between treatments with regard to number of pods per plant (11.22 to 25.45), seed yield/ plant (5.31 to 7.26 g) and seed yield/ha (4.71 to 10.88 q). However in the present investigation, treatment (T_4) ST with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50 WP @ 0.1% at 30 DAS and second foliar spray with Acetamiprid 20 SP @ 0.5g/l at 45 DAS respectively + yellow sticky trap @ 20/ha; observed higher growth and seed yield followed by treatment (T_4) ST with Imidacloprid 600 FS @ 5 ml/kg and two foliar spray of Acetamiprid 20 SP @ 0.5 g/l at 30 and 45 DAS + yellow sticky trap compared to other treatments. These treatments were indirectly contributed for lower incidence of disease. Further, it was observed that, the virus infection at a later stage had no profound effect on the yield and pod size. The systemic insecticides were attributed to greater residual activity, high level of protection and quick knock down effect on viruliferous vectors compared to botanicals (Baranwal *et al.,* 1997). These findings are in corroborated with the findings of Archana *et al*, (2018) in blackgram.

Benefit cost ratio

In the present study, highest cost benefit ratio (2.41) was obtained in treatment, T_4 consisting of (ST with Imidacloprid 600 FS @ 5 ml/kg, first foliar spray of Diafenthuron 50WP@0.1% at 30 DAS and second foliar spray with Acetamiprid 20SP @ 0.5g/l at 45 DAS respectively + yellow sticky trap@ 20/ha), followed by treatment, T_1 consisting of (ST with Imidacloprid 600 FS @ 5 ml/kg and two foliar spray of Acetamiprid 20SP @ 0.5g/l at 30 and 45 DAS + yellow sticky trap@ 20/ha.) which recorded B:C ratio of 2.30 and T_3 treatment (three foliar spray of Thiametoxam 25WG@ 0.01% at 30 and 45 DAS + yellow sticky trap@ 20/ha) with B:C ratio of 2.22. However lowest cost benefit ratio of 0.86 was recorded in untreated control (Table 3).

CONCLUSION

The integrated approaches like seed treatment, yellow trap, neem oil and other eco friendly chemicals effectively reduce the incidence of whiteflies in black gram. Among the different treatments, seed treatment with Imidacloprid 600 FS @ 5 ml/ kg, first foliar spray of Diafenthuron 50 WP@0.1% and second foliar spray with Acetamiprid 20SP @ 0.5g/l at 30 & 45 DAS respectively + yellow sticky trap resulted in significantly less YMD incidence and the minimum mean whitefly population and highest seed yield of black gram. So, it is advisable to incorporate different non chemical methods along with the insecticide for the efficient management of the pests by keeping the view of environmental safety.

Conflict of interest: None.

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