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Management of *Mungbean Yellow Mosaic Virus (MYMV)* Disease of Blackgram by Chemical and Non-chemical Methods

M. Kasi Rao*[1], M. Adinarayana[2], A.K. Patibanda[3] and T. Madhumathi[4]
[1]Department of Plant Pathology, Agricultural College, UAS, Raichur, Karnataka.
[2]Principle Scientist, RRU Plant Pathology, RARS Lam, Guntur, Andhra Pradesh.
[3]Professor and Head, Department of Plant Pathology, Agricultural College, Bapatla, Andhra Pradesh.
[4]Professor, Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh.

(Corresponding author: M. Kasi Rao)*
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ABSTRACT: Yellow mosaic disease (YMD) remains a most important destructive viral disease of blackgram production in the Indian subcontinent with the economic losses account up to 85%. YMD is caused by a single stranded DNA containing begomovirus *viz.*, *Mungbean yellow mosaic virus (MYMV)* which is mainly transmitted through whitefly (*Bemisia tabaci* Genn.). However, management of this deadly disease is still the biggest challenge. A field experiment with botanicals, micronutrients and chemical insecticides was conducted at RARS, Lam, Guntur, Andhra Pradesh during *kharif* and *rabi* 2019-20 to find out the best treatment for the management of *MYMV* and to increase the grain yield of blackgram. Results from the two field trials suggest seed treatment with thiamethoxam (5.0g/kg) and two sprays of acetamiprid (4%) + fipronil (4%) (2.0ml/l) (T_7) reported the least mean *MYMV* incidence (3.75 and 4.84%) and severity (6.01% and 7.32%) with whitefly population of (4.14 and 2.95/plant) during *kharif* and *rabi* followed by seed treatment with imidacloprid 600 FS @ 5.0 ml/ kg and 2 sprays of flonicamid @ 0.2ml/l (T_6). Observations also revealed seed treatment with thiamethoxam and two sprays of acetamiprid (4%) + fipronil (4%) (T_7) have showed highest number of primary branches, pods per plant, seeds per pod, grain yield per plant and seed yield per hectare as compared to other treatments employed in the experiment and it was cost-effective, as it provided the highest benefit cost ratio. However, based on results obtained *Mirabilis jalapa* leaf extract (white flower) @ 10.00 % spray was not effective in the management of *MYMV*.

Keywords: *MYMV*, Blackgram, Whitefly, Management.

INTRODUCTION

Blackgram[*Vigna mungo* (L.) Hepper](2n=22) is indigenous to India or Indo-Burma region and one of the most important self-pollinated, short-duration grain leguminous crop grown extensively in major tropical and sub-tropical countries of the world (Biswass *et al.*, 2008). Blackgram is the third important pulse crop of India. It is a drought tolerant, grown twice in a year and fits well in Indian crop rotation program. It contains a relatively high proportion of easily digestible good quality protein (24%) with low flatulence and is also rich in iron contents (40-70 ppm), making it an ultimate choice for balanced diets (Salam *et al*., 2009). Worldwide, India is the largest producer of blackgram, yielding 3.60 million tons of grains in an area about 5.60 million hectares. However, the average productivity of blackgram in India is quite low (~546 kg/ha), even lower than most of the other legume crops (Project Coordinators Report-2018).

However, the reasons for low yield of blackgram are numerous has the crop is attacked many insects (e.g.: pod borers, sucking pests etc.), diseases (e.g.: Alternaria leaf spot, Cercospora leafspot, powdery mildew, viral diseases etc.) and other abiotic factors from seedling to maturity stage. Among the various constraints, YMD is caused by *Mungbean yellow mosaic virus (MYMV)* is the most serious disease and major bottle neck for the blackgram cultivation and production (Biswas *et al.,* 2012; Malathi and John, 2008). *MYMV* is a single standard DNA containing virus belongs to the genus Begomovirus of the family Geminivirideae. In India, Nariani (1960) first reported *MYMV* from the fields of mungbean in Indian Agricultural Research Institute (IARI), New Delhi during 1950s. The infected blackgram plant produce small sized pods, yellowing of the leaves reduces the photosynthetic ability which ultimately manifested as severe yield penalty (Malathi and John, 2008). At suitable climatic conditions, *MYMV* disease is widespread and destructive, can cause yield loss 5-100% annually (Nene, 1972; Varma *et al.*, 1992; Ghafoor *et al.*, 2000; Singh *et al.*, 1982; Rathi, 2002). Besides blackgram, *MYMV* also affect number of pulse crops including greengram (*Vigna radiata*), mothbean (*Vigna aconitifolia*), pigeonpea (*Cajanus cajan*), French bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), Dolichos (*Lablab purpureus*), horsegram (*Macrotyloma uniflorum*), and soybean (*Glycine max*) of the family Malvaceae and Solannceae (Dhingra and

Chenulu 1985) This disease is known popularly as "Yellow plague" (Archana *et al.,* 2018). However, strategies for management of *MYMV* include growing of resistant varieties, vector control, managing alternate hosts of viruses and modifying the cultural practices of the crop are not effective in managing the disease remarkably. Consequently, there is need to develop a better management practice. So far there are no control measures directly aimed at virus, use of chemicals against vector is the only available method. With this background, the present study was conducted with the main objective to identify the best treatment in the management of the *MYMV* of blackgram by implying seed treatment as well as foliar spraying.

MATERIALS AND METHODS

A. Experimental design and treatments

A field experiment was carried out at RARS, Lam, Guntur, Andhra Pradesh in a randomized block design (RBD) with 3 replications and 10 treatments to find out the best treatment for the management of *Mungbean yellow mosaic virus (MYMV)* during *kharif* and *rabi* 2019-20 (Fig. 1). In the present study, LBG -752 is used as tolerant variety. Ten treatments such as two botanicals, two micronutrients, five chemicals and an untreated check were included in the study during both the seasons. Two spraying were done at 30 and 45 days after sowing and the details of treatment in experiment are given below:

T_1: Neem oil 5%
T_2: *Mirabilis jalapa* @ 10%
T_3: $MnSo_4$(0.2%)+ $ZnSo_4$(0.2%)
T_4: $ZnSo_4$(0.2%)
T_5: Thiamethoxam 25WG (0.2g/l)
T_6: Flonicamid 50 WG (0.4g/l)
T_7: Acetamiprid 4% + Fipronil 4% (2 ml/l)
T_8: Imidacloprid 600 FS Seed Treatment @ 5ml/kg + T6
T_9: Thiamethoxam Seed Treatment @ 5g/kg + T7
T_{10}: Untreated check

Fig. 1. View of field experiment on management of *MYMV* disease of black gram during *rabi* 2019-20.

B. Observations and data analysis

Observations were recorded from 10 DAS to 75 DAS and per cent disease incidence for *MYMV* disease was calculated as per the formula below:

$$\text{Per cent disease incidence (PDI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

MYMV severity was calculated by using the modified scale of All India Coordinated research Project on MULLaRP given by Alice and Nadarajan (2007) and the per cent disease index was calculated by using the formula given by wheeler (1969).

$$\text{PDI} = \frac{\text{Sum of all the numerical ratings}}{\text{Number of observations} \times \text{Maximum disease grade}} \times 100$$

The per cent disease reduction over control for each treatment was calculated by using formula given by Vincent (1927).

$$\text{Per cent disease reduction} = \frac{(C - T)}{C} \times 100$$

Where, C = Per cent disease in control; T = Per cent disease in treatment

Pre-spraying counts of the vector population (*Bemisia tabaci*) were made one day before spray were recorded in each treatment at 15, 30, 45, 60 and 75 DAS by random selection of 10 plants in each treatment. Three trifoliate leaves each from top, middle and bottom canopies were taken into a polythene cover from ten plants in each treatment plot. The samples were taken to the laboratory and the live nymphal population count was taken using stereo zoom microscope. The observations were recorded from ten randomly selected plants in each plot leaving the border rows. Per cent reduction over control was calculated by using formula.

$$\% \text{ reduction over control} = \frac{\text{No. of whiteflies in control - No. of whiteflies in treatment}}{\text{No. of whiteflies in control}} \times 100$$

C. Yield parameters

Randomly five plants from each treatment plot were collected (at harvesting stage) for assessing yield parameters. The effect of *MYMV* on yield parameters and yield per ha was recorded and average data obtained from sample plants was analysed statistically.

RESULTS AND DISCUSSION

Under natural field conditions, *Mungbean yellow mosaic virus (MYMV)* produce typical yellow mosaic symptoms in plant and symptoms first appeared on young leaves in the form of yellow, diffused, round spots scattered on the leaf lamina. Severely infected plants showed complete chlorotic leaves which later turn to necrotic and death occurs (Fig. 2).

Fig. 2. Yellow mosaic virus disease of black gram leaves.

A. MYMV

Comprehensive analysis of data from the two field trials confirmed that the mean *MYMV* incidence and severity in untreated control was 11.03% and 12.06% during *kharif* and 13.60% and 13.29% during *rabi* (Table 1 and 2). *MYMV* incidence and severity was nil at 15 DAS and disease was increases gradually from 30 DAS till harvest. When no sprays were given, the percent disease incidence and severity was varied from 0 to 22.86% and 0 to 28.23% (during *kharif*) and 0 to 25.25% and 0 to 29.54% (during *rabi*) in untreated control. Among the various treatments, seed treatment with thiamethoxam @ 5.0 g/ kg and 2 sprays of acetamiprid (4%) + fipronil (4%) (T_7) @ 2.0 ml/l recorded significantly least *MYMV* incidence and severity (8.99% and 13.12% during *kharif* and 10.08% and 15.13% during *rabi*) followed by seed treatment with imidacloprid 600 FS @ 5.0ml/kg and 2 sprays of flonicamid @ 0.4g/l (T_6) (11.04% and 13.86% during *kharif* and 10.80% and 15.95% during *rabi*) at 75 DAS. However, highest *MYMV* disease incidence and severity was observed with the treatment involving *Mirabilis jalapa* leaf extract @ 10.00 % (T_2) spray (19.24% and 24.28% during *kharif* and 20.78% and 24.06% during *rabi*). Among the test treatments imposed, seed treatment with thiamethoxam (5.0g/ kg) and two sprays of acetamiprid (4%) + fipronil (4%) (2.0ml/l) reported lowest mean *MYMV* incidence and severity with mean per cent reduction of 66.00 and 50.17 during *kharif* and 64.39 and 44.92 during *rabi* season respectively. Our results were agreed with the Archana *et al.*, (2018) and Jayappa *et al.*, (2017) where they reported seed treatment with imidacloprid contributed to relatively low disease incidence of *YMV* on blackgram. Swathi *et al.* (2018) reported foliar spray with flonicamid 50 WG @ 0.0325% was found to be very effective in reducing *YMV* disease incidence (17.66%). Similarly, Ghosh *et al.* (2009), reported that Imidacloprid and Thiamethoxam were more effective in reducing the incidence of *YMV* when compared to conventional insecticides. The systemic nature of thiamethoxam and imidacloprid on the insect vector at initial stages might be the reason for low disease incidence.

B. Whitefly population

In *kharif* and *rabi*, the average whitefly (*B. tabaci* Genn.) population per plant at one day before the first spray varied from (Table 3) 2.31 - 3.62 and 1.95 - 3.27 whiteflies on 3 top leaves / plant respectively. Seed treatment with thiamethoxam @ 5.0 g/ kg and 2 sprays of acetamiprid (4%) + fipronil (4%)@ 2.0 ml/l (T_7) recorded the least mean whitefly population of 4.14 and 2.19 per plant during *kharif* and *rabi* with the per cent reduction of 30.58 and 42.84 per cent over control respectively, and which was on par with seed treatment with imidacloprid 600 FS @ 5.0ml/kg and 2 sprays of flonicamid @ 0.4g/l (T_6) which recorded the vector population of 4.28 and 3.30 per plant and reduction of 28.22 and 35.91per cent over control respectively. Highest mean whitefly population was recorded in treatment involving *Mirabilis jalapa* leaf extract @ 10.00 % spray 5.52 and 4.56 whiteflies per leaf with the reduction of 7.39 and 11.64 per cent over control.

Table 1: Effect of different treatments on *MYMV* disease incidence during *kharif* and *rabi* 2019-20.

Treatments	Per cent disease incidence (*Kharif*)					Mean DI(%)	% reduction over control	Per cent disease incidence (*Rabi*)					Mean DI (%)	% reduction over control
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS			15 DAS	30 DAS	45 DAS	60 DAS	75 DAS		
T1: Neem oil 5%	0.00 *(1.00)	3.99 *(2.00)	7.41 *(2.72)	11.14 *(3.34)	14.11 *(3.75)	7.33	33.54	0.00 *(1.00)	5.22 *(2.28)	10.60 *(3.25)	13.26 *(3.64)	14.24 *(3.77)	8.66	36.28
T2:*Mirabilis jalapa* leaf extract 10%	0.00 (1.00)	5.93 (2.43)	9.33 (3.05)	14.90 (3.86)	19.24 (4.39)	9.88	10.43	0.00 (1.00)	6.46 (2.54)	13.40 (3.66)	15.09 (3.88)	20.78 (4.56)	11.15	18.01
T3: $MnSo_4$ (0.2%) + $ZnSo_4$ (0.2%)	0.00 (1.00)	4.12 (2.02)	8.02 (2.83)	12.91 (3.59)	16.16 (4.02)	8.24	25.29	0.00 (1.00)	5.63 (2.37)	11.64 (3.41)	13.47 (3.67)	15.27 (3.90)	9.20	32.33
T4: $ZnSo_4$ (0.2%)	0.00 (1.00)	5.01 (2.24)	9.06 (3.01)	14.16 (3.76)	17.05 (4.13)	9.06	17.86	0.00 (1.00)	5.71 (2.38)	12.25 (3.49)	14.45 (3.80)	17.56 (4.19)	9.99	26.51
T5: Thiamethoxam 25WG (0.2g/l)	0.00 (1.00)	1.98 (1.40)	4.96 (2.23)	8.81 (2.97)	11.61 (3.41)	5.47	50.41	0.00 (1.00)	2.43 (1.55)	7.24 (2.69)	10.46 (3.23)	11.44 (3.38)	6.31	53.56
T6: Flonicamid 50WG (0.4g/l)	0.00 (1.00)	3.45 (1.85)	6.98 (2.64)	10.65 (3.26)	13.92 (3.73)	7.00	36.54	0.00 (1.00)	4.92 (2.21)	9.80 (3.12)	12.50 (3.53)	13.80 (3.71)	8.21	39.65
T7: Acetamiprid (4%) + Fipronil (4%) (2ml/l)	0.00 (1.00)	2.48 (1.55)	6.17 (2.48)	9.92 (3.15)	12.10 (3.48)	6.14	44.33	0.00 (1.00)	4.16 (2.03)	8.67 (2.94)	11.66 (3.41)	12.41 (3.52)	7.38	45.72
T8: Imidacloprid (5ml/kg) (ST) + T6	0.00 (1.00)	1.44 (1.19)	4.62 (2.14)	8.43 (2.90)	11.04 (3.32)	5.11	53.67	0.00 (1.00)	1.64 (1.28)	6.48 (2.54)	8.58 (2.93)	10.80 (3.28)	5.50	59.54
T9: Thiamethoxam (5g/kg) (ST) + T7	0.00 (1.00)	0.96 (1.13)	2.59 (1.59)	6.22 (2.48)	8.99 (2.99)	3.75	66.00	0.00 (1.00)	1.38 (1.17)	5.34 (2.30)	7.41 (2.71)	10.08 (3.17)	4.84	64.39
T10: Untreated check	0.00 (1.00)	5.98 (2.44)	10.15 (3.18)	16.18 (4.02)	22.86 (4.78)	11.03	0.00	0.00 (1.00)	8.37 (2.89)	15.84 (3.98)	18.53 (4.30)	25.25 (5.02)	13.60	0.00
SEM±	-	0.11	0.10	0.08	0.07			-	0.11	0.12	0.10	0.08		
CD ($P \leq 0.05$)	-	0.32	0.29	0.25	0.22			-	0.33	0.36	0.31	0.25		
CV (%)	-	10.19	6.45	4.37	3.34			-	9.28	6.72	5.13	3.74		

*Figures in parentheses are square root transformed values

Table 2: Effect of different treatments on *MYMV* disease severity during *kharif* and *rabi* 2019-20.

Treatments	Per cent disease index (PDI) (*Kharif*)					Mean DI(%)	% reduction over control	Per cent disease index (PDI)(*Rabi*)					Mean DI(%)	% reduction over control
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS			15 DAS	30 DAS	45 DAS	60 DAS	75 DAS		
T1: Neem oil 5%	0.00 *(1.00)	3.25 *(1.80)	6.36 *(2.52)	14.04 *(3.75)	20.19 *(4.49)	8.77	27.28	0.00 *(1.00)	4.94 *(2.22)	9.15 *(3.02)	15.25 *(3.90)	20.31 *(4.50)	9.93	25.28
T2: *Mirabilis jalapa* leaf extract 10%	0.00 (1.00)	3.72 (1.93)	7.21 (2.68)	17.28 (4.15)	24.28 (4.93)	10.50	12.94	0.00 (1.00)	5.32 (2.30)	10.07 (3.17)	19.83 (4.45)	24.06 (4.90)	11.86	10.76
T3: $MnSo_4$ (0.2%) + $ZnSo_4$ (0.2%)	0.00 (1.00)	3.49 (1.86)	6.49 (2.54)	14.70 (3.83)	20.85 (4.56)	9.11	24.46	0.00 (1.00)	5.01 (2.23)	9.63 (3.10)	17.50 (4.18)	22.21 (4.71)	10.87	18.21
T4: $ZnSo_4$ (0.2%)	0.00 (1.00)	3.62 (1.90)	6.63 (2.57)	15.82 (3.98)	22.20 (4.71)	9.66	19.90	0.00 (1.00)	5.18 (2.27)	9.83 (3.13)	18.30 (4.28)	23.30 (4.83)	11.32	14.82
T5: Thiamethoxam 25WG (0.2g/l)	0.00 (1.00)	2.98 (1.73)	5.63 (2.37)	11.19 (3.34)	14.58 (3.81)	6.88	42.95	0.00 (1.00)	4.65 (2.14)	7.72 (2.77)	11.70 (3.42)	17.59 (4.19)	8.33	37.32
T6: Flonicamid 50WG (0.4g/l)	0.00 (1.00)	3.18 (1.78)	6.18 (2.48)	12.17 (3.48)	18.56 (4.30)	8.02	33.50	0.00 (1.00)	4.87 (2.20)	8.69 (2.94)	14.15 (3.76)	18.85 (4.34)	9.31	29.95
T7: Acetamiprid (4%) + Fipronil (4%) (2ml/l)	0.00 (1.00)	3.18 (1.78)	6.03 (2.46)	11.93 (3.45)	16.73 (4.09)	7.57	37.23	0.00 (1.00)	4.80 (2.17)	8.05 (2.83)	12.16 (3.47)	18.05 (4.25)	8.61	35.21
T8: Imidacloprid (5ml/kg) (ST) + T6	0.00 (1.00)	2.94 (1.71)	5.63 (2.37)	10.87 (3.29)	13.86 (3.72)	6.66	44.78	0.00 (1.00)	5.10 (2.25)	7.18 (2.67)	10.79 (3.28)	15.95 (3.99)	7.80	41.31
T9: Thiamethoxam (5g/kg) (ST) + T7	0.00 (1.00)	2.64 (1.62)	5.20 (2.28)	9.07 (3.01)	13.12 (3.62)	6.01	50.17	0.00 (1.00)	4.44 (2.08)	6.93 (2.62)	10.13 (3.18)	15.13 (3.89)	7.32	44.92
T10: Untreated check	0.00 (1.00)	3.84 (1.93)	8.11 (2.84)	20.10 (4.48)	28.23 (5.31)	12.06	0.00	0.00 (1.00)	5.42 (2.32)	10.21 (3.19)	21.30 (4.61)	29.54 (5.44)	13.29	0.00
SEM±	-	0.10	0.11	0.10	0.09			-	0.17	0.13	0.10	0.07		
CD ($P \leq 0.05$)	-	0.29	0.32	0.30	0.25			-	0.50	0.38	0.30	0.21		
CV (%)	-	9.31	7.48	4.73	3.40			-	13.04	7.52	4.51	2.75		

*Figures in parentheses are square root transformed value

Table 3: Effect of different treatments on whitefly population during *kharif* and *rabi* 2019-20.

Treatments	Whitefly population (*Kharif*)					Mean WP	% reduction over control	Whitefly population (*Rabi*)					Mean WP	% reduction over control
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS			15 DAS	30 DAS	45 DAS	60 DAS	75 DAS		
T1: Neem oil 5%	1.57 *(1.25)	2.95 *(1.72)	5.59 *(2.36)	8.10 *(2.84)	6.33 *(2.51)	4.91	17.64	0.98 *(0.99)	2.79 *(1.66)	3.56 *(1.89)	6.47 *(2.54)	6.14 *(2.48)	3.99	22.67
T2: *Mirabilis jalapa* leaf extract 10%	1.89 (1.37)	3.44 (1.85)	6.23 (2.49)	8.83 (2.97)	7.20 (2.68)	5.52	7.39	1.18 (1.08)	3.10 (1.76)	4.10 (2.02)	7.45 (2.72)	6.95 (2.64)	4.56	11.64
T3: $MnSo_4$ (0.2%) + $ZnSo_4$ (0.2%)	1.70 (1.30)	3.11 (1.76)	5.84 (2.41)	8.41 (2.89)	6.57 (2.56)	5.13	13.94	1.08 (1.04)	2.87 (1.69)	3.82 (1.95)	6.68 (2.58)	6.25 (2.50)	4.14	19.69
T4: $ZnSo_4$ (0.2%)	1.82 (1.34)	3.26 (1.81)	6.08 (2.46)	8.57 (2.93)	6.83 (2.61)	5.31	10.80	1.13 (1.06)	2.94 (1.71)	3.89 (1.97)	6.90 (2.62)	6.68 (2.57)	4.31	16.42
T5: Thiamethoxam 25WG (0.2g/l)	1.19 (1.09)	2.67 (1.63)	5.10 (2.26)	7.70 (2.77)	5.51 (2.34)	4.43	25.57	0.85 (0.92)	2.28 (1.51)	3.16 (1.78)	5.95 (2.44)	5.25 (2.29)	3.50	32.17
T6: Flonicamid 50WG (0.4g/l)	1.44 (1.20)	2.87 (1.69)	5.36 (2.31)	7.96 (2.82)	5.97 (2.44)	4.72	20.73	0.96 (0.97)	2.67 (1.63)	3.41 (1.85)	6.30 (2.51)	6.06 (2.46)	3.88	24.75
T7: Acetamiprid (4%) + Fipronil (4%) (2ml/l)	1.32 (1.13)	2.76 (1.66)	5.24 (2.29)	7.85 (2.80)	5.75 (2.39)	4.58	23.06	0.92 (0.96)	2.56 (1.60)	3.24 (1.80)	6.13 (2.47)	5.89 (2.42)	3.75	27.32
T8: Imidacloprid (5ml/kg) (ST) + T6	0.97 (0.99)	2.44 (1.56)	4.98 (2.23)	7.61 (2.75)	5.38 (2.32)	4.28	28.22	0.77 (0.87)	2.06 (1.43)	2.97 (1.72)	5.77 (2.40)	4.95 (2.22)	3.30	35.91
T9: Thiamethoxam (5g/kg) (ST) + T7	0.92 (0.96)	2.31 (1.52)	4.75 (2.18)	7.45 (2.73)	5.25 (2.29)	4.14	30.58	0.49 (0.69)	1.95 (1.39)	2.80 (1.67)	5.17 (2.27)	4.33 (2.08)	2.95	42.84
T10: Untreated check	1.94 (1.39)	3.62 (1.90)	6.81 (2.58)	9.17 (3.02)	8.25 (2.87)	5.96	0.00	1.41 (1.19)	3.27 (1.81)	4.57 (2.14)	8.38 (2.89)	8.15 (2.84)	5.16	0.00
SEM±	0.07	0.06	0.08	0.11	0.09			0.07	0.06	0.06	0.09	0.10		
CD ($P \leq 0.05$)	0.22	0.17	0.24	0.32	0.27			0.20	0.19	0.17	0.26	0.30		
CV (%)	10.81	5.68	5.91	6.63	6.29			12.23	6.91	5.42	6.06	7.07		

*Figures in parentheses are square root transformed values

Table 4: Effect of different treatments on yield parameters of blackgram during *kharif* and *rabi* 2019-20.

Treatments	Yield parameters (*Kharif*)							Yield parameters (*Rabi*)						
	No. of primary branches /plant	No. of Pods/ Plant	No. of Seeds/ Pod	Test weight (g)	Seed yield (g) / Plant	Seed yield (q/ha)	Benefit cost ratio (BCR)	No. of primary branches /plant	No. of Pods/ Plant	No. of Seeds/ Pod	Test weight (g)	Seed yield (g) / Plant	Seed yield (q/ha)	Benefit cost ratio (BCR)
T1: Neem oil 5%	9.47	18.02	4.55	4.57	5.59	6.16	1.85	7.67	14.13	4.53	4.46	6.30	4.61	1.96
T2: *Mirabilis jalapa* leaf extract 10%	8.70	15.95	4.21	4.28	4.96	5.28	1.64	7.27	12.26	4.12	4.21	5.28	4.15	1.76
T3: MnSo4 (0.2%) + ZnSo4 (0.2%)	9.13	17.93	4.37	4.51	5.44	5.55	1.72	7.56	13.47	4.32	4.41	5.70	4.48	1.83
T4: ZnSo4 (0.2%)	8.73	16.89	4.28	4.36	5.11	5.44	1.70	7.63	12.76	4.18	4.29	5.50	4.26	1.82
T5: Thiamethoxam 25WG (0.2g/l)	10.77	21.10	5.19	4.95	6.24	7.26	2.25	9.18	16.00	5.24	4.73	7.09	5.33	2.55
T6: Flonicamid 50WG (0.4g/l)	9.87	18.74	4.68	4.70	5.73	6.37	1.94	8.40	14.53	4.95	4.56	6.56	4.78	2.11
T7: Acetamiprid (4%) + Fipronil (4%)	10.33	19.76	5.02	4.82	5.96	6.72	2.06	8.76	14.93	5.14	4.67	6.78	5.05	2.29
T8: Imidacloprid (5ml/l) (ST) + T6	11.54	22.52	5.45	5.01	6.54	8.05	2.42	9.07	16.60	5.40	4.81	7.16	5.87	2.74
T9: Thiamethoxam (5g/l) (ST) + T7	11.90	24.87	6.19	5.14	6.98	8.73	2.65	9.57	17.00	5.88	4.96	7.95	6.05	2.82
T10: Untreated check	8.67	15.07	4.05	4.17	4.37	5.05	1.59	7.01	12.20	4.08	4.14	4.94	3.83	1.75
SEM±	0.55	0.85	0.39	0.19	0.41	0.66		0.16	0.42	0.25	0.12	0.28	0.36	
CD (P ≤ 0.05)	1.63	2.52	1.16	0.57	1.22	1.97		0.47	1.24	0.75	0.36	0.83	1.07	
CV (%)	9.60	7.71	14.12	7.16	12.52	17.73		3.37	5.03	9.17	4.70	7.67	12.83	

However, the observations of ten treatments showed that, when no sprays were given, the mean whitefly populations per plant were 5.96 and 5.16 respectively. The results indicated that all the treatments were found significantly superior in reducing *MYMV* disease incidence, severity and whitefly population than untreated check during both seasons.

The present results are agreed with Archana *et al.*, (2018) and Jayappa *et al.*, (2017) where they have revealed that seed treatment with imidacloprid contributed to relatively lowest populations of whitefly. Corresponding results were reported by Rhadika *et al.*, (2018), lowest population of whiteflies were recorded in seed treatment with thiamethoxam @ 3 g/kg with 2.40 whiteflies and was on par with seed treatment of imidacloprid @ 5 g/kg with 2.60 whiteflies per six leaves. Swathi *et al.*, (2018) reported foliar spray of flonicamid @ 0.0325% was found to be highly effective in reducing whitefly population. Similarly, the present investigations are also in agreement with Naik *et al.* (2017) and Kalyan *et al.*, (2017) who reported flonicamid followed by acetamiprid 4% + fipronil 4% @ 2ml/l were very effective against whitefly population in Bt.cotton. Findings of Dubey and Singh (2010) also reported that Imidacloprid and Thiamethoxam were significantly superior in efficacy against sucking insect pests. Ganapathy and Karuppaiah (2004) who revealed that seed treatment with thiamethoxam at 5 g/kg seed recorded minimum whitefly population in blackgram.

C. Yield attributes

Among the ten treatments, seed yield was numerically highest from seed treatment with thiamethoxam (5.0g/ kg) and two sprays of acetamiprid (4%) + fipronil (4%) (T_7) (2.0ml/l) and found statistically on par with seed treatment with imidacloprid 600 FS @ 5.0ml/kg and 2 sprays of flonicamid @ 0.4g/l (T_6) (Table 4). Results showed treatments which recorded least disease incidence and whitefly population have recorded a significant positive impact on yield parameters evaluated. The number of primary branches/plants, number of seeds per pod and test weight varied from 8.67 to 11.90, 4.05 to 6.19 and 4.17 to 5.14g during *kharif* whereas in *rabi*, 7.01 to 9.57, 4.08 to 5.88 and 4.14 to 4.96g and there was no significant difference among them. However, significant difference was observed between treatments with regard to number of pods per plant 15.07 to 24.87 and 12.20 to 17.00), seed yield per plant (4.37 to 6.98gand 4.94 to 7.95g) and yield/ha (5.05 to 8.73q and 3.8 to 6.05q) during *kharif* and *rabi* respectively. Highest B: C ratio recorded with seed treatment with thiamethoxam @ 5g/l and spraying of acetamiprid 4% + fipronil 4% (2.65 and 2.82) during *kharif* and *rabi* (Table 4). The systemic insecticides were attributed to greater residual activity, high level of protection, and quick knock down effect on viruliferous vectors compared to botanicals (Venkatesan, 2017) and micronutrients (Basavaraj, 2012). The results were positively correlated with Archana *et al.*, (2018) Jayappa *et al.*, (2017). The seed yield and other yield attributes were low from the treatments with high *MYMV* incidence of which was in accordance with earlier reports. A strong negative correlation was recorded between the incidence of *MYMV* and yield attributes (Gupta, 2003).

CONCLUSION

In the present study botanicals, micronutrients and insecticides were used for the management of *MYMV* rather than relying upon chemical insecticides alone. Based on two seasons experimentation, treatment involving seed treatment with thiamethoxam (5.0g/ kg) and two sprays of acetamiprid (4%) + fipronil (4%) (2.0ml/l) (T_7) recorded least mean *MYMV* incidence and whitefly population with significant enhancement of grain yield and other yield contributing attributes.

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