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Jayappa
Department of Plant Pathology, College of Agriculture, UAS, GKVK Bengaluru, Karnataka, India

HK Ramappa
Department of Plant Pathology, College of Agriculture, UAS, GKVK Bengaluru, Karnataka, India

BD Devamani
Department of Plant Pathology, College of Agriculture, UAS, GKVK Bengaluru, Karnataka, India

Correspondence
Jayappa
Department of Plant Pathology, College of Agriculture, UAS, GKVK Bengaluru, Karnataka, India

Management of Mungbean Yellow Mosaic Virus (MYMV) in Mungbean (*Vigna radiata* L.)

Jayappa, HK Ramappa and BD Devamani

Abstract
Experiments were conducted on integrated management of MYMV by using different combination of insecticides and neem based pesticides during January and March in 2016. Among the treatments in both the experiment, seed treatment with imidacloprid at 5 ml/kg seeds and two sprays of imidacloprid at 0.5 ml/l at 25 and 40 days after sowing (DAS) or two sprays of imidacloprid at 0.5 ml/l alone at 25 and 40 DAS were found effective in reducing the incidence of MYMV (41.86 per cent) and its vector (3.5 per plant). Seed treatment with imidacloprid at 5 ml/kg seeds plus two sprays of neemazal at 3 ml/l was also effective in management of MYMV (45.20 per cent) and its vector (3.7 per plant). Compared to these treatments, maximum per cent incidence and whitefly population was recorded in control.

Keywords: Incidence, Insecticide, MYMV, Management, Whitefly

1. Introduction
Vigna radiata (L.) Wilczek, generally called as green gram or mungbean which is native to India or the Indo Burma region [1]. It is well adapted to large number of cropping systems and creates an important source of cereal based diet worldwide, grown in more than six million hectares. Presently about 90% of world's mungbean is produced in Asia alone [2]. India accounts for about 65% of world's acreage and 54% of its global production and it is the world's largest mungbean producer [3].

In India, mungbean is grown on an area of 3.42 lakh ha and production of 1.03lakh tonnes with productivity 302 kg/ha. Important mungbean growing states are Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Odisha, Tamil Nadu and Uttar Pradesh [4]. Nutritional status of crop mainly consists of carbohydrate (51%), protein (24-26%), minerals (4%) and vitamins (3%). It also has the capacity to fix good amount of atmospheric nitrogen and thus, enhances soil fertility [4]. The standard worldwide yield of mungbean is very low (384 kg/ha) and besides many efforts its production has not considerably increased. The major reason for the low yield is the sensitivity of the crop to insects; weeds and diseases caused by fungi, virus and bacteria [5].

Among the three, the viruses are the most crucial group of plant pathogens, which substantially decreases the yield of the crop. They cause serious diseases and economic losses in mungbean by decreasing seed yield and quality [5]. MYMV is transmitted by the vector, whitefly (*Bemisia tabaci*). Depending up on the sequence identity analyses, the bipartite begomovirus isolates, namely, mungbean yellow mosaic virus (MYMV), mungbean yellow mosaic India virus (MYMIV) and horse gram yellow mosaic virus (HgYMV) are recognized as the causal agents of MYMV in different regions of the world [6]. The magnitude of loss depends on the stage of the crop when infected; the severity of disease on individual plant and number of plants infected [7].The disease appears in sever form every year and in epidemic years, it could cause up to 100 per cent yield loss [8].

Though there is large area under mungbean cultivation, the productivity levels are lower, because of MYMV infection [9]. Even though, strategies for management of MYMV disease include planting resistant or tolerant varieties, vector management, management of alternative weeds or hosts of viruses and modifying the cultural practices of the crop which are lesser supportive for disease development and are not effective in managing the disease. Therefore, there is need to develop a better management practices. With this background, the present investigation was done on different aspects of integrated management of MYMV by using different chemicals and neem based pesticides.

2. Materials and Methods

To know the effectiveness of different insecticides as seed treatment and spraying under field condition against MYMV, the experiment was conducted at ZARS, GKVK with two different sowings during 2016. Experimental details of first sowing (early summer) and second sowing (late summer) are given as Design: RCBD, Plot size: 3×1.5 m, Replications: 3, Treatments: 7, Spacing: 30×10cm, Variety: KKM-3, Spraying is done at 25 and 40 days after sowing and the treatment details for experiment have shown in Table 1.

2.1. Per cent disease incidence

It was calculated by counting number of plants infected and total number of plants in a plot.

$$\text{Per cent Disease Incidence (PDI)} = \frac{\text{Number of infected plants in a row}}{\text{Total number of plants in a row}} \times 100$$

The readings were recorded at 15 days before initiation of sprays, 15 days after first and 15 days after second spray and data were analyzed statistically. The per cent disease reduction over control was calculated by using formula given by Vincent [10].

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

Where, C= Per cent disease in control

T= Per cent disease in treatment

2.2. Vector population

The number of whiteflies on top 3 trifoliate leaves per plant from each of five randomly selected plants at one day before and 5 days after first and second sprays were recorded in each treatment. Per cent reduction over control was calculated by using formula.

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

2.3. Growth and yield parameters

Randomly five plants from each treatment were collected (at harvesting stage) for assessing growth and yield parameters. The effect of MYMV on plant height, pods per plant and yield per ha was studied and five plant average data was analyzed statistically.

3. Statistical analysis

After conducting experiments, data was analyzed by using Two-way ANOVA with CD at 5%. Experimental Design used was Randomized complete block design.

4. Results and Discussion

Comprehensive analysis of data from the experiment conducted during two consecutive sowings confirmed the following results. The result obtained here is the mean values of both first and second sown with respect to per cent disease incidence, vector population and growth parameters.

4.1. Per cent disease incidence

The observations of seven treatments revealed that, when no sprays were given, the per cent disease incidence varied from 26.65 to 28.00 per cent in first sown and 28.17 to 30.13 in second sown crop (Table.2). Seed treatment with imidacloprid @ 5 ml/kg seeds and two spray of Imidacloprid @ 0.5 ml/l (T_2) recorded significantly lowest mean disease incidence were followed by two sprays of imidacloprid @ 0.5 ml/l alone (T_3), seed treatment with imidacloprid @ 5 ml/kg seeds and two sprays of neemazal @ 3 ml/l (T_6) with mean incidence of 37.12, 37.43 and 39.47 per cent and 0.89, 46.13 and 48.75 in order of their effectiveness respectively in both first and second sowings, whereas the mean disease incidence in untreated check/control plot was 53.31 per cent which is represented in Table.2. Salam [11] also found incidence of 49.15 per cent and 55.98 per cent at 15 days after first and second spray of azadirachtin 0.03EC (5ml/l) during his study. Wang [11] reported that effect of imidacloprid was due to its systemic action on vector.

In both the sowings, seed treatment with imidacloprid @ 5 ml/kg seeds and two sprays of imidacloprid @ 0.5 ml/l (T_2) and two sprays of imidacloprid @ 0.5 ml/l alone (T_3) recorded highest per cent disease reduction over control (25.51, 24.88 and 34.49, 33.10 per cent, respectively). Whereas, seed treatment with imidacloprid @ 5 ml/kg seeds (T_1) recorded least (4.03 and 10.66 per cent) disease reduction over control.

The data presented in the Table.5 depicts that the average per cent incidence of MYMV of both first and second sown crops during 2016 was recorded minimum, on seed treatment with imidacloprid @ 5 ml/kg seeds followed by two sprays of imidacloprid @ 0.5 ml/l (37.16%) which was on par with T_3 treatment two sprays of imidacloprid @ 0.5 ml/l alone (37.71%). Highest incidence of 49.28 per cent was observed in seed treatment with imidacloprid @ 5 ml/kg seeds (T_1)

Mote [12], Walunj and Mote [13], Dandale [14] and Salam [11] reported similar results on effectiveness of imidacloprid for management of whitefly transmitted viral diseases.

4.2. Vector population

In first and second sown crop, the vector (*B. tabaci* Genn.) population per plant at one day before the first spray varied from (Table.1) 3.3-5.8 and 2.7-6.8 whiteflies on 3 top leaves / plant respectively.

Five days after spray during both sowings, seed treated with imidacloprid @ 5 ml/kg seeds followed by two sprays of imidacloprid @ 0.5 ml/l (T_2) recorded the least vector population of 3 and 2.3 per plant and per cent reduction of vector population over control respectively, and which was on par with two sprays of imidacloprid @ 0.5 ml/l alone (T_3) which recorded vector population of 3.2 and 2.6 per plant and reduction of 48.38 and 63.88 per cent over control respectively.

Seed treatment with imidacloprid @ 5 ml/kg seeds followed by two sprays of neemazal @ 3 ml/l (T_6) was found to be next best treatment recording vector population of 3.6 and 4.1 per plant with per cent of 41.93 and 43.05 reductions over control. Singh [3] observed the similar results and he said it was due to prevention of the nymphal stage from developing into adult with the application of neem seed karnal extract (NSKE) and foliar spray of neem oil.

The values presented in Table. 3 indicated that the next best results were observed in seed treatment with imidacloprid @ 5 ml/kg seeds plus two sprays of neemazal @ 3 ml/l (T_6) and seed treatment with imidacloprid @ 5 ml/kg seeds along with two sprays of triazophos 40% EC @ 1.5ml/l (T_4) which are on par with each other observed that 41.93 and 43.05 per cent reduction over control with whiteflies of 3.6 and 5.4 per plant respectively.

The obtained results were correlates with the results of Nandihalli [15] wherein, he found an average of 10.51 and 14.82 per cent reduction in incidence by using combinations of commercially available neem products like, Neemguard and Neemark at 3ml per liter each with monocrotophos 36 WSC at 1 ml per liter. Lower whitefly count of 3.20 and 4.0 whiteflies per plant at 5 days after first and second spray documented by Salam[11] with same combination of insecticides.

Seed treatment with imidacloprid @ 5 ml/kg seeds along with two sprays of thiamethaxom @ 0.3 g/l (T_5) which recorded 3.7 11 and 5.3 whiteflies per plant with per cent of 40.32 and 26.38 reduction over control respectively. Foliar sprays of thiamethoxam 0.02% at 21 days after sowing resulted in lowest intensities of mungbean yellow mosaic observed by Sunil and Birendra Singh [16]. Highest vector population was recorded in control (no spray) with whiteflies of 6.15 per plant (Table.5).

4.3. Growth and yield parameters

The effect of mungbean yellow mosaic virus disease on various growth and yield parameters *viz.*, plant height, pods per plant and Yield/ha in different treatments were evaluated. It is evident from the results that the treatments which recorded least per cent disease incidence and whitefly population have shown a significant positive effect on all the growth and yield parameters evaluated.

4.3.1. Plant height

At the end of each sowing period (70 DAS), no significant difference was observed between various treatments with regard to plant height. However, the plant height varied from 28.8 to 29.8 cm in first sown crop and 28.6 to 30 cm in second sown crop (Table. 4). However, plant height in all the treatments was found statistically non-significant.

4.3.2. Pods per plant

In both the sowings, the treatment T_2 (seed treatment with imidacloprid @ 5 ml/kg seeds along with two sprays of imidacloprid @ 0.5 ml/l) was found to be the best with regard pod per plant recorded pods of 21.43 and 19.43 per plant respectively which was followed by two sprays of imidacloprid @ 0.5 ml/l alone (T_3) and seed treatment with imidacloprid @ 0.5 ml/l and two sprays of neemazal @ 3 ml/l (T_6) which recorded mean of 18.73 and 16.12 pods per plant, respectively.

Seed treatment with imidacloprid @ 5 ml/kg seeds plus two sprays of thiamethaxom @ 0.3 g/l (T_5), seed treatment with imidacloprid @ 5 ml/kg seeds alone (T_1) and seed treatment with imidacloprid @ 5 ml/kg seeds along with two sprays of triazophos 40% EC 40% EC @ 1.5 ml/l (T_4) were the next best treatments. Corresponding results were reported by Rajnish[17] an average reduction of 24.76 per pods per plant, 25.28 per cent reduction in yield per plant in highly susceptible variety of greengram, PIMS-4 and by Salam [11] in mungbean against MYMV.

4.3.3. Yield

Among seven treatments, in two sowings, seed treated with imidacloprid @ 5 ml/kg seeds plus two sprays of imidacloprid @ 0.5 ml/l (T_2) recorded highest yield of 1017.50 kg/ha, two sprays of imidacloprid @ 0.5 ml/l alone (T_3), seed treated with imidacloprid @ 5 ml/kg seeds along with two sprays of neemazal @ 3 ml/l (T_6) and seed treated with imidacloprid @ 5 ml/kg seeds plus two sprays of thiamethaxom @ 0.3 g/l (T_5) were recorded next best at yield 972.50, 898.50 and 864.56 kg/ha respectively.

Seed treated with imidacloprid @ 5 ml/kg seeds along with two sprays of triazophos 40% EC 40% EC @ 1.5 ml/l (T_4) and seed treatment with imidacloprid @ 0.5 ml/l (T_1) recorded least yield/ha (Table.5).

Between treatments, highest per cent grain yield increase over control was recorded in T_2, seed treated with imidacloprid @ 5 ml/kg seeds plus two sprays of imidacloprid @ 0.5 ml/l (42.87) whereas least was recorded in seed treatment with imidacloprid @ 0.5 ml/l (T1) with 817.78 kg/ha (Table.5). Similar results are observed by Ghosh [18].

The effectiveness of insecticides was attributed to greater residual activity, high level of protection, quick knock down effect of insecticides on viruliferous vectors compared to botanicals, plant products and cultural practices that act indirectly by enhancing growth of plant, delaying disease appearance as reported by Baranwal and Ahmed [19] and by inducing resistance as reported by Verma and Varsha [20], changing feeding behavior, by deterring settling activity of vector or acting as ovipositional deterrents by Patel [21] which are not sharp and accurate enough to restrict the activity of viruliferous vectors.

5. Conclusion

The results of the present investigation showed that seed treated with imidacloprid @ 5 ml/kg seeds followed by two sprays of imidacloprid @ 0.5 ml/l could be effectively exploited for the management of MYMV in mungbean.

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Table 1: Treatment details for experiments (1&2nd sowing).

Trt. No.	Treatment combinations	Dosage of chemical
T_1	Seed treatment with imidacloprid 17.8 % SL	5 ml/kg seeds
T_2	T_1+ 2 sprays of imidacloprid 17.8 % SL	0.5 ml/l
T_3	2 sprays of imidacloprid 17.8 % SL	0.5 ml/l
T_4	T_1+ 2 sprays of triazophos 40 % EC	1.5 ml/l
T_5	T_1+ 2 sprays of thiamethaxom 25% WG	0.3 g/l
T_6	T_1+ 2 sprays of neemazal (5% azadirachtin)	3 ml/l
T_7	Control/ untreated	-

Note; The imidachloprid, triazophos, thiamethoxam and neemazal sprays were taken at 25 and 40 days after sowing.

Table 2: Effect of seed treatment, spraying of insecticides and neem pesticide on the incidence of MYMV and grain yield

Trt. No	Per cent disease incidence												Yield					
	Before sprays		15 days after first spray		15 days after second spray		Mean			% reduction over control			Yield (kg/ha)			% increase over control		
T_1	27.01 (31.31) **	30.12 (33.28) **	53.33 (46.91)	56.23 (48.57)	63.12 (52.61)	65.85 (54.24)	47.82	50.73	49.27	4.03	10.66	7.34	835.55 (28.91)	800 (28.29)	817	30.94	30.55	30.74
T_2	28.00 (31.95)	29.15 (32.67)	41.23 (39.95)	40.32 (39.41)	42.13 (40.47)	42.13 (40.47)	37.12	37.20	37.16	25.51	34.49	30	1010 (31.78)	1025 (32.02)	1017	42.87	45.8	44.33
T_3	26.65 (31.08)	28.61 (32.33)	42.50 (40.69)	41.25 (39.96)	43.15 (41.06)	44.12 (41.62)	37.43	37.99	37.71	24.88	33.10	28.9	970 (31.15)	975 (31.23)	972	40.51	43.02	41.65
T_4	27.02 (31.32)	29.01 (32.58)	55.10 (47.93)	57.12 (49.09)	56.01 (48.45)	60.14 (50.85)	46.04	48.75	47.39	7.61	14.10	10.8	845.80 (29.09)	840 (28.99)	842	31.78	33.86	32.82
T_5	26.99 (31.30)	28.17 (32.05)	54.11 (47.36)	55.12 (47.93)	55.12 (47.94)	56.12 (48.51)	45.40	46.13	45.76	8.89	18.77	13.8	856.12 (29.26)	873 (29.55)	864	32.60	36.36	34.48
T_6	27.11 (31.38)	30.10 (33.27)	45.20 (42.25)	45.67 (42.51)	46.12 (42.77)	46.9 (43.22)	39.47	40.89	40.18	20.79	27.99	24.3	900 (30)	897 (29.95)	898	35.88	38.06	36.97
T_7	27.13 (31.39)	30.13 (33.91)	60.23 (50.90)	64.12 (53.20)	62.13 (52.02)	62.13 (52.02)	49.83	56.79	53.95	0	0	0	577 (24.03)	555.55 (23.58)	566	0	0	0
S.Em± CD 5%	0.01 0.02	0.02 0.05	0.15 0.46	0.19 0.60	0.19 0.59	0.21 0.66							0.5 0.15	0.5 0.15				

**Figures in parenthesis are Arc sine transformed values; sprays were taken at 25 and 40 days after planting, Bold values are mean of the 2 sowings.

Table 3: Effect of seed treatment, spraying of insecticides and neem pesticide on vector whitefly population*

Tr. No	Average no. of whiteflies on 3 top leaves /plant					
	1st sowing			2nd sowing		
	1 DBS	5DAS	% reduction over control	1 DBS	5DAS	% reduction over control
T_1	4.0(2.12)	3.9(2.10)	37.09	5(2.345)	4.9(2.32)	31.94
T_2	3.3(1.95)	3.0(1.87)	51.61	2.8(1.81)	2.3(1.67)	68.05
T_3	3.5(2.00)	3.2(1.92)	48.38	2.7(1.78)	2.6(1.76)	63.88
T_4	3.8(2.07)	3.6(2.02)	41.93	5.8(2.50)	5.4(2.42)	25
T_5	3.9(2.10)	3.7(2.05)	40.32	5.6(2.46)	5.3(2.40)	26.38
T_6	3.77(2.0)	3.6(2.02)	41.93	4.2(2.16)	4.1(2.14)	43.05
T_7	5.8(2.51)	6.2(2.59)	0	6.8(2.70)	7.2(2.77)	0
S. Em ± CD at 5%	0.0 0.1	0.0 0.1		0.01 0.03	0.01 0.03	

*Spraying done at 40 DAS *Figures in parenthesis are $\sqrt{x}$ transformed value, DBS- Days before spraying, DAS- Days after spraying

Table 4: Effect of seed treatment, spraying of insecticides and neem pesticide on growth parameters of mungbean**

Tr. No	First sown crop			Second sown crop		
	Plant height (cm)	Pods / plant	% increase over control	Plant height (cm)	Pods / plant	% increase over control
T_1	28.9	11(3.39) **	10.91	28.9	11(3.39) **	10.90
T_2	29.7	21.43(4.68)	54.27	28.7	19.43(4.46)	49.56
T_3	29.8	19.23(4.44)	49.04	29.8	18.23(4.32)	46.24
T_4	29.5	11(3.39)	10.91	30	10(3.24)	2
T_5	28.8	11.5(3.46)	14.78	28.8	11.1(3.40)	11.71
T_6	29.1	16.12(4.08)	39.21	29.1	16.12(4.07)	39.20
T_7	29.6	9.8(3.21)	0.00	28.6	9.8(3.20)	0
S.Em ± CD at 5%		0.01 0.03			0.01 0.03	

**Figures in parenthesis are $\sqrt{x}$ transformed value

Table 5: Effect of seed treatment, spraying of insecticides and neem pesticide on MYMV incidence, vector population and yield*

Tr. no	Per cent incidence			Vector population**			Yield (kg/ha)		
	1st sown	2nd sown	Mean	1st sown	2nd sown	Mean	1st sown	2nd sown	Mean
T1	47.82	50.73	49.28	4.05	5.05	4.55	835.55	800	817.78
T2	37.12	37.20	37.16	3.25	2.25	2.75	1010	1025	1017.50
T3	37.43	37.99	37.71	3.5	2.55	3.03	970	975	972.50
T4	46.04	48.75	47.40	3.8	4.7	4.25	845.80	840	842.90
T5	45.40	46.13	45.77	3.71	4.8	4.26	856.12	873	864.56
T6	39.47	40.89	40.18	3.6	3.95	3.78	900	897	898.50
T7	49.83	56.79	53.31	5.65	6.65	6.15	577	555.55	566.28

*Pooled data of two seasons, **Vector population at 5 DAS after 1st (25days) and 2nd (40 days) spray

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