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Evaluation of certain Newer insecticides in Management of Whitefly (*Bemisia tabaci*): A Vector of Yellow Mosaic Disease (YMD) in Blackgram (*Vigna mungo* L.)

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ABSTRACT: A field experiment was conducted at dryland farm, S.V. Agricultural College, Tirupati during *rabi* 2020-21 to evaluate the efficacy of nine insecticides *i.e.* Thiocloprid 21.7 SC @ 1.0 ml l^{-1}, Thiomethoxam 25 WG @ 0.2g l^{-1}, Spiromesifen 240 SC @ 1.0 ml l^{-1} Acetamiprid 20 SP @ 0.25g l^{-1} Buprofezin 25 SC @ 1.5ml l^{-1}, Pymetrozine 50 WG @ 0.6 g l^{-1}, Spinoteram 11.7 SC @ 1.0 ml l^{-1}, Diafenthiuron 50 WP @ 1.25 g l^{-1} and Flonicamid 50 WG @ 0.30 g l^{-1} against whitefly. The results revealed that diafenthiuron 50 WP @ 1.25 g l^{-1} was found to be most effective in reducing the whitefly population (75.23%) and YMD incidence (13.51%) followed by spiromesifen 240 SC @ 1.0 ml l^{-1} (65.19% and 17.17%) and Thiomethoxam 25 WG @ 0.2g l^{-1} (54.64% and 21.27%) while thiocloprid 21.7 SC @ 1.0 ml l^{-1} (20.21% and 48.88%) and spinoteram 11.7 SC @ 1.0 ml l^{-1} (25.16% and 43.91%) showed least efficacy in reducing whitefly population and YMD incidence.

Keywords*:* *Bemisia tabaci*, MYMV, Management, newer insecticides, *vigna mungo*.

INTRODUCTION

Blackgram (*Vigna mungo* (L.) Hepper), commonly known as urdbean, mash, or black matpe, is a short-duration and highly profitable pulse crop predominantly grown in India as a traditional *kharif* crop. India leads global production, contributing over 70% of the world's supply, followed by Myanmar, Pakistan, and Thailand. Although traditionally a kharif crop, in Andhra Pradesh it is mainly cultivated as a *rabi* (winter) crop in both uplands and rice fallows, accounting for 10% of the nation's pulse production (Rajawat *et al*., 2021).Whitefly, *Bemisia tabaci* (Gennadius) is the most important pest during early stages of crop growth in blackgram, causing damage by sucking cell sap from leaves and excretes honeydew on which sooty mold develops which hinders photosynthesis. Besides, it also acts as a vector for deadly viral disease Mungbean Yellow Mosaic Virus, (MYMV) which is a serious threat to pulse production in India (Mahalakshmi *et al*., 2015).

In the Southern Zone of Andhra Pradesh, Chittoor district cultivates blackgram on 3439 hectares, producing 3997 tonnes with a productivity of 740 kg per hectare, which is significantly below the state average. Under changing climatic conditions, the incidence of whitefly and the severity of yellow mosaic virus disease are major factors contributing to the unsuccessful cultivation of blackgram and its low production in Chittoor district. Given devastating impact of whitefly infestations and the rampant spread of YMD, this study was undertaken to rigorously evaluate potent novel modes of action insecticides, deploying them in lower doses to effectively control these pests during the most vulnerable stages of crop growth.

MATERIAL AND METHODS

A field trial was carried out during the late *rabi* season of 2020-21 at the dryland farm of S.V. Agricultural College, Tirupati. The experiment, using the susceptible blackgram variety "LBG-623," followed a randomized complete block design with ten treatments, including a control. The efficacy of various insecticidal treatments against whitefly was tested. Thiocloprid 21.7 SC at 1.0 ml/l, Thiomethoxam 25 WG @ 0.2 g/l, Spiromesifen 240 SC @ 1.0 ml/l, Acetamiprid 20 SP at 0.25 g/l, Buprofezin 25 SC @ 1.5 ml/l, Pymetrozine 50 WG at 0.6 g/l, Spinetoram 11.7 SC @ 1.0 ml/l, Diafenthiuron 50 WP @ 1.25 g/l, and Flonicamid 50 WG @ 0.30 g/l. Plots sprayed with water served as the control.

Plots measuring 5 × 4 meters were used to replicate each treatment three times. Foliar sprays were carried out twice during the crop period, with a 15-day gap between applications. For each replication, data on whitefly population were taken from three leaves each from the top, middle, and bottom of five randomly selected plants: one day prior to each spray and at three, seven, ten and fifteen days after each spray.

Percentage reduction in population for different treatments was calculated using a modified Abbot's formula (Fleming and Ratnakaran 1985)

$$\text{Per cent Population reduction} = 1 - \frac{\text{Post treatment population in treatment}}{\text{Pre - treatment population in treatment}} \times \frac{\text{Pre - treatment population in check}}{\text{Post treatment population in check}}$$

From the entire plot, we randomly selected five rows, each measuring 4 meters, and counted the total plants and those with YMD disease symptoms to estimate the percentage incidence of YMD.

The data on per cent disease incidence was calculated by using the following formula.

$$\text{Per cent disease incidence (PDI)} = \frac{\text{No. of diseased plants per row}}{\text{Total no. of plants per row}} \times 100$$

Data on percentage reduction compared to control and YMD incidence were transformed using the angular transformation method and then statistically analyzed using Analysis of Variance (ANOVA).

RESULTS

First spray. Whitefly population counts (Pre treatment count) were taken one day prior to spraying across all experimental plots. The counts ranged from 6.20 to 6.93 adults per plant, showing no significant differences among the experimental plots, indicating uniform distribution of whiteflies across all treatments (Table 1). At three days after spraying, all insecticidal treatments showed significantly better efficacy compared to the untreated control. Diafenthiuron 50 WP @ 1.25 g/l demonstrated the highest effectiveness against whitefly with a 66.87% reduction, followed by Spiromesifen 240 SC @ 1.0 ml/l (62.16%) and Thiamethoxam 25 WG @ 0.2 g/l (50.12%). The remaining treatments in descending order of efficacy were Acetamiprid 20 SP @ 0.25 g/l (46.50%), Flonicamid 50 WG @ 0.30 g/l (39.32%), Buprofezin 25 SC @ 1.5 ml/l (37.28%), and Pymetrozine 50 WG @ 0.6 g/l (34.05%). However, Thiocloprid 21.7 SC @ 1.0 ml/l (20.76%) and Spinetoram 11.7 SC @ 1.0 ml/l (26.84%) were found to be the least effective, showing the lowest percentage reduction compared to the control.

The similar trend was observed at 7, 10 and 15 days after spraying in all treatments except buprofezin 25SC which recorded the highest percent reduction compared to acetamiprid 20 SP @ 0.25g l^{-1}, flonicamid 50 WG @ 0.30 g l^{-1} and pymetrozine 50 WG @ 0.6 g l^{-1} at 7th and 10th day after spraying. Whitefly population reduction slightly declined from 10 to 15 days after spraying compared to 3 to 7 days, highlighting the need for a second spray. Sunil *et al.* (2015) ; Rajawat *et al.* (2021) reported similar findings.

After the first spray, diafenthiuron 50 WP @ 1.25 g/l achieved the highest effectiveness with a 71.40% reduction compared to control, followed by Spiromesifen 240 SC @ 1.0 ml/l (64.26%) and Thiomethoxam 25 WG @ 0.2 g/l (55.45%). Buprofezin 25 SC @ 1.5 ml/l, Acetamiprid 20 SP @ 0.25 g/l, and Flonicamid 50 WG @ 0.30 g/l followed in descending order of efficacy, with reductions of 46.17%, 45.73%, and 38.34% over the control, respectively. Thiocloprid 21.7 SC @ 1.0 ml/l (22.06%) and Spinetoram 11.7 SC @ 1.0 ml/l (27.60%) were found to be the least effective treatments, showing the lowest reduction percentages than aforementioned treatments (Table 1).

Table 1: Efficacy of certain insecticides after first spray against whitefly in blackgram during late *rabi* 2020-21.

Sr. No.	Treatment	Dose per litre	PTC	Per cent reduction of whitefly population over control				YMD Incidence (%)	Mean (%) reduction
				3 DAT	7DAT	10 DAT	15 DAT		
T_1	Thiacloprid 21.7 SC	1.0ml l^{-1}	6.83	20.76 *(26.49)^{f}	28.35 (32.15)^{g}	23.39 (28.36)^{g}	15.73 (23.56)^{g}	43.21 (41.08)^{b}	22.06 (27.88)^{f}
T_2	Thiomethoxam 25 WG	0.2 g l^{-1}	6.53	50.12 (45.08)^{bc}	63.01 (52.52)^{c}	61.24 (51.47)^{bc}	47.42 (43.49)^{abc}	18.61 (25.84)^{ef}	55.45bc (48.13)^{bc}
T_3	Spinoteram 11.7 SC	1.0ml l^{-1}	6.27	26.84 (31.17)^{ef}	37.17 (37.51)^{f}	26.49 (30.95)^{g}	19.92 (26.37)^{ef}	37.50 (37.73)^{bc}	27.60 (31.55)^{ef}
T_4	Spiromesifen 240 SC	1.0ml l^{-1}	6.77	62.16 (52.08)^{ab}	72.05 (58.12)^{b}	70.51 (57.13)^{ab}	52.34 (46.32)^{ab}	14.66 (22.05)^{f}	64.26 (53.37)^{ab}
T_5	Diafenthiuron 50 WP	1.25 g l^{-1}	6.20	66.87 (54.86)^{a}	82.16 (65.13)^{a}	77.15 (61.43)^{a}	59.42 (50.46)^{a}	10.93 (19.25)^{f}	71.40 (57.91)^{a}
T_6	Acetamiprid 20SP	0.25g l^{-1}	6.27	46.50 (42.96)^{cd}	50.70 (45.38)^{d}	45.49 (42.34)^{de}	40.25 (39.31)^{bcd}	22.94 (28.59)^{e}	45.73 (42.52)^{cd}
T_7	Flonicamid 50 WG	0.30 g l^{-1}	6.93	39.32 (38.73)^{cde}	44.29 (41.04)^{e}	40.19 (39.30)^{ef}	30.67 (33.42)^{de}	33.00 (35.03)^{cd}	38.34 (38.20)^{de}
T_8	Pymetrozine 50 WG	0.6 g l^{-1}	6.60	34.05 (35.66)^{def}	43.16 (41.70)^{ef}	31.26 (33.83)^{fg}	26.21 (30.62)^{def}	36.41 (37.08)^{bc}	33.95e (35.53)^{e}
T_9	Buprofezin 25 SC	1.5ml l^{-1}	6.80	37.28 (37.61)^{cde}	57.45 (49.27)^{c}	53.26 (46.86)^{cd}	36.69 (37.01)^{cd}	25.63 (30.36)^{de}	46.17 (42.74)^{cd}
T_{10}	Untreated control	—	6.47	—	—	—	—	54.64 (47.72)^{a}	—
	SE±(m)			3.75	1.99	3.57	3.59	2.67	1.96
	CD (5%)			11.22	5.98	10.68	10.76	8.02	5.73
	CV (%)			16.91	7.23	14.41	12.94	15.59	9.71

Values in parentheses are arcsine transformed values ; PTC: Pre treatment count ; DAT: Days after treatment; YMD –PDI at 45 DAS;
Values followed by same letter in each column are not significantly different (DMRT)

Following the first spray at 45 days after sowing (DAS), the percentage incidence of YMD was assessed across all treatments, showing significantly lower values than the untreated control (54.64%).The disease incidence ranged from 10.93% (Diafenthiuron 50 WP @ 1.25 g/l) to 54.64% (Control). Diafenthiuron was the most effective against YMD, with the lowest percentage of disease incidence of 10.93%, followed by Spiromesifen 240 SC @ 1.0 ml/l (14.66%) and Thiamethoxam 25 WG @ 0.2 g/l (18.61%), which showed similar effectiveness. Acetamiprid 20 SP @ 0.25 g/l, and Buprofezin 25 SC @ 1.5 ml/l resulted in disease incidences of 22.94% and 25.63%, respectively, indicating moderate efficacy. Thiocloprid 21.7 SC @ 1.0 ml/l (43.21%) and Spinetoram 11.7 SC @ 1.0 ml/l (37.50%) were the least effective treatments, with the highest disease incidences among the tested treatments (Table 1).

Second spray. The pre-treatment whitefly population per plant ranged from 2.67 to 6.17. After the second spray, all insecticidal treatments showed a further reduction in whitefly population compared to the control (Table 2).

At three days after spraying, Diafenthiuron 50 WP @ 1.25 g/l demonstrated superior efficacy among all treatments, achieving a 57.38% reduction in whitefly population compared to the untreated control. This was followed by Spiromesifen 240 SC @ 1.0 ml/l (46.32%) and Thiomethoxam 25 WG @ 0.2 g/l (39.06%). Acetamiprid 20 SP @ 0.25 g/l and Buprofezin 25 SC @ 1.5 ml/l showed reductions of 36.07% and 27.53%, respectively. Flonicamid 50 WG @ 0.30 g/l (21.03%) and Pymetrozine 50 WG @ 0.6 g/l (15.65%) followed, while Thiocloprid 21.7 SC @ 1.0 ml/l (11.05%) and Spinetoram 11.7 SC @ 1.0 ml/l (15.13%) were the least effective treatments, showing the lowest percentage reductions compared to other treatments (Table 2).

At 7, 10, and 15 days after spraying, a consistent trend was noted across all treatments, except for Buprofezin 25 SC @ 1.5 ml/l, which had the highest percentage reduction on the 7th and 10th days compared to Acetamiprid 20 SP @ 0.25 g/l, Flonicamid 50 WG @ 0.30 g/l, and Pymetrozine 50 WG @ 0.6 g/l. This slower effect may be attributed to its mode of action. This observation is supported by Das and Islam (2014).

Fifteen days after spraying, the highest mean percentage reduction in whitefly population when compared with the control was observed with Diafenthiuron 50 WP @ 1.25 g/l (79.07%), followed by Spiromesifen 240 SC @ 1.0 ml/l (66.12%) and Thiomethoxam 25 WG @ 0.2 g/l (58.82%). The lowest reductions were seen with Thiocloprid 21.7 SC @ 1.0 ml/l (18.36%), followed by Spinetoram 11.7 SC @ 1.0 ml/l (22.71%) and Pymetrozine 50 WG @ 0.6 g/l (26.06%). Buprofezin 25 SC @ 1.5 ml/l, Acetamiprid 20 SP @ 0.25 g/l, and Flonicamid 50 WG @ 0.30 g/l showed reductions of 42.33%, 41.27%, and 31.81%, respectively, with Acetamiprid performing similarly to Buprofezin (Table 2).

After the second spray (at 60 DAS), the plot treated with Diafenthiuron 50 WP @ 1.25 g/l recorded the lowest disease incidence at 16.08%, followed by Spiromesifen 240 SC @ 1.0 ml/l (19.67%) and Thiomethoxam 25 WG @ 0.2 g/l (23.93%), which showed similar efficacy. The highest percentage of disease incidence was observed in the untreated control (74.50%), followed by Thiocloprid 21.7 SC @ 1.0 ml/l (54.54%) and Spinetoram 11.7 SC @ 1.0 ml/l (50.32%). Acetamiprid 20 SP @ 0.25 g/l, buprofezin 25 SC @ 1.5 ml/l, and flonicamid 50 WG @ 0.30 g/l exhibited disease incidences of 32.11%, 37.83%, and 43.49%, respectively (Table 2).

Table 2: Efficacy of different insecticides after second spray against whitefly in blackgram during late *rabi* 2020-21.

Sr. No.	Treatment	Dose per litre	PTC	Per cent reduction of whitefly population over control				YMD (%)	Mean (%) reduction
				3 DAT	7DAT	10 DAT	15 DAT		
T_1	Thiacloprid 21.7 SC	1.0ml l^{-1}	4.57	11.05 (18.79)^{g}	17.13 (24.40)^{g}	20.40 (26.65)^{g}	24.85 (29.88)^{g}	54.54 (47.58)^{b}	18.36 (25.14)^{e}
T_2	Thiomethoxam 25 WG	0.2 g l^{-1}	3.20	39.06 (38.60)^{bc}	52.17 (46.22)^{c}	59.50 (50.50)^{c}	64.55 (54.04)^{bc}	23.93 (29.20)^{fg}	58.82 (47.19)^{bc}
T_3	Spinoteram 11.7 SC	1.0ml l^{-1}	4.43	15.13 (22.57)^{ef}	19.46 (25.94)^{g}	26.73 (31.09)^{fg}	29.51 (37.02)^{g}	50.32 (45.16)^{bc}	22.71 (28.26)^{e}
T_4	Spiromesifen 240 SC	1.0ml l^{-1}	3.07	46.32 (42.86)^{b}	64.46 (53.38)^{b}	76.46 (60.98)^{b}	77.31 (61.36)^{ab}	19.67 (26.26)^{g}	66.12 (54.67)^{ab}
T_5	Diafenthiuron 50 WP	1.25 g l^{-1}	2.67	57.38 (49.23)^{a}	82.88 (65.56)^{a}	87.11 (69.00)^{a}	88.92 (74.08)^{a}	16.08 (23.55)^{g}	79.07 (63.55)^{a}
T_6	Acetamiprid 20SP	0.25g l^{-1}	3.60	36.07 (36.87)^{c}	37.82 (37.81)^{de}	40.09 (39.16)^{de}	51.11 (45.63)^{cd}	32.11 (34.49)^{ef}	41.27 (39.92)^{cd}
T_7	Flonicamid 50 WG	0.30 g l^{-1}	4.00	21.03 (27.23)^{de}	31.81 (34.22)^{ef}	35.69 (36.63)^{ef}	38.70 (38.40)^{def}	43.49 (41.23)^{cd}	31.81 (34.18)^{de}
T_8	Pymetrozine 50 WG	0.6 g l^{-1}	4.23	15.65 (23.16)^{ef}	24.90 (29.83)^{fg}	30.04 (33.18)^{efg}	33.67 (35.43)^{ef}	47.08 (43.40)^{bc}	26.06 (30.47)^{e}
T_9	Buprofezin 25 SC	1.5ml l^{-1}	4.10	27.53 (31.60)^{d}	44.86 (41.97)^{cd}	48.13 (43.90)^{d}	48.81 (44.30)^{cde}	37.83 (37.93)^{de}	42.33 (40.47)^{cd}
T_{10}	Untreated control		6.17	—	—	—	—	74.50 (56.29)^{a}	—
	SE±(m)			2.79	3.90	3.37	5.28	2.84	2.45
	CD (5%)			8.37	11.69	10.10	15.83	8.50	7.15
	CV (%)			17.99	18.02	13.78	14.31	12.49	12.86

Values in parentheses are arcsine transformed values ; PTC: Pre treatment count ; DAT: Days after treatment ; YMD –PDI at 45 DAS; Values followed by same letter in each column are not significantly different (DMRT)

After two sprays, the cumulative average percentage reduction in whitefly population in comparision with the control revealed that diafenthiuron 50 WP @ 1.25 g/l was highly effective with a 75.23% reduction, followed by Spiromesifen 240 SC @ 1.0 ml/l (65.19%) and Thiomethoxam 25 WG @ 0.2 g/l (54.64%). Acetamiprid 20 SP @ 0.25 g/l, and Buprofezin 25 SC @ 1.5 ml/l demonstrated reductions of 43.50% and 38.25%, respectively, in descending order of efficacy. Thiocloprid 21.7 SC @ 1.0 ml/l (20.21%), Spinetoram 11.7 SC @ 1.0 ml/l (25.16%), and Pymetrozine 50 WG @ 0.6 g/l (30.01%) exhibited the lowest mean percentage reductions (Table 3).

The cumulative impact of insecticidal treatments on YMD incidence demonstrated significantly lower disease rates relative to the untreated control. Disease incidence ranged from 13.51% to 61.62% in the control plots. Diafenthiuron 50 WP @ 1.25 g/l showed the lowest disease incidence at 13.51%, statistically superior to all treatments, followed by Spiromesifen @ 1.0 ml/l (17.17%) and Thiomethoxam 25 WG @ 0.2 g/l (21.27%). The highest percentage of disease incidence was noticed in the untreated plots at 61.62%, followed by Thiocloprid 21.7 SC @ 1.0 ml/l (48.88%) and Spinetoram 11.7 SC @ 1.0 ml/l (43.91%). acetamiprid 20 SP @ 0.25 g/l, buprofezin 25 SC @ 1.5 ml/l, and flonicamid 50 WG @ 0.30 g/l showed disease incidences of 27.52%, 31.73%, and 38.25%, respectively (Table 3).

Table 3: Cumulative efficacy of different insecticidal treatments against whitefly during late *rabi* 2020-21.

Sr. No.	Treatment	Dose per litre	PTC	Per cent reduction of whitefly population over control				YMD incidence (%)	Mean (%) reduction
				3 DAT	7DAT	10 DAT	15 DAT		
T_1	Thiacloprid 21.7 SC	1.0ml l^{-1}	5.70	15.91 $(23.25)^{de}$	22.74 $(28.29)^{f}$	21.89 $(27.87)^{h}$	20.29 $(26.62)^{de}$	48.88 $(44.44)^{ab}$	20.21 $(26.68)^{g}$
T_2	Thiomethoxam 25 WG	0.2 g l^{-1}	4.87	44.59 $(41.85)^{ab}$	57.59 $(49.37)^{bc}$	60.37 $(50.96)^{c}$	55.99 $(48.47)^{abc}$	21.27 $(27.41)^{def}$	54.64 $(47.64)^{c}$
T_3	Spinoteram 11.7 SC	1.0ml l^{-1}	5.35	20.98 $(27.03)^{cd}$	28.31 $(31.85)^{ef}$	26.61 $(31.04)^{gh}$	24.72 $(29.69)^{de}$	43.91 $(41.45)^{bc}$	25.16 $(30.06)^{fg}$
T_4	Spiromesifen 240 SC	1.0ml l^{-1}	4.98	54.24 $(47.44)^{a}$	68.25 $(55.72)^{ab}$	73.49 $(59.01)^{b}$	64.80 $(53.90)^{ab}$	17.17 $(21.46)^{ef}$	65.19 $(53.82)^{b}$
T_5	Diafenthiuron 50 WP	1.25 g l^{-1}	4.60	62.12 $(52.03)^{a}$	82.52 $(65.26)^{a}$	82.13 $(65.17)^{a}$	74.17 $(60.46)^{a}$	13.51 $(24.40)^{f}$	75.23 (60.19)a
T_6	Acetamiprid 20SP	0.25g l^{-1}	4.93	41.29 $(39.93)^{abc}$	44.26 $(41.65)^{cdef}$	42.79 $(40.83)^{e}$	45.68 $(42.48)^{bcd}$	27.52 $(31.55)^{cdef}$	43.50 $(41.24)^{d}$
T_7	Flonicamid 50 WG	0.30 g l^{-1}	5.47	30.18 $(33.05)^{bcd}$	37.48 (37.68)def	37.94 $(37.99)^{ef}$	34.69 $(36.03)^{cd}$	38.25 $(38.14)^{bcd}$	35.07 $(36.28)^{e}$
T_8	Pymetrozine 50 WG	0.6 g l^{-1}	5.42	24.85 $(29.48)^{bcd}$	34.59 $(35.81)^{def}$	30.66 $(33.60)^{fg}$	29.94 $(33.11)^{cd}$	41.75 $(40.24)^{bc}$	30.01 $(33.15)^{ef}$
T_9	Buprofezin 25 SC	1.5ml l^{-1}	5.45	32.41 $(34.64)^{bcd}$	51.56 $(45.64)^{bcd}$	50.70 $(45.38)^{d}$	42.75 $(40.78)^{bcd}$	31.73 $(34.17)^{bcde}$	38.25 $(41.68)^{d}$
T_{10}	Untreated control		6.32	—	—	—	—	61.62 $(51.77)^{a}$	—
	SE±(m)			2.66	3.27	2.48	4.36	1.67	2.28
	CD (5%)			8.66	10.63	8.04	14.17	5.42	7.39
	CV (%)			11.56	10.85	8.22	15.72	6.83	8.20

Values in parentheses are arcsine transformed values; PTC: Pre treatment count ; DAT: Days after treatment ; YMD –PDI at 45; DAS
Values followed by same letter in each column are not significantly different (DMRT)

DISCUSSION

In this study, Diafenthiuron 50 WP @ 1.25 g/l proved highly effective against both whitefly population and YMD, achieving a 75.23% reduction in whitefly population and the lowest disease incidence at 13.51% (Table 3). This high efficacy is likely attributable to its specific mode of action as a pro-insecticide, which converts to a toxic compound upon activation. Diafenthiuron is activated to its carbodiimide form on the leaf surface under sunlight or within insects catalyzed by P450 monooxygenases. The carbodiimide form of diafenthiuron binds to the glutamate residue in the transmembrane F0 subunit of ATP synthase, where it disrupts proton transport from the intermembrane space, thereby inhibiting ATP synthesis and mitochondrial respiration.

The present findings align with those of Shakya *et al.* (2020), who demonstrated that Diafenthiuron 50 WP @ 312.5 g. a.i/ha was effective against whitefly, achieving the highest mean percentage reduction of 85.9% and 77.8% over the control after the first and second sprays, respectively, in greengram. Similar findings were also reported by Kharel *et al.* (2016) in greengram, and by Rajasekhar *et al.* (2018) ; Kumar *et al.* (2019) in cotton, where diafenthiuron 50% WP @ 1.25 g/l recorded the maximum reduction in whitefly population compared with the control.

Spiromesifen 240 SC @ 1.0 ml/l was the second most effective treatment, achieving a 65.19% reduction in whitefly population compared with the control and a 17.17% disease incidence (Table 3). Spiromesifen's efficacy may stem from its action against the developmental stages of the pest, disrupting nymphal molting and preventing adult emergence, thereby reducing adult fecundity (Kontsedalov *et al.*, 2009). These findings consistent with those of Mahalakshmi *et al.* (2015), who observed that spiromesifen 240 SC @ 0.4 ml/l to be highly effective, achieving a 75% mean reduction in nymphal population and maintaining YMV incidence below 20% in blackgram. Similar results were reported by Sujay *et al.* (2013) in brinjal.

Thiocloprid 21.7 SC @ 1.0 ml/l and Spinoteram 11.7 SC @ 1.0 ml/l were proved to be the least effective treatments, by achieving less than 30.00% reduction in whitefly population compared to the control, in contrast to other treatments. Shaik *et al*. (2014) ; Afzal *et al*. (2014) reported that thiocloprid at 500 ml/ha also in effective to whitefly on brinjal, cotton, and brinjal, respectively.

CONCLUSIONS

The study recommends two applications of diafenthiuron 50 WP or thiomethoxam 25 WG: the first at 20-30 DAS (vegetative stage) and the second at 35-45 DAS (flowering stage) for effective management for YMD and to improve yields.

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Conflict of Interest. None.

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