

EFFICACY OF NEW-CHEMISTRY INSECTICIDES AGAINST WHITEFLY AND APHIDS IN POTATO

Mohd Abas Shah^{1*}, Sanjeev Sharma² and Raj Kumar³

ABSTRACT: The efficacy of new-chemistry insecticides *viz.*, dinotefuran, diafenthiuron, flupyradifurone and pymetrozine was evaluated against whitefly, *Bemisia tabaci* and the peach-potato aphid, *Myzus persicae* in separate trials. Against whitefly adults, diafenthiuron 50 WP @ 0.08% and @ 0.1%, and pymetrozine 50 WG @ 0.06% and 0.08% performed best till 14 DAT with over 80% reduction in whitefly incidence. Against the peach-potato aphids, Flupyradifurone 200 SL @ 0.1%, diafenthiuron 50 WP @ 0.06% and 0.08% and pymetrozine 50 WG @ 0.04%, 0.06% and 0.08% performed on a par and reduced the aphid incidence by more than 80% throughout the period. Consequent incidence of viruses was also found lowest for the respective treatments. Therefore, diafenthiuron 50 WP @ 0.08% and pymetrozine 50 WG @ 0.06% can be used for the management of whiteflies, and flupyradifurone 200 SL @ 0.1%, diafenthiuron 50 WP @ 0.06% and pymetrozine 50 WG @ 0.04% can be used for the management of peach-potato aphids in potato crops.

KEYWORDS: Aphids, whitefly, virus transmission, systemic insecticides, seed potato, new chemistry insecticides, viruses, tuber yield

INTRODUCTION

Potato crops are infested by a number of insect pests which can cause substantial reduction in tuber yield and quality. Among the sucking pests, aphids are the most important pests of potato worldwide. Aphids are sap feeding insects but the major damage inflicted is by transmission of numerous potato viruses limiting disease free seed production with a progressive decline in yield. More than fifteen species of aphids are known to infest potato crops in India (Bhatnagar *et al.*, 2017; Sridhar *et al.*, 2022). In India, in addition to the aphids, the sweetpotato whitefly, *Bemisia tabaci* (Gennadius) is a major concern as it transmits the begomovirus *Tomato leaf curl New Delhi virus-potato* (ToLCNDV[potato]) that causes the apical leaf curl disease in potato crops (Usharani *et al.*, 2004; Shah *et al.*, 2019; Kumar *et al.*, 2021). Disease incidence to the extent of 40–100% with heavy yield losses

and degeneration of seed stocks is reported (Lakra, 2003).

The sucking pests infesting potato crops have been managed with the use of systemic insecticides ever since the inception of seed plot technique. Commonly used insecticides include dimethoate, imidacloprid, thiamethoxam and phorate (Sharma *et al.*, 2012). While the use of such insecticides helps to reduce the vector population infesting potato crops, the use of insecticides with knockdown activity can be useful to kill the target insects before appreciable spread of the various potato viruses. Among the new chemistry pesticides, Pymetrozine, a pyridine-azomethine compound which paralyzes cibarium muscles and prevents certain Hemiptera from feeding (Smith and Giurcanu, 2014); Flupyradifurone and Dinotefuran, new generation neonicotinoid insecticides, which bind agonistically to nicotinic acetylcholine receptors in the central nervous system

¹ICAR-Central Institute of Temperate Horticulture, Rangreth-191132, Srinagar, J&K

²ICAR-Central Potato Research Institute, Shimla - 171 001, Himachal Pradesh, India

³ICAR-Central Potato Research Institute, Regional Station, Jalandhar - 144003, Punjab, India

*Corresponding author; email: mabas.shah@icar.gov.in, khubaib20@gmail.com

(Wakita *et al.*, 2003; Maluta *et al.*, 2021); and Diafenthiuron, a thiourea derivative which inhibits mitochondrial ATP synthase (Ishaaya *et al.*, 1993), are widely recommended for the management of whitefly and aphid vectors and to control the consequent spread of viruses. Therefore, in this study, we evaluated the acute and residual toxicity of these insecticides against major vector insects in potato crops.

MATERIALS AND METHODS

Field experiments were conducted at ICAR-Central Potato Research Institute-Regional Station, Jalandhar (Punjab) during *rabi* 2018-19 and 2019-20 to evaluate the knockdown and residual toxicity of insecticides to adult whiteflies and aphids in potato crops. The experiments were laid in Randomised Complete Block Design, separately for evaluation against whitefly (*Bemisia tabaci*) and the peach-potato aphid (*Myzus persicae*). Crops were planted on 10th and 12th October for pesticide evaluation against whiteflies, and on 15th and 17th November for evaluation against aphids during the two years. Potato variety *Kufri Khyati* was grown in the experimental plots with a recommended package of agronomic practices without any crop protection measures.

A total of thirteen treatments were applied against both the whiteflies and aphids which included dinotefuran 20 SG @ 0.03% (0.3 gram per litre of water) and 0.04% (0.4 gram per litre), flupyradifurone 200 SL @ 0.05% (0.5 ml per litre), 0.75% (0.75 ml per litre) and 0.1% (1 ml per litre), diafenthiuron 50 WP @ 0.06% (0.6 gram per litre), 0.08% (0.8 gram per litre) and 0.1% (1 gram per litre), pymetrozine 50 WG @ 0.04% (0.4 gram per litre), 0.06% (0.6 gram per litre) and 0.08% (0.8 gram per litre) in comparison to imidacloprid 17.8 SL @ 0.04% (0.4 ml per litre) besides untreated control.

The treatments were replicated thrice. The insecticides were applied with a manually operated knapsack sprayer using 500 L of water/ha.

Observations on the number of insects *i.e.*, adult whiteflies or adults and 3rd and 4th instar nymphs of peach-potato aphid were taken from five randomly selected plants per plot (plot size 3.6 × 3.2 m) one day before treatment (pre-count) and 1, 3, 7 and 14 days after treatment (DAT). The numbers were counted from three leaves on each plant, one each from upper, middle and lower strata. Pesticide treatments were given at 80% crop emergence for whitefly trials and at 50 days after emergence in case of aphid trials.

The per cent reduction in pest population size over control was calculated using the Henderson-Tilton's formula (Henderson and Tilton, 1955). The total tuber yield in all experiments was recorded on a whole plot basis. Percent virus incidence (expressed as percentage of infected plants over total number of plants/plot) was noted three weeks after the last observation on whitefly/aphid population size. Observations based on the symptoms of potato apical leaf curl virus (PALCV) disease were noted in whitefly trials, and on the incidence of mild and severe mosaic and leaf roll in aphid management trials. The data on number of insects, per cent population reduction over control and tuber yield were subjected to analysis of variance (ANOVA) after appropriate transformation. The treatment means were separated by least significant difference (LSD) test at 5% level of significance.

RESULTS AND DISCUSSION

Whitefly, *Bemisia tabaci*

The error mean squares of the per cent pest incidence reduction were homogeneous over the two years, therefore data were

pooled for analysis. The effect of insecticide treatments on the average incidence of adult whiteflies on potato are shown in Table 1. None of the tested insecticides had a significant knockdown effect (1 DAT) on the incidence of adult whiteflies however, diafenthiuron 50 WP @ 0.1% and pymetrozine 50 WG @ 0.06% and @ 0.08% performed best with $55.4 \pm 4.69\%$, $54.7 \pm 1.60\%$ and $52.3 \pm 7.01\%$ reduction in whitefly incidence, respectively in comparison to imidacloprid 17.8 SL @ 0.04% ($52.3 \pm 5.43\%$) ($F = 35.18$, $d.f. = 12, 24$, $p = 0.00$). All the tested insecticides exhibited maximum toxicity at 7 DAT and by 14 DAT, slight to appreciable decline in toxicity of all the insecticides was observed.

For dinotefuran 20 SG, slight increase in the toxicity was noted as the dose increased from 0.03 to 0.04% however, maximum reduction in whitefly incidence

achieved with dinotefuran 20 SG @ 0.04% was $57.9 \pm 4.38\%$ at 7 DAT. Similarly, the toxicity of flupyradifurone 200 SL increased with increasing dose with maximum reduction in whitefly incidence achieved with flupyradifurone 200 SL @ 0.1% was $66.4 \pm 1.46\%$ at 7 DAT. Opposite to these, the efficacy of diafenthiuron 50 WP increased appreciably with increase in dosage. By 7 DAT, diafenthiuron 50 WP @ 0.1% reduced the adult whitefly incidence by $83.1 \pm 1.34\%$ and by 14 DAT, diafenthiuron 50 WP @ 0.08% and @ 0.1% performed at par with $76.2 \pm 1.38\%$ to $80.4 \pm 1.15\%$ reduction in whitefly incidence. Similarly, pymetrozine 50 WG exhibited high level of toxicity against adult whiteflies. Pymetrozine 50 WG @ 0.06% and 0.08% performed at par and reduced the adult whitefly incidence by $84.9 \pm 0.99\%$ to $85.6 \pm 1.35\%$ at 7 DAT. At 14 DAT, the

Table 1: Efficacy of knockdown insecticides against whitefly, *Bemisia tabaci* in potato

No.	Treatments	Pre-Count	Per cent reduction over control				% Virus incidence
			1 DAT	3 DAT	7 DAT	14 DAT	
1.	Dinotefuran 20 SG @ 0.03%	13.33 ± 0.88	30.1 ± 9.30 (5.46)	43.1 ± 2.88 (6.63)	50.0 ± 6.46 (7.11)	50.9 ± 2.86 (7.20)	8.3 ± 1.6 (3.03)
2.	Dinotefuran 20 SG @ 0.04%	13.0 ± 0.58	37.1 ± 2.28 (6.16)	49.8 ± 1.70 (7.12)	57.9 ± 4.38 (7.66)	56.4 ± 3.94 (7.56)	8.3 ± 2.8 (2.96)
3.	Flupyradifurone 200 SL @ 0.05%	11.0 ± 1.00	40.0 ± 2.40 (6.39)	35.0 ± 8.40 (5.91)	48.1 ± 2.95 (7.00)	52.4 ± 2.74 (7.30)	7.4 ± 0.9 (2.88)
4.	Flupyradifurone 200 SL @ 0.075%	11.33 ± 0.33	31.9 ± 4.65 (5.70)	37.3 ± 6.94 (6.12)	64.1 ± 5.48 (8.05)	61.5 ± 4.21 (7.89)	7.4 ± 2.4 (2.82)
5.	Flupyradifurone 200 SL @ 0.1%	11.0 ± 0.58	39.7 ± 2.34 (6.37)	46.3 ± 4.42 (6.85)	66.4 ± 1.46 (8.21)	64.3 ± 2.08 (8.07)	7.4 ± 0.9 (2.88)
6.	Diafenthiuron 50 WP @ 0.06%	12.33 ± 0.33	37.4 ± 4.28 (6.17)	50.9 ± 5.91 (7.18)	65.0 ± 3.23 (8.12)	57.6 ± 2.45 (7.65)	9.3 ± 0.9 (2.19)
7.	Diafenthiuron 50 WP @ 0.08%	11.0 ± 0.58	48.6 ± 3.96 (7.02)	57.6 ± 1.51 (7.65)	65.6 ± 5.73 (8.14)	76.2 ± 1.38 (8.78)	7.4 ± 0.9 (2.88)
8.	Diafenthiuron 50 WP @ 0.10%	13.33 ± 0.88	55.4 ± 4.69 (7.49)	66.6 ± 2.78 (8.21)	83.1 ± 1.34 (9.17)	80.4 ± 1.15 (9.02)	6.5 ± 2.4 (2.66)
9.	Pymetrozine 50 WG @ 0.04%	13.33 ± 1.20	39.9 ± 5.98 (6.36)	52.7 ± 3.22 (7.32)	69.8 ± 3.66 (8.40)	60.7 ± 2.25 (7.85)	8.3 ± 0.0 (3.05)
10.	Pymetrozine 50 WG @ 0.06%	13.0 ± 1.53	54.7 ± 1.60 (7.46)	67.9 ± 0.64 (8.30)	84.9 ± 0.99 (9.26)	79.9 ± 1.15 (8.99)	7.4 ± 0.9 (2.88)
11.	Pymetrozine 50 WG @ 0.08%	12.0 ± 0.58	52.3 ± 7.01 (7.27)	69.6 ± 1.73 (8.39)	85.6 ± 1.35 (9.30)	81.8 ± 3.91 (9.09)	6.5 ± 0.9 (2.72)
12.	Imidacloprid 17.8 SL @ 0.04%	13.0 ± 0.58	52.3 ± 5.43 (7.28)	59.8 ± 1.99 (7.79)	84.5 ± 2.57 (9.24)	82.9 ± 4.05 (9.15)	7.4 ± 0.9 (2.88)
13.	Control	± 1.53	0	0	0	0	10.2 ± 1.9 (3.32)
SEm			0.28	0.29	0.17	0.12	0.26
CD			0.83	0.86	0.50	0.36	NA

Values are mean $\pm$ SE, NA = Not applicable,

Values in parenthesis are square root transformed as $\sqrt{x} + 1$.

corresponding figures were noted as $79.9 \pm 1.15\%$ and $81.8 \pm 3.91\%$, respectively.

Incidence of PALCV disease was considerably lower in diafenthiuron 50 WP @ 0.1% ($6.50 \pm 2.43\%$) and pymetrozine 50 WG @ 0.08% ($6.50 \pm 0.90\%$) as compared to untreated control ($10.16 \pm 1.86\%$) with no significant variation among the treatments ($F = 0.84$, $d.f. = 12, 24$, $p = 0.61$). No phytotoxicity symptoms were associated with any of the treatments and the total tuber yield showed insignificant variation among the treatments ($F = 1.09$, $d.f. = 12, 24$; $p = 0.40$) (data not shown).

Peach potato aphid, *Myzus persicae*

The tested insecticides exhibited significant knockdown effect against the peach-potato aphid ($F = 201.15$, $d.f. = 12, 24$, $p = 0.00$) (Table 2). Flupyradifurone 200 SL @ 0.1% and diafenthiuron 50 WP @ 0.1% performed best with $74.60 \pm 1.60\%$ and $75.60 \pm 2.82\%$ reduction in the incidence of aphids at 1 DAT. All the tested insecticides performed consistently up to 14 DAT, except dinotefuran 20 SG. For dinotefuran 20 SG @ 0.04%, maximum reduction in the incidence of aphids was noted at 3 DAT ($71.91 \pm 2.63\%$) which decreased subsequently.

Table 2: Efficacy of knockdown insecticides against peach-potato aphid, *Myzus persicae* in potato

No.	Treatments	Pre-Count	Per cent reduction over control				% Virus Incidence
			1 DAT	3 DAT	7 DAT	14 DAT	
1.	Dinotefuran 20 SG @ 0.03%	13.00 ± 0.58	59.95 ± 0.00 (7.81)	67.68 ± 5.41 (8.27)	65.53 ± 5.96 (8.14)	60.07 ± 2.25 (7.81)	9.6 ± 1.8 (3.24)
2.	Dinotefuran 20 SG @ 0.04%	13.33 ± 0.33	67.46 ± 1.63 (8.27)	71.91 ± 2.63 (8.53)	66.77 ± 4.83 (8.22)	64.66 ± 1.58 (8.10)	9.6 ± 1.8 (3.24)
3.	Flupyradifurone 200 SL @ 0.05%	12.00 ± 0.58	69.27 ± 3.63 (8.37)	76.38 ± 0.83 (8.79)	85.61 ± 3.13 (9.30)	74.42 ± 2.22 (8.68)	8.8 ± 2.3 (3.08)
4.	Flupyradifurone 200 SL @ 0.075%	14.00 ± 0.00	70.56 ± 1.53 (8.45)	76.50 ± 2.96 (8.80)	87.66 ± 2.66 (9.41)	78.08 ± 1.91 (8.89)	8.8 ± 0.9 (3.11)
5.	Flupyradifurone 200 SL @ 0.1%	13.67 ± 0.33	74.60 ± 1.60 (8.69)	82.59 ± 3.75 (9.13)	89.93 ± 2.67 (9.53)	87.98 ± 1.50 (9.43)	7.0 ± 0.9 (2.82)
6.	Diafenthiuron 50 WP @ 0.06%	12.00 ± 0.58	69.27 ± 3.63 (8.37)	76.38 ± 0.83 (8.79)	77.06 ± 3.33 (8.83)	82.42 ± 3.12 (9.12)	10.5 ± 1.5 (3.38)
7.	Diafenthiuron 50 WP @ 0.08%	12.33 ± 0.88	73.62 ± 3.06 (8.63)	77.43 ± 6.03 (8.84)	83.36 ± 0.40 (9.18)	88.53 ± 0.20 (9.46)	8.8 ± 0.9 (3.11)
8.	Diafenthiuron 50 WP @ 0.10%	13.33 ± 0.88	75.60 ± 2.82 (8.74)	79.12 ± 5.57 (8.94)	84.61 ± 0.40 (9.25)	89.48 ± 2.89 (9.50)	6.1 ± 2.3 (2.60)
9.	Pymetrozine 50 WG @ 0.04%	13.00 ± 0.00	61.62 ± 1.66 (7.91)	71.19 ± 2.70 (8.49)	84.21 ± 0.40 (9.23)	89.12 ± 0.20 (9.49)	9.6 ± 1.9 (3.24)
10.	Pymetrozine 50 WG @ 0.06%	12.33 ± 0.33	66.58 ± 3.50 (8.21)	80.71 ± 4.15 (9.03)	89.04 ± 2.43 (9.48)	92.32 ± 2.01 (9.66)	7.0 ± 0.9 (2.82)
11.	Pymetrozine 50 WG @ 0.06%	12.33 ± 0.88	70.10 ± 1.76 (8.42)	84.40 ± 4.50 (9.23)	91.68 ± 0.19 (9.62)	94.27 ± 0.10 (9.76)	6.1 ± 0.9 (2.66)
12.	Imidacloprid 17.8 SL @ 0.04%	13.67 ± 0.33	71.43 ± 2.74 (8.50)	86.30 ± 3.16 (9.34)	89.93 ± 2.67 (9.53)	82.81 ± 1.40 (9.15)	8.8 ± 0.9 (3.11)
13.	Control	13.67 ± 0.33	0	0	0	0	11.4 ± 1.8 (3.50)
SEm			0.15	0.21	0.15	0.09	0.22
CD			0.42	0.63	0.44	0.29	NA

Values are mean $\pm$ SE, NA = Not applicable,

Values in parenthesis are square root transformed as $\times x + 1$.

Opposite to this, flupyradifurone 200 SL @ 0.05%, 0.075% and 0.1% performed at par and reduced the aphid incidence by 76.38 to 82.59% at 3 DAT, by 85.61 to 89.93% at 7 DAT. At 14 DAT, the highest dose reduced the aphid incidence by $87.98 \pm 1.50\%$ which was significantly higher than the lower doses (74.42 to 78.08%). Similarly, diafenthiuron 50 WP @ 0.06% and 0.08% performed equally and reduced the aphid incidence by 76.38 to 79.12% at 3 DAT, by 77.06 to 83.36% at 7 DAT, and by 82.42 to 88.53% at 14 DAT. Pymetrozine 50 WG performed best with highest residual toxicity against the peach-potato aphid. Pymetrozine 50 WG @ 0.04%, 0.06% and 0.08% performed almost on a par and reduced the aphid incidence by 71.19 to 84.40% at 3 DAT, by 84.21 to 91.68% at 7 DAT, and by 89.12 to 94.27% at 14 DAT.

The incidence of mild and severe mosaic, and leaf roll symptoms was lowest in pymetrozine 50 WG @ 0.08% ($6.16 \pm 0.86\%$), diafenthiuron 50 WP @ 0.1% ($6.1 \pm 2.3\%$), and flupyradifurone 200 SL @ 0.1% ($7.03 \pm 0.86\%$) as compared to control ($11.43 \pm 1.76\%$) with no statistically significant variation among the treatments ($F = 1.44$, $d.f. = 12, 24$, $p = 0.21$). Again, no phyto-toxicity symptoms were associated with any of the treatments and the total tuber yield showed insignificant variation among the treatments ($F = 1.09$, $d.f. = 12, 24$; $p = 0.40$) (data not shown).

Razaq *et al.* (2005) reported the highest mortality of whiteflies for diafenthiuron which was statistically different from imidacloprid and acetamiprid. Diafenthiuron and acetamiprid also proved effective after 7 days of application. Kalyan *et al.* (2017) reported that seven days after spray, the maximum percent reduction in jassids and whitefly population was recorded in difenthiuron 50 WP. Venkateshalu and Math

(2017) reported that dinotefuran 20% SG @ 30 g a.i. was significantly superior and recorded a lower whitefly population.

Whitworth *et al.* (2016) reported significant control of aphids, *Melanaphis sacchari* on sorghum with flupyradifurone 200 SL at Kansas University. Three evaluated doses of flupyradifurone 200 SL performed the best in suppressing rosy apple aphids, *Dysaphis plantaginea* on apple up to 26 days post-treatment (Alston and Lindstrom, 2012). Flupyradifurone 200 SL was found most effective in suppressing jassids and whiteflies population on brinjal. Similar results were reported by Kumar *et al.* (2017) against whitefly eggs and nymphs. Nauen *et al.* (2014) reported excellent field control of lettuce aphids with Flupyradifurone (SL 200) at 125 g/ha after foliar application.

Roditakis *et al.* (2017) reported significant inhibition of *Tomato yellow leaf curl virus* (TYLCV) transmission by flupyradifurone compared to thiamethoxam. Similar results were reported by Maluta *et al.* (2021) who found significant suppression in the incidence of *Tomato chlorosis virus* (ToCV) after treatment of tomato seedlings with flupyradifurone.

CONCLUSION

It is concluded that the tested insecticides are not useful as knockdown insecticides against whitefly adults while Flupyradifurone 200 SL @ 0.1% and diafenthiuron 50 WP @ 0.1% exhibited significant knockdown activity against peach-potato aphids. Against whitefly adults, diafenthiuron 50 WP @ 0.08% and @ 0.1%, and pymetrozine 50 WG @ 0.06% and 0.08% performed best till 14 DAT with over 80% reduction in incidence. Consistent with this, the lowest incidence of PALCV disease was noted for the respective diafenthiuron and pymetrozine treatments.

Therefore, diafenthiuron 50 WP @ 0.08% and pymetrozine 50 WG @ 0.06% can be used for the management of whiteflies in potato crops. Against the peach-potato aphids, Flupyradifurone 200 SL @ 0.1%, diafenthiuron 50 WP @ 0.06% and 0.08% and pymetrozine 50 WG @ 0.04%, 0.06% and 0.08% performed equally and reduced the aphid incidence by more than 80% throughout the period. The lowest incidence of mild and severe mosaic and leaf roll symptoms was noted for the respective treatments. Therefore, flupyradifurone 200 SL @ 0.1%, diafenthiuron 50 WP @ 0.06% and pymetrozine 50 WG @ 0.04% can be used for the management of peach-potato aphids in potato crops.

CONFLICTS OF INTEREST

The authors confirm that this manuscript has no conflicts of interest

LITERATURE CITED

- Alston D and Lindstrom T (2012) Rosy apple aphid insecticide efficacy trial. Report –Apple Aphid insecticide, Utah State University, p. 26-27.
- Bhatnagar A, Jandrajupalli S, Venkateswarlu V, Malik K, Shah MA and Singh BP (2017) Mapping of aphid species associated with potato in India using morphological and molecular taxonomic approaches. *Potato J* **44**(2): 117-125.
- Henderson CF and Tilton EW (1955) Tests with acaricides against the brown wheat mite. *J Econ Entomol* **48**: 157-161.
- Ishaaya I, Mendelson Z and Horowitz AR (1993) Toxicity and growth-suppression exerted by diafenthiuron in the sweetpotato whitefly, *Bemisia tabaci*. *Phytoparasitica* **21**: 199-204.
- Kalyan RK, Saini DP, Meena BM, Pareek A, Naruka P, Verma S and Joshi S (2017) Evaluation of new molecules against jassids and whiteflies of Bt cotton. *J Entomol Zool Stud* **5**(3): 236-240.
- Kumar R, Tiwari RK, Jeevalatha A, et al. (2021) Potato apical leaf curl disease: current status and perspectives on a disease caused by tomato leaf curl New Delhi virus. *J Plant Dis Prot* **128**: 897-911.
- Kumar V, Kakkar G, McKenzie CL and Osborne LS (2017) Effect of drench application of flupyradifurone on *Bemisia tabaci* (MED Whitefly) and *Amblyseius swirskii*. *Arthropod Manag Tests* **42**(1): tsx131.
- Lakra BS (2003) Effect of date of planting on whitefly population, leaf curl incidence and yield of potato cultivars. *J Indian Potato Assoc* **30**(1-2): 115-16.
- Maluta NKP, Lopes JRS, Fiallo-Olivé E, et al. (2021) Foliar application of systemic insecticides disrupts feeding behavior of the whitefly *Bemisia tabaci* MEAM1 and the transmission of tomato chlorosis virus in potato plants. *J Pest Sci* **94**: 1265-1276.
- Nauen R, Jeschke P, Velten R, et al. (2015) Flupyradifurone: a brief profile of a new butenolide insecticide. *Pest Managt Sci* **71**(6): 850-862.
- Razaq M, Suhail A, Aslam M, et al. (2005) Evaluation of neonicotinoids and conventional insecticides against cotton jassid, *Amrasca devastans* (Dist.) and cotton whitefly, *Bemisia tabaci* (Genn.) on cotton. *Pak Entomol* **27**(1): 75-78.
- Roditakis E, Stavrakaki M, Grispou M, et al. (2017). Flupyradifurone effectively manages whitefly *Bemisia tabaci* MED (Hemiptera: Aleyrodidae) and tomato yellow leaf curl virus in tomato. *Pest Managt Sci* **73**(8): 1574-1584.
- Shah MA, Malik K, Bhatnagar A, Katore S, Sharma S and Chakrabarti SK (2019) Effect of temperature and cropping sequence on the infestation pattern of *Bemisia tabaci* in potato. *Indian J Agric Sci* **89**(11):1802-7.
- Sharma S, Thakur M, Chandla VK, Singh BP and Chakrabarti SK (2012) Integrated management of potato pests. Central Potato Research Institute, Shimla, Himachal Pradesh, India. Technical Bulletin No. 96, 52p.
- Smith HA and Giurcanu MC (2014) New insecticides for management of Tomato yellow leaf curl, a virus vectored by the silverleaf whitefly, *Bemisia tabaci*. *J Insect Sci* **14**(1): 183. <https://doi.org/10.1093/jisesa/ieu045>
- Sridhar J, Venkateswarlu V, Shah MA, et al. (2022) Incidence of the cabbage aphid, *Brevicoryne brassicae* L. in potato crops in India and its efficiency for transmission of potato virus Yo. *Int J Trop Insect Sci* **42**: 285-291.
- Usharani KS, Surendranath B, Paul Khurana SM, Garg ID and Malathi VG (2004) Potato leaf curl—a new

- disease of potato in northern India caused by a strain of Tomato leaf curl New Delhi virus. *Plant Pathol* **53**(2): 235-235.
- Venkateshalu and Math M (2017) Bio-efficacy of dinotefuran 20 per cent SG against sucking insect pests of okra. *Asian J Bio Sci* **12**(1): 8-14.
- Wakita T, Kinoshita K, Yamada E, *et al.* (2003) The discovery of dinotefuran: a novel neonicotinoid. *Pest Manag Sci* **59**(9): 1016-1022.
- Whitworth J, Davis H and Ewing JR (2016) Sugarcane Aphid Efficacy Trial # 2, Dickinson Co., KS., K. State Research and Extension, Kansas State University, 14p.

MS Received: 05 May, 2022; Accepted: 05 July, 2022