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Bioefficacy of different insecticides against aphid on potato (*Solanum tuberosum* L.)

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Abstract
The field experiment on bioefficacy of insecticides against aphid on potato was carried out at Kodit Tal. Purandar, Dist. Pune (Maharashtra) in *Rabi* 2020-2021. The application of cyantraniliprole 10.26% OD @ 1.2 ml/litre of water found to be most effective against aphid and was at par with flonicamid 50% WG @ 0.3 g/ litre, imidacloprid 17.8% SL @ 0.3 ml/litre and thiamethoxam 25% WG @ 0.2 g/litre. No significant impact of any insecticidal treatment was observed on the predatory population of both coccinellid and chrysopid. The treatment of cyantraniliprole 10.26% OD recorded with higher yield of potato and maximum B:C ratio which was most effective and economical.

Keywords: potato, aphid, bioefficacy, insecticides, natural enemies, yield

Introduction
Potato (*Solanum tuberosum* L.) belongs to family *Solanaceae* is one of the most important vegetable tuber crop and it ranks at third position in production after rice and wheat in the world as well as in India. The complete vegetable basket will not be possible without potato due to its properties and characters like dry matter content, edible energy i.e. carbohydrates and edible proteins content of potato which makes it superior in terms of nutrition as well as staple food not only in our country but also throughout the world. Now, it not only remained as an essential part of different consumption patterns throughout worldwide but also largely becoming as raw material for processing of different food products, food ingredients, starch, alcohol and as feed for animals. Therefore, potato is considered to be the "King of Vegetable" because of its greater utility.

Potato crop are prone to attacked by more than 80 insects and nematode pests in the field and in store which are one of the important limiting factor in raising productivity and production of potato in India, (Misra and Agrawal, 2008). The sucking pests *viz.*, aphids, hoppers, whiteflies and thrips are considered as a major group because of their role as the vectors of viral diseases. The yield loss caused by the potato viruses may continue to spread as long as the farmers use the same lot or the infected tubers for planting purpose and the average yield loss were upto 6 per cent of total yield due to aphid (Basavaraju *et al.*, 2009) [1].

Aphids are economically important polyphagous pests known to cause damage to many crops. Thirteen aphid species were found associated with potato crop in different parts of India (Bhatnagar *et al.*, 2017) [3]. Among them, *Myzus persicae* (Sulzer) and *Aphis gossypii* (Glover) are extremely important species of aphid. The nymphs and adults damage the plants by sucking plant cell sap from tender leaves, etc. which results into curling and twisting of tender parts and general revitalization causing heavy losses and reduction in yield as well as adversely affecting quality of potato.

Looking to the apparent importance of the pest, no much information is available with farmers pertaining to suitable control measures against aphids on potato. The farmers are using different insecticides with higher and repeated doses for controlling aphid population that lead to development of resistance and resurgence of the pest. Therefore, it becomes necessary to test the newer molecules against aphid.

Materials and Methods
The field experiment was carried out during *Rabi* 2020-2021 at Kodit Tal. Purandar, Dist. Pune. A distance of 1.0 m was kept between two replications whereas 0.50 m distance was kept between two treatments. The agronomical practices were carried out as per the requirement of crop.

The first spray of different insecticides was made 30 days after planting and successive sprays were given at 10 days interval. Considering the incidence of aphids three sprays were given during the crop growth period.

In each plot 5 plants were randomly selected and tagged before first spray. The observations on number of aphids were recorded on 3 compound leaves /plant (top, middle and bottom leaves) of five selected plants. Number of aphids was recorded one day before spraying and on 3rd, 7th and 10th days after each spray. The observations on mean population of natural enemies *viz.,* coccinellids and chrysopids recorded from 5 plants per treatment and safetyness of insecticides was determined based on their survival. Cost of cultivation, gross and net monetary return, benefit cost ratio (B: C) and incremental cost benefit ratio (I.C.B.R.) were also worked out. The data was transformed to $\sqrt{0+1}$ and analyzed by using Randomized Block Design as suggested by Panse and Sukthame (1985) [12].

Results and Discussion

The experiment was carried out with three sprays at 10 days interval and mean data of 3, 7 and 10 days after application of insecticides against aphid was provided in Table no. 1. The mean population of aphid after 3rd day of each spray was ranged from 2.76 to 11.41 aphids per plant in all treatments. The treatment with thiamethoxam 25% WG when applied at 0.2 g/ litre was recorded with lowest mean aphid population (2.76 aphids/ plant) and it was found at par with imidacloprid 17.8% SL @ 0.3 ml / litre (2.77 aphids / plant), cyantraniliprole 10.26% OD @ 1.2 ml / litre (3.12 aphids/ plant) and flonicamid 5% WG @ 0.3 g/litre (3.24 aphids /plant) respectively. However, at 7 days after spray, significantly lowest aphid population (1.63 aphids/plant) was recorded in plot sprayed with cyantraniliprole 10.26% OD @ 1.2 ml/ litre and it was found at par with flonicamid 50% WG @ 0.3g/litre (1.82 aphids/plant), imidacloprid 17.8% SL @ 0.3 ml/litre (2.13 aphids/plant) and thiamethoxam 25% WG @ 0.2 g/ litre (2.20 aphids/plant) respectively. At 10 days after spray, treatment of cyantraniliprole 10.26% OD when applied at 1.2 ml/ litre was recorded with significantly lowest aphid population *i.e.* 1.24 aphids per plant and it was at par with flonicamid 50% WG @ 0.3 g/litre (1.40 aphids/plant), imidacloprid 17.8% SL @ 0.3 ml/litre (1.62 aphids/plant) and thiamethoxam 25% WG @ 0.2 g/litre (1.74 aphids/plant) respectively.

Overall (pooled) bioefficacy of 3 sprays

The overall pooled data (Table no. 1) for three spray indicated that the spray of cyantraniliprole 10.26% OD @ 1.2 ml/litre excelled over all other treatments by recording significantly lowest aphid population (2.00 aphids/plant) with 83.70 per cent pest reduction over control and it was found at par with the treatment of flonicamid 50% WG @ 0.3g/ litre (2.15 aphids/ plant) with 82.48 per cent population reduction over control, imidacloprid 17.8% SL @ 0.3 ml / litre (2.17 aphids /plant) with 82.31 per cent reduction over control and thiamethoxam 25% WG @ 0.2 g/ litre (2.23 aphids/ plant) with 81.82 per cent reduction over control. The treatment of acetamiprid 20% SP @ 0.1 g/ litre (2.99 aphids/ plant), fipronil 5% EC @ 1.6 ml/ litre (3.25 aphids/ plant) and azadirachtin 10,000 ppm @ 3 ml/ litre (4.15 aphids/ plant) were found to be next effective treatments.

Superiority of cyantraniliprole 10.26% OD @ 1.2 ml/litre against aphid as observed in the present investigation are in conformity with Lodaya *et al.* (2017) [8] they reported that the treatment of cyantraniliprole 10% OD @ 60 g a.i/ha provided excellent protection against aphid on potato. Similarly, Bojan (2021) [5] also reported effectiveness of cyantraniliprole 10% OD @ 75 and 90 g a.i/ha against aphid on potato. The present findings of flonicamid 50% WG @ 0.3 g/litre was found next best subsequent treatment to cyantraniliprole 10.26% OD is in accordance with outcome of Malik *et al.* (2017) [9] they reported 90 per cent mortality of aphid on potato with flonicamid 50% WG on potato.

Basavaraju *et al.* (2015) [2] reported that imidacloprid was very effective for the management of aphid and thrips. Similarly, the effectiveness of imidacloprid and thiamethoxam against aphid infesting potato was reported by More *et al.* (2015) [10] Further, Nag *et al.* (2018) [11] also reported foliar spray of imidacloprid followed by thiamethoxam at 15 days interval was most effective against aphid.

Effect of insecticides on survival population of natural enemies of aphid on potato crop

It was found that there was no significant impact of any insecticide treatment after its application as results was found non-significant. The data on survival population of coccinellids and chrysopids was presented in Table No. 2 and 3 revealed that all the insecticidal treatments recorded much lower population of coccinellids and chrysopids as compared to control treatment. Among the different insecticidal treatments, azadirachtin 10,000 ppm @ 3 ml/ litre was recorded with maximum overall mean population of coccinellids (0.69 coccinellids / plant) and chrysopids (0.58 chrysopids / plant). Birader *et al.* (2002) [4] reported that, N.S.K.E. and commercial neem formulation does not affect any parasite or predator. Gour and Pareek (2005) [6] reported that the treatment of imidacloprid found to be moderately toxic whereas, neem extract was relatively less toxic to C. *septumpunctata.* The safety of flonicamid against various natural enemies was reported by Jansen *et al.* (2011) [7]. The insecticidal safetyness of cyantraniliprole against natural enemies like spider on potato crop was reported earlier by Lodaya *et al.* (2017) [8] and Bojan (2021) [5].

Effect of different insecticides on yield and economics of potato

The yield of potato in all the treatments (Table No. 4) was significantly higher than control treatment (10.93 t/ha). However, treatment of cyantraniliprole 10.26% OD recorded significantly higher yield of potato (16.20 t/ha) and which was succeed by flonicamid 50% WG (14.83 t/ ha), thiamethoxam 25% WG (14.00 t/ ha) and imidacloprid 17.8% SL (13.83 t/ ha). The same treatments also recorded higher net monetary return. In terms of cost to benefit ratio all insecticidal treatments were found superior over the control treatment. The cost to benefit ratio was maximum for treatment of cyantraniliprole 10.26% OD (1:1.66) followed by flonicamid 50% WG @ (1:1.65) and thiamethoxam 25% WG (1:1.62). Among insecticidal treatments, the lowest cost to benefit ratio was recorded in azadirachtin 10,000 ppm (1:1.36). Regarding to incremental cost benefit ratio (I.C.B.R.) the highest I.C.B.R. (1:9.83) was recorded in treatment acetamiprid 20% SP when applied at 0.1 g/litre followed by in treatment of imidacloprid 17.8% SL (1:9.28). The price of acetamiprid 20% S.P. is less as compared to prices of other insecticides which gives more economic return which leads to higher

I.C.B.R. Lodaya *et al.* (2017) [8] reported that the treatment of cyantraniliprole 10% OD recorded with higher potato tuber yield. Similarly Bojan (2021) [5] recorded cyantraniliprole 10.26% OD with highest potato yield. Superiority of imidacloprid against aphid and recording higher yield were earlier reported by Basavaraju *et al.* (2015) [2].

Table 1: Overall bioefficacy of different insecticides against aphid on potato crop

Tr. No	Treatments	Dose / lit. of Water	Mean aphid population (3 spray) /3 leaves/plant				Per cent reduction over control
			3 DAS	7 DAS	10 DAS	Overall mean	
1	Imidacloprid 17.8% SL	0.3 ml	2.77 (1.94)	2.13 (1.77)	1.62 (1.62)	2.17 (1.78)*	82.31
2	Cyantraniliprole 10.26% OD	1.20 ml	3.12 (2.03)	1.63 (1.62)	1.24 (1.50)	2.00 (1.73)	83.70
3	Fipronil 5% EC	1.6 ml	4.01 (2.24)	3.12 (2.03)	2.63 (1.90)	3.25 (2.06)	73.51
4	Flonicamid 50% WG	0.3 g	3.24 (2.06)	1.82 (1.68)	1.40 (1.55)	2.15 (1.77)	82.48
5	Thiamethoxam 25% WG	0.2 g	2.76 (1.94)	2.20 (1.79)	1.74 (1.65)	2.23 (1.80)	81.82
6	Acetamiprid 20% SP	0.1 g	3.78 (2.19)	2.81 (1.94)	2.39 (1.83)	2.99 (1.99)	75.63
7	Azadirachtin 10,000 ppm	3 ml	4.83 (2.41)	4.00 (2.23)	3.62 (2.15)	4.15 (2.27)	66.18
8	Control	-	11.41 (3.52)	12.30 (3.65)	13.09 (3.75)	12.27 (3.64)	
SE(m)±			0.07	0.09	0.08	0.07	
CD at 5%			0.20	0.27	0.26	0.23	
C.V. %			5.00	7.33	7.29	6.05	

DAS: Days After Spraying
Tr.No.: Treatment Number
*Figures in parenthesis are $\sqrt{x+1}$ transformed value

Table 2: Effect of insecticides on survival population of coccinellids on potato crop

Tr. No	Treatments	Average Coccinellid (grub & adult) population/ plant				
		Before spray	10 days after 1st spray	10 days after 2nd spray	10 days after 3rd spray	Overall mean
1	Imidacloprid 17.8% SL	0.60 (1.26)	0.33 (1.15)	0.20 (1.09)	0.13 (1.06)	0.22 (1.10)*
2	Cyantraniliprole10.26% OD	0.53 (1.24)	0.33 (1.15)	0.27 (1.13)	0.13 (1.06)	0.24 (1.12)
3	Fipronil 5%EC	0.53 (1.24)	0.40 (1.18)	0.27 (1.13)	0.20 (1.10)	0.29 (1.14)
4	Flonicamid 50%WG	0.60 (1.26)	0.53 (1.24)	0.33 (1.15)	0.27 (1.13)	0.38 (1.17)
5	Thiamethoxam 25%WG	0.73 (1.32)	0.40 (1.18)	0.27 (1.11)	0.13 (1.06)	0.27 (1.12)
6	Acetamiprid 20% SP	0.67 (1.29)	0.47 (1.20)	0.33 (1.15)	0.13 (1.06)	0.31 (1.14)
7	Azadirachtin 10,000 ppm	0.60 (1.26)	0.60 (1.26)	0.67 (1.29)	0.80 (1.31)	0.69 (1.29)
8	Control	0.53 (1.23)	0.67 (1.29)	0.73 (1.32)	0.87 (1.36)	0.76 (1.33)
	SE(m)±	0.07	0.08	0.07	0.08	0.06
	C.D. at 5%	NS	NS	NS	NS	NS
	C.V. %	8.97	11.42	9.55	12.08	8.62

*****Figures in parenthesis are $\sqrt{x+1}$ transformed value

Table 3: Effect of insecticides on survival population of chrysopids on potato crop

Tr. No	Treatments	Average Chrysopids (larvae) population/plant				
		Before spray	10 days after 1st spray	10 days after 2nd spray	10 days after 3rd spray	Overall mean
1	Imidacloprid 17.8% SL	0.33 (1.15)	0.20 (1.09)	0.13 (1.06)	0.00 (1.00)	0.11 (1.05)*
2	Cyantraniliprole10.26% OD	0.40 (1.18)	0.33 (1.15)	0.20 (1.09)	0.13 (1.06)	0.22 (1.10)
3	Fipronil 5%EC	0.33 (1.15)	0.27 (1.12)	0.20 (1.09)	0.13 (1.06)	0.20 (1.09)
4	Flonicamid 50%WG	0.40 (1.18)	0.40 (1.18)	0.27 (1.12)	0.13 (1.06)	0.27 (1.12)

5	Thiamethoxam 25%WG	0.33 (1.15)	0.27 (1.12)	0.20 (1.09)	0.07 (1.03)	0.18 (1.08)
6	Acetamiprid 20% SP	0.27 (1.12)	0.13 (1.06)	0.07 (1.03)	0.00 (1.00)	0.07 (1.03)
7	Azadirachtin 10,000 ppm	0.33 (1.14)	0.47 (1.20)	0.60 (1.26)	0.67 (1.28)	0.58 (1.25)
8	Control	0.33 (1.15)	0.53 (1.23)	0.67 (1.28)	0.80 (1.34)	0.67 (1.29)
	SE(m)±	0.09	0.08	0.07	0.06	0.06
	C.D. at 5%	NS	NS	NS	NS	NS
	C.V. %	13.15	12.45	10.66	8.76	9.21

*****Figures in parenthesis are $\sqrt{x+1}$ transformed value, while out sides are original value

Table 4: Effect of different insecticides sprays on yield and economics of potato

Tr. No.	Treatments	Dose ml/gm/ ha	Yield (T/ha)	Cost of treatments +Spraying (Rs./ha)	Cost of cultivation + Cost of insecticides (Rs./ha)	Gross monetary return (Rs.)	Net monetary return (Rs.)	Additional income over control (Rs)	C: B ratio	I.C.B.R.
1	Imidacloprid 17.8% SL	150	13.833	3102.00	95091.00	152166.63	57075.63	28798.00	1:1.60	1:9.28
2	Cyantraniliprole10.26% OD	600	16.200	15500.00	107489.00	178200.00	70711.00	42433.37	1:1.66	1:2.74
3	Fipronil 5%EC	800	12.500	3660.00	95649.00	137500.00	41851.00	13573.37	1:1.44	1:3.71
4	Flonicamid 50%WG	150	14.833	6675.00	98664.00	163166.63	64502.63	36225.00	1:1.65	1:5.43
5	Thiamethoxam 25%WG	100	14.000	3300.00	95289.00	154000.00	58711.00	30433.37	1:1.62	1:9.22
6	Acetamiprid 20% SP	50	13.000	2100.00	94089.00	143000.00	48911.00	20633.37	1:1.52	1:9.83
7	Azadirachtin 10,000 ppm	1500	12.070	5500.00	97489.00	132770.00	35281.00	7003.37	1:1.36	1:1.27
8	Control		10.933		91989.00	120266.63	28277.63		1:1.31	
	SE(m)±		0.92							
	C.D. at 5%		2.80							
	C.V.%		11.90							

*Market price of potato 11.00 Rs./Kg,
Prices of insecticides: Rs./Lit./Kg.
Imidacloprid 17.8 SL : Rs. 3560.00 Cyantraniliprole10.26% OD : Rs. 7778.00 Fipronil 5% EC : Rs. 900.00
Flonicamid 50% WG : Rs.11500.00 Thiamethoxam 25% WG : Rs.6000.00
Acetamiprid 20% SP : Rs. 4000.00 Azadirachtin 10,000 ppm : Rs.900.00

Conclusion

Studies on bioefficacy of different insecticides against aphid on potato indicated that, the cyantraniliprole 10.26% OD @ 1.2 ml/litre was most superior in suppressing aphid population with 83.70 per cent pest reduction over control and was at par with treatments of flonicamid 50% WG @ 0.3 g/ litre, imidacloprid 17.8% SL @ 0.3 ml/litre and thiamethoxam 25% WG @ 0.2 g/litre. The maximum overall mean population of both coccinellids and chrysopids was recorded in untreated control and among different insecticidal treatments comparatively higher population of both predators was observed in treatment of azadirachtin 10,000 ppm. The treatment of cyantraniliprole 10.26% OD recorded with significantly higher yield of potato and maximum cost to benefit ratio.

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