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Relative Efficacy of Insecticides against Potato Aphid (*Myzus persicae* Sulzer), White Fly (*Bemisia tabaci* Genn.) and Lady Bird Beetle

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Abstract
The effect of conventional insecticides *viz.*, Dimethoate 30EC, Imidacloprid 17.8 SL, Thiamethoxam 25 WG and Thiacloprid 21.7SC on incidence of major insect pest associated with potato variety Kufri Lauvkar along with other yield attribute were reported. The treatment proved highly effective in reducing the vector population on potato plants as compared to untreated plot. The treatment Imidacloprid 17.8SL (150 ml/ha) followed by Thiamethoxam (100 g/ha) at 15 days interval was most effective against sucking pest with least population of aphids (1.91 per plant) and whiteflies (1.56 per plant). The effect of Imidacloprid on lady bird beetle showed least detrimental effect followed by Thiacloprid and Thiamethoxam. After tubarization, highest harvested yield of tuber found 129.17 q/ha on treatment combination Imidacloprid and Thiamethoxam.

Keywords: Potato, Aphid, White fly, Insecticide

Introduction
Potato, (*Solenum tuberosum* L.) as a cash crop, grown all over the country under wide range of agro-climatic conditions and secure fourth rank in area and third in the production of potato in the world (Pandey *et al.*, 2007) [25]. Potato is grown in all the states of India except Kerala. India produced 41.55 million tones of potato from 1.99 million hectares of land with an average yield of 21.10 tones ha^{-1} (Anonymous, 2015) [5]. In Chhattisgarh potato is cultivated in 0.67 million hectares of area with the production of 11.35 million tones and average productivity of 14.68 tones ha^{-1}. It is mainly cultivated in Surguja, Jashpur, Raigarh, Bilaspur, Bastar and Raipur districts of the State and its share is 1% of total India production (Anonymous, 2015) [5].

However, the production of this crop is hampered by various biotic and abiotic factors. Insect pests associated with this crop are major factors for its low production (Mishra *et. al.*, 2001) [23]. Among the various insects, aphids (*Myzus persicae* Sulzer), thrips (*Thrips palmi* Karny), leafhopper (*Amrasca biguttula biguttula* Ishida), white fly (*Bemisia tabaci* Genn.) and soil insects like cutworm (*Agrotis sp.)* have significant influence on potato yield (Mishra, 1995 and Bhatnagar, 2007) [24, 7]. These insects have become a threat to crop by sucking the sap directly from tender parts of plant and also act as vector in transmitting number of important viruses, while cutworm is a sporadic pest and feeds on tubers, there by affecting both tuber yield and its market value (Dharpure, 2002 and Bhatnagar, 2007) [10, 7]. For manage above pest various biochemical are available and required to found best of them, so this experiment conducted to help the farmer to find out better argo-chemical for potato pest.

Material and Methods
A field investigation was conducted in randomized block design during *rabi* season of 2014-15 at Research cum Instructional Farm of Horticulture, IGKV, Raipur, (C.G.) to evaluate four insecticides against potato aphid and white fly and natural enemy, lady bird beetle. Kufri louvkar a high yielding potato variety were planted in second week of November in 5×5m plots with 60×20cm spacing by following standard agronomic practices. These varieties were evaluated for aphid and whitefly. The observations were recorded at weekly interval. Four insecticides *viz*. Dimethoate (Tata Tafgor 30 EC Insecticide Limited Mumbai), Imidacloprid

(Confidor 17.8 SL Bayer India Limited, Mumbai), Thiacloprid (Alanto 21.7 SC Bayer India Limited, Mumbai) and Thiamethoxam (Maxima 25WG Pesticide India limited Gurgaon) were evaluated. The treatments T_1-Control (no insecticide application), T_2- Dimethoate 30EC @ 6.5ml 5 l^{-1} (666ml/ha) water as foliar spray at the time of aphid appearance and second spray after 15 days, T_3 - Foliar spray of Imidacloprid 17.8SL @ 1.5ml 5 l^{-1} (150ml/ha) at the time of aphid appearance, T_4 - Foliar spray of Imidacloprid 17.8SL @ 1.5ml 5 l^{-1} (150ml/ha) at the time of aphid appearance, second spray with Thiamethoxam 25WG @1g 5 l^{-1} (100g/ha) after 15 days, T_5 - Foliar spray of Thiacloprid 21.7 SC @ 2.5ml 5 l^{-1} (248ml/ha) at the time of aphid appearance and T_6 - Foliar spray of Thiacloprid 21.7 SC @ 2.5ml 5 l^{-1} (248ml/ha) at the time of aphid appearance, second spray with Thiamethoxam 25WG @ 1g 5 l^{-1} (100g/ha) after 15 days. All six treatments were replicated 4 times. Weekly density of major insect pests and their natural enemies were recorded on 5 random plants from each treatment separately to observe the effectiveness of each treatment against the test insects and survival of natural enemies. Yield of each plot was recorded separately in different treatments.

In this experiment, Observations were recorded one day before spraying in randomly selected 5 plants in each plot which formed the pre-treatment count. The post treatment counts were taken after 7 days and 15 days of spraying of insecticides. The population of aphid was recorded by counting both nymphs and adults as per method described by Heathcote (1972) [14] and white fly recorded by counting as per method described Butter and vir (1990) [9]. In the initial stage of the crop, counting of aphid and whiteflies were done on whole plant and in later stage on six leaves two each from *i.e.* top middle and bottom of each from five randomly selected plants. For counting the aphid and whitefly population, the leaf was held at the petiole by thumb and fore finger and turned until the entire underside of leaf was clearly visible. The aphid and whitefly present on the lower side of the leaves were counted. The mean population of pests per plant was calculated and data were subjected to suitable transformation and analyzed statistically.

Results and Discussion

Aphid

In the pretreatment observations, the aphid population ranged from 2.20 to 3.20 aphids per plant in different treatments (Table 1) which differed non- significantly. Overall seasonal mean of both the sprays revealed that the treatment Imidacloprid 17.8 SL (150 ml/ha) followed by Thiamethoxam (100 g/ha) (T_3) at 15 days interval was most effective against aphid with least population of aphids 1.91 per plant. It was followed by Thiacloprid 21.7 SC 248ml/ha + Thiamethoxam 25 WG 100 g/ha (T_5) and Imidacloprid 17.8 SL @ 150 ml/ha (T_2) with 2.60 and 3.23 aphids per plant, respectively. The results are in agreement with the findings of Wyman (2005) [31] who recorded Imidacloprid and thiametoxam equally effective against aphids. Similar results were obtained by Ananda *et al* (2010) [4]; Khan (2011) [19] and Sarwar *et al.* (2011) [29] and Pawar and Bharpoda (2014) [6, 27]. Kumar *et al*. (2007) [20, 21] observed Imidacloprid most effective against aphid after 7 days. Khalequzzaman (2008) [18] reported Imidacloprid moderatety toxic to aphids after cypermethrin. On the other hand Akashe *et.al.* (2010) observed Thiamethoxam best against aphids producing highest yield and B:C ratio. Gavkare (2013) [11] reported Thiamethoxam most effective against aphids followed by Imidacloprid. Mandal and Mandal (2010) [22] found difenthiuron 50 WP most effective against aphid followed by Thiamethoxam.

White fly

In case of white fly, overall seasonal mean of both the sprays revealed that the treatment Imidacloprid 17.8 SL (150ml/ha) (Table 2) followed by Thiamethoxam (100g/ha) (T_3) at 15 days interval was most effective against whitefly with least population of whiteflies 1.56 per plant. It was followed by Thiacloprid 21.7 SC 248ml/ha + Thiamethoxam 25 WG 100 g/ha (T_5) and Dimethoate 30 EC 666 ml/ha (T_1) with 1.67 and 1.95 whiteflies per plant, respectively. The results are supported by Preetha (2009) [28] who evaluated Imidacloprid and Thiamethoxam equally effective against whiteflies and aphids. Jambulkar *et al.* (2013) [7] reported Imidacloprid most effective against whitefly and reduced the yellow vein mosaic disease by 67.9 to 70.9%. Ghosal and Chatterjee (2013) [12] observed Imidacloprid superior against whitefly with lowest pest population and highest marketable yield. Similar results were reported by Afzal *et al.* (2014) [1] and Ananda *et al.* (2009). Mondal *et al.* (2010) [22] observed soil application with phorate followed by spraying with Chlorpyriphos, Imidacloprid and Cartap hydrochloride at 40, 55 and 70 days after planting most effective against aphids and whiteflies.

Lady bird beetle

Based on overall seasonal mean Imidacloprid 17.8 SL 150 ml/ha (T_2) (Table 3) with 0.50 lady bird beetle per plant was most safe to lady bird beetles. Similar observations were reported by Soni *et al.* (2013) [30]. It was followed by Imidacloprid 17.8 SL 150ml/ha + Thiamethoxam 25 WG 100 g/ha (T_3), Thiacloprid 21.7 SC (248 ml/ha) + Thiamethoxam 25 WG (100 g/ha) (T_5) and Thiacloprid 21.7 SC (T_4) 248 ml/ha with 0.46, 0.41 and 0.36 lady bird beetle per plant as against 0.78 lady bird beetle per plant in untreated control. This study revealed that Dimethoate 30 EC 666 ml/ha was most toxic to lady bird beetle. Gour and Pareek (2005) [13] evaluated the contact toxicity of nine insecticides against grubs and adults of *Coccinella septumpunctata* and found Imidacloprid to be moderately toxic and neem extract to be less toxic. Hossain *et al.* (2012) [15] reported Imidacloprid 70WS most effective against aphid, whiteflies and thrips and safer to ladybird beetle, lace wing, syrphids and spiders. Wyman (2005) [31] who reported that Provado (Imidacloprid 1.6 F) and Actara (Thiamethoxam 25 WG) significantly reduced *M. persicae* population on potatoes.Insecticides have been found toxic to natural enemies, however, Imidacloprid is much less toxic to natural enemies than Carbamate, Organophosphate, Pyrethroid, Etofenprox and Acetamiprid.

Yield

Based on the yield performance and efficacy against aphid and white fly, tuber yield recorded at harvest was subjected to statistical and economical analysis after converting it into q/ha (Table 4). It revealed that the treatment Imidacloprid 17.8 SL (150ml/ha) + Thiamethoxam 25WG @ 100g/ha (T_3) was most effective with 129.17 q/ha yield. It was at par with Thiacloprid 21.7 SC (248 ml/ha) + Thiamethoxam 25 WG 100g/ha (T_5) with 122.91 q/ha tuber yield but varied significantly from Diamethoate 30 EC @ 666ml/ha (T_1) and Thiacloprid 21.7 SC @ 248 ml/ha (T_4) with 110.75 and 107.50 q/ha, yield, respectively. Imidacloprid 17.8 SL @ 150 ml/ha (T_2) was least effective with minimum 102.50 q /ha tuber yield. It was at par with untreated control and Thiacloprid 21.7 SC when applied at 248 ml/ha (T_4).

Benefit cost ratio

Based on overall seasonal mean, Imidacloprid 17.8 SL (150ml/ha) (Table 4) followed by Thiamethoxam 25WG @ 100 g/ha (T_3) was most effective and economical against sucking pests with maximum tuber yield of 129.17q/ha and 16.95:1 benifit cost ratio. It was followed by Thiacloprid 21.7 SC @ 248 ml/ha + Thiamethoxam 25 WG 100g/ha (T_5) with 122.91 q/ha yield and 11.57:1 benefit cost ratio, Thiacloprid 21.7 SC@ 248 ml/ha (T_4) with 107.50q/ha yield and 7.69:1 benefit cost ratio and Dimethoate 30 EC @ 666 ml/ha with 110.75q/ha tuber yield and 8.50:1 benefit cost ratio. Imidacloprid 17.8 SL @ 150ml/ha (T_2) with 5.69:1 benefit cost ratio was recorded least economical.

The present study on management of sucking pest revealed that the treatmeant Imidacloprid 17.8 SL (150ml/ha) + Thiamethoxam 25 WG (100g/ha) (T_3) was most effective against the sucking pests with 1.60 mean sucking pest/plant, highest tuber yield (129.17 q/ha) and highest Benefit cost ratio 16.52:1 but second against natural enemies (0.52/plant) after Imidacloprid 17.8 SL at 150 ml/ha (T_2) with mean predatory population of 0.56 per plant which was most safe to natural enemies. The results are in agreement with the findings of Bharpoda *et al*. (2014) [6, 27] who reported Imidacloprid 17.8 SL@ 0.008% followed by Thiamethoxam 25 WG @ 0.175% more effective against sucking pests and safer to natural enemies *viz.*, *Chrysoperla carnea* (adult), spiders and coccinellids (grubs and adults) with highest yield and highest cost benefit ratio (1:16.54). Similarly, Hossain *et al*. (2013) [16] obtained significantly higher yield (1.73 t/ha) with a benefit cost ratio 12.47. Akashe *et al*. (2009) [2], while testing the efficacy of nine insecticides against sucking pests, identified Thiamethoxam 0.005% most effective against aphid population with highest seed yield of 1224kg/ha and highest B:C ratio (2.28). In the present investigation, Thiamethoxam in combination with Imidacloprid was most effective against sucking pests with highest benefit cost ratio.

Table 1: Bio-efficacy of insecticides against potato Aphid, *Myzus persicae*

S. N.	Treatments	Dose (ml/ha)	Mean population of Aphid / plant							MEAN	Overall seasonal mean
			Pre-treatment observation	First spray		MEAN	Pre-treatment observation	Second spray			
				Post treatment				Post treatment			
				7 DAS	15 DAS			7 DAS	15 DAS		
1	Dimethoate30EC (Two sprays)	666	2.20 (1.78)	1.80 d (1.67)	3.00ab (1.99)	2.40	4.80 (2.39)	9.25 e (3.09)	34.70c (5.60)	21.97	12.18
2.	Imidacloprid 17.8 SL (One spray)	150	2.65 (1.78)	0.85bc (1.35)	4.00ab (2.22)	2.42	-	(22 DAS) 4.50bc (2.33)	(30 DAS) 3.60ab (2.14)	4.05	3.23
3	Imidacloprid 17.8SL/ Thiamethoxam 25 WG (Two spray)	150+100	2.35 (1.81)	1.10c (1.44)	3.00a (1.98)	2.05	5.80 (2.58)	1.55a (1.59)	2.00a (1.73)	1.77	1.91
4	Thiacloprid 21.7SC (One spray)	248	2.50 (1.86)	0.50ab (1.22)	5.20bc (2.47)	2.85	-	(22DAS) 5.90c (2.61)	(30 DAS) 6.25ab (2.69)	6.07	4.46
5	Thiacloprid 21.7SC /Thiamethoxam 25WG (Two Spray)	248+100	1.95 (1.71)	0.25a (1.11)	5.00b (2.42)	2.62	5.50 (2.52)	2.45ab (1.85)	2.70ab (1.92)	2.57	2.60
6	Control	0	3.20 (2.04)	3.95e (2.22)	6.55c (2.73)	5.25	6.45 (2.72)	7.10cd (2.83)	13.60b (3.81)	10.35	7.60
SEm		-	0.089	0.044	0.141		0.123	0.186	0.483		
CD at 5%		-	NS	0.13	0.42		NS	0.56	1.47		

* DAS-Days after spray.

* Figures in parentheses are square root transformed values.

* In a column treatment means marked with same letter do not show significant difference at 5 per cent level of significance.

Table 2: Bio-efficacy of insecticides against potato Whitefly, *Bemisia tabaci*

S. N.	Treatments	Dose (ml/ha)	Mean population of Whitefly / plant							MEAN	Overall seasonal mean
			Pre-treatment observation	First spray		MEAN	Pre-treatment observation	Second spray			
				Post treatment				Post treatment			
				7 DAS	15 DAS			7 DAS	15 DAS		
1	Dimethoate30EC (Two sprays)	666	3.45 (2.10)	0.55 ab (1.24)	0.90 a (1.37)	0.72	3.05 (2.00)	2.90 bc (1.97)	3.45 bc (2.10)	3.17	1.95
2.	Imidacloprid 17.8 SL (One spray)	150	4.00 (2.13)	0.40 a (1.18)	1.70 bc (1.63)	1.05	-	(22 DAS) 2.50 ab (1.86)	(30 DAS) 3.40 bc (2.09)	2.95	2.00
3	Imidacloprid 17.8SL/ Thiamethoxam 25 WG (Two spray)	150+100	3.90 (2.21)	0.60 ab (1.25)	1.45 b (1.56)	1.02	2.40 (1.83)	2.00 a (1.73)	2.20 ab (1.77)	2.10	1.56
4	Thiacloprid 21.7SC (One spray)	248	4.15 (2.25)	0.80 b (1.34)	1.95 cd (1.71)	1.37	-	(22 DAS) 3.25 c (2.06)	(30 DAS) 3.20 b (2.04)	3.22	2.30
5	Thiacloprid 21.7SC /Thiamethoxam 25WG (Two Spray)	248+100	3.60 (2.14)	0.70 ab (1.30)	1.75 bc (1.65)	1.22	2.65 (1.90)	2.15 ab (1.77)	2.10 a (1.75)	2.12	1.67
6	Control	0	3.80	2.50	2.00 d	2.25	3.35	4.10 d	4.90 c	4.50	3.37

			(2.18)	(1.86)	(1.73)		(2.08)	(2.25)	(2.42)		
SEm		-	0.089	0.052	0.057		0.094	0.050	0.069		
CD at 5%		-	NS	0.15	0.17		NS	0.15	0.21		

* DAS-Days after spray.
* Figures in parentheses are square root transformed values.
* In a column treatment means marked with same letter do not show significant difference at 5 per cent level of significance.

Table 3: Effect of insecticides on survival of lady bird beetles on potato crop

S. N.	Treatments	Dose (ml/ha)	Mean population of Lady bird beetle/ plant							MEAN	Overall seasonal mean
			Pre-treatment observation	First spray		MEAN	Pre-treatment observation	Second spray			
				Post treatment				Post treatment			
				7 DAS	15 DAS			7 DAS	15 DAS		
1	Dimethoate 30EC (Two sprays)	666	0.60 (1.26)	0.15 a (1.07)	0.30 (1.13)	0.22	0.70 (1.30)	0.30 a (1.13)	0.20 (1.09)	0.25	0.23
2.	Imidacloprid 17.8 SL (One spray)	150	0.50 (1.22)	0.45b (1.20)	0.60 (1.26)	0.52	-	(22 DAS) 0.45 ab (1.20)	(30 DAS) 0.50 (1.22)	0.47	0.50
3	Imidacloprid 17.8SL/ Thiamethoxam 25 WG (Two spray)	150+100	0.40 (1.18)	0.35 ab (1.16)	0.40 (1.17)	0.35	0.90 (1.37)	0.40 ab (1.18)	0.70 (1.30)	0.55	0.46
4	Thiacloprid 21.7SC (One spray)	248	0.35 (1.16)	0.25 ab (1.11)	0.40 (1.18)	0.32	-	(22 DAS) 0.35 ab (1.16)	(30 DAS) 0.45 (1.20)	0.40	0.36
5	Thiacloprid 21.7SC /Thiamethoxam 25WG (Two Spray)	248+100	0.25 (1.11)	0.30 ab (1.13)	0.45 (1.16)	0.37	0.00 (1.31)	0.50 ab (1.22)	0.40 (1.17)	0.45	0.41
6	Control	0	0.30 (1.13)	0.65 c (1.27)	0.80 (1.33)	0.72	1.05 (1.42)	0.95 b (1.39)	0.75 (1.31)	0.85	0.78
SE m		-	0.042	0.036	0.047		0.082	0.039	0.058		
CD at 5%		-	NS	0.11	NS		NS	0.12	NS		

* Figures in parentheses are square root transformed values.

Table 4: Economics of different chemical insecticides for the management of sucking pests of potato

S. No.	Insecticide	Dose (ml/ha.)	Yield (q/ha)	Increase in yield over control	Value of increased yield	Cost of chemicals & labour (Rs./ha)	Net return	B:C ratio
T1	Dimethoate 30EC	666	110.75	15.75	15750.00	1657	14093	8.50: 1
T2	Imidacloprid 17.8SL	150	102.50	7.5	7500.00	1120	6380	5.69: 1
T3	Imidacloprid 17.8SL / Thiamethoxam 25WG	150 + 100	129.17	34.17	34170.00	1903	32267	16.95:1
T4	Thiacloprid 21.7SC	248	107.50	12.50	12500.00	1437	11063	7.69:1
T5	Thiacloprid21.7SC / Thiamethoxam 25WG	248 + 100	122.91	27.50	27910.00	2220	25690	11.:1
T6	Control		95.00	0.00	0.00	0.00	0.00	0.00

*Labour rate per day = Rs 215.33/labour
*Market price of potato t @ Rs 1000/quintal.

Conclusion

It may be concluded that among the six different insecticides, Imidacloprid and Thiamethoxam was most effective against aphid and white fly and safer for lady bird beetle. Economics of potato against sucking pests with maximum tuber yield of 129.17q/ha and 16.95:1 benefit cost ratio.

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