Potato J (2018) 45 (2): 99-106

EFFECT OF BORDER CROPS ON POPULATION BUILDUP OF WHITEFLY, APHIDS AND VIRUS INCIDENCE IN POTATO CROP

Anuj Bhatnagar[1], RP Pant[2] and SK Chakrabarti[3]

ABSTRACT: Field experiments were conducted over two years to determine the effect of maize and mustard as border crops on buildup of whitefly and aphid populations and transmitted virus diseases in potato during 20113-14 and 2014-15 at Modipuram, India. The results indicated that placement of mustard as trap crop towards south direction in potato plots reduced aphid and whitefly population and also reduced virus incidence to a level of 1.3 per cent followed by mustard placed on north direction (1.2%) in comparison to control (4.7 and 6.4%) . However, the maize as border crop had comparatively less significant effect on the buildup of vector population and corresponding diseases development in potato crop as compared to mustard crop. The result indicated that mustard border rose at south and north directions in potato field would be effective in the management of potato aphids, whitefly and corresponding transmitted virus diseases in comparison to maize border. The significant effect of the mustard border on tuber yield shows that the technology would be most ideal for small scale potato production that could be done in small propagation plots planted with mustard as trap crop toward south and north directions.

KEYWORDS: Potato, Aphids, Whitefly, Viruses, Maize, Mustard, Border crop

INTRODUCTION

Potato (*Solanum tuberosum* Linn.) is not native to India and it was introduced in this country in late 16th century from the Europe. Initially, potato was limited to certain parts or pockets of few states of India but with the development of indigenous potato cultivars, improvement of irrigation facilities, seed plot technique, cold storage facilities, etc. lead to wide scale cultivation of potato in Indo-Gangatic plains. Now, potato is grown in almost all states and available throughout the year (Rana and Pandey, 2007).The potato is presently grown in 1.35 million hectares in India, which accounts for approximately 1 per cent of total area of country under cropping. Uttar Pradesh is one of the important potatoes producing state and its area under potato cultivation has increased by three folds as compared to other crops since independence. In India, potato crop is normally grown as a sandwich crop in the winter season, either after the rainy season crop of paddy or maize or before the winter or spring season crops of wheat, pulses or vegetables, thus increasing intensity of cropping systems (Malik and Singh, 2007). In Northern plains, potato is grown mainly in two seasons i.e. autumn and spring. In India, the potato crop is subjected to the attack of more than 101 insect pests and important were aphids, leaf hoppers, defoliators, cutworms white grubs, beetles, whitefly and potato tuber moth which caused about 20-25 per cent losses in yield of potato every year (Rajendran and Chandla 1986; Bhatnagar, 2007) and gave a comprehensive list of insect pests damaging this crop directly and indirectly in different agro climatic conditions of India. Whitefly population was significantly high during October to first fortnight of

[1]ICAR-Central Potato Research Institute, Regional Station, Modipuram-250110, Meerut, Uttar Pradesh, India
E-mail: dr.anujbhatnagar@gmail.com
[2]ICAR-IARI, New Delhi, India
[3]ICAR-CPRI, Shimla 17100, Himachal Pradesh, India

November with two peaks (Kishore *et al*. 2005). The aphid population remained low up to 2nd week of January. Aphids trapped in yellow pan water traps had positive correlation with aphid population counts on potato crop in the field (Bhatnagar *et al*. 2012). The small and marginal farmers have very low capacity to manage aphids and whitefly and virus diseases in potato (Garg *et al*. 2001). APCLV and other viral diseases cause 40-75 per cent infections in the potato cultivars grown in Indo-Gangetic plains of India (Venkatasalam *et al*. 2011). The use of trap and barrier crops is a simple cultural practice that requires no specialized equipment or technique as compared to use of insecticides. The raised of trap and barrier crops in potato plots reduces the use of chemicals, hence reducing chemical residues in the tubers (Osakable and Honda, 2002). Barrier crops have been used in management of the PVY which is transmitted in a non-persistent manner (Difonzo *et al*. 1996). In the non-persistently transmitted viruses the aphid acquires virus and loses the ability to transmit it with in a very short time (Garg *et al*., 2001). Ones the viruliferous alate aphid lands on the trap and barrier crops it losses the virus during the brief probing while trying to identify a suitable host (Fereres, 2000). Aphids are the most dangerous vector in the cultivation of healthy seed potatoes. Similarly, whitefly is also established as a new vector and transmitting apical leaf curl virus in potato crop (Bhatnagar, 2013; Chandel *et al*. 2010). The objective of the study was therefore to determine effective placement of border crops (maize) and (mustard) towards specific direction of potato field for the management of whitefly and aphids and subsequently the virus transmission in potato crop.

MATERIALS AND METHODS

Field experiments were conducted at the Central Potato Research Institute Campus, Modipuram, India during two consecutive main crop seasons (October-February) of 2013-14 and 2014-15. Potato cv. Kufri Bahar was planted in 4.5 × 4.5 m^2 plots with inter row spacing of 75 cm and intra row spacing of 20 cm. The border crop consisted of three rows of mustard and maize planted 15 days earlier at 0.5 m away from potato plots in respective south, east, west and north directions. The control consisted of potato plot without maize and mustard border. The experiment was laid out in a randomized block design with three replications. The plots were separated by 1 meter (m) paths while the blocks were separated by 2 m paths. Data collected included aphid, whitefly populations, virus disease incidence and tuber yield.

Aphid and whitefly populations were determined on compound leaves and on yellow sticky traps. The whitefly nymphs, apterous and alate aphids were monitored on potato leaves while alate aphids and whitefly adults were also monitored in yellow traps. Sampling of leaves was done weekly from the 5th week after emergence until physiologically maturity of potato crop to record the vector population. Five plants per plot were selected at random and three compound leaves selected from top, middle and bottom of each plant. The number of vector per leaf was counted. Before the emergence, yellow sticky traps were also placed at the four different directions in respect to potato plot at a height of 90 cm. Aphids and whitefly were collected and stored in 70% ethyl alcohol. The collected population of whitefly and aphids were counted and identified under stereo microscope based on morphological features as described by Chandla *et al*. 2004; Chandel *et al*. 2010). The number of potato plants showing virus disease symptoms per plot was recorded from crop emergence up to 60 days after planting. The symptoms observed as indicative of presence of virus infection included leaf roll erectiveness, brittle leaves,

feathery leaves, mild and severe mottling and dwarfness. Dehaulming was done one week before harvesting of potato crop and yield of each plot was determined. The data was subjected to statistical analysis by using analysis of variance technique for RBD.

RESULTS AND DISCUSSION

Effect of border crops on aphid and whitefly population in potato

Aphid species identified were *Myzus persicae* Sulzer, *Aphis gossypii* Glover, *Aphis fabae* Scopoli, *Lipaphis erysimi* Kalt., *Rhopalsosiphum madis* Fitch. More aphids (8.0/5.0 plants, 5.67/5.0 plants) were recorded on potato leaves in plots with no maize and mustard borders during 2013-14 and 2014-15 while the lowest number of aphids (2.33 and 1.37 five plants) was recorded in potato plots with mustard border placed at south direction during the respective years. Initially the population of *A. gossypii* was higher on potato crop followed by *M. persicae*. There were no significant differences among the maize border placed at different directions with respect to aphid population. However, mustard border at different directions showed significant difference in the population buildup of *M. persicae* on potato crop. Similarly, whitefly, *Bemisia tabaci* also showed significant differences in buildup of population when maize and mustard crops placed in different directions of potato plots **(Table 1 and 2; Fig. 1)**. Maximum number of aphids was caught on yellow sticky trap installed towards south direction as compared to other directions in potato plots. There were significant differences in the numbers of aphids caught in yellow traps among different maize and mustard borders **(Table 3 and 4)**.

Effects of border crops sowing direction on potato virus incidence, aphids and whitefly population on border crops and tuber yield

The direction of border crops with respect to potato field had a significant effect on virus disease incidence **(Table 3 and 4)**. Higher virus infected plants were observed during the year 2014-15 as compared to 2013-14. **(Table 5 and 6)** The highest virus disease incidence was recorded in plots without border crops while the lowest disease incidence was recorded in plots with mustard and maize crops placed towards south directions from the potato crop. The placement of border crops in a specific

Table 1 Effect of border crops on whitefly and aphid population in potato plots during 2013-14

Treatments	Whiteflies/ five plants on indicative dates					Aphids/ five plants on indicative dates				
	17.12	24.12	02.01	10.01	17.01	17.12	24.12	02.01	10.01	17.01
Control	2.00	2.00	0.00	2.67	1.33	3.67	3.73	2.33	7.00	8.00
Potato+Maize (North)	0.67	0.67	0.00	1.33	0.00	1.67	2.00	0.67	3.37	4.00
Potato+Maize (South)	0.67	0.67	0.00	1.00	0.00	1.00	1.00	0.67	2.00	4.33
Potato+Maize (East)	1.00	0.00	0.00	1.67	0.33	1.00	2.27	1.33	5.00	4.00
Potato+Maize (West)	1.33	1.00	0.00	1.00	0.33	0.33	1.90	2.00	4.60	4.00
Potato+Mustard (North)	0.33	0.67	0.00	0.67	0.00	0.67	1.33	1.00	2.00	4.67
Potato+Mustard (South)	1.17	0.33	0.00	1.00	0.33	0.50	1.00	0.67	2.60	2.33
Potato+Mustard (East)	1.00	0.33	0.00	0.67	0.33	0.67	1.00	1.67	2.93	4.33
Potato+Mustard (West)	0.83	0.33	0.00	1.67	0.67	1.33	1.33	1.67	3.00	5.00
SEm±1	0.58	0.36	-	0.71	0.31	0.45	0.52	0.64	1.19	1.65
CD (P=0.05)	NS	NS	-	NS	NS	1.38	1.58	NS	NS	NS

Fig. 1 Use of border crops in potato

Table 2 Effect of border crops on whitefly and aphid population in potato plots during 2014-15

Treatments	Whiteflies/ five plants on indicative dates					Aphids/ five plants on indicative dates				
	17.12	24.12	02.01	10.01	17.01	17.12	24.12	02.01	10.01	17.01
Control	4.00	3.80	1.00	1.67	0.90	0.33	3.00	5.00	5.67	5.67
Potato+Maize (North)	2.17	1.80	0.00	1.00	0.00	0.00	1.67	2.67	3.17	3.33
Potato+Maize (South)	2.13	1.23	0.00	0.33	0.00	0.00	1.50	2.00	1.53	1.93
Potato+Maize (East)	1.77	1.27	0.00	1.00	0.33	0.33	1.60	3.00	1.67	4.10
Potato+Maize (West)	1.70	1.33	0.00	0.33	0.33	0.00	1.63	1.93	2.00	3.17
Potato+Mustard (North)	1.27	1.17	0.00	0.67	0.00	0.00	1.07	1.77	1.33	1.33
Potato+Mustard (South)	1.17	0.73	0.00	1.00	0.00	0.00	0.90	1.53	0.83	1.37
Potato+Mustard (East)	1.67	1.27	0.00	0.67	0.00	0.00	0.83	1.60	2.00	2.33
Potato+Mustard (West)	1.70	1.17	0.00	1.00	0.00	0.00	1.53	1.63	1.67	2.27
SEm±1	0.32	0.30	0.19	0.75	0.16	0.45	0.58	0.97	1.07	0.60
CD (P=0.05)	0.98	0.92	0.58	2.29	NS	NS	NS	NS	2.29	1.83

direction significantly restricted virus disease incidence less than 4% in comparison to control plots (4.7% and 6.4%) in the respective years **(Table 5 and 6)**.

M. persicae and *L. erysimi* were recorded on mustard crop while *R. madis* on maize crop. Mustard crop placed towards south direction had recorded higher population of aphids in comparison other directions **(Fig. 2)**. The maize crop might have acted as only barrier for the movement of aphids and whitefly. While, border of mustard crop acted as trap

Fig. 2 Aphid complex on mustard crop in potato field

Table 3 Population buildups of whiteflies and aphids on potato and their respective catch in yellow traps placed in different directions during 2013-14

Period	Population / 100 compound potato leaves		Population of aphids on yellow trap placed in direction				Population of whitefly on yellow trap placed in direction			
	Aphids	Whitefly	South	North	East	West	South	North	East	West
2nd week of December	0	0	0	0	0	0	0	0	0	0
3rd week of December	13.3	0	10	0	0	0	0	0	0	0
4th week of December	233.4	0	17	8	0	0	0	0	0	0
1st week of January	340.8	8	21	10	2	0	4	0	0	0
2nd week of January	540.2	10	34	8	5	5	4	4	0	0
3rd week of January	620.7	12	40	10	2	5	5	4	0	0
4th week of January	962.4	22	55	12	4	7	4	0	0	0
1st week of February	1491.3	30	65	17	4	10	5	4	0	0
SEm±1	0.81	0.5	0.6	0.5	0.4	0.3	0.4	0.5	-	-
CD (P=0.05)	2.54	1.7	1.9	1.7	1.4	1.1	1.2	1.7	-	-

Table 4 Population buildups of whiteflies and aphids on potato and their respective catch in yellow traps placed in different directions during 2014-15

Period	Population / 100 compound potato leaves		Population of aphids on yellow trap placed in direction				Population of whitefly on yellow trap placed in direction			
	Aphids	Whitefly	South	North	East	West	South	North	East	West
2nd week of December	0.3	0	0	0	0	0	0	0	0	0
3rd week of December	10.8	5	0	0	0	0	0	0	0	0
4th week of December	170.7	8	10	0	5	0	0	0	0	0
1st week of January	313.7	10	18	8	0	0	0	0	0	0
2nd week of January	447.0	15	22	12	4	4	4	0	0	0
3rd week of January	566.7	20	35	10	4	5	4	0	0	0
4th week of January	827.0	22	40	12	5	7	3	0	0	0
1st week of February	1211.3	10	54	17	4	10	4	2	0	0
SEm±1	0.51	0.4	0.5	0.4	0.4	0.3	0.3	0.2	-	-
CD (P=0.05)	1.57	1.3	1.8	1.3	1.3	1.1	1.1	0.6	-	-

crop for the movement of aphids and act as a barrier for the movement of whitefly towards potato crop.

The border crops did not significantly affect the per cent germination of tubers in potato plots during both the years, although potato plots without border crops had lower tuber yield compared to plots with border crop **(Table 5 and 6)**. However, there were significant differences among border crop types and their direction during both the years. Plots with mustard crop placed towards south direction from potato crop had the highest tuber yields 31.13 and 30.6 t/ha in comparison to control plots (24.47 and 23.63 t/ha) in the years 2013-14 and 2014-15, respectively. All the potato plots having border crops recorded 3.0-6.5 t/ha more tuber yield as compared to potato plot without border crop.

M. persicae and *A. gossypii* were two aphid species identified on potato crop. These aphid species have the potential to transmit viral

Table 5 Aphids population on border crops, virus incidence, germination and tuber yield of potato during 2013-14

Treatments	Aphid population / 5 plants of border crop on indicative dates						% virus disease plants after 60 DAP	% germination	Total tuber yield (t/ha)	Increase in tuber yield (t/ha)
	17.12	24.12	02.01	10.01	17.01	26.01				
Control	0.00	0.00	0.00	0.00	0.00	0.00	4.7	85.6	24.47	-
Potato+ Maize (North)	0.00	0.00	0.00	0.00	0.00	0.00	1.2	87.8	29.40	4.93
Potato+ Maize (South)	0.00	0.00	0.00	0.00	0.00	0.00	0.8	90.6	30.40	5.93
Potato+ Maize (East)	0.00	0.00	0.00	0.00	0.00	0.00	2.7	87.8	27.80	3.33
Potato+ Maize (West)	0.00	0.00	0.00	0.00	0.00	0.00	3.3	90.0	27.13	2.66
Potato+ Mustard (North)	28.00	22.67	13.00	29.00	34.67	27.67	1.2	88.9	29.67	5.20
Potato+ Mustard (South)	35.67	25.67	29.00	37.33	40.33	36.67	0.4	88.3	31.13	6.66
Potato+ Mustard (East)	15.00	12.67	12.67	20.33	23.00	20.00	2.9	91.1	28.10	3.63
Potato+ Mustard (West)	25.33	16.00	16.67	30.33	34.33	27.33	2.2	90.0	27.83	3.36
SEm±1	5.37	4.14	3.34	2.90	5.58	2.85	0.67	2.70	0.37	-
CD(P=0.05)	16.24	12.52	10.12	8.78	16.87	8.62	2.04	NS	1.13	-

Table 6 Aphids population on border crops, virus incidence, germination and tuber yield of potato during 2014-15

Treatments	Aphid population / 5 plants of border crop on indicative dates						% virus disease plants after 60 DAP	% germination	Total tuber yield (t/ha)	Increase in tuber yield (t/ha)
	17.12	24.12	02.01	10.01	17.01	26.01				
Control	0.00	0.00	0.00	0.00	0.00	0.00	6.4	86.7	23.63	-
Potato+ Maize (North)	0.00	0.00	0.00	0.00	0.00	0.00	1.6	89.2	28.67	5.04
Potato+ Maize (South)	0.00	0.00	0.00	0.00	0.00	0.00	1.3	92.2	29.50	5.87
Potato+ Maize (East)	0.00	0.00	0.00	0.00	0.00	0.00	3.6	88.2	27.20	3.57
Potato+ Maize (West)	0.00	0.00	0.00	0.00	0.00	0.00	3.8	90.4	26.73	3.1
Potato+ Mustard (North)	34.67	25.67	14.67	35.00	40.67	36.67	1.4	88.8	29.17	5.54
Potato+ Mustard (South)	53.00	35.00	36.67	45.00	48.33	44.33	1.3	91.4	30.60	6.97
Potato+ Mustard (East)	19.33	16.67	11.67	16.33	25.00	25.67	3.5	91.0	27.73	4.10
Potato+ Mustard (West)	27.00	21.67	20.00	39.00	39.00	32.33	2.6	90.8	27.07	3.44
SEm±1	4.49	6.4	3.25	4.45	6.86	4.51	0.71	2.13	0.35	-
CD(P=0.05)	13.6	19.6	9.77	13.5	20.8	13.6	2.15	NS	1.06	-

infection as both being the most polyphagous and efficient vector species (Trivedi and Verma, 1990; Verma and Chandla, 1999; Garg *et al*., 2001). Similarly, whitefly, *Bemisia tabaci* (Gennadius) also had the potential to transmit virus in potato crop (Lakra 2003; Bhatnagar, 2007). In addition to virus transmission, population of aphids and whiteflies on potato plant causes considerable injury through sucking plant sap and leaf curling (Chandla *et al*. 2004; Chandel *et al*. 2010; Bhatnagar 2012). The results of the study showed significant differences among the type of border crops placed in different directions for aphids and whitefly on potato leaves during both the years.

Fewer aphids were found colonizing potato leaves with mustard borders placed at south and north directions from crop. The highest number of aphids and whitefly were

recorded in plots with no border crops. This indicates that the type of border crop and their placement towards specific direction nearer to potato crop are more effective in reducing the population of aphids and whitefly on potato crop. The maize borders may have acted as physical barriers for aphids and whitefly, while mustard border for traping and retaining aphids and barrier for whitefly. The border crops have been used in reducing the spread of non-persistent transmitted aphid borne viruses by acting as a natural sink (Uthama, 2001; Boiteau *et al*., 2009). A viruliferous winged aphid searching for a host plant will alight in the barrier crop and probes after which it loses its infectivity before entering the area of susceptible primary crop (Difonzo *et al*., 1996). Success of barrier crop depends on the height of that crop at the time of maximum risk of the primary crop.

The presence of other aphid species such as *Aphis fabae, Lipaphis erysimi, Rophalsosiphum madis* could be attributed due the presence of mustard, maize and beans (in the nearby fields). Many alternate host crops and weeds are reported to support green peach aphid and whitefly (Dharpure and Paradkar, 1999). Mustard and maize borders placed at south and north directions from the potato crop significantly reduced the viral disease incidence less than 4% compared to plots without border crops. The incidence of virus infection in the potato plots having mustard border placement towards south direction was less than 1 per cent and that is maximum incidence recommended for seed potato production (Konar 1998; Trivedi *et al*. 2002; Lakra, 2003). The reduction in virus disease incidence corresponded to the low number of aphids and whitefly observed in the same plots. This indicates that maize border placed towards south and north directions to the potato crop are more effective in the management of vector transmitted virus diseases. This can be attributed to border crops for aphids or reducing the virus content of the infected aphids through stylet probing of the border crop. The factors that affect the symptoms expression and development in the potato infected plant by the virus are the potato cultivar, time of infection, type of virus or its strain, mixed or pure infection and the environment (Bird and Maramorisch, 1978; Brown 1994; Biwas and Mohasin, 2000).

Although the placement of mustard and maize crops toward south direction to the potato crop resulted in a significant reduction in aphid and whitefly infestation and corresponding virus incidence, it increased the total tuber yield 6.66 and 6.97 t/ha as compared to potato crop without border in the respective years. This indicates that management of aphid, whitefly and transmitted potato viruses by the use of mustard border placed in south direction to the potato crop would be more appropriate for seed and ware potato production. This will also further reduced plant protection cost. The effectiveness of border crops in controlling vector as well as transmitted virus diseases can be improved by incorporation of eco-friendly insecticides and oil sprays in the border crops and would be useful in controlling Myzus *persicae* and *Bemisia tabaci* that transmit *PLRV* and *APCLV* in a persistent manner in potato crop.

ACKNOWLEDGEMENT

The research was financed by the Indian council of Agricultural Research. The fractural support and encouragement by the ICAR-CPRI, Director is dully acknowledged.

LITERATURE CITED

Bhatnagar A (2007) Incidence and succession of thrips, leafhoppers and whitefly in combination of planting dates and potato varieties. *Annals Plants Prot Sci* **15** (1): 101-105

Bhatnagar A (2013) Management of sap sucking and soil insect pests of potato with insecticides, *Pesticide Res J* **30**(1): 1-4

Bhatnagar A, Somani AK and Chander S (2012) Buildup of *Myzus persicae* and development of mosaics on potato in central India. *Potato J* **39(2)**: 208-210

Bird J and Maramorosch K(1978) Viruses and virus diseases associated with whiteflies. *Advance Virus Res* **22***:* 55-110

Biswas M K, De B K and Mohasin M (2000) Relationship between vector pressures (*Myzus persicae* and *Aphis gossypii*) and spread of PVY and PLRV invoked diseases in plains of West Bengal. *Potato global research and development volume-I*, Editors Khurana SMP, Shekawat GS, Singh BP, Pandey SK, IPA, Shimla, 483-486

Boiteau G, Singh M and Lavoie J (2009) Crop border and mineral sprays used in combination as physical control methods of aphid transmitted potato virus Y in potato. *Pest Management Sci* **65**: 255-259

Brown JK (1994) The status of *Bemisia tabaci* (Genn.) as a pest and vector in world agro ecosystems. *FAO Plant Protection Bull* **42**: 3-32

Chandla VK, Khurana SMP and Garg, ID (2004) Aphids, their importance, monitoring and management in seed potato crop. *Technical Bull* **61**, CPRI, Shimla, 12 pp.

Chandel RS, Banyal DK, Singh BP, Kamlesh M and Lakra BS (2010) Integrated management of whitefly, *Bemisia tabaci* (Gennadius) and potato apical leaf curl virus in India. *Potato Res* **53**:129-139

Dharpure SR and Paradkar VK (1999) Some weed hosts of *Myzus persicae* in satpura plateau of Madhya Pradesh. *J Indian Potato Assoc* **26**(1&2):74

Difonzo CD, Ragsdale DW, Radehffe EB, Gudmestand NC and Sencor GA (1996) Crop borders reduce potato virus Y incidence in seed potato. *Annals Applied Biol* **129**: 289-302

Fereres A (2000) Border crops as a cultural measure of non persistently transmitted aphid borne viruses. *Virus Res* **21**:221

Garg ID, Khurana SMP, Kumar S and Lakra BS (2001) Association of a gemini virus with potato apical leaf curl in India and its immune electron microscopic detection. *J Indian Potato Assoc* **28**: 227-232

Kishore R, Singh BP and Parihar SBS (2005) Population dynamics of whitefly (*Bemisia tabaci* Genn.) on potato crop in relation to weather factors. *Proc Nat Acad Sci India* **75**(B) 257-260

Konar A (1998) Buildup of aphids on potato in Kalyani, West Bengal. *Potato J* **25** (1): 76-78

Lakra BS (2003) Effect of date of planting on whitefly population, leaf curls incidence and yield of potato cultivars. *J Indian Potato Assoc* **30**: 115-116

Malik K and Singh BP (2007) Studies on *Bemisia tabaci* and its management. *Potato J*. **34** (1-2): 91-92

Osakabe M and Honda K (2002) Influence of trap crop and barrier crops on occurrence of and damage by stink bug and lepidopterous pod borers in soybean fields. Japanese *J Applied Entomol Zool* **36**: 233-241

Rajendran TP and Chandla VK (1986) Pests of potato in Himachal Pradesh. *Technical Bull.* **15**: 43-46. CPRI, Shimla

Rana RK and Pandey SK (2007) In India: An analysis of industry demand. *Processed Food Industry* **10**: 26-35

Trivedi TP, Khurana SMP, Puri SN, Bhar LM, Mehta SC, Jain RC, Singh G, Chaudhari SM, Mohasin M, Dhandapani A and Chona N (2002) Development of forewarning system of potato aphid (*Myzus persicae*) on potato (*Solanum tuberosum*) in India. *Indian J Agric Sci* **72**: 315-318

Trivedi TP and Verma KD (1990) Population trend of *Myzus persicae* Sulzer on different stages of potato crop in Karnataka. *J Indian Potato Assoc* **17**(1&2): 65-66

Uthama Swamy (2001) Insect pests of potato and their management. IPM in India. *Annual Rev Entomol* **24**(1): 25-29

Verma KD and Chandla VK (1999) Potato aphids and their management. *Technical Bull*, **26**, CPRI, Shimla, 34 p

Venkatasalam EP, Pandey KK, Singh V and Singh BP (2011) Seed potato production technology. Tech. Bull.,CPRI, Shimla, 57 p.

MS received : 07 July 2018; Accepted: 03 December 2018