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Research Article

SELECTION OF POTATO APICAL LEAF CURL VIRUS DISEASE-RESISTANT GENOTYPES, PEST SURVEILLANCE, SEED DEGENERATION, AND MANAGEMENT OF APHID IN FIELD CONDITIONS

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ABSTRACT

Objectives: Under All India Co-ordinated Research Project on Potato, studies on the selection of potato apical leaf curl virus disease-resistant genotypes, pest surveillance, seed degeneration, and management of aphid in field conditions were conducted at Hisar during 2017–2018.

Methods: Sowing of seed tubers was done at recommended time and spacing in every experiment followed by spraying of required insecticides. Observations on different aspects were recorded and statistically analyzed to present results in tabular format.

Results and Discussion: Out of 100 germplasm, seven were resistant and one was moderately resistant to potato apical leaf curl New Delhi virus, all the local genotypes were susceptible to disease. There was infestation of aphids, jassids, thrips, and whitefly irrespective of cultivars. Severe mosaic incidence ranged from 63.6 to 93.2%. The breeder seed was superior as it resulted in the highest seed tuber emergence (98.94%) and the least incidence of leafroll disease (0.80%) followed by seed tuber of seed plot technique (SPT). The conventional seed performed the poorest in terms of emergence and exhibited the highest disease incidence. Aphid appeared in the 47th meteorological week and it approached the ET level in the 52nd week. Whitefly population was the highest in the 47th week which continuously declined. Jassid population was very mild and thrips appeared in the 52nd week. Flonicamid 50 WG caused higher aphid mortality than imidacloprid after 24 h of spray. The maximum and minimum temperatures varied from 16.9 to 35.7 and 2.6 to 16.2° C, respectively. The morning and evening relative humidity was in the range of 82–100 and 24–75%, respectively. The wind speed ranged from 1.0 to 3.6 KMPH and the sun was shined from 0.3 to 7.6 h. The results of this study are close conformity of earlier researchers.

Conclusion: It is concluded that resistant genotypes, breeder seed, and seed produced through SPT are promising in managing the disease successfully. Flonicamid is a good alternative of imidacloprid. Aphid is a major pest that plays a key role in transmitting viral disease of this crop, its population touched ET level in the 52nd week.

Keywords: Potato, Germplasm, Viral diseases, Insect pests, Seed degeneration.

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is an economically important cash crop and plays a significant role in sustaining global food security [1]. It is a nutritionally rich staple food containing Vitamin-C, potassium, and fiber [2]. The human being consumes it as food, vegetable, and many more products such as chips, wafers, and French fries [3]. It is a short duration crop of about 75–125 days and requires lesser inputs as compared to other vegetable crops. It is the fourth important crop after rice, maize, and wheat as far as food consumption is concerned [4]. Potatoes provide high food energy and carbohydrates while taking up a smaller unit of land than other vegetables.

Globally, China is the biggest producer of it, China and India together contribute about one-third of global potato production. According to FAO estimates, over 368 million metric tons of potatoes were produced worldwide in 2018, from approximately 17.58 million hectares (https://www.statista.com/statistics/625120/global-potato-area-harvested). India produced about 51310.01 thousand tonnes of potato during 2017–2018 and the Haryana state produced 897.58 thousand tonnes [5].

In Haryana state, the success of potato cultivation is limited by the occurrence of viral diseases, sucking insect pests, and the poor quality of seed tubers to a great extent. Favorable weather conditions also play a key role in supporting the severity of pests and disease development. There are several viral diseases of potatoes [6], however, potato apical leaf curl (PALCVD) and leafroll are of great importance in Haryana state [7]. PALCVD is transmitted through whitefly, *Bemisia tabaci,* and leafroll through aphids, *Myzus persicae* [8-10].

Seed degeneration is an another issue of low potato productivity in the developing countries [11,12]. It is an increase in pest and pathogen incidence and severity associated with a reduction in yield or quality of seed tubers over successive cycles of vegetative propagation [13]. Potato viruses have long been recognized as the primary cause of this problem which generally spread systemically from parent to progeny tubers [14,15]. Potato virus Y (PVY), potato leafroll virus (PLRV), and potato virus X (PVX) are the global challenge for successful potato production [16]. PVX in combination with PVY causes more harm than alone itself [14,17].

Availability of resistant genotypes and protecting the crop from sucking insect pests through promising insecticides are the strategies for managing viral diseases. Weather conditions influences the population dynamics of these pests and hence their knowledge is helpful in understanding and solving the pest problems. The non-availability of affordable quality of the seed tubers is one of the primary aspects in deciding its bountiful or profitable crop production [18,19]. Looking into important plant protection concerns, the present studies were conducted under the All India Co-ordinated Research Project on Potato (AICRP-Potato) aimed to identify the resistant source of viral disease, surveillance of diseases and insect pests, seed degeneration, and management of aphids through systemic insecticides.

METHODS

Evaluation for potato apical leaf curl disease

One hundred potato germplasm accessions of Central Potato Research Station, Jalandhar (Punjab), India, and five local genotypes were studied. Five tubers per entry in two replications were sown following randomized block design (RBD). One row of K. Khyati was sown after every 10 germplasm lines and all around the experimental plot to maintain the source of infection. Observations on plant emergence after 30 days were recorded. Disease incidence was recorded after 20 days of emergence than subsequent observations were recorded at an interval of 10 days till hulm killing. Disease incidence was computed by the following formula:

$$\text{Disease incidence} = \frac{\text{Total number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

Based on the disease incidence, genotypes were further categorized as resistant or susceptible using the following disease scale:

Disease rating scale	
Disease incidence (%)	**Disease reaction**
<10	Resistant
10.1–20.0	Moderately resistant
20.1–40.0	Moderately susceptible
40.1–60.0	Susceptible
>60.0	Highly susceptible

Surveillance of important potato pests in the region (pest capture plots)

Commercial varieties Kufri Bahar, K. Pushkar, K. Pukhraj, and K. Badshah were sown each in 20 m^2. Then, plots were monitored for the appearance of new disease or pest. Observations on the incidence and intensity of different diseases and insect pests were recorded.

Studies on seed degeneration

The experiment was carried out in a RBD with three treatments in five replications. Treatments were as follows: T_1 – Fresh breeder seed, T_2 – Previous year's seed produced by seed plot technique (SPT), and T_3 – Previous year's seed produced without SPT. The crop was not sprayed with insecticide for the control of insect vectors. Observations were recorded on plant emergence and potato leafroll (PLRV), PVY, PALCV, mild, and severe mosaic disease incidence.

Monitoring of sucking insect pests in unsprayed crop

Potato variety K. Bahar was sown in a plot size of 4.0 × 5.0 m^2 in six plots. Observations on aphid (*M. persicae* and *Aphis gossypii*) population were recorded from 100 compound leaves (top, middle, and bottom leaves) at weekly intervals soon after plant emergence till haulm killing. The whitefly (*Bemisia tabaci*) and leafhopper (*Empoasca devastans*) population were assessed from the fully expanded top, middle, and bottom compound leaves from 10 tagged plants in each plot at weekly intervals. The whitefly population was recorded in the early morning. The thrips population was assessed at weekly intervals by shaking and collecting them onto sticky traps from 10 tagged plants. The first appearance of mites (*Polyphagotarsonemus latus*) and buildup of infestation was recorded periodically.

Efficacy of flonicamid 50 wg against aphids

Five rows (10 tubers per row) of seed tubers (var. K. Bahar) were grown in a 3 m × 2 m size plot in five replications per treatment following RBD. Treatments were as follows: T1 – Control (no insecticide), T2 – Foliar spray of imidacloprid 17.8 SL at 0.3 ml/l, and T3 – Foliar spray of flonicamid 50 wg at 0.3 g/l. Five plants per treatment were tagged, pre-spray aphid population was assessed and sprayed with insecticide when the number of aphids reached above 50 individuals on these plants. Insect mortality after the 2^{nd}, 4^{th}, and 6^{th} day of the spray from the lower, middle, and the upper leaves of five tagged plants was noted.

Crop sowing

In all experiments, the seed potato tubers were sown in mid-October 2017 at 60 cm × 20 cm spacing.

Weather conditions

Data of temperature, relative humidity, sunshine hours, wind velocity, and rainfall were collected from the Department of Agrometeorology, College of Agriculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar, from October 2017 to February 2018.

Data analysis

Experimental data were analyzed through the online statistical package "OPSTAT" of Chaudhary Charan Singh Haryana Agricultural University, Hisar.

RESULTS AND DISCUSSION

Evaluation for potato apical leaf curl disease

Out of evaluated germplasm against potato apical leaf curl New Delhi virus (PALCNDV), accession codes CP-4173, 4223, 4226, 4283, 4388, 4395, and 4399 were found resistant. Moreover, accession CP-4170 was moderately resistant to disease (Table 1) and 12 entries failed to emerge, among the local genotypes, none was resistant to disease (Fig. 1). Of more than 300 potato germplasm lines tested for resistance source against apical leaf curl virus, three were resistant and 32 were highly susceptible [20]. Earlier researchers evaluated several genotypes against this disease and reported a few genotypes as highly resistant [21].

Surveillance of important potato pests in the region (pest capture plots)

The crop was infested with sucking insect pest, namely, aphids, jassids, thrips, and whitefly irrespective of cultivars during the crop season. Tested cultivars showed 63.6–93.2% incidence of severe mosaic, however, the cultivar K. Bahar was free from severe mosaic, mild mosaic, and leafroll disease (Table 2). Aphid, *M. persicae* (Sulzer) population was surveyed in Meghalaya, Sikkim, Arunachal Pradesh, and Nagaland for seed as well as commercial crop production. The aphid-free or low aphid populated locations were selected for seed production [22]. Punjab survey indicated that the higher aphid population had laid into a higher incidence of several viruses during 2015 as compared to the year 2014. Disease incidence was directly correlated with aphid population in potato growing areas [23].

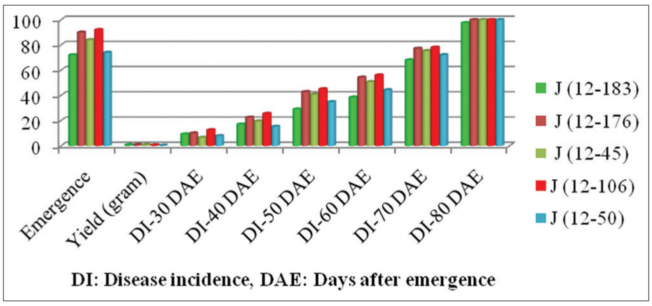

Fig. 1: Performance of local potato genotypes with respect to emergence, yield, and potato apical leaf curl disease

Table 1: Response of genotypes toward potato apical leaf curl disease

Disease reaction	Disease incidence (%)	Number of germplasm entry
Resistant	<10	7
Moderately resistant	10.1–20.0	1
Moderately susceptible	20.1–40.0	3
Susceptible	40.1–60.0	16
Highly susceptible	>60.0	61

Studies on seed degeneration

The breeder seed found superior among tested seed categories which resulted in the highest seed tuber emergence (98.94%) and the least incidence of leafroll (Fig. 2a-c) disease (0.80%) followed by seed tuber of SPT. The conventional seed showed the highest degeneration in terms of minimum emergence and the highest disease incidence (Table 3).

Potato seed tuber was tested against PVY and PLRV in Bangladesh continuously for many generations and it was noted that the first generation was free from PVY infection; however, the incidence was started in the second generation. Then, infection continuously went on the increase, and in the fifth generation, there was the maximum reduction in plant height, tuber number, and tuber yield [24].

A study conducted in Gujarat indicated that conventional seed tuber resulted in reduced emergence when compared with seed produced through SPT and fresh breeder seeds. The breeder seed as well as the seed of SPT of K. Anand, K. Pukhraj, and K. Sutlej exhibited the least viral disease incidence and yielded higher crop production when compared with the conventional seed [25]. Variety K. Jyoti showed yield reduction due to viral degeneration after four seasons of continuous growing under Indian conditions as compared to K. Giriraj [26].

The increased incidence of seed-borne PVY reduced tuber yield significantly even at 1% incidence and at 100% incidence it may cause yield reduction of up to 40% [27].

It is mentioned that the informal potato seed system is dominant over the formal potato seed system. The first one ranges from 80 to 100% whereas the second ranges from 0 to 20% in the developing countries [13], however, under Indian conditions, formal seed system is not developed up to mark [28].

Resistant varieties, on-farm management techniques including the establishment of seed plots, tuber-uniting, rouging, vector management, and plant selection are the integrated approaches for seed health management in a successful certified seed production system [29].

Virus-resistant genotypes [30], native varieties and its wild species [15,31], plant selection [32], roguing [33], choice of field sites and manipulation of planting dates [13], and planting of pre-sprouted tubers [34] could tackle the seed degeneration.

Table 2: Disease incidence and insect pests on the potato crop

Potato variety	Disease incidence (%)			Insect pests
	Severe mosaic	Mild mosaic	Leafroll	
V1 – Kufri Bahar	0.0	0.0	0.0	Aphids, jassids, thrips, whitefly
V2 – K. Pushkar	68.2	0.0	0.0	
V3 – K. Pukhraj	63.6	0.0	0.0	
V4 – K. Badshah	93.2	0.0	0.0	

Table 3: Effect of different types of seed tubers on the emergence and apical leaf curl virus disease of potato

Treatment	Emergence (%)		Disease incidence (%)	
	30 DAP	40 DAP	45 DAP	60 DAP
T1 – Breeder seed	98.94	98.94	0.53	0.80
T2 – Seed of seed plot technique	98.40	98.40	1.06	1.33
T3 – Seed of without seed plot technique	93.33	93.33	13.60	14.67
SEd	1.32	1.32	1.55	1.17
CD at 5%	3.09	3.09	3.63	2.75

Monitoring of sucking insect pests in unsprayed crop

Aphid (Fig. 2c) appeared on the crop in the 47th meteorological week and its population gradually increased till the 5th week, however, due to the rain, the population might come down in the 4th week. It approached the ET level in the 52nd week. In the case of whitefly, the trend of population increase was reverse; its population was the highest in the 47th week which continuously declined as the crop season arrived at haulm killing. Jassid population was very mild, thrips appeared in the 52nd week and gradually increased (Fig. 3).

Cucurbits are the suitable hosts for the perpetuation of tomato leaf curl New Delhi virus (ToLCNDV) and potato apical leaf curl disease, in North India [35]. Earlier researchers studied the incidence of *B. tabaci* and ToLNDV disease of potato in insecticide sprayed and unsprayed fields for 2 successive years. They found that three sprays of insecticide could reduce the incidence of *B. tabaci* in K. Bahar and K. Khyati, K. Pukhraj and K. Chipsona-1. The population of whitefly varied in both years in potato cultivars [36].

Efficacy of flonicamid 50 WG against aphids

Application of flonicamid 50 WG caused higher aphid mortality (70.17–94.33) than imidacloprid (57.20–83.13) after 24 h of spray (Fig. 4) in the present study.

It was noted that flonicamid caused significant mortality of whiteflies and delayed its further population build-up as well as nymphal development time [37]. This insecticide could effectively control the western flower thrips, *Frankliniella occidentalis* (Pergande) in the greenhouses at Varamin of Tehran province and Karaj of Alborz province [38]. The spray of imidacloprid 200 SL showed very good control of potato aphid, *M. persicae* Sulzer at Madenur, Bengaluru [39].

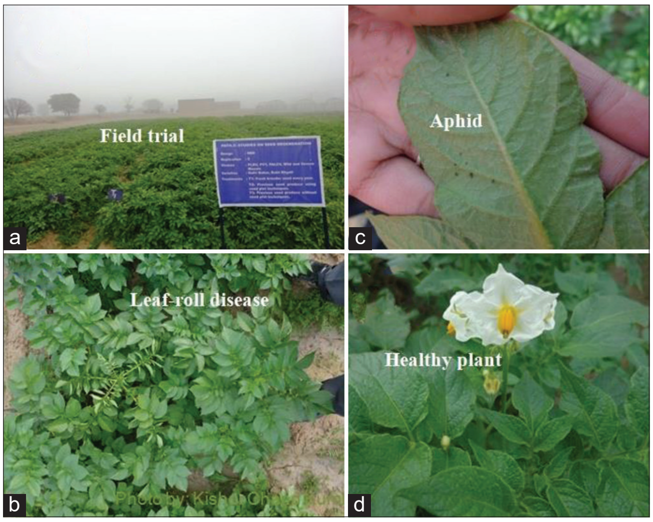

Fig. 2: (a-d) Seed degeneration of potato

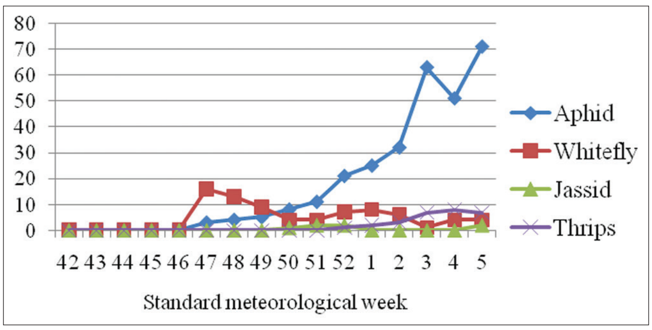

Fig. 3: Population dynamics of aphid, whitefly, jassid, and thrips during crop period

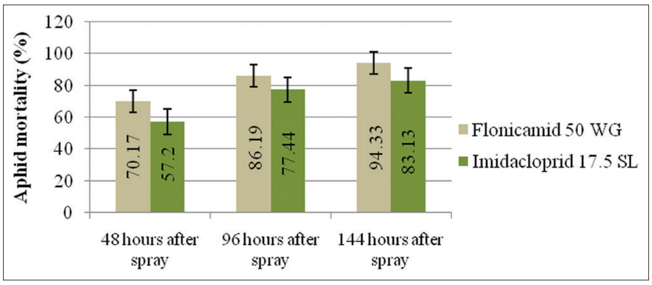

Fig. 4: Performance of insecticides in managing aphid on potato crop

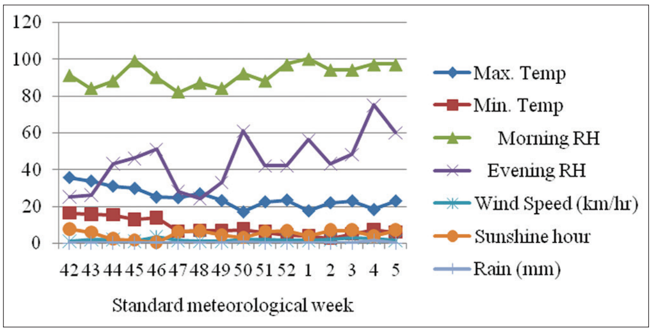

Fig. 5: Weather conditions during crop period

Flonicamid and other insecticides protected very effectively the Celery plant (*Apium graveolens*) from aphid infestation and further reduced its population build-up [40].

Aphid populations have developed resistance against pesticides due to their indiscriminate usage [41]. Growing soybean, wheat, or resistant potato varieties as border crops could be a safer approach to manage this pest [42,43]. Straw mulch [44], polymer webs [45], traps, and insecticidal soap are also management measures for aphids.

Weather conditions

The maximum and minimum temperatures varied from 16.9 to 35.7 and 2.6 to 16.2° C, respectively, during the crop season. The morning and evening relative humidity was in the range of 82–100 and 24–75%, respectively. The wind speed ranged from 1.0 to 3.6 KMPH and the sun was shined from 0.3 to 7.6 h. There was almost negligible rainfall during the entire crop season (Fig. 5).

CONCLUSION AND RECOMMENDATIONS

In this study, resistant as well as moderately resistant tomato genotypes against PALCNDV were screened out. The crop was infested with sucking insect pests irrespective of cultivars and there was severe mosaic incidence up to 93.2%. The performance of breeder seed was superior in terms of the enhanced seed tuber emergence and reduced incidence of leafroll disease followed by seed tuber of SPT. The sucking insect pests showed a variable trend in their occurrence and population build-up. Systemic insecticide, flonicamid 50 WG was found better than imidacloprid in controlling aphid infestation. Weather parameters during crop season showed little ups and downs. Based on 1 year's data, no viable recommendation can be made.

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