Nutrition and weather effects on population dynamics of insect-pests in potato (*Solanum tuberosum*)

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ABSTRACT

Insect population studies were conducted to estimate the relative population abundance of sucking insect-pests on potato (*Solanum tuberosum* L.) in relation to nutrition management and weather parameters at Punjab Agricultural University, Ludhiana, India during *rabi* 2014–15 and 2015–16. The lowest and the highest aphid, jassid and whitefly populations were recorded with recommended dose of manures and fertilizers (T_1-RDMF), and the unfertilized control (T_{10}), respectively during 46th to 51st Standard Meteorological Week (SMW). Seasonal fluctuation of insect-pest-infestation revealed that the weather parameters influenced the insects population. The aphid population was the lowest (0.27/plant) during 46th SMW and it increased with advancement in the crop growth stage with its highest population (3.43/plant) during 52nd SMW. Contrary to the aphid population, the highest populations of jassid (2.89/plant) and whitefly (2.23/plant), irrespective of the nutrition treatments, were recorded during 47th SMW, and decreased with advancement of the crop-growth stage with the lowest population (0.49 jassid and 0.55 whitefly/plant) being during 52nd SMW. A negative correlation was observed between the aphid population, and the maximum-(T_{max}) and minimum-temperatures (T_{min}) and sunshine hours (SH) but the positive correlation with relative humidity (RH). However, the trends for the jassid and whitefly populations were the opposite.

Keywords: Nutrition management, Potato, Population dynamics, Sucking insect-pests, Weather parameters

Potato (*Solanum tuberosum* L.), the most important non-cereal food crop, occupies a prominent place in India and abroad. India is the second largest potato producer in the world with an area of 2.17 million ha and production of 50.2 million tonnes (FAOSTAT 2021). Among its various production constraints, the insect-pests are the most important. The major insect-pests include aphids, potato tuber moth, jassids, whitefly, cutworm, thrips and leaf-minor (Elango *et al.* 2021) which damage the crop either directly by feeding on tubers, or indirectly by feeding on leaves and reducing the photosynthetic activity. The sucking insect-pests are a major constraint in seed potato production as they act as vectors of many viruses (Bhatnagar *et al.* 2017, Ghorai *et al.* 2018). The environmental factors have a determining effect on the extent of pest population (Thakur and Rawat 2014). Moreover, the response of organisms to climatic variation is species specific occurring at different rates in each species thus, resulting in an altered community structure (Sharma *et al.* 2014). Thus, understanding the complex interaction between weather parameters and insect-pest-incidence can be helpful in developing timely and efficient pest management strategies.

Cultural practices like nutrition management can be used as a tool in integrated pest management as the excessive or inappropriate use of inorganic fertilizers can cause nutrient imbalances and lower pest resistance (Singh and Sood 2017). Potato crop takes up large quantities of plant nutrients, especially nitrogen, phosphorus and potassium (White *et al.* 2007) and their optimization helps to obtain an economically optimal yield of quality potato tubers (Kumar *et al.* 2020) along with a fair degree of insect-pest-resistance. High nitrogen levels in plant tissue decrease resistance and increase susceptibility to pest-attacks (Ghorbani and Khajehali 2013). However, potassium and phosphorus decrease the host suitability of potato plants to insects and are detrimental to the pest (Facknath and Lalljee 2005). The present studies were conducted to record the population dynamics of sucking insect-pests in potato crop in relation to nutrition management and weather parameters.

MATERIALS AND METHODS

Field studies were conducted on potato var. Kufri Pukhraj during *rabi* 2014–15 and 2015–16 with three replications in randomized complete block design at Punjab Agricultural University, Ludhiana to study the effect of

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nutrition management and weather parameters on incidence of sucking insect-pests. The experimental site, represents the Indo-Gangetic alluvial plains, situated at 30º56´ N latitude and 75º52` E longitudes. The soil was loamy sand having neutral pH (7.00), normal electrical conductivity (0.24 mmhos/cm), medium organic carbon (0.45%), low available nitrogen (252 kg/ha), high available phosphorus (42.1 kg/ha) and medium available potassium (318 kg/ha). The crop was sown in mid-October by using medium sized (35-45 mm) seed tubers at inter- and intra-row spacing of 65 and 11.5 cm, respectively. The experimental site was kept free from pesticide application. Haulm cutting was done in first week of January and the crop was harvested in end January. The experiment comprised 10 treatments, viz. T_1-$F_{100}N_{100}P_{100}K_{100}$ (100% of recommended dose of manures and fertilizers [RDMF], i.e. 50 tonnes farmyard manure (FYM) + 187.5 kg N + 62.5 kg P_2O_5 + 62.5 kg K_2O/ha); T_2- $F_{50}N_{75}P_{100}K_{100}$; T_3- $F_{50}N_{75}P_{150}K_{150}$; T_4- $F_0N_{75}P_{100}K_{100}$; T_5- $F_0N_{75}P_{150}K_{150}$; T_6- $F_0N_{75}P_{200}K_{200}$; T_7- $F_0N_{100}P_{100}K_{100}$; T_8- $F_0N_{100}P_{150}K_{150}$; T_9- $F_0N_{100}P_{200}K_{200}$ and T_{10}- $F_0N_0P_0K_0$ (unfertilized control). The data on sucking insect-pests were recorded at weekly interval starting at 30 days after sowing (46th SMW) till the haulm cutting (52nd SMW). The number of adults and nymphs of aphid, jassid, and adult whitefly were recorded as number per plant. The counts of aphid and jassid were made from upper three leaves and of whitefly from three (top, middle and lower) leaves of 10 randomly selected plants. The data on maximum (T_{max}) and minimum temperature (T_{min}), rainfall, sunshine hours (SH) and relative humidity (RH) during the crop-growing season at Ludhiana were sourced from the School of Climate Change and Agricultural Meteorology, PAU, Ludhiana. Correlation and regression equations were calculated to estimate the effects of these abiotic factors on population counts of insect-pests. The data were subjected to statistical analysis using OPSTAT software (http://14.139.232.166/opstat) developed by CCS Haryana Agricultural University, Hisar (Haryana), India.

RESULTS AND DISCUSSION

Insect-pests incidence in relation to nutrition management: The lowest aphid, jassid and whitefly populations were recorded with recommended dose of manures and fertilizers (T_1- RDMF) and the highest with unfertilized control (T_{10}) during 46th to 51st SMW (Table 1). However, during 52nd SMW, the lowest populations of these insects were recorded with unfertilized control (T_{10}) which was due to early senescence of crop in unfertilized treatment near the end of the potato-growing cycle. Among the treatments, where FYM was applied (T_1-T_3), the lowest aphid, jassid and whitefly populations at all the growth stages were observed with treatment T_1 (RDMF) and it was statistically at par with treatment T_2 ($F_{50}N_{75}P_{100}K_{100}$) and T_3 ($F_{50}N_{75}P_{150}K_{150}$) during most of the SMWs. Among the non-FYM treatments (T_4-T_9), the lowest aphid population was recorded with treatment T_6- $F_0N_{75}P_{200}K_{200}$ during all the growth stages and it was statistically at par with treatment T_5-

$F_0N_{75}P_{150}K_{150}$; T_8- $F_0N_{100}P_{150}K_{150}$ and T_9- $F_0N_{100}P_{200}K_{200}$ during most of the growth stages but significantly lower than rest of the treatments. The lowest jassid population, among the non-FYM treatments (T_4-T_9), was recorded with treatment T_6- $F_0N_{75}P_{200}K_{200}$ during 47th, 51st and 52nd SMW and with treatment T_9- $F_0N_{100}P_{200}K_{200}$ during 48th and 49th SMW. These treatments were statistically at par with each other and with treatment T_5- $F_0N_{75}P_{150}K_{150}$ and T_8- $F_0N_{100}P_{150}K_{150}$ during most of the growth stages. The lowest whitefly incidence was recorded with treatment T_9- $F_0N_{100}P_{200}K_{200}$ during most of the growth stages and it was statistically at par with treatments T_5- $F_0N_{75}P_{150}K_{150}$ and T_6- $F_0N_{75}P_{200}K_{200}$.

The pooled data over SMWs revealed that the lowest aphid, jassid and whitefly populations (1.66, 1.41 and 1.12/plant, respectively) were recorded with treatment T_1 (RDMF) and it was statistically at par with treatment T_3 ($F_{50}N_{75}P_{150}K_{150}$) for aphid and whitefly (Table 1) but significantly lower than rest of the treatments. The highest mean population of these insects was recorded with treatment T_7- $F_0N_{100}P_{100}K_{100}$. Among the non-FYM treatments (T_4-T_9), the lowest mean aphid and jassid populations (1.80 and 1.57/plant, respectively) were observed with treatment T_6- $F_0N_{75}P_{200}K_{200}$ and it was statistically at par with treatments T_5- $F_0N_{75}P_{150}K_{150}$ and T_9- $F_0N_{100}P_{200}K_{200}$. The lowest whitefly population (1.22/plant) was recorded with treatment T_6- $F_0N_{75}P_{200}K_{200}$ and T_9- $F_0N_{100}P_{200}K_{200}$ and it was significantly lower than rest of the treatments. It indicated that the sucking insect-pests incidence, irrespective of growth stage of the crop, decreased with application of recommended dose of FYM and fertilizers or with increased levels of inorganic phosphorus and potassium, whereas their populations were higher with no or lower fertilization. The increased level of potassium fertilizers generally appeared to have a negative effect on insect-pests incidence which might be due to a higher proteogenesis in plants, a physiological phenomenon correlated with the elimination of amino acids and reducing sugars in the sap, which otherwise favour the development of sap feeders (Shaikh and Patel 2012). They also reported significantly lower aphid, jassid and whitefly populations in brinjal with higher level of potash while the incidence of these insects was higher in unfertilized treatment. Khairnar and Patel (2015) also reported the lowest incidence of sucking insect-pests (aphid, jassid and whitefly) with higher dose of phosphorus and the highest incidence with unfertilized control.

Insect-pests incidence in relation to weather parameters

Weather during the crop seasons: The pooled meteorological data during the crop growing seasons (Fig 1) indicated that the weekly mean T_{max} during crop season (46th - 52nd SMW) ranged from 16.3 to 27.1°C, the lowest recorded during 51st SMW and the highest during 46th SMW while, the weekly mean T_{min} ranged from 5.3 to 10.9°C with maximum (10.9°C) during 46th and minimum (5.3°C) during 52nd SMW. Total rainfall received during the crop season was 22 mm, out of which 21.7 mm was

Table 1   Influence of nutrition management on insect population (pooled data)

Treatment	Standard meteorological week (SMW)							Pooled mean
	46th	47th	48th	49th	50th	51st	52nd	
Aphid (number/plant)								
T_1	0.20	0.40	0.87	1.73	2.17	3.03	3.20	1.66
T_2	0.30	0.50	0.97	1.93	2.50	3.20	3.50	1.84
T_3	0.23	0.43	0.90	1.83	2.40	3.07	3.30	1.74
T_4	0.33	0.63	1.10	2.13	2.77	3.60	3.87	2.06
T_5	0.23	0.57	1.00	2.00	2.53	3.27	3.47	1.87
T_6	0.23	0.43	0.97	1.93	2.37	3.23	3.40	1.80
T_7	0.30	0.70	1.17	2.20	2.93	3.73	4.00	2.15
T_8	0.27	0.63	1.10	2.10	2.70	3.40	3.63	1.98
T_9	0.23	0.47	1.03	1.97	2.53	3.30	3.50	1.86
T_{10}	0.37	0.73	1.23	2.27	3.17	3.43	2.40	1.94
SEm±	0.03	0.06	0.06	0.06	0.10	0.08	0.09	0.03
CD (P=0.05)	0.09	0.17	0.18	0.18	0.29	0.22	0.24	0.09
Jassid (number/plant)								
T_1	1.97	2.60	2.07	1.72	0.77	0.40	0.37	1.41
T_2	2.07	2.77	2.23	1.87	0.93	0.53	0.50	1.56
T_3	2.03	2.70	2.23	1.73	0.83	0.50	0.47	1.50
T_4	2.43	3.07	2.53	1.97	1.00	0.63	0.57	1.74
T_5	2.10	2.90	2.40	1.87	0.93	0.53	0.53	1.61
T_6	2.13	2.80	2.33	1.87	0.87	0.53	0.47	1.57
T_7	2.47	3.13	2.67	2.03	1.03	0.67	0.60	1.80
T_8	2.30	2.90	2.43	1.90	0.97	0.60	0.57	1.67
T_9	2.13	2.87	2.27	1.83	0.90	0.53	0.50	1.58
T_{10}	2.53	3.20	2.67	2.10	1.03	0.43	0.33	1.76
SEm±	0.08	0.08	0.09	0.06	0.06	0.05	0.05	0.03
CD (P=0.05)	0.23	0.22	0.26	0.18	NS	0.13	0.13	0.08
Whitefly (number/plant)								
T_1	1.67	2.03	1.57	0.93	0.80	0.43	0.40	1.12
T_2	1.83	2.20	1.80	1.07	0.87	0.60	0.60	1.28
T_3	1.70	2.03	1.73	0.90	0.87	0.53	0.50	1.18
T_4	2.10	2.50	2.13	1.20	1.03	0.73	0.70	1.49
T_5	1.87	2.23	1.93	1.03	0.93	0.63	0.60	1.32
T_6	1.67	2.17	1.73	1.03	0.97	0.50	0.50	1.22
T_7	2.20	2.73	2.20	1.20	1.07	0.77	0.77	1.56
T_8	1.87	2.53	2.03	1.13	1.03	0.63	0.67	1.41
T_9	1.73	2.17	1.83	0.97	0.90	0.50	0.47	1.22
T_{10}	2.20	2.67	2.23	1.23	1.10	0.50	0.30	1.46
SEm±	0.05	0.08	0.08	0.08	0.07	0.06	0.07	0.03
CD (P=0.05)	0.15	0.24	0.23	0.22	0.19	0.18	0.19	0.08

T_1- $F_{100}N_{100}P_{100}K_{100}$; T_2-$F_{50}N_{75}P_{100}K_{100}$; T_3- $F_{50}N_{75}P_{150}K_{150}$; T_4- $F_0N_{75}P_{100}K_{100}$; T_5- $F_0N_{75}P_{150}K_{150}$; T_6- $F_0N_{75}P_{200}K_{200}$; T_7-$F_0N_{100}P_{100}K_{100}$; T_8- $F_0N_{100}P_{150}K_{150}$; T_9- $F_0N_{100}P_{200}K_{200}$; T_{10}- $F_0N_0P_0K_0$.
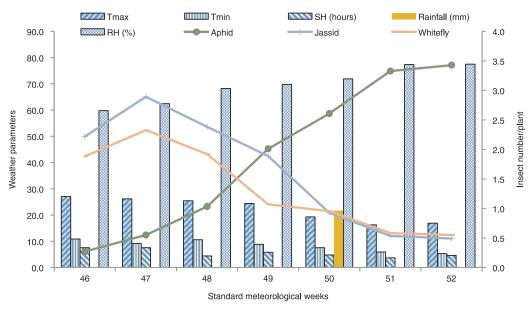
Fig 1 Weather parameters and abundance of insect-pests on potato crop (Pooled mean).

during 47th SMW and decreased with advancement of the crop growth stage with the lowest populations (0.49 jassid and 0.55 whitefly/plant) during the 52nd SMW. It might be due to the positive correlation of these insects with T_{max} and T_{min}, and SH, and the negative correlation with RH. Sharma *et al.* (2019) also reported that the aphid population gradually increased while the mean population of whitefly and jassid decreased

received during 50th SMW. The mean weekly RH ranged from 59.8 to 77.5%, the lowest being during 46th SMW and the highest during 52nd SMW.

Incidence of insect-pests: The aphid population was the lowest (0.27/plant) during 46th SMW and it increased with advancement in the crop-growth stage with its highest population (3.43/plant) during 52nd SMW (Fig 1). It might be due decrease in T_{max} and T_{min}, and SH from 46th to 52nd SMW which had negative correlation with aphid population (Table 2). Similarly, RH increased with advancement of the crop season from 46th to 52nd SMW and had positive correlation with aphid population. Unlike the aphid incidence, the highest populations of jassid (2.89/plant) and whitefly (2.23/plant), irrespective of the nutrition treatments, were recorded

from November to December. Shah *et al.* (2019) also reported the decreased whitefly population with decreased daily T_{min} below 12°C.

Relationship of insect-pests incidence with weather parameters: The aphid population had a highly significant negative correlation with the T_{max} and T_{min}, and SH while highly significant positive correlation with RH (Table 2). In contrast, the jassid and whitefly populations had highly significant positive correlation with the T_{max} and T_{min} and SH, while highly significant negative correlation with RH. The aphid population had positive but non-significant correlation, while jassid and whitefly populations had negative but non-significant correlation with rainfall. The values of coefficient of correlation (r) of aphid population

Table 2   Correlation coefficient and regression equations of insect-pests on potato with weather parameters

Weather parameter	Aphid			Jassid			Whitefly		
	Correlation coefficient (r)	Regression equation	R^2	Correlation coefficient (r)	Regression equation	R^2	Correlation coefficient (r)	Regression equation	R^2
T_{max}	-0.965**	y = -0.2727x + 7.9496	0.9277	0.960**	y = 0.2012x - 2.8535	0.9206	0.901**	y = 0.1392x - 1.7662	0.8116
T_{min}	-0.931**	y = -0.5611x + 6.5599	0.8703	0.874**	y = 0.3903x - 1.6293	0.7669	0.846**	y = 0.2791x - 0.9963	0.7231
RH	0.974**	y = 0.1864x - 11.079	0.9499	-0.888**	y = -0.1259x + 10.376	0.789	-0.904**	y = -0.0945x + 7.8991	0.8194
SH	-0.797*	y = -0.6664x + 5.5527	0.6327	0.734*	y = 0.4546x - 0.8799	0.5364	0.726*	y = 0.3308x - 0.4914	0.5235
Rainfall	0.245NS			-0.316NS			-0.232NS		

*Significant at P = 0.05 level; **Significant at P = 0.01 level; NS- Non-significant; T_{max}- maximum temperature; T_{min}- minimum temperature; RH- relative humidity; SH- sunshine hours, T_{max}- maximum temperature, T_{min}- minimum temperature, SH- sunshine hours, RH- relative humidity.

were -0.931 with T_{min}; -0.965 with T_{max}; 0.974 with RH (%) and -0.797 with SH. Similarly, the values of coefficient of correlation (r) of jassid population were 0.874 with T_{min}; 0.960 with T_{max}; -0.888 with RH and 0.734 with SH. The correlation coefficients (r) of whitefly population were 0.846, 0.901, -0.904 and 0.726 for T_{min}, T_{max}, RH and SH, respectively. Based on significant correlations obtained with different weather parameters, simple regression equations were developed for each insect-pest (Table 2). The R-squared values (R^2) of aphid population were 0.9277, 0.8703, 0.6327 and 0.9499 with the T_{max}, T_{min}, SH and RH, respectively which showed that T_{max}, T_{min}, SH and RH were responsible for 92.8, 87.0, 63.3 and 95.0% variation of aphid population. In jassid population, R^2 values were 0.9206, 0.7669, 0.5364 and 0.789 with the T_{max}, T_{min}, SH, and RH, respectively which means 92.1, 76.7, 53.6 and 78.9% variation in jassid population was attributed to T_{max}, T_{min}, SH, and RH, respectively. Similarly, the values of R^2 for whitefly population were 0.8116, 0.7231, 0.5235 and 0.8194 with T_{max}, T_{min}, SH and RH, respectively. Thus, it was observed that aphid, jassid and whitefly populations were highly influenced by T_{max}, T_{min} and RH, however, the SH had the least influence on population of these insects. Sharma *et al.* (2019) also reported negative correlation of aphid population in potato with T_{max} and T_{min} but positive correlation with RH. Saxena *et al.* (2012) reported that population buildup of *Lipaphis erysimi* in mustard was negatively correlated with T_{max} and T_{min}. Bapuji Rao *et al.* (2012) reported that mustard aphids were negatively correlated with temperature and positively correlated with RH. Similarly, Sharma *et al.* (2017) reported negative correlation of *M. persicae* population with T_{max} and T_{min} and positive correlation with RH in sugarbeet.

The nutrition management had significant influence on aphid, jassid and whitefly populations. The crop receiving recommended dose of FYM and fertilizers or higher levels of inorganic phosphorus and potassium fertilizers harboured lower population of these insect-pests as compared to the one with no or lower level of fertilizers. Weather parameters viz. T_{max}, T_{min}, SH and RH had significant influence on the population dynamics of these sucking insect-pests with aphid population showing negative correlation with T_{max}, T_{min} and SH but positive correlation with RH. However, the opposite trends were observed for jassid and whitefly populations.

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