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Effect of foliar application of plant growth regulators on incidence of insect-pests and diseases in autumn planted seed potato (*Solanum tuberosum)*

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ABSTRACT

A field experiment was conducted during 2019–20 and 2020–21 at Punjab Agricultural University, Ludhiana, Punjab to study the effect of foliar application of plant growth regulators on insect-pest and disease incidence in potato (*Solanum tuberosum* L.) under subtropical conditions. A total of 11 treatments including control were tested in a randomized complete block design (RCBD) with three replications on the potato cv. Kufri Pukhraj. The results indicated that plant growth regulators, like GA_3, IBA, NAA, ethrel, *jeevamrit* and waste decomposer were not producing any significant effect on the incidence of aphid, jassid and whitefly population in comparison to untreated control. However, diseases such as scab and scurf did not reveal any significant differences among the plant growth regulator's treatments except in late blight. Foliar application of gibberellic acid (200 ppm) at 45 and 60 days after sowing (DAS) significantly reduced the late blight incidence and severity in seed potato cv. Kufri Pukhraj.

Keywords: Aphid, Growth regulators, Jassid, Late blight, Potato, Whitefly

Potato (*Solanum tuberosum* L.) are a key cash crop in India, providing farmers with income and supporting the national economy (Ganga *et al*. 2021). The demand for high-quality seed potatoes is rising due to the popularity of processed potato products and the need to increase production. However, poor seed quality remains a major issue. Farmers often use their own saved seed, which may be improperly stored or unscreened for disease, leading to pest and disease infections that significantly reduce yields (Ranalli 1997). According to a study by Gupta and Nanda (2019), the quality of seed potatoes in India is often low due to the lack of certified seed. Several factors, particularly in the subtropics, limit potato production, including the availability of suitable varieties, agro-techniques, high-quality seeds, and storage infrastructure besides the incidence of insect-pest and diseases (Sharma and Singh 2018). To successfully grow seed potatoes, it is essential to have access to pest-free seeds, take precautions to safeguard the plants, maintain cool temperatures and minimize daytime hours during the tuberization period. Among abiotic factors, temperature, rainfall, and photoperiod have a significant impact on potato plants (Singh 2002). Among biotic factors such as whitefly, jassid, and aphid easily transmit diseases in potato tubers (Kumar *et al.* 2021).

Currently, the primary approach for controlling these insects-pests and diseases are chemical control (Nauen and Elbert 2003). However, numerous pesticide applications to control insect-pests on potato crops are often not cost-effective. Due to aphids' strong reproductive capacity and widespread pesticide resistance in most agricultural systems, insecticides occasionally fail to be effective against them (Nauen and Elbert 2003). Therefore, other pest management strategies need to be explored. It is primarily necessary to use plant growth regulator (GRs)-based management techniques to solve these issues (Van 2000). Growth regulator effects plant's physiology and may change an arthropod's morphology and behaviour (Prado and Frank 2013). GRs can alter agronomic features of plant growth processes as well as host plant-insect interactions as reported by Sohal *et al.* (2006). Similarly, Kaur and Rup (2003) also reported a lower incidence of sucking pests with the application of growth regulators. Therefore, an experiment was planned to record the population dynamics of important insect-pests and diseases related to seed potato crops under subtropical conditions after the application of plant growth regulators.

MATERIALS AND METHODS

A field experiment was conducted during 2019–20 and 2020–21 at Punjab Agricultural University, Ludhiana (30°56' N latitude and 75°52' E longitude), Punjab. The experimental site represents the Indo-Gangetic plains, situated in the central region of Punjab (Ludhiana). Subtropical, semi-arid climate with hot, dry summers (up to 46°C), humid

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monsoons (July–September), cold winters (below 5°C with frost), and mild spring (February–March). Receives 75% of 759 mm annual rainfall from July–September. The soil was loamy sand having neutral *p*H (7.20), normal electrical conductivity (0.30 m mhos/cm), medium organic carbon (0.45%), medium available nitrogen (288 kg/ha), high available phosphorus (26 kg/ha) and high potassium (335 kg/ha). The crop was sown in the first fortnight of October by using medium-sized (35–45 mm) seed tubers at inter and intra row spacing of 65 and 15 cm, respectively. The experimental site was kept free from insecticide application during both the years of study. The experiment was conducted in a randomized complete block design (RCBD) comprised of 11 treatments, viz. IBA_{100}, IBA (100 ppm); IBA_{200}, IBA (200 ppm); NAA_{25}, NAA (25 ppm); NAA_{50}, NAA (50 ppm); $Ethrel_{25}$, Ethrel (25 ppm); $Ethrel_{50}$, Ethrel (50 ppm); GA_{100}, GA_3 (100 ppm); GA_{200}, GA_3 (200 ppm); JA, *Jeevamrit* (Prepared by mixing 10 kg cow dung + 10 litres cow urine + 2 kg jaggery + 2 kg gram flour + handful of soil in 200 litres of water and fermented for 5–7 days); WD, Waste decomposer (Prepared by mixing 2 kg jaggery + 30 g of waste decomposer in 200 litres of water and further diluting culture in the ratio of 1:3 with water) and C, Control (Water spray). The foliar application of plant growth regulators was applied at 45 and 60 days after sowing (DAS). The data on the incidence of sucking insect-pests were recorded at weekly intervals starting at 45 DAS till the haulm cutting during both years. The number of aphids and jassids were made from the upper three leaves of the crop canopy from ten randomly selected plants while for whitefly from three (top, middle and lower) leaves of 10 randomly selected plants.

The data on disease incidence (late blight, scurf and scab) were calculated as:

$$\text{Disease incidence} = \frac{\text{No. of infected plants}}{\text{Total plant observed}} \times 100$$

Observations on per cent late blight and scurf severity were recorded as per the formula given by Kumar *et al.* (2020). Scab severity was calculated by using the formula described by Liu *et al.* (1995). The following method was used to assess disease severity and scab and scurf diseases usually occur on tubers at haulm cutting:

Disease severity grade	Disease severity (%)		
	Late blight	Scurf	Scab
0	No disease	No disease	No disease
1	1–10	<1	Very small lesions
2	11–20	1–10	Small lesions
3	21–30	11–20	Periderm broken
4	31–50	21–50	Light pitted
5	51–100	>50	Deep pitted

Statistical analysis: The data were subjected to statistical analysis using R studio software developed by Posit, PBC company.

RESULTS AND DISCUSSION

In potato cultivation, aphids, jassids, and whiteflies are prevalent insect pests, known to inflict substantial damage on crop health and productivity. These pests feed on plant sap, potentially causing significant harm to potato plants, leading to symptoms like reduced vigour, stunted growth, and diminished yields. Effective pest management strategies are crucial to mitigate their impact, necessitating a holistic approach incorporating cultural practices, biological control methods, and prudent use of insecticides to safeguard crop health and optimize yield potential (Amiri *et al*. 2019).

Throughout both years of the study, the population of aphids (*Myzus* spp.) exhibited minimal variation across different plant growth regulator treatments (47^{th}–1^{st} Standard Meteorological Week [SMW]) (Table 1). The lowest aphid population was observed during the 47^{th} SMW in 2019–20 and the 48^{th} SMW in 2020–21, irrespective of growth regulator treatments. As the crop season progressed, aphid populations increased, reaching their peak during the 52^{nd} SMW in 2019–20 and the first SMW in 2020–21. Seasonal mean aphid populations showed no significant differences with varying plant growth regulator treatments during both study years (2019–21). Li *et al*. (2020) similarly noted that the seasonal population dynamics of aphids in potato crops remained largely unaffected by gibberellic acid treatments. Likewise, Bayram and Tonga (2018) reported that the population of sucking insects, including aphids, remained unchanged by growth regulator treatments. These findings suggest that while growth regulators may have effects on certain aspects of crop development, they do not significantly impact aphid populations in potato crops. Further research may be warranted to explore alternative strategies for aphid management in potato cultivation.

The jassid mean population ranged from 1.45–1.74 during the first year and 1.23–1.49 during the second year of study. The population of jassid (*Amrasca* spp.) did not vary significantly with growth regulator treatments (47^{th}–1^{st} SMW) during both the years of study (Supplementary Table 1). The jassid population was the highest during the 48^{th} SMW in 2019–20 and 49^{th} SMW in the 2020–21 irrespective of the growth regulator treatments and it decreased with the advancement of crop season with the lowest population during the 52^{nd} SMW in 2019–20 and 1^{st} SMW in 2020–21. These findings are consistent with those of Samui and Roy (2007), who similarly observed that the seasonal population incidence of insects, including jassids, was not significantly influenced by growth regulator application in potatoes. Despite the potential effects of growth regulators on certain aspects of crop development, they do not appear to have a substantial impact on jassid populations in potato crops. Further investigations may be necessary to explore alternative strategies for managing jassid infestations in potato cultivation, given their persistence across different growth regulator treatments.

Cultural practices deter crop pests such as whitefly by adjusting planting density, rotation, and soil management, disrupting pest cycles and preserving yields sustainably

Table 1 Effect of plant growth regulators on incidence of aphid in autumn planted potato during 2019–20 and 2020–21

Treatment	Aphid population (number/plant)															
	Standard meteorological week (SMW)															
	47th		48th		49th		50th		51th		52nd		1st		Mean	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
IBA_{100}	0.54	-	0.90	0.44	1.00	0.64	2.00	1.27	2.60	1.57	3.60	2.20	-	2.84	1.77	1.49
IBA_{200}	0.50	-	0.84	0.40	0.94	0.60	1.87	1.20	2.47	1.50	3.40	2.10	-	2.70	1.67	1.42
NAA_{25}	0.57	-	0.94	0.47	1.04	0.67	2.07	1.34	2.67	1.64	3.70	2.30	-	2.97	1.83	1.57
NAA_{50}	0.54	-	0.90	0.44	1.00	0.64	2.00	1.27	2.60	1.57	3.60	2.20	-	2.84	1.77	1.49
$Ethrel_{25}$	0.60	-	0.97	0.50	1.07	0.70	2.14	1.40	2.74	1.67	3.84	2.37	-	3.07	1.89	1.62
$Ethrel_{50}$	0.60	-	1.00	0.50	1.10	0.70	2.20	1.40	2.80	1.70	3.90	2.40	-	3.10	1.93	1.63
GA_{100}	0.50	-	0.84	0.40	0.94	0.60	1.87	1.20	2.47	1.50	3.40	2.10	-	2.70	1.67	1.42
GA_{200}	0.47	-	0.80	0.37	0.90	0.57	1.80	1.14	2.40	1.44	3.30	2.00	-	2.57	1.61	1.35
JA	0.57	-	0.94	0.47	1.04	0.67	2.07	1.34	2.67	1.64	3.74	2.30	-	2.97	1.84	1.57
WD	0.57	-	0.94	0.47	1.07	0.67	2.14	1.34	2.70	1.67	3.77	2.34	-	3.00	1.87	1.58
Control	0.57	-	0.97	0.50	1.07	0.67	2.14	1.37	2.74	1.67	3.80	2.34	-	3.00	1.88	1.59
CD (P=0.05)	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	NS	NS	NS

NS, Non-significant. Treatment details are given under Materials and Methods.

Table 2 Effect of plant growth regulators on incidence of whitefly in autumn planted potato during 2019–20 and 2020–21

Treatment	Whitefly population (number/plant)															
	Standard meteorological week (SMW)															
	47th		48th		49th		50th		51th		52nd		1st		Mean	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
IBA_{100}	2.04	-	2.34	1.90	1.60	2.04	0.84	1.20	0.44	0.87	0.34	0.34	-	0.28	1.27	1.11
IBA_{200}	1.94	-	2.24	1.87	1.50	2.00	0.77	1.10	0.40	0.80	0.30	0.30	-	0.24	1.19	1.05
NAA_{25}	2.14	-	2.44	2.00	1.70	2.14	0.90	1.30	0.47	0.90	0.37	0.37	-	0.30	1.33	1.17
NAA_{50}	2.10	-	2.40	1.97	1.64	2.10	0.87	1.24	0.44	0.87	0.34	0.34	-	0.27	1.30	1.13
$Ethrel_{25}$	2.17	-	2.47	2.07	1.74	2.17	0.94	1.34	0.47	0.97	0.37	0.37	-	0.34	1.36	1.21
$Ethrel_{50}$	2.20	-	2.50	2.07	1.77	2.20	0.97	1.37	0.47	0.97	0.37	0.37	-	0.34	1.38	1.22
GA_{100}	1.94	-	2.24	1.87	1.50	2.00	0.77	1.14	0.40	0.80	0.30	0.30	-	0.24	1.19	1.06
GA_{200}	1.84	-	2.14	1.74	1.40	1.87	0.70	1.00	0.37	0.77	0.27	0.27	-	0.20	1.12	0.97
JA	2.14	-	2.44	2.00	1.74	2.14	0.90	1.34	0.44	0.90	0.37	0.34	-	0.30	1.34	1.17
WD	2.17	-	2.44	2.00	1.74	2.14	0.94	1.34	0.44	0.90	0.37	0.34	-	0.30	1.35	1.17
Control	2.17	-	2.47	2.04	1.77	2.17	0.97	1.34	0.47	0.94	0.37	0.37	-	0.34	1.37	1.20
CD (P=0.05)	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	NS	NS	NS

NS, Non-significant. Treatment details are given under Materials and Methods.

(Abubakar *et al*. 2022). During both years of the experiment (2019–21), the population of whiteflies (*Bemisia* spp.) did not alter substantially with different growth regulator treatments (47^{th}–1^{st} SMW) (Table 2). The whitefly population was at its peak (2.50 and 2.07 number/plant) during the 48^{th} SMW in 2019–20 and the 49^{th} SMW in 2020–21, regardless of plant growth regulator treatments, and it decreased as the crop season progressed, with the lowest population dynamics (0.27 and 0.20 number/plant) during the 52^{nd} SMW in 2019–20 and the first SMW in 2020–21. The seasonal mean population (1.12–1.38 during the first year and 0.97–1.22 during the second year, respectively) of whiteflies did not vary significantly with different growth regulator treatments. Yao *et al*. (2017) corroborated these findings, suggesting that agronomic interventions failed to exert a discernible impact on whitefly infestation levels in agricultural crops.

The late blight incidence and per cent severity varied significantly with the plant growth regulator treatments. The lowest incidence of late blight was recorded with foliar application of GA_{200} (Table 3). A significantly higher incidence (%) of late blight occurred with $Ethrel_{50}$ than all the other treatments except $Ethrel_{25}$, C, WD, JA and NAA_{25}, which were statistically at par with $Ethrel_{50}$ during both years of study. All the plant growth regulator treatments except $Ethrel_{50}$, $Ethrel_{25}$, WD, JA and NAA_{25} had significantly lower incidences of late blight than the untreated control. The significantly lowest severity (8.57 and 5.62%) occurred with GA_{200} and was statistically at par with IBA_{200} and GA_{100} during both the years. Significantly higher severity (11.85 and 7.78%) than all the other treatments was obtained with $Ethrel_{50}$ and it was statistically at par with untreated control during both the years. Gilani *et al*. (2021) found that gibberellic acid activates pathogen defense-related enzymes, including polyphenol oxidase and peroxidase, while also boosting phenolic content, thereby inducing systemic resistance against pathogens. Similarly, Glosek-Sobieraj *et al*. (2018) reported reduced incidence and severity of late blight with growth regulator treatments. The decrease in late blight incidence and severity attributed to gibberellic acid may be linked to its positive impact on the DELLA protein and salicylic acid signaling pathways, which regulate plant resistance against diseases, as proposed by Ding *et al*. (2013) and Pieterse *et al*. (2012). This suggests a potential role for gibberellic acid in enhancing plant defenses against pathogens, offering insights into disease management strategies in agriculture.

In the course of the two-year study, the incidence and severity of scurf remained unchanged across various growth regulator treatments (Table 3), suggesting that environmental factors like soil temperature, moisture levels, and crop

Table 3 Effect of plant growth regulators on incidence of disease in autumn planted potato during 2019–20 and 2020–21

Treatment	Late blight (%)				Scab (%)				Scurf (%)			
	Incidence		Severity		Incidence		Severity		Incidence		Severity	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
IBA_{100}	10.33 (3.36)	7.33 (2.87)	10.27 (3.35)	6.62 (2.76)	4.67 (2.37)	3.67 (2.15)	4.02 (2.24)	3.52 (2.12)	2.33 (1.82)	1.33 (1.52)	1.85 (1.68)	1.26 (1.50)
IBA_{200}	9.00 (3.16)	6.33 (2.69)	9.29 (3.20)	6.11 (2.66)	4.00 (2.22)	3.33 (2.07)	3.69 (2.15)	3.21 (2.04)	2.00 (1.72)	1.17 (1.47)	1.70 (1.64)	1.09 (1.44)
NAA_{25}	11.00 (3.46)	8.33 (3.05)	10.75 (3.42)	7.07 (2.84)	5.33 (2.21)	4.33 (2.30)	4.31 (2.30)	3.69 (2.16)	2.50 (1.87)	1.67 (1.63)	2.00 (1.73)	1.34 (1.52)
NAA_{50}	10.67 (3.41)	7.67 (2.94)	10.51 (3.39)	6.84 (2.80)	5.00 (2.44)	4.00 (2.23)	4.17 (2.25)	3.60 (2.14)	2.50 (1.87)	1.50 (1.58)	1.90 (1.70)	1.30 (1.51)
$Ethrel_{25}$	12.00 (3.60)	9.00 (3.16)	11.42 (3.52)	7.49 (2.91)	5.67 (2.58)	4.67 (2.37)	4.58 (2.35)	3.92 (2.21)	2.83 (1.95)	1.83 (1.68)	2.10 (1.76)	1.46 (1.56)
$Ethrel_{50}$	12.33 (3.64)	9.67 (3.26)	11.85 (3.58)	7.78 (2.96)	6.00 (2.64)	5.00 (2.44)	4.77 (2.40)	4.06 (2.24)	2.83 (1.95)	2.00 (1.73)	2.16 (1.77)	1.50 (1.58)
GA_{100}	9.33 (3.21)	6.33 (2.70)	9.36 (3.21)	6.10 (2.66)	4.33 (2.30)	3.33 (2.07)	3.69 (2.16)	3.19 (2.04)	2.17 (1.77)	1.17 (1.47)	1.70 (1.64)	1.13 (1.46)
GA_{200}	4.67 (2.37)	3.33 (2.07)	8.57 (3.09)	5.62 (2.57)	4.00 (2.22)	3.00 (2.00)	3.38 (2.08)	2.94 (1.99)	2.00 (1.72)	1.00 (1.41)	1.45 (1.56)	0.97 (1.40)
JA	11.33 (3.50)	8.33 (3.05)	10.75 (3.42)	7.13 (2.85)	5.33 (2.50)	4.33 (2.29)	4.35 (2.31)	3.69 (2.16)	2.67 (1.90)	1.67 (1.62)	2.00 (1.73)	1.38 (1.54)
WD	11.33 (3.50)	8.33 (3.05)	10.94 (3.45)	7.13 (2.85)	5.33 (2.50)	4.33 (2.29)	4.38 (2.32)	3.75 (2.18)	2.67 (1.91)	1.67 (1.62)	2.00 (1.73)	1.43 (1.55)
Control	11.67 (3.55)	8.67 (3.10)	11.24 (3.49)	7.33 (2.88)	5.33 (2.50)	4.67 (2.30)	4.48 (2.34)	3.85 (2.20)	2.83 (1.95)	1.83 (1.68)	2.05 (1.74)	1.42 (1.55)
CD (P=0.05)	(0.21)	(0.24)	(0.12)	(0.09)	NS	NS	NS	NS	NS	NS	NS	NS

Figures in parenthesis indicates arc sine transformation. NS, Non-significant. Treatment details are given under Materials and Methods.

rotation exerted a greater influence on scurf dynamics than growth regulators (Kumar *et al*. 2020). Similarly, Cwalina-Ambroziak *et al*. (2015) observed minimal effects of growth regulators on scurf in potatoes. Recent findings by Kumar *et al*. (2020) corroborate this, emphasizing the predominant role of environmental conditions in scurf management. This underscores the complexity of disease control strategies in potato cultivation, where the interplay between agronomic practices and natural conditions poses challenges. Understanding these dynamics is crucial for developing effective management approaches that consider not only the application of treatments but also the broader context of environmental factors influencing disease development and spread in potato crops.

Analysis of the data (Table 3) reveals that there were no significant discrepancies observed in the incidence of scab and the percentage severity across the various growth regulator treatments employed. Over the course of the study, the incidence of scab ranged from 4.00–6.00% in the initial year, followed by a range of 3.00–5.00% in the subsequent year. This consistency in scab occurrence suggests that factors such as soil *p*H levels, tillage techniques, fertilizer application methods, and irrigation practices might exert a more dominant influence on the prevalence of scab disease within the potato crop. Consequently, it appears that the application of growth regulators did not yield discernible effects on scab incidence, potentially due to the overriding influence of these environmental and management factors. Consistent with these findings, McIntosh and Bateman (1979) reported similar results, indicating that growth regulator applications did not exert a significant influence on scab incidence in potato crops. Furthermore, recent research by Clarke *et al.* (2020) introduced a noteworthy development, demonstrating that foliar application of auxin analogs effectively suppressed common scab occurrence in field conditions, regardless of the specific potato cultivar employed.

The findings of this study demonstrated that the application of plant growth regulators had a non-significant impact on the population dynamics of insect pests. Over the course of the two-year experimentation period, there were no significant variations observed in the incidence of scurf and scab among the different growth regulator treatments. Notably, foliar application of gibberellic acid (200 ppm) at 45 and 60 DAS significantly mitigated the incidence and severity of late blight in the seed potato variety Kufri Pukhraj, reducing late blight incidence to 4.67% in the first year and 3.33% in the second year. This suggests that while growth regulators do not directly affect insect pest populations, they can be effective in controlling certain fungal diseases, thereby improving crop health and yield.

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