

Impact of applying plant growth regulators topically on the frequency of illnesses and insect pests in autumn-planted seed potatoes (*Solanum tuberosum*)

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ABSTRACT

In order to investigate the impact of foliar application of plant growth regulators on insect-pest and disease incidence in potatoes (*Solanum tuberosum* L.) in subtropical circumstances, a field experiment was carried out in 2019–20 and 2020–21 at Punjab Agricultural University, Ludhiana, Punjab. On the potato cultivar, a randomized complete block design (RCBD) with three replications was used to evaluate 11 treatments, including the control. Pukhraj Kufri. The findings showed that, as compared to the untreated control, plant growth regulators such as GA3, IBA, NAA, ethrel, jeevamrit, and waste decomposer did not significantly affect the incidence of aphid, jassid, and whitefly populations. With the exception of late blight, illnesses like scab and scurf did not show any appreciable variations in the plant growth regulator's treatments. Gibberellic acid (200 ppm) applied topically at 45 and 60 days after sowing (DAS) dramatically decreased the frequency and severity of late blight in the seed potato variety Kufri Pukhraj.

Keywords: Potato, Whitefly, Late Blight, Jassid, Growth Regulators, and Aphid

Introduction

In India, potatoes (*Solanum tuberosum* L.) are a major cash crop that supports the country's economy and gives farmers a source of income (Ganga et al. 2021). The popularity of processed potato products and the desire to boost output are driving up demand for premium seed potatoes. Poor seed quality is still a big problem, however. Farmers often utilize their own preserved seed, which may not be adequately maintained or tested for disease, resulting in pest and disease infections that drastically lower output (Ranalli 1997). A research by Gupta and Nanda (2019) found that India's seed potato quality is often poor since there isn't enough certified seed. In addition to the prevalence of insect pests and illnesses, a number of constraints, especially in the subtropics, restrict potato output, including the availability of appropriate varieties, agro-techniques, high-quality seeds, and storage facilities (Sharma and Singh 2018). Maintaining cold temperatures, minimizing sunlight hours during the tuberization stage, having access to pest-free seeds, and taking steps to protect the plants are all necessary for effective seed potato cultivation. Potato plants are significantly impacted by temperature, rainfall, and photoperiod, among other abiotic elements (Singh 2002). Diseases in potato tubers are readily spread by biotic agents such as aphids, jassids, and whiteflies (Kumar et al. 2021).

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Chemical management is now the main strategy used to manage these insects, pests, and illnesses (Nauen and Elbert 2003). However, using a lot of pesticides to manage insect pests on potato crops is often not economical. Insecticides are sometimes ineffective against aphids because of their high capacity for reproduction and broad pesticide tolerance in most agricultural systems (Nauen and Elbert 2003). Therefore, it is necessary to investigate alternative pest control techniques. To address these problems, management strategies based on plant growth regulators (GRs) are essential (Van 2000). Growth regulators have an impact on the physiology of plants and may alter the shape and behavior of arthropods (Prado and Frank 2013). According to Sohal et al. (2006), GRs may modify host plant-insect interactions and agronomic aspects of plant development processes. In a similar vein, Kaur and Rup (2003) found that using growth regulators reduced the occurrence of sucking bugs. Thus, after the application of plant growth regulators, an experiment was designed to document the population dynamics of significant insect pests and illnesses associated with seed potato crops in subtropical circumstances.

METHODS AND MATERIALS

At Punjab Agricultural University in Ludhiana (30°56' N latitude and 75°52' E longitude), Punjab, a field experiment was carried out in 2019–20 and 2020–21. The Indo-Gangetic plains, located in Punjab's center

portion (Ludhiana), serve as the trial location. The climate is subtropical and semi-arid, with hot, dry summers (up to 46°C) and humid

monsoons (July–September), warm spring (February–March), and harsh winters (below 5°C with frost). receives 75% of the yearly 759 mm of precipitation during July and September. Neutral pH (7.20), normal electrical conductivity (0.30 m mhos/cm), medium organic carbon (0.45%), medium available nitrogen (288 kg/ha), high accessible phosphorus (26 kg/ha), and high potassium (335 kg/ha) were all present in the loamy sand soil. In the first two weeks of October, the crop was seeded using medium-sized (35–45 mm) seed tubers spaced 65 cm apart between rows and 15 cm inside rows. Throughout the two research years, no insecticides were applied to the experimental location. The experiment was conducted in a randomized complete block design (RCBD) comprised of 11 treatments, viz. IBA100, IBA (100 ppm); IBA200, IBA (200 ppm); NAA25, NAA (25 ppm); NAA50, NAA (50 ppm); Ethrel25, Ethrel (25 ppm); Ethrel50, Ethrel (50 ppm); GA100, GA3 (100 ppm); GA200, GA3 (200 ppm); JA, Jeevamrit (Prepared by mixing 10 kg cow dung + 10 liters cow urine + 2 kg jaggery + 2 kg gram flour + handful of soil in 200 liters of water and fermented for 5–7 days); WD, Waste decomposer (Prepared by mixing 2 kg jaggery + 30 g of waste decomposer in 200 liters of water and further diluting culture in the ratio of 1:3 with water) and C, Control (Water spray). Plant growth regulators were administered topically 45 and 60 days after sowing (DAS). Beginning at 45 DAS and continuing until the haulm cutting in both years, weekly statistics on the prevalence of sucking insect pests were collected. The topmost three leaves of the crop canopy from ten randomly chosen plants were used to calculate the number of aphids and jassids, whilst the top, middle, and lower leaves of ten randomly chosen plants were used to calculate the number of whiteflies.

The disease incidence statistics (scab, scurf, and late blight) were computed as follows:

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

The formula provided by Kumar et al. (2020) was used to record observations on the percentage of late blight and scurf severity. The formula outlined by Liu et al. (1995) was used to determine the severity of the scab. The severity of the illness was evaluated using the following technique; scab and scurf diseases often affect tubers during haulm cutting:

OUTCOMES AND TALK

Aphids, jassids, and whiteflies are common insect pests in potato farming that are known to seriously harm crop health and yield. These pests may seriously damage potato plants by feeding on their sap, which can result in symptoms including weakened vigor, stunted growth, and lower yields. In order to protect crop health and maximize production potential, effective pest management techniques are essential to reducing their impact. This calls for a comprehensive strategy that includes cultural practices, biological control techniques, and the sensible use of insecticides (Amiri et al. 2019).

The population of aphids (*Myzus* spp.) showed no fluctuation across the various plant growth regulator treatments over the two research years (47th–1st Standard Meteorological Week [SMW]) (Table 1). Regardless of growth regulator treatments, the lowest aphid population was recorded during the 47th SMW in 2019–20 and the 48th SMW in 2020–21. Aphid numbers grew as the crop season went on, peaking during the first SMW in 2020–21 and the 52nd SMW in 2019–20. During both research years (2019–21), seasonal mean aphid populations did not significantly change with different plant growth regulator treatments. Similarly, Li et al. (2020) observed that gibberellic acid treatments had no effect on the seasonal population dynamics of aphids in potato crops. Similarly, Bayram and Tonga (2018) found that growth regulator treatments had no effect on the number of sucking insects, including aphids. These results imply that growth regulators do not much affect aphid populations in potato crops, even if they may have an influence on other elements of crop development. Alternative approaches of controlling aphids in potato farming may need further investigation.

During the first and second years of the research, the jassid mean population varied between 1.45 and 1.74 and 1.23 and 1.49, respectively. Growth regulator treatments (47th–1st SMW) did not substantially alter the jassid (*Amrasca* spp.) population in any of the two research years (Supplementary Table 1). Regardless of the growth regulator treatments, the jassid population peaked between the 48th SMW in 2019–20 and 49th SMW in 2020–21. As the harvest season progressed, the population declined, reaching its lowest point during the 52nd SMW

in 2019–20

1st SMW in 2020–21. These findings are consistent with

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

findings of Samui and Roy (2007), who also noted that the use of growth regulators in potatoes had no discernible effect on the seasonal population incidence of insects, including jassids. Growth regulators may have an influence on certain elements of crop development, but they don't seem to have a significant effect on jassid populations in potato crops. Given their durability under various growth regulator treatments, further research may be required to examine other approaches for controlling jassid infestations in potato agriculture.

Statistical analysis: R studio software, created by Posit, a PBC firm, was used to statistically analyze the data.

By modifying planting density, rotation, and soil management, cultural activities prevent agricultural pests like whiteflies, upsetting pest cycles, and sustainably maintaining yields.

Table 1: Impact of plant growth regulators on aphid incidence in autumn-planted potatoes in 2019–20 and 2020–21 Treatment Aphid population (number/plant)

SMW, or standard meteorological week

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
IBA100		0.54	-	0.90	0.44	1.00	0.64	2.00	1.27	2.60	1.57	3.60	2.20	-
IBA200		0.50	-	0.84	0.40	0.94	0.60	1.87	1.20	2.47	1.50	3.40	2.10	-
NAA25		0.57	-	0.94	0.47	1.04	0.67	2.07	1.34	2.67	1.64	3.70	2.30	-
NAA50		0.54	-	0.90	0.44	1.00	0.64	2.00	1.27	2.60	1.57	3.60	2.20	-
Ethrel25		0.60	-	0.97	0.50	1.07	0.70	2.14	1.40	2.74	1.67	3.84	2.37	-
Ethrel50		0.60	-	1.00	0.50	1.10	0.70	2.20	1.40	2.80	1.70	3.90	2.40	-
GA100		0.50	-	0.84	0.40	0.94	0.60	1.87	1.20	2.47	1.50	3.40	2.10	-
GA200		0.47	-	0.80	0.37	0.90	0.57	1.80	1.14	2.40	1.44	3.30	2.00	-
JA		0.57	-	0.94	0.47	1.04	0.67	2.07	1.34	2.67	1.64	3.74	2.30	-
WD		0.57	-	0.94	0.47	1.07	0.67	2.14	1.34	2.70	1.67	3.77	2.34	-
Control		0.57	-	0.97	0.50	1.07	0.67	2.14	1.37	2.74	1.67	3.80	2.34	-
CD (P=0.05)	NS	-	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-

NS stands for non-significant. Details of the treatment are provided under Materials and Methods.

Table 2: Whitefly incidence in autumn-planted potatoes treated with plant growth agents in 2019–20 and 2020–21 Population of whiteflies (number/plant)

SMW, or standard meteorological week

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
IBA100		2.04	-	2.34	1.90	1.60	2.04	0.84	1.20	0.44	0.87	0.34	0.34	-
IBA200		1.94	-	2.24	1.87	1.50	2.00	0.77	1.10	0.40	0.80	0.30	0.30	-
NAA25		2.14	-	2.44	2.00	1.70	2.14	0.90	1.30	0.47	0.90	0.37	0.37	-
NAA50		2.10	-	2.40	1.97	1.64	2.10	0.87	1.24	0.44	0.87	0.34	0.34	-

Ethrel25	2.17	-	2.47	2.07	1.74	2.17	0.94	1.34	0.47	0.97	0.37	0.37	-
Ethrel50	2.20	-	2.50	2.07	1.77	2.20	0.97	1.37	0.47	0.97	0.37	0.37	-
GA100	1.94	-	2.24	1.87	1.50	2.00	0.77	1.14	0.40	0.80	0.30	0.30	-
GA200	1.84	-	2.14	1.74	1.40	1.87	0.70	1.00	0.37	0.77	0.27	0.27	-
JA	2.14	-	2.44	2.00	1.74	2.14	0.90	1.34	0.44	0.90	0.37	0.34	-
WD	2.17	-	2.44	2.00	1.74	2.14	0.94	1.34	0.44	0.90	0.37	0.34	-
Control	2.17	-	2.47	2.04	1.77	2.17	0.97	1.34	0.47	0.94	0.37	0.37	-
CD (P=0.05)	NS	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-

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

(Abubakar and others, 2022). The population of whiteflies (*Bemisia* spp.) did not significantly change with various growth regulator treatments (47th–1st SMW) over the experiment's two years (2019–21) (Table 2). Regardless of plant growth regulator treatments, the whitefly population peaked (2.50 and 2.07 number/plant) during the 48th SMW in 2019–20 and the 49th SMW in 2020–21. As the crop season went on, it declined, reaching its lowest population dynamics (0.27 and 0.20 number/plant) during the 52nd SMW in 2019–20 and the first SMW in 2020–21. Different growth regulator treatments did not substantially affect the seasonal mean population of whiteflies (1.12–1.38 during the first year and 0.97–1.22 during the second year, respectively). These results were supported by Yao et al. (2017), who suggested that agronomic treatments had no appreciable effect on the levels of whitefly infection in agricultural crops. The plant growth regulator treatments had a substantial impact on the occurrence and percentage severity of late blight. Applying GA200 topically resulted in the lowest frequency of late blight (Table 3). Ethrel50 had a considerably greater incidence (%) of late blight than all other treatments, with the exception of Ethrel25, C, WD, JA, and NAA25, which were statistically comparable to Ethrel50 in both study years. With the exception of Ethrel50, Ethrel25, WD, JA, and NAA25, all plant growth regulator treatments exhibited much lower late blight occurrences than the untreated control. GA200 had the noticeably lowest severity (8.57 and 5.62%) and was statistically comparable to GA100 and IBA200 in both years. Ethrel50 produced significantly greater severity (11.85 and 7.78%) than all other treatments, and it was statistically comparable to the untreated control in both years. According to Gilani et al. (2021), gibberellic acid increases phenolic content and activates enzymes linked to pathogen defense, such as polyphenol oxidase and peroxidase, creating systemic resistance to infections. In a similar vein, Glosek-Sobieraj et al. (2018) found that growth regulator treatments decreased the frequency and severity of late blight. According to Ding et al. (2013) and Pieterse et al. (2012), gibberellic acid's beneficial effects on the DELLA protein and salicylic acid signaling pathways, which control plant resistance to diseases, may be connected to the reduction in late blight incidence and severity. This implies that gibberellic acid may play a part in strengthening plant defenses against pathogens, providing information on agricultural disease control techniques. The prevalence and severity of scurf did not alter over the course of the two-year trial across different growth regulator treatments (Table 3), indicating that environmental parameters such as 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
IBA100	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)
IBA200	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)
NAA25	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)
NAA50	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)

Ethrel25	12.00	9.00	11.42	7.49	5.67	4.67	4.58	3.92	2.83	1.83	2.10	1.46
	(3.60)	(3.16)	(3.52)	(2.91)	(2.58)	(2.37)	(2.35)	(2.21)	(1.95)	(1.68)	(1.76)	(1.56)
Ethrel50	12.33	9.67	11.85	7.78	6.00	5.00	4.77	4.06	2.83	2.00	2.16	1.50
	(3.64)	(3.26)	(3.58)	(2.96)	(2.64)	(2.44)	(2.40)	(2.24)	(1.95)	(1.73)	(1.77)	(1.58)
GA100	9.33	6.33	9.36	6.10	4.33	3.33	3.69	3.19	2.17	1.17	1.70	1.13
	(3.21)	(2.70)	(3.21)	(2.66)	(2.30)	(2.07)	(2.16)	(2.04)	(1.77)	(1.47)	(1.64)	(1.46)
GA200	4.67	3.33	8.57	5.62	4.00	3.00	3.38	2.94	2.00	1.00	1.45	0.97
	(2.37)	(2.07)	(3.09)	(2.57)	(2.22)	(2.00)	(2.08)	(1.99)	(1.72)	(1.41)	(1.56)	(1.40)
JA	11.33	8.33	10.75	7.13	5.33	4.33	4.35	3.69	2.67	1.67	2.00	1.38
	(3.50)	(3.05)	(3.42)	(2.85)	(2.50)	(2.29)	(2.31)	(2.16)	(1.90)	(1.62)	(1.73)	(1.54)
WD	11.33	8.33	10.94	7.13	5.33	4.33	4.38	3.75	2.67	1.67	2.00	1.43
	(3.50)	(3.05)	(3.45)	(2.85)	(2.50)	(2.29)	(2.32)	(2.18)	(1.91)	(1.62)	(1.73)	(1.55)
Control	11.67	8.67	11.24	7.33	5.33	4.67	4.48	3.85	2.83	1.83	2.05	1.42
	(3.55)	(3.10)	(3.49)	(2.88)	(2.50)	(2.30)	(2.34)	(2.20)	(1.95)	(1.68)	(1.74)	(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**.

Growth regulators had less of an impact on scurf dynamics than rotation (Kumar et al. 2020). In a similar vein, Cwalina-Ambroziak et al. (2015) found that growth regulators had no influence on potato scurf. This is supported by recent research by Kumar et al. (2020), which highlights the critical role that environmental factors play in scurf control. This highlights how difficult it is to manage disease in potato farming due to the interaction of agronomic techniques and environmental factors. Developing efficient management strategies that take into account not just the administration of remedies but also the larger context of environmental variables impacting disease development and dissemination in potato crops requires an understanding of these dynamics. According to an analysis of the data (Table 3), there were no significant differences in the percentage severity and occurrence of scab between the several growth regulator treatments used. During the trial, the incidence of scab varied between 4.00 and 6.00% in the first year and between 3.00 and 5.00% in the second. This regularity in scab recurrence raises the possibility that variables including soil pH levels, tillage procedures, fertilizer application strategies, and irrigation techniques may have a greater impact on the prevalence of scab disease in potato crops. As a result, it seems that the use of growth regulators had no appreciable impact on the incidence of scab, perhaps because these environmental and management variables had a greater influence. Growth regulator sprays did not significantly affect the incidence of scab in potato crops, according to McIntosh and Bateman's (1979) findings. Furthermore, independent of the particular potato cultivar used, recent study by Clarke et al. (2020) presented an important advance, showing that foliar treatment of auxin analogs significantly inhibited common scab incidence in field circumstances.

The results of this investigation showed that the population dynamics of insect pests were not significantly affected by the use of plant growth regulators. The incidence of scurf and scab did not significantly vary amongst the various growth regulator treatments over the two-year trial period. In the seed potato variety Kufri Pukhraj, foliar treatment of gibberellic acid (200 ppm) at 45 and 60 DAS greatly reduced the frequency and severity of late blight, bringing it down to 4.67% in the first year and 3.33% in the second. This implies that growth regulators might be useful in managing certain fungal infections, hence enhancing crop health and productivity, even while they do not directly impact insect pest populations.

CITATIONS

Abubakar M, Koul B, Chandrashekar K, Raut A, and Yadav D. 2022. A overview of whitefly (*Bemisia tabaci*) management (WFM) techniques for sustainable agriculture. 2019. Amiri A N and Bakhsh A. Agriculture 12: 1317. An efficient method of controlling insect pests and herbicides in potatoes. 3 Biotech 9(1): 16–20. Tonga A. and Bayram A. (2018). Wheat pests and beneficial insects are affected by cis-jasmone treatments: The impact of dosages and plant development stages. Clarke C R, Tegg R S, Thompson H K, Frederick C, Haynes K G, Kramer M, and Wilson C R. Crop Protection 105: 70–9. 2020. For certain potato varieties, low-dose foliar applications of the auxin analog 2,4-D improve root growth and lessen powdery and common scab. Crop Protection 136: 105208.

- Kowalska E, Glosek-Sobieraj M, and Cwalina-Ambroziak B. 2015. the impact of plant growth regulators on potato disease frequency and severity. *Polish Journal of Natural Science* 30(1): 5–20.
- In 2013, Ding Y, Wei W, Wu W, Davis, R E, Jiang Y, Lee I M, Hammond R W, Shen L, Sheng J P, and Zhao Y. Gibberellic acid's function in protecting tomatoes against potato purple top phytoplasma infection. 191–99 in *Annals of Applied Biology* 162(2).
- Das M K, Ganga G, and Raju B M K. 2021. An economic study of India's potato industry. 252–63 in the *Indian Journal of Agricultural Economics*, 76(2).
- Ullah I, Mohamed H I, Sajid M, Shah S T, Gilani S A Q, and Basit A. 2021. In *Pyrus communis* L. Gesunde Pflanzen 73: 395–406, gibberellic acid and boron improve yield quality, phenolic content, and antioxidant activity.
- Hamouz K, Cwalina-Ambroziak B, and Glosek-Sobieraj M. 2018. Growth regulators and biostimulators' effects on potato health, yield, and yield components (*Solanum tuberosum*). *Gesunde Pflanzen* 70: 1–11.
- Nanda S. and Gupta A. 2019. India's seed potato industry: current state, obstacles, and prospects. *Potato Journal* 46(1): 1–17.
- Rup P. and Kaur R. 2003. *Bactrocera cucurbitae* (Coquillett), the melon fruit fly, is affected by four plant growth regulators. *Tropical Insect Science International Journal* 23: 121–25.
- Chawla N, Kaur J, Aulakh C S, and Kumar V. 2020. Potato (*Solanum tuberosum*) tuber quality and production are affected by nutrition management. 65: 337–43, *Indian Journal of Agricultural Sciences*.
- Kumar V, Kooner R, Aulakh C S, and Kaur J. 2021. Effects of weather and nutrition on insect pest population dynamics in potatoes (*Solanum tuberosum*). *Journal of Agricultural Sciences in India* 91: 1690–94.
- Li J, Zhang W, Li H, Li X, Ma D, and Ma Y. 2020. Applying gibberellic acid increases potato resistance to aphids by upregulating genes linked to defense. *Plant Growth Regulation Journal* 39(2): 522–31.
- Liu D, Kinkel L G, and Anderson N A. 1995. Using antagonistic *Streptomyces* scabies, potato scab is biologically controlled in the field. *Phytopathology* 85: 827–31.
- Bateman and McIntosh, A. H. 1979. effects of daminozide foliar sprays on potato common scab incidence. 29–38 in *Annals of Applied Biology* 92(1).
- Elbert A. and Nauen R. (2003). Imidacloprid resistance in *Myzus persicae* and *Aphis gossypii* (Hemiptera: Aphididae) is being monitored across Europe. *Entomological Research Bulletin* 93(1): 47–54.
- Hormonal regulation of plant immunity, Pieterse C M, Van der Does D, Zamioudis C, Leon-Reyes A, and Van Wees S C. 2012. *Cell and Developmental Biology Annual Review* 28: 489–521.
- Frank S. D. and Prado S. G. (2013). Plant growth's tritropic effects aphid-parasitoid system regulators. 72–76 in *Biological Control* 66.
- P. Ranalli. 1997. novel approaches to seed tuber multiplication initiatives. *Research on Potatoes* 40: 439–53.
- Roy A. and Samui R C. 2007. Potato growth, yield, and natural enemies are all impacted by growth regulators. Sharma S and Singh B P. *Journal of Crop and Weed* 3: 35–6. 2018. Systems for producing potato seeds: before and today. *Journal of Potatoes* 45(1): 1–16.
- Singh I. P. (2002). *Production of Vegetable Crop Seeds*. Aman Meerut, India: Publication House.
- Rup P, Arora G, and Sohal S. 2006. Plant growth regulator (PGR) cytokinin's effect on the activity of several metabolic enzymes in *Lipaphis erysimi* nymphs (Kalt.). *Environmental Biology Journal* 27: 217.
- Van L. J. C. (2000). A pesticide-free greenhouse: real or imagined? *Crop Protection* 19: 375–84.
- Zheng Y, Huang X Y, and Yao F L. 2017. *Bemisia tabaci* biotype and pesticide resistance dynamics in China's Fujian province from 2005 to 2014. 7: 40803 in *Scientific Reports*.