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SHORT NOTE

SEED POTATO GROWTH AND YIELD AFFECTED BY PLANT GROWTH REGULATORS UNDER SEED PLOT TECHNIQUE

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Potatoes, found as a dietary staple in numerous countries across the globe, inherently harbour a genetic capacity to produce substantial biomass within a limited timeframe per unit of land. In India, farmers have consistently cultivated this crop, even amidst significant price volatility and a scarcity of cold storage facilities. The commercial propagation of potatoes primarily relies on tubers, which serve as the pivotal foundation for projecting yields and concurrently constitute approximately 40% of the total cultivation expenses. This crop demands substantial inputs, particularly a significant quantity of seed tubers, for successful cultivation. The crop's overall performance hinges on the metabolic processes of the plant, especially during its growth and developmental stages. To address the challenge of achieving maximum production and productivity, plant growth regulators play a crucial role, even though they are needed in relatively small quantities. Research has shown that plant growth regulators can influence growth and contribute significantly to increasing yields by 10-15%, either by suppressing or stimulating plant growth (Birbal *et al*., 2009). The growth and development of the seed potato are mainly due to the accumulation of photosynthates and the response of available nutrients, which are regulated by the different hormonal balances in the plant system and can be modified by their external application. Out of the various plant growth regulators, gibberellins and auxins are primarily responsible for the growth and development of plants (Tekalign *et al*., 2005). Rafeekher *et al*., (2002) have shown that gibberellic acid is an important plant growth regulator that can be used to influence growth, yield and quality of potato. Singh *et al*., (2005) studied the effects of gibberellic acid and 1-nephthalene acetic acid (NAA) on the growth and productivity of seed potato at Potato Research Station, Gwalior and observed increment in tuber yield by 18 percent with gibberellic acid application. The gibberellic acid gave a significantly higher number and weight of seed size (20-80g) tubers as compared to all other treatments. Alexopoulos *et al*., (2006) observed the effect of gibberellic acid and its time of application on the growth of potato at Agricultural University of Athens, Greece and reported that the application of gibberellic acid increased the number of tubers per plant in potato. Therefore, this current investigation was initiated to explore the impact of foliar application of various plant growth regulators on the growth and yield of seed potato tubers.

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A field experiment was conducted for two consecutive years in randomized complete block design with cultivar *Kufri Pukhraj* at the Research Farm, School of Organic Farming, Punjab Agricultural University, Ludhiana, during the autumn seasons of 2019-20 and 2020-21. The experimental field's soil composition was characterized by a loamy sand texture, with a pH level within the normal range at 7.2 and electrical conductivity measuring 0.30 ds/m. Soil fertility analysis revealed that it possessed a medium organic carbon content of 0.50%, along with 288 kg/ha of available nitrogen. Additionally, the soil exhibited high levels of available phosphorus at 26 kg/ha and potassium at 335 kg/ha. The eleven growth regulation treatments were Control (Water spray), IBA [Indole-3-butyric acid] (100 ppm), IBA (200 ppm), NAA [1-Naphthaleneacetic acid] (25 ppm), NAA (50 ppm), Ethrel (25 ppm), Ethrel (50 ppm), GA_3 [Gibberellic acid] (100 ppm), GA_3 (200 ppm), 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) and Wastedecomposer (Prepared by mixing 2 kg jaggery + 1 bottle (30g) of waste decomposer in 200 litres of water and further diluting culture in the ratio of 1:3 with water). The treatments were applied at 45 and 60 days after sowing. Prior to field preparation, 50 tons per hectare of farmyard manure were applied, followed by pre-planting irrigation. The seed tubers of the Kufri Pukhraj variety were subjected to treatment with Monceren fungicide and allowed to sprout in a well-ventilated room at room temperature (20°C) for one week. These well-sprouted tubers were then planted in October, with a row spacing of 65 cm and a plant-to-plant spacing of 15 cm. The experimental layout featured plots measuring 3.25 m × 3.45 m, each containing 115 plants. Immediately after planting, irrigation was administered to enhance emergence, followed by five additional irrigations up to the point of seed crop harvesting. The necessary nutrients, consisting of 187.5 kg of nitrogen, 62.5 kg of P_2O_5, and 62.5 kg of K_2O per hectare, were supplied through urea, single superphosphate, and muriate of potash. At the time of sowing, half of the nitrogen dose and the full doses of phosphorus and potassium were applied, while the second nitrogen dose was top-dressed at 30 days after sowing (DAS). No insecticide was applied to the crop during both the years at both the locations (Ludhiana and Jalandhar). Plant height and leaf area index (LAI) were measured in each plot, with data collected from five randomly selected plants within each treatment during manual haulm cutting (86 DAS during 2019 and 87 DAS during 2020). Tuber and haulm weights were recorded using electronic balances from three randomly selected uprooted plants in each treatment during haulm cutting. Following the January harvest, the total yield of tubers and haulm for each net plot (6.72 m^2) was weighed.

The plant height at 45 DAS did not vary significantly with different growth regulation treatments during both the years of study as the first application of growth regulators was made at this stage i.e., 45 DAS (Table 1). However, at 60 DAS, the significantly higher plant height than all the treatments were secured with the application of GA_{200} (63.0 and 65.4 cm during the first and second year, respectively). Notably, the lowest plant height (35.3 and 39.5 cm during the first and second year, respectively) was acquired with $Ethrel_{50}$ than all the other treatments, except being statistically at par with $Ethrel_{25}$ and control during both the years. All the treatments except ethrel, jeevamrit and wastedecomposer had significantly higher plant height than the control. These findings

Table 1: Effect of plant growth regulators on plant height and leaf area index

Treatment*	Plant height				Leaf area index			
	45 DAS		60 DAS		45 DAS		60 DAS	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Control	34.5	36.2	40.0	43.8	1.80	1.99	2.29	2.50
IBA_{100}	34.3	37.0	53.1	55.6	1.79	1.96	3.03	3.18
IBA_{200}	33.4	35.7	55.8	58.1	1.75	1.92	3.19	3.32
NAA_{25}	33.2	37.3	46.6	48.3	1.73	1.98	2.66	2.76
NAA_{50}	35.0	36.9	48.7	51.0	1.81	1.94	2.79	2.92
$Ethrel_{25}$	34.7	37.6	38.1	42.4	1.78	1.96	2.18	2.42
$Ethrel_{50}$	34.6	37.1	35.3	39.5	1.77	1.98	2.02	2.26
GA_{100}	34.1	36.6	56.4	58.4	1.79	1.91	3.22	3.34
GA_{200}	33.5	36.9	63.0	65.4	1.77	1.92	3.60	3.74
Jeevamrit	33.2	37.4	44.0	46.5	1.74	1.91	2.52	2.66
Wastedecomposer	33.3	36.8	42.8	46.4	1.76	1.97	2.44	2.65
LSD (p=0.05)	NS	NS	6.1	6.7	NS	NS	0.34	0.38

*The subscripts in treatments are ppm values

closely align with those of Birbal *et al.*, (2009), who similarly asserted that gibberellic acid applied externally during the early tuberization phase improved plant height. The LAI at 45 DAS did not vary significantly with different growth regulation treatments during both the years (Table 1). However, at 60 DAS, the significantly highest LAI than all the treatments were obtained with application of GA_{200} (3.60 and 3.74 during the first and second year, respectively). Significantly, lowest LAI (2.02 and 2.26 during the first and second year, respectively) was acquired with $Ethrel_{50}$ than all the other treatments, except being statistically at par with $Ethrel_{25}$ and control during both the years of study. Similarly, Mallick *et al.,* (2009) also reported an increment in LAI with growth regulation treatments.

The tuber weight per plant at 45 days after sowing (DAS) showed no significant variation among different growth regulator treatments in both study years (Table 2). However, at 60 DAS, the application of GA_{200} resulted in significantly higher tuber weight per plant compared to all other treatments, with values of 192.5 g and 201.1 g during the first and second years, respectively. Conversely, the lowest tuber weight per plant was significantly obtained with $Ethrel_{50}$, measuring 132.2 g and 143.0 g during the first and second years, respectively. This weight was lower than all other treatments, except for $Ethrel_{25}$ and the control, which were statistically similar in both study years. These findings closely align with those of Alexopoulos *et al.*, (2007), who similarly noted a considerable increase in fresh potato weight with the administration of gibberellic acid when compared to the control and other growth regulators. The haulm weight at 45 DAS did not vary significantly with different growth regulation treatments during both the years of study. However, at 60 DAS, the significantly higher haulm weight per plant than all the other treatments were secured with the application of GA200 (96.2 and 102.3 g during the first and second year, respectively). The lowest haulm weight per plant (58.4 and 64.4 g during the first and

Table 2: Effect of plant growth regulators on tuber and haulm weight

Treatment*	Tuber weight (g/plant)				Haulm weight (g/plant)			
	45 DAS		60 DAS		45 DAS		60 DAS	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Control	47.8	48.9	142.8	152.9	51.7	55.0	64.2	69.5
IBA_{100}	45.6	48.1	168.8	176.8	51.3	55.4	83.5	86.8
IBA_{200}	48.0	50.3	176.6	184.3	51.4	56.9	86.7	92.2
NAA_{25}	47.6	49.5	158.6	165.1	50.9	55.9	70.9	75.2
NAA_{50}	48.3	51.1	162.6	170.4	52.4	54.9	76.0	80.1
$Ethrel_{25}$	46.8	48.0	139.2	150.1	51.8	55.5	61.3	66.9
$Ethrel_{50}$	46.7	49.9	132.2	143.0	51.9	55.9	58.4	64.4
GA_{100}	47.7	49.9	175.7	183.1	50.9	54.8	84.8	90.8
GA_{200}	47.8	52.3	192.5	201.1	51.5	56.5	96.2	102.3
Jeevamrit	46.2	49.5	153.9	161.7	51.5	56.5	70.0	74.6
Wastedecomposer	46.0	49.9	150.0	159.5	52.3	55.8	68.2	73.6
LSD (p=0.05)	NS	NS	14.6	16.0	NS	NS	8.5	9.2

* The subscripts in treatments are ppm values

second year, respectively) was acquired with $Ethrel_{50}$ than all the other treatments, except being statistically at par with $Ethrel_{25}$ and control during 2019-20 and with $Ethrel_{25}$, control and wastedecomposer during 2020-21. These results are in close conformity with El-Aal *et al*., (2008), who also reported an increase in shoot weight with the foliar application of gibberellic acid in potatoes.

Total tuber yield differed significantly with different growth regulation treatments (Table 3). The significantly higher tuber yields (322.7 and 329.9 q ha^{-1} during the first and second year, respectively) than all the other treatments were obtained with the application of GA_{200}, which produced 34.9 and 31.5 percent higher tuber yields as compared to untreated control. Significantly lowest tuber yields (221.5 and 234.5 q ha^{-1} during the first and second year, respectively) were observed with $Ethrel_{50}$ than all the other treatments except $Ethrel_{25}$, control and wastedecomposer, which were statistically at par with $Ethrel_{50}$. However, IBA_{200}, GA_{100}, and IBA_{100}, statistically at par with each other, were significantly better than the control. The IBAs performed better than the NAAs among auxins. The $Ethrel_{25}$, jeevamrit and wastedecomposer statistically at par with each other, had a non-significant influence on total tuber yield. All the growth regulation

Table 3: Effect of plant growth regulators on tuber number and tuber yield

Treatment*	Tuber yield (q/ha)	
	2019-20	2020-21
Control	239.2	250.9
IBA_{100}	282.8	290.1
IBA_{200}	295.9	302.4
NAA_{25}	265.8	270.9
NAA_{50}	272.4	279.5
$Ethrel_{25}$	233.3	246.3
$Ethrel_{50}$	221.5	234.5
GA_{100}	294.5	300.3
GA_{200}	322.7	329.9
Jeevamrit	257.9	265.3
Wastedecomposer	251.3	261.6
LSD (p=0.05)	24.4	25.8

*The subscripts in treatments are ppm values treatments except $Ethrel_{50}$, $Ethrel_{25}$, jeevamrit and wastedecomposer had significantly higher tuber yield than control. Similarly, Birbal *et al.*, (2009) reported the highest total tuber yield with the gibberellic acid application compared to other growth regulators.

The growth and yield attributes *viz.* plant height, leaf area index, tuber weight $plant^{-1}$ and haulm weight $plant^{-1}$ were significantly higher with foliar application of GA (200 ppm) than all the other treatments during both the years. The significantly lowest values of these parameters were secured with the foliar application of $Ethrel_{50}$. Significantly higher total tuber yields were obtained with foliar application of gibberellic acid (200 ppm) at 45 and 60 days after sowing.

CONFLICT OF INTEREST

The authors confirm that this manuscript has no conflict of interest

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