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Effect of growth regulators on growth, seed yield and quality attributes in garden pea (*Pisum sativum* var *Hortense*) cv. Pusa Pragati

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ABSTRACT

The effect of foliar sprays of plant growth regulators (PGRs), viz. NAA (10, 15 and 20 ppm), GA_3 (50, 75 and 100 ppm) and kinetin (10, 15 and 20 ppm) at 25 and 35 DAS was evaluated on growth, yield and seed quality attributes in garden pea (*Pisum sativum* var *Hortense*) cv. Pusa Pragati under field condition. Plant morphology was affected by spray of the three PGRs at vegetative stage. Plant height increased with increase in concentration of GA_3 and kinetin, albeit NAA. However, GA_3 did not influence the number of primary branches/plant, which were significantly increased by kinetin and NAA. GA_3 had a profound effect on hastening the initiation of flowering by 3-5 days over water sprayed control, whereas other plant growth regulators did not affect the days to flowering. The seed quality parameters did not increase significantly on increasing the concentration of PGRs except seedling length and vigour index I. Application of GA_3 led to best quality of harvested seed. Protein, N, P, Cu, Fe and Mn content of seeds increased with increase in concentration of kinetin and NAA. GA_3 had no significant effect on nitrogen and crude protein content of seed but markedly increased K, Cu, Fe and Mn content. Maximum P content in seed was observed in plants sprayed with NAA. No significant change was observed in Zn content with either plant growth regulator.

Key words: Garden pea, Growth regnlators, GA_3, NAA, Kinetin, Seed yield, Seed quality

Garden pea (*Pisum sativum* var. *hortense* L.) is one of the most popular vegetable crops grown all over the world, both for fresh market and canning. It is highly nutritive and contains high proportion of digestible protein, carbohydrates, minerals and vitamins (Sharma 2010). It is grown commercially as a winter crop in the northern Indian plains and as an early crop in the mid hills and popular off-season vegetable crop grown in north-western Himalayan region in India (Sharma *et al.* 2014). India ranks second after China, in terms of area and production, however it occupies third position in the world in productivity, after UK and Egypt. Garden pea is grown in an area of 4.2 lakh ha with annual productivity of 9.5 t/ha in India. At the state level, Uttar Pradesh contributes about 47% of the total garden pea production having highest productivity among Indian states. Other major garden pea growing states are Madhya Pradesh, Jharkhand, Himachal Pradesh and Punjab.

Despite having lot of potential to feed and nourish the increasing population, it has received very less attention compared to other legumes which may be one of the reasons for no improvement in its productivity. Effect of plant growth regulators (PGRs) on growth and seed yield in many legumes have been studied (Basuchaudhuri 2016) but information on garden pea is scarce. PGRs are believed to be involved in nodulation in garden pea (Chan and Gresshoff 2009) and may also have potential to improve the growth and seed yield. Keeping these facts in view, an experiment on garden pea variety Pusa Pragati was conducted at ICAR-IARI, New Delhi during 2014-15 and 2015-16 to find out the effect of plant growth regulators on growth, yield and seed quality attributes.

MATERIALS AND METHODS

Plant material and experimental conditions: The seeds of garden pea variety Pusa Pragati were obtained from the seed production unit of ICAR-IARI, New Delhi. Two field experiments were conducted at the research farm of ICAR-IARI, New Delhi during two successive winter seasons of 2014-15 and 2015-16. The experimental plot size was 5×2 m^2 with 8 rows/plot and 25 cm row to row spacing. Basal recommended dose of N, P_2O_5 and K_2O in the ratio 20:40:50 kg/ha was applied to each plot. All the treatments were replicated thrice in randomized block design. Seed rate for sowing was 125 kg/ha. The treatments comprised

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Table 1 Effect of PGRs on growth parameters of garden pea cv. Pusa Pragati

Treatment		Plant height (cm)			Primary branches/plant			Days to flowering		
PGR	Conc. applied	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Kinetin	10 ppm	63.83^{F}	66.30^{DE}	65.07^{F}	2.90^{C}	3.10^{ABC}	3.00^{B}	44.67^{A}	43.67^{A}	44.17^{A}
	15 ppm	71.00^{D}	69.27^{CD}	70.13^{DE}	3.43^{B}	3.63^{A}	3.53^{A}	45.00^{A}	44.00^{A}	44.50^{A}
	20 ppm	71.33^{D}	73.87^{C}	72.60^{D}	3.80^{A}	3.17^{ABC}	3.48^{A}	45.00^{A}	44.67^{A}	44.83^{A}
GA_3	50 ppm	87.27^{C}	89.13^{B}	88.20^{C}	2.70^{C}	2.97^{BC}	2.83^{BC}	39.67^{B}	40.33^{B}	40.00^{B}
	75 ppm	97.07^{B}	99.90^{A}	98.48^{B}	2.37^{DE}	2.63^{C}	2.50^{D}	39.00^{B}	39.33^{B}	39.17^{B}
	100 ppm	104.20^{A}	101.90^{A}	103.05^{A}	2.17^{E}	2.57^{C}	2.37^{D}	39.67^{B}	38.00^{B}	38.83^{B}
NAA	10 ppm	66.97^{E}	69.90^{CD}	68.43^{E}	3.27^{B}	3.53^{AB}	3.40^{A}	43.67^{A}	45.00^{A}	44.33^{A}
	15 ppm	69.47^{D}	70.87^{CD}	70.17^{DE}	3.40^{B}	3.50^{AB}	3.45^{A}	44.00^{A}	45.33^{A}	44.67^{A}
	20 ppm	60.50^{G}	62.60^{E}	61.55^{G}	3.30^{B}	3.40^{AB}	3.35^{A}	45.67^{A}	44.33^{A}	45.00^{A}
Control	Water sprayed	54.47^{H}	55.93^{F}	55.20^{H}	2.40^{D}	2.63^{C}	2.52^{CD}	43.67^{A}	45.33^{A}	44.50^{A}
Mean		74.61	75.97	75.29	2.97	3.11	3.04	43	43	43
LSD (P= 0.05)		2.288	5.5625	2.7541	0.2237	0.6161	0.3193	3.823	2.8206	2.19

of three levels each of GA_3 (50, 75 and 100 ppm), NAA (10, 15 and 20 ppm) and kinetin (10, 15 and 20 ppm) along with water sprayed as control. Foliar application of all the doses of growth regulators was done twice; one before flowering (25 DAS) and another at onset of flowering (35 DAS) with freshly prepared solutions of NAA, GA_3 and kinetin of different concentrations.

Growth and yield attributes: Data was recorded on plant height, days to flowering, number of primary branches/plant, number of pods/plant, pod length, number of seeds/pod, seed yield/plant, seed index, seed germination percentage, seedling length, seedling dry weight, seedling vigour indices, electrical conductivity and nutrient contents in seeds from 10 randomly selected plants from each replicate /treatment.

Statistical analysis: The average values were used for the statistical analysis. Statistical analysis was carried out using Statistical Analysis Software version 9.3 (SAS 9.3). Data were subjected to analysis of variance and means were compared. Conclusions were drawn only on significant differences between the treatment mean at 0.05 level of probability. The least significant difference test was used to decipher the effect of treatments at 5% level of significance (P=0.05).

RESULTS AND DISCUSSION

Growth parameters: Data on the growth parameters of garden pea (cv. Pusa Pragati) under the effect of applied growth regulators are presented in Table 1. Results showed that application of the three growth regulators (kinetin, GA_3 and NAA) resulted in a significant increase in plant height and number of primary branches/plant compared with control plants in both successive winter seasons.

Plants sprayed with GA_3 recorded maximum height followed by kinetin and NAA. Increasing the concentration of GA_3 resulted in plants with a height of 88.2 cm, 98.48 cm and 103.05 cm at 50, 75 and 100 ppm respectively.

Table 2 Effect of PGRs on seed yield attributes of Pusa Pragati garden pea

Treatment		Pods/plant			Pod length (cm)			Number of seeds/pod			Seed yield/plant (g)		
PGR	Conc. Applied	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Kinetin	10 ppm	13.57^{E}	14.03^{E}	13.80^{EF}	9.02^{D}	8.85^{DE}	8.93^{D}	9.13^{CD}	9.30^{CD}	9.22^{CD}	21.94^{B}	22.41^{BC}	22.18^{B}
	15 ppm	16.70^{C}	17.93^{ABCD}	17.32^{BC}	9.23^{D}	9.30^{CDE}	9.27^{D}	9.10^{CD}	9.00^{D}	9.05^{DE}	21.45^{B}	21.77^{C}	21.61^{B}
	20 ppm	16.43^{C}	15.13^{CDE}	15.78^{CDE}	9.25^{D}	9.32^{CDE}	9.28^{D}	9.07^{CD}	9.13^{D}	9.10^{DE}	21.99^{B}	22.91^{B}	22.45^{B}
GA_3	50 ppm	19.73^{B}	18.83^{ABC}	19.28^{AB}	10.02^{C}	9.80^{BCD}	9.91^{C}	9.90^{A}	10.13^{A}	10.02^{A}	23.89^{A}	24.60^{A}	24.25^{A}
	75 ppm	21.67^{AB}	19.93^{A}	20.80^{A}	10.25^{BC}	10.68^{AB}	10.47^{AB}	9.50^{B}	9.87^{AB}	9.68^{AB}	24.15^{A}	24.57^{A}	24.36^{A}
	100 ppm	21.77^{A}	19.70^{AB}	20.73^{A}	10.60^{A}	10.82^{A}	10.71^{A}	9.30^{BC}	9.63^{BC}	9.47^{BC}	24.19^{A}	24.52^{A}	24.36^{A}
NAA	10 ppm	14.33^{DE}	15.00^{CDE}	14.67^{DE}	10.05^{C}	10.12^{ABC}	10.08^{BC}	9.00^{CD}	9.07^{D}	9.03^{DE}	22.39^{B}	22.06^{BC}	22.22^{B}
	15 ppm	15.87^{CD}	16.00^{BCDE}	15.93^{CD}	10.32^{B}	9.85^{ABC}	10.08^{BC}	9.10^{CD}	9.17^{D}	9.13^{CDE}	22.20^{B}	22.13^{BC}	22.17^{B}
	20 ppm	15.03^{CDE}	14.53^{DE}	14.78^{DE}	9.17^{D}	9.23^{CDE}	9.20^{D}	8.83^{D}	8.90^{D}	8.87^{E}	21.83^{B}	21.76^{C}	21.80^{B}
Control	Water sprayed	11.57^{F}	12.23^{E}	11.90^{F}	8.08^{E}	8.75^{E}	8.42^{E}	7.50^{E}	7.83^{E}	7.67^{F}	19.86^{C}	20.09^{D}	19.98^{C}
Mean		16.67	16.33	16.5	9.6	9.67	9.64	9.04	9.2	9.12	22.39	22.68	22.54
LSD (P=0.05)		1.9713	3.8938	2.1017	0.2593	0.9949	0.4623	0.3528	0.4535	0.3398	1.1947	1.1245	1.0862

However, water sprayed plants had a height of 55.2 cm only. This effect is explained as an effect of GA_3 on elongation of internodes (Krishnamurthy 1981). Huttly and Phillips (1995) also suggested that GA_3 causes an increase in cell number and size to produce a significant effect on growth. Similar results showing longer vine length were obtained with application of 100 ppm GA_3 than 50 ppm GA_3 in a study on variety Bonneville of garden pea (Thompson *et al.* 2015). Singh *et al.* (2015) used higher concentration of auxins (up to 45 ppm NAA) and gibberellins (200 ppm GA_3) on garden pea cv. Arkel and obtained an increase in height. The response was varied with respect to increase in hormone concentration in different varieties tested. The application of gibberellins to promote shoot elongation was also reported by Schroeder (2011) and Musmade *et al.* (2013). Number of primary branches/plant was maximum in foliar spray of kinetin with a concentration of 15 and 20 ppm (3.53 and 3.48 respectively) followed by NAA (Table 1). However, the response was not significant when the two growth regulators were compared although both were significantly higher than control. The application of GA_3 caused reduction in number of primary branches (2.37 at 100 ppm) or at par (2.50 at 75 ppm) with the control (2.52). Days to initiation of flowering were statistically at par for kinetin, NAA and control whereas days taken to 50% flowering were minimum in plants sprayed with any of the three concentrations of GA_3. The least number of days to 50% flowering was 38.67 days when plants were sprayed with 75 ppm of GA_3. Our results corroborated with the findings of Thompson *et al.* (2015) who recorded 48.97 days to first flowering by the treatment of 100 ppm GA_3 compared to NAA and control in Bonneville garden pea. They attributed the early flowering response to early completion of vegetative growth and better nourishment of the plants. These results are also supported by the findings of Medhi and Borbora (2002), Uddain *et al.* (2009), Chovatia *et al.* (2010) and Chatterjee and Choudhuri (2012).

*Yield parameters***:** Application of growth regulators significantly increased the yield parameters (number of pods/plant, pod length, number of seeds/pod and seed yield/plant) over the control (Table 2). Foliar spray of GA_3 recorded significantly higher values for yield parameters compared to either kinetin or NAA. Number of pods/plant was maximum (20.80) at 75 ppm GA_3 and minimum (13.80) at 10 ppm kinetin and it was higher than control (11.90). The number of pods/plant however increased with increasing GA_3 concentration, but the increase was not significant. Maximum pod length (10.71 cm) was recorded by the application of 100 ppm GA_3 followed by 75 ppm GA_3 (10.47 cm) while minimum (8.93 cm) by the application of 10 ppm kinetin which was at par with control (8.42 cm). However, the increase in pod length was similar with the application of growth hormone GA_3 at all concentrations and NAA at 15 ppm.

Maximum number of seeds/pod was obtained with 50 ppm GA_3 while maximum seed yield/plant (24.36 g) with treatments of 75 and 100 ppm GA_3. Thus, number of

Table 3 Effect of PGRs on seed quality attributes of Pusa Pragati garden pea

Treatment		Seed index (g)		Germination (%)			Seedling length (cm)			Seedling dry weight (mg)			Vigour index I		Vigour index II			EC (µS/cm/g)
PGR	Conc. applied	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	Pooled
Kinetin	10 ppm	25.31^{C}	25.47^{D}	25.39^{B}	97.33	96.67	97	25.69^{BC}	25.27^{CD}	25.48^{DE}	0.02^{CD}	0.03^{CD}	0.03^{C}	2499^{CD}	2441^{C}	2470DE	2.43^{CD}	2.51^{BC}	2.47^{C}	20.28^{BCD}
	15 ppm	26.02^{BC}	26.21^{CD}	26.12^{B}	97	96.67	96.83	26.19^{BC}	26.31^{BCD}	26.25^{CDE}	0.03^{BC}	0.03^{C}	0.03^{B}	2540^{BCD}	2543^{BC}	2542^{CDE}	2.94^{BC}	3.03^{B}	2.99^{B}	21.2^{AB}
	20 ppm	26.04^{BC}	26.38^{BCD}	26.21^{B}	97	96.67	96.83	27.45^{AB}	26.54^{BCD}	27.00^{BCD}	0.03^{BC}	0.03^{BC}	0.03^{B}	2663^{ABC}	2565^{BC}	2614^{BCD}	3.01^{BC}	3.09^{B}	3.05^{B}	21.377^{A}
GA3	50 ppm	26.64^{ABC}	26.43^{BCD}	26.54^{AB}	97.67	97.67	97.67	27.55^{AB}	27.08^{ABC}	27.32^{ABC}	0.04^{AB}	0.04^{AB}	0.04^{A}	2689^{AB}	2645^{AB}	2667^{ABC}	3.72^{AB}	3.81^{A}	3.76^{A}	19.9^{CD}
	75 ppm	27.19^{AB}	27.82^{A}	27.51^{A}	96.67	97	96.83	28.39^{A}	27.44^{AB}	27.92^{AB}	0.04^{A}	0.04^{A}	0.04^{A}	2744^{A}	2662^{AB}	2703^{AB}	3.83^{A}	3.98^{A}	3.91^{A}	18.21^{E}
	100 ppm	27.47^{A}	27.35^{AB}	27.41^{A}	97.67	97.67	97.67	28.74^{A}	28.50^{A}	28.62^{A}	0.04^{A}	0.04^{A}	0.04^{A}	2807^{A}	2784^{A}	2795^{A}	3.94^{A}	4.06^{A}	4.00^{A}	20.62^{ABC}
NAA	10 ppm	26.13^{ABC}	26.62^{BC}	26.38^{AB}	96.67	96.33	96.5	25.24^{C}	25.92^{BCD}	25.58^{DE}	0.03^{C}	0.03^{BC}	0.03^{BC}	2435^{D}	2496^{BC}	2466^{E}	2.67^{C}	2.73^{B}	2.70^{BC}	20.33^{BCD}
	15 ppm	26.07^{BC}	26.18^{CD}	26.13^{B}	96.67	96.67	96.67	25.85^{BC}	24.85^{D}	25.35^{E}	0.03^{C}	0.03^{C}	0.03^{B}	2498^{CD}	2402^{C}	2450^{E}	2.87^{C}	2.93^{B}	2.90^{B}	19.44^{D}
	20 ppm	26.18^{ABC}	26.17^{CD}	26.17^{B}	98.33	96.33	97.33	25.67^{BC}	25.26^{CD}	25.47^{DE}	0.03^{BC}	0.03^{C}	0.03^{B}	2523^{BCD}	2432^{C}	2478DE	2.98^{BC}	2.96^{B}	2.97^{B}	19.8^{CD}
Control	Water sprayed	23.54^{D}	23.21^{E}	23.38^{C}	95.33	95.33	95.33	22.90^{D}	22.29^{E}	22.59^{F}	0.02^{D}	0.02^{D}	0.02^{D}	2183^{E}	2124^{D}	2154^{F}	1.81^{D}	1.84^{C}	1.83^{D}	20.04^{CD}
	Mean	26.06	26.19	26.12	97.03	96.7	96.87	26.37	25.95	26.16	0.03	0.03	0.03	2558	2510	2534	3.02	3.09	3.06	20.12
LSD (P=0.05)		1.396	1.1198	1.1809	NS	NS	NS	1.9517	1.8666	1.5345	0.0077	0.0071	0.0039	170.79	189.47	147.22	0.7784	0.6851	0.3991	0.9704

seeds/pod and seed yield/plant was increased significantly over the control with the treatment of GA_3. The findings of this experiment are in line with the observation of Estruch *et al.* (1989) who reported that growth regulators may function in sucrose assimilation. Pereto *et al.* (1988) also reported that GA_3 is particularly important in growth and development of plants. Although, pod length increased with increasing concentration of GA_3, number of seeds/pod decreased significantly which indicates that there may be positive correlation of GA_3 with seed size. The seed yield/plant also increased with increasing concentrations of GA_3. There was no significant difference between the kinetin and NAA sprayed treatments with respect to seeds/pod and seed yield/plant.

*Seed quality attributes***:** Seed quality parameters (seed index, germination percentage, seedling length, seedling dry weight, seedling vigour indices and electrical conductivity) showed significant increase after the application of three growth regulators (Kinetin, GA_3 and NAA) over the control as shown in Table 3.

It is considered that seed index (100 seed weight) is an important seed quality parameter and plant growth regulators have a significant effect on 100 seed weight. Maximum value for seed index was obtained with GA_3 (27.51 g) followed by NAA and kinetin, however, the difference between these two growth hormones was not significant. Seed germination was not significantly affected by treatment with any of the plant growth regulators. Seedling length and seedling vigour index I were significantly increased with the application of GA_3 compared to kinetin and NAA and this increase was also significant with increasing concentration of GA_3. Seedling dry weight and seedling vigour index II were significantly

Table 4 Effect of PGRs on seed nutrient content of Pusa Pragati garden pea

Treatment		Protein (%)			N (%)			P (mg/kg of seed)			K (%)		
PGR	Conc. applied	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Kinetin	10 ppm	18.97^{BC}	18.83^{BCD}	18.90^{BC}	3.03^{BC}	3.01^{BCD}	3.02^{BC}	451.3^{CD}	441.3^{EF}	446.3^{DE}	0.98^{DE}	0.98^{DE}	0.98^{DE}
	15 ppm	19.42^{B}	19.11^{B}	19.27^{B}	3.11^{B}	3.06^{B}	3.08^{B}	477.0^{BCD}	471.3^{CD}	474.1^{C}	0.99^{CD}	0.99^{CD}	0.99^{CD}
	20 ppm	20.72^{A}	20.83^{A}	20.78^{A}	3.32^{A}	3.33^{A}	3.32^{A}	507.3^{AB}	501.3^{AB}	504.3^{B}	1.01^{BCD}	1.01^{BCD}	1.01^{BCD}
GA3	50 ppm	17.47^{EF}	17.55^{EF}	17.51^{EF}	2.80^{EF}	2.81^{EF}	2.80^{EF}	440.6^{D}	438.6^{F}	439.6^{E}	1.01^{BCD}	1.01^{BCD}	1.01^{BCD}
	75 ppm	17.78^{DE}	17.88^{DE}	17.83^{DE}	2.85^{DE}	2.86^{DE}	2.85^{DE}	468.8^{BCD}	468.0^{DE}	468.4^{CD}	1.02^{AB}	1.03^{AB}	1.02^{AB}
	100 ppm	17.87^{DE}	18.08^{CDE}	17.97^{DE}	2.86^{DE}	2.89^{CDE}	2.88^{DE}	488.0^{BC}	482.6^{BCD}	485.3^{BC}	1.04^{A}	1.04^{A}	1.04^{A}
NAA	10 ppm	18.35^{CD}	17.99^{CDE}	18.17^{CDE}	2.94^{CD}	2.88^{CDE}	2.91^{CDE}	477.6^{BCD}	476.6^{BCD}	477.1^{C}	1.00^{BCD}	1.00^{BCD}	1.00^{BCD}
	15 ppm	18.72^{BC}	18.45^{BCDE}	18.58^{BCD}	2.99^{BC}	2.95^{BCDE}	2.97^{BCD}	505.3^{AB}	499.3^{BC}	502.3^{B}	1.01^{BC}	1.01^{BC}	1.01^{BC}
	20 ppm	19.09^{BC}	18.86^{BC}	18.98^{BC}	3.05^{BC}	3.02^{BC}	3.04^{BC}	531.07^{A}	530.0^{A}	530.5^{A}	1.02^{ABC}	1.02^{ABC}	1.02^{ABC}
Control	Water sprayed	16.84^{F}	16.91^{F}	16.87^{F}	2.69^{F}	2.71^{F}	2.70^{F}	382.6^{E}	374.6^{G}	378.6^{F}	0.96^{E}	0.96^{E}	0.96^{E}
Mean		18.52	18.45	18.49	2.96	2.95	2.96	472.9	468.4	470.6	1.01	1	1
LSD (P=0.05)		0.7767	0.9546	0.8096	0.1243	0.1527	0.1295	42.369	28.93	24.741	0.0264	0.0281	0.0271

Table 5 Effect of PGRs on seed nutrient content of Pusa Pragati garden pea

Treatment		Cu (mg/kg of seed)			Fe (mg/kg of seed)			Mn (mg/kg of seed)			Zn (mg/kg of seed)		
PGR	Conc. Applied	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
Kinetin	10 ppm	101.87^{EF}	104.93^{BCD}	103.40^{DE}	129.40^{DE}	129.53^{D}	129.47^{DE}	113.40^{D}	113.20^{C}	113.30^{CD}	26.8	26.53	26.67
	15 ppm	103.47^{DE}	103.47^{CDE}	103.47^{DE}	134.87^{CD}	135.07^{CD}	134.97^{CD}	114.33^{C}	114.80^{ABC}	114.57^{BC}	25.93	26.13	26.03
	20 ppm	104.80^{CD}	104.87^{BCD}	104.83^{CD}	136.80^{CD}	136.87^{CD}	136.83^{CD}	115.53^{B}	115.33^{ABC}	115.43^{AB}	24.2	23.93	24.07
GA^3	50 ppm	106.67^{BC}	106.40^{ABC}	106.53^{BC}	139.33^{BC}	139.27^{BC}	139.30^{BC}	114.33^{C}	114.27^{ABC}	114.33^{C}	22.2	22.47	22.3
	75 ppm	108.40^{AB}	108.53^{AB}	108.47^{AB}	148.33^{A}	148.33^{A}	148.33^{A}	115.33^{B}	115.80^{AB}	115.33^{B}	20.93	20.87	20.9
	100 ppm	110.33^{A}	110.13^{A}	110.23^{A}	152.73^{A}	153.07^{A}	152.90^{A}	116.33^{A}	116.40^{A}	116.33^{A}	20.73	21.07	20.9
NAA	10 ppm	101.40^{EF}	101.27^{DE}	101.33^{EF}	135.47^{CD}	135.20^{CD}	135.33^{CD}	111.60^{F}	113.07^{C}	112.33^{D}	23.87	24.33	24.1
	15 ppm	103.27^{DE}	103.60^{CDE}	103.43^{DE}	136.60^{CD}	137.07^{CD}	136.83^{CD}	112.47^{E}	113.07^{C}	112.77^{D}	24.13	24.33	24.23
	20 ppm	105.20^{CD}	105.07^{BCD}	105.13^{CD}	146.80^{AB}	146.80^{AB}	146.80^{AB}	113.73^{D}	113.60^{BC}	113.67^{CD}	26.73	27.27	27
Control	Water sprayed	100.47^{F}	100.40^{E}	100.43^{F}	123.67^{E}	129.13^{D}	126.40^{E}	109.73^{G}	109.53^{D}	109.63^{E}	27.07	27.47	27.27
Mean		104.59	104.87	104.73	138.4	139.03	138.72	113.68	113.91	113.79	24.26	24.44	24.35
LSD (P=0.05)		2.1847	3.8224	2.6653	7.9865	8.4503	7.8421	0.5939	2.5035	1.4404	NS	NS	NS

higher with the application of GA_3 compared with kinetin and NAA, however unlike seedling vigour index I, effect of concentration of GA_3 was not significant. Application of growth regulators caused much variation in the electrical conductivity (EC) of seeds. Highest EC was recorded with the application of kinetin at 20 ppm concentration whereas lowest EC was observed with GA_3 at 75 ppm. Other concentrations of all the three plant growth regulators were at par with control.

*Seed nutrient contents***:** The nutrient content in the seeds were significantly increased by the application of three plant growth regulators (Table 4 and Table 5). The nitrogen and protein content were found to be maximum in the treatments with kinetin, followed by NAA and gibberellins and the values increased with increasing concentration of growth hormones.

Maximum protein (20.78%) and nitrogen content (3.32%) were found in the treatment with 20 ppm kinetin. Leopolda and Kriedeman (1975) reported that kinetin plays an important role in protein synthesis through activation of nucleic acid synthesis. Phosphorus content was found to be maximum (530.5 mg/kg seed) with 20 ppm NAA while potassium was found to be maximum (1.04%) at 100 ppm GA_3. The increasing hormone concentration had a significant positive effect on seed nutrient content. Copper, iron and manganese content was found maximum, i.e. 110.23, 152.90 and 116.33 mg/kg seed, respectively in the treatment with 100 ppm GA_3 and decreased insignificantly with decreasing concentration of hormones. No significant change was observed in zinc content with all the three hormone treatments and the values obtained were low as compared to control.

Conclusion

From the present investigation, it may be concluded that the foliar application of plant growth regulators (Kinetin, GA_3 and NAA) positively affected different growth and seed yield parameters such as plant height, number of primary branches, days to flowering, number of pods/plant, number of seeds/pod and 100-seed weight which ultimately contributed to increased growth, yield and seed quality parameters on the Pusa Pragati garden pea variety under New Delhi climatic condition. Among the three growth regulators, GA_3 gave the best results, particularly at 75 ppm for seed yield and quality parameters.

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