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Effect of plant growth regulators on growth characters of pea (*Pisum sativum* L.)

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Abstract
A field experiment entitled "Effect of Plant Growth Regulators on Growth and Yield of Pea (*Pisum sativum* L.)" was conducted during *rabi* season of 2023-24 at the Kalaghat Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan. The soil of experimental field was sandy loam in texture, neutral in reaction with EC in safer range, medium in organic carbon, nitrogen, phosphorus and potassium. The experiment was laid out in randomized block design comprising of nine treatments of plant growth regulators *viz*. (T_1) TRIA 0.5 ppm, (T_2) AUX 12 ppm (Auxin), (T_3) GA_3 12 ppm (Gibberellic acid), (T_4) CK 1.5 ppm (Cytokinin), (T_5) TRIA 0.5 + AUX 12 ppm, (T_6) TRIA 0.5 + GA_3 12 ppm, (T_7) TRIA 0.5 + CK 1.5 ppm, (T_8) TRIA 0.5 + AUX 12 + GA_3 12 ppm+ CK 1.5 ppm and (T_9) Control with three replications. Recommended dose of fertilizer (20:60:30 kg NPK ha^{-1}) were applied through urea, SSP and MOP at the time of sowing as basal dose. PB-89 variety of pea was used for sowing. Application of plant growth regulators were applied at 15 and 30 DAS as per treatment. Other crop management practices were followed as per the recommendation of the area. Significantly higher plant height, number of branches $plant^{-1}$, dry matter accumulation and crop growth rate of pea were observed with application of (T_8) TRIA 0.5 + AUX 12 + GA3 12 ppm + CK 1.5 ppm which was statistically at par with (T_6) TRIA 0.5 + GA3 12 ppm, respectively over rest of the treatments.

Keywords: Pea, foliar application, plant growth regulators

Introduction

Pea (*Pisum sativum* L.) is one of the important pulse and leguminous vegetable crop. It is also identified by many others names such as, field pea, garden pea, green pea, yellow pea, smooth pea, and wrinkled pea worldwide used for human and animal consumption (Tulbek *et al*., 2017) [19]. It is a member of Fabaceae family and self-pollinated diploid (2n=14) annual cool season pulse crop (McKay *et al*., 2003) [11]. It is one of the most important crops utilized as fresh or canned beans. Moreover, it is nutritious food stuff when fully matures and they are valuable food legume, often being ground into flour and used extensively in the manufacturing of soups. Fresh green pea is almost universally accepted as a nutritious vegetable (Rezene *et al*., 2015) [18]. It is often called "poor man's meat" due to its high protein, vitamin and mineral and prebiotic carbohydrate content (Amarakoon *et al*., 2012; Kandel *et al*., 2016) [1, 9]. Dried pea contains 18 to 28.4 per cent protein, 60.7 per cent carbohydrate, 1.4 per cent crude fiber, 1.4 per cent fat and 2.7 per cent ash (Hulse, 2000) [8]. Green pea are a good source of vitamins A, B and C and other important gradients such as minerals, riboflavin and carotene.

Some well-tested and proven security enhancements are still a concern for many developing countries. Being productive is paramount to feeding millions of hungry people. In the field of agriculture, the one of most recent development to boosting up crop production is the use of plant growth regulators. Plant growth regulators are chemicals that are naturally biosynthesized in plants and influence physiological processes. Numerous biochemical and physiological processes involved in plant growth and development are triggered by their synthetic analogues (Bagher *et al*., 2021) [3]. Plant growth regulators (PGRs) are known to play an important role in improving the physiological efficiencies of plants such as root growth, increasing number of flowers, fruit size, inducing early and uniform fruit ripening, including their photosynthetic capacity, and achieving higher yields. PGR are also known to improve the source-sink relationship and stimulate the movement of photoabolites to improve productivity.

Some plant growth regulators like gibberellic acid (GA_3) help to promote cell elongation or increase the maturity of plant (Khan *et al*., 2002; Bora and Sarma, 2003; Rahman *et al*., 2004) [10, 5, 16], number of pods plant^{-1}, pod and seed weight (Pandey *et al*., 2004; Chaurasiy *et al*., 2014; Mulagund *et al*., 2015) [13, 6, 12] whereas, Triacontanol has been well documented for their essential roles in plants response to abiotic stresses such as acid mist, chilling, drought, heavy metal, and salt stress. Cytokinin also impede plant senescence by inhibiting the decomposition of chlorophyll, nucleic acid, proteins, and other substances in plants. The spike in pea acreage in recent years has created a severe shortage in seed supply and a greater disparity between production and total seed demand. Any attempt to increase the quantity and quality of seed per unit area, where appropriate, to minimize the disparity between seed supply and demand. Hence, three is urgent need to boost up the seed yield per unit area.

Materials and Methods

The experiment was carried out during *rabi* season of 2023-24 at the Kalaghat Agriculture Farm (Located at 1,270 mean above sea level, latitude 30º 51’26.9 N and longitude 77º 09’29.6 E), MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan. The soil of experimental field was sandy loam in texture, neutral in reaction with EC in safer range, medium in organic carbon, nitrogen, phosphorus and potassium. The experiment was laid out in randomized block design comprising of nine treatments of plant growth regulators *viz*. (T_1) TRIA 0.5 ppm (Triacontanol), (T_2) AUX 12 ppm (Auxin), (T_3) GA_3 12 ppm (Gibberellic acid), (T_4) CK 1.5 ppm (Cytokinin), (T_5) TRIA 0.5 + AUX 12 ppm, (T_6) TRIA 0.5 + GA_3 12 ppm, (T_7) TRIA 0.5 + CK 1.5 ppm, (T_8) TRIA 0.5 + AUX 12 + GA_3 12 ppm+ CK 1.5 ppm and (T_9) Control (Water spray) with three replications. Recommended dose of fertilizer (20:60:30 kg NPK ha^{-1}) were applied through urea, SSP and MOP at the time of sowing as basal dose. PB-89 variety of pea was used for sowing. Application of plant growth regulators were applied at 15 and 30 DAS as per treatment. Other crop management practices were followed as per the recommendation of the area. The data relating to each character will be statistically analyzed with standard method of analysis of variance as suggested by Panse and Sukhatme (1984) [14].

Results and Discussion

Data on growth characters as influenced by the various plant growth regulators are presented in Table 1 to 4. Significantly higher plant height (54.16 cm), number of branches plant^{-1} (5.83), dry matter accumulation (10.03 g plant^{-1}) and crop growth rate (0.20 g plant^{-1} day^{-1}) were recorded under foliar application of (T_8) TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm which was statistically at par with (T_6) TRIA 0.5 + GA_3 12 ppm at 30 DAS. Similar trend was also observed at 60, 90, 120 DAS and at harvest. However, least value of growth characters was recorded under control treatment during course of study.

Increase in plant height might be due to that TRIA by itself has no remarkable effect on the growth and yield of pea, only when TRIA is combined with other plant growth regulators such as AUX, GA_3 and CK increased plant height. The positive interaction of TRIA and GA_3 that triacontanol potentiates the effects of GA_3. AUX at low concentrations inhibit stem growth in favor of root growth and development. The height of the plant is a visible measurement of growth and is a function of the internodal elongation and the increasing number of nodes plant^{-1}. The emergence of the leaves on the stem, the development of the leaf and the biomass show close relationship with plant height Dhage *et al*. (2011) [7] and Ayyub *et al*. (2013) [2]. Application of CK 1.5 ppm increased the branching of the shoots and the number of branches in the plants. This might be due to the application of plant growth regulators which enhanced the physiological phenomena and nutrients uptake which leads to increased number of branches. Prakash *et al*. (2003) [15] reported that the application of mepiquat chloride at 120 ppm increased number of branches plant^{-1}. Growth regulators are known to improve the physiological efficiencies including photosynthetic ability and can enhance the effective partitioning of accumulates from source and sink in the field crop (Ramesh and Ramprasad, 2013) [17]. The hormonal effect of triacontanol and its role in growth promoting processes has been reported to increase yield of dry matter reported by Vyas *et al*. (2000) [20]. Increase in crop growth rate might be due to better absorption of nutrients applied through plant growth regulators leading to better activity of functional root, resulting in increasing more leaf area, dry matter production and uptake of nutrients increases the plant dry weight (Banerjee *et al*., 2012) [4].

Table 1: Periodic plant height (cm) of pea as influenced by plant growth regulators

Treatments	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
TRIA 0.5 ppm	43.50	49.61	67.46	95.58	97.41
AUX 12 ppm	48.44	56.55	76.48	106.59	108.63
GA_3 12 ppm	46.30	53.43	72.23	101.42	103.53
CK 1.5 ppm	41.40	46.56	63.32	90.49	91.20
TRIA 0.5 + AUX 12 ppm	50.00	60.29	82.43	114.16	116.33
TRIA 0.5 + GA_3 12 ppm	51.70	62.96	85.79	118.87	121.10
TRIA 0.5 + CK 1.5 ppm	49.52	58.65	79.85	110.49	112.72
TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm	54.16	66.3	90.48	124.22	126.66
Control	31.87	35.31	51.91	73.38	74.55
S.Em ±	1.35	1.49	1.81	1.89	1.98
LSD (p = 0.05)	4.03	4.48	5.44	5.65	5.94

Table 2: Number of branches plant^{-1} of pea as influenced by plant growth regulators

Treatments	Number of branches plant^{-1}				
	30 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
TRIA 0.5 ppm	4.48	6.07	9.43	13.17	14.17
AUX 12 ppm	4.93	6.45	9.67	13.67	14.51
GA_3 12 ppm	4.53	6.40	9.53	13.50	14.33
CK 1.5 ppm	4.40	6.03	9.17	13.00	14.00
TRIA 0.5 + AUX 12 ppm	5.30	7.18	10.17	14.31	15.31
TRIA 0.5 + GA_3 12 ppm	5.43	7.45	10.27	14.72	15.38
TRIA 0.5 + CK 1.5 ppm	5.07	7.07	9.87	14.03	15.03
TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm	5.83	7.57	11.60	14.80	15.47
Control	4.20	6.00	9.00	11.33	12.00
S.Em ±	0.24	0.34	0.44	0.63	0.65
LSD (p = 0.05)	0.72	1.03	1.31	1.88	1.96

Table 3: Dry matter accumulation (g plant^{-1}) of pea as influenced by plant growth regulators

Treatments	Dry matter accumulation (g plant^{-1})				
	30 DAS	60 DAS	90 DAS	120 DAS	At - harvest
TRIA 0.5 ppm	4.51	8.41	15.61	27.31	31.39
AUX 12 ppm	5.42	9.82	17.62	30.22	35.50
GA_3 12 ppm	5.22	9.32	17.00	29.30	34.10
CK 1.5 ppm	4.25	7.75	14.65	25.75	29.35
TRIA 0.5 + AUX 12 ppm	7.72	12.62	22.00	35.80	41.56
TRIA 0.5 + GA_3 12 ppm	8.41	14.01	24.21	39.21	45.93
TRIA 0.5 + CK 1.5 ppm	6.40	11.10	19.50	32.70	37.74
TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm	10.03	15.93	26.73	42.33	49.63
Control	4.11	7.31	13.61	23.51	26.54
S.Em ±	0.35	0.44	0.54	0.92	0.97
LSD (p = 0.05)	1.06	1.18	1.63	2.76	2.92

Table 4: Crop growth rate (g plant^{-1} day^{-1}) of pea as influenced by plant growth regulators

Treatments	Crop growth rate (g plant^{-1} day^{-1})			
	30-60 DAS	**60-90 DAS**	**90-120 DAS**	**120-At harvest**
TRIA 0.5 ppm	0.13	0.24	0.39	0.17
AUX 12 ppm	0.15	0.26	0.42	0.22
GA_3 12 ppm	0.14	0.25	0.41	0.20
CK 1.5 ppm	0.12	0.23	0.37	0.15
TRIA 0.5 + AUX 12 ppm	0.16	0.31	0.46	0.24
TRIA 0.5 + GA_3 12 ppm	0.19	0.34	0.5	0.28
TRIA 0.5 + CK 1.5 ppm	0.16	0.28	0.44	0.21
TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm	0.20	0.36	0.52	0.30
Control	0.11	0.21	0.33	0.12
S.Em ±	0.01	0.01	0.01	0.01
LSD (p = 0.05)	0.02	0.03	0.04	0.04

Conclusion

Marked improvement in growth parameters were observed with application of (T_8) TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm which was statistically at par with (T_6) TRIA 0.5 + GA_3 12 ppm over rest of the treatments. This study suggests that the application of TRIA 0.5 + AUX 12 + GA_3 12 + CK 1.5 ppm followed by TRIA 0.5 + GA_3 12 ppm significant improvement in growth characters of pea under mid-hills of Himachal Pradesh.

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