Research Article

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Effect of growth regulators on the growth and yield of ginger (*Zingiber officinale* Rosc.) under polyhouse condition

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Abstract

The experiment has been conducted to resolve the poor partitioning of dry matter towards rhizome by using plant growth regulators (PGRs). Therefore, two pot culture experiments were conducted during 2020-22 using the variety IISR Varada to investigate the effects of foliar application of PGRs (6-BAP, cycocel, GA3 and PBZ at five different concentrations viz. control, 50ppm, 100ppm,150ppm and 200ppm in three replications) on growth and yield. The experiment was laid out in Factorial CRD design under polyhouse condition. The results revealed that 6-BAP at 100ppm significantly increased the number of tillers, secondary rhizomes, tertiary rhizomes, length, diameter of rhizomes, and rhizome yield (322.3g/ plant) which is 240% more than the control.

Keywords: Plant growth regulators, growth, yield

Introduction

Zingiber officinale R. (culinary ginger) is a monocotyledonous rhizomatous plant that belongs to the family Zingiberaceae, commercial spice known for its aroma, flavour and pungency (Sasikumar, 1996). Ginger is one of the major sources of spice and medicine since ancient times in India (Purseglove *et al*., 1981). The year 2020-2021 witnessed an export of 2.22 Mt of ginger from India having an area of production of 0.204 Mha. Several reasons are attributed to decreasing productivity, among which urbanization, land degradation and disease incidence played major role. However, the demand for quality seed rhizomes is on the increase. Adoption of a poly house system of cultivation is desirable for a crop like ginger for better production. However, due to the heavy canopy, there is a reduction in the translocation of assimilates to the rhizomes. The issue of partitioning of assimilates among the various plant organs could be solved to some extent with the help of plant growth regulators. Kishore *et al.,* (2015) reported the residual effect of the Paclobutrazol, such that it is considered moderately hazardous for human beings with remote chance of being genotoxic and carcinogenic. The optimized use of the paclobutrazol offers maximum benefit with least undesirable effect. Application of the 100 ppm GA, when applied twice i.e. one month after planting and 15 days after 1st flowering, proved to

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be best among the chemicals evaluated for vigour, generative characters and yield in strawberry (Surya Narayan 2014). Several plant growth regulators (PGRs) are tested in ginger crop to improve source sink relationship (*Maruthi et al*., 2003). Therefore, strategies have been designed to enhance the assimilate partitioning in ginger by using different PGRs. This study was aimed to evaluate the effectiveness of different PGRs chemicals at various concentrations for improving yield and yield attributing parameters in ginger crop.

Materials and methods

Planting materials and growth conditions

Pot culture experiment was conducted during the period of two years (June 2020 to May 2022) at ICAR-Indian Institute of Spices Research, Kozhikode (Longitude 75.78° E, latitude 11.25°N) under the poly house conditions. The average temperature, light intensity, the humidity of the polyhouse was 20-30 ºC, 200 to 800 k lux, and 60-70%, respectively during the cropping period. IISR Varada, a good quality, high yielding variety with an average yield 22.6 tha^{-1}, essential Oil (1.75%) and oleoresin (6.7%) was selected for the study. Healthy 25 g ginger rhizomes (cv. IISR Varada) were planted in the polythene bags (40x40 inch) containing potting mixture (soil, sand and farmyard manure in a 2:1:1). Samples of potting mixtures were analyzed for initial nutrient status by following standard procedures. Nitrogen and phosphorous contents were determined by using Kjeldhal method (AOAC,1999) and Bray method, respectively. The potassium and the micronutrient content were determined by using Lindsay & Norvell (1978). Soil organic matter was determined by using Walkley-Black method (1934). Physio-chemical characteristics of the soil *viz*. texture: sandy loam, pH: 4.48, E.C: 506.3 µs, available N, P and K 170.8, 4. and 245ppm, respectively were documented. Cultural operations were performed following the package of practices recommended by ICAR-IISR, Kozhikode. Rhizomes were treated with mancozeb 0.3% before sowing in poly bags. Hence disease incidence was less. However slight infections of leaf eating caterpillar were noticed in some plants, and the disease was managed by spraying chlorantraniliprole (0.01%) as soon as the infection was noticed.

Uniform plants were maintained in each treatment with three replications under factorial CRD. Four different types of hormones were used for the experiment *viz;* cycocel, paclobutrazol, gibberellin (GA_3), and 6-benzyl amino purine (BAP) at four different concentrations 0(control),50 ppm, 100ppm, 150ppm and 200ppm from each hormone. The growth regulators were applied as a foliar spray with specific surfactants at 120 DAP.

Growth and yield attributes

The growth parameters such as plant height and number of tillers were recorded at 150DAP. The yield characters were recorded at the time of harvest by uprooting the plant carefully and the fresh weight of rhizomes was weighed. Number of primary, secondary, and tertiary rhizomes, length, and diameter of the rhizome were observed after cleaning the rhizomes.

Statistical analysis

The compiled data was subjected to analysis of variance and Duncan's multiple range tests to study the differences in means as described by Duncan. Values were considered at a significance level of 95 % ($p< 0.05$). Statistical analyses were performed using SAS 9.3 using Factorial CRD design. The mean values of the two years' data have been considered for the presentation of results and discussion.

Materials and methods

Plant height and tillers

The plant growth regulators influence the physiology of the plants and thereby create both positive and negative impacts. Cytokinins, N6-substituted adenine derivatives, had a major impact on the growth and physiology of plants. BAP, it antagonizes the action of auxin and suppress the stem height, direct application to the plant improves the cell division, ultimately improves the plant bushiness (Khalil *et al.,*2021). In the present study, the rhizome morphology and yield recorded have shown significant differences among the PGRs treatments. Plant growth is accelerated by GA_3, which also speeds up cell division and lengthening, thereby helping the internode and stem to grow longer (Taiz and Zeiger 2002). In present study the effect of plant growth regulators on height of ginger was found significant (Table 1). The maximum height (87.1 cm) was recorded by GA_3 at 50ppm followed by GA_3 at 150ppm during the first year. During the second year, GA_3 at 100 ppm recorded maximum height (115.1 cm) followed by GA_3 at 150ppm (104.7 cm). The elongation of stem due to the application of GA_3 might be due to the increased mitotic activity possibly through the increased production of auxin in the meristematic region (Arney *et al.* 1966). Also, with an increase in the concentration of growth regulators a decrease in the height of ginger plants observed. This result was supported by Sengupta *et al.* (2008) who noticed that reduction in height of plants due to increased concentration of growth regulators application in ginger. BAP increased the tiller production and yield due to its cytokinin effects which stimulates the cell division and increased cell number. Local applications of kinetin and BAP, promotes the tiller bud proliferation in cereals (Clifford and Langer, 1975). Application of PGRs significantly increased the number of tillers in ginger (Fig.1). Among the treatments, the maximum number of tillers was recorded in 6-BAP at 150 ppm (4.16) followed by 6-BAP at 50 ppm (4.0) than that observed in control.

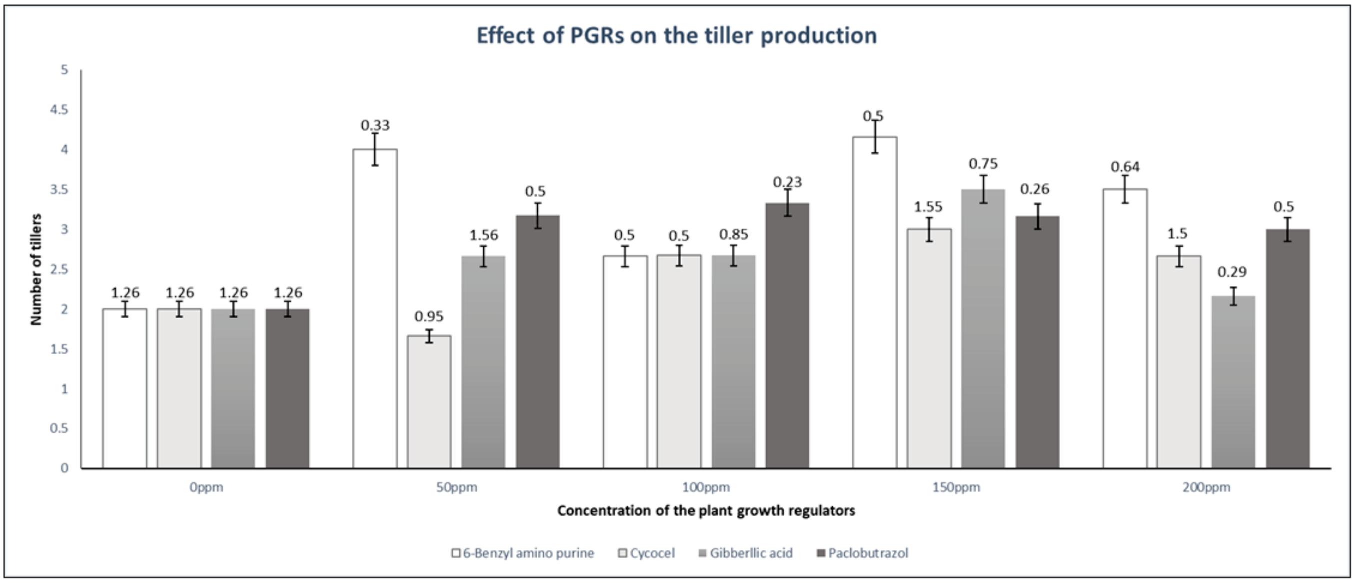

Fig. 1: Effect of growth regulators on tiller production in ginger

Table 1: Effect of PGRs on height (cm) of ginger

Source/ concentration	0	50 ppm	100 ppm	150 ppm	200 ppm	Mean	0	50 ppm	100 ppm	150 ppm	200 ppm	Mean	Pooled mean
		First year								Second year			
6-BAP	39.2	50.9	49.1	58.2	45.7	48.6	65.2	95.1	89.5	98.5	92.7	88.2	68.40
Cycocel	30.1	53.9	61.6	58.8	40.7	49.0	60.1	94.3	102.5	101.7	101.5	92.0	70.51
GA_3	25.9	87.1	64.9	73.8	50.3	60.4	56.6	106.0	115.1	104.7	94.8	95.5	77.95
PAC	32.6	67.2	65.7	73.6	61.7	60.2	76.9	84.5	95.3	83.3	73.0	80.3	70.25
Mean	31.9	64.5	60.3	66.2	49.6		64.7	97.5	100.6	97.1	80.5	82.6	
Hormone (p=0.05)	1.16						0.87						0.65
Concentration (p=0.05)	1.15						0.71						0.66
H*C(p=0.05)	2.35						1.53						1.35

H-Hormone C- Concentration

Yield

The application of 6-BAP promotes plant growth, increases the chlorophyll and soluble protein contents in plant leaves, delay senescence, and regulate the transportation and allocation of nutrients and leads to improved yield (To and Kieber, 2008). In the present study, during first year the maximum yield was reported in 6-BAPat 100 ppm (343.5g plant^{-1}) followed by paclobutrazol at 100 ppm (284.6g plant^{-1}). In the second year, maximum yield was reported in 6-BAPat 100 ppm (301.1g plant^{-1}) followed by paclobutrazol at 100ppm (285.3g plant^{-1}). The lowest yield was recorded in control in both the years. Muluken Bezabih *et al.* (2017) also reported that the application of 6-BAP at 150 ppm in ginger increases yield.

The effect of PGRs on the production of primary rhizomes is shown in Table 3. The production of primary rhizomes was found to be non-significant. The PGRs increased the production of secondary rhizomes significantly and the maximum number of secondary rhizomes was observed in treatment cycocel at 200ppm (16.00) followed by 6-BAP at 150 ppm (15.67) (Table. 4). The present study showed that that foliar spray of BAP at 150ppm (4.16) significantly enhanced production of tertiary rhizomes (10.9) (Table. 5).

Regarding the length of the rhizome, maximum rhizome length was reported in the treatment of 6-BAP at 150ppm (11.9 cm) (Table 6). The maximum diameter of rhizomes was observed in the treatment of GA_3 at 100ppm (2.51cm) (Table7).

The highest yield in ginger following the application of 6-BAP at 150 ppm could be due to the positive influence of the yield characters such as increased rhizome weight, number of tertiary rhizomes, increased length and girth.

Table 2: Effect of PGRs on yield of ginger (g)/ plant

Source/ concentration	0	50 ppm	100 ppm	150 ppm	200 ppm	Mean	0	50 ppm	100 ppm	150 ppm	200 ppm	Mean	Pooled mean
	First year						Second year						
6-BAP	90.0	218.5	325.5	325.5	255.0	242.9	94.3	293.4	301.1	294.9	265.3	249.8	246.4
Cycocel	87.0	188.3	110.3	110.3	141.6	127.5	100.8	155.5	152.6	156.3	210.6	155.1	141.3
GA_3	97.0	210.3	178.0	178.0	212.6	175.2	95.4	227.8	245.7	231.5	255.1	211.0	193.1
PAC	80.0	245.1	284.6	284.4	281.6	235.2	103.8	255.8	285.3	230.6	252.9	225.7	230.5
Mean	78.5	215.6	224.6	224.5	222.7		97.0	233.2	246.0	228.3	219.8		87.8
Hormone (p=0.05)	1.37						2.41						1.24
Concentration (p=0.05)	1.93						2.01						1.37
H*C(p=0.05)	3.71						4.32						2.74

Table 3: Effect of PGRs on the number of primary rhizomes in ginger

Source/ concentration	**0**	**50 ppm**	**100 ppm**	**150 ppm**	**200 ppm**
6-BAP	4.67	5.33	4.33	5.33	6.00
Cycocel	3.82	6.83	4.83	6.00	6.33
GA_3	4.21	5.33	5.66	6.00	5.67
PAC	4.84	5.16	6.50	6.16	6.67
Mean	4.38	5.66	5.45	5.87	6.16
H (p=0.05)	NS				
C (p=0.05)	0.87				
H*C(p=0.05)	1.61				

Table 4: Effect of PGRs on the number of secondary rhizomes in ginger

Source/ concentration	**0**	**50 ppm**	**100 ppm**	**150 ppm**	**200 ppm**
6-BAP	5.40	11.67	8.38	15.67	10.00
Cycocel	6.33	14.33	10.66	8.00	16.00
GA_3	6.40	10.67	8.33	12.33	6.67
PAC	7.50	9.33	4.67	8.33	12.33
Mean	6.40	11.50	8.01	11.08	11.25
CD* H (0.05)	1.10				
CD C (0.05)	1.83				
C D H* C (0.05)	3.44				

Table 5: Effect of PGRs on the number of tertiary rhizomes in ginger (Unit: cm)

Source/ concentration	0	50 ppm	100 ppm	150 ppm	200 ppm
6-BAP	1.53	4.00	2.66	4.16	3.50
Cycocel	1.66	2.08	2.67	3.00	3.16
GA_3	1.33	2.66	2.54	3.50	3.16
PAC	2.10	3.17	3.33	3.16	3.00
Mean	1.65	2.97	2.80	3.45	3.20
CD* H (0.05)	2.07				
CD C (0.05)	1.84				
C D H* C (0.05)	3.88				

H-Hormone C- Concentration

Table 6: Effect of PGRs on the length of rhizomes in ginger (Unit: cm)

Source/ concentration	0	50 ppm	100 ppm	150 ppm	200 ppm	Mean of hormones
6-BAP	6.37	10.65	12.43	11.9	9.47	10.16
Cycocel	6.16	9.82	9.38	10.05	11.21	9.32
GA_3	5.40	8.88	8.80	10.95	8.70	8.70
PAC	5.21	11.28	8.80	4.48	9.96	8.74
Mean	5.78	10.15	9.85	10.34	9.83	
CD* H (0.05)	0.24					
CD C (0.05)	0.21					
C D H* C (0.05)	0.44					

H-Hormone C- Concentration

Table 7: Effect of PGRs on the diameter of rhizomes in ginger (Unit: cm)

Source/ concentration	0	50 ppm	100 ppm	150 ppm	200 ppm	Mean
6-BAP	1.44	2.06	1.85	2.07	1.94	1.87
Cycocel	1.50	1.89	1.93	1.87	2.32	1.90
GA_3	1.00	2.31	2.51	1.91	1.97	1.94
PAC	1.14	1.98	2.36	1.87	1.94	1.85
Mean	1.27	2.06	2.16	1.93	2.04	
CD* H (0.05)	0.08					
CD C (0.05)	0.11					
C D H* C (0.05)	0.22					

H-Hormone C- Concentration

Conclusion

Plant growth and the production can be manipulated with the time, concentration and type of plant growth regulator used and the environmental factors also plays a major role. In general, from the experiments it can be concluded that the application of BAP in ginger could improve the yield (240%) and the production of ginger due to its action on cell division. From the experimental results, it could be concluded that 6- BAP at 100 ppm as foliar spray in ginger is a suitable growth regulator for better growth and rhizome yield. Among the PGRs, a maximum Benefit:Cost (1.30) was observed with the application of benzyl adenine at 100ppm followed by GA3 (1.2) and paclobutrazol (1.19), respectively and no benefit was noticed in cycocel (0.80) treatment.

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