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Phenology of radish (*Raphanus sativus* L.) var. Pusa Chetki as affected by seed priming of plant growth regulators (GA_3, NAA, IAA and SA)

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ABSTRACT

The present investigation was carried out at S.G.College of Agriculture and Research Station, Jagdalpur, Bastar (C.G.) during *Rabi* season of 2022. The experiment was laid out in randomized block design with three replications and thirteen treatments comprising of GA_3 (5,10 and 15 ppm), NAA (10, 20 and 30 ppm), IAA (20, 25 and 30 ppm), Salicylic acid (15, 30 and 45 ppm) and control (no growth regulator) to improve various growth and yield contributing parameters of radish. The result revealed highest days to 50% germination (5.33 days), plant height (35.95 cm), root length of plant (24.40 cm), root diameter (3.73 cm), fresh weight of root (133.51 g), dry weight of root (18.41 g), root yield (24.38 t ha^{-1}), TSS (5.53 °Brix) and antioxidants (21.14 mg/100g^{-1}) with the pre-treatment of GA_3 15 ppm.

Key words: *Radish, Seed priming, GA_3, NAA, IAA, Salicylic acid (SA).*

Introduction

Radish (*Raphanus sativus* L.) belongs to the family Cruciferae (2n=18). It has originated from the Central and Western China and India. It is mainly grown in West Bengal, Madhya Pradesh, Bihar, Uttar Pradesh, Karnataka, Punjab, Maharashtra and Assam. In India, it is cultivated in an area of 202 m ha with an annual production of 3145 MT (NHB, 2019). According to the Directorate of Horticulture and Farm Forestry (2021) the area and production of white radish in Chhattisgarh was 13,431 ha and 244,364 MT respectively.

Radish is a good source of vitamin-C (14.8 mg per 100 g of edible portion) and supplies variety of minerals. The characteristic pungent flavour of radish is due to is isothiocyanate (Kushwah, 2019). Radish is considered as an appetizer. Its roots have anti-diabetic properties and are relished for its pungent flavour. It is useful in liver and gall bladder troubles. In homoeopathy, radish is used for neuralgic headache, sleeplessness and chronic diarrhoea and the roots are said to be useful in urinary complaints, piles and gastrodynia (Brintha and Seran, 2009 and Dhananjaya, 2007).

The growth regulators are used in different ways in radish however seed priming is adopted majorly. Several reports on regulatory effects of PGR's on plant growth and development shows that some of them can be used to enhance crop yield. GA_3 is known to increase the seed germination percentage whereas NAA is basically used for vegetative

(*Research Scholar, [1]Scientist, [2]Scientist, [3]Scientist) growth particularly flowering. NAA at higher concentrations also enhances the yield in radish (Singh *et al*., 1989). Salicylic acid (SA) is recognized as an endogenous regulator of plant metabolism mainly involved in biotic and abiotic stress. Exogenous application of SA manipulates various physiological, biochemical and molecular processes in plants including antioxidative enzyme activities (Idrees *et al*., 2011).

Materials and Methods

The investigation was carried out at Research Field of AICRP on Palms, S.G. College of Agriculture and Research Station, Jagdalpur, Bastar (C.G.) during *Rabi* season, 2022. Soil of the field was slightly acidic in nature with pH 6.8 with 0.56 kg ha^{-1} organic carbon. The experiment was laid out in randomized block design (RBD) with three replications having 13 different treatments. The experimental material for the present investigation comprised of thirteen treatments which was laid in randomized block design and replicated thrice, *i.e*. T_0 (Control), T_1 (GA_3 5 ppm), T_2 (GA_3 10 ppm), T_3 (GA_3 15 ppm), T_4 (NAA 10 ppm), T_5 (NAA 20 ppm), T_6 (NAA 30 ppm), T_7 (IAA 20 ppm), T_8 (IAA 25 ppm), T_9 (IAA 30 ppm), T_{10} (Salicylic acid 15 ppm), T_{11} (Salicylic acid 30 ppm) and T_{12} (Salicylic acid 45 ppm). The phenological observations recorded were recorded days to 50% germination, plant height (cm), number of leaves $plant^{-1}$, root length (cm), dry weight root (g), fresh weight root (g), root diameter (cm) and root yield (t/ha^{-1}) from five randomly selected plants from each replication. Ascorbic acid content in root was determined by using 2, 6-dichloro phenol indophenols titration method given by Sadasivam and Manickam (1992) and calculated as per the formula given below:

$$\text{Amount of ascorbic acid mg per 100 g sample} = \frac{0.5\text{ mg} \times V_2\text{ ml} \times 100\text{ ml} \times 100}{V_1\text{ ml} \times 5\text{ ml} \times \text{weight of root sample}}$$

Where,

V_1 = Volume of titrant used against sample (ml)

V_2 = Volume of titrant used against standard ascorbic acid.

The total soluble solids (Znidarcic and Pozrl, 2006) of juice were determined by placing few drops of radish juice on hand held ERMA refractometer (brix range = 0-32% at 20°C).

Results and Discussion

The perusal of data revealed (Table 1) that seed priming with higher concentration of GA_3 (15 ppm) was found to be significantly superior over all other treatments and required the minimum number of days to 50% germination (5.33 days) followed by IAA 25 ppm (5.67). According to Yari *et al*. (2011) the metabolic processes are activated by the pre-treatment that are essential for occurrence of germination before the real germination to get start. The syntheses of a few enzymes get activated in by pre-treatment that catalyze the mobilization of storage assets

Table 1. Effect of seed priming of PGR's on successive crop growth stages

Treatment	Days to 50% germination	Plant height (cm)			Number of leaves $plant^{-1}$		
		30 DAS	45 DAS	At harvest	30 DAS	45 DAS	At harvest
T_0 (Control)	8.33	15.55	22.39	26.83	6.40	9.80	10.00
T_1 (GA_3 5 ppm)	7.67	17.91	27.17	32.16	7.47	9.67	10.60
T_2 (GA_3 10 ppm)	6.33	19.59	31.87	34.05	8.20	12.13	13.13
T_3 (GA_3 15 ppm)	5.33	21.20	32.01	35.95	8.40	11.33	11.73
T_4 (NAA 10 ppm)	8.67	17.87	28.22	30.89	7.06	10.87	11.53
T_5 (NAA 20 ppm)	7.33	18.27	29.13	32.75	7.27	8.67	11.60
T_6 (NAA 30 ppm)	7.00	18.87	29.23	33.61	7.87	11.27	12.00
T_7 (IAA 20 ppm)	7.33	16.15	28.59	31.39	6.87	9.40	10.47
T_8 (IAA 25 ppm)	5.67	18.06	30.33	32.06	7.13	10.00	10.93
T_9 (IAA 30 ppm)	7.00	18.20	29.45	32.19	7.47	10.27	11.80
T_{10} (Salicylic acid 15 ppm)	7.33	18.04	26.63	30.08	7.73	9.53	11.53
T_{11} (Salicylic acid 30 ppm)	7.00	19.59	27.60	33.73	7.93	10.87	11.60
T_{12} (Salicylic acid 45 ppm)	6.33	20.07	29.95	33.97	8.20	12.00	12.20
Mean	7.03	18.41	28.66	32.28	7.54	10.74	11.47
SEm±	0.62	0.30	0.82	0.53	0.23	0.31	0.25
CD@ 5%	1.83	0.88	2.40	1.55	0.67	0.90	0.72

in radish seeds, while hydrolase activities weaken the endosperm (Noreen and Ashraf, 2009).

The plant height at successive stages of growth in radish responded significantly by the different treatments at 30 and 45 DAS and at harvest (Table 1). The maximum plant height (35.95) was observed with GA_3 15 ppm which was at par with all the other treatments except GA_3 10 ppm, SA 45 ppm and control recording 15.55, 22.39 and 26.83 cm respectively. The increase in plant height was mainly due to the hormonal action of enhancing cell division and cell elongation (Shruthi *et al.*, 2016). With regard to the number of leaves plant^{-1}, the variety responded variedly to the different seed priming treatments. It ranged from 6.40 to 8.40 and 9.80 to 12.13 with a mean of 7.54 and 10.74 at 30 and 45 DAT respectively. The maximum number of leaves plant^{-1} (13.13) was recorded in the treatment T_3 (GA_3 15ppm) at harvest. However, it was the minimum in control (10.00). Gibberellic acid resulted in a significant increase in the number of leaves plant^{-1} due to the fact that gibberellic acid enhances the vegetative growth in radish (Mishra and Nagaich, 2019). Similarly Little and Mac-Donald (2003) reported that GA_3 helps to stimulate the activity of sub-apical meristem during new-formed growth and the apical meristem during vegetative bud development.

Table 2 depicts the fresh and dry weight of radish roots. Seed priming significantly affected the weight of radish roots. The maximum fresh weight of root (133.51 g) was recorded with the application of GA_3 15 ppm which was statistically at par with SA 30 ppm (121.10 g). The accumulation of fresh weight in root is directly related to the crop's growth pattern, which affects the biological yield linearly. As per the observations of Hopkins, 1999 and Sadana *et al*. (2015), the fresh weight of radish root was increased as the GA_3 rate increased, since this hormone is well known to be a growth facilitating substance which is implicated in cell division and expansion.

The data (Table 2) with respect to dry weight of root (g) revealed that the character was significantly influenced by seed priming of radish by different PGR's. The application of GA_3 showed significantly higher values over the other treatments. The maximum dry weight of root (18.41 g) was observed in the treatment T_3 (GA_3 15 ppm) which was statistically at par (16.96 g) with T_{11} (SA 30 ppm) however, it was the minimum in control (9.41 g). It might be due to increased translocation of assimilates from source to the economic part. These results were in close agreement with observations of Uikey (2009) and Shruthi (2015) who observed quite similar results in radish.

Table 2. Effect of seed priming of PGR's on fresh and dry weight of root (g)

Treatment	Fresh weight of root (g)	Dry weight of root (g)
T_0 (Control)	78.55	9.41
T_1 (GA_3 5 ppm)	111.60	12.01
T_2 (GA_3 10 ppm)	106.83	10.23
T_3 (GA_3 15 ppm)	133.51	18.41
T_4 (NAA 10 ppm)	98.56	12.81
T_5 (NAA 20 ppm)	101.22	9.99
T_6 (NAA 30 ppm)	120.35	13.55
T_7 (IAA 20 ppm)	95.79	9.58
T_8 (IAA 25 ppm)	99.62	9.71
T_9 (IAA 30 ppm)	110.88	11.25
T_{10} (Salicylic acid 15 ppm)	111.08	13.38
T_{11} (Salicylic acid 30 ppm)	121.10	16.96
T_{12} (Salicylic acid 45 ppm)	117.63	12.52
Mean	108.21	12.29
SEm±	4.49	1.28
CD@ 5%	13.10	3.73

Table 3 shows the effect of seed priming on the root development in radish. The data of the present experiment showed that the seed priming treatment with different plant growth regulators had significant effect on the length and diameter of root. With regard to the length of root GA_3 15 ppm recorded the maximum value of 17.43 cm at 30 DAS, 24.03 cm at 45 DAS and 24.40 cm at harvest which was statistically at par with SA 30 ppm (23.49 cm). The increase in root length with the increased GA_3 concentration might be attributed to cell growth and cell elongation which results in elongation of root system (Sarkar *et al.*, 2018) and Shruthi *et al*. (2016). Responses of root diameter to PGR's application showed that substantial increases in root diameter coincided with the increasing rates of GA_3. The maximum diameter was recorded by 15 ppm GA_3 (3.73 cm) which, was at par with IAA 20 ppm (3.71cm), NAA 10 ppm (3.69 cm) and GA_3 10 ppm (3.57 cm) respectively. As per the reports of Wien (1999) the root formation results from the activity of secondary cambia, whose initiation is dependent upon a supply of sucrose and growth regulators from the shoots.

The effect of seed priming with the pre treatment of plant growth regulators revealed the highest yield

Table 3. Influence of seed priming of PGR's on yield and yield attributing traits

Treatment	Root length (cm)			Root diameter (cm)			Root yield (t/ha^{-1})
	30 DAS	45 DAS	At harvest	30 DAS	45 DAS	At harvest	At harvest
T_0 (Control)	14.03	18.93	19.70	2.03	2.55	2.73	19.13
T_1 (GA_3 5 ppm)	15.91	20.47	20.51	2.69	3.19	3.35	21.88
T_2 (GA_3 10 ppm)	16.98	19.37	21.21	3.14	3.54	3.57	23.10
T_3 (GA_3 15 ppm)	17.43	24.03	24.40	3.25	3.41	3.73	24.38
T_4 (NAA 10 ppm)	16.39	19.78	19.99	2.87	3.59	3.69	22.96
T_5 (NAA 20 ppm)	16.80	22.26	22.19	2.90	3.49	3.51	23.71
T_6 (NAA 30 ppm)	17.20	21.95	22.67	2.65	3.41	3.52	23.70
T_7 (IAA 20 ppm)	15.79	20.40	21.09	2.47	3.08	3.71	20.58
T_8 (IAA 25 ppm)	16.32	21.34	22.19	2.11	3.01	3.55	19.78
T_9 (IAA 30 ppm)	17.21	20.95	22.11	2.36	3.17	3.28	22.95
T_{10} (Salicylic acid 15 ppm)	15.82	21.30	21.42	2.40	3.50	3.05	20.92
T_{11} (Salicylic acid 30 ppm)	15.15	22.43	23.49	2.21	3.09	3.15	22.54
T_{12} (Salicylic acid 45 ppm)	15.13	21.57	22.60	2.32	2.88	3.13	23.74
Mean	16.17	21.14	21.81	2.57	3.22	3.38	22.26
SEm+	0.49	0.52	0.49	0.16	0.14	0.14	0.77
CD@ 5%	1.44	1.55	1.43	0.47	0.43	0.39	2.28

(24.38 t/ha^{-1}) in T_3 (GA_3 15 ppm) which was at par with SA 45 ppm (23.74), NAA 20 ppm (23.71), NAA 30 ppm (23.70), GA_3 10 ppm (23.10), NAA 10 ppm (22.96), IAA 30 ppm (22.95) and SA 30 ppm (22.54). This increase in yield as well as yield attributes by growth regulators may be due to increased vegetative growth and foliage giving better opportunities for photosynthetic activities and consequently increasing the carbohydrates in the roots resulting high yield (Dahal *et al.*, 2021). Quite similar results were deduced by Mishra and Nagaich, 2019.

Table 4. Effect of seed priming of PGR's on ascorbic acid ($mg/100g^{-1}$) and TSS (°Brix)

Treatment	Ascorbic acid $mg/100g^{-1}$	TSS (°Brix)
T_0 (Control)	14.29	4.77
T_1 (GA_3 5 ppm)	17.48	5.30
T_2 (GA_3 10 ppm)	18.30	5.37
T_3 (GA_3 15 ppm)	21.14	5.53
T_4 (NAA 10 ppm)	16.70	4.80
T_5 (NAA 20 ppm)	17.24	5.20
T_6 (NAA 30 ppm)	17.45	5.43
T_7 (IAA 20 ppm)	15.70	4.93
T_8 (IAA 25 ppm)	17.37	5.20
T_9 (IAA 30 ppm)	17.87	5.23
T_{10} (Salicylic acid 15 ppm)	15.32	5.23
T_{11} (Salicylic acid 30 ppm)	16.68	5.30
T_{12} (Salicylic acid 45 ppm)	17.65	5.27
Mean	17.17	5.20
SEm$\pm$	0.47	0.10
C.D. @ 5%	1.36	0.30

Table 4 depicts the qualitative characters in radish as affected by the seed priming of PGR's. The ascorbic acid ($mg/100g^{-1}$) content in radish is presented in Table 4. The results revealed that the maximum ascorbic acid was recorded in the treatment GA_3 15 ppm (21.14) which was followed by GA_3 10ppm (18.30) and IAA 30 ppm (17.87). The increase in ascorbic acid content in radish might be due to the physiological influence of GA_3 on the activity of enzymes that produces more energy and food material for the strong vegetative growth. Results are in close agreement with the observations of Sadana *et al*. (2015) and Yogesh (2020) in radish. With regard to the TSS, the maximum value was recorded with GA_3 15 ppm (5.53) which was statistically at par with NAA 30 ppm (5.43), GA_3 10 ppm (5.37), GA_3 5 ppm (5.30), SA 45 ppm (5.27), IAA 30 ppm (5.23) and SA 15 ppm (5.23). According to Bawkar *et al*. (2011) the increase in TSS content is associated with hydrolytic changes in polysaccharides and their conversion to sugar.

Conclusion

The perusal of data revealed that seed priming of radish var. Pusa Chetki with different plant growth regulators significantly enhanced the growth, yield and quality. The comparison of various treatments under study showed that the pre-treatment of GA_3

15 ppm (T_3) showed better response with respect to the days to 50% germination, plant height, number of leaves plant^{-1}, length of root, diameter of root, fresh weight of root, dry weight of root and root yield (t ha^{-1}). The TSS (°Brix) and ascorbic acid content were also the maximum in T_3.

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