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Effect of Salicylic acid, 2,4-dichlorophenoxyacetic acid and gibberellic acid on growth, flowering, and fruit quality of Cape gooseberry (*Physalis peruviana* L.)

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ABSTRACT

Cape gooseberry (Physalis peruviana L.) has received significant attention recently due to its high value and medicinal qualities. The experiment was carried out in Randomized Block Design (RBD), with 10 treatments, replicated 03 times. The goal of the current study was to examine the effects of three plant growth regulators on the growth, blooming, and fruit quality of cape gooseberries, namely salicylic acid (SA), 2,4-D, and gibberellic acid (GA_3) at various doses. Salicylic acid (20, 40, and 60 ppm), 2,4-D (4, 8 and 12 ppm), GA_3 (20, 40, and 60 ppm), and a control were used as treatments. The best treatment combination in terms of plant height (90 cm), number of leaves (106.11), leaf area (36.11 cm^2), and number of branches (12.11) was T9-GA_3 @ 60 ppm. The higher concentration of GA_3 @ 60 ppm led to earlier flowering, earlier fruiting, and more flowers overall. GA_3 @ 60 ppm significantly improved the total soluble solid (12.93 0B), ascorbic acid content (53.30 mg/100g), and TSS:acid ratio (15.34). Acidity decreased with increasing concentration of GA_3.

***Keywords*:** Cape gooseberry, flowering, fruit quality, gibberellic acid, salicylic acid

INTRODUCTION

The Cape gooseberry *Physalis peruviana* L.), belongs to family Solanaceae, is one of the world's lesser-known and underutilized fruit crops. Many distinct names, including Poha, Tepari, Golden Berry, and Husk Berry, are used to refer to Cape gooseberries around the world. It belongs to the *Physalis* genus, which is part of the Solanaceae family and contains 80 species. Of these, only three, *P. peruviana* L., *P. pubescens* L., and *P. ixocarpa* Brot., have been recognized as species that produce edible fruit. When maturing, the Cape gooseberry's berries are a yellow-orange color, 1 to 3.5 cm in diameter, very juicy, aromatic, and have a distinct bitter-sweet flavor. The bigger, papery crescent epicalyx encloses the fruits. Its fruit contains a variety of bioflavonoids, including vitamin P, which reduce inflammation and function as natural blood thinners. It effectively lowers cholesterol levels and has anti-ulcer properties (Mayorga *et al*., 2001). The fruit's pulp contains 1.6 mg/100g carotene, 0.1-0.18 mg/100g thiamine, 0.03-0.18 mg/100g riboflavin, 0.8-1.7 mg/100g niacin, 20-43 mg/100g vitamin C, 210-467mg/100g K, 7-19 mg/100g Mg, 8-28 mg/100g Ca, 27-55.3 mg/100g P, 0.3-1.2 mg/100 (Puente *et al*., 2011; Ramadan and Morsel, 2009). The plants are naturally fast-growing and are easily propagated through seeds and cuttings. Being a warm season crop, it needs a lengthy growing season to provide a profit. Farmers continue to occasionally cultivate cape gooseberries on a modest scale, producing low-quality fruits that prevent them from realizing the full value of the crop. Plant growth regulators are chemicals that, when used sparingly, alter plant development, typically by activating a portion of the plant's inherent growth regulation system. In this regard, plant growth regulators (PGR) may be crucial to the crop's ability to produce high-quality fruits. Yet, there is a dearth of literature on PGRs' impact on fruit quality. Plant growth regulators (PGR) are widely used in horticulture crops to promote output by boosting flowering time, fruit set, and fruit size. By interacting with important metabolic processes including nucleic acid metabolism and protein synthesis, plant growth regulators like promoters, inhibitors, and retardants play a crucial role in directing internal mechanisms of plant growth. It aids in changing the canopy structure and other yield factors. A useful approach to boost crop yield may be the application of plant growth regulators (PGR). The significance of PGRs in boosting crop productivity has just come to light on a global scale.SA plays a crucial part in the growth and development of the plant by improving the plant's response to tolerance and resistance to numerous plant-affecting diseases. It increases the representation of CO_2 gas, gas exchange, protein synthesis, ion absorption, and nutrition transfer. It also stimulates blooming.2, 4- D enhances fruit set, fruit number, TSS, number of secondary roots, and yield; however, it significantly decreases plant height, internode length, days to flowering, acidity, and number of seeds per fruit. Gibberellic acid is essential for the growth of the morphological traits that give plants and their fruits their distinctive appearance. GA_3 has the ability to speed up some sub apical meristem cell processes like cell division and mitosis. Internodes length, leaf number, branch count, fruit and berry size all increase as a result.With the aim of determining the appropriate concentrations of Salicylic acid, 2,4-D, and GA_3 plant growth regulators on the vegetative development, flowering, and quality of Cape gooseberries, the current study was conducted.

MATERIALS AND METHODS

The experiment was conducted during October 2020 to March 2021 at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The region of experimental site (Naini, Prayagraj) has a sub-tropical climate, situated in the South-East part of U.P. at 25.45^0 North latitude and 81.84^0 East longitudes and an elevation of 98 meters above sea mean level (MSL). In hot summer temperatures rise up to 46 ^{0}C to 48 ^{0}C and minimum 4 ^{0}C – 5 ^{0}C in winter and average rainfall is 1013.4 mm. With three replications and ten treatments, the experiment was set up using a randomized block design. As a foliar spray, three plant growth regulators in each of three concentrations were used. The treatment consisted T_0- Control, T_1- SA @ 20 ppm, T_2 - SA @ 40 ppm , T_3 - SA @ 60 ppm , T_4 - 2-4,D @ 4 ppm , T_5 - 2-4,D @ 8 ppm, T_6 - 2-4,D @ 12 ppm, T_7 - GA_3 @ 20 ppm, T_8 - GA_3 @ 40 ppm, T_9 - GA_3 @ 60 ppm. Application of PGRs was given at 20 days after transplanting, At flowering, at fruit set and maturity stage. Data on numerous parameters from chosen plants were collected at various phases of plant growth and statistically examined using the Analysis of Variance (ANNOVA) method.

RESULTS AND DISCUSSION

Growth parameters

The treatment T_3 - SA @ 60 ppm, showed maximum plant height which is 26.22 cm followed by T_9 - GA_3 @ 60 ppm after 25 days after transplanting. T_9 - GA_3 @ 60 ppm registered the maximum height in the plant after 50 days and 75 days after transplanting. Control T_0 had the shortest plant height. The outcomes demonstrate a beneficial impact on plant height from the usage of GA_3 at higher doses. Because GA_3 encourages cell division and cell elongation, which results in cell enlargement, it is conceivable that this is the cause of the increased plant height. Additionally, Wanyama *et al.* (2006) and Udden *et al.* (2009) reported a similar conclusion. Final reading of Table 1 shows that treatment T_9 (GA_3 @ 60 ppm), which has significantly more leaves (106.11), leaf area (79.89 cm^2), and branches (12.11) than control. A higher quantity of GA_3 may have caused an increase in leaf counts, which is one explanation for the phenomenon. There are more leaves on each plant as a result of gibberellin's stimulation of auxin action. In comparison to other treatments, treatment T_9 (GA_3@ 60 ppm) was shown to be the best and recorded the largest leaf area and branches, followed by treatment T8 (GA_3 @ 40 ppm). In term of Salicylic acid treatment T_3 - SA @ 60 ppm showed increased number of leaves (10.11), leaf area (70.56 cm^2) and number of branches (9.67) as compare to its lower concentration and have no significance difference to other salicylic acid treatment but at par with control. GA_3 encourages cell expansion and boosts photosynthetic rate, increasing leaf area. Similar findings were provided by Kaur and Kaur (2016). Gibberellic acid's anti-

Table 1: Effect of Salicylic acid, 2,4- dichlorophenoxyacetic acid and Gibberellic acid on growth of Cape gooseberry (*Physalis peruviana* L.).

Treatment symbols	Treatments	Plant height (cm)			No. of leaves			Leaf area (cm^2)	No. of branches
		25 days	50 days	75 days	25 days	50 days	75 days	75 days	
T_0	**Control (Water spray)**	17.78	32.22	57.67	7.32	31.89	66.22	60.56	
T_1	**SA @ 20 ppm**	22.44	38.55	72.67	9.44	42.11	85.11	66.22	
T_2	**SA @ 40 ppm**	19.55	42.67	76.44	8.56	48.66	88.33	65.44	
T_3	**SA @ 60 ppm**	26.22	45.33	86.78	10.11	47.78	95.78	70.56	
T_4	**2,4-D @ 4 ppm**	19.55	37.11	65.55	8.33	39.78	78.44	61.89	
T_5	**2,4-D @ 8 ppm**	18.66	36.11	64.22	8.44	41.99	81	62.33	
T_6	**2,4-D @ 12 ppm**	16.11	35.67	62.78	7.89	36.89	75.22	61.33	
T_7	**GA_3 @ 20 ppm**	23.78	39	82.11	9.44	46.67	98.56	72.89	
T_8	**GA_3 @ 40 ppm**	20.33	40.89	79.89	9.55	45.33	91.89	76.44	
T_9	**GA_3 @ 60 ppm**	24.67	49.44	90	9.22	53.55	106.11	79.89	
	CD at 5%	6.26	7.14	6.46	2.11	10.56	13.47	6.94	
	F – test	**NS**	**S**	**S**	**NS**	**S**	**S**	**S**	

Table 2: Effect of Salicylic acid, 2,4- dichlorophenoxyacetic acid and Gibberellic acid on flowering, fruiting, yield and quality of Cape gooseberry.

Treatment symbols	Treatments	Days taken to first flowering	Days taken to first fruiting	No. of flower per plant	Fruits/ plant	Yield (g/plant)	TSS (°B)	Acidity (%)	TSS : Acid ratio	Ascorbic acid (mg/100g)
T_0	**Control (Water spray)**	56.11	67.89	93.78	61.03	384.67	7.7	1.12	6.85	35.53
T_1	**SA @ 20 ppm**	50.33	59	106.11	84.30	699.98	10.47	0.97	10.76	37
T_2	**SA @ 40 ppm**	51.67	60.78	108.22	87.63	768.45	10.03	0.95	10.61	44.53
T_3	**SA @ 60 ppm**	49.56	57.89	109.89	89.30	848.53	11.7	0.93	12.6	45.97
T_4	**2,4-D @ 4 ppm**	53	63	101.11	73.03	545.28	8.6	1.01	8.51	38.7
T_5	**2,4-D @ 8 ppm**	53.89	64.33	98	68.60	534.96	8.97	1.05	8.51	40.53
T_6	**2,4-D @ 12 ppm**	54.55	65.11	96	66.94	471.26	9.43	1.08	8.74	42.67
T_7	**GA_3 @ 20 ppm**	48	56.67	112.44	95.02	871.41	10.93	0.89	12.22	49.05
T_8	**GA_3 @ 40 ppm**	48.89	55.56	115.33	97.38	970.75	12.26	0.87	14.11	50.89
T_9	**GA_3 @ 60 ppm**	47.33	54.89	117.11	102.40	1096.18	12.93	0.84	15.34	53.30
	CD at 5%	1.31	2.31	1.88	2.24	40.19	0.79	0.06	1.20	1.23
	F – test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**

mitotic action, which has an inhibitory influence on apical growth, is what causes the increase in branch number. Gocher *et al.* (2017), Tiwari and Singh (2014), and El-Tohamy *et al*. (2012) reported findings that were similar to present findings.

Flowering and yield parameter

From the Table 2 it is clear that T_9 - GA_3 @ 60ppm (47.33 days) and T_7 - GA_3 @ 20ppm (48 days) produced the best results in terms of early blooming when compared to other treatments. With the untreated plant T_0, blooming took longer than usual (56.11 days). T_9 (GA_3 @ 60 ppm) recorded the shortest number of days needed to reach first fruiting (54.89 days), followed by T_8 (GA_3 @ 60 ppm), which is (55.56 days). T_0 (control) took the longest number of days to first fruiting (67.89). Early blossoming was evident in all GA_3 treatments, and this was noteworthy. A higher GA_3 concentration causes early flowering because it produces more leaves and encourages vegetative growth. With the higher concentration of GA_3, the first fruiting start time was greatly accelerated. The cape gooseberry's early flowering results in early fruit setting. This outcome is in agreement with Verma *et al.* (2014). Treatment T_3 - SA @ 60 ppm record minimum days to flowering (49.56 days) followed by T_1 - SA @ 20 ppm T_2 - SA @ 40 ppm and (50.33 and 51.67 days respectively) and also results early fruiting treated with salicylic acid as compared to non treated plant. About 2,4-D, blooming time rises as concentration increases. Compared to its previous treatments (2,4-D @ 8 and 12 ppm), 2,4-D @ 4 ppm concentration significantly shortens the flowering period, resulting in early fruiting. This finding is supported by the tomato experiment conducted by Tiwari and Singh (2014) and Pundhir and Yadav (2001). The number of flowers was revealed to be 112.44, 115.33, and 117.11 at GA_3 concentrations of 20, 40, and 60 ppm, respectively. T_9 (GA_3 @ 60 ppm) produced better results, whereas the control had the fewest flowers. Plants produced more flower primordia when gibberelic acid was present. The GA_3 treated plants were able to accumulate and store enough carbohydrates, which resulted in increased flower production. Both Udden *et al.* (2009) and Verma *et al.* (2014) validated these findings. In salicylic acid treatment, highest no of flower per plant (109 flower) was counted in T_3 (SA @ 60 ppm) followed by T_2 (SA @ 40 ppm) and T_1 (SA @ 20 ppm) which is 108.22 and 106.11 flower per plant respectively. All salicylic acid treatment give superior result over all 2,4-D treatments and control. The greatest number of flowers were evident at the lowest 2,4-D concentration of 4 ppm compared to its higher values. When 2,4-D is present in higher concentrations, it has a herbicidal effect on plants and causes flower bud abscission, which results in flower drop. Tiwari and Singh (2014) and Pundhir and Yadav (2001) also came to the same conclusion.The results showed that T_9(GA_3 @ 60 ppm), followed by T_8 (GA_3 @ 40 ppm) and T_7 (GA_3 @ 20 ppm), had recorded the highest number of fruits per plant (102.4) and fruit output (1096.18 g/plant) when compared to other treatments. The control group, however, also recorded minimum yield and fruit production. T4 (2,4-D @ 4 ppm) recorded 73.03 fruits, although 2,4-D concentrations above this result in less fruits because of their herbicidal effects, which produce bud abscission. When the cape gooseberry has an adequate supply of carbohydrates and an optimal concentration of growth regulators, fruiting is sustained. As food reserves develop, the fruiting process becomes more active and produces more fruit. This conclusion was very similar to that of Kaur *et al.* (2013). Higher concentration of salicylic acid (SA @ 60 ppm) record 848.53 g/plant which is at par with its lower concentration and showed significant difference over control. 646.99 g/plant fruit yield recorded under T_4(2,4-D @ 4 ppm) which was maximum over its higher concentration. Yield reduced with increasing the concentration of 2,4-D. The similar findings were reported by Kavyashree *et al.*(2018) in sapota, Singh *et al*. (2018), Kaur *et al.*, (2013) and EL-Tohamy *et al.* (2012) on cape gooseberry.

Quality parameter

The results show that T_9 (GA_3 @ 60 ppm) significantly reported the highest total soluble solids value (12.93 ^{0}B), followed by T_8 (12.26 ^{0}B), as opposed to 7.7 ^{0}B under control. Fruit TSS values increased in proportion to GA_3 content. Higher concentration of salicylic acid (SA @ 60 ppm) revealed increase T.S.S. over lower concentration of GA_3, 2,4-D (4, 8 and 12 ppm) and control. Another explanation for the rise in TSS is the rapid metabolic conversion of starch and pectin into soluble compounds and the translocation of sugar from the leaves to the washbasin (fruits). El-Thohamy *et al.* (2012) and Kaur *et al.* (2013) also opined that the TSS of cape gooseberry fruit rises with the administration of gibberellic acid, The results showed that T_9 considerably reported a lower acidity percentage (0.84%), followed by T_8 (0.87%), whereas T_0 (the control) recorded an acidity percentage (1.12%). Every treatment has a considerable impact on the acidity % compared to the control. Salicylic acid have lower acidity percentage than 2,4-D treatments and control. Increase in T.S.S. is result of decreasing in percentage of acidity. Salicylic acid @ 60 ppm showed 0.93 % acidity over control. The best treatment was discovered to be T_9 (GA_3 @ 60 ppm), followed by T_8 (GA_3 @ 40 ppm), and T_7 (GA_3 @ 20 ppm).That might be because the fruit TSS value increases when GA_3 is applied, and the cape gooseberry's acidity percentage drops (Tohamy *et al.,* 2012 Kaur *et al.,* 2013 and Gelmesa *et al*., 2010).T_9 significantly had the highest TSS: Acid ratio (15.34), followed by T_8 (14.11). T0 (the control) reported the lowest value (6.85). When gibberellic acid is used, total soluble solids rise and acidity falls as concentration rises. Best salicylic acid treatment in respect to T.S.S: Acid ratio was SA @ 60 ppm (12.6) and lowest was SA @ 40 ppm (10.61) and showed significant difference with each salicylic acid treatments. Increased in TSS caused by higher GA_3 content, and higher TSS: Acid ratio in fruits is caused by lower acidity values. Singh and Lal (2001) supported the aforementioned conclusion. The maximum ascorbic acid content observed significantly under T_9 (53.3 mg) followed by T_8 (50.89 mg). T_9 - GA_3 @ 60 ppm (53.3 mg) was found to be best treatment over control. SA @ 60 ppm showed best result for ascorbic acid content (45.97 mg/100g) over control. 2,4-D 8 ppm and @ 12 ppm showed best result over SA @ 20 ppm. In accordance to the result lower concentration of 2,4-D showed superior result in flowering and fruiting while higher concentration of 2,4-D found suitable for quality content in cape gooseberry. Ascorbic acid content in comparison to other PGRs was significantly impacted by GA_3concentration. On the other hand, Cape gooseberry plants that had not been treated were given a minimum value. Due to enhanced ascorbic acid synthesis-related enzyme activity and a reduced rate of oxygen oxidation during respiration, GA_3 raises ascorbic acid concentration. By rising gibberellic acid concentration, ascorbic acid concentration rose. Kaur *et al.* (2013) also reported similar findings.

CONCLUSION

According to the results of the experiment, treatment T_9 (GA_3 @ 60 ppm) was determined to be the best treatment in terms of vegetative growth, including plant height, number of leaves, leaf area, and number of branches. TreatmentT_9 (GA_3 @ 60ppm) exhibited early blooming and fruiting, number of fruit per plant and yield. While the application of GA_3 at a concentration of 60 ppm increased TSS, the TSS: acid ratio, and the amount of ascorbic acid, it lowered the acidity percentage. When compared to higher concentration of 2,4-D, lowest concentration of 2,4-D produced effective results, and the minimum values for all the qualities were disclosed by the control. Under the agro-climatic conditions of Prayagraj, the treatment T_9 (GA_3 @ 60 ppm) demonstrated the best results and was determined to be the optimum course of action.

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