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Split application of GA_3: Effective to improve growth, yield and quality of cape gooseberry (*Physalis peruviana* L.)

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ABSTRACT

The current research work was conducted during 2019-20 in the Department of Horticulture (Fruit and Fruit Tech.), BAC, Sabour to standardize the optimum concentration of GA_3 for split application to improve the growth, yield and fruit quality attributes of cape gooseberry. From the investigation, it was observed that the vegetative and physiological growth in terms of leaf length and breadth was increased significantly by 75-100 ppm GA_3 application at vegetative stage only. However, the ratio of chlorophyll a:b of the experimental cape gooseberry plants had improved significantly by three repeated application of GA_3 @ 25-100 ppm each during vegetative, anthesis and fruit setting stage together. The reproductive growth with respect to precocity in flowering after bud break was obtained in 50-100 ppm GA_3 spray either at anthesis or fruit setting stage; however three repeated application of GA_3 @ 25-100 ppm delayed the flowering significantly after bud break. On the other hand, highest yield acre^{-1} was recorded in three repeated application of GA_3 @ 50-100 ppm each during vegetative, anthesis and fruit setting stage together (12.06-12.80 t acre^{-1}). The quality attributes of ripped cape gooseberry fruit in terms of sugar: acid ratio was also improved significantly in three repeated application of GA_3 @ 25-100 ppm each during vegetative, anthesis and fruit setting stage together (15.63-16.90). Hence, it can be concluded that the application of GA_3 @ 50 ppm each at vegetative, flowering and again at fruit setting stage is optimum for improving the yield of better quality cape gooseberry fruit significantly.

Key words: *Cape gooseberry, GA_3, Split application, Yield*

Introduction

Cape gooseberry (*Physalis peruviana* L.), belongs to the family Solanaceae, is an important annual fruit crop. It is the rich source of vitamin A (36 IU/100g), vit. C (11 mg/100g), Vit. B1, B2, B3, P (40 mg/100 g), Ca and Fe. Besides, antioxidants, it contain phenols, flavonoids, which also exhibit a high degree of anti-oxidant capacity against free radical. Due to annual nature of the crop, it gives return in shortest possible time and has great demand in fresh market as well as in processing industries to prepare sauces, puddings, pies, jams, chutneys, ice cream etc.

The climatic condition of Bihar is suitable for growing cape gooseberry. However, the yield of the crop in the state is still under rated (only 400 – 500 g plant^{-1} as compared to 700-900 g plant^{-1} in leading cape gooseberry producing countries). This is mainly due to poor soil and nutrients management as well as lack of technical knowledge among the growers. A large number of well-established low cost production technologies have been reported throughout the world to increase quality as well as productivity of different agri-horticultural crops. Among them, application of recommended dose of nutrients, use of intercrops, adaptation of high density planting system, use of drip irrigation system, application of different plant growth regulators and use of biofertilizers play significant role to improve the productivity as well as quality of different fruit crops (Khatoon *et al*., 2021; Nandita *et al*., 2020; Khatoon *et al*., 2020; Kumar *et al*., 2019a; Kumar *et al*., 2019b; Kumari *et al*., 2019; Kundu *et al*., 2013). Among all these techniques, exogenous application of different plant growth regulators has been found effective for stimulation of fruit growth and maturity. Increased yield with improved fruit quality by the application of plant growth regulators has been reported earlier in apple (Turk and Stopar, 2010), mango (Wahdan *et al*., 2011) and other fruits.

Among different plant growth regulators, gibberellic acid (GA_3) exhibits an indispensable role in plant growth and development. When GA_3 was applied exogenously, it accelerated the rates of cell division and cell elongation at the sub apical meristematic region resulting improved vegetative growth with better quality fruits (Singh and Lal, 2001). Kumar *et al*. (2017) reported that the foliar application of increased concentration of GA_3 had significant effect on fruit quality of cape gooseberry. Hence, the present investigation was formulated to study the impact of split application of gibberellins at different growth stages of the plants on growth, yield and fruit quality attributes of cape gooseberry.

Materials and Methods

For the current investigation, cape gooseberry (*Physalis peruviana* L.) was used as the experimental plants. The plants were planted at the main field at 60 × 45 cm spacing on 18th November 2019.

The lay out of the experiment was on Completely Randomized Block Design (CRBD) with three replications. Vegetative, physiological and reproductive growth of the plants was observed under field condition. After harvesting, yield was calculated and biochemical analyses of fruit were carried out.

Vegetative and physiological growth of the plant

Leaf length and breadth was measured manually with the help of measuring scale. Further, chlorophyll content (chlorophyll a, and b) of the leaves was analyzed at vegetative stage and again at fruiting stage following the method of Barnes *et al.* (1992) and the ratio of chlorophyll a: b was calculated thereafter.

Reproductive growth, yield and fruit quality attributes

The duration from bud break to flowering was counted manually for each and every experimental cape gooseberry plants.

On the other hand, all the fruits from an individual plant were picked manually in each harvesting and weighted them on digital weighing balance. At the end of last harvesting, yield/plant was calculated by adding the value of fruit weight in each harvesting. Thereafter, yield per acre area was calculated by using following formula-

Yield $acre^{-1}$ = Yield $Plant^{-1}$ × No. of plants accommodates $acre^{-1}$ area

Thereafter, sugar: acid ratio of the ripped cape gooseberry fruits was determined by dividing the total sugar content with titratable acidity for ten individual fruits under each replication and average value was calculated thereafter. Sugar content in the ripe fruit was estimated by Lane and Eynone (1923) method.

Data were analyzed using statistical software (OPSTAT, HAU, Hissar).

Results

Vegetative and physiological growth of the plant

The experimental results revealed that the leaf length and breadth of the experimental cape goose-

The details of the treatments are as follows:

Stages of application	Concentration of GA_3				
	C1	C2	C3	C4	C5
Vegetative stage (S1)	0 ppm	25 ppm	50 ppm	75 ppm	100 ppm
Anthesis (S2)	0 ppm	25 ppm	50 ppm	75 ppm	100 ppm
Fruit setting (S3)	0 ppm	25 ppm	50 ppm	75 ppm	100 ppm
All three stages (S4)	0 ppm	25 ppm	50 ppm	75 ppm	100 ppm

berry plants varied significantly with varying concentration of GA_3 spray at different growth stage of the plant (Table 1). Leaf length was measured maximum in the plants which received 100 ppm GA_3 at vegetative stage only with par result in 75 ppm spray at vegetative stage only and 100 ppm GA_3 spray at all the three growth stages (Vegetative, anthesis and again at fruit setting stage) (10.90, 10.57 and 10.41 cm, respectively).

Similarly, leaf breadth was also recorded maximum in the plants which received 100 ppm GA_3 at vegetative stage only with par result in 75 ppm spray at vegetative stage only and 100 ppm GA_3 spray at all the three growth stages (Vegetative, anthesis and again at fruit setting stage) (9.02, 8.75 and 8.62 cm, respectively).

Chlorophyll a:b ratio of cape gooseberry at vegetative stage was not differed significantly by the application of GA_3 with different concentration at different growth stages of the plant; however, it differed significantly when estimated again at reproductive stage of the plant (Table 1). At vegetative stage, the ratio of chlorophyll a and b was recorded maximum in three repeated GA_3 application @ 100 ppm each at vegetative, anthesis and again at fruit setting stage together (3.90) which was marginally higher from three repeated GA_3 application @ 75 ppm each at vegetative, anthesis and again at fruit setting stage together (3.85), three repeated GA_3 application @ 50 ppm each at vegetative, anthesis and again at fruit setting stage together (3.85) and single application of GA_3 @ 100 ppm only at vegetative stage (3.83). On the other hand, chlorophyll a:b ratio at reproductive stage was also recorded significantly higher as compared to vegetative stage. At reproductive stage, the ratio of chlorophyll a:b was recorded maximum in three repeated GA_3 application @ 100 ppm each at vegetative, anthesis and again at fruit setting stage together (4.35) with at par result in single application of GA_3 @ 100 ppm only at vegetative stage (4.35), single application of GA_3 @ 100 ppm only at fruit setting stage (4.31), single application of GA_3 @ 100 ppm only at anthesis stage (4.25), three repeated GA_3 application @ 75 ppm each at vegetative, anthesis and again at fruit setting stage together (4.24) and three repeated GA_3 application @

Table 1. Effect of gibberellins (GA_3) on vegetative and physiological growth of cape gooseberry (*Physalis peruviana* L.)

Treatment		Leaf Length (cm)	Leaf Breadth (cm)	Chlorophyll a:b ratio at vegetative stage	Chlorophyll a:b ratio at reproductive stage
Vegetative	0 ppm	8.96	7.42	3.41	3.87
	25 ppm	10.04	8.31	3.47	3.90
	50 ppm	10.10	8.36	3.73	3.93
	75 ppm	10.57	8.75	3.73	4.00
	100 ppm	10.90	9.02	3.83	4.35
Anthesis	0 ppm	8.98	7.44	3.25	3.74
	25 ppm	9.51	7.88	3.31	3.88
	50 ppm	9.71	8.04	3.37	3.94
	75 ppm	9.95	8.24	3.65	4.02
	100 ppm	10.15	8.40	3.69	4.25
Fruit setting	0 ppm	8.98	7.44	3.68	3.82
	25 ppm	9.27	7.68	3.70	4.02
	50 ppm	9.47	7.84	3.73	4.05
	75 ppm	9.61	7.96	3.76	4.15
	100 ppm	9.91	8.20	3.84	4.31
Vegetative, anthesis and fruit setting	0 ppm	8.97	7.43	3.73	4.09
	25 ppm	9.69	8.02	3.80	4.11
	50 ppm	9.96	8.25	3.85	4.18
	75 ppm	10.14	8.40	3.85	4.24
	100 ppm	10.41	8.62	3.90	4.35
CD ($p \leq 0.05$)		0.502	0.412	NS	0.179
SE (m)		0.010	0.009	0.165	0.062
SE (d)		0.014	0.012	0.234	0.088
CV (%)		0.177	0.186	4.983	7.810

50 ppm each at vegetative, anthesis and again at fruit setting stage together (4.18). However, single application of GA_3 @ 0-75 ppm either at vegetative or anthesis or fruit setting stage had significantly lower ratio of chlorophyll a:b as estimated at reproductive stage.

Reproductive growth, yield and fruit quality attributes

The duration from bud break to flowering was recorded earliest in GA_3 application @ 25-100 ppm at anthesis stage (18.11-18.67 days after bud break) (Table 2). However, longest duration for the same was recorded in three repeated GA_3 application @ 100 ppm each at vegetative, anthesis and again at fruit setting stage together (25.86) with at par result in single application of GA_3 @ 100 ppm only at vegetative stage (25.25). In addition, one interesting observation was recorded that with the increase of GA_3 concentration, irrespective of stage of application, the duration from bud break to flowering was delayed significantly.

The yield of cape gooseberry was improved significantly by varying concentration of GA_3 spray at different growth stage of the plant (Table 2). The yield was recorded maximum in three repeated application of GA_3 @ 25 ppm each at vegetative, anthesis and again at fruit setting stage together (12.84 tonnes acre^{-1}) with at par yield in three repeated application of GA_3 @ 50 ppm each at vegetative, anthesis and again at fruit setting stage together (12.80 tonnes acre^{-1}), three repeated application of GA_3 @ 75 ppm each at vegetative, anthesis and again at fruit setting stage together (12.43 tonnes acre^{-1}) and three repeated application of GA_3 @ 100 ppm each at vegetative, anthesis and again at fruit setting stage together (12.06 tonnes acre $^{-1}$). However, it was recorded minimum in control (without GA_3 application).

The sugar: acid ratio which in the predominant indicator for fruit quality was also improved significantly by varying concentration of GA_3 spray at different growth stage of the plant (Table 2). It was recorded maximum in three repeated application of GA_3 @ 100 ppm each at vegetative, anthesis and again at fruit setting stage together (16.90) with par

Table 2. Effect of gibberellins (GA_3) on yield and fruit quality of cape gooseberry (*Physalis peruviana* L.)

Treatment		Duration from bud break to flowering (Days)	Yield (Tonnes acre^{-1})	Sugar: Acid ratio
Vegetative	0 ppm	19.67	7.85	10.46
	25 ppm	22.33	10.68	14.14
	50 ppm	23.11	11.70	15.40
	75 ppm	24.33	11.65	15.32
	100 ppm	25.25	11.93	16.04
Anthesis	0 ppm	19.33	7.93	11.10
	25 ppm	18.11	9.38	13.94
	50 ppm	18.67	10.22	15.21
	75 ppm	18.11	10.27	15.53
	100 ppm	18.26	10.54	16.43
Fruit setting	0 ppm	19.00	8.02	10.90
	25 ppm	19.11	10.25	14.27
	50 ppm	18.87	10.52	15.41
	75 ppm	18.67	11.02	16.11
	100 ppm	18.75	11.24	16.08
Vegetative, anthesis and fruit setting	0 ppm	19.33	8.06	10.73
	25 ppm	21.56	12.84	15.14
	50 ppm	22.33	12.80	15.63
	75 ppm	24.11	12.43	16.60
	100 ppm	25.86	12.06	16.90
CD ($p \leq 0.05$)		2.510	0.874	1.772
SE (m)		0.752	0.304	0.554
SE (d)		0.945	0.430	0.784
CV (%)		8.512	4.983	6.565

value in three repeated application of GA_3 @ 75 ppm each at vegetative, anthesis and again at fruit setting stage together (16.60), three repeated application of GA_3 @ 50 ppm each at vegetative, anthesis and again at fruit setting stage together (15.63) and three repeated application of GA_3 @ 25 ppm each at vegetative, anthesis and again at fruit setting stage together (15.14). Besided, single application of GA_3 @ 50-100 ppm either at vegetative or anthesis or fruiting stage also increased the sugar: acid ratio significantly over control.

Discussion

The increased vegetative growth with respect to leaf length and breadth and physiological growth with respect to the ratio of chlorophyll a:b of the experimental cape gooseberry plants with the increased concentration of gibberellins might be due to the key role of GA_3 for cell division as well as cell expansion (Krishnamoorthy, 1985). Higher the concentration of GA_3, higher the rate of cell division and cell expansion resulting significant increase in vegetative growth of cape gooseberry with 100 ppm GA_3 spray. Similar findings were also noted in tomato (Latimer, 1992; Khan *et al.* 2006) strawberry (Mirinda *et al.* 1990) and cape gooseberry (Kumar *et al.* 2017). Khan *et al.* (2006) reported that the increased concentration of GA_3 within the plant system helps to synthesize several amino acids. These amino acids are subsequently incorporated in proteins and nucleic acid and ultimately provide the framework for chloroplast and other photosynthetic structure to accelerate different biochemical reactions resulting improved physiological activities within the plant system. It confirms the earlier observations of Palei *et al.* (2016), Rokaya *et al.* (2016), Gocher *et al.* (2017) in strawberry, mandarin and cape gooseberry, respectively.

In the present experiment, fruit yield has improved significantly in three repeated applications of GA_3 @ 25 ppm with at par result in 50 ppm spray for three times. However, with the further increase of GA_3 concentration to 75 ppm and 100 ppm, all these yield attributes started to decreased. Application of GA_3 at 25 ppm or 50 ppm for three times could help to divert the photosynthates from vegetative part to the developing flower buds resulting maximum conversion of flowers to fruits. These findings are in agreement with the observations of Al-Taweel *et al.* (2018) in jojoba.

The quality attributes of ripped cape gooseberry fruits under the current experiment were improved significantly with three repeated application of GA_3 at higher concentration (25-100 ppm) with at par result in three sprays of GA_3 @ 75 ppm, 50 ppm or 25 ppm. The improvement of sugar:acid ratio in three application of GA_3 might be due to the increased production of sugars and other soluble compounds from protein hydrolysis and ascorbic acid oxidation (Kumari *et al.*, 2018). Finding of the current investigation confirms the earlier report of Hosein-Beigi *et al.* (2019) in pomegranate, Mahorkar *et al.* (2020) in custard apple, Chen *et al*. (2014) in litchi and Kaur and Kaur (2016) in cape gooseberry.

Conclusion

The current research work confirms that repeated application of GA_3 improved the vegetative and physiological growth of cape gooseberry significantly with maximum yield. Fruit quality attributes in terms of sugar : acid ratio of ripped cape gooseberry fruit was also increased significantly in three repeated application of GA_3. Among four different concentration of GA_3, improvement in yield and quality attributes was statistically at par in 50, 75 and 100 ppm concentration. Hence, it can be concluded that the application of GA_3 @ 50 ppm each at vegetative, flowering and again at fruit setting stage is optimum for improving the yield of better quality cape gooseberry fruit significantly.

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