emergent
Life Sciences Research

Research Article

Optimization of stage of gibberellin spray in Cape gooseberry (*Physalis peruviana* L.) for the improvement of yield and fruit quality under subtropical condition

Madhvendra Bahadur Singh, Pawan Kumar, Manoj Kundu, Dinabandhu Samanta, Samik Sengupta

Received: 07 November 2022
Accepted: 08 December 2022
Online: 09 December 2022

Authors:
M. B. Singh, P. Kumar, M. Kundu ✉,
D. Samanta, S. Sengupta
Department of Horticulture (Fruit & Fruit Technology), Bihar Agricultural University Sabour, Bhagalpur, Bihar, India

✉ manojhorti18@gmail.com

Emer Life Sci Res (2022) 8(2): 206-213

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2022.82206213

Abstract

The current experiment was conducted to optimize the actual time of gibberellin (GA_3) spray in cape-gooseberry (*Physalis peruviana* L.) to improve growth, yield, and fruit quality traits. Experimental observations revealed that physiological growth (leaf relative water content, specific leaf weight) was improved significantly by three repeated applications of GA_3 @ 100 ppm each at vegetative, anthesis, and again at the fruit setting stage. GA_3 spray @ 25 ppm each at all three growth stages had the longest flowering period; although the harvest span was calculated maximum in three repeated GA_3 sprays @ 100 ppm each. Three applications of GA_3 @ 25 ppm each also increased the fruit yield at its maximum level (31.79 t ha^{-1}). Three foliar spray of GA_3 at any concentration increased the TSS significantly over the respective control; however, the acidity was reduced at the maximum level when GA_3 was applied @ 50-100 ppm each at all three growth stages. But reducing and non-reducing sugar content was maximum under GA_3 spray @ 100 ppm each during all three growth stages (8.33 and 2.70%, respectively) with statistically at par results in three applications of GA_3 @ 25-75 ppm each. Hence, it can be concluded that GA_3 application @ 25 ppm each at vegetative, anthesis, and again at fruit setting stage is optimum to improve the yield of better quality cape gooseberry fruit significantly.

Keywords cape gooseberry, fruit quality, gibberellins, physiological growth, yield

Introduction

Cape gooseberry (*Physalis peruviana* L.) is one of the most important nutritious fruit crops of the Solanaceae family. It is a good source of vitamin A (2380 IU 100 g^{-1}), pectin (0.9%), minerals (calcium, phosphorus), and fibers which provide considerable health benefits. Various bioactive compounds (with anilides and phenolics) are also reported to be present in cape gooseberry. Keeping these nutritional benefits, the demand for this crop has increased many folds during the last two decades. To meet this demand, the area and production of the crop have increased significantly in the country. Although, it is a crop of tropical climate, its wide adaptability to different soil and climatic conditions, makes it suitable crop to grow in the wide subtropical region of the country too. Hence, growers from different patches of subtropics are now started to cultivate cape gooseberry commercially. But the key problem of growing this crop under subtropical climate is the low yield potentiality (only 400 – 500 g $plant^{-1}$ as compared to 700-900 g $plant^{-1}$ in

leading cape gooseberry producing countries) with poor keeping quality. This is mainly because of poor soil and nutrient management as well as a 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 the quality as well as production of different crops. Application of recommended dose of nutrients, adaptation of high-density planting system, use of micro-irrigation, application of plant growth regulators (PGRs) and biofertilizers play a significant role to improve the production as well as keeping quality of different fruit crops [1-6]. Among them, the foliar application of PGRs has emerged as an effective technique to stimulate fruit growth and quality. Getting higher yield with better fruit quality by the application of PGRs has also been reported earlier in different fruit crops [7-9].

Among different PGRs, gibberellic acid (GA_3) plays a crucial 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 in improved physiological growth with better quality fruits [9]. Kumar et al., [10] reported that the foliar application of increased concentration of gibberellins had a significant impact on the improvement of the fruit quality of cape gooseberry. But the high cost of this hormone makes it difficult for fruit growers to use it in too large quantity. It enforces researchers worldwide to optimize the precise dose of GA_3 for its application. Further, no literature is available regarding the exact plant growth stages to apply GA_3 for enhancing yield with improved fruit quality. Hence, it is also necessary to optimize the time of GA_3 spray on cape gooseberry plants to enhance yield potentiality with improvement in keeping quality. Therefore, the current experiment was formulated to study the impact of different concentrations of GA_3 spray (at different growth stages) on the growth, yield, and fruit quality of cape gooseberry, particularly in the subtropical region.

Methodology

Materials

The local cultivar of cape gooseberry (*Physalis peruviana* L.) was used as experimental material. Healthy cape gooseberry seedlings with uniform growth and free from any pest and disease injuries were selected for transplanting in the main experimental plot.

Methods

GA_3 was sprayed on the experimental plants at 25, 50, 75, and 100 ppm only at the vegetative, anthesis, and fruit setting stages and also all three growth stages together. Double distilled water was sprayed on the control plants. The experiment was carried out for two successive growing seasons.

Physiological and reproductive growth

Specific leaf weight was also estimated manually at the fruiting stage [11]. The duration for planting to the anthesis of 1^{st} flower and the anthesis of 1^{st} flower to 1^{st} fruit setting were also recorded manually. Thereafter, the total flowering span was calculated by recording the date of anthesis of 1^{st} flower to the last one. Similarly, the duration of fruit set to maturity was recorded manually. Further, the harvesting span was calculated by counting the duration between the harvesting of 1^{st} fruit and to last one.

Yield and fruit quality traits

Yield per plant was measured manually and yield hectare^{-1} was calculated following the formula:

$$\text{Yield ha}^{-1} = \text{Yield plant}^{-1} \times \text{No. of plants accommodated in one hectare (37037).}$$

Total soluble solids of the ripped fruits were measured through a hand refractometer (Make: Atago, Tokyo, Japan). Titratable acidity was estimated through the titration method [12]. Reducing sugar content was determined by the method described by Lane and Eynone [13], while the total carotenoid content of the fruit was estimated following the protocol described by Roy [14].

Statistical analysis

The entire experiment was laid on a completely randomized block design (CRBD) having three replications. Pool data for two successive seasons were analyzed by statistical analysis software (SAS 9.3; SAS Institute, Cary, NC, USA) and means were differentiated through Duncan's multiple range test (DMRT).

Results and Discussion

Physiological and reproductive growth

The specific leaf weight of the cape gooseberry plant was influenced significantly in all the GA_3 treatments (Figure 1). It was recorded maximum when GA_3 was applied at all three growth stages (32.25 mg cm^{-2}) and increased gradually with the increasing concentration of GA_3 with maximum at 100 ppm concentration (39.00% higher than the control). However, the interaction showed that three repeated applications of GA_3 @ 100 ppm each at vegetative, anthesis, and again at fruiting stage had the highest specific leaf weight (43.30% higher than the control).

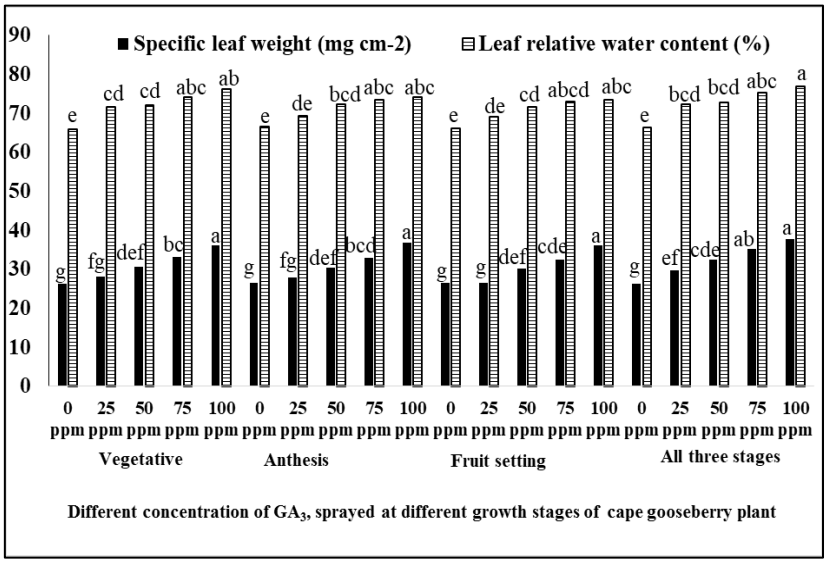

Figure 1. Effect of foliar application of GA_3 on specific leaf weight and leaf relative water content of cape gooseberry (*Physalis peruviana* L.) plants

Similarly, 100 ppm GA_3 spray each at all three growth stages had maximum leaf relative water content too (76.87%) which was statistically at par with three applications @ 75 ppm each (75.26%) (Figure 1). 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 elements resulting in improved physiological functions within the plant system [15]. Further, regardless of concentration, foliar application of GA_3 repeatedly for three times during vegetative, anthesis, and again at fruit setting stage had its long-lasting effect resulting in higher physiological growth as compared to a single application. Duration from planting to anthesis of 1st flower indicates a significant variation among the treatments (Figure 2). A single application of GA_3 @ 25 ppm during the vegetative stage helped to induce flowering in cape gooseberry at the earliest with par result in its single application (25 ppm) at the fruit setting stage and its application (25 ppm) at all three growth stages.

Similarly, the longest flowering span was calculated in the treatment comprising three repeated applications of 25 ppm GA_3 each at vegetative, anthesis, and again at fruiting stage (18.00 extra days as compared to respective control) which was statistically at par with 25 ppm GA_3 spray only at vegetative stage. However, the smallest flowering duration was recorded in three repeated sprays of GA_3 at all three growth stages @ 100 ppm each (Figure 2).

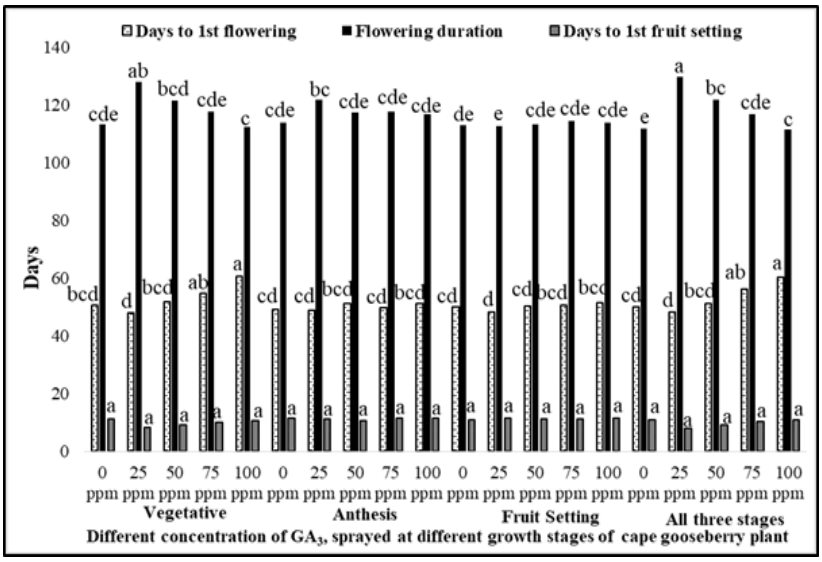

Figure 2. Effect of foliar application of GA_3 on flowering and fruiting bahaviour of cape gooseberry (*Physalis peruviana* L.) plants

Further, the earliest fruit setting was recorded in three repeated applications of GA_3 @ 25 ppm each (3.00 days earlier than the respective control) (Figure 2). Reproductive growth of cape gooseberry plants in terms of precocity in flowering, flowering duration, and precocity in fruit setting has improved significantly in three repeated applications of GA_3 @ 25 ppm with at par result in 50 ppm spray. However, a concentration beyond 50 ppm was found ineffective for improving the reproductive growth of cape gooseberry plants. It might be due to the early completion of the vegetative phase in the plants, sprayed with either 25 or 50 ppm GA_3 as compared to its higher concentrations [9].

The duration of fruit set to maturity also varied significantly under different GA_3 treatments (Figure 3). A single application of GA_3 @ 25 ppm at vegetative stage had the least duration from fruit set to maturity (51 days). However, the duration from fruit set to maturity increased gradually with the increasing concentration of GA_3, and it was recorded maximum when GA_3 was sprayed at all three growth stages @ 100 ppm each (63.33 days). Similarly, repeated application of GA_3 @ 100 ppm each at all three growth stages had the largest harvest span too (143.00 days) with at par duration in single spray @ 100 ppm at fruit setting stage only (142.33 days) and anthesis stage only (142.00 days) (Figure 3).

Yield and fruit quality traits

Average fruit weight was also increased gradually with the increasing GA_3 concentration, irrespective of stages of application with the maximum in 100 ppm spray (35.10% larger than the control) (Table 1). Further, regardless of concentration, maximum fruit weight (9.94 g) was estimated in the plants that received three sprays of GA_3 (vegetative, anthesis, and fruiting stages) with par value in single GA_3 treatment at fruit setting stage (9.77 g). The interaction revealed that a single application of 100 ppm GA_3 at the fruit setting stage had the highest fruit weight (40.78% higher than the respective control) with per result in three repeated applications of 100 ppm GA_3 (38.48% higher than the respective control). Similarly, irrespective of concentration, yield ha^{-1} was increased significantly when GA_3 was applied at all three growth stages (28.82 tonnes ha^{-1}). A shape increase in yield was obtained with the increase of GA_3 concentration and it was obtained maximum in 100 ppm spray (28.34 tonnes ha^{-1}) with non-significant variation in 75 and 50 ppm spray (28.09 and 28.01 tonnes ha^{-1}, respectively). The interaction indicates that 25 ppm GA_3 applications each at three growth stages had maximum fruit yield ha^{-1} (59.19% higher than the respective control) with par value in three repeated applications at either 50 or 75 ppm. The yield of any crop mainly depends on the physiological growth of the plant. The plants having improved physiological growth *viz*. relative water content of leaf, specific leaf weight would produce more photosynthetic

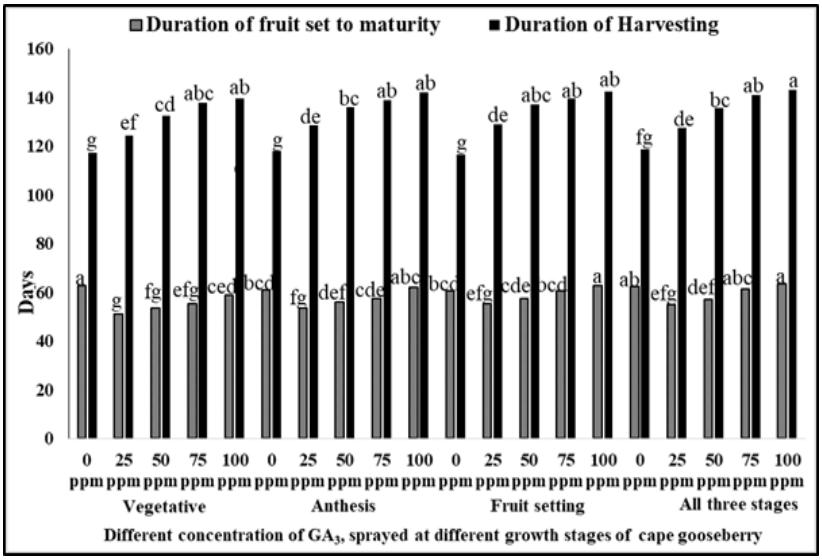

Figure 3. Effect of foliar application of GA_3 on duration of fruit set to maturity and harvesting span of cape gooseberry (*Physalis peruviana* L.) plants

Table 1. Effect of gibberellins (GA_3) on yield and biochemical attributes of cape gooseberry (*Physalis peruviana* L.)

Treatment		Fruit weight (g)	Yield (t ha^{-1})	TSS (°B)	Titratable acidity (%)	Carotenoid content (µg g^{-1} FW)
Stage of application (S)						
Vegetative		9.08^{b}	26.66^{b}	15.28^{a}	0.77^{a}	49.12^{b}
Anthesis		9.27^{b}	23.95^{c}	15.36^{a}	0.77^{a}	48.96^{b}
Fruit setting		9.77^{a}	25.29^{b}	15.40^{a}	0.75^{ab}	50.36^{b}
Vegetative, anthesis and fruit setting		9.94^{a}	28.82^{a}	15.41^{a}	0.74^{b}	51.80^{a}
Concentration of gibberellins (C)						
0 ppm		7.72^{d}	19.73^{c}	13.95^{a}	0.91^{a}	40.97^{c}
25 ppm		9.34^{c}	26.72^{b}	15.59^{a}	0.77^{b}	51.02^{b}
50 ppm		9.93^{b}	28.01^{a}	15.71^{a}	0.73^{c}	52.03^{ab}
75 ppm		10.16^{ab}	28.09^{a}	15.77^{a}	0.70^{d}	53.01^{a}
100 ppm		10.43^{a}	28.34^{a}	15.79^{a}	0.68^{e}	53.28^{a}
S × C Interaction						
Vegetative	0 ppm	7.61^{h}	19.44^{g}	0.93^{a}	14.67^{d}	40.95^{d}
	25 ppm	8.67^{g}	26.45^{de}	0.78^{bc}	20.01^{c}	49.13^{c}
	50 ppm	9.53^{ef}	28.97^{bc}	0.73^{cde}	21.58^{abc}	50.94^{bc}
	75 ppm	9.63^{ef}	28.86^{bc}	0.72^{def}	21.78^{abc}	52.11^{abc}
	100 ppm	9.94^{cde}	29.55^{ab}	0.70^{efgh}	22.71^{ab}	52.48^{abc}
Anthesis	0 ppm	7.80^{h}	19.64^{g}	0.90^{a}	15.72^{d}	40.58^{d}
	25 ppm	8.92^{fg}	23.24^{f}	0.79^{b}	19.81^{c}	49.39^{c}
	50 ppm	9.63^{ef}	25.31^{ef}	0.74^{bcde}	21.21^{bc}	50.78^{bc}
	75 ppm	9.81^{de}	23.43^{efg}	0.71^{efg}	22.08^{abc}	51.78^{abc}
	100 ppm	10.17^{abcde}	26.11^{de}	0.69^{efgh}	22.97^{ab}	52.28^{abc}
Fruit setting	0 ppm	7.70^{h}	19.85^{g}	0.91^{a}	15.51^{d}	41.25^{d}
	25 ppm	9.75^{de}	25.39^{ef}	0.77^{bcd}	20.20^{c}	51.39^{abc}
	50 ppm	10.10^{abcde}	26.06^{de}	0.73^{cde}	21.61^{abc}	52.11^{abc}
	75 ppm	10.48^{abcd}	27.29^{cd}	0.69^{efgh}	22.78^{ab}	53.45^{ab}
	100 ppm	10.84^{a}	27.83^{cd}	0.66^{h}	24.06^{a}	53.62^{ab}
Vegetative, anthesis and fruit setting	0 ppm	7.77^{h}	19.97^{g}	0.92^{a}	15.26^{d}	41.08^{d}
	25 ppm	10.02^{bcde}	31.79^{a}	0.73^{cde}	21.44^{bc}	54.16^{ab}
	50 ppm	10.43^{abcd}	31.71^{a}	0.72^{efg}	21.99^{abc}	54.28^{ab}
	75 ppm	10.67^{abc}	30.78^{a}	0.67^{fgh}	23.48^{ab}	54.71^{a}
	100 ppm	10.76^{ab}	29.86^{ab}	0.67^{gh}	23.67^{ab}	54.75^{a}

Value indicates mean of three replicates. Different letters in the same column indicate significant differences at P ≤ 0.05 (Duncan's Multiple Range Test).

assimilates which in turn improve the yield of the crop. In addition, increased accumulation of carbohydrates directly increased the fruit weight which ultimately improves the crop yield. Earlier findings of Singh et al., [9] in cape gooseberry also confirmed similar results. The total soluble solid (TSS) of ripped cape gooseberry fruits has improved significantly in all GA_3-treated plants (Table 1). Application of GA_3 at either concentration but at all three growth stages increased the TSS content significantly as compared to the respective control. The improvement of TSS in three applications of GA_3 might be due to the higher accumulation of sugars and other soluble compounds, particularly through protein hydrolysis and ascorbic acid oxidation [16]. However, the reverse pattern was observed for titratable acidity and it was reduced significantly when GA_3 was applied at all three growth stages (0.74%). The lowest acidity in three repeated applications of GA_3 might be due to the dilution effect and increased conversion of fruit acidity to sugar and other solids as observed by Kaur and Kaur [17] in cape gooseberry. The amount of reducing along with non-reducing sugar content in ripped cape gooseberry fruits was not varied significantly with different stages of application (Figure 4).

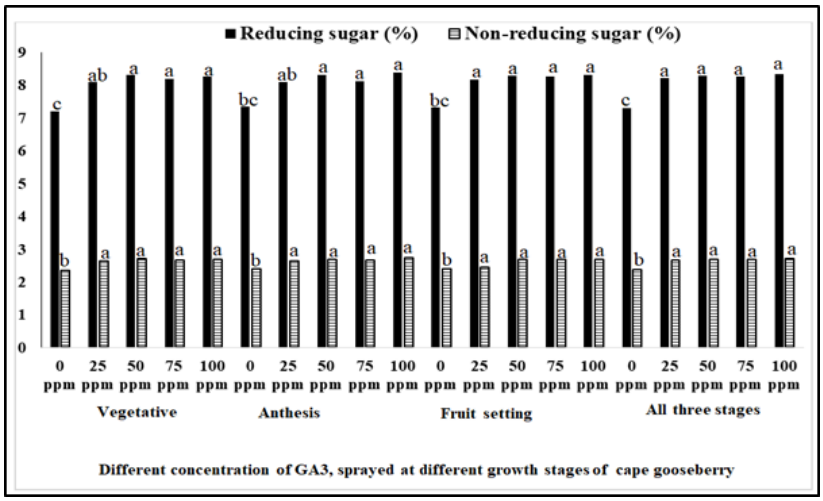

Figure 4. Effect of foliar application of GA_3 on sugar content of Ripped cape gooseberry (*Physalis peruviana* L.) fruits

However, reducing as well as non-reducing sugar content was estimated maximum in the plants that received three repeated applications of GA_3 (8.07 and 2.62, respectively). The interaction table revealed that the reducing sugar content was estimated maximum under a single GA_3 spray @ 100 ppm at anthesis (8.38%) which was statistically at par with its application during all three growth stages @ 25-100 ppm (8.21 - 8.33%). A similar pattern was also observed for non-reducing sugar content in ripped cape gooseberry fruits. Increased accumulation of reducing and non-reducing sugars by GA_3 spray might be due to the faster conversion of starch and acids into simple sugars [18]. Further application of GA_3 @ 25-100 ppm each at all three growth stages also helped to increase the carotenoid content to its maximum level in the fruit (54.16 – 54.75 µg g^{-1} FW) with a statistically non-significant variation. Present research work confirms that repeated application of GA_3 improved the physiological growth of cape gooseberry significantly with improved reproductive behavior, resulting in maximum yield.

Fruit quality traits in terms of TSS, sugar, and carotenoid content of ripped cape gooseberry fruit was also improved significantly in three repeated application of GA_3. Among four different concentrations, improvement in yield and quality attributes was statistically at par in 25- 100 ppm concentration. Hence, it can be concluded that the application of GA_3 @ 25 ppm each at vegetative, anthesis, and again at fruit setting stage is optimum to improve the yield of better quality cape gooseberry fruit significantly under subtropical conditions.

Acknowledgements

Financial support from PG Research Contingency, Bihar Agricultural University, BAU, Sabour, Bhagalpur, India, is thankfully acknowledged

References

[1] K. Nandita, M. Kundu, R. Rakshit and S. Nahakpam **(2022)**. Effects of foliar application of micronutrients on growth, yield and quality of sweet orange (*Citrus sinensis* (L.) Osbeck). Bangladesh J. Bot., **51:** 57-63.

[2] F. Khatoon, M. Kundu, H. Mir, K. Nandita and D. Kumar **(2020)**. Foliar Feeding of Brassinosteriod: A Potential Tool to Improve Growth, Yield and Fruit Quality of Strawberry (*Fragaria* × *ananassa* Duch.) under Non-Conventional Area. Int. J. Curr. Microbiol. Appl. Sci., **9:** 733-741.

[3] K. Nandita, M. Kundu, R. Rani, F. Khatoon and D. Kumar **(2020)**. Foliar feeding of micronutrients: an essential tool to improve growth, yield and fruit quality of sweet orange (*Citrus sinensis* (L.) Osbeck) cv. Mosambi under non-traditional citrus growing track. Int. J. Curr. Microbiol. Appl. Sci., **9:** 473-483.

[4] V. Kumar, M. Kundu, H. Mir, S. Sahay, V. Bharati and M. B. Singh **(2021)**. Integrated nutrient module can uphold the growth and yield of Cape gooseberry (*Physalis peruviana* L.). J. Pharma. Innov., **10:** 1044-1048.

[5] S. Kumar, M. Kundu, A. Das, R. Rakshit, Md. W. Siddiqui and R. Rani **(2019)**. Substitution of mineral fertilizers with biofertilizer: An alternate to improve the growth, yield and functional biochemical properties of strawberry (*Fragaria×ananassa* Duch.) cv. Camarosa. J. Plant Nutr., **42:** 1-20.

[6] M. Kundu, R. Joshi, P. N. Rai and L. D. Bist **(2013a)**. Effect of Plant Bio-Regulators on fruit growth, quality and productivity of pear [*Pyrus pyrifolia* (Brum.) Nakai] cv Gola under *tarai* condition. J. Appl. Hortic., **15:** 106-109.

[7] M. Kundu, R. Joshi, P. N. Rai and L. D. Bist **(2013b)**. Response of different plant bio-regulators (PBRs) on vegetative and reproductive growth of pear [*Pyrus pyrifolia* (Brum.) Nakai] cv. gola under subtropical plains. Environ. Ecol., **31:** 310-313.

[8] F. Khatoon, M. Kundu, H. Mir and S. Nahakpam **(2021)**. Efficacy of foliar feeding of brassinosteroid to improve growth, yield and fruit quality of strawberry (*Fragaria* × *ananassa* Duch.) grown under subtropical plain. Commun. Soil Sci. Plant Anal., **52:** 803-814.

[9] M. B. Singh, P. Kumar, M. Kundu, S. Sahay and V. Kumar **(2022)**. Split Application of GA_3: Effective to improve growth, yield and quality of cape gooseberry (*Physalis peruviana* L.). Eco. Env. Cons., **28:** 863-868.

[10] R. Kumar, S. P. Singh, A. Tiwari, S. Maji and V. L. Patidar **(2017)**. Effect of gibberellic acid (GA3) on fruit yield and qualityof cape gooseberry (*Physalis peruviana* L.). Int. J. Adv. Biol. Res., **7:** 724-727.

[11] P. E. Weatherley **(1950)**. Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytol., **49:** 81-97.

[12] S. Ranganna **(1986)**. Handbook of Analysis and quality control for fruit and vegetable products. Tata Mc Grow-Hill Ltd., New Delhi.

[13] J. H. Lane and L. Eynone **(1923)**. Determination of reducing sugars by means of Fehling solution with methylene blue indicator as an internal indicator. J. Soc. Chem. Ind., **42:** 32-36.

[14] S. K. Roy **(1973)**. Simple and rapid methods for the estimation of total carotenoids pigments in mango. J. Food Sci. Technol., **10:** 45.

[15] M. M. A. Khan, C. Gautam, F. Mohammad, M. H. Siddiqui, M. Naeem and M. N. Khan **(2006)**. Effect of gibberellic acid spray on performance of tomato. Turk. J. Biol., **30:**11-16.

[16] P. Kumari **(2018)**. Effect of GA_3 and Urea phosphate on yield and post-harvest quality of Strawberry (*Fragaria* × *ananassa* Duch) cv. Nabila. M.Sc. Thesis, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India.

[17] G. Kaur and A. Kaur **(2016)**. Plant growth and fruit yield attributes of cape gooseberry cv. Aligarh as affected by the use of different growth regulators. Agric. Sci. Dig., **36:** 138-141.

[18] E. Antognozzi, A. Battistelli, F. Famiani, S. Moscatello, F. Stanica and A. Tombesi **(1996)**. Influence of CPPU on carbohydrate accumulation and metabolism in fruits of *Actinidia deliciosa*. Sci. Hortic., **65:** 37-47.