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Sibabrata Behera
Department of Vegetable Science, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

CN Hanchinamani
Department of Vegetable Science, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Correspondence
Sibabrata Behera
Department of Vegetable Science, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Effect of growth regulators yield and yield parameters in sweet potato (*Ipomoea batatas* (L.) Lam.)

Sibabrata Behera and CN Hanchinamani

Abstract
A field experiment was carried out during *kharif* 2016-17 at Kittur Rani Channamma College of Horticulture, Arabhavi (Karnataka) to study the effect of growth regulators yield of sweet potato [*Ipomoea batatas* (L.) Lam.]. The results revealed that, there was a significant difference among the growth regulators and their combination with respect to total tuber yield. The maximum tuber yield (28.09 t ha^{-1}) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}) as compared to other treatments. However, it was on par with the single treatment of CCC @ 300 ppm (T_6) (27.01 t ha^{-1}). The results revealed that, there was a significant difference among the growth regulators and their combination with respect to harvest index. The maximum harvest index (62.56) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}) as compared to other treatments.

Keywords: sweet potato, plant growth regulators and yield and yield parameters

Introduction
Sweet potato [*Ipomoea batatas* (L.) Lam.] is an important tuber crop belonging to the family Convolvulaceae. It is an important starchy vegetable crop in tropics and sub tropics. It is mainly grown as one of the supplementary food crops to meet the requirements of carbohydrates and also to provide raw materials for manufacture of starch, alcohol, lactic acid, vinegar etc. The nutrition of sweet potato in human diet is quite appreciable since, it provides high quantity of starch, substantial amount of vitamins (A, B and C) (Hung *et al.* 1999) [9], minerals and trace elements compared to cereals. It would be a good substitute for rice and wheat (Thakur, 1975) [31]. It also contains considerable amount of beta-carotene (5.40 to 20.00 mg/100g) and sugar content.

Sweet potato tubers are consumed usually after boiling, baking and frying and may also be candied as ‘Puree’. Tubers are utilized for canning, dehydration and flour manufacturing and also as an important source of starch, glucose, pectin and sugar hence used in syrup and industrial alcohol preparation. Sweet potato ‘vine tips’ are used as leafy vegetable in China, Japan and Korea (Dhankhar, 2001) [7].

The role of plant growth substances in the physiology of plant is one of the most interesting chapters in the science. The plant growth substances are organic compounds, other than nutrients which in small concentration influence the physiological processes of plants. They have been used for various beneficial effects such as promoting plant growth, increasing number of flowers, fruit size and inducing early and uniform fruit ripening.

The gibberellins a large family of closely related tetracyclic diterpenoid compounds have been applied to enhance the productivity of crops. GA_3 has a major effect on growth and development activating the entire metabolic activities of many crops. GA_3 is one of the important growth regulators that stimulate vegetative growth (Singh and Rajodia, 2001) [20], yield (Khan *et al.*, 2002) [12] and sugar content (Babu, 2000) [3]. With this background, the studies on effect of growth regulators on yield of Sweet potato was undertaken during *Kharif* 2016 at Dept. of vegetable science, Kittur Rani Channamma College of Horticulture, Arabhavi.

Material and Methods
The field experiment was conducted at the Kittur Rani Channamma College of Horticulture, Arabhavi, Gokak Taluk, Belgaum district of Karnataka state during the *Kharif -2016*. Arabhavi is situated in northern dry zone of Karnataka state at 16^0 13’ 39.6” north latitude, 74^0

50' 13.5" east longitude and at an altitude of 612.03 m above the mean sea level. Arabhavi, which lies in Zone-3 of Region-2 of agro-climatic zones of Karnataka, is considered to have the benefit of both South-West and North-East monsoons. The average rainfall of this area is about 530 mm, distributed over a period of five to six months (May-October) with peak (226.10 mm) during September. The area receives water from Ghataprabha Left Bank Canal from mid-July to mid-March. During the experimental period, the mean minimum temperature varied from 11.80 ^{0}C (December 2016) to 23 ^{0}C (August 2016), whereas the mean maximum temperature varied from 26.10 ^{0}C (December 2016).

The experiment was laid out in Randomized block design and replicated thrice. Vine cuttings of 15-20 cm length were planted at a spacing of 60 x 30 cm and 5-7 cm depth. Standard recommended cultural practices were followed during the entire crop grown period.The experiment consisted of different PGR concentrations (GA_3 @ 25, 50 and 100 ppm, CCC @ 100, 250 and 300 ppm and IBA @ 100 and 200 ppm and control). In each treatment, the plants were sprayed twice at 45 and 60 days after transplanting. The data on vegetative growth, tuber characters were recorded and analyzed statistically.The experimental data collected on various growth, yield and quality aspects were subjected to Fisher's method of analysis of variance (ANOVA) as per methods outlined by Panse and Sukhatme (1967). The critical difference (CD) was calculated wherever the 'F' test was found significant. The data were analyzed and presented with the level of significance at 5 per cent.

Results and Discussion

Tuber diameter (cm)

The results revealed that, the highest diameters of fresh tubers (7.42 cm) was recorded in combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}), which was on par with single treatment of CCC @ 300 ppm (T_6) (7.27 cm). (Fig. -1).

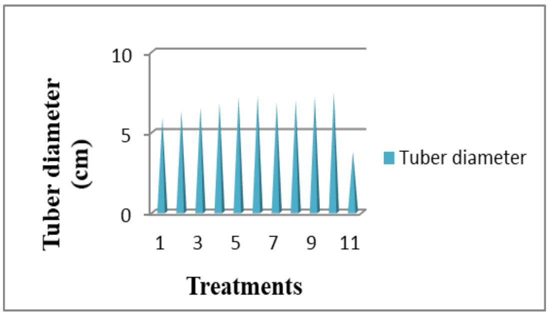

Fig 1: Effect of different growth regulators on tuber diameter (cm) of sweet potato

Usha *et al.* (2009) stated that the cycocel applied as a foliar spray in rhubarb produced rhizomes with largest diameter by suppressing shoot growth by inhibition of the biosynthesis of endogenous Gibberillic acids, thereby increasing photo assimilates allocation to the rhizomes. Similar response of CCC increase the girth of root tuber was earlier reported by Abdul and Kumaran (1980) [1], Tohamy *et al.* (2015) [32], Shee (1983) [27] in sweet potato, Mohamed and Anbu (1996) [16] in radish and Jirali *et al.* (2008) [11] in ginger, Patel *et al.* (2010) [20] in onion, Desai *et al.* (2012) [6] in tomato, Patil and Chaitanya (2014) [21] in okra.

Average fresh tuber weight (g)

Among the different treatments, combination treatment of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}) recorded the maximum tuber fresh weight (431.90 g) followed by single treatment of CCC @ 300 ppm (T_6) (419.83 g). Whereas, minimum fresh tuber weight (277.03 g) was reported in control (T_{11}). (Fig. -2)

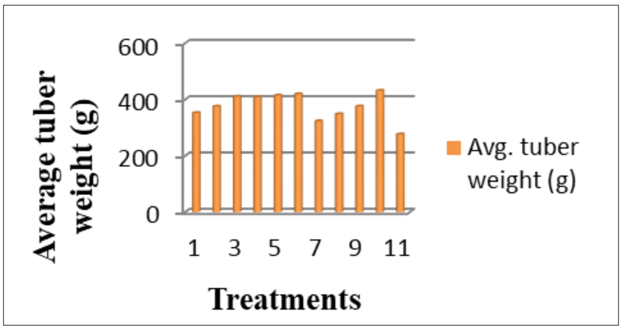

Fig 2: Effect of different growth regulators on average tuber weight (g) of sweet potato

The significant increase in average fresh tuber weight might be attributed due to the higher chlorophyll content, photosynthetic activity, increased assimilation and accumulation of photosynthates from source to sink by foliar application of GA_3 and CCC. These results are in conformity with the findings of Abdul and Kumaran (1980) [1] in sweet potato, Sillu *et al.* (2012) [29], Baijal *et al.* (1983) [4] in potato, Mohamed and Anbu (1996) [16] in radish.

Marketable tuber weight (kg plot^{-1})

The results revealed that, there was a significant difference among the growth regulators and their combination with respect to marketable tuber weight per plot. Among the different treatments, T_{10} – treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm recorded the highest marketable tuber weight (15.88 kg plot^{-1}) and it was on par with T_6 – single treatment of CCC @ 300 ppm (13.87 kg plot^{-1}). (Fig. -3)

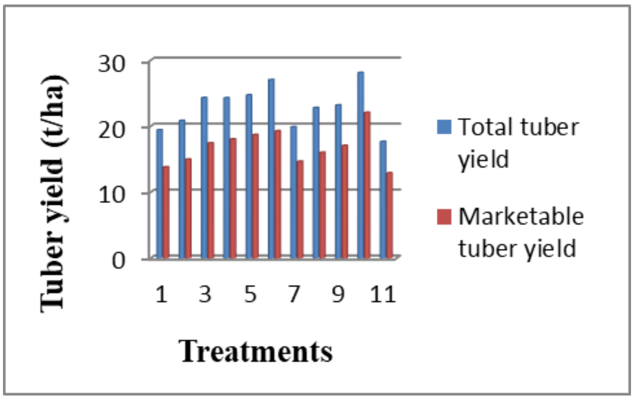

Fig 3: Effect of different plant growth regulators on total tuber yield and marketable tuber yield (t ha-1) of sweet potato

The increase in marketable tuber weight was due to uniform and uninfected tubers. The increase in weight of tuber and yield might be due to accumulation of carbohydrates owing to greater photosynthesis. The another probable reason for increasing yield attributes might be due to the increasing growth characters by cell division, cell elongation and cell expansion that might have ultimately increased in tuber yield. The increase in vegetative characters may be due to cell division and quick cell multiplication, while the high yield may be attributed to better carbon assimilation and better carbon accumulation of carbohydrates in the plants. GA_3 enhanced the yield by better utilization of photosynthates and metabolic machinery and CCC application manifests in increased yield of crops was reported by Indira *et al.* (1984) [10], Shah *et al.* (1991) [25], Arora *et al.* (1985) [2] and Srivastava *et al.* (2001).

Unmarketable tuber weight (kg plot^{-1})

The results revealed that, there was a significant difference among the growth regulators and their combination with respect to unmarketable tuber weight per plot. The unmarketable tuber weight per plot (4.91 kg plot^{-1}) was found to be highest with the application of single treatment of GA_3 @ 100 ppm (T_3), which was on par with single treatment of CCC @ 300 ppm (T_6) (4.77 kg plot^{-1}). It might be due to development of some small irregular and over size tubers. These results are in conformity with the findings of Abdul and Kumaran (1980) [1], Shedge *et al.* (2008) [26] in sweet potato, Patel *et al.* (2010) [20] in onion.

Marketable tuber yield (t ha^{-1})

The results revealed that, there was a significant difference among the growth regulators and their combination with respect to marketable tuber yield. Among the different treatments, treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}) recorded the highest marketable tuber yield (22.04 t ha^{-1}) and it was on par with the single treatment of CCC @ 300 ppm (T_6) (19.26 t ha^{-1}), single treatment of CCC @ 250 ppm (T_5) (18.69 t ha^{-1}). (Fig. -3)

It might be due to increase in concentration of GA_3 that enhanced the marketable tuber yield by better utilization of photosynthates and metabolic machinery and CCC application manifests in increased yield of crops was reported by Indira *et al.* (1984) [10], Shah *et al.* (1991) [25], Arora *et al.* (1985) [2] and Srivastava *et al.* (2001). They reported that increased yield was the result of increased number of leaves and increase in chlorophyll content. Similar results were also recorded by Baijal *et al.* (1983) [4] and Banerjee and Das (1984) [5] in potato, Maurya and Lal (1987) [15] in carrot, Abdul and Kumaran (1980) [1], Remison *et al.* (2002) [23], Shedge *et al.* (2008) [26], Seema sarkar (2008), Tohamy *et al.* (2015) in sweet potato.

Total tuber yield (t ha^{-1})

The results revealed that, there was a significant difference among the growth regulators and their combination with respect to total tuber yield. The maximum tuber yield (28.09 t ha^{-1}) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}) as compared to other treatments. However, it was on par with the single treatment of CCC @ 300 ppm (T_6) (27.01 t ha^{-1}). The plant growth regulator GA_3 is an important component to enhance cell multiplication and quick cell division which resulted in increasing the morphological characters of plants that ultimately increased the yield. The increase in vegetative characters may be due to cell division and quick cell multiplication, while the high yield may be attributed to better carbon assimilation and better carbon accumulation of carbohydrates in the plants. GA_3 enhanced the yield by better utilization of photosynthates and metabolic machinery and CCC application manifests in increased yield of crops was reported by Indira *et al.* (1984) [10], Shah *et al.* (1991) [25], Arora *et al.* (1998) [2] and Srivastava *et al.* (2001). They reported that increased yield was the result of increased number of leaves and increase in chlorophyll content. Similar results were also recorded by Prakash *et al.* (2001), Baijal *et al.* (1983) [4] and Banerjee and Das (1984) [5] in potato, Maurya and Lal (1987) [15] in carrot, Verma (2000) in coriander, Padmavathi (1998) in onion,

Harvest index (%)

The results revealed that, there was a significant difference among the growth regulators and their combination with respect to harvest index. The maximum harvest index (62.56) was recorded in treatment combination of GA_3 @ 100 ppm and CCC @ 250 ppm (T_{10}) as compared to other treatments and it was on par with the single treatment of CCC @ 300 ppm (T_6) (59.16). It was due to increase in dry matter production of both plant and tubers. These results obtained in the present study were in conforming with the findings of Baijal *et al.* (1983) [4] and Kumar *et al.* (2012) in potato, Remison *et al.* (2002) [23] in cassava, Emongor (2007) [8] in cowpea, Nawalagatti *et al.* (2009) [17] in french bean and Lendve *et al.* (2010) [14] in cabbage.

Table 1: Effect of growth regulators on tuber diameter (cm), average tuber weight (g), marketable tuber weight (kg/plot) and unmarketable tuber weight (kg/plot) in sweet potato

Sl. No.	Treatments	Tuber diameter (cm)	Avg. tuber weight (g)	Marketable tuber weight (kg/plot)	Unmarketable tuber weight (kg/plot)
1.	T_1- GA_3 @ 25 ppm	5.89	352.67	9.93	4.04
2.	T_2- GA_3 @ 50 ppm	6.29	375.67	10.78	4.22
3.	T_3- GA_3 @ 100 ppm	6.53	411.17	12.54	4.91
4.	T_4- CCC @ 200 ppm	6.79	408.17	12.98	4.49
5.	T_5- CCC @ 250 ppm	7.20	414.83	13.46	4.33
6.	T_6- CCC @ 300 ppm	7.27	419.83	13.87	4.77
7.	T_7- IBA @ 100 ppm	6.85	323.67	10.54	4.25
8.	T_8- IBA @ 200 ppm	6.98	348.66	11.52	4.62
9.	T_9- Combination of GA_3 @ 50 ppm + IBA @ 200 ppm	7.23	376.17	12.27	4.14
10.	T_{10}- Combination of GA_3 @ 100 ppm + CCC @ 250 ppm	7.42	431.90	15.88	4.35
11.	T_{11}- Control	3.78	277.03	9.29	3.42
	S.Em±	0.53	14.06	0.96	0.25
	C. D. at 5%	1.59	41.50	2.84	0.76
	C.V.	14.22	6.47	13.81	10.33

DAP = Days after planting

Table 2: Effect of growth regulators on marketable tuber yield (t/ha), total tuber yield (t/ha) and harvest index (%) on sweet potato

Sl. No.	Treatments	Marketable tuber yield (t/ha)	Total tuber yield (t/ha)	Harvest index (%)
1.	T_1- GA_3 @ 25 ppm	13.79	19.40	51.60
2.	T_2- GA_3 @ 50 ppm	14.96	20.82	53.76
3.	T_3- GA_3 @ 100 ppm	17.42	24.31	57.30
4.	T_4- CCC @ 200 ppm	18.02	24.27	56.18
5.	T_5- CCC @ 250 ppm	18.69	24.71	57.82
6.	T_6- CCC @ 300 ppm	19.26	27.01	59.16
7.	T_7- IBA @ 100 ppm	14.64	19.87	52.42
8.	T_8- IBA @ 200 ppm	15.99	22.79	54.69
9.	T_9- Combination of GA_3 @ 50 ppm + IBA @ 200 ppm	17.04	23.17	56.80
10.	T_{10}- Combination of GA_3 @ 100 ppm + CCC @ 250 ppm	22.04	28.09	62.56
11.	T_{11}- Control	12.90	17.65	47.78
	S.Em±	1.33	1.49	2.20
	C. D. at 5%	3.95	4.41	6.49
	C.V.	13.81	11.31	6.88

DAP = Days after planting

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