International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 30, 2017, pp.-4403-4407.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECT OF PLANT GROWTH REGULATORS ON VEGETATIVE AND ROOT TUBER YIELD CHARACTERS OF ORANGE FLESH SWEET POTATO VARIETIES

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Received: May 24, 2017; Revised: June 04, 2017; Accepted: June 05, 2017; Published: June 30, 2017

Abstract- A field experiment was conducted during *kharif* 2015-16 at Horticultural College & Research Institute, Dr. Y.S.R. Horticultural University, Venkataramannagudem (A.P) to find out the effect of plant growth regulators on orange flesh sweet potato varieties for vegetative and root tuber characters. Among the varieties tested, ST-14 registered significantly higher values for length of leaf lobe, leaf area, vine length, vine inter nodal length and number of branches per plant, while the width of leaf lobe, petiole length and number of flowers per plant were maximum in the variety Kamala sundari at 80 DAT. Spraying of GA_3 @ 300 ppm showed maximum values for vegetative attributes. Significantly highest number of flowers per plant was recorded with the application of 2,4-D @ 15 ppm in the variety Kamala sundari. The higher values of plant dry matter percentage, number of root tubers per plant, root tuber length and root tuber yield per plant were recorded in the variety ST-14 by GA_3 @ 300 ppm, while root tuber girth was maximum in the variety Kamala sundari by CCC @ 500 ppm.

Keywords- Orange flesh sweet potato, Plant growth regulators, Root tuber Yield, Varieties, and Vegetative characters

Citation: Rao G. Koteswara, et al., (2017) Effect of Plant Growth Regulators on Vegetative and Root Tuber Yield Characters of Orange Flesh Sweet Potato Varieties. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 30, pp.-4403-4407.

Academic Editor / Reviewer: Dr Venkata Satish Kuchi

Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam.) is an important starchy food crop grown throughout the tropical and sub-tropical parts of the world. It is an herbaceous, perennial vine cultivated as an annual belongs to family Convolvulaceae. It is originated from Central America. 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, butanol, vinegar etc. It is a rich source of provitamin A, vitamin B_1 (Thiamin) and vitamin C (Huang, et al. [1]). Sweet potato yields high amount of energy per unit area per unit time and is expected to bridge the food shortages and malnutrition.

In India, sweet potato is being cultivated in almost all the states with an area of 111 ha, with a production of 1450 metric tonnes and productivity of 10.4 MT/ha (NHB, [2]). India accounts for about 68% of the total production of South Asia followed by 27% in Bangladesh and about 5% in Sri Lanka. In India, Sweet potato is cultivated mainly in Odisha, Uttar Pradesh, West Bengal, Bihar, Karnataka, Andhra Pradesh, Tamil Nadu and Kerala. The plant growth substances are organic compounds, other than nutrients which in small concentration influence the physiological processes of plants. Foliar application of growth regulators is reported to improve growth, early flowering, increased flowering and tuber yield. Growth regulators are also reported to improve yield of many horticultural crops those in which the underground part is economically important.

As sweet potato is clonally propagated crop, crop improvement is possible through clonal hybridization. For this, the desired genotypes for crossing should have more number of flowers, often this is not so. Growth regulators which influence the flower development and seed set need to be tested. Therefore, the present study was undertaken to study the varietal response of orange flesh sweet potato to different plant growth regulators for vegetative and root tuber yield characters.

Materials and Methods

The experiment was laid out in Randomized block design with factorial concept and replicated thrice. The experiment consisted of two factors *viz*., varieties (ST-14, Kamala sundari and Kiran) and different PGR concentrations (GA_3 @ 200 & 300 ppm, CCC @ 300 & 500 ppm, 2,4-D @ 10 &15 ppm and Control. The planting material was collected from AICRP on tuber crops project, HRS, Venkataramannagudem. Vine cuttings of 25-30 cm length were planted at a spacing of 60 X 20 cm. The prepared plant growth regulator solutions were sprayed with baby sprayer for uniform coverage. In each treatment, the plants were sprayed twice at 30 and 60 days after transplanting. The data on vegetative growth, flower and root tuber characters were recorded and analysed statistically by using OPSTAT software.

Results and Discussion

Vegetative attributes

The vegetative attributes *viz*., length of the leaf lobe, width of the leaf lobe, petiole length, leaf area, vine length, vine inter nodal length, number of branches per plant and plant dry matter were significantly influenced by varieties and different PGR concentrations at 80 DAT [Table-1].

Length of leaf lobe

Maximum length of leaf lobe (13.05 cm) was recorded in the variety ST-14. Significantly maximum length of leaf lobe (12.91 cm) was recorded with GA_3 @ 300 ppm than control. These results are in conformity with the findings of Mahabir Singh, et al. [3] in radish, Sengupta, et al. [4] in ginger and Patel, et al. [5] in onion.

Width of leaf lobe

Maximum width of leaf lobe (11.93 cm) was recorded in Kamala sundari. Among different PGR concentrations, significantly maximum width of leaf lobe (9.19 cm) was recorded in GA_3 @ 300 ppm compared to control (C_7). Similar trends are observed by Mahabir Singh, et al. [3] in radish and Sengupta, et al. [4] in ginger.

Petiole length

Significantly the highest petiole length (36.01 cm) was recorded in Kamala sundari (V_2). Among different PGR concentrations, GA_3 @ 300 ppm (C_2) was recorded maximum petiole length (33.67 cm). The increase in petiole length by the GA_3 treatment may be due to cell elongation and cell division.

Table- 1 *Varietal response of orange flesh sweet potato (Ipomoea batatas. (L.). Lam) to plant growth regulators for vegetative characters at 80 DAT*

	Length of leaf lobe (cm)	Width of leaf lobe (cm)	Petiole length (cm)	Leaf area (cm^2)	Vine length (cm)	Vine inter nodal length (cm)	Number of branches per plant	Plant dry matter (%)
Varieties								
ST-14 (V_1)	13.05	7.96	31.86	83.22	211.79	9.03	12.52	33.51
Kamala sundari (V_2)	12.69	11.93	36.01	76.99	203.64	6.84	9.77	24.61
Kiran (V_3)	11.19	4.84	27.57	72.34	210.55	7.36	11.10	31.71
SEm±	0.093	0.04	0.11	0.08	1.27	0.04	0.21	0.16
CD at 5%	0.268	0.13	0.33	0.23	3.65	0.11	0.62	0.46
PGR								
C_1 (GA_3- 200 ppm)	12.60	8.72	31.67	77.46	224.29	7.88	11.71	31.57
C_2 (GA_3- 300 ppm)	12.91	9.19	33.67	78.67	248.36	8.78	13.83	33.80
C_3 (CCC-300 ppm)	11.91	8.23	31.65	77.50	194.72	7.34	10.21	29.33
C_4 (CCC-500 ppm)	12.23	7.92	31.33	76.97	194.64	7.21	11.33	30.53
C_5 (2,4-D-10 ppm)	12.07	8.00	31.78	77.36	198.88	7.65	10.50	27.88
C_6 (2,4-D-15 ppm)	12.85	8.32	31.88	77.94	205.11	8.33	11.17	29.30
C_7 (Control)	11.59	7.33	30.70	76.61	194.62	7.03	9.16	27.21
SEm±	0.143	0.07	0.17	0.12	1.95	0.06	0.33	0.25
CD at 5%	0.409	0.20	0.51	0.36	5.58	0.18	0.95	0.71

Leaf area

Maximum leaf area (83.22 cm^2) was recorded with ST-14 (V_1). Among different PGR concentrations, significantly maximum leaf area (78.67 cm^2) was recorded with GA_3 @ 300 ppm (C_2). The increase in the leaf area due to GA_3 application might be due to increase in plasticity of the cell wall followed by hydrolysis of starch to sugars which lowers the water potential of cell, resulting in the entry of water into the cell causing elongation. These osmotic driven responses under the influence of gibberellins might have attributed to increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell division in the growing portion (Sargent, [6]). These results are in conformity with the findings of Singh and Choudhary, [7] in watermelon, cucumber and bottle gourd; Arora, et al. [8] in watermelon and summer squash; Emongor, [9] and Chatterjee and Choudhuri, [10] in cowpea, Bhagure and Tambe, [11] in okra.

Vine length

Maximum vine length (211.79 cm) was recorded with ST-14. Among different PGR concentrations, significantly maximum vine length (248.36 cm) was recorded with GA_3 @ 300 ppm than control. GA_3 has been found to increase the cell wall plasticity and also thus creating water diffusion pressure deficit, which result in water uptake, thereby causing cell elongation followed by cell division as suggested by Randhawa, [12]. However, the response to GA_3 in terms of cell division and cell elongation depends upon nature of tissues and the balance of the different kinds of growth substances. These results are in confirmation with the findings of Natesh, et al. [13] in chilli; Dheer singh, et al. [14]; Sengupta, et al. [4] in ginger; Moslesh Ud-deen, [15] in *Colocasia esculenta*, Nawalagatti, [16] in french bean; Uddain, et al. [17] in tomato, Patel, et al. [5] in onion and El-Tohamy, et al. [18] in sweet potato.

Vine inter nodal length

The Highest vine inter nodal length (9.03 cm) was recorded in the variety ST-14. Significantly maximum vine inter nodal length (8.78 cm) was recorded in GA_3 @ 300 ppm than control. It might be due to cell elongation and cell division, the length of internode has increased, hence GA_3 played an important role in enhancing the mean length of internode on main vine. Similar results are observed by Brumbaugh, [19] in pea and Avinash, et al. [20] in okra.

Number of branches per plant

It was observed that number of branches per plant was significantly influenced with different varieties and PGR concentrations at 80 DAT. The maximum number of branches (12.52) per plant was recorded in the variety ST-14. Among different PGR concentrations GA_3 @ 300 ppm was recorded maximum number of branches (13.83) per plant than control. The application of GA_3 enhanced the lateral buds and vegetative growth which increases the number of branches per plant. These results are in conformity with the findings of Natesh, et al. [13] in chilli; Sengupta, et al. [4] in ginger; Jaymala singh, et al. [21] in okra; Nawalagatti, et al. [16] in french bean; Uddain, et al. [17] in tomato; Chovatia, et al. [22] in cowpea and El-Tohamy, et al. [18] in sweet potato.

Plant dry matter (%)

Significantly maximum plant dry matter (33.51%) was recorded in the variety ST-14. Among different levels of plant growth regulators, the maximum plant dry matter (33.80%) was recorded in GA_3 @ 300 ppm than control. The higher values of fresh weight and dry matter production with the foliar application of growth regulators could be due to more number of leaves, more plant spread and leaf area which resulted in more photosynthetic rate and better accumulation of food material in plant. Similar results are obtained by Baijal, et al. [23] and Ashok, et al. [24] in potato; Remison, et al. [25] in cassava; Seema sarkar. [26] in sweet potato; Emongor, [9] in cowpea and Nawalagatti, et al. [16] in french bean.

Flower and root tuber characters

The characters like total number of flowers per plant, root tubers per plant, root tuber length, tuber girth and tuber yeild were significanlty influenced by varieties nd differnt PGRs' [Table -2 & 3].

Total number of flowers per plant

The data on total number of flowers per plant was recorded from days taken to first flower initiation to till to the harvest. Highest number of flowers per plant (606.08) was recorded in Kamala sundari. With respect to different levels of plant growth regulators, maximum number of flowers per plant (620.12) was recorded with the application of 2,4-D @ 15 ppm than control. It may be due to at low concentration, 2,4-D stimulates flowering. It readily penetrate leaves, roots and stems and is rapidly transported via symplastic and apoplastic pathways (Chinalia, et al. [27]) and stimulate excessive biosynthesis of ethylene and abscissic acid. Increase in endogenous ethylene and abscissic acid results in floral organs development and flowering (Tan and Swain, [28]). Similar results of increase in number of flowers by application of 2,4-D were recorded by Ricard, et al. [29]; Shalaby, et al. [30] and Walter, et al. [31] in sweet potato; Anwar, et al. [32] in tomato and Thomson, et al.[33] in pea.

Table-2 *Varietal response of orange flesh sweet potato (Ipomoea batatas. (L.). Lam) to plant growth regulators for flower and root tuber yield characters*

Varieties	Total number of flowers per plant	Number of root tubers per plant	Root tuber length (cm)	Root tuber girth (cm)
ST-14 (V_1)	567.19	5.90	18.33	17.40
Kamala sundari (V_2)	606.08	5.23	17.50	18.81
Kiran (V_3)	506.86	5.33	15.88	14.01
SEm±	4.74	0.18	0.18	0.10
CD at 5%	13.56	0.36	0.53	0.29
PGR				
C_1 (GA_3- 200 ppm)	541.92	5.55	17.31	16.27
C_2 (GA_3- 300 ppm)	568.47	7.94	19.36	16.87
C_3 (CCC-300 ppm)	536.38	4.11	17.00	17.31
C_4 (CCC-500 ppm)	544.48	6.94	17.17	18.54
C_5 (2,4-D-10 ppm)	598.76	4.40	17.08	16.30
C_6 (2,4-D-15 ppm)	620.12	5.94	17.36	16.78
C_7 (Control)	518.31	3.53	15.37	15.10
SEm±	7.24	0.27	0.28	0.15
CD at 5%	20.71	0.55	0.82	0.44

Table-3 *Varietal response of orange flesh sweet potato (Ipomoea batatas (L.) Lam.) to plant growth regulators on root tuber yield/plant (g)*

Root tuber yield/plant (g)				
Varieties / PGR	ST-14 (V_1)	Kamala sundari (V_2)	Kiran (V_3)	Mean
C_1 (GA_3 @ 200 ppm)	562.12	323.96	336.67	**407.58**
C_2 (GA_3 @ 300 ppm)	582.60	369.32	403.83	**451.91**
C_3 (CCC @ 300 ppm)	505.75	213.10	293.33	**337.39**
C_4 (CCC @ 500 ppm)	553.44	241.72	333.33	**376.16**
C_5 (2,4 D @ 10 ppm)	495.29	284.33	289.67	**356.43**
C_6 (2,4 D @ 15 ppm)	557.21	324.46	322.14	**401.27**
C_7 (Control)	477.70	193.71	270.90	**314.10**
Mean	**533.44**	**278.66**	**321.41**	

	SEm±	CD at 5%
Varieties	2.86	8.19
PGR	4.37	12.51
Interaction effect	7.58	21.68

Number of root tubers per plant

Among different varieties, the maximum number of root tubers per plant (5.90) was recorded in ST-14. Among different plant growth regulators, the maximum number of root tubers per plant (7.94) was recorded with GA_3 @ 300 ppm than control. GA_3 might be attributed to the better plant growth and canopy area which might have resulted in more number of fruits per plant and fruit yield per hectare ultimately increased seed yield per plant and seed yield per hectare. Further, the significant increase in seed yield 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. These results are in conformity with the findings of Baijal, et al. [23] in potato, Padmavathi, [34] in onion and Remison, et al. [25] in cassava.

Root tuber length

Among the varieties, the maximum root tuber length (18.33 cm) was recorded in ST-14 whereas significantly maximum root tuber length (19.36 cm) was recorded in GA_3 @ 300 ppm than control. The increase in length of the root tuber could be a reflection of plant growth substance (GA_3) on growth and development, it might be due to marked increase in the vine length which gave a chance to the plant to carry more photosynthesis resulting in greater transfer of assimilates to developing sink and increasing the length of root tuber. Similar results were obtained by El-Tohamy, et al. [18]; Jones, [35] in sweet potato.

Root tuber girth

Significantly maximum root tuber girth (18.81 cm) was recorded in Kamala sundari. Among different levels of plant growth regulators, the maximum root tuber girth (18.54 cm) was recorded in CCC @ 500 ppm compared with control. Usha, et al. [36] 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 in increasing the girth of root tuber was earlier reported by Abdul Vahab and Mohan Kumaran, [37] in sweet potato, Mohamed Yassin and Anbu, [38] in radish and Jirali, et al. [39] in ginger.

Root tuber yield per plant

The data regarding root tuber yield per plant was significantly influenced with different varieties, plant growth regulators and their interactions [Table-3]. Among different varieties, the highest root tuber yield per plant (533.44 g) was recorded in

ST-14 Among different plant growth regulators, the maximum root tuber yield per plant (451.91 g) was recorded in GA_3 @ 300 ppm than control. Significantly maximum root tuber yield per plant (582.60 g) was recorded in the treatment combination of ST-14 + GA_3 @ 300 ppm (V_1C_2). GA_3 might be attributed to the better plant growth and leaf area which might have resulted in more number of roots per plant and root yield per plant ultimately increased root yield per hectare. Further, the significant increase in root yield 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. Similar results of increase in root tuber yield per plant by application of GA_3 was recorded by Baijal, et al. [23] and Banerjee and Das, [40] in potato, Padmavathi, [34] in onion, Remison, et al. [25], Seema sarkar, [26] and El-Tohamy, et al. [18] in sweet potato, Sengupta, et al. [4], Thondaiman Velayutham and Parthiban. [41] in ginger, Tirakannawar, et al.[42] in capsicum, Uddain, et al. [17] in tomato, Patel, et al. [43] in onion and Bhagure and Tambe. [11] in okra.

Conclusion

Based on the results obtained, it can be concluded that, ST-14 was found to be superior for vegetative and yield characters, while Kamala sundari was found to be superior for flower characters. Among PGR concentrations, GA_3 @ 300 ppm has improved the vegetative and yield characters whereas flower characters were improved by 2,4-D @ 15 ppm.

Acknowledgement/Funding

I express my sincere gratitude to my teacher and chairman, Dr. P. Ashok, Scientist, Horticultural Research station, Venkataramannagudem, Dr.YSRHU, who have meticulously planned the undertaken Research programme. I express my heartful gratitude to members of the advisory committee. The assistance and help received during the course of investigation was been duly acknowledged.

Author Contributions

1. G. Koteswara Rao*1- Carried out the entire research programme.
2. P. Ashok2 – Major Guide/Chairman of the advisory committee.
3. D.V. Swami3 - Member of the advisory committee
4. K. Sasikala4 - Member of the advisory committee

Abbreviations

AICRP	: All India co-ordinated research project
A.P	: Andhra Pradesh
@	: at the rate of
CCC	: Cycocel
CD	: critical difference
DAT	: Days after transplanting
2,4-D	: 2, 4- Dichlorophenoxy acetic acid
et al	: and so on
GA_3	: Gibberellic acid
MT/ha	: Metric tonn per hectare
NHB	: National Horticulture Board
%	: percent
PGR	: Plant growth regulators
ppm	: parts per million
SEm	: standard error of mean

Conflict of Interest: None declared

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