Influence of Plant Growth Regulators on Growth, Root Tuber Yield and Quality of Orange Flesh Sweet Potato (*Ipomoea batatas* (L.) Lam.) Varieties

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**Abstract**

A field experiment was carried out during kharif 2015-16 at Horticultural College and Research Institute, Dr. Y.S.R. Horticultural University, Venkataramannagudem (A.P) to study the performance of orange flesh sweet potato varieties to plant growth regulators for vegetative, flower, root tuber yield and quality characters. The results revealed that the spraying of GA$_3$ @ 300 ppm showed maximum length of leaf lobe and leaf area in the variety ST-14. Flower characters like maximum number of flowers per plant and seed set percentage were recorded in the variety Kamala sundari by the application of 2, 4-D @ 15 ppm, while maximum number of seeds per capsule was recorded in the variety Kamala sundari by the application of GA$_3$ @ 300 ppm. The maximum root tuber yield was recorded in the combination of V$_1$C$_2$ (ST-14 + GA$_3$ @ 300 ppm) and highest total sugars was recorded in the combination of V$_2$C$_2$ (Kamala sundari + GA$_3$ @ 300 ppm).

**Keywords**
Orange flesh sweet potato, Plant growth regulators, Quality characters, Varieties, Vegetative characters and Yield

**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. 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$^{-1}$ (NHB, 2015). 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 application of plant growth regulators has positive effect in sweet potato. 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 varieties to different plant growth regulators for vegetative, root tuber yield and quality characters and to determine optimum concentration of plant growth regulators for improving the flower 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 and 300 ppm, CCC @ 300 and 500 ppm, 2, 4-D @ 10 and 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 data on vegetative attributes as influenced by plant growth regulators and varieties was presented in table 1.

Length of leaf lobe

The length of leaf lobe was significantly influenced by different varieties at harvest. Maximum length of leaf lobe (12.81 cm) was recorded with ST-14 ($V_1$) at harvest, followed by Kamala sundari ($V_2$), and also length of leaf lobe was significantly influenced with different levels of plant growth regulators at harvest. Maximum length of leaf lobe (12.72 cm) was recorded with GA$_3$ @ 300 ppm ($C_2$), whereas the minimum length of leaf lobe (11.44 cm) was recorded with control ($C_7$). These results were in conformity with the findings of Mahabir Singh 	extit{et al.}, (1989) in radish, Sengupta 	extit{et al.}, (2008) in ginger and Patel 	extit{et al.}, (2010b) in onion. They reported that leaf width and leaf length were improved by the application of GA$_3$.

Leaf area (cm$^2$)

Maximum leaf area (92.46 cm$^2$) was recorded with ST-14 ($V_1$) at harvest, followed by Kamala sundari ($V_2$) (87.23 cm$^2$). Maximum leaf area (88.86 cm$^2$) was recorded with GA$_3$ @ 300 ppm ($C_2$), followed by GA$_3$ @ 200 ppm ($C_1$) (88.04 cm$^2$), whereas the minimum leaf area (86.66 cm$^2$) was recorded in control ($C_7$). The promotion of growth either in terms of increase the leaf area due to GA$_3$ has been thought to be by increasing 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, 1965). These results are in conformity with the findings of Singh and Choudhary (1989) in watermelon.
Vine inter nodal length (cm)

Significantly maximum vine inter nodal length was recorded in the combination of ST-14 + GA₃ @ 300 ppm (V₁C₂) compared to ST-14 + Control (V₁C₇) (Plate I).

Application of GA₃ played an important role in enhancing the mean length of internode on main vine due to cell elongation and cell division. Similar results were observed by Brumbaugh (2008) in pea and Avinash et al., (2011) in okra.

Number of branches per plant

Highest number of branches per plant (21.08) was recorded in the treatment combination of ST-14 + GA₃ @ 300 ppm (V₁C₂) compared to ST-14 + Control (V₁C₇) (Plate II).

The application of GA₃ enhances the lateral buds and vegetative growth which in turn increases the number of branches per plant. The results are in conformity with the findings of Mahesh and Sen (2005) in okra.

Flower attributes

The data on flower attributes as influenced by plant growth regulators and varieties was presented in table 1.

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. The maximum total number of flowers per plant (606.08) was recorded in Kamala sundari (V₂), followed by ST-14 (V₁) (567.19), whereas the minimum total number of flowers per plant (506.86) was recorded in Kiran (V₃). With respect to different levels of plant growth regulators, the highest total number of flowers per plant (620.12) was recorded in 2,4-D @ 15 ppm (C₆), followed by 2,4-D @ 10 ppm (C₅) (598.76). Significantly maximum number of flowers per plant (656.54) was recorded in the combination of Kamala Sundari + 2,4-D @ 15 ppm(V₂C₆) compared to Kamala Sundari + Control (V₂C₇) (Plate III).

Plate.1 Performance of GA₃ @ 300 ppm over the control on Vine inter nodal length of variety ST-14

ST-14 + Control (V₁C₇) ST-14 + GA₃ @ 300 ppm (V₁C₂)
Plate.2 Performance of GA$_3$ @ 300 ppm over the control on Number of branches per plant of variety ST-14

ST-14 + Control (V$_1$C$_7$)  
ST-14 + GA$_3$ @ 300 ppm (V$_1$C$_2$)

Plate.3 Performance of 2, 4-D @ 15 ppm over the control on total Number of flowers per plant of variety Kamala sundari

Kamala sundari + Control (V$_2$C$_7$)  
Kamala sundari + 2,4-D @ 15 ppm (V$_2$C$_6$)
### Table 1 Effect of plant growth regulators on orange flesh sweet potato (*Ipomoea batatas* (L.). Lam) varieties for vegetative and flower characters at harvest

| Varieties               | Length of leaf lobe (cm) | Leaf area (cm²) | Total number of flowers per plant | Length of the stamen (cm) | Length of the style (cm) | Seed set (%) | Number of seeds per capsule |
|-------------------------|--------------------------|-----------------|-----------------------------------|--------------------------|-------------------------|--------------|----------------------------|
| ST-14 (V₁)              | 12.81                    | 92.46           | 567.19                            | 1.64                     | 1.86                    | 47.92        | 2.51                       |
| Kamala sundari (V₂)     | 12.57                    | 87.23           | 606.08                            | 1.74                     | 1.68                    | 65.86        | 2.89                       |
| Kiran (V₃)              | 11.06                    | 82.90           | 506.86                            | 1.63                     | 1.90                    | 38.78        | 2.73                       |
| **SEM±**                | 0.07                     | 0.04            | 4.74                              | 0.02                     | 0.02                    | 0.10         | 0.04                       |
| **CD at 5%**            | 0.22                     | 0.13            | 13.56                             | 0.06                     | 0.06                    | 0.29         | 0.12                       |

#### PGRs’

| PGRs’                  |                          |                 |                                  |                          |                          |              |                            |
|------------------------|--------------------------|-----------------|-----------------------------------|--------------------------|-------------------------|--------------|---------------------------|
| C₁ (GA₃- 200 ppm)      | 12.50                    | 88.04           | 541.92                            | 1.63                     | 1.84                    | 48.08        | 2.31                       |
| C₂ (GA₃- 300 ppm)      | 12.72                    | 88.86           | 568.47                            | 1.69                     | 1.88                    | 51.83        | 3.67                       |
| C₃ (CCC-300 ppm)       | 11.73                    | 87.18           | 536.38                            | 1.65                     | 1.77                    | 45.64        | 2.40                       |
| C₄ (CCC-500 ppm)       | 12.01                    | 86.94           | 544.48                            | 1.70                     | 1.82                    | 49.93        | 2.72                       |
| C₅ (2,4-D-10 ppm)      | 11.98                    | 87.12           | 598.76                            | 1.68                     | 1.78                    | 55.73        | 2.71                       |
| C₆ (2,4-D-15 ppm)      | 12.64                    | 87.89           | 620.12                            | 1.73                     | 1.82                    | 61.99        | 3.28                       |
| C₇ (Control)           | 11.44                    | 86.66           | 518.31                            | 1.62                     | 1.77                    | 42.77        | 1.86                       |
| **SEM±**               | 0.11                     | 0.07            | 7.24                              | 0.03                     | 0.03                    | 0.16         | 0.06                       |
| **CD at 5%**           | 0.33                     | 0.20            | 20.71                             | NS                       | NS                      | 0.45         | 0.18                       |

### Table 2 Effect of plant growth regulators on orange flesh sweet potato (*Ipomoea batatas* (L.). Lam) varieties for root tuber yield and total sugars

| PGRs’                  | Root tuber yield (t ha⁻¹) | Total sugars (%) |
|------------------------|---------------------------|------------------|
| Varieties              | ST-14 (V₁) Kamala sundari (V₂) Kiran (V₃) ST-14 (V₁) Kamala sundari (V₂) Kiran (V₃) |
| C₁ (GA₃ @ 200 ppm)     | 20.34 17.52 18.10         | 6.53 7.26 6.93   |
| C₂ (GA₃ @ 300 ppm)     | 23.90 20.24 20.04         | 6.88 7.74 7.30   |
| C₃ (CCC @ 300 ppm)     | 21.08 15.96 16.15         | 6.32 7.44 6.66   |
| C₄ (CCC @ 500 ppm)     | 22.01 17.00 17.25         | 6.44 7.47 6.77   |
| C₅ (2,4 D @ 10 ppm)    | 19.87 16.44 16.14         | 6.12 6.94 6.43   |
| C₆ (2,4 D @ 15 ppm)    | 20.28 16.96 16.96         | 6.30 6.96 6.61   |
| C₇ (Control)           | 19.54 13.26 15.10         | 5.13 6.88 6.35   |
| **SEM±**               |                          |                  |
| **CD at 5%**           |                          |                  |

| Varieties              | 0.18 0.52 0.04 | 0.11 |
| PGR                    | 0.28 0.80 0.06 | 0.48 |
| Interaction effect     | 0.48 1.38 0.11 | 0.32 |
At low concentration, 2, 4-D stimulates flowering. This was in conformity with the findings of (Grossmann, 2007). It readily penetrate leaves, roots and stems and is rapidly transported via symplastic and apoplastic pathways (Chinalia et al., 2007) and stimulate excessive biosynthesis of ethylene and abscisic acid. Increase in endogenous ethylene and abscisic acid results in floral organs development and flowering (Tan and Swain, 2006). Similar results of increase in number of flowers by application of 2,4-D were recorded by Ricard et al., (1990), Shalaby et al., (1994) and Walter et al., (2010) in sweet potato, Anwar et al., (2010) in tomato and Thomson et al.,(2015b) in pea.

**Length of the stamen (cm) and style (cm)**

The length of the stamen and style were found to be significantly influenced by different varieties. The maximum length of the stamen (1.74 cm) was recorded with Kamala sundari. The variety Kiran recorded significantly maximum length of style (1.90 cm). The effect of PGRs’ on length of the stamen and style was found to be non-significant.

**Seed set (%)**

The data on the seed set percentage was significantly influenced with different varieties and plant growth regulators. Maximum seed set percentage (65.86%) was recorded in Kamala sundari followed by ST-14. With respect to different levels of plant growth regulators, the highest seed set percentage (61.99%) was recorded with the application of 2, 4-D @ 15 ppm than control. The growth substance, 2, 4-D is recognised as a growth promoter which induces more number of flowers, results into conversion of more flowers into capsules. Similar response of 2,4-D were earlier reported by Ricard et al., (1990), Shalaby et al., (1994) and Walter et al.,(2013) in sweet potato.

**Number of seeds per capsule**

Significantly maximum number of seeds per capsule (2.89) was recorded in Kamala sundari followed by Kiran. Among different plant growth regulators, maximum number of seeds per capsule (3.67) was recorded with the application of GA₃ @ 300 ppm than control. The increased number of seeds per capsule due to improved vegetative growth due to GA₃ application coupled with increased photosynthesis on one hand and greater mobilization of photosynthates towards reproductive sites, on the another hand, might have been found to increase the yield attributes in crop plants. Similar trends were also observed by Ricard et al., (1990) in sweet potato, Jaymala Singh et al., (2012) in okra, Natesh et al., (2005) and Dheer Singh et al., (2012) in coriander.

**Root tuber yield and quality characters**

**Root tuber yield (t ha⁻¹)**

With respect to interactions, the maximum root tuber yield (23.90 t ha⁻¹) was recorded in the treatment combination of ST-14 + GA₃ @ 300 ppm (V₁C₂), whereas the minimum root tuber yield (13.26 t ha⁻¹) was recorded in the treatment combination of Kamala sundari + Control (V₂C₇) (Table 2). The plant growth regulator GA₃ 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. Similar results were also recorded by Baijal et al., (1983) and Banerjee and Das (1984) in potato, Maurya and Lal (1987) in carrot, Vijay Kumar and Ray (2000) in cauliflower,
Verma (2000) in coriander, Padmavathi (1998) in onion, Remison et al., (2002), Seema sarkar (2008) and El-Tohamy et al., (2015) in sweet potato, Sengupta et al., (2008), Thondaiman Velayutham and Parthiban (2013) in ginger, Tirakannawar et al., (2009) in capsicum, Uddain et al., (2009) and Ranjeet et al., (2014) in tomato, Patel et al., (2010a) in onion, Sawant et al., (2010), Kotecha et al., (2010) and Roy et al., (2011) in cabbage and Bhagure and Tambe (2015) in okra.

**Total sugars**

Significantly maximum total sugars (7.74%) were recorded with the treatment combination of Kamala sundari + GA$_3$ @ 300 ppm (V$_2$C$_2$) (Table 2), whereas the minimum total sugars (5.13%) was recorded in the treatment combination of ST-14 + Control (V$_1$C$_7$). The increase in content of total sugars might be due to the quick transformation of starch into soluble solids and rapid mobilization of photosynthetic metabolites and minerals from other parts of the plant to developing parts (Singha, 2004). Similar trends were observed by Seema sarkar (2008) in sweet potato.

Based on the results obtained, it can be concluded that, ST-14 was found to be superior for vegetative characters and yield, while Kamala sundari is superior for flower characters. Among PGR concentrations, GA$_3$ @ 300 ppm has improved the vegetative and yield, whereas flower characters were improved with the application of 2, 4-D @ 15 ppm. Among interactions, ST-14 + GA$_3$ @ 300 ppm (V$_1$C$_2$) was found to be superior for yield, whereas the interaction of Kamala sundari + GA$_3$ @ 300 ppm (V$_2$C$_6$) was found to be superior for total sugars.

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