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Studies on the influence of plant growth regulators and their time of application on growth and tuber yield of sweet potato (*Ipomoea batatas* L.) cv. Kiran under southern Telangana conditions

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Abstract
A field experiment was conducted at College of Horticulture, Mojerla during Rabi 2016-17 to study the influence of plant growth regulators and their time of application on growth and tuber yield of sweet potato Cv. Kiran. The treatment comprised six plant growth regulators *viz*.. Cycocel, Paclobutrazole, ALAR, Salicylic acid, Gibberellic acid and Ethrel each with two different concentrations and control (water) were used as foliar spray at 30 and 45 days after planting. Experiment was carried out under factorial randomized block design (FRDB) with two replications. The result revealed that, among different plant growth regulator treatments, GA_3 200 ppm registered higher vine length, more number of leaves per branch, bigger leaf area, more fresh weight & dry weight of branches per vine and higher fresh weight and dry weight of leaves per vine, whereas maximum number of branches per vine was recorded in CCC 500 ppm. All treatments differed significantly with respect of tuber parameters, CCC 500 ppm recorded highest tuber yield per hectare (40.06 t) and maximum harvest index were (49.17 %).

Keywords: Studies, influence of plant growth regulators, their time, application on growth and tuber yield

Introduction
Sweet potato (*Ipomoea batatas* L.) is one of the important tuber crop of tropical and sub-tropical regions of the world, belongs to the family convolvulaceae and is native to South America. It is popularly known as *sakar kand* in India. It constitutes the staple diet for tribal population due to hardiness and adaptability into diversified farming system. It is a crop of economic, social importance and a potential staple food in the developing world. In the worldwide, Sweet potato is the sixth most important food crop after rice, wheat, potato, maize and cassava.

One of the recent developments in the field of Horticultural science has been the use of growth regulators, which have brought about a sort of revolution in boosting up different crop yields. Plant growth regulating substances have been reported to exert a favourable effect on physiological and other biochemical activities of crop plants. Now days the use of plant growth regulating chemicals have become an important component of Agri-technical procedure for most of the cultivated crops Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant (Alexopoulos *et al*., 2006) [2]. Cycocel, one of the growth retardants, has been widely applied for chemical manipulation of growth and development of various crops, and it causes retardation of vegetative part while photosynthetic activities are accelerated at appreciable rate (Stoddart 1964) [11]. Alar (B-995 or SADH) is another important growth retardant which retard the growth of plants. The inhibition of growth by alar application was reported by Devi (2002) [4] and Bora (2002).

Material and Methods
The study was conducted in College of Horticulture, Mojerla. Sri Konda Laxman Telangana State Horticultural University, Hyderabad. Experiment consisting of one cultivar Kiran and 6 growth regulators with two different concentrations (CCC 250ppm, CCC 500ppm, PBZ

50ppm, PBZ 100ppm, ALAR 250ppm, ALAR 500ppm, SA 100ppm, SA 200ppm GA_3 100ppm GA3 200 ppm, Ethrel 250ppm and Ethrel 500ppm) and control (water) with two different time of schedule (30 and 45 days after planting) are arranged in FRBD with two replication.

The land was thoroughly ploughed to a depth of 15-20 cm and brought in to a fine tilth. Well decomposed FYM @ 10 t ha^{-1} was incorporated into the soil uniformly during the final ploughing as a basal application. The experimental area was divided in to plots of 3.5 × 1.2 m size. Irrigation channels of 0.5 m size were prepared between two plots. Cuttings were planted in the plots at a spacing of 60×30 cm and 5-7 cm depth. Standard recommended cultural practices were followed during the entire crop period.

The required weight of the PGRs was taken using electronic sensitive balance and solution was prepared by dissolving in 1 mg L-1. The solution was poured into hand-held sprayer and was directly sprayed on the plants at 30 and 45 days after planting. Spraying was performed early in the morning to avoid rapid drying of the spray solution, due to transpiration. All the recommended cultural practices were followed during the conduction of the experiment. Data were collected from selected plants in the rows.

Results and Discussion

Vine length (cm)

All the treatments differed significantly on vine length. Among the growth regulator treatments, GA_3 200 ppm recorded significantly the longest vine length (351.87 cm), while it was lowest in Alar 500 ppm (150.45 cm). in schedule of spray, spray at 45 DAP recorded significantly the highest vine length (219.84 cm) than spray at 30 days after planting (211.26 cm).The interaction effect of treatment and schedule of spray was found to be significant on vine length. Foliar application of GA_3 200 ppm at 30 DAP recorded the highest vine length (359.85 cm), where it was lowest in Alar 500 ppm spray at 30 DAP (140.60).

The highest value of vine length was recorded in GA_3 200 ppm might be due to increased cell division and cell elongation resulting in more number of cells and in cell length which ultimately effect plant height (Taiz and Zeiger, 1998). These results were in accordance with that of El-Tohamy *et al* (2015) [5] in sweet potato and found that foliar application of GA_3 at 200 ppm significantly increased the vine length.

The minimum vine length was registered in Alar 500 ppm was due to decreased cell division and number resulted in restricted vegetative growth. The similar result were also reported by Fortes and Camilo (1982) [6] in potato and found that Alar at the range of 500 ppm decreased the internodal length and ultimately vine length.

Number of branches per vine

Significantly more number of branches per vine was recorded in CCC 500 ppm (21.20) while minimum number of branches observed in control (12.48). Schedule of spray significantly influence the number of branches. More number of branches per vine was recorded in spray at 45 days after planting (18.40) compared to spray at 30 days after planting (17.05).

Significant interaction effect was observed between treatment and schedule of spray on this parameter. More number of branches per vine was recorded in CCC 500 ppm spray at 30 DAP (21.60) while it was minimum in control (water) spray at 30 DAP (11.90).

The data on number of branches per vine revealed that CCC 500 ppm significantly recorded the maximum value at all growth stages might be due to CCC suppressed the apical dominance, by their diverted the polar transport of auxin towards the basal buds leading to increased branching (Pravin Prakesh *et al*,1999). These results were in accordance with that of Jitendra Kumar *et al*. (2012) [7] in potato who stated that foliar application of CCC at 3000 ppm increased the number of branches.

Fresh weight of branches per vine (g)

Fresh weight of branches was found significant in all the growth regulator treatments. Significantly maximum fresh weight of branches was recorded in GA_3 200 ppm (1236.00 g), while it was recorded minimum in control (598.80 g). Similarly, the schedule of spray also significantly influences the fresh weight of braches. The maximum fresh weight (924.92 g) was recorded with spray at 45 days after planting compare to spray at 30 days after planting (855.76 g). Treatments and schedule of spray showed significant influence with respect to fresh weight of branches. Foliar spray of GA_3 200 ppm at 30 DAP recorded significantly maximum fresh weight of the branches (1284.00 g), whereas lowest in control (water) spray at 30 DAP (571.20 g).

The present investigation was in consistent with reports of El-Tohamy *et al.* (2015) [5] in sweet potato, who reported that foliar application of GA_3 200 ppm increased the fresh weight of branches.

Dry weight of branches per vine (g)

It is evident from the data that all the plant growth regulators significantly influence the dry weight of branches per vine. Significantly Maximum value recorded in GA_3 200 ppm (219.21 g). Minimum dry weight of branches per vine was recorded in control (106.23 g).

The two schedule of spray influenced the parameter significantly. Spray at 45 days after planting recorded significantly maximum value (164.06 g) over spray at 30 days after planting (151.79 g). In interaction significantly maximum dry weight of branches was recorded in GA_3 200 ppm spray at 30 DAP (227.74 g) while it was lowest in control (water) spray at 30 DAP (101.33).

The maximum dry weight of branches per vine was recorded in GA_3 200 ppm, which might be due to the maximum fresh weight of branches per vine as compared to rest of the treatments. Similar results were also observed by El-Tohamy *et al.* (2015) [5] in sweet potato

Tuber length (cm)

All the plant growth regulator treatments influence the tuber length. Higher tuber length was recorded in GA_3 200 ppm (19.31 cm) and it was on par with GA_3 100 ppm (18.26 cm), whereas minimum value was recorded in control (14.82 cm).

Significant interaction effect observed between treatments and schedule of spray with respect to tuber length. Foliar spray of GA_3 200 ppm at 45 DAP recorded the highest tuber length (19.65 cm) followed by GA_3 100 ppm (19.48 cm), which were on par with each other. The lowest value was recorded in CCC 500 ppm spayed at 30 days after planting (13.58 cm).

The highest tuber length was recorded in GA_3 200 ppm might be due to marked increase in the vine length ultimately more photosynthesis, resulted in greater transfer of assimilates to sink and increased the length of tuber. The similar results were also reported by El-Tohamy *et al*. (2015) [5] in sweet potato and they found that GA_3 200 ppm significantly increased the tuber length.

Tuber diameter (cm)
Significantly maximum tuber diameter was recorded in CCC 500 ppm (5.18 cm) while it was minimum in control treatment (3.38 cm).

Significant difference was observed between schedules of sprays, the result with regard to tuber diameter. Foliar spray at 45 days after planting recorded significantly maximum tuber diameter (4.28 cm) than spray at 30 days after planting (4.04 cm)

Treatments	Vine length (cm)	No. of branches per vine	No. of leaves per branch	Fresh weight of branches (g)	Dry weight of branches (g)	Tuber length (cm)	Tuber diameter (cm)	Number of tubers per vine	Tuber yield per plot (kg/plot)
Plant growth regulators (G)									
G_1 - CCC 250 ppm	200.87	19.78	62.16	858.43	152.26	15.38	4.70	7.6	15.56
G_2 - CCC 500 ppm	165.77	21.20	71.07	872.40	154.75	15.24	5.18	7.6	16.83
G_3 - PBZ 50 ppm	187.15	17.93	65.01	860.40	152.61	16.69	4.48	6.7	11.46
G_4 - PBZ 100 ppm	196.75	17.40	69.96	835.20	148.16	15.92	4.18	6.3	10.66
G_5 - ALAR 250 ppm	168.82	19.45	69.81	933.60	165.59	16.60	4.05	7.0	14.37
G_6 - ALAR 500 ppm	150.45	18.35	64.92	880.80	156.23	16.33	3.93	7.1	15.08
G_7 - SA 100 ppm	211.70	16.90	54.64	811.20	143.89	16.53	3.68	5.6	10.33
G_8 - SA 200 ppm	210.75	17.25	57.93	828.00	146.88	15.62	3.65	5.8	11.77
G_9 - GA_3 100 ppm	321.72	16.08	75.69	1,048.80	190.49	18.26	3.68	5.1	10.42
G_{10} - GA_3 200 ppm	351.87	16.43	80.69	1,236.00	219.21	19.31	3.60	5.3	10.01
G_{11} - Ethrel 250 ppm	176.22	18.80	65.27	902.40	160.07	15.06	4.83	6.3	14.31
G_{12} - Ethrel 500 ppm	165.92	18.40	66.06	883.20	142.62	15.32	4.80	6.6	15.12
G_{13} - Control	294.17	12.48	39.92	598.80	106.23	14.82	3.38	4.1	6.86
SEm ±	3.76	0.36	1.24	19.35	3.40	0.44	0.13	0.18	0.29
CD at 5 %	11.04	1.05	3.64	56.68	9.95	1.31	0.38	0.53	0.85
Schedule of spray (S)									
S_1- spray at 30 days after planting	211.26	17.05	64.66	855.76	151.79	15.99	4.04	6.4	12.60
S_2 spray at 45 days after planting	219.84	18.40	65.66	924.92	164.06	16.48	4.28	6.0	12.43
SEm ±	1.47	0.14	0.48	7.59	1.33	NS	0.05	0.07	NS
CD at 5 %	4.33	0.41	1.43	22.23	3.90	NS	0.15	0.20	NS
Interaction									
SEm ±	5.33	0.51	1.76	27.36	4.80	0.63	0.18	0.258	0.412
CD at 5 %	15.61	1.49	5.14	80.16	14.08	1.85	0.54	0.755	1.207

Tuber diameter differed significantly due to interaction between treatments and schedule of spray. Foliar spray of PBZ 50 ppm at 45 DAP recorded highest tuber diameter (5.30 cm) and was on par with CCC 250 (5.05 cm) and 500 ppm (5.25 cm) spay at 30 DAP and CCC 500 ppm spray at 45 DAP (5.10 cm), while lowest was registered in SA 100 ppm sprayed at 30 DAP (3.10 cm.

The maximum tuber diameter was recorded in CCC 500 ppm might be due to suppress vine growth by inhibition of the endogenous Gibberillic acid biosynthesis resulted increasing photo assimilates allocation to the tuber portion only. Our results are comparable with that of Abdul Vahab and Mohan Kumaran (1980) [1] in sweet potato and they found that CCC 500 and 1000 ppm increased tuber diameter.

Number of tubers per vine
More number of tubers per vine was recorded in CCC 500 ppm (7.6) followed by CCC 250 ppm (7.6), Alar 500 (7.1) and 250 ppm (7.0) and were on par with each other, whereas control has taken minimum value (4.10).

Significant difference observed between schedules of spray on this parameter Spray at 30 days after planting recorded significantly more number of tubers per vine (6.4) over spray at 45 days after planting (6.0)

In interaction maximum number of tubers per vine was recorded in CCC 250 ppm spray at 30 DAP (8.2) followed by CCC 500 ppm spray at 45 and 30 DAP ((7.7 and 7.5 respectively) and were on par with each other, while it was minimum in control (water) spray at 30 DAP (4.0).

The maximum number of tubers per vine was recorded in CCC 500 ppm might be due to restricted vegetative growth resulted in diversion of photo assimilates for the production of more number of tubers per vine. These results were in accordance with the findings of Abdul Vahab and Mohan Kumaran (1980) [1] in sweet potato and found that CCC 500 ppm increased the number of tubers per vine.

Tuber yield per vine (g)
There was significant difference observed among the growth regulator treatments with respect to tuber yield per vine. Among the treatments, CCC 500 ppm recorded significantly maximum tuber yield per vine (841.25 g), whereas control has taken minimum value (342.75 g).

The interaction between treatments and schedule of spray was found to be significant on this parameter. Foliar spray of CCC 500 ppm at 30 DAP recorded maximum tuber yield per vine (844.50 g) followed by CCC 500 ppm spray at 45 DAP (838.00 g) which were on par with each other, while it was minimum in control (water) spray at 45 DAP (338.00 g).

It is observed that, CCC 500 ppm recorded maximum tuber yield per vine might be due to maximum diameter and more number of tubers per vine as compared to rest of the treatments. These findings are in consonance with the reports of Seema sarkar and Sarma (2008) and shedge *et al* (2008) in sweet potato and they found that CCC 500 ppm recorded the highest tuber yield per vine.

Tuber yield per plot (kg)
The results related to tuber yield per plot as affected by the plant growth regulator treatments and schedule of spray is presented in the table 4.2.2 and fig. 4.2.6

There was significant difference observed among the treatments with respect to tuber yield per plot. Among the treatments, CCC 500 ppm recorded significantly maximum tuber yield per plot (16.83 kg), whereas it was minimum in control (6.86 kg).

Significant interaction effect observed between treatments and schedule of spray on this parameter. Foliar spray of CCC 500 ppm at 30 DAP recorded maximum tuber yield per plot (16.89 kg) followed by CCC 500 ppm spray at 45 DAP (16.76 kg) and were comparable with each other, while it was minimum in control (water) spray at 45 DAP (6.76 kg).

The data enunciated on tuber yield per pot revealed that, CCC 500 ppm recorded the highest value which was due to maximum tuber diameter, higher tuber yield per vine and better mean weight of tuber per vine as compare to rest of the treatments. Similar result was also observed by Shedge *et al* (2008) [10] in sweet potato and stated that CCC 500 ppm recorded the highest tuber yield per plot.

Conclusion

It could be concluded from the present investigation that, the plant growth regulators significantly influence the growth, yield and quality of Sweet potato Cv. Kiran. Among the different plant growth regulator treatments, CCC 500 ppm showed positive effect on yield and quality parameter *viz*. maximum tuber diameter, higher tuber yield per plot, maximum tuber yield per hectare, best harvest index and higher carbohydrate & protein percentage

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