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Response of hybrid sweet corn (*Zea mays* saccaharata) to fertility levels with and without gibberellin on production potential and economics in Southern Odisha

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Abstract
The field experiment was taken over at Campus Farm, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India in winter season during 2018-2019 in acidic sandy clay loam soil with low in available N and medium in available P_2O_5, K_2O and S. All together eight treatments combination comprised of 100% recommended fertilizer dose (120-60-60 kg N, P_2O_5 and K_2O/ha) and 125% recommended fertilizer dose (150-75-75 kg N, P_2O_5 and K_2O/ha) with 0 and 30 kg S/ha conjugated with gibberellin @100 g/ ha and without gibberellin were tested in factorial randomized block design with three replications. Experimental results revealed that the NPK levels with sulphur significantly influenced the crop growth parameters such as plant height, number of leaves/plant and leaf area index and yield parameters like cob length, weight along with green cob and forage yield. The number of cobs/plant and girth of cob were not remarkably affected by fertility levels. Application of 125% recommended dose of fertilizer + 30 kg S/ha recorded the highest cob (15.34 t/ha) and green forage (25.13 t/ha) yield. The foliar spraying of gibberellin @ 100 g/ha exerted significant effect on plant height and leaf area index and cob weight along with green cob and forage yield. But it failed to exhibit significant effect on number of leaves and cobs/plant and cob length and girth. The significant augmentation in green cob (14.86 t/ha) and forage yield (24.07 t/ha) was observed with application of gibberellin @100 g/ ha over no gibberellin. The use of 125% recommended fertilizer dose + 30 kg S/ha recorded the maximum net return (Rs. 237273/ ha) and benefit cost ratio (2.51) followed by 125% recommended fertilizer dose without sulphur recording the corresponding values of Rs. 225006/ha and 2.45, respectively. The net profit (Rs. 226979/ha) and B: C ratio (2.41) were enhanced with application of gibberellin @ 100 g /ha over no gibberellin.

Keywords: Fertility levels, gibberellin, production potential, economics, hybrid sweet corn

Introduction
Sweet corn is used for human consumption, fodder for cattle's and raw materials for industry. Sweet corn is preferred for fresh consumption owing to it's soft and sugary endosperm and delicious taste compared to other types corn. Sweet corn is a heavy feeder crop like grain crop of maize and requires adequate supply of nutrients for better crop growth and production. The judicious management of nitrogen, phosphorus and potassium greatly affects the productivity of sweet corn. Sweet corn is increasing the farm income ranking second position in farm value and fourth among commercial crops (Rathod *et al.* 2018) [8]. The beneficial effect of NPK fertilization in augmenting the yield attributes and fresh cob yield of sweet corn has been recorded by Bharud *et al.* (2014) [2]. Application of 100% recommended dose of fertilizer to sweet corn resulted in significant increase in green cob and fodder yield along with improvement in net return and benefit cost ratio (Rathod *et al*., 2018) [8]. In addition to N, P and K, sulphur has an important role in plant nutrition and it's deficiency is reported over past several years (Nader and Nadia, 2011) [6]. Due to substantial or no use of organic manure, use of high analysis sulphur free fertilizers, growing of high yielding varieties and hybrids and adoption of multiple cropping systems, the sulphur deficiency is noticed in Indian soil. In conjunction with primary nutrients, S application is indispensible to get full advantage of applied nutrients for improving production and productivity of crops. Sulphur fertilization enhances the growth, yield attributes and yield in corn Sutar *et al*. 2017) [10]. At all stages of crop growth and development, the phyto hormone gibberellin is involved in seed germination, stem elongation, leaf expansion and flowering (Achard *et al.* 2009) [1]. Besides to this, gibberellin influences the physiological and developmental process that augment production and productivity of crops (Hedden and Sponsel, 2015) [4].

Application of gibberellic acid @ 40 to 60 g/ ha had beneficial effect in increasing the growth, yield attributes and yield of maize as reported by Singh *et al*. (2018) [9]. Basing upon those facts, an attempt has been made to find out the effect of fertility levels with and without gibberellin on hybrid sweet corn to devise the suitable production technology for growers of north eastern ghat zones of Odisha.

Material and Methods

The field experiment was conducted at Campus Farm, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha during winter season in 2018-2019. The soil was sandy clay loam in texture with pH 6.24 containing available N, P_2O_5 and K_2O of 171, 29.4, 276.67 and 27.48 kg/ha, respectively. The eight treatments combination comprised of 100% recommended fertilizer dose (120-60-60 kg N, P_2O_5 and K_2O /ha), 100% recommended fertilizer dose with 30 kg S/ha and 125% recommended fertilizer dose (RFD), 125% recommended fertilizer dose (RFD) with 30 kg S/ha in factor A and gibberellin @ 100 g/ ha and without gibberellins in factor B were tested in factorial randomized block design with three replications in the plot size of 5.0 m x 4.2 m . The sweet corn hybrid Golden cob F1 of East West seed international company was sown on 26 th December, 2018 with spacing of 50 cm between rows and 30 cm within plants. The full dose of phosphorus and sulphur along with 50% nitrogen and potassium were applied as basal in crop rows. The rest 50% nitrogen and potassium were top dressed at 35 days after sowing. The sources of fertilizer were diammonium phosphate, urea, and muriate of potash for the treatment of 100% and 125% recommended dose of NPK fertilizer without sulphur. The complex fertilizer of IFFCO grade 20: 20: 0:13 along with diammonium phosphate, urea and muriate of potash were applied in treatments containg 100% recommended dose of NPK fertilizer + 30 Kg S/ha and 125% recommended dose of NPK fertilizer + 30 Kg S/ha. The gibberellin through commercial gibberric acid GA 94 @ 100 g/ ha was sprayed in two equal splits at 6 and 8 weeks after sowing in spray volume of 500 l /ha using hand operated knapsack sprayer. The crop was harvested on 21st March, 2019. The biometric observation on crop growth parameters like plant height, number of leaves/plant and leaf area index along with the yield attributes such as number of cobs/plant, cob length, cob girth and green cob weight were recorded from five randomly selected plants from each plot. For determination of leaf area/plant, the factor 0.75 was multiplied with product of leaf length (cm) and maximum breadth (cm) and also number of leaves/ plant to calculate the total leaf area of a plant. The unit of mean leaf area/ plant was estimated in cm^2. As per suggestion of Watson, (1947) [11], the formula of the leaf area index (LAI) is depicted below.

$$LAI = \frac{\text{Leaf Area of plant}}{\text{Ground area covered by plant}}$$

From each net plot, the green cob was plucked manually followed by harvesting of green fodder by sickles and their weight was recorded. The economics of cultivation of sweet corn was computed basing upon the prevailing market price. The benefit cost ratio was estimated by dividing net return with cost of cultivation. The statistical analysis of data tabulated from various growth and yield characters was performed by adopting the method of analysis of variance as suggested by Gomez and Gomez, 1984 [3]. Statistical significance test was done taking the F value at 0.05 level of probability. The critical difference was calculated to compare the treatment means if the table F value is found significant.

Results and Discussion

Effect of fertility levels on crop growth

The data presented in Table 1 indicated that crop growth parameters like plant height, number of leaves/ plant and leaf area index (LAI) in sweet corn were significantly influenced by fertility levels. Application of 125% recommended fertilizer dose (RFD) + 30kg S/ha recorded the highest plant height (216 cm) followed by 125% RFD (213 cm) which were at par. The number of leaves /plant was found maximum in 125% RFD + 30kg S/ha (12.15) being at par with 125% RFD (11.75) and 100% RFD + 30 kg S/ha (11.73). The leaf area index behaved the similar trend as that of number of leaves. The combined application of 125% RFD + 30kg S/ha recorded the highest leaf area index (3.66) followed by 125% RFD (3.48) which were at par. Increase in crop growth was possible owing to better availability, absorption and mobilization of nutrients by conjugated use of NPK and S. It had beneficial effect on translocation of reserve food material from source to growing plant parts by influencing the photosynthetic efficiency and meristematic activities that resulted in increasing of plant height, number of leaves/plant and leaf area index through canopy development. The favorable effect of NPK fertilization in enhancing the plant growth parameter of sweet corn was reported by Rathod *et al*. (2018) [8]. However, the photosynthetic efficiency is accelerated due to nutrition of sulphur which is a constituent of succinyl coenzyme that helps in chlorophyll formation and meristematic activities to promote apical growth, leaf area expansion and bio mass production. It is substantiated with the findings of Mahapatra *et al.* (2018) [5].

Effect of gibberellin on crop growth

The plant growth parameters like plant height and leaf area index were remarkably affected by gibberellin application which had no significant effect on number of leaves/plant (Table1)**.** Significant increase in plant height (212 cm) was observed with gibbberellin @ 100 g/ha over no gibberellins (203 cm). The spraying of gibberellin @ 100 g/ha produced more number of leaves /plant (11.85) than no gibberellin application (11.58). The leaf area index was enhanced with gibberellin @ 100 g/ha (3.55) over no gibberellins (3.27). The positive effect of gibberellin in improving the plasticity of cell wall in conjunction with hydrolysis of starch to sugar is resulted in decreasing the water potential of cell wall thus help in entry of water to cell wall thereby resulting in expansion and proliferation of tissue. The cell elongation and proliferation in growing plant part is possible due to osmotic driven response of gibberellin that affects the better translocation and efficient use of photosynthates. It is in agreement with the findings of Singh *et al.* 2018 [9].

Effect of fertility levels on yield attributes

The yield attributes data depicted in Table- 1 revealed that fertility levels significantly affected the cob length and weight but it had no significant role on number of cobs/plant and girth of cob. The maximum number of cobs/plant (1.85) was observed in 125% recommended fertilizer dose (RFD) + 30 kg S/ha followed by 125% RFD (1.82) and 100% recommended fertilizer dose (RFD) + 30 kg S/ha (1.79). Application of 125% RFD with 30 kg S/ha remarkably

increased the cob length (23.08 cm) being at par with 125% RFD (22.47cm). The cob girth was maximum in 125% RFD + 30 kg S/ha (21.58 cm) closely followed by 125% RFD (21.52 cm). The conjugated use of 125% RFD + 30 kg S/ha recorded the highest cob weight (477 g) which did not differ significantly from 125% RFD (453g) and 100% RFD + 30 kg S/ha (449 g). The improvement in yield attributes with the application of 125% RFD + 30 kg S/ha is due to steady supply, timely availability and better utilization of nutrients resulted in better vegetative growth that helps in effective translocation of photosynthates from source to sink. The beneficial effect of higher levels of NPK on yield attributes of sweet corn was reported by Bharud *et al*. (2014) [2]. The favourable effect of sulphur fertilization in increasing the yield attributes of sweet corn was recorded by Sutar *et al*. 2017 [10].

Effect of gibberellin on yield attributes

The yield components like number of cobs/ plant, cob length and cob girth were significantly unaffected by use of foliar spray of gibberellin at 100 g/ha (Table1). Rather gibberellin exerted significant effect on cob weight. Application gibberellin @ 100 g/ha had higher the number of cobs/plant (1.85), cob length (22.49 cm) and cob girth (23.38) than no gibberellin giving the corresponding values of1.76, 22.32 cm and 21.27 cm , respectively. Significant increase in cob weight by use of gibberellin @100 g/ha (465 g) was observed over no gibberellin (438 g). The regulation of physiological process due to gibberellin application favorably enhanced the crop growth that facilitated the translocation and accumulation of photosynthetes from source to the developing yield components to reflect the yield. Gibberellic acid stimulated cell growth and stem elongation thus influenced the yield attributes. It is in conformity with the earlier findings of Naghashzadeh *et al*. 2009 [7] and Singh *et al*. 2018 [9].

Effect of fertility levels on green cob and forage yield

The green cob and forage yield was significantly augmented by nutrient management treatments in sweet corn (Table 2). Application of 125% RDF + 30 kg S/ha recorded the highest cob (15. 34 t/ha) and green forage (25.13 t /ha) yield over other treatments. It was followed by 125% RDF producing the cob (14.65 t/ha) and green forage (24.01 t/ha) yield that remained at par with 100% RDF + 30 Kg S/ha producing green cob and forage yield of 14.14 t/ha and 23.10 t/ha, respectively. Increase in yield is ascribed to adequate nutrient supply that facilitates the better availability and absorption of nutrients thus helpful in effective translocation of photosynthates from source to sink. The higher yield with 125% RFD of NPK with 30 kg S/ha is owing to enhancement of yield attributes that reflected cob yield and crop growth parameters that enhanced the green forage yield. The effect of higher doses of NPK in augmenting the yield of sweet corn is in agreement with findings of Bharud *et al*. (2014) [2]. The beneficial effect of sulphur fertilization in enhancing the yield of sweet corn was corroborated with the findings of Sutar *et al*. 2017 [10].

Effect of gibberellin on green cob and forage yield

The close view of yield data presented in Table-2 indicated that gibberellin @ 100 g/ha markedly influenced the green cob and forage yield. Gibberellin application @ 100 g/ha surpassed the green cob (14.86 t/ha) and forage yield (24.07 t/ha) over no gibberellin which gave the green cob and fodder yield of 14.15 and 23.30 t/ha, respectively. The beneficial effect of gibberellin in enhancing the hydrolyzing and oxidizing enzymes activity promotes the efficient translocation of photo assimilates from source to sink that enhances the yield by improving the crop growth and yield parameters. Similar favourable effect of gibberellic acid in improvement of yield in maize is in pipe line with the research result of Singh *et al*. 2018 [9].

Effect of fertility levels on economics

The economics of cultivation presented in table-2 showed that integration of 125% RDF with 30 kg S /ha registered the highest gross return (Rs. 331930/ha), net return (Rs. 237273/ha) and benefit cost ratio (2.51). It was closely followed by 125% RFD with the corresponding values of Rs. 317010/ha, Rs. 225006/ha and 2.45, respectively. This is ascribed to enhanced cob and fodder yield that consequently resulted in higher net return and benefit cost ratio.

Effect of gibberllin on economics

The data on economics of cultivation (Table 2) indicated that the maximum gross return (Rs.321270/ha), net return (Rs.226979/ha) and benefit cost ratio (2.41) was obtained with application of gibberellin @ 100 g/ha compared with no gibberellin application. This is possible due to positive effect of gibberellins in enhancing the cob and green forage yield which reflected the economics.

Table 1: Effect of fertility levels and gibberellin on growth and yield components of hybrid sweet corn.

Treatments	Plant height (cm)	Leaves/ plant	Leaf area index	Cobs / plant	Cob length (cm)	Cob girth (cm)	Cob weight (g)
Fertility levels							
100% RFD (120-60-60 kg N, P_2O_5 and K_2O/ha)	196	11.23	3.09	1.77	22.00	20.95	426
125% RFD (150-75-75 kg N, P_2O_5 and K_2O/ha)	213	11.75	3.48	1.82	22.47	21.52	453
100% RFD + 30 kg S/ha	203	11.73	3.42	1.79	22.07	21.23	449
125% RFD + 30kg S/ha	216	12.15	3.66	1.85	23.08	21.58	477
SEM ±	3.7	0.24	0.07	0.12	0.21	0.27	10.2
CD (P=0.05)	11.0	0.72	0.20	NS	0.63	NS	31.0
Gibberlin							
No gibberlin	203	11.58	3.27	1.76	22.32	21.27	438
Gibberlin @ 100 g/ha	212	11.85	3.55	1.85	22.49	21.38	465
SEM ±	2.7	0.17	0.06	0.09	0.17	0.22	7.00
CD (P=0.05)	8.0	NS	0.19	NS	NS	NS	21

Table 2: Yield and economics as influenced by fertility levels and gibberellin in hybrid sweet corn.

Treatments	Cob yield (t/ha)	Green forage yield (t/ha)	Gross return (Rs/ha)	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Benefit: cost ratio
Fertility levels						
100% RFD (120-60-60 kg N, P_2O_5 and K_2O/ha)	13.88	22.48	300080	90564	209516	2.31
125% RFD (150-75-75 kg N, P_2O_5 and K_2O/ha /ha)	14.65	24.01	317010	92004	225006	2.45
100% RFD + 30 kg S/ha	14.14	23.10	305900	93041	212859	2.29
125% RFD + 30kg S/ha	15.34	25.13	331930	94657	237273	2.51
SEM ±	0.22	0.35	-	-	-	-
CD (P=0.05)	0.66	1.07	-	-	-	-
Gibberlin						
No gibberlin	14.15	23.30	306300	90841	215459	2.37
Gibberlin @ 100 g/ha	14.86	24.07	321270	94291	226979	2.41
SEM ±	0.18	0.25	-	-	-	-
CD (P=0.05)	0.54	0.76	-	-	-	-

Cost of produce
Green cob- Rs.20000/t and green forage- Rs.1000/ t

Conclusion

It is concluded that integration of 125% recommended dose of fertilizer (150 kg N, 75 kg P_2O_5 and 75 kg K_2O /ha) with 30 Kg S/ha along with gibberellin @ 100 g/ha is preferred for enhancing the yield and economics of sweet corn grown during winter season in southern Odisha.

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