Influence of integrated nutrient management on the growth, yield and economics of sweet corn (*Zea mays saccharata*) in spring season

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ABSTRACT: A field experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar to study the response of sweet corn (*Zea mays* L. *saccharata*) to different levels of FYM and nutrients. The experiment consisting of 4 levels of FYM (0, 5, 10 and 15 t/ha) and 4 doses of nutrients (50, 75, 100 and 125% recommended NPK) was laid out in factorial RBD with three replications. Results revealed that plant growth in terms of height, leaf area and shoot dry matter accumulation increased significantly with increase in FYM and nutrient levels. Crop nourished with FYM showed significant improvement in yield attributes *viz*. cob length and cob girth, cob yield and net return but did not respond beyond 5 t/ha. The increase in husked and dehusked cob yields under 5t/ha FYM was 13.5 and 17.6%, respectively over no use of FYM. An increase in nutrient level from 50 to 125% resulted into significant improvement in cob yield up to 100% recommended dose of nutrients. The yield advantage under 100 % NPK over 50 and 75% was 35.8 and 8.4% for husked and 36.4 and 11.0% for dehusked cob yields, respectively. Application of 5 t FYM/ha and 100% recommended dose of nutrients was economically viable as these recorded significantly more net return.

Key words: Cob, FYM, NPK, sweet corn

Maize (*Zea mays* L.) is the most widely distributed crop in the world and cultivated in the tropics, sub-tropics and temperate regions. Recently, specialty corns such as baby corn, sweet corn, quality protein maize (QPM) have emerged as alternative food sources. Sweet corn (*Zea mays saccharata*) also known as sugar corn is a hybridized variety of maize (*Zea mays* L.) specifically bred to increase the sugar content. Sweet corn is used as a human food in the soft dough stage with succulent grain. The green cobs are eaten, roasted or boiled. Sweet corn has the highest edible quality in milky stage. It is very delicious and rich source of energy, antioxidants and vitamin C and A. It is also used in preparation of soup, salad and other recipes. The higher content of water soluble polysaccharide in the kernel adds texture and quality in addition in sweetness. Sweet corn may not only help in crop diversification but also increase value addition of maize. In addition to its sweet and delicious taste, its nutritive value is also comparable to other vegetables such as cauliflower, cabbage and tomato. It has a great market potential and high market value in India (Sahoo and Mahapatra, 2007). The climatic conditions of *tarai* region of Uttarakhand are very much favourable for production of good quality sweet corn. Sweet corn is an exhaustive crop and requires large amount of nutrients in a short period. Therefore, nutrient supply is one of the most important factors that influences the growth and development of crop. Hence, optimization of nutrient availability during the crop growth needs priority in sweet corn production. The potential of the sweet corn is not being exploited satisfactorily due to many constraints including inappropriate nutrient management. Chemical fertilizers are considered as the major source of nutrients. Crops respond quickly to chemical fertilizer application due to higher concentration of nutrients present in them. But enhanced cost of fertilizers, depleting soil health and their low use efficiencies are making the situation complex. On the other hand, organic manures play direct role in plant growth as a source of all the necessary macro and micro nutrients in available forms during mineralization besides improve both the physical and biological properties of the soil but suffer from drawback of slow release of nutrients (Sharma and Mittra, 1991). To hasten the nutrient availability, an integrated nutrient supply system provides an ideal nutrition for a crop to sustain yield levels and also increase farm income. Efficient use of chemical fertilizers in combination with organics is essential to enhance and maintain soil organic carbon and fertility status for obtaining sustainable crop yield. Balanced fertilization through organic manures and chemical fertilizers would go a long way in maximizing production per unit area, without affecting the soil fertility and productivity. Hence, to meet nutrient demand of sweet corn throughout crop period, there is need to develop a suitable nutrient management strategy by combining organic manures with chemical fertilizers. Keeping all these points in view, experiment was conducted to study the effect of integrated nutrient management on growth, yield and economics of sweet corn.

MATERIALS AND METHODS

The field experiment was conducted during the spring season 2014 at the N.E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand representing the *Tarai* belt of

Uttarakhand. It is situated at 29°N latitude, 79.5°E longitude and altitude of 243.83 m above mean sea level in the foot hill of Himalaya. The soil of experimental plot was sandy loam in texture, neutral in reaction (7.21), medium in organic carbon (0.624 %), low in available nitrogen (226.3 kg/ ha), high in available phosphorus (30.5 kg/ha) and medium in available potassium (243.3 kg/ha). The experiment consisted of 16 treatments; having 4 levels of FYM (0, 5, 10 and 15 t/ha) and 4 levels of nutrients (50, 75, 100 and 125% recommended dose of NPK) and was laid out in factorial randomized block design with three replications. The recommended dose of N, P_2O_5 and K_2O was 120, 60 and 40 kg/ha, respectively. FYM was applied before sowing on fresh weight basis as per treatment. It was well incorporated into soil by spade. The moisture content in FYM was 46% and N, P and K content was 0.48, 0.17, and 0.41%, respectively. The nutrients were applied through fertilizers NPK mixture (12:32:16), urea and muriate of potash. The field was deep ploughed with tractor drawn mould board plough and pulverized followed by two cross harrowing with a tractor mounted disc harrow. Thereafter, the field was leveled with leveler. Furrows were opened by a tractor operated furrow opener at the distance of 60 cm and seeds were placed at the distance of 25 cm. Sweet corn variety 'Sugar-75' was sown on February 25 and harvested on May 30, 2014. The area of gross plot and net plot was 18.0 and 4.8 m^2, respectively. The 20% of nitrogen and full amount of phosphorous, potassium was applied as basal. Remaining 80% nitrogen was applied in 3 splits as 20, 30 and 30% at 4 leaf- stage, knee high and at tasseling stage respectively. Crop was irrigated six times. Weeds were controlled by both chemically and manually. Pre-emergence application of atrazine @ 1 kg a.i. /ha in 500 litre of water was made one day after sowing. Manual weeding was done at 27 days after sowing of crop for effective weed control. Five plants were selected randomly in each net plot to record growth parameters such as plant height, leaf area per plant and dry matter accumulation at harvest stage. The days taken for 50 per cent tasseling and 50 per cent silking were calculated by taking the difference of date of sowing and date of 50 per cent plants had tasseling and silking, respectively. Five cobs were randomly selected from each net plot for determination of yield attributes *viz*. cob length, cob girth, number of grain rows/ cob, number of grains/row, number of grains/cob and individual cob weight. Cobs from the net plot area were harvested at milky stage and weighed, without removing husk for husked cob yield. After recording the weight of green cobs with husk, the husk was removed and the weight of cobs without husk was determined for dehusked cob yield. The cost of cultivation of different treatments was worked out separately. Labour and requirement of mechanical power for different operations such as land preparation, planting, irrigation, weeding and harvesting was calculated as per local market rate. The cost of FYM was Rs. 750 per ton. The sweet green cobs were sold at the rate of Rs. 15 per kg cob without husk. Benefit cost (B:C) ratio was calculated by dividing cost of cultivation by net return. The data recorded on various parameters were analyzed at 5% level of significance as per the analysis of variance technique for factorial randomized block design.

RESULTS AND DISCUSSION

Growth parameters

A significant improvement in growth parameters such as plant height, leaf area and dry matter accumulation was observed with increase in dose of FYM and nutrient (Table 1). Crop did not show significant differences in days to reach 50% tasseling and 50% silking due to variation in FYM and nutrient levels. Plant height increased significantly with the application of FYM where 15 t /ha had significantly more plant height but remained statistically similar to 5 and 10 t /ha but (131.7 cm) than that of no FYM. The application of 100 and 125 % RDF being at par with each other resulted in significantly more plant height (134.4 cm). Moreover, application of 50% RDF exhibited significantly the lowest plant height. More plant height under high application of FYM and fertilizers might be due to more cell division and elongation favoured by high metabolic activity as a consequence of adequate availability of nutrients. Pal and Bhatnagar (2012) also found enhancement in plant height of maize with increase in nutrient dose. Maximum leaf area per plant (3817 cm^2) was obtained with FYM @ 10 t/ha that was statistically similar to 15 t/ha but significantly higher than rest of the treatments. Among nutrient levels, 125 % NPK was significantly higher to 50 and 75% NPK by 21.8 and 7.3% but remained at par with 100% NPK. The increase in leaf area with increasing amount of FYM and nutrients may be attributed to increased amount of cellular constituents, mainly protoplasm and also due to the influence of phytochromes in promotion of cell division, cell enlargement, cell differentiation and cell multiplication resulting in consistent and statistically significant increase in total leaf area per plant (Rao and Padmaja, 1994). Similarly crop grown with FYM @ 15 t/ha being at par with 5 and 10 t/ha exhibited significantly more dry matter accumulation per plant (83.6 g) than that of without FYM (Table 1). Crop fertilized with 125% NPK being at par with 100% NPK accumulated significantly more dry matter (83.1 g) than rest of the treatments.

Application of 50% NPK resulted into significantly lowest dry matter per plant. More dry matter accumulation under high level of FYM and nutrients was the result of better plant growth owing to better utilization of resources under adequate supply of nutrients and more availability of nutrients as evident by higher plant height and leaf area under these treatments. Increased leaf area in turn resulted in higher dry matter accumulation. The proper utilization of NPK along with FYM by the plant might be ascribed to increased productivity in terms of carbohydrate production. These results are in agreement with those of Bisht *et al*. (2015). Similar findings were also reported by Grazia *et al.* (2003) and Bisht *et al*. (2012).

Yield attributes

Cob length, cob girth, number of grains /row, number of grains /cob and individual cob weight varied significantly due to FYM and nutrient levels. But non significant variations in number of grain rows/ cob, plant population and number of cobs/ha were recorded (Table 2 and 3). Significantly higher cob length (19.5 cm) and individual cob weight (190 g) was obtained in FYM @ 10 t/ha as compared to no application of FYM, however it remained at par with 5 and 15 t FYM/ha. Application of FYM @ 10 t/ha with at par with 15 t/ha and also resulted in significantly more cob girth (16.0 cm), number of grains /row (39.8) and higher number of grains/cob (543.6) than 0 and 5 t/ha. Improvement in the values of yield attributes was noted with each successive increase in the dose of nutrient dose where 125% NPK produced significantly more cob length (19.5 cm) and individual cob weight (196 g) than 50 and 75% NPK but remained statistically same with 100% NPK. Maximum cob girth (16.0 cm), number of grains /row (39.7) and number of grains /cob was observed in 100% NPK which was significantly superior to 50% NPK but was non- significant with 75 and 125% NPK. Better availability of nutrients under high nutrient levels improved the plant growth in terms of leaf area and dry matter accumulation which in turn might helped in increasing cob length and cob girth. These findings are in close conformity with the results obtained by Zende *et al*. (2009) and Hargilas (2012). The number of grains/row depends on cob length therefore, treatments having significantly more cob length had more number of grains/cob. Since, number of grains/cob is product of

Table 1: Effect of integrated nutrient management on growth of sweet corn

Treatment	Plant height (cm)	Leaf area / (cm^2)	Dry matter accumulation / plant (g)	Days to 50% tasseling	Days to 50% silking
FYM (t/ha)					
0	119.3	2947	62.5	69.7	73.4
5	128.4	3565	79.2	70.5	73.7
10	130.2	3847	82.3	70.5	74.0
15	131.7	3817	83.6	69.9	73.1
SEm±	1.9	52	2.2	0.45	0.5
CD (5%)	5.5	151	6.6	NS	NS
Nutrient level (% recommended dose of NPK)					
50	114.6	3130	66.7	70.8	74.4
75	126.0	3552	75.7	70.5	74.0
100	134.5	3683	82.1	69.9	73.2
125	134.4	3813	83.1	69.5	72.7
SEm±	1.9	52	2.2	0.45	0.5
CD (5%)	5.5	151	6.6	NS	NS

Table 2: Yield attributes of sweet corn as affected by integrated nutrient management

Treatment	Cob length (cm)	Cob girth (cm)	No. of grain rows/cob	No. of grains /row	No. of grains/cob	Individual cob weight (g)
FYM (t/ha)						
0	17.9	14.7	12.7	38.0	482.2	149
5	19.2	15.4	12.9	38.7	496.3	178
10	19.5	16.0	13.7	39.8	543.0	187
15	19.4	15.9	13.7	39.8	543.6	190
SEm±	0.27	0.21	0.38	0.38	16.0	7
CD (5%)	0.77	0.60	NS	0.77	46.2	20
Nutrient level (% recommended dose of NPK)						
50	18.1	14.7	12.6	37.9	474.2	140
75	18.7	15.5	13.3	39.0	516.7	172
100	19.5	16.0	13.6	39.7	539.0	196
125	19.5	15.9	13.5	39.5	535.3	196
SEm±	0.27	0.21	0.38	0.38	16.0	7
CD (5%)	0.77	0.60	NS	0.77	46.2	20

number of grain rows/cob and number of grains/row; hence variation in number of grains/cob may be ascribed to significant differences in number of grains/row. Similar observations were also made by Kumar *et al*. (2007). Cob weight depends on number of grains/cob and weight of individual grain. Hence, the increase in weight of cob with increased fertilizer application could be attributed to more number of grains/cob under these treatments. These results conform with those of Pal and Bhatnagar (2012).

Yields

A significant increase in cob yield was noted with progressive increase in FYM levels. Crop fertilized with FYM @ 15 t/ha being at par with 5 and 10 t/ha resulted in significantly more husked (16525 kg/ha) and dehusked cob yields (11938 kg/ha) than that grown without FYM (Table 3). Moreover, cob yields obtained in 5 t FYM/ha were also significantly superior to that of no application of FYM. The increase in husked cob yields in 5, 10 and 15 t FYM /ha over no use of FYM was to the tune of 13.5, 20.7 and 21.8%, respectively whereas for the same treatments the increase in dehusked cob yield was 17.6, 26.4 and 27.9%. These results made it clear that increase in FYM from 5 to 15 t/ha though improved the yields but non-significantly. Raising the nutrient level from 50 to 125% also caused significant increase in husked and dehusked cob yield. Crop nourished with 125% NPK produced significantly more husked and dehusked cob yield (17124 and 12347 kg/ha, respectively) than that of 50 and 75% NPK but did not differ statistically with 100% NPK. The advantage in husked cob yield under 125% NPK was 1596 and 4738 kg/ha compared to 75 and 50% NPK, respectively. Moreover, both 75 and 100% NPK were significantly higher than 50% NPK with yield advantage of 25.4 and 35.8%, respectively. The advantage in dehusked cob yield under 100 and 125% NPK over 50% RDF was 36.4 and 39.9%, respectively whereas these values in comparison to 75% NPK were 11.0 and 13.9%, respectively. Fresh cob yield is the manifestation of growth characters. Significant increase in cob yield of sweet corn can be traced back to the significant increase in the yield components like cob length, cob girth, number of rows/cob, number of grains/row, number of grains/cob and individual cob weight which had direct influence. These findings are in accordance with Sahoo and Mahapatra (2007).

Economics

Significant differences in economic parameters were observed due to FYM treatments (Table 3). Cost of cultivation of sweet corn was very high due to high price of seed i.e. Rs. 2000 per kg and purchase of FYM from outside. Crop grown without FYM and with 15 t FYM/ha had minimum (Rs. 43306/ha) and maximum (Rs. 54956/ha) cost of cultivation, respectively. Among nutrient levels, 50 % NPK and 125% NPK exhibited the lowest and the highest cost of cultivation i.e., 47107 and Rs. 51355/ha, respectively. The variations in cost of cultivation were also due to difference in amount of FYM and fertilizers in different treatments. The maximum gross return (Rs. 179065/ha) was obtained under application of 15 t FYM/ha that was significantly superior to 0 t FYM /ha but at par with application of 5 and 10 t FYM /ha. The gain in gross returns under 5, 10 and 15 t FYM/ha was Rs. 24712, 36971 and 39056 /ha over no application of FYM, respectively. The maximum gross return was obtained under 125% NPK (Rs.185213/ha) that was significantly higher than 50 and 75% NPK but was at par with 100% NPK. Gross return under 100 and 125% NPK was higher by 36.4 and 39.9% over 50% NPK, respectively. Since

Table 3: Plant population, number of cobs/ha, cob yields and economics of sweet corn under different levels of FYM and nutrients

Treatment	Plant population /ha	No. of cobs /ha	Husked cob yield (kg/ha)	Dehusked cob yield (kg/ha)	Cost of cultivation (Rs. /ha)	Gross return (Rs. /ha)	Net return (Rs. /ha)	B:Cratio
FYM (t/ha)								
0	63728	62635	13565	9334	43306	140009	96703	2.22
5	62932	61929	15398	10981	47456	164721	117265	2.46
10	63781	63086	16374	11799	51206	176980	125774	2.45
15	63259	62950	16525	11938	54956	179065	124109	2.25
SEm±	770	544	525	430	-	6447	6447	0.13
CD (5%)	NS	NS	1515	1241	-	18620	18620	NS
Nutrient level (% recommended dose of NPK)								
50	63561	62790	12386	8824	47107	132362	85255	1.81
75	64031	63176	15528	10844	48523	162675	114152	2.35
100	62114	61466	16825	12035	49939	180525	130586	2.61
125	63994	63169	17124	12347	51355	165213	133858	2.61
SEm±	770	544	525	430	-	6447	6447	0.13
CD (5%)	NS	NS	1515	1241	-	18620	18620	0.37

gross return was obtained from cob yield hence, variation in dehusked cob yield resulted in significant differences in gross return under different treatments. The maximum net return of Rs. 125774 /ha was obtained under 10 t FYM/ha which was at par with 5 and 15 t FYM/ha but was significantly higher than 0 t FYM/ha. Crop grown without FYM gave significantly lowest net return. Crop grown with 5, 10 and 15 t FYM /ha gave Rs. 20562, 29071 and 27406/ha more net return than that of no FYM, respectively. The maximum net return (Rs. 133858/ha) was obtained under 125% NPK that was significantly superior to 50 and 75% NPK but remained at par with 100% NPK. An increase of 53.2 and 57.0% was noticed in 100 and 125% NPK, respectively over 50% NPK. The variations in net return were due to differences in cost of cultivation and gross return in respective treatments. Singh *et al.* (2010) also reported more gross and net returns with increase in nutrient levels. Non-significant difference in benefit: cost ratio was observed due to different levels of FYM. However, the maximum B:C ratio (2.46) was obtained under 5 t FYM /ha. Among nutrient levels, the maximum B: C ratio (2.61) was noted under 100% NPK that was significantly superior to 50% NPK but did not differ statistically with 75 and 125% NPK. Benefit cost ratio in different treatments varied owing to difference in net return and cost of cultivation. These results corroborate the findings of Zende *et al*. (2009) who also noticed more B:C ratio in sweet corn at high level of nutrients as compared to low levels.

CONCLUSION

Results of the study indicate that higher green cob yield and profit from sweet corn in spring season may be obtained by fertilizing it with 100 % recommended dose of nutrients (120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha) along with 5 t FYM/ha.

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