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Effect of Integrated Nutrient Management on Yield, Economics and Post-harvest Soil Properties of Sweet Corn Grown under Mid-Central Table Land Zone of Odisha

Meenakhi Prusty [a], Debashish Swain [a], M. A. Alim [a], Monika Ray [b] and Debadatta Sethi [c*]

[a] Regional Research and Technology Transfer Station, Dhenkanal, Odisha, India.
[b] Regional Research and Technology Transfer Station, Odisha University of Agriculture and Technology, Keonjhar, Odisha, 758002, India.
[c] Regional Research and Technology Transfer Station, Odisha University of Agriculture and Technology, G. Udayagiri, Kandhamal, Odisha, 762100, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Sweet corn (*Zea mays* var. *saccharata*), popularly known as sugar corn or pole corn is a specialty maize having high sugar content at milk or early dough stage. As the corn is considered as an exhaustive crop, requires more nutrient, so integrated nutrient management practices play an important role in sustaining productivity of sweet corn. A field experiment was conducted during 2019 and 2020 in order to study the effect of integrated nutrient management on sweet corn yield and post harvest soil properties. Different growth parameters like plant height (206 cm), cob length (28.5 cm), cob girth (16.43 cm), no of seed rows per cob (18.80), no of grains per row (47.55) and green cob wt. (335.43g) were found highest in integrated package where bio fertilizer consortia, B and Zn were applied along with STD fertilization (T_6)**.** Total harvested yield of sweet corn including stover (2.58 to 2.98 t ha^{-1}) and kernel (1.33 to 2.37t ha^{-1}) varied from 3.91 to 5.35 t ha^{-1} in different

**Corresponding author: E-mail: debadattaouat@gmail.com;*

treatments and was observed highest in T_6 (5.35 t ha^{-1}). Harvest index (44.29%), B: C ratio (3.15) and 1000 kernel weight (198.90 g) was also recorded highest in treatment T_6. The post- harvest soil properties were also recorded highest in T_6 where bio fertilizer consortia, B and Zn were applied along with STD fertilization in the INM package**.**

Keywords: Economics; harvest index; integrated nutrient management; post-harvest soil properties.

1. INTRODUCTION

Sweet corn (*Zea mays var. saccharata*) has gained popularity across the world owing to its sweet, creamy, tender, crispy and almost shell-less kernels. It is gaining popularity in India and other Asian countries. The green cobs are harvested at dough stage at which out of 18-20% carbohydrates, the kernels contain 5-6% free sugar, 2.1–4.5% of proteins and 70% water. Sweet corn is gaining importance in the star hotels and urban areas for the preparation of vegetables, special soups, syrup, sweets, jams, cream, pastes and other delicious eatables. Besides, its fodder is highly succulent, palatable and digestible Sweet corn is an excellent source of sugars, dietary fibre, vitamin-C, beta-carotene, niacin, in addition to calcium and potassium [1]. It is an exhaustive crop and it is harvested at milky stage and requires fertile soils for optimum production. As the corn is considered as an exhaustive crop, requires more nutrient, organic nutrient management practices play an important role in sustaining productivity of sweet corn. Though chemical fertilizers alone provide high yield in initial year but it adversely affects the soil health in long run. Therefore, integrated use of organic and inorganic fertilizers has been found to be promising in obtaining sustained crop productivity on a long term basis under modern intensive cropping besides meeting the nutrients turn over in soil-plant systems. FYM enhances soil physical features such as soil aggregation, density, soil water holding capacity, soil air movement, and chemical properties such as buffering capacity and nutrient availability. Bio fertilizer is a non-bulky, low-cost plant augmenting organic fertilizer that is environmentally friendly, cost effective and sustainable when used in integrated nutrient management package. As this crop is nutrient-responsive, soil exhaustive and heavy-feeding, reducing soil fertility to a great extent, improper recycling of organic resources also leads to nutritional deficiency problems (Kumar, 2008). The primary purpose of an integrated nutrient management system is to improve the soil health and supply plant nutrient on optimal level that can lead to attain maximum yield through optimization of the benefits from different inputs in an integrated manner. Therefore, the present investigation was undertaken with an objective to find out the effect of integrated nutrient management on yield attributing characters, yield, recovery, post-harvest soil properties and Economics of sweet corn in Mid- central Table land zone of Odisha.

2. MATERIALS AND METHODS

A field experiment was conducted at Regional Research and Technology Transfer Station situated at Mahisapat of Dhenkanal district in Mid Central Table Land Zone of Odisha under Odisha University of Agriculture and Technology during 2019& 2020. The farm is located in the geographical parallels between 20^0-3'and 21^0-16' North latitudes and 84^0 and 86^0-6' East longitude. The important soil groups of the zone are alluvial (*Entisol*), black (*Vertisol*), red-laterite (*Alfisol*) and lateritic (*Oxisol*). The soil of experimental site was red, sandy loam in texture & acidic in reaction (pH=5.8) with available N (262 kg ha^{-1}), available P_2O_5 (18.7 kg ha^{-1}), available K_2O (189 kg ha^{-1}), available B (0.49 mg kg^{-1}) and Zn (0.5 mg kg^{-1}). The experiment was laid out in RBD with six treatments and four replications. The detailed of the treatments are as follows. T_1: Control, T_2: STD (NPK), T_3: STD (NPK) +FYM @5 t ha^{-1}, T_4 : STD (NPK) +FYM @ 5 t ha^{-1}+ Borax @ 10 kg ha^{-1} + $ZnSO_4$ @25 kg ha-^{1}, T_5: STD(NPK) +FYM @ 5 t ha^{-1}+ Bio fertilizer (Consortia @ 12 kg ha^{-1}), T_6: STD (NPK) +FYM @ 5 t ha^{-1} + Borax @ 10 kg ha^{-1} + $ZnSO_4$ @25 kg ha^{-1} +Bio fertilizer (Consortia @ 12 kg ha^{-1}). The Sweet corn variety Sugar 75 was the test variety. The sweet corn crop was sown on 4th week of July. The plant geometry was maintained at 60 cm× 45 cm spacing in each experimental plot. The crop received soil test based fertilizer doses of N:P:K::150:75:60 kg ha^{-1} though Urea, DAP and MOP. The 1/3rd dose of N, Full dose of P and 1/2nd dose of K were applied as basal at the time of sowing. Again 1/3rd dose of N and 1/2nd dose of K were applied during 1st earthing up operations. Remaining 1/3rd dose of N was applied before tassel formation. FYM @ 5 t ha^{-1}, Borax @ 10 kg ha^{-1}, $ZnSO_4$ @ 25 kg ha^{-1} and Bio fertilizer (Consortia @ 12 kg ha^{-1}) was applied as per the treatment.

Table 1. Initial Soil Properties

Sl. No.	Parameters	Value
1	Soil textural class (Sand 79.2 %, Silt 6.1 % and Clay 14.7%)	Sandy loam
2	pHw (1:2.5)	5.8
3	EC (dSm^{-1})	0.029
4	OC (g kg^{-1})	5.8
5	Available N (kg ha^{-1})	262
6	Available P (kg ha^{-1})	18.7
7	Available K (kg ha^{-1})	189
8	Available B (mg kg^{-1})	0.49
9	Available Zn (mg kg^{-1})	0.54

A hand weeding was carried out within 20 days of sowing. Two earthing up operations were carried out within 15-20 and 35-40 days after sowing. After full maturity (80-85 days), cobs from each plot were harvested and weight separately. Two plants from each plot were selected randomly; cut from the base and fresh and dry weight were recorded. The maize kernels and stovers after harvest were air dried and weighed plot wise to record the yield data.Initial and post-harvest soil samples were collected following the procedure. The composite soil samples were collected treatment wise after harvest and analyzed as per the standard procedureThe economics of cultivation was computed basing upon the prevailing market prices of the local area. The recorded data was analysed statistically in Randomized Block Design (RBD) as per the procedure described by Gomez and Gomez [2].

3. RESULT AND DISCUSSION

3.1 Effect of Integrated Nutrient Management Practices on Yield Attributes

The data related to biometrical observation (plant height, cob girth, cob length, green cob weight, no. of seed rows per cob, no. of grains per row and 1000 grain weight of sweet corn under the influence of INM practices have been presented in Table 2. Plant height varied significantly between 178.2 to 206.6 cm, cob girth varied significantly between 8.0 to 16.4 cm, cob length varied from 19.7 to 28.5 cm, green cob weight varied significantly between 264 to 335 g, no.of seed rows per cobvaried between10to19,no. of grains per row varied between 32 to 48 and thousand grain weight varied between 177 to 199 g. Lowest result found with control and highest with integrated treatment T_6 (STD (NPK) +FYM @ 5 t ha^{-1}+ Borax @ 10 kg /ha + $ZnSO_4$ @ 25 kg ha^{-1} +Bio fertilizer (Consortia@ 12 kg ha^{-1}).Combined uses of organics (FYM), micronutrients (B, Zn) and Bfs together increased the plant height by 12 per cent over STD alone. Similarly integrating use of agro inputs like organics (FYM), micronutrients (B, Zn) and Bfs together increased cob girth by 74.4%, cob length by 30.7%, Green cob weight by 17% ,seed rows per cob by 58 % , no of grains per row by 29.7 % and thousand grain weight by 10.5 % over STD alone. The combined effect of organic and inorganic nutrients improves the translocation and availability of nutrients to the plant which increase the yield attributing characters. Aravinth et al., [3] found that recommended NPK + vermicompost @ 5 t ha^{-1} recorded higher baby corn yield attributing characters than recommended NPK alone. This was also in confirmation with the result of Mahapatra et al. [4].

3.2 Effect of Integrated Nutrient Management Practices on Yield

The yield of sweet corn crop also varied in response to different nutrient management practices. The variation in grain yield ranged from1.33 to 2.37tha^{-1}, stover yield from 2.58 to 2.98 t ha^{-1} and total biomass varied between 3.91 to 5.35 t ha^{-1}, lowest was recorded in the control and highest in the treatment of combined nutrient practice. That integrated use of different inputs resulted the highest performance. This can be justified from the observation of increase in grain yield of 55 percent, stover yield of 10.4 per cent and total biomass yield of 26.7 per cent over that of the STD alone. There was loss of 6.8 per cent potential grain yield when micronutrients were deleted from the complete package of practice (STD + F + B + Zn + Bfs), but with withdrawal of biofertilizers ended up with a highere conomic yield lost to the extent of 23.6 per cent.

Table2. Effect of INM practices on yield attributing characters of sweet corn

Treatments	Plant height (cm)	Cob girth	Cob length	Green cob weight (g)	No. of seed rows / cob	No. of grains / row	1000 Grain wt. (g)
Control	178.2	8.0	19.7	264	10	32	177
STD	184.5 (3.5)*	9.4 (17.5)	21.8 (10.6)	286 (8.3)	12 (20)	37 (15.6)	180 (1.7)
STD+FYM	191.9 (4.0)**	11.3 (20.2)	24.2 (11.0)	292 (2.0)	14 (16)	40 (8.1)	185 (2.7)
STD+FYM+B +Zn	196.5 (2.4)❖	12.9 (14.1)	25.7 (6.2)	310 (6.0)	15 (17)	42 (5)	190 (2.8)
STD+ FYM+ Bf	201.5 (5.0)▲	14.9 (31.9)	27.0 (11.6)	321 (10)	17 (21.4)	45 (12.5)	194 (4.9)
STD+FYM+B +Zn +Bf	206.6 (12)■	16.4 (74.4)	28.5 (30.7)	335 (17.1)	19 (58)	48 (29.7)	199 (10.5)
SE.m(±)	0.46	0.42	0.11	0.55	0.16	0.19	1.38
CD(P=0.05)	1.39	1.27	0.33	1.67	0.49	0.56	4.15

**Data in the parenthesis indicate percentage response of the STD practice over control; **Data in the parenthesis indicate percentage response of the FYM over STD practice; ❖Data in the parenthesis indicate percentage response due to micronutrients over STD+FYM; ▲Data in the parenthesis indicate percentage response due to bio fertilizer over STD+ F package; ■Data in the parenthesis indicate percentage response due to combined in puts like F, B, Zn and Bfs over STD*

Table 3. Effect of Integrated nutrient management practices on yield, RAE & HI of sweet corn

Treatments	Crop productivity (tha^{-1})			Grain: Stover	Harvest Index (%)	Relative Agronomic Efficiency (RAE) (%)		B:C
	Grain	Stover	Total biomass			(a)	(b)	
Control	1.33	2.58	3.91	0.52	34.0	-	-	2.15
STD	1.52 (14.2)*	2.70 (4.6)*	4.22 (7.9)*	0.56	36.0	50	50	2.49
STD+FYM	1.71 (12.5)**	2.82 (4.4)**	4.53 (7.3)**	0.61	37.7	100	100	2.62
STD+FYM+B +Zn	1.81 (5.9)❖	2.84 (0.7)❖	4.65 (2.6)❖	0.64	38.9	126	119	2.80
STD+ FYM+ Bf	2.21 (29.2)▲	2.93 (3.9)▲	5.14 (13.4)▲	0.75	43.0	232	198	3.06
STD+FYM+B +Zn +Bf	2.37 (55.9)■	2.98 (10.4)■	5.35 (26.7)■	0.80	44.2	274	232	3.15
SE.m(±)	0.02	0.02	0.03	-	-	-		-
CD(P=0.05)	0.07	0.06	0.08	-	-	-		-

**Data in the parenthesis indicate percentage response of the STD practice over control; **Data in the parenthesis indicate percentage response of the FYM over STD practice; ❖Data in the parenthesis indicate percentage response due to micronutrients over STD + FYM; ▲Data in the parenthesis indicate percentage response due to bio fertilizer over STD+ F package; ■Data in the parenthesis indicate percentage response due to combined inputs like F, B, Zn and Bfs over STD; (a) RAE based on economic yield; (b) RAE based on total biomass yield*

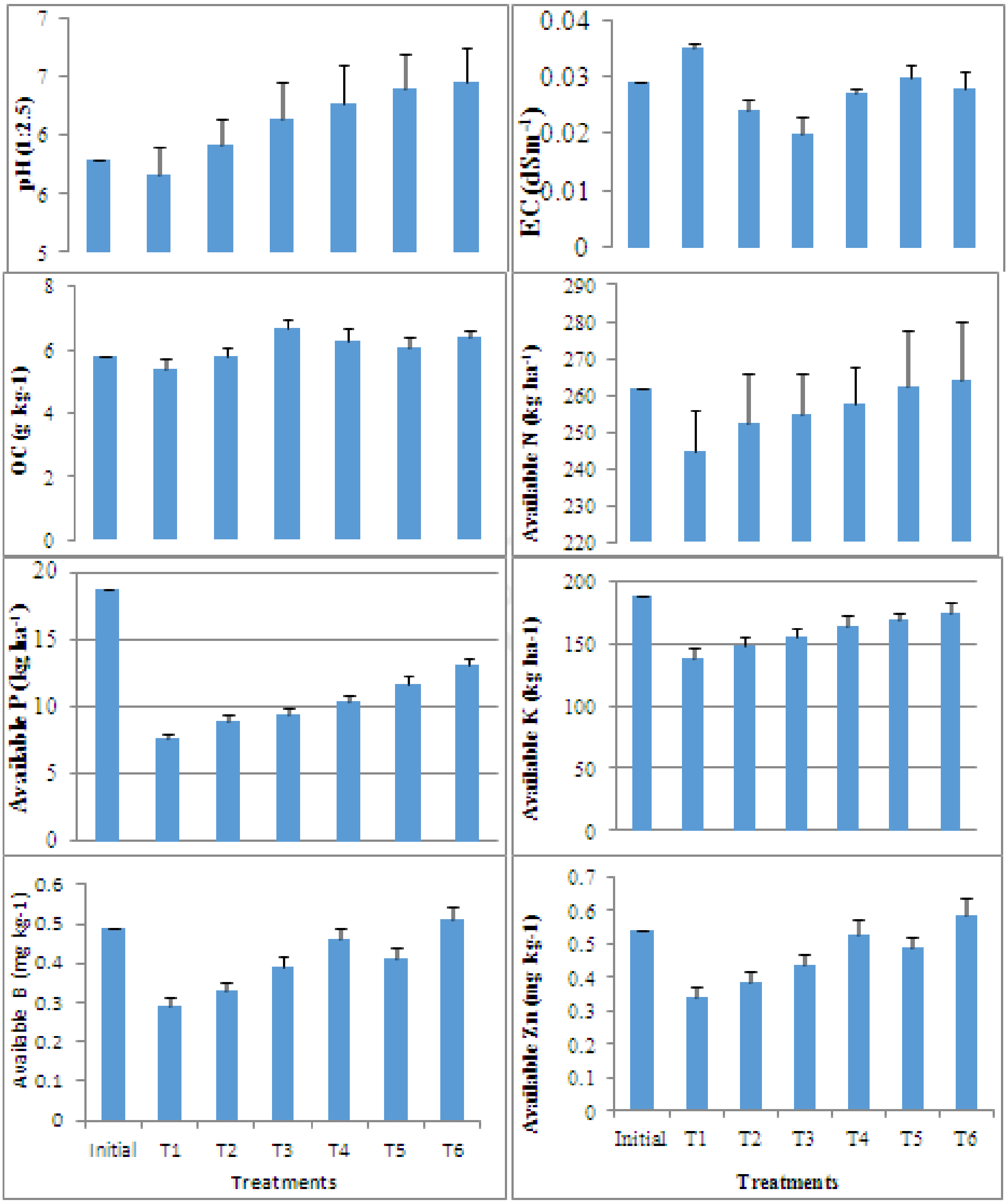

Fig. 1. Post harvest nutritional properties of soil

T_1: Control, T_2: STD, T_3: STD+FYM, T_4: STD+FYM+B+Zn, T_5:STD+FYM+Bf, T_6: STD+FYM+ B+Zn+Bf

That economic yield loss to the tune of 27.9 per cent with the withdrawal of both biofertilizers and micronutrients and the maximum yield loss could be of 35.9 per cent if lone soil test based fertilizers were applied with no inputs integration. Integrated use of organic and inorganic source of nutrients improve the soil physico-chemical and biological properties which resulted in better availability, absorption and utilization of nutrients there by enhanced the yield of crops. Sharma and Banik [5] also found that Arbuscular mycorrhiza, *Azospirillum* and chemical fertilizer application to baby corn produced maximum baby cob and green fodder yield. This result was also corroborated with the findings of Mani et al. [6], Rathod et al. [7] and Panchal et al. [8], Singh et al. [9].

The grain to stover ratio and harvest index also varied between 0.52 to 0.80 and34 to 44.3 per cent respectively, lowest with the control and highest with the combineduse of inputs. The relative agronomic efficiency based on economic yield in different treatments followed the order of STD+F+B+Zn+Bfs (274) > STD+F+Bfs (232) > STD+F+B+Zn (126) > STD+F (100) > STD (50) and STD+F+B+Zn+Bfs (274) > STD+F+Bfs (232) > STD+F+B +Zn (126) > STD+F (100) > STD(50) basing upon total biomass yield. The Rupee earned per Rupee investment ranged from 2.15 to 3.15, lowest with control and highest with complete integrated treatment combination. B: C of different treatments followed the order: 3.15 (STD + FYM + B + Zn + Bfs) > 3.06 (STD + FYM + Bfs) >2.80(STD+FYM +B +Zn)>2.62 (STD+FYM)>2.49(STD)>2.15 (control).

3.3 Effect of INM Practices on Post-harvest Soil Properties

The soil reaction (pH) (5.8) was mildly acidic at the beginning. After crop harvest the pH had decreased in control and in STD treatment only but increased and maintained between 6.1 to 6.4 in rest of the integrated treatments using mostly FYM as organic manure (Fig. 1). The soluble salts content in soil before experimentation was 0.029 dSm^{-1}. After harvest of the crop due to removal of nutrients the soluble salts content decreased irrespective of the treatments. The organic carbon content of the experimental soil was medium in status. After harvest of the crop without its supplementation through any source, the content had decreased whereas increased in rest of the treatments with its supplementation through FYM@ 5 t ha^{-1}. The $KMnO_4$ oxidisable (available) N in soil was medium in status. Without supplementation the content decreased (control) in soil. The content more or less maintained in the medium level due to its supplementation in spite of crop removal. The experimental soil was medium in status for Bray's-1 P. After crop harvest, irrespective of its application the content decreased due to crop removal and the P status become much low in the treatments like control and STD alone. The available K was medium in status in the experimental soil. In spite of its supplementation through fertilizers and to some extend through FYM, the content decreased. The lowest content was in the control treatment which had not received any supplementation during crop production. The B was deficient micronutrient in the experimental soil. The content in post-harvest soil decreased where it was not supplemented. The content maintained or increased in soil where there was supplementation as borax @ 10 kg ha^{-1}. The Zn was a deficient micronutrient in the experimental soil. The content in post-harvest soil decreased without external supplementation but with supplementation the content in soil was maintained in spite of crop removal. When FYM and bio fertilizer applied with chemical fertilizer, they supply nutrients in a balanced ratio and improved the physical characteristics possibly increasing nutrient availability. So though the available nutrient status decreased from the initial level but the status was remain better in the treatment of integrated approach than that of only chemical one. The application of organic and inorganic fertilizer enhances the post harvest soil [10]. This result was in conformity with the findings of Kalhapure et al. [11], Bharath et al. [12], Khan et al. (2017)and Rekha et al. [13].

4. CONCLUSION

Thus it was concluded from the above study that integrated application of organics along with inorganic fertilizer in sweetcorn not only increase the yield of the crop but also maintain the soil health in sustainable basis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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