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Integrated nutrient management in sweet corn and its residual effect on green gram in mid-central table land zone of Odisha

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Abstract
Judicious use of plant nutrients is a key for higher productivity and sustainability. Though increased use of inorganic fertilizers improved the levels of production but later it may lead to deterioration in soil health besides pollution problems. So in addition to agricultural productivity maintaining and improving soil quality is very crucial for sustainable agriculture. Therefore, integrated nutrient management including appropriate fertilizers application combined with organic manures, biofertilizers has developed not only to meet the growing need for nutrients under intensive cultivation but also helps in maintaining good physico-chemical characteristics and fertility of soils. So a study was conducted on Integrated Nutrient Management in sweet corn and its residual effect on green gram in Mid- Central Table Land Zone of Odisha. Experimental results revealed that **i**ntegrated application of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) significantly augmented the sweet corn yield attributes along with sweet corn (2.37 t/ha) and green forage (29.85 t/ ha) yield. The conjunctive use of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) applied to preceding sweet corn recorded the maximum seed yield (920 kg/ha) in green gram which was at par with residual effect of STD (NPK) +FYM @ 5 t/ha+ Bio fertilizer (Consortia @ 12 kg /ha). The system yield was enhanced with application of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) applied to sweet corn producing highest yield (8.9 t/ha) followed by STD (NPK) +FYM @ 5 t/ha+ Bio fertilizer (Consortia @ 12 kg /ha). Application of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) registered the highest net return (` Rs. 1,98,400/ha) and benefit cost ratio (3.10) in sweet corn- green gram system when green gram was grown under residual fertility condition. The post-harvest soil properties were also found to be improved in the same treatment after harvest of green gram.

Keywords: bio fertilizer, economics, post-harvest soil properties

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. Sweet corn is one of the most popular vegetables in the USA, Canada and Australia. It is gaining popularity in India and other Asian countries. The green cobs are harvested at dough stage and the kernels contain 18-20% carbohydrates, 5-6% free sugar, 2.1–4.5% of proteins and 70% water (Khan *et al.*; 2018) [5]. 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. Its fodder is also very succulent, palatable and digestible. 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. Integrated nutrient management as one of the production technology contributes substantially towards higher productivity and maintenance of soil fertility. The productivity of cropping system depends on efficient utilization of residual and cumulative nutrients. Judicious combination of organics like FYM and bio-fertilizers and chemical fertilizers will facilitate profitable and sustainable production. Among the micronutrients zinc deficiency appears to be the most widespread owing to intensive agricultural practices, use of NPK fertilizers only and limited or no application of Zinc by farmers (Rakshit *et al.* 2017; Meena *et al.* 2013) [9, 7]. Boron is essential for the development of reproductive tissues and its deficiency results in low grain set. Pulses are considered as rich source of protein for vegetarian people and maintain soil fertility through biological nitrogen fixation.

Green gram grown both as a catch crop in between two main seasons can be suitably grown after sweet corn in residual soil moisture and nutrient condition which can improve the soil fertility status after harvest. Therefore, the present investigation was undertaken with an objective to find out the effect of integrated nutrient management on growth and yield of sweet corn and its residual effect on green gram under Mid- central Table land zone of Odisha.

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 2019-20 & 2020-21. 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 ppm) and Zn (0.5 ppm). 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, T_4 - STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg /ha, T_5 – STD (NPK) +FYM @ 5 t/ha+ Bio fertilizer (Consortia @ 12 kg /ha), T_6 - STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha).The Sweet corn variety Sugar 75 was the test variety. The sweetcorn crop was sown on 4 th 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 NPK @ 150:75:60 kg/ha 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, Borax @ 10 kg /ha, $ZnSo_4$ @25 kg /ha and Bio fertilizer (Consortia@ 12 kg /ha) was applied as per the treatment. 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. After harvest of sweet corn, the green gram Variety IPM 02-14 was sown under residual environmental condition. The biometric observations of sweet corn and green gram were recorded at harvest. The economics of cultivation was computed basing upon the prevailing market prices of the local area. Initial and post-harvest soil samples were collected following the procedure after both the crops. The composite soil samples were collected treatment wise after harvest and analysed as per the standard procedure. The recorded data was analysed statistically in Randomized Block Design (RBD) as per the procedure described by Gomez and Gomez (1984) [3].

Results and Discussion

Effect of nutrient management on yield and yield attributes of sweet corn

The data depicted in Table-1 indicated that application of integrated nutrient management practice's exerted significant effect on pooled cob yield, green forage yield and yield attributes of sweet corn. The combined application of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) markedly augmented the yield attributes like plant height (206.57 cm), cob girth (16.43 cm), cob length (28.52 cm), no of seed rows/cob (18.80), no of grains/row (47.55) and green cob weight (335.43g). The same treatment provided highest grain yield of (2.37 t/ha) and green forage yield of (29.85 t/ha). It was in agreement with the findings of Thavaprakash *et al*. (2015) [14] and Rasool *et al.* (2015) [10]. The said treatment was found to remain at par with treatment STD (NPK) +FYM @ 5 t/ha+ Bio fertilizer (Consortia @ 12 kg /ha). The beneficial effect of integrated nutrient supply in improving the yield components of sweet corn was resulted in enhancement of sweet corn yield. Increase in yield and its attributes observed with integrated application of inorganic, organic and bio fertilizer is ascribed to better translocation, utilization of applied nutrients which increased sink capacity and partitioning of photosynthates. The favourable effect of applied Zn and B had positive influence on physiological and metabolic process of plant which ultimately augmented sweet corn and fodder yield. This result was evidenced with earlier work done by Kumar and Bhora (2014).

Residual effect of nutrient management on yield and yield attributes of green gram

The combined application of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) to sweet corn exerted significant residual effect in increasing the yield components of green gram like number of pods /plant (17.43), number of seeds/pod (13.07), test weight (38.50 g) along with seed yield (920 kg/ha) and stover yield (1980 kg/ha) grown under residual fertility (Table-2). The favourable residual effect of organic component and micronutrients resulted in increasing the yield attributes which reflected in seed yield of green gram. Similar favourable residual effect of RDF with FYM or vermicompost + zinc sulphate + ferrous sulphate applied to baby corn had positive effect on chickpea in increasing the yield and yield attributing characters reported earlier by Asoka *et al.* (2008).

Sweet corn – green gram system yield

System yield in sweet corn – green gram system expressed in sweet corn equivalent yield (SEY) was significantly influenced by adoption of integrated nutrient management practices (Table -3). The pooled system yield was augmented with STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) applied to sweet corn producing the SEY (8.9 t/ ha) being remained at par with STD (NPK) +FYM @ 5 t/ha+ Bio fertilizer (Consortia @ 12 kg /ha). It was possible due to conjunctive use of organic manure and inorganic NPK sources of nutrient mixed with bio fertilizers applied to sweet corn enhanced the yield of sweet corn and succeeding green gram under residual condition which ultimately increased the system productivity. It was in agreement with the findings of Meena *et al.* (2012). The judicious use of Zn + B in balanced manner increased the efficiency of NPK and added micronutrient in deficient soil resulted in enhancement of system yield which as reported alike by Shukla (2011) [11].

Economics in Sweet corn – green gram system

Integrated use of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg

/ha) provided the highest net return (Rs.1,98,400/ha) and benefit cost ratio (B:C) of 3.10 but use of STD (NPK) +FYM @ 5 t/ha+ Bio fertilizer (Consortia @ 12 kg /ha) gave net return (Rs.1,81,900/ha) and benefit cost ratio (B:C) of 2.92 (Table-3). This was mainly attributed to the higher system yield obtained through improvement in soil health by judicious integrated nutrient management approach using STD with organic manure (FYM) and bio fertilizers along with combination of micro nutrients (Zn and B). Asoka *et al*. 2008 also obtained the maximum system economics with combined use of RDF + vermicompost / FYM + zinc sulphate + ferrous sulphate applied to baby corn and chickpea was grown in residual soil fertility in baby corn – chickpea system.

Post-harvest soil properties in Sweet corn – green gram system

At the harvest of sweet corn it was found that the nutrient status of soil was declined from the initial status as sweet corn is an exhaustive crop. But in comparison to the other treatments the maximum available nutrient was found in the treatment where Integrated use of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) was done having available N, P, K, B, Zn (264, 13, 174 kg/ha and 0.51, 0.59 mg/kg respectively) (Table- 4). As biofertelizers helps N_2 fixation due to presence of diazotrophs like *Azotobacter* and *Azospirillum* and the *Azotobacter* also helps in increasing P, K availability through mineralisation and solubilisation by releasing growth regulating substances like IAA, NAA, GA, cytokines and organically active substances such as B vitamins, nicotinic acid, pantothenic acid, biotin etc. which improved the root growth of plants. (Sneha *et al*., 2018) [13]. The PSB also plays an important role in P availability by releasing P from organic and inorganic soil phosphorous pool by solubilisation and mineralisation. (Devi *et al*., 2003, Singh and Singh, 2007) [2, 12]. But after the final harvest of green gram the nutrient status of the soil was improved from the initial status as green gram is a soil restorative crop. The continuous use of organic manure with mixed bio fertilizers had beneficial effect in maintenance and build-up of available nutrient in soil. It corroborated with the findings of Prasad *et al*. 2010 [8]. The judicious application of nutrient along with organic manure, bio fertilizer and deficient micronutrient help in maintaining the final nutrient status of available N, P, K, B, Zn (279,15.9, 181 kg/ha and 0.59, 0.64 mg/kg respectively which was depicted in Table- 4.

Table 1: Effect of Nutrient Management on Yield Parameters of Sweet corn (Pooled 2019 & 2020)

Treatments	Plant ht (cm)	Cob girth (cm)	Cob Length (cm)	No. of seed rows/cob	No. of grains/row	Green cob wt.(g)
T1	178.18	7.99	19.72	9.70	31.95	263.63
T2	184.46	9.41	21.81	11.45	37.45	285.97
T3	191.91	11.32	24.17	13.65	39.65	292.31
T4	196.53	12.98	25.67	15.35	41.70	309.79
T5	201.52	14.91	27.04	17.05	44.95	321.43
T6	206.57	16.43	28.52	18.80	47.55	335.43
SEm (±)	0.34	0.42	0.11	0.16	0.19	0.55
CD (P=0.05)	1.02	1.27	0.32	0.49	0.56	1.69

Table 2: Effect of Nutrient Management in Sweet corn –Green gram cropping sequence (Green gram) (Pooled 2019 & 2020)

Treatments	No. of Pods/Plant	No. of seeds/Pod	1000 seed wt. (g)	Seed Yield (t /ha)	Stover Yield (t/ha)
T1	9.30	5.67	34.77	0.65	1.58
T2	10.20	6.63	36.40	0.76	1.70
T3	12.20	8.07	36.70	0.77	1.82
T4	16.20	11.27	37.37	0.83	1.84
T5	17.07	12.10	37.97	0.87	1.93
T6	17.43	13.07	38.50	0.92	1.98
SEm (±)	0.16	0.18	0.20	0.02	0.02
CD (P=0.05)	0.51	0.54	0.61	0.06	0.06

Table 3: Effect of Nutrient Management on yield and Economics of Sweet corn –Green gram Cropping Sequence (Pooled 2019 & 2020)

Treatments	Green fodder Yield (t/ha)	Sweet corn yield (cob) (t/ha)	Green gram Yield(t/ha)	System Yield (t/ha)	NMR (Rs.)	B:C
T1	25.87	1.33	0.65	5.94	80,260	2.12
T2	27.04	1.52	0.76	6.91	1,11,600	2.35
T3	27.88	1.71	0.77	7.18	1,42,200	2.52
T4	28.47	1.81	0.83	7.62	1,62,800	2.75
T5	29.33	2.21	0.87	8.1	1,81,900	2.92
T6	29.85	2.37	0.92	8.9	1,98,400	3.10
SEm (±)	0.14	0.02	0.02	-	-	-
CD (P=0.05)	0.43	0.07	0.06	-	-	-

Table 4: Post-Harvest Soil Properties

Treatments	After Sweet corn harvest					After Green gram harvest				
	Avl N kg/ha	Avl P kg/ha	Avl K kg/ha	Avl B mg/kg	Avl Zn mg/kg	Avl N kg/ha	Avl P kg/ha	Avl K kg/ha	Avl B mg/kg	Avl Zn mg/kg
T1	244	7.62	139	0.29	0.34	253	8.25	144	0.35	0.41
T2	252	8.87	148	0.33	0.39	259	9.20	153	0.39	0.46
T3	254	9.37	156	0.39	0.44	266	9.88	161	0.44	0.49
T4	257	10.37	164	0.46	0.53	271	12.40	168	0.51	0.56
T5	262	11.70	169	0.41	0.49	276	13.70	175	0.46	0.51
T6	264	13.02	174	0.51	0.59	279	15.9	181	0.59	0.61
SE.m (±)	1.11	0.21	1.96	0.02	0.02	1.82	0.24	1.80	0.02	0.02
CD (P=0.05)	3.33	0.64	5.90	0.05	0.06	5.47	0.72	5.43	0.05	0.05

Conclusion

It was concluded that integrated application of STD (NPK) +FYM @ 5 t/ha+ Borax @ 10 kg /ha + $ZnSo_4$ @25 kg/ha +Bio fertilizer (Consortia@ 12 kg /ha) to preceding sweet corn was found suitable in increasing the yield and economics of sweet corn and green gram when green gram was grown under residual fertility condition under sweet corn- green gram sequence.

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