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Yield attributes, yield and economics of sweet corn (*Zea mays* L. Ssp. *saccharata*) as affected by tillage practices and nutrient sources

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Abstract
A field experiments was conducted during the *rabi* seasons of 2015-16 and 2016-17 in a split-plot design having four tillage practices in main plots and five nutrient sources in subplots with three replications to find out their effects on yield attributes and yield of sweet corn (*Zea mays* L. Ssp. *saccharata*). Sweet corn crop grown in soil prepared with one mouldboard ploughing + one pass of cultivator + one pass of rotavator (T_4) recorded significantly the highest yield attributes, green cob yield and green fodder yield over rest of the tillage practices. Combined application of 75% recommended dose of nitrogen (RDN) through chemical fertilizers + 25% RDN through vermicompost (S_3) recorded significantly higher value of yield attributes, green cob yield with sheath and green fodder yield over rest of the nutrient sources. Tillage practice T_4 recorded significantly maximum gross returns of Rs. 356968 and net returns Rs. 238648 /ha than other tillage practices. Nutrient source S_3 earned significantly higher gross returns of Rs. 356518 /ha and net returns of Rs. 233690 /ha.

Keywords: Nutrient sources, tillage practices, sweet corn, yield attributes, green cob yield with sheath, green fodder yield, gross returns, net returns, B: C ratio

Introduction
Sweet corn (*Zea mays* L. Ssp. *saccharata*) also known as sugar corn is hybridized version of maize specifically breed to increase the sugar content. It is one of the most popular type for human consumption among the different types of corn grown. Sweet corn is gaining popularity both in rural and urban areas because of its high sugar and low starch content. It has great market potential and high market value in India. The demand for sweet corn in the amusement, parks, theatres, circus and exhibitions is increasing with increasing urban population. Roasted green cobs provide starch, fat, protein, sugar, minerals and vitamins in palatable and digestible form at relatively low cost. Urban peoples prefer the roasted sweet corn cobs as they are very tasty and nutritious. There are several ways to maximize sweet corn yield in unit area. Two of them are tillage practice and nutrient management. Tillage is an important aspect regarding crop production as tillage accounts 30 percent of cost of production. Now a day, considering the high cost of tillage there is needed to plan suitable tillage system for profitable crop production. Several studies suggest that tillage is one of the most essential operations carried out to improve soil structure, increase infiltration capacity, expand pore volume and aeration (Lio, 2006) [3] that in turn increases crop growth and yield, consequently production boosts.
In many countries in the world, balanced use of organic manure and inorganic fertilizers has been considered as one of the best and comprehensive soil fertility management strategies. Now-a-days chemical fertilizers are quite expensive input and their usage over a long period may deplete the soil fertility, it is also considered that their indiscriminate usage may also cause environmental pollution problems, soil sickness, reduce the microbial activities and availability of essential nutrients and deteriorate the product quality. Therefore the search of alternative source of plant nutrients is imperative.
In recent times the concept of integrated nutrient management system has been receiving increasing attention worldwide obviously for reasons of economization of fertilizer usage, safeguarding and ensuring scientific management of soil health for optimum growth, yield and quality of crops. Keeping this point in the view, the proposed research entitled, "Yield attributes, yield and economics of sweet corn (*Zea mays* L. Ssp. *saccharata*) as affected by tillage practices and nutrient sources" was conducted.

Materials and Methods

A field experiment was conducted at Agronomy Farm, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, which is situated at 17^0 45' N latitude and 73^0 1' E longitude having altitude of 250 meters above the mean sea level in Maharashtra. Soils of experimental plot were sandy clay loam in texture, moderately acidic in reaction (pH 5.73 and 5.68) with high in organic carbon content (0.90 and 0.91%). Soil was medium in available nitrogen (285.38 and 288.51 kg/ha), low in available phosphorus (12.72 and 12.93 kg/ha) and high in available potassium (271.20 and 269.85 kg/ha^1).

The experiment was laid out in a split-plot design with three replications on a net plot of 2.40 m × 4.60 m. The main plot consisted of four tillage practices, *viz*. One pass of rotavator (T_1), One pass of cultivator + One pass of rotavator (T_2), One mouldboard ploughing + One pass of rotavator (T_3) and One mouldboard ploughing + One pass of cultivator + One pass of rotavator (T_4), while five nutrient sources *viz*. 100% recommended dose of fertilizer (RDF through) chemical fertilizers (S_1), 75% recommended dose of nitrogen (RDN) through chemical fertilizer + 25% RDN through FYM (S_2), 75% RDN through chemical fertilizer + 25% RDN through vermicompost (S_3), 75% RDN through chemical fertilizer+ 25% RDN through poultry manure (S_4) and 75% RDN through chemical fertilizer+ 25% RDN through goat manure (S_5) constituted the subplot. Sweet corn variety 'Sugar 75' was sown at spacing of 60 cm × 20 cm apart on 6 January 2016 and 29 December 2017 during two *rabi* seasons. The chemical fertilizers and organic manures were applied as per treatments taking in to account the recommended dose of fertilizers *i.e.* 200 - 60 - 60 kg N-P-K/ha. Full dose of organic manures were applied as per treatments after the experimental layout and thoroughly mixed in the soil. Basal dose of fertilizers *i.e.* 50% nitrogen (through chemical fertilizers and organic manures) and full dose of phosphorus and potash was applied at the time of sowing. Remaining dose of nitrogen was applied in two splits *i.e*. 25% at 30 DAS and 25% at 60 DAS. The nitrogen, phosphorus and potash were supplied through urea, single super phosphate and muriate of potash, respectively.

Two hand weedings first at 20th and second at 40th days after sowing were carried out to remove the weeds from the experimental plot, so as to reduce the competition for space, light and nutrients. The relative economics was computed considering the local price of input and output. Net returns were calculated as the difference between gross income and total cost. Benefit: cost ratio was worked out by dividing net returns with total cost of cultivation. All the data were subjected to analysis of variance (ANOVA) by using a split-plot design and main effects and interactions were tested for significance. Treatment means obtained by ANOVA were compared using critical difference (CD) at *P*=0.05 level of significance.

Results and Discussion

Yield attributes and yields

There was a remarkable influence of various tillage practices on the yield attributes and yield of sweet corn. The higher values of yield attributes *i.e.* number of cob/ plant, length of cob with and without sheath, girth of cob with and without sheath, weight/ cob with and without sheath, number of grain rows/cob, number grains/row, number of grains/cob and yield was recorded in tillage practice of one mouldboard ploughing + one pass of cultivator + one pass of rotavator (T_4) followed by one mouldboard ploughing+ one pass of rotavator (T_3).

Significant increase were noted in yield attributes and yield of sweet corn due to tillage practice of one mouldboard ploughing + one pass of cultivator + one pass of rotavator (T_4) over rest of the tillage practices, however tillage practices fail to produce significant effect on number of grains/row. Tillage practice T_4 recorded 7.77, 5.24 and 2.81 percent higher green cob yield with sheath and 10.20, 6.54 and 3.41 percent higher green fodder yield over tillage practices T_1, T_2 and T_3, respectively. The possible reason of high yield attributing characters may be traced due to the increased dry matter production might have resulted in greater synthesis of photosynthates contributing to an increase in yield attributes. The higher green cob yield with sheath and green fodder yield obtained from tillage practice T_4 may be due to significant increase in yield attributes. These results corroborated the findings of Alam *et al*. (2014) [1] and Salem *et al.* (2015) [8].

Nutrient sources had a remarkable influence on the yield attributes and yield of sweet corn. The maximum number of cobs/plant, length of cob with and without sheath, girth of cob with and without sheath, weight/cob with and without sheath, number of grain rows/cob, number grains/row, number of grains/cob and yield was recorded in the treatment of combined application of 75% RDN through chemical fertilizer + 25% RDN through vermicompost (S_3) followed by combination of inorganic fertilizer with FYM (S_2), poultry manure (S_4) and goat manure (S_5). Application of entire nutrients through inorganic sources (S_1) produced the lowest values of yield attributes and yield. Use of nutrient source S_3 registered 8.54, 6.89, 6.16 and 0.71 percent higher green cob yield with sheath and 6.86, 3.83, 2.04 and 0.90 percent higher green fodder yield over nutrient sources S_1, S_5, S_4 and S_2, respectively. The marked increase in various yields attributes and yield of sweet corn with combined application of chemical fertilizer and vermicompost can be ascribed not only to adequate supply of nutrients but in enhancing the activity of microorganisms in soils which further enhances solubility of nutrients and their consequent availability to plants. The beneficial effect of combined use of chemical fertilizer and organic manures over sole chemical fertilizer on yield attributes and yield might be attributed to the adequate and balanced supply of plant nutrients throughout the growth period of crops, improvement of soil environment resulting in higher root proliferation leading to better absorption of moisture and nutrient, plant vigor and superior growth and yield attributes and ultimately higher yield. After proper decomposition and mineralization, the manures supplied available nutrients directly to the plants and also had solubilizing effect on fixed forms of nutrients in soil. These results are also comparable with Rasool *et al.* (2015) [7].

Table 1: Effect of tillage practices and nutrient sources on yield attributes of sweet corn (mean of 2 years)

Treatment		Number of cobs/plant	Length of cob (cm)		Girth of cob (cm)		Average weight of cob (g)	
			With sheath	Without sheath	With sheath	Without sheath	With sheath	Without sheath
Main plant: Tillage practices								
T_1:	One pass of rotavator	1.00	20.82	18.05	17.66	14.14	324.22	236.55
T_2:	One pass of cultivator + one pass of rotavator	1.03	22.31	18.86	18.33	14.84	339.67	256.69
T_3:	One mouldboard ploughing + one pass of rotavator	1.07	22.92	19.62	18.80	15.31	349.79	261.07
T_4:	One mouldboard ploughing+ one pass of cultivator+ one pass of rotavator	1.11	24.52	20.47	19.18	15.65	354.97	271.48
SEm.±		0.011	0.36	0.29	0.20	0.12	3.44	3.02
CD (P= 0.05)		0.035	1.11	0.90	0.63	0.37	10.59	9.31
Sub plot: Nutrient sources								
S_1:	100% RDF through chemical fertilizers	1.00	20.75	17.49	17.29	14.04	324.53	233.73
S_2:	75% RDN through chemical fertilizer + 25% RDN through FYM	1.09	23.51	20.24	19.12	15.47	353.64	268.58
S_3:	75% RDN through chemical fertilizer + 25% RDN through VM	1.13	24.09	20.72	19.59	15.84	361.22	279.37
S_4:	75% RDN through chemical fertilizer + 25% RDN through PM	1.04	22.67	19.18	18.54	15.03	341.67	258.68
S_5:	75% RDN through chemical fertilizer + 25% RDN through GM	1.01	22.18	18.62	17.94	14.55	329.77	241.89
SEm.±		0.010	0.21	0.20	0.19	0.13	3.50	2.10
CD (P= 0.05)		0.028	0.58	0.55	0.52	0.36	9.88	5.94

Table 2: Effect of tillage practices and nutrient sources on yield attributes, yield, gross returns, net returns and B: C ration of sweet corn (mean of 2 years)

Treatment		Number of grain rows/cob	Number of grains/ row	Number of grains/ cob	Green cob yield with sheath (t/ha)	Green fodder yield (t/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B: C ratio
Main plant: Tillage practices									
T_1:	One pass of rotavator	14.85	35.92	533.47	20.96	24.28	329636	216517	1.94
T_2:	One pass of cultivator + one pass of rotavator	15.10	36.36	549.07	21.46	25.12	338312	223792	1.98
T_3:	One mouldboard ploughing + one pass of rotavator	15.25	37.17	567.04	21.97	25.88	346824	230603	2.01
T_4:	One mouldboard ploughing+ one pass of cultivator+ one pass of rotavator	15.55	37.21	578.82	22.58	26.76	356968	238648	2.04
SEm.±		0.05	0.44	6.34	0.20	0.24	2481	2481	0.022
CD (P= 0.05)		0.14	NS	19.54	0.63	0.74	7646	7646	NS
Sub plot: Nutrient sources									
S_1:	100% RDF through chemical fertilizers	14.85	35.41	525.55	20.90	24.51	329659	228207	2.25
S_2:	75% RDN through chemical fertilizer + 25% RDN through FYM	15.42	37.19	573.37	22.53	25.96	353883	215639	1.56
S_3:	75% RDN through chemical fertilizer + 25% RDN through VM	15.63	37.56	586.98	22.69	26.19	356518	233690	1.90
S_4:	75% RDN through chemical fertilizer + 25% RDN through PM	15.11	37.01	559.14	21.37	25.67	338849	231495	2.16
S_5:	75% RDN through chemical fertilizer + 25% RDN through GM	14.95	36.16	540.45	22.12	25.22	335766	227919	2.11
SEm.±		0.04	0.33	4.38	0.06	0.11	802	802	0.008
CD (P= 0.05)		0.12	0.93	12.38	0.16	0.30	2265	2265	0.022

Table 3: Interaction effect of the tillage practices and nutrient sources on number of cobs/plant, weight/cob without sheath and green cob yield with sheath

Treatment	Number of cobs/ plant				Weight/cob without sheath (g)				Green cob yield with sheath (t/ha)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
S_1	1.00	1.00	1.00	1.00	224.33	233.60	235.80	241.20	20.34	20.61	21.21	21.45
S_2	1.00	1.00	1.17	1.20	242.87	273.04	273.33	285.07	21.63	22.21	22.64	23.63
S3	1.00	1.13	1.17	1.20	250.00	277.08	289.00	301.40	21.70	22.32	23.01	23.72
S_4	1.00	1.00	1.03	1.13	237.27	260.27	265.20	271.97	20.59	21.12	21.51	22.26
S_5	1.00	1.00	1.00	1.03	228.30	239.47	242.03	257.77	20.53	21.04	21.47	21.87
Same tillage practice for different nutrient sources	SEm.± 0.020		CD (P= 0.05) 0.057		SEm.± 4.20		CD (P= 0.05) 11.87		SEm.± 0.11		CD (P= 0.05) 0.32	
Same nutrient source for different tillage practices	SEm.± 0.038		CD (P= 0.05) 0.107		SEm.± 9.00		CD (P= 0.05) 25.42		SEm.± 0.48		CD (P= 0.05) 1.17	

Table 4: Interaction effect of the tillage practices and nutrient sources on gross returns, net returns and B: C ratio of sweet corn

Treatment	Gross returns (Rs/ha)				Net returns (Rs/ha)				B: C ratio			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
S_1	320538	325112	334056	338930	221511	224685	231929	234703	2.24	2.24	2.27	2.25
S_2	338652	348421	356731	371729	202834	211202	217812	230711	1.49	1.54	1.57	1.64
S3	340063	350572	361513	373925	219660	228769	238009	248321	1.82	1.88	1.93	1.98
S_4	325286	334609	342019	353482	220357	228281	233990	243353	2.10	2.15	2.17	2.21
S_5	323643	332847	339799	346774	218222	226025	231277	236152	2.07	2.12	2.13	2.14
Same tillage practice for different nutrient sources	SEm.±		CD (P= 0.05)		SEm.±		CD (P= 0.05)		SEm.±		CD (P= 0.05)	
	1604		4530		1604		4530		0.016		0.044	
Same nutrient source for different tillage practices	SEm.±		CD (P= 0.05)		SEm.±		CD (P= 0.05)		SEm.±		CD (P= 0.05)	
	5994		16935		5994		16935		0.055		0.155	

Economic analysis

Significantly higher gross return and net return was recorded under tillage practice T_4 over rest of the tillage practices. Treatment T_4 achieved an additional gross return of Rs.10144, 18656 and 27332/ha and additional net returns of Rs. 8045, 14856 and 22131/ha than tillage practices T_3, T_2 and T_1, respectively. It is obvious because increased level of tillage had given higher yield which consequently resulted in higher gross and net returns. These findings are in close agreement with Mishra *et al*. (2014) [5].

Nutrient sources S_3 recorded significantly higher gross returns among different nutrient sources (Table 2). Nutrient source S_3 earned significantly higher gross return of Rs. 356518/ha, which was 8.15, 6.18, 5.21 and 0.74 percent higher than S_1, S_5, S_4 and S_2, respectively. This was due to higher yield obtained in this treatment which ultimately resulted in higher gross return. These findings are in accordance with Kalhapure *et al*. (2013) [2].

Application full dose of nutrients through chemical fertilizers recorded significantly higher benefit cost ratio than than rest of the nutrient sources. Chemical fertilizer content higher nutrients, therefore less quantity of chemical fertilizers were needed to fulfil the requirement of nutrients. This resulted in lower cost of cultivation and ultimately the higher benefit cost ratio. Similar, findings were also observed by Nath, *et al.* (2009) [6].

Interaction effect

The data revealed that interaction of tillage practice T_4 with nutrient sources S_3 recorded the significantly the highest number of cobs/plant, weight/cob without sheath and green cob yield with sheath. The significant enhancement in yield performance under interaction of tillage practice T_4 with nutrient sources S_3 was associated with better performance of yield attributes. These findings are in close conformity with the results of Memon *et al*. (2013) [4]. Results appended from Table 4 revealed that maximum gross and net returns were received under treatment combination T_4S_3, which was due to the higher green cob yield with sheath and fodder yield produced by the said treatment combination.

Conclusion

It could be concluded that under prevailing agro-climatic conditions of South Konkan Coastal Zone of Maharashtra sweet corn should be grown in soil prepared by one mouldboard ploughing + one pass of cultivator + one pass of rotavator with combined application of 75% RDN through chemical fertilizer + 25% RDN through vermicompost to obtain higher green cob yield with sheath, green fodder yield, gross returns and net returns.

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