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Effect of organic and inorganic fertilizers on growth parameters of sweet corn

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Abstract
The success of future agriculture depends upon sustainability of production systems. The integrated nutrients management sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of chemical inputs with adverse effects. By considering above facts a field experiment was carried out during the *kharif* season 2018-19, at departmental farm of Soil Science and Agricultural Chemistry, College of Agriculture, Latur. The experiment was laid out in RBD with 10 treatment combination along with three replications. Application of organic materials along with inorganic fertilizers in the soil leads to sustained productivity and fertility. Corn being an exhaustive crop, its requirement for fertilizers especially for nitrogen is very high. The results of field trial on response of sweet corn to application of chemical fertilizers along with organic manure and inoculation of liquid biofertilizers showed beneficial effect on growth parameters, nutrient uptake, yield and quality of sweet corn on low nitrogen and phosphorus content in inceptisol as compared to applied treatments content only chemical fertilizer. The growth parameter *viz.* root length and chlorophyll content significantly improved due to application of organic, inorganic fertilizers and biofertilizers found superior with treatments T_{10} -125% RDF + FYM @ 5t ha^{-1} + PSB followed T_7 -125% RDF + FYM @ 5t ha^{-1} + *Azospirillum* respectively.

Keywords: Organic, inorganic fertilizers, growth parameters, sweet corn

Introduction
Sweet corn (*Zea mays* L. *saccharata*), a diploid species with 2n = 20 chromosomes, is a member of the grass family (Grammineae), (Wolfe *et al*., 1997) [16]. It is the world's third leading cereal crop after wheat and rice. Corn has good nutritional values with 46% total sugars, 18% starch, 14.5% protein, moisture (72.7%), carbohydrate (81%), lipids (3.5%) and 17% oil (Johari and Kaushik 2016). It also contains good amount of energy 86 Kcal per 100g and minerals *viz*, phosphorus (P) 89 mg/100g, potassium (K) 270 mg/100g, calcium (Ca) 2 mg/100g, iron (Fe) 0.52 mg/100g, and magnesium (Mg) 37 mg/100g, and Vitamins A, B6, and C as major vitamins as well as thiamine, riboflavin, and niacin (USDA 2018) [3].

Application of organic materials along with inorganic fertilizers in the soil leads to sustained productivity and fertility. Corn being an exhaustive crop, its requirement for fertilizers especially for nitrogen is very high. Nitrogen is the key element in crop growth and it is the most limiting nutrient in Indian soils.

Application of organic manures plays a direct role in plant growth as a source of all the necessary major and minor nutrients in available forms during mineralization. The beneficial effect of FYM organic manure, in improving soil fertility and productivity is well documented and it also supplies plant growth promoting substances, humus forming microbes and N-fixers in the soil (Baran and Wisniewaki 1998) [6]. Nutrients contained in organic manures are released more slowly and are stored for longer periods in the soil, thereby ensuring a long residual effect.

Bio fertilizers play an important role in the increasing availability of nitrogen and phosphorus. Among several bioagent *Azospirillum* is known to fix atmospheric nitrogen and increased about 10-15 % grain yield in maize (Patil *et al.,* 2001) [10]. The availability of phosphorous are also low as compared to that of N & K. under such situation, the phosphate solubilizing micro organism (PSB) plays significant role in making the phosphorous available to plants by secretion of organic acids and enzyme phosphatase which solubilizes the insoluble phosphate and thereby it helps in increasing the crop production.

Now-a-days sweet corn is becoming popular and is being cultivated in maize growing areas of India. Sweet corn is gaining popularity both in rural and urban areas as well as tourist place because of its high sugar and low starch content. It has a great market potential and high market value in India.

Due to rising in demand, the sweet corn is able to increase the farm income. By considering above fact experiment will be studies on fertilization management of sweet corn is very meager hence, planned to study the management of organic and inorganic fertilizers on growth, nutrient uptake, yield and quality of sweet corn (*Zea mays. L., Saccharata)* in inceptisol soil.

Material and Methods

The experiment was conducted at SSAC Department Research Farm, College of Agriculture, Latur during *kharif* season 2018-2019. The topography of experimental field was uniform and leveled. The black soils of Latur district of Marathwada region were formed from the weathering of trap rock and rich in iron, lime and magnesia but they vary widely both in texture and depth (Gajbhiye *et al*. 1975) [8]. Soils of Latur district were classified by Challa *et al*., (1997) [7] as clayey, Smectite and isohyperthermic having very gently sloping with moderate erosion. The physiographic position of soil is north deccan upper plateau. These soils are dark grayish brown in color with adequate content of calcium carbonate.

In this investigation, the variety of sweet corn Madhubala was used for experiment with application of different levels organic (FYM) and inorganic (NPK) fertilizers along with recommendation. To know the effect of different levels of organic and inorganic fertilizers on growth, nutrient uptake, yield and quality of sweet corn (*Zea mays.* L., *saccharata*) in inceptisol. The application of organic manure (FYM) with recommended dose @ 5t ha^{-1} and liquid biofertilizers PSB as well as Azospirillum used as seed treatments @ 10 ml kg^{-1} of seeds. The uniform from (N-175 kg ha^{-1}) half dose of N was applied to each plot through urea at the time of sowing and full dose of P_2O_5 75 kg ha^{-1} and K_2O 75 kg ha^{-1} were applied through the single super phosphate and muriate of potash respectively, as a chemical fertilizers and the method of application of fertilizer was band placement.

Table 1: The seed treatments with liquid biofertilizers (ml / kg of seed) used during course of investigation.

Seed Inoculants (Liquid)	Application
Azospirillum	10 ml / kg of seed
PSB	10 ml / kg of seed

Table 2: Details of experimental treatments

Treatments	
T_1	Absolute control
T_2	75% RDF
T_3	100% RDF
T_4	125% RDF
T_5	75% RDF + FYM @5t/ha + Azospirillum
T_6	100% RDF + FYM @5t/ha + Azospirillum
T_7	125% RDF + FYM @5t/ha + Azospirillum
T_8	75% RDF + FYM @5t/ha + PSB
T_9	100% RDF + FYM @5t/ha + PSB
T_{10}	125% RDF + FYM @5t/ha + PSB

Organic Manure Application: The crop was manured prior to week before sowing according to treatment is given in Table 2. Enriched FYM procured from Department of SSAC, composting unit, college of agriculture latur. The well rotten farm yard manure prepared from cow dung and farm wastages were used for experiment.

Fertilizer Application: The crop was fertilized as per respective treatment is given in Table 1. The full dose of P and K, half dose of nitrogen in through urea were applied as a basal dose at the time of sowing and remaining half quantity of nitrogen was applied as a top dressing at knee height stage and silking stage.

Biofertilizer Application: The Azospirillum and phosphate solubilizer bacteria (PSB-16) procured from the biofertilizer Department, VNMKV, Parbhani were used @ 10 ml per kg of seeds used as seed inoculants of prior to sowing.

Sowing

The seeds of sweet corn variety Madhubala was dibbled manually in previously opened furrows at a distance of 60 cm between rows and 20 cm within the plant to plant. Two seeds per hill were sown at 3-4 cm depth. The furrows were slightly covered with soil.

Experimental findings

The effect of organic and inorganic fertilizer on growth parameters of sweet corn

1. Root length

The effect of organic, inorganic fertilizers and biofertilizers on root length was presented in Table 3 and depicted in (Fig 1). From the data it was observed general the rate of root length was rapidly increased from 45 DAS to 60 DAS and it was continued to slowly increase till 90 DAS of sweet corn. The application of FYM, chemical fertilizers and inoculation with liquid biofertilizers significantly influencing root length was recorded in range from 13.8 to 28.42 cm during various growth stages of sweet corn.

The data indicated that significantly increase in root length with the application of integrated nutrients were found in T_{10} - 125% RDF + FYM @ 5t ha^{-1} + PSB (17.8, 22.8, 26.3, 28.4 cm) followed by T_7 -125% RDF + FYM @ 5t ha^{-1} + *Azospirillum* (17.7, 22.7, 26.2, 28.3 cm) as compared to inorganic fertilizer was found in T_4 – 125% RDF (17.1, 22.08, 25.5, 27.7 cm) at 45, 60, 75, and 90 DAS respectively.

Further from the data, The combined application of organic, inorganic fertilizers and biofertilizers were found in T_9 -100% RDF + FYM @ 5t ha^{-1} + PSB (17.0, 22.1, 25.6, 27.6 cm) followed by T_6- 100% RDF + FYM @ 5t ha^{-1} + *Azospirillum* (16.9, 21.9, 25.4, 27.6 cm) shows that the higher root length as compared to chemical fertilizer was found in T_3 -100 % RDF (16.4, 20.7, 24.9, 27.1 cm) at 45, 60, 75 and 90 DAS of sweet corn respectively.

Table 3: Effect of organic, inorganic fertilizers and biofertilizers on root length (cm) at 45, 60, 75, and 90 DAS of sweet corn.

Treatments	45 DAS	60 DAS	75 DAS	90 DAS
T_1 - Absolute control	13.8	18.6	22.3	24.5
T_2 -75% RDF	15.7	20.7	24.2	26.3
T_3 -100% RDF	16.4	21.5	24.9	27.1
T_4 -125% RDF	17.1	22.08	25.5	27.7
T_5 -75% RDF + FYM @ 5 t/ha + Azospirillum	16.3	21.4	24.8	26.9
T_6 -100% RDF + FYM @ 5t/ha + Azospirillum	16.9	21.9	25.4	27.6

T_7 -125% RDF + FYM @ 5t/ha + Azospirillum	17.7	22.7	26.2	28.3
T_8 -75% RDF + FYM @ 5t/ha + PSB	16.4	21.4	25.01	27.01
T_9 -100% RDF + FYM @ 5t/ha + PSB	17.0	22.1	25.6	27.6
T_{10} -125% RDF + FYM @ 5t/ha + PSB	17.8	22.8	26.3	28.4
Mean	16.51	21.54	25.04	27.1
SEm±	0.69	0.76	0.71	0.68
CD @ 5%	2.05	2.26	2.12	2.04

Increasing in the rate of root length might be ascribed to application of organic manures plays a direct role in plant growth as a source of all the necessary major and minor nutrients in available forms during mineralization. The beneficial effect of FYM organic manure, in improving soil fertility and productivity in well documented and it also supplies plant growth promoting substances, humus forming microbes and N-fixers in the soil. Biofertilizers keep the soil environment rich in all kinds of micro- and macro-nutrients *via* nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth promoting substances, production of antibiotics and biodegradation of organic matter in the soil. Application of inorganic fertilizer helps in development of better environment in soil to produce effective root formation, proliferation and their functional activates and thus plant uptake more nutrients from the soil.

These results were conformity with findings of Rekha *et al.*, (2018) [14] observed that root length was highest in the treatments with *Azospirillum* + 75% RDF + FYM in pearl millet compared to treatments applied with chemical fertilizers alone and Sheikh *et al*., (2018) [15] revealed that after 45 days of growth it was found maximum in 10% VC + 100 gm NPK followed by 20% VC, 10% VC + 100 gm urea, 10% FYM + 100 gm NPK, 20% FYM, 10% FYM + 100 gm urea and minimum root length was observed in control similarly Meena *et al.,* (2013) [9] studied that the maximum root length of per plant was observed with 100% RDF + FYM + BF + Zn over 75% RDF + FYM + BF + Zn.

2 Chlorophyll content

The influence of various levels of organic, inorganic fertilizers and biofertilizers on chlorophyll content of sweet corn was tabulated in Table 4 (Fig 2). It was noticed that chlorophyll a, chlorophyll b, and total chlorophyll were found in range from 1.09 to 1.71, 0.53 to 0.93 and 1.63 to 2.64 mg g^{-1} at 45 DAS of sweet corn respectively.

Data clearly depicts that application of recommended dose of fertilizer in combination with other organic sources of nutrient recorded significantly higher chlorophyll content in T_7 -125% RDF + FYM @5t/ha + *Azospirillum* (1.81, 0.98, and 2.77 mg g^{-1}) followed by T_{10} -125% RDF + FYM @5t/ha + PSB (1.71, 0.93, and 2.64 mg g^{-1}) over the application of sole chemical fertilizer was found in T_4 – 125% RDF (1.60, 0.94, and 2.51 mg g^{-1}) at 45 DAS respectively.

Further data pertaining to the incorporation of organic sources together with inorganic nutrients application were found in T_6- 100% RDF + FYM @ 5t ha^{-1} + *Azospirillum* (1.40, 0.83, and 2.24 mg g^{-1}) followed by T_9 -100% RDF + FYM @ 5t ha^{-1} + PSB (1.38, 0.82, and 2.20 mg g^{-1}) shows that the significantly better chlorophyll content than rest of single application of inorganic fertilizer was found in T_3 -100 % RDF (1.33, 0.79, and 2.12 mg g^{-1}) at 45 DAS respectively.

The chlorophyll content was found to be statistically superior with application of N which was essential constituent of chlorophyll and helps in formation of chlorophyll content and other ways the impact of combined application of different levels of organic, inorganic fertilizer with biofertilizers inoculation which helps in increased availability of N to the plants showed that superiority in chlorophyll content.

Well decomposed FYM in addition to supplying plant nutrients acts as binding material and improves both the physical and biological properties of the soil. Bio fertilizers play an important role in the increasing availability of nitrogen and phosphorus. Among several bioagent *Azospirillum* is known to fix atmospheric nitrogen and PSB plays significant role in making the phosphorous available to plants by secretion of organic acids. From the chemical fertilizer the use of nitrate form of nitrogen sources were higher than N sources in the form of ammonium.

Chlorophyll assimilation is a biochemical process which directly related with N, P and K in soil. In absence of these elements plant may suffer yellowing of leaves and chlorosis phenomenon.

Table 4: The influence of various levels of organic and inorganic fertilizer and liquid biofertilizers on chlorophyll content (mg g^{-1}) at 45 DAS of sweet corn.

Treatments	Chlorophyll 'a'	Chlorophyll 'b'	Total chlorophyll 'a+b'
T_1 - Absolute control	1.09	0.53	1.63
T_2 -75% RDF	1.19	0.70	1.90
T_3 -100% RDF	1.33	0.79	2.12
T_4 -125% RDF	1.60	0.94	2.51
T_5 -75% RDF + FYM @5 t/ha + Azospirillum	1.23	0.74	1.97
T_6 -100% RDF + FYM @5t/ha + Azospirillum	1.40	0.83	2.24
T_7 -125% RDF + FYM @5t/ha + Azospirillum	1.81	0.98	2.77
T_8 -75% RDF + FYM @5t/ha + PSB	1.21	0.72	1.95
T_9 -100% RDF + FYM @5t/ha + PSB	1.38	0.82	2.20
T_{10} -125% RDF + FYM @5t/ha + PSB	1.71	0.93	2.64
Mean	1.39	0.80	2.19
SEm±	0.08	0.06	0.11
CD @ 5%	0.23	0.18	0.32

Similar results were found by Purbajanti *et al.,* (2016) [13] showed that chlorophyll content index of corn increased along with the increasing of nitrogen doses of 50-150 kg N per ha which is in the amount of 24-66% compared with no nitrogen. Priya *et al.,* (2014) [12] noticed that highest chlorophyll content at 45 and 60 DAS was obtained with application of 150%

NPK which was at par with 100% NPK+ FYM @ 10 t/ha. Pavithra *et al.*, (2018) [11] studied that higher chlorophyll content was observed with the application of 125% RDN followed by FeSO4 foliar spray @ 1% at critical growth stages and was comparable with higher dose of N application 125% RDN and lower dose of N application along with 100% RDN followed by $FeSO_4$ foliar spray @ 1% while lower content of chlorophyll at critical growth stages, was noted with lower level 100% RDN.

3 Physico-chemical properties of soil

The impact of various levels of organic and inorganic fertilizer and biofertilizers on physico-chemical properties *Via*, Soil pH, Electrical conductivity and Organic carbon of soil after harvest of sweet corn narrated in Table 5.

3.1 Soil pH

From a perusal of data it was observed that, there was non-significant effect on soil pH by application of different levels organic, inorganic fertilizer and biofertilizers. The pH influenced the crop growth as availability of nutrients is more in the range of 6.5 to 7.5.

From the given data it was noticed that the soil pH was lower in treatment T_7 -125% RDF + FYM @ 5t ha^{-1} + *Azospirillum* (7.77) followed by T_{10} -125% RDF + FYM @5t ha^{-1}+ PSB (7.78) as compared to application of chemical fertilizer alone in T_4 – 125% RDF (7.80) respectively.

According to data the effect of application of integrated nutrients were found minimum in T_9-100% RDF + FYM @ 5t ha-^{1} + PSB (7.83) than the application of single inorganic fertilizer was found in T_3 -100 % RDF (7.84).

The slightly decrease in soil pH with application of organic manure and bio-inoculants treatments may be ascribed to the secretion of organic acids by FYM, Azospirillum and PSB.

3.2 Electrical conductivity (dSm^{-1})

The EC of (0.30 dSm^{-1}) of experimental soil was suitable for growing of crop. The application of various levels of organic, chemical fertilizer and inoculation did not showed any significant effect on EC after harvest of crop. The maximum EC value recorded with treatment T_1-Absolute control (0.29 dSm^{-1}) and minimum T_7- 125% RDF + FYM @ 5 t ha-^{1} + Azospirillum (0.21 dSm-^{1}) followed by T_{10} -125% RDF + FYM @ 5t ha^{-1} + PSB (0.22) respectively.

Table 5: Influence of organic and inorganic fertilizers and biofertilizers on physic-chemical properties soil pH, EC, and organic carbon of sweet corn at harvest of sweet corn.

Treatments	Soil pH (1:2.5)	EC (dSm^{-1}) (1:2.5)	OC (%)
T_1 - Absolute control	7.96	0.29	0.50
T_2 -75% RDF	7.91	0.28	0.52
T_3 -100% RDF	7.84	0.25	0.54
T_4 -125% RDF	7.80	0.23	0.56
T_5 -75% RDF + FYM @5 t/ha + Azospirillum	7.89	0.27	0.53
T_6 -100% RDF + FYM @5t/ha + Azospirillum	7.84	0.23	0.57
T_7 -125% RDF + FYM @5t/ha + Azospirillum	7.77	0.21	0.62
T_8 -75% RDF + FYM @5t/ha + PSB	7.87	0.26	0.53
T_9 -100% RDF + FYM @5t/ha + PSB	7.83	0.24	0.58
T_{10} -125% RDF + FYM @5t/ha + PSB	7.78	0.22	0.61
Mean	7.85	0.25	0.55
SEm±	0.51	0.01	0.02
CD @ 5%	1.53	0.04	0.07

It might be due to leaching of salts to rains and utilization of nutrients by crop decrease in EC at post harvest soil. As minimum EC obtained in T_7 treatments hence the availability of nutrients found more which in turn helped in increasing crop yield.

3.3 Soil organic carbon (g kg^{-1})

Influence of organic and inorganic fertilizers and biofertilizers on soil organic carbon found in range of (0.50 to 0.62 g kg^{-1}). Application of higher dose of RDF with organic manure and biofertilizers, the slightly increased in organic carbon was found with treatment T_7- 125% RDF + FYM @ 5t ha^{-1} + Azospirillum (0.62 g kg-^{1}) followed by T_{10}- 125% RDF + FYM @ 5t ha-^{1}+ PSB (0.61 g kg-^{1}) over T_4 – 125% RDF (0.23) which was comprised only chemical fertilizer.

The organic carbon recorded higher might be due to application organic manure and seed treatment with *azospirillum* which secretion of organic acids and increased in the activity of microbes in the soil. Therefore the production of total biomass was higher in these treatments due to more amount of residue might have added in the soil in form of leaves fall and roots which will build up the organic matter level in soil.

Conclusion

The growth parameters like Root length and Chlorophyll a, Chlorophyll b and total chlorophyll were influenced by application of different levels of recommended dose of fertilizer in combination with other organic sources and biofertilizers of nutrients recorded significantly higher in growth parameters (root length) was found in treatment T_{10} followed by T_7 as compared to inorganic fertilizer was found in T_4 at different growth stages of crop respectively. And in chlorophyll was found in T_7 (1.81, 0.98, and 2.77 mg g^{-1}) followed by T_{10} over the application of sole chemical fertilizer was found in T_4 (1.60, 0.94, and 2.51 mg g^{-1}) at 45 DAS respectively.

Thus, from the present investigation it can be concluded that higher dose of chemical fertilizers (NPK) along with organic (FYM) and inoculation of liquid biofertilizers (*Azospirillum* and PSB) (125% RDF + FYM @ 5t ha^{-1} + *Azospirillum* or PSB) shows significantly increase in growth parameters, nutrient availability and uptake, yield and quality of sweet corn on low nitrogen and phosphorus content in inceptisol as compared to chemical fertilizer only. As application of FYM improves soil fertility and productivity while biofertilizers maintain suitable soil environment for crop production

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