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Influence of organics and inorganics on plant nutrient status and uptake in maize

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Abstract
A study was carried out in maize to find the biochar effect on plant nutrient status and plant uptake with seven treatments *viz.*, control (no fertilizers) (T_1), RDF (T_2), RDF+Azophos (T_3), 75% RDF+biochar @ 5 t ha^{-1} (T_4),75% RDF+biochar @ 5 t ha^{-1}+Azophos (T_5), 75% RDF+FYM @ 5 t ha^{-1} (T_6), 75% RDF+FYM @ 5 t ha^{-1}+ Azophos (T_7) in Randomised Block Design (RBD). The plants supplied with 100 % RDF showed highest nutrient status and is at par with the treatments supplied with biochar. Plant uptake of NPK was observed maximum in the treatments supplied with RDF and was at par with treatments supplied with biochar and FYM. Iron and zinc contents in sweet corn at knee high, tasseling, in grain and stover at harvest were not significantly influenced by the treatments, whereas uptake of micronutrients was significantly influenced by imposed treatments.

Keywords: biochar, FYM, RDF, azophos

Introduction
Soil health management and pollution is major aspect for all agricultural scientists, as modern agriculture in the name of yield maximization either directly or indirectly contributing greenhouse gases and other pollutants to the atmosphere. Carbon sequestration is very important to minimize the load of oxides of carbon in atmosphere, either through increase in vegetation or by minimizing the CO_2 conversion of terrestrial carbon, particularly from agricultural fields. Burning of farm wastes has become a common phenomenon, despite the awareness of their value as fodder or an important carbon source to the soil, mainly due to lack of disposal mechanism and high labour requirement. Under these circumstances use of machines to chop and incorporate them in soils is the right way. However mechanization to such an extent is yet to be ventured in India. The only other way is making bio char with farm wastes and using the same as source of organic carbon in soil. Bio char is a fine grained, carbon rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperature (~ 350^0C – 600^0C) in an environment with little or no oxygen. Bio char shows depletion of nitrogen and sulphur as they volatalize at 200 ^{0}C and 375 ^{0}C, respectively. Whereas, K and P retained in the bio char as they volatalize between 700 ^{0}C and 800 ^{0}C. Several studies emphasized the positive role of bio char in improving soil physical, physico chemical, biological properties and fertilizer use efficiency.

Materials and Methods
A field study entitled "Influence of biochar on soil properties and maize yield" was conducted during *kharif*, 2014 at Agricultural College Farm, Bapatla using inorganic fertilizers, bio char, FYM and Azophos. The material used and the methods followed during the course of the study are described below.

Collection and preparation of plant samples
The plant samples collected at knee high, tasseling and harvest were washed with dilute HCl and then with distilled water. The samples were shade dried initially and then oven dried at 60 ^{0}C temperature and powdered in willey mill.

Plant analysis
A. Nitrogen
The nitrogen content in sweet corn plants was estimated by micro Kjeldahl distillation method (Piper, 1966) [10].

B. Preparation of acid extract by wet digestion

One gram of powdered plant sample was taken in 150 mL Erlenmeyer flask and digested with diacid mixture (HNO_3 and $HClO_4$ in 9: 4 ratio). The sample digest was filtered through Whatman No. 42 filter paper by washing the residue with double glass distilled water till chloride free and made up to 100 mL volume and the clear extract was used for the determination of P, K, Fe, Zn, Cu and Mn.

C. Phosphorus

Phosphorus in the diacid extract of plant samples was estimated by vanado molybdo phosphoric yellow colour method using spectrophotometer at 420 nm wave length as described by Jackson (1973) [4].

D. Potassium

Potassium in the diacid extract of plant samples was determined using flame photometer as per the method described by Jackson (1973) [4].

E. Micronutrients

Zinc, copper, manganese, and iron in the diacid extract were determined using atomic absorption spectrophotometer as per the specifications mentioned by Lindsay and Norvell (1978) [7].

Nutrient uptak

The uptake of nutrients at harvest was worked out by using the following formulae. Macronutrients uptake was expressed as kg ha^{-1} and micronutrient uptake was expressed in g ha^{-1}.

$$\text{Macronutrient Uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%)} \times \text{Dry matter yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Micronutrient Uptake (g ha}^{-1}\text{)} = \frac{\text{rient concentration (\%)} \times \text{Dry matter yield (g ha}^{-1}\text{)}}{100}$$

Results and Discussions

1. Plant nutrient status

Macro nutrients

A. Nitrogen: At all the stages of the crop growth nitrogen content among all the treatments received RDF with and without Azophos, organics (bio char/ FYM) with and without Azophos were at par with each other and were significantly superior to control. The nitrogen content was higher at harvest (grain and stover) compared to tasseling and knee high stages in all the treatments. The highest nitrogen content was recorded in RDF + Azophos (T_3) at knee high (2.52 %), tasseling (2.56%), stover (1.15%) and in grain (1.82%) which was comparable with all the treatments except control (T_1). The lowest nitrogen content at knee high, tasseling, in seed and stover were 1.64, 1.73, 1.21 and 0.75 observed in control. No nitrogen application in control resulted in the lowest plant nitrogen at all stages indicating the short supply of N. The integrated application of FYM/ biochar and inorganic nitrogen resulted in higher nutrient contents at all stages of crop growth. This might be due to the increase in the fertilizer use efficiency by the addition of organics. Nitrogen content in the maize grown in soils supplied with biochar along with mineral nitrogen was at par with treatments supplied with FYM + mineral nitrogen and mineral nitrogen alone (Widowati *et al*., 2012) [12].

A. Phosphorus: Phosphorus content in the plants supplied with inorganics and combination of organics and inorganics were at par with each other and superior to control. The highest phosphorus content (0.59, 0.72, 0.66 and 0.44%, respectively at knee high, tasseling, in grain and stover) were recorded in the treatment supplied with lone inorganics. Higher contents of phosphorus were accumulated in grain than in stover in all the treatments. The lowest phosphorus content of 0.38, 0.54, 0.43 and 0.26 per cent, respectively at knee high, tasseling, in grain and stover were recorded in T_1 (control). Addition of organics and bio fertilizer might have prevented the fixation of phosphorus in soil and ensure steady supply throughout the growth period that helped in better root growth, higher availability of P to plants. This was in close conformity with the findings of Chatterjee and Bandyopadhyay (2014) [3].

C. Potassium: Imposed treatments showed significant influence on the plant potassium content. Higher contents of potassium were observed in stover than grain in all the treatments. At knee high stage plant potassium content ranged from 1.00 per cent (control) to 1.81 per cent (RDF + Azophos). Treatments from T_2 to T_7 (RDF, RDF + Azophos, 75% RDF + biochar @ 5 t ha^{-1}, 75% RDF + biochar @ 5 t ha^{-1} + Azophos, 75% RDF + FYM @ 5 t ha^{-1} and 75% RDF + FYM @ 5 t ha^{-1} + Azophos) were at par with one another and significantly superior to control. At tasseling stage highest (2.42%) potassium content was observed in RDF, RDF + Azophos treatments which was significantly superior to rest of the treatments. Treatments received biochar/ FYM with and without Azophos were at par with each other and significantly superior to control. Lowest plant potassium content was noticed in control (1.56%). At harvest, in grain highest potassium content was observed in RDF, RDF + Azophos (0.65%) which was at par with the treatments received bio char with Azophos and FYM with Azophos, while it was significantly superior to rest of the treatments. In stover the highest (1.20%) potassium content was noticed in the treatments supplied with RDF, RDF + Azophos which were at par with 75% RDF + biochar @ 5 tha^{-1}, 75% RDF + FYM @ 5 t ha^{-1} and significantly superior to rest of the treatments. Treatments supplied with 75% RDF + biochar @ 5 t ha^{-1} + Azophos and 75% RDF + FYM @ 5 t ha^{-1} + Azophos were at par with each other and significantly superior to control. The lowest potassium content in seed and stover at harvest were observed as 0.40 and 0.54, respectively. Increase in the potassium content in plant among all the treatments was due to the application of potassium through fertilizer. Organics improved the potassium availability and decreased the losses.

Micro nutrients

A. Iron: At knee high and tasseling the values ranged from 51.17 to 68.5 and 63.28 to 82.12 ppm, respectively with the lowest and highest recorded by T_4 (75% RDF + bio char @ 5 t ha^{-1}) and T_7 (75% RDF + FYM @ 5 t ha^{-1} + Azophos), respectively. In grain and stover at harvest the lowest values (43.54 and 60.77 µg g^{-1}, respectively) were recorded in T_4 whereas the highest values 53.82 and 78.44 ppm, respectively were recorded in T_7. Less iron content was reported in grain than in stover. FYM treatments resulted in more iron content than remaining treatments which might be due to the supply of more iron through added manures. Lowest was recorded in the treatments supplied with biochar which was because of disability of bio char to supply iron to maize plants due to iron immobilization.

Table 1: Influence of biochar on N, P, K (%) contents of sweet corn

Treatments	Nitrogen				Phosphorus				Potassium			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Seed	Stover			Seed	Stover			Seed	Stover
T_1	1.64	1.73	1.21	0.75	0.38	0.54	0.43	0.26	1.00	1.56	0.40	0.54
T_2	2.43	2.52	1.77	1.12	0.59	0.71	0.65	0.44	1.79	2.42	0.65	1.20
T_3	2.52	2.56	1.82	1.15	0.58	0.72	0.66	0.44	1.81	2.42	0.65	1.20
T_4	2.15	2.17	1.52	0.96	0.51	0.66	0.56	0.37	1.69	2.06	0.52	1.09
T_5	2.21	2.24	1.57	0.98	0.52	0.68	0.60	0.38	1.67	1.99	0.57	0.95
T_6	2.24	2.30	1.53	1.03	0.50	0.66	0.56	0.37	1.71	1.89	0.52	1.08
T_7	2.29	2.37	1.59	1.05	0.51	0.67	0.59	0.39	1.69	2.06	0.54	0.98
SEm±	0.15	0.13	0.10	0.06	0.04	0.04	0.04	0.03	0.09	0.10	0.04	0.06
CD @ 0.05	0.45	0.41	0.30	0.20	0.11	0.11	0.11	0.10	0.28	0.30	0.11	0.19
CV (%)	11.48	10.20	10.58	10.96	12.41	10.15	10.83	15.34	4.71	8.42	11.7	10.9

T_1 – Control T_4 - 75% RDF + bio char @ 5 t ha^{-1} T_6 - 75% RDF + FYM @ 5 t ha^{-1}

T_2 – RDF T_5 - 75% RDF + bio char @ 5 t ha^{-1} + Azophos T_7 - 75% RDF + FYM @ 5 t ha^{-1} + Azophos

T_3 - RDF + Azophos

B. Zinc: The highest (51.07 and 65.03 ppm) zinc content at knee high and tasseling, respectively was reported in T_7 (75% RDF + FYM @ 5 t ha^{-1} + Azophos) while the lowest (41.32 and 46.00 ppm) in T_4 (75% RDF + biochar @ 5 t $ha^{-1)}$. The highest values of 38.3 and 61.00 ppm in grain and stover, respectively were recorded in treatment which received 75 % RDF + FYM @ 5 t ha^{-1} + Azophos (T_7). The lowest zinc contents of 33.55 and 44.33 ppm, respectively in grain and stover were recorded by the treatment T_4. FYM treatments resulted in more plant zinc content than remaining treatments as FYM undergone decomposition and through mineralisation process it supplied zinc to maize plants. Lowest was recorded in the treatments supplied with bio char which might be because of disability of bio char to supply zinc to maize plants due to its immobilization.

C. Copper: Significant influence on copper content was observed with the imposed treatments. The highest (8.2 and 12.47 ppm) content at knee high and tasseling, respectively was reported in the treatments supplied with FYM while the lowest (5.1 and 7.57 ppm) in biochar treated plots. The highest values of 6.60 and 8.07 ppm in grain and stover, respectively were recorded in T_7. The lowest contents of 4.09 and 6.43 ppm, respectively in grain and stover were recorded by the treatment T_4. Bio char treatments resulted in significantly lower copper contents than remaining treatments at all stages of the crop growth. The results were confirmed with Namgay et al., 2010. Significant reduction in Cu content as a result of bio char application might be due to sorption of copper strongly by bio char led to the formation of stable bio char – trace element complexes in soil was main reason for unavailability of copper to plants.

D. Manganese: Significant influence on manganese content was observed with the imposed treatments. At knee high stage highest (80.67 ppm) manganese content of sweet corn, was observed in T_4 (75% RDF +biochar @ 5 t ha^{-1}) which was significantly superior to control and RDF + Azophos, and at par with rest of the treatments, while the lowet (63.33 ppm) was in control. The discernible ranges at the tasseling stage were 79.00 ppm (control) to 97.33 ppm (T_5 i.e., 75% RDF +biochar @ 5 t ha^{-1} + Azophos). The highest manganese content was observed in T_5 which was significantly superior to the control and RDF treatments with and without Azophos, while it was at par with the remaining treatments. Highest (32.22 ppm) manganese content in seed at harvesting stage was observed in T_4 (75% RDF +bio char @ 5 t ha^{-1}) which was significantly higher when compared to treatments received RDF with and without Azophos inoculation and control treatment. Manganese content in T_4 treatment was at par with rest of the treatments, whereas lowest (22.22 ppm) was recorded in control treatment. In stover the highest (89.00 ppm) manganese content was noticed in treatment supplied with 75% RDF +biochar @ 5 t ha^{-1} + Azophos which was numerically higher when compared to RDF treated plots and control, it was at par with remaining treatments. The lowest was noticed (76.33 ppm) in control.

The increase in micronutrient content of sweet corn in organic treatments could be due to their direct supply by manures after mineralization or solubilisation of insoluble forms and chelation of the cationic micronutrients by the decomposition products. The results of the present study revealed that more organically treated plots recorded higher contents of micronutrients as it influenced the microbial activity (Bacteria, fungi) that in turn enhanced rate of decomposition of organic matter and solubility of nutrients (Wu *et al.,* 2005).

2. Nutrient uptake

Macro nutrients

A. Nitrogen: Treatments supplied with RDF were significantly superior to other treatments, whereas biochar and FYM imposed treatments were on par with each other and were significantly superior to control. The highest nitrogen uptake at knee high and tasseling stages was recorded in treatment supplied with RDF + Azophos, which was on par with T_2 (RDF) and T_7 (75% RDF + FYM @ 5 t ha^{-1}+ Azophos) and significantly superior to rest of the treatments. The lowest at knee high, tasseling, respectively was observed in control. In grain and stover the highest values (47.90 and 53.55, respectively) were recorded in the soils supplied with RDF + Azophos, lowest values (25.7 and 26.85, respectively) in control. In grain the nitrogen uptake in the treatment supplied with RDF + Azophos was significantly superior to FYM/ biochar without Azophos inoculation and control, while it was at par with remaining treatments. The inorganic nitrogen not only provides an immediate source of nitrogen for plant growth but also enhances the mineralization of applied as well as native organic matter meeting the nitrogen requirement of the decomposers. Higher nitrogen uptake of plants grown in biochar, FYM amended soils might be due to the controlled supply of nitrogen throughout the growing season. Higher nitrogen uptake of plants grown in biochar amended soils indicates the potential of biochar to improve fertilizer use efficiency (Chan *et al*., 2008).

Table 2: Influence of biochar on contents of zinc and iron (ppm) of sweet corn

Treatments	Zinc (ppm)				Iron (ppm)			
	Knee high	Tasseling	harvest		Knee high	Tasseling	Harvest	
			Seed	Stover			Seed	stover
T_1 - Control	43.33	54.63	35.05	51.67	59.39	68.47	46.28	64.54
T_2 - RDF	46.67	60.67	36.00	53.67	63.79	73.42	49.15	68.44
T_3 - RDF + Azophos	47.72	62.06	36.25	54.72	65.40	75.90	51.79	69.69
T_4 - 75% RDF + biochar @ 5 t ha^{-1}	41.32	46.00	33.55	44.33	51.17	63.28	43.54	60.77
T_5 - 75% RDF + biochar @ 5 t ha^{-1} + Azophos	42.33	51.00	33.67	46.21	54.22	64.44	44.11	62.61
T_6 - 75% RDF + FYM @ 5 t ha^{-1}	49.67	64.67	37.11	60.37	67.43	81.88	53.59	77.61
T_7 - 75% RDF + FYM @ 5 t ha^{-1} + Azophos	51.07	65.03	38.30	61.00	68.50	82.12	53.82	78.44
SEm±	3.07	4.37	1.43	3.23	3.21	4.98	2.72	4.80
CD @ 0.05%	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	11.54	13.11	6.96	10.53	9.07	11.87	9.66	12.06

Table 3: Influence of biochar on contents of manganese and copper (ppm) of sweet corn

Treatments	Manganese (ppm)				Copper (ppm)			
	Knee high	Tasseling	harvest		Knee high	Tasseling	Harvest	
			Seed	Stover			Seed	Stover
T_1 - Control	63.33	79.00	22.22	76.33	6.80	10.07	5.41	7.33
T_2 - RDF	67.33	83.67	23.60	77.67	7.67	11.00	5.50	7.43
T_3 - RDF + Azophos	66.67	83.33	24.29	76.67	7.20	11.50	5.79	7.53
T_4 - 75% RDF + biochar @ 5 t ha^{-1}	80.67	96.00	32.22	86.67	5.10	7.57	4.09	6.43
T_5 - 75% RDF + biochar @ 5 t ha^{-1} + Azophos	80.00	97.33	28.61	89.00	5.20	7.57	4.10	6.49
T_6 - 75% RDF + FYM @ 5 t ha^{-1}	76.67	86.07	27.00	82.33	8.20	12.33	6.48	7.93
T_7 - 75% RDF + FYM @ 5 t ha^{-1} + Azophos	76.17	85.77	27.06	83.21	8.17	12.47	6.60	8.07
SEm±	4.53	4.00	1.75	3.09	0.49	0.79	0.42	0.27
CD @ 0.05%	13.97	12.34	5.39	9.53	1.50	2.44	1.30	0.83
CV (%)	10.70	7.95	11.49	6.60	12.29	13.29	13.56	6.40

B. Phosphorus: At knee high and tasseling the uptake varied from 4.63 to 9.73 and 11.10 to 21.17 kg ha^{-1}, respectively. The highest P uptake was recorded by the treatment which received RDF and significantly superior to remaining treatments at knee high stage. At tasseling stage the highest uptake (21.17 kg ha^{-1}) of phosphorus was noticed in treatment supplied RDF which was superior to control and at par with remaining treatments. The phosphorus uptake at harvest by grain and stover were significantly higher (17.29 and 20.71 kg ha^{-1}, respectively) in the pots supplied with sole inorganics. Inspite of lower phosphorus content in plant, sole inorganic treatment recorded higher phosphorus uptake due to high biomass production. Application of organics have improved the soil environment, which encouraged the proliferous root system resulting in better absorption of nutrients from lower layers and thus resulting in higher yield and nutrient uptake. Lehman *et al*., 2003 reported that the higher phosphorus uptake on bio char addition attributed to high P content in maize stalk bio char. Increase in the uptake of P by plants in the soils supplied with bio char and AMF inoculation was observed (Mau and Utami, 2014) [8].

C. Potassium: The potassium uptake in plants was significantly influenced by the treatments imposed. The highest potassium uptake at knee high (30.40 kg ha^{-1}), tasseling (64.71 kg ha^{-1}), in grain (15.66 kg ha^{-1}) and stover (52.75 kg ha^{-1}) at harvest was recorded in treatment received RDF + Azophos (T_3), which was on par with remaining all treatments and significantly superior over control. The lowest potassium uptake values (13.07, 31.98, 8.29 and 19.34 kg ha^{-1} at knee high, tasseling, grain and stover, respectively) were observed in control. Higher uptake of K under integrated management might be due to release of K from organic manures during decomposition and increase of native K availability. Higher cation exchange capacity of the biochar reduced losses of potassium and thus increased the potassium uptake. The results were in confirmation with Lehman *et al*., 2011 [6].

Table 4: Influence of biochar on uptake of N, P, K (kg ha^{-1}) by sweet corn

Treatments	Nitrogen				Phosphorus				Potassium			
	Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest		Knee high	Tasseling	Harvest	
			Seed	Stover			Seed	Stover			Seed	Stover
T_1	21.46	35.48	25.70	26.85	4.63	11.10	9.02	9.23	13.07	31.98	8.29	19.34
T_2	40.37	74.76	45.92	51.01	9.73	21.17	16.99	20.71	29.77	62.69	15.62	51.69
T_3	42.43	75.69	47.90	53.55	9.73	21.02	17.29	20.68	30.40	64.71	15.66	52.75
T_4	33.15	54.53	37.50	41.36	7.87	16.66	13.92	15.23	25.92	51.73	12.73	47.17
T_5	34.22	57.49	38.90	41.74	7.99	17.36	14.80	15.85	25.86	50.85	12.94	40.13
T_6	33.78	57.45	37.38	42.89	7.30	16.67	13.54	15.50	25.97	47.75	12.49	46.06
T_7	34.93	60.61	39.24	44.20	7.79	17.08	14.41	16.84	25.89	52.73	13.18	42.24
SEm±	2.49	4.98	2.60	3.86	0.42	1.8	0.78	0.68	2.02	4.75	0.95	3.16
CD @ 0.05	7.68	15.33	8.00	11.88	1.29	5.55	2.41	5.17	6.22	14.63	2.93	9.74
CV (%)	12.57	14.50	11.56	15.50	9.24	19.00	9.51	17.85	13.84	15.89	12.68	12.8

T_1 – Control T_4 - 75% RDF + biochar @ 5 t ha^{-1} T_6 - 75% RDF + FYM @ 5 t ha^{-1}
T_2 – RDF T_5 - 75% RDF + biochar @ 5 t ha^{-1} + Azophos T_7 - 75% RDF + FYM @ 5 t ha^{-1} + Azophos
T_3 - RDF + Azophos

Micro nutrients

A. Iron: All the treatments supplied with 100% RDF were significantly superior and on par with the treatments supplied with FYM and were significantly superior over control and soils supplied with bio char at all the stages of the crop growth**.** At knee high and tasseling the highest values (111.15 and 224.34 g ha^{-1}, respectively) were noticed in T_3 and the lowest (79.33 and 140.53 g ha^{-1}) was in control. The iron uptake at harvest by grain and stover were significantly higher (133.81 and 322.92 g ha^{-1}, respectively) in T_3 and lowest (96.72 and 228.2 g $ha^{-1,}$ respectively) was in control. Highest uptake in the soils treated with RDF might be due to the higher biomass content.

B. Zinc: All the treatments supplied with 100% RDF were on par with the treatments supplied with FYM/ bio char and were significantly superior over control and soils supplied with bio char at all the stages of the crop growth. At knee high and tasseling stages of the crop growth the highest values (80.28 and 183.65 g ha^{-1}, respectively) were noticed in T_3 and the lowest was in control (57.35 and 112.31 g ha^{-1}, respectively). The zinc uptake at harvest by grain 93.62 g ha^{-1} in T_3, by stover 259.29 g ha^{-1} in T_7 were significantly higher, whereas lowest (73.25 and 187.29 g ha^{-1}, respectively) was observed in control. The highest zinc uptake by plants which received 100% RDF might be because of higher dry matter content.

C. Copper: Uptake of Cu increased from knee high to harvesting stage of the crop growth. Uptake at knee high and tasseling, the highest (12.72 and 34.07 g ha^{-1}, respectively) uptake was observed in the treatments supplied with 100% RDF and the lowest (7.85 and 19.13 g ha^{-1}) was recorded in the treatments supplied with bio char. At harvest, the treatment supplied with 75 % RDF + FYM @ 5 t ha^{-1} + Azophos (T_7) recorded the highest copper uptake of 16.12 g ha^{-1} and the lowest 9.96 g ha^{-1} in T_5 in grain. In stover, the highest copper uptake of 35 g ha^{-1} was recorded in T_3 and lowest (26.27 g ha^{-1}) was in control. Lowest uptake of Cu in bio char treatments was due to the low Cu content in shoots whereas highest Cu uptake by plants in inorganic treatments was due to the highest dry matter production.

D. Manganese: Manganese uptake was higher at harvest as compared to knee high and tasseling stages of the crop growth. The highest uptakes (124.37 and 248.42 g ha^{-1}), respectively, at knee high and tasseling was observed in the treatments supplied with 75% RDF + bio char @ 5 t ha^{-1} + Azophos and the lowest value of 83.73 and 162.74 g ha^{-1} was recorded in control (T_1). At harvest, the treatment supplied with bio char recorded the highest manganese uptake of 79.69 (T_4) and 381.56 g ha^{-1} (T_5) in grain and stover, respectively. The treatments T_2 to T_7 were statistically on par with one another and significantly superior over control (T_1). The significantly higher uptake of Mn in bio char treatments was due to the more manganese content in the plant as bio char supplied high available manganese. In general the uptake of all the micronutrients was increased considerably with fertilizer application that shows the importance of fertilizer in influencing the plants ability in absorption and translocation of nutrients. The increase in the uptake of cationic micronutrients with application of FYM along with inorganic nitrogen might be due to release of micronutrients on mineralization or production of organic acids during their decomposition which aids in solubilisation of insoluble micronutrient compounds in soil due to supply of natural chelating agents which makes it more available (Barik *et al.*, 2006 and Kumar *et al.*, 2009) [1, 5]. On the whole, the critical study of the data related to nutrient contents and uptake revealed favourable effect of organics on concentration and uptake of nutrients which might have resulted in augmented protein content of the grains, thus improving the overall quality of the grain and stover.

Table 5: Influence of biochar on iron and zinc uptake (g ha^{-1}) by sweet corn

Treatments	Iron (g ha-1)				Zinc (g ha-1)			
	Knee high	Tasseling	harvest		Knee high	Tasseling	Harvest	
			Seed	Stover			Seed	Stover
T_1 - Control	79.33	140.53	96.72	228.20	57.35	112.31	73.25	187.29
T_2 - RDF	106.77	220.10	126.59	311.73	77.86	178.40	92.78	247.73
T_3 - RDF + Azophos	111.15	224.34	133.81	322.92	80.28	183.65	93.62	254.01
T_4 - 75% RDF + biochar @ 5 t ha^{-1}	78.83	162.87	106.91	249.07	63.64	115.29	81.86	185.71
T_5 - 75% RDF + biochar @ 5 t ha^{-1} + Azophos	84.15	165.03	107.64	262.24	65.83	127.69	81.96	199.77
T_6 - 75% RDF + FYM @ 5 t ha^{-1}	103.53	204.06	129.13	323.01	75.11	162.38	91.17	253.32
T_7 - 75% RDF + FYM @ 5 t ha^{-1} + Azophos	104.75	209.93	131.65	331.71	78.24	165.25	93.20	259.29
SEm±	7.77	18.51	8.58	25.35	6.16	8.14	5.67	16.01
CD @ 0.05%	23.93	57.02	26.44	78.10	18.98	25.07	17.47	49.33
CV (%)	14.13	16.91	12.50	15.15	14.99	9.44	11.34	12.23

Table 6: Influence of biochar on copper and manganese uptake (g ha^{-1}) by sweet corn

Treatments	Copper (g ha-1)				Manganese (g ha-1)			
	Knee high	Tasseling	harvest		Knee high	Tasseling	Harvest	
			Seed	Stover			Seed	Stover
T_1 - Control	8.94	20.72	11.36	26.27	83.73	162.74	46.49	271.25
T_2 - RDF	12.72	32.37	14.09	34.31	111.84	246.27	60.85	356.96
T_3 - RDF + Azophos	12.11	34.07	14.89	35.00	113.00	246.55	62.72	356.70
T_4 - 75% RDF + biochar @ 5 t ha^{-1}	7.85	19.26	9.99	27.23	123.99	242.21	79.69	368.93
T_5 - 75% RDF + biochar @ 5 t ha^{-1} + Azophos	8.09	19.13	9.96	27.52	124.37	248.42	70.14	381.56
T_6 - 75% RDF + FYM @ 5 t ha^{-1}	12.35	30.80	15.63	33.22	120.01	217.76	64.62	342.11
T_7 - 75% RDF + FYM @ 5 t ha^{-1} + Azophos	12.46	32.05	16.12	34.26	116.14	219.28	65.70	352.85
SEm±	0.76	2.50	1.34	1.52	8.14	17.78	6.04	19.40
CD @ 0.05%	2.34	7.71	4.13	4.69	25.09	54.78	18.59	59.76
CV (%)	12.38	16.10	17.64	8.48	12.45	13.62	16.25	9.68

Conclusions

In a field experiment, it was revealed that the N, P, K concentrations in plant among the imposed treatments was at par and significantly superior to that of control. Fe and Zn concentrations in plant were not influenced by imposed treatments. Significant reduction in the Cu concentrations and increase Mn concentrations were noticed in biochar treated plots. The uptakes of N, P, K, Fe, Zn and Cu by sweet corn crop at all the stages were significantly influenced by the imposed treatments and was higher in the treatments supplied with 100% RDF which was superior to control. Mn uptake was significantly superior in T_5 (75% RDF + bio char @ 5 t ha^{-1}) and lowest in control.

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