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# Nutrient status of soils influenced by the interaction of Biochar and FYM with chemical Fertiizers

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**Abstract**
The field study was conducted in Agricultural college farm, Bapatla, Andhra Pradesh to study the influence of biochar on soil properties and yield of maize (sugar cane-var. sugar 75) during *kharif* season of 2014-15 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). Integrated application of organics and inorganics showed numerically proximate values with the treatments supplied with RDF in N, P, K contents. Availability of Ca, Mg and Mn was maximum in treatments incorporated with biochar and were found significantly superior to rest of the treatments. Iron, zinc and copper contents not differed significantly by imposed treatments, however numerically slight decrease was observed in Fe and Zn contents of biochar treatments.

**Keywords:** Biochar, FYM, RDF, Azophos

## Introduction
There are many soil amendment technologies to improve soil properties such as chemical fertilizers, organic fertilizers and lime. The potential of biochar as a soil amendment in agricultural fields is a recently recognized and yet it is underutilized technology. Biochar 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 $^{0}$C – 600 $^{0}$C) in an environment with little or no oxygen. Biochar can be produced from different plant materials. In this study maize stalk was used for biochar preparation. FYM is one of the oldest manure used by the farmers because of its easy availability and presence of all the essential nutrients in easily mineralizable form. The present study was aimed to address the potential of biochar for improving fertility.

## Materials and Methods
A field study entitled "Influence of biochar on soil properties and maize yield" was conducted during *kharif*, 2014 in Agricultural college farm, Bapatla, Andhra Pradesh Agricultural using inorganic fertilizers, biochar, FYM and Azophos. The experimental soil was clay loam in texture, slightly alkaline reaction, low in organic carbon, low in available nitrogen (179 kg ha$^{-1}$), medium in available phosphorus (25.71 kg ha$^{-1}$) and high in available potassium (850 kg ha$^{-1}$), Ca (26.50 cmol (p$^{+}$) kg$^{-1}$), Mg (2.30 cmol (p$^{+}$) kg$^{-1}$). All the micronutrients were sufficient in the soil with values above their critical limits. Biochar, FYM and Azophos were applied to the field according to the treatments one week before sowing. Inorganic fertilizers were applied at different levels as per the treatments (RDF: 120-50-60 NPK kg ha$^{-1}$). Soil samples were collected in each treatment at different stages of the crop growth and analysed for N, P, K, Ca, Mg and micronutrient contents. Available nitrogen content in the soils was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956) [14], available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ of pH 8.5 and the phosphorus in the extract was estimated colorimetrically by ascorbic acid method using spectrophotometer at 660 nm (Watanabe and Olsen, 1954). Available potassium in soil was extracted using neutral normal ammonium acetate and potassium in the extract was determined flame photometrically (Muhr *et al 002E* 1965) [9]. Exchangeable calcium and magnesium were extracted with neutral normal ammonium acetate and the content was determined by versanate titration method (Jackson, 1973) [4] and available micronutrients by DTPA extract, using atomic absorption spectrophotometer (Lindsay and Norvell, 1978) [7].

**Table 1:** Characteristics of Biochar

| S. No. | Characterstics | |
|---|---|---|
| 1. | Nitrogen (%) | 0.14 |
| 2. | Phosphorus (%) | 0.44 |
| 3. | Potassium (%) | 0.68 |
| 4. | Calcium (%) | 2.0 |
| 5 | Magnesium (%) | 1.2 |
| 6 | Iron (ppm) | 9.42 |
| 7 | Zinc (ppm) | 25.03 |
| 8 | Copper (ppm) | 29.1 |
| 9 | Manganese (ppm) | 318.4 |

## Results and Discussions

### 1. Macro nutrients

### a. Soil Available Nitrogen

Nitrogen content in treatments supplied with 100% RDF with and without Azophos was on par with organic (biochar/ FYM) treated plots and were significantly superior to control (Table 2) at all the stages of the crop growth. In all the treatments supplied with Azophos ($T_3$, $T_5$ and $T_7$), slightly higher nitrogen contents was noticed as compared to their respective treatments without Azophos ($T_2$, $T_4$ and $T_6$). The results were in confirmation with Rama lakshmi *et al.*, 2008 [12]. At knee high stage available nitrogen ranged from 169 kg $ha^{-1}$ in control to 207 kg $ha^{-1}$ in $T_3$ (RDF + Azophos). It ranged from 166 kg $ha^{-1}$ to 214 kg $ha^{-1}$ and 150 to 197 kg $ha^{-1}$, respectively at tasseling and harvest. At both the stages highest available N was observed in the treatment with RDF + Azophos and lowest was in control. Significant increase in the nitrogen content at $T_2$ and $T_3$ treatments over control might be due to direct supply of mineral nitrogen in the form of urea. Biochar application along with 75% RDF has increased the nitrogen content as direct fertilizer application readily supplied the nitrogen, albeit biochar was not an initial direct source of nitrogen. Residual fertilizer trapped inside the biochar pores might have become available at later stages of crop growth. Biochar improved the soil physical properties which might have altered the inorganic nitrogen pool. Biochar might also reduce the leaching losses as it have higher surface area. Sukartono *et al.*, 2011[15] supported the increase in nitrogen content as biochar minimizes nutrient leaching, especially ammonical nitrogen. Biochar increases the nitrogen use efficiency by improving the nitrification process (Zwieten *et al*., 2010 and Ulyett *et al*., 2014) [18, 16].

**Table 2:** Influence of biochar on soil available N, P, K (kg $ha^{-1}$)

| Treatments | Nitrogen | | | $P_2O_5$ | | | $K_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Knee high | Tasseling | Harvest | Knee high | Tasseling | Harvest | Knee high | Tasseling | Harvest |
| $T_1$ - Control | 169 | 166 | 150 | 24.41 | 23.27 | 21.64 | 824 | 847 | 837 |
| $T_2$ - RDF | 204 | 210 | 194 | 37.59 | 41.46 | 40.78 | 931 | 947 | 943 |
| $T_3$ - RDF + Azophos | 207 | 214 | 197 | 38.63 | 44.10 | 41.78 | 927 | 950 | 947 |
| $T_4$ -75% RDF + biochar @ 5 t $ha^{-1}$ | 194 | 199 | 189 | 36.59 | 39.61 | 38.29 | 923 | 940 | 946 |
| $T_5$ -75% RDF + biochar @ 5 t $ha^{-1}$ + Azophos | 195 | 203 | 192 | 37.71 | 41.54 | 39.74 | 931 | 954 | 952 |
| $T_6$ - 75% RDF + FYM @ 5 t $ha^{-1}$ | 198 | 200 | 192 | 36.40 | 38.97 | 36.58 | 923 | 938 | 938 |
| $T_7$ - 75% RDF + FYM @ 5 t $ha^{-1}$ + Azophos | 199 | 206 | 194 | 36.83 | 39.80 | 37.31 | 924 | 939 | 935 |
| SEm± | 8 | 10 | 10 | 1.86 | 1.85 | 1.65 | 31 | 29 | 32 |
| CD @ 0.05 | 24 | 30 | 31 | 5.72 | 5.71 | 5.10 | 96 | 90 | 99 |
| CV (%) | 7 | 8 | 9 | 9.07 | 8.36 | 7.83 | 6 | 5 | 6 |

### b. Soil Available Phosphorus ($P_2O_5$)

Treatments supplied with 100% RDF and organic treated plots were at par with each other and significantly superior to control (Table 2) at all the stages of the crop growth. At knee high stage available phosphorus ranged from 24.41 kg $ha^{-1}$ in control to 38.63 kg $ha^{-1}$ recorded in $T_3$ (RDF + Azophos). It ranged from 23.27 kg $ha^{-1}$ to 44.10 kg $ha^{-1}$ at tasseling stage with the lowest and highest values recorded in control and $T_3$(RDF + Azophos), respectively. Similar observation was made, also at harvest with the lowest (21.64 kg $ha^{-1}$) recorded in control and the highest (41.78 kg $ha^{-1}$) in treatments supplied with RDF + Azophos ($T_3$). Abewa *et al*., 2014 [1] reported that biochar application improves available phosphorus due to synergetic effect of biochar and fertilizer. By the addition of biochar, phosphorus availability improved due to increased colonization by carbuncular mycorrhizal fungi (Blackwell *et al*., 2010) [10]. Increase in the available phosphorus on FYM addition might be due to the decomposition and release of organic acids which solubilise the native and inorganic phosphates.

### C Soil Available Potassium

Available potassium was not significantly influenced by different treatments ($T_2$ – $T_7$) at all the stages of crop growth and were superior to control. At knee high stage available potassium ranged from 824 kg $ha^{-1}$ which was recorded in the control to 931 kg $ha^{-1}$ in $T_2$ (RDF) and $T_5$ (75% RDF + biochar @ 5 t $ha^{-1}$ + Azophos). It ranged from 847 kg $ha^{-1}$ (control) to 954 kg $ha^{-1}$ in 75% RDF + biochar @ 5 t $ha^{-1}$ + Azophos at tasseling stage. At harvest lowest (837 kg $ha^{-1}$) available potassium was observed in control and highest (952 kg $ha^{-1}$) in 75% RDF + biochar @ 5 t $ha^{-1}$ + Azophos. Increase in surface charge of soils on biochar addition which might hold positively charged ions and minimises the leaching losses (Sukartono *et al*., 2011) [15]. Rapid decomposition of FYM released the potassium content, thus increased the available potassium. Similar result was observed by Chatterjee and Bandyopadhyay, 2014.

### D Exchangeable Calcium and Magnesium

The data presented in the table 3 indicated that the available calcium and magnesium contents in biochar supplied plots were significantly superior to control and at par with rest of the treatments. Increase in the available calcium and magnesium contents on biochar application was due to the high amount of basic cations present in the biochar. Higher cation exchange capacity of biochar helped to hold the positively charged ions and reduced the leaching losses. Increase in the available calcium and magnesium contents by applying biochar was supported by Abewa *et al*., 2014 [1] which might be due to dissolution of basic cations in biochar and high surface positive charge which might decrease the leaching of positively charged ions (Sukartono *et al*., 2011) [15]

## 2. Micronutrients

### a.Iron, Zinc and Copper

High available iron and zinc was observed in FYM treated plots at all stages of the crop growth. However slight reduction in iron and zinc content was discernible in biochar treatments than to control at all stages of crop growth. Slight increase in the available Fe content with the application of FYM might be due to the mineralization and release of Fe and it was supported by Jat *et al*., 2012 [5]. Reduction in the soluble iron content in the soil with the addition of biochar at all stages of the crop growth might be due to the immobilization of iron (Masulili *et al*., 2010) [8].

Available Zn content was increased on FYM addition might be due to mineralization process and it was supported by Narwal *et al*., 2010 [11]. Marked reduction in the extractable zinc content by supplying biochar was discernible as the zinc present in the soil solution might strongly sorbed to biochar, hence may formed more stable complex due to the recalcitrant nature of biochar. The decrease in the available zinc content on biochar addition due to immobilization was supported by Rees *et al*., 2014 [13].

Available copper contents in soil was not significantly influenced by the imposed treatments at all stages of the crop growth. Namgay *el al*., 2010 [10] reported that on biochar application there was no significance influence of soil available copper content

**Table 3:** Influence of biochar on soil available Ca and Mg (cmol $(p^+)$ $kg^{-1}$)

| Treatments | Calcium | | | Magnesium | | |
|---|---|---|---|---|---|---|
| | Knee high | Tasseling | Harvest | Knee high | Tasseling | Harvest |
| $T_1$ - Control | 25.36 | 24.75 | 23.08 | 2.13 | 2.30 | 1.97 |
| $T_2$ - RDF | 27.52 | 28.93 | 28.12 | 2.27 | 2.80 | 2.49 |
| $T_3$ - RDF + Azophos | 28.62 | 29.40 | 28.43 | 2.40 | 2.90 | 2.53 |
| $T_4$ - 75% RDF + biochar @ 5 t $ha^{-1}$ | 29.24 | 30.35 | 30.27 | 3.40 | 3.98 | 3.78 |
| $T_5$ - 75% RDF + biochar @ 5 t $ha^{-1}$ + Azophos | 29.35 | 31.11 | 30.63 | 3.57 | 4.05 | 3.92 |
| $T_6$ - 75% RDF + FYM @ 5 t $ha^{-1}$ | 28.85 | 29.00 | 28.27 | 2.67 | 3.11 | 2.97 |
| $T_7$ - 75% RDF + FYM @ 5 t $ha^{-1}$ + Azophos | 28.33 | 29.48 | 29.11 | 2.87 | 3.17 | 3.08 |
| **SEm±** | 1.23 | 1.63 | 2.49 | 0.12 | 0.24 | 0.19 |
| **CD @ 0.05** | 3.78 | 5.01 | 6.19 | 0.38 | 0.73 | 0.60 |
| **CV (%)** | 5.56 | 7.23 | 9.09 | 7.65 | 12.95 | 11.35 |

**Table 4:** Influence of biochar on available micro nutrients (ppm) in soil

| Treatments | Zinc | | | Iron | | | Manganese | | | Copper | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Knee high | Tasseling | Harvest | Knee high | Tasseling | Harvest | Knee high | Tasseling | Harvest | Knee high | Tasseling | Harvest |
| T1 | 1.35 | 1.40 | 1.37 | 6.34 | 6.81 | 6.60 | 4.59 | 4.78 | 4.61 | 2.56 | 2.84 | 2.70 |
| T2 | 1.51 | 1.54 | 1.50 | 6.66 | 7.08 | 6.71 | 4.87 | 5.07 | 4.98 | 2.81 | 2.89 | 2.77 |
| T3 | 1.54 | 1.60 | 1.54 | 6.79 | 7.14 | 6.73 | 5.08 | 5.13 | 5.12 | 2.89 | 2.95 | 2.78 |
| T4 | 1.23 | 1.24 | 1.24 | 5.77 | 6.43 | 6.26 | 6.15 | 6.61 | 6.59 | 2.87 | 3.13 | 2.83 |
| T5 | 1.23 | 1.28 | 1.25 | 5.96 | 6.55 | 6.28 | 6.30 | 6.86 | 6.64 | 2.92 | 3.21 | 2.88 |
| T6 | 1.58 | 1.65 | 1.63 | 6.88 | 7.25 | 7.08 | 5.71 | 6.46 | 6.41 | 2.87 | 3.16 | 2.91 |
| T7 | 1.61 | 1.67 | 1.62 | 6.96 | 7.27 | 7.15 | 5.66 | 6.54 | 6.41 | 2.94 | 3.23 | 2.98 |
| SEm± | 0.11 | 0.11 | 0.08 | 0.31 | 0.26 | 0.52 | 0.47 | 0.58 | 0.26 | 0.14 | 0.14 | 0.10 |
| CD @ 0.05 | NS | NS | NS | NS | NS | NS | 1.45 | 1.78 | 0.79 | NS | NS | NS |
| CV (%) | 13.75 | 12.66 | 9.87 | 8.25 | 6.53 | 13.45 | 14.93 | 16.88 | 7.59 | 8.44 | 8.18 | 6.14 |

### b. Manganese

Maximum available manganese content was significantly influenced by the imposed treatments. At knee high and tasseling stage the highest available manganese content (6.30 ppm) was registered in 75% RDF + biochar @ 5 t $ha^{-1}$ + Azophos ($T_5$) which was superior to control and at par with rest of the treatments.At harvest the treatments supplied with biochar/ FYM were at par with one another and significantly superior to remaining treatments.

Increase in the available manganese content might be because of enhanced solubilisation of manganese content due to reduction potential of manganese and non complexation by organic ligands. Lentz and Ippolito, 2011 supported the significant increment in available manganese on biochar addition as biochar acts as a source of manganese. Slight increment in the available manganese content on FYM addition was because of mineralisation of FYM and release of manganese into soil system.

All the micro nutrients showed slight increase on FYM addition was because of the beneficial role of FYM in mineralisation of nutrients which enhance the available nutrient pool of soil. The results were confirmed with the findings of Jat *et al*., 2012 [5].

## Conclusions

A field experiment was conducted to study the influence of biochar on soil properties and maize (sweet corn) yield during *kharif*, 2014 at Agricultural College Farm, Bapatla. The experimental soil was slightly alkaline, low in organic carbon, available nitrogen (179 kg $ha^{-1}$), medium in available $P_2O_5$ (25.71 kg $ha^{-1}$), high in available $K_2O$ (850 kg $ha^{-1}$) and sufficient in all micro nutrients. The influence of various treatments on soil macronutrients at different stages of the crop growth was studied by collecting and analysing soil samples following standard procedures. The available N, P and K were significantly increased by the imposed treatments ($T_2$ to $T_7$) over control. The biochar treated plots recorded higher available Ca and Mg content, which were on par with treatments supplied with lone inorganics and their integration with FYM and azophos and significantly superior over control. Among micronutrients (Fe, Zn, Cu and Mn), the treatmental influence was significant in respect of Mn only.

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