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**GS Laharia**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

**YD Kadam**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

**AB Age**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

**SD Jadhao**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

**DV Mali**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

**OS Rakhonde**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

**Corresponding Author:**
**GS Laharia**
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

# Interactive effect of biochar, fym and nitrogen on soil properties and yield of blackgram grown in vertisol

**GS Laharia, YD Kadam, AB Age, SD Jadhao, DV Mali and OS Rakhonde**

## Abstract
The experiment was conducted during *Kharif*- 2018-19 to study the interactive effect of biochar, FYM and nitrogen on soil properties and yield of blackgram" at Department of Agronomy, Dr. PDKV, Akola. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. The treatments comprised of control, various levels of N, FYM and biochar and their combinations. On the basis of results obtained in the present investigation, highest seed yield (788 kg $ha^{-1}$) and straw yield (994 kg $ha^{-1}$) of black gram were recorded with soil application of biochar @ 10 t $ha^{-1}$ + FYM @ 10 t $ha^{-1}$ and nitrogen @ 20 kg $ha^{-1}$ and it was on par with treatment of biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1,}$ and biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$. The organic carbon, available N (231.5 $kgha^{-1}$), P (22.19 $kgha^{-1}$) and K (348.2 kg $ha^{-1}$) were significantly increased with the application of biochar @ 10 t $ha^{-1}$ + FYM @ 10 t $ha^{-1}$ and nitrogen @ 20 kg $ha^{-1}$ and it was on par with treatment of biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$and biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$. The bulk density (1.44 Mg $m^{-3}$) and WHC (47.33%) was non- significant. The soil microbial biomass carbon (SMBC) (204 mg $kg^{-1}$) was increased significantly with the application biochar @ 10 t $ha^{-1}$ + FYM @ 10 t $ha^{-1}$ and nitrogen @ 20 kg $ha^{-1}$ and it was found to be on par with the treatments of biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$and biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$. The positive and significant relationship of yield was observed with available P (0.839**), available N (0.785**), organic carbon (0.735**) and available K (0.713**) indicating their contribution in improving yield of blackgram.

**Keywords:** Blackgram, Biochar, FYM, Nitrogen, SMBC, NM

## Introduction
Blackgram (*Vigna mungo* L.) is one of the important pulse crops grown in India which belong to the family Leguminoceae. Blackgram reported as originated in the India. The taproot produces a branched root system with smooth, rounded root 2 nodules. The whole plant is used as fodder for cattle and is a good green manure and soil conservation crop. Blackgram seeds are a good source of minerals and energy. It is rich in proteins (24%), carbohydrates (60%), fat (1-5%), amino acids, vitamins and minerals and much richer than most of grains used as concentrate.

Biochar is a fine grained charcoal high in organic carbon and largely resistant to decomposition. It is produced from pyrolysis of plants and waste feed stocks. It can enhance plant growth by improving soil chemical characteristics (i.e. nutrient retention and availability) and soil physical characteristics (bulk density and water holding capacity). The net effect on the soil physical properties depends on the interaction of the biochar with the physico-chemical characteristics of the soil and other determinant factors such as the climatic conditions prevalent at the site and the management of biochar application. In addition, biochar is highly recalcitrant to microbial decomposition and thus guarantees a long term benefit for soil fertility. Biochar effect on regulation and production function in the agricultural soil. Some of the common agricultural by-products available in large quantities include bagasse, rice husk, wheat straw, groundnut shell, tea waste, casuarina leaf litter, silk cotton shell, cotton waste, oil palm fiber and shells, cashew nut shell, coconut shell, coir pith etc. (Sugumaran and Sheshadri, 2009) [15]. As per Yeboah, 2009 [18], the biochar contains organic carbon (38.8%), Total $P_20_5$ (1 g $kg^{-1}$), $K_20$ (3.3 g $kg^{-1}$), $CaC0_3$ (5.7 g $kg^{-1}$), MgO (1.1 g $kg^{-1}$) and C/N ratio (68.2).

FYM is one of the components of INM as it is a very good organic source of nutrients. It is a cheap and easily available source of organic nutrients for farmer. Integrating FYM with inorganic fertilizer, scientists are getting very good response of the crop. Application of this source of organic improves physical, chemical and biological condition of the soils. FYM can supply all nutrients required by the plant and it is always advised to apply along with chemical fertilizer so that to achieve very good crop yield. Nitrogen fertilization plays an important role in improving soil fertility and increasing crop productivity. Nitrogen fertilization increases grain yield and biomass in crop. It contributes 18-34% increase in soil residual N. Sole residue incorporation or in combination with N fertilizer have positive effects on plant growth and production as well as on soil physico-chemical properties.

The use of organic materials in combination with inorganic fertilizers to optimize nutrient availability to plants is a difficult task as organic materials have variable and complex chemical nature. Therefore, it is necessary to assess the effects of biochar and FYM on crop productivity under field conditions in relation to agronomic practices at a given site because such research is rare and is little known about possible interaction effects. For this purpose, a field experiment has been initiated on various levels of biochar, FYM and Nitrogen and their combinations on soil properties and yield of Blackgram (*Vigna mungo* L.).

## Materials and methods

A field experiment was conducted during 2018-19 at Research farm, Department of Agronomy, Dr. PDKV Akola to study different levels of FYM, biochar and nitrogen and their combinations on soil properties and yield of Black gram. The present study was undertaken during 2018-19 with nine treatments replicated three times with Blackgram as a test crop. The treatments comprised of $T_1$- Control, $T_2$- FYM 5 t ha$^{-1}$ + Nitrogen 10 kg ha$^{-1}$, $T_3$- FYM 5 t ha$^{-1}$ + Nitrogen 20 kg ha$^{-1}$, $T_4$- FYM 10 t ha$^{-1}$ + nitrogen 10 kg ha$^{-1}$, $T_5$- FYM 10 t ha$^{-1}$ + Nitrogen 20 kg ha$^{-1}$, $T_6$- Biochar 5 t ha$^{-1}$ + FYM 5 t ha$^{-1}$ + Nitrogen 10 kg ha$^{-1}$, $T_7$- Biochar 5 t ha$^{-1}$ + FYM 5 t ha$^{-1}$ + Nitrogen 20 kg ha$^{-1}$, $T_8$- Biochar 10 t ha$^{-1}$ + FYM 10 t ha$^{-1}$ + Nitrogen 10 kg ha$^{-1}$, $T_9$- Biochar 10 t ha$^{-1}$ + FYM 10 t ha$^{-1}$ + Nitrogen 20 kg ha$^{-1}$. The recommended dose of fertilizer (RDF) was 20:20:0 kg N, $P_2O_5$ and $K_2O$. The nitrogen through urea was applied at the time of sowing. The chemical properties of biochar indicates that pH, EC and total carbon content was to the extent of 8.72, 0.59 dSm$^{-1}$ and 73.0% respectively (Table 1). While, the total nitrogen, phosphorus and potassium content were 0.36%, 0.17% and 1.12% respectively and C: N ratio content was 202.77%. The biochar obtained from different crop residue was alkaline in nature with pH 8.72. Similar properties were observed by Pandian *et al.* (2016) [12]. The various soil properties were analyzed following standard method. The seed and straw of Black gram yield was recorded and expressed in appropriate unit. The data were subjected to statistical analysis as per Panse and Sukhtme (1967) [13].

## Results and discussion

### Yield of blackgram

The significantly higher seed (788 kg ha$^{-1}$) and straw (994 kg ha$^{-1}$) yield of blackgram (Table 2) were found with soil application of biochar @ 10 t ha$^{-1}$ + FYM @ 10 t ha$^{-1}$ and nitrogen @ 20 kg ha$^{-1}$ and it was on par with treatment biochar @ 5 t ha$^{-1}$ + FYM @ 5 t ha$^{-1}$ + Nitrogen 20 kg ha$^{-1}$ and biochar @ 10 t ha$^{-1}$ + @ FYM 10 t ha$^{-1}$ + Nitrogen 10 kg ha$^{-1}$. This might be due to blackgram is being a leguminous crop, fix atmospheric nitrogen and biochar enhanced the nitrogen amount thus lead to greater grain yield and reproductive efficiency of crop. Also the blackgram has the ability to fix atmospheric nitrogen, however, microorganisms initially need energy for fixation and therefore N application improves efficiency of microorganisms. Timely and slowly release of nutrients from FYM throughout the growing season might be possible reason for improving seed yield in FYM amended plots. Similar results were observed by Rab *et al.* (2016) [14].

### Chemical properties

The pH of soil ranges from 7.93 to 7.95 indicating that soil was slightly alkaline in reaction (Table 3). The higher value of pH was recorded in control treatment $T_1$. The lowest pH was recorded with the soil application of biochar @ 10 t ha$^{-1}$ + FYM @ 10 t ha$^{-1}$ and N @ 20 kg ha$^{-1}$. Biochar contains carbonate and soluble base cations, such as calcium and magnesium. The combination of cations and carbonate in the soil will form slightly soluble carbonates and restrict the hydrolyzation of carbonate, while decreasing content of hydroxyl in the soil. Thus, the soil pH was decreased to some extent after the addition of biochar reported by Yuan *et al.*(2011) [19].The electrical conductivity (EC) was ranged from 0.25 to 0.30 dS m$^{-1}$ and highest value of EC were recorded in treatment $T_8$ and $T_9$.The increase in soil EC due to application of biochar might be attributed that ash accretion. The ash residues are generally dominated by carbonates of alkali and alkaline earth metals. Similar results were found by Bandara *et al.* (2015) [4].

The significantly highest organic carbon (4.95 g kg$^{-1}$) in soil after harvest of blackgram was observed with the soil application of biochar @ 10 t ha$^{-1}$ + FYM @ 10 t ha$^{-1}$ and nitrogen @ 20 kg ha$^{-1}$ and it was on par with treatment biochar 10 t ha$^{-1}$ + FYM 10 t ha$^{-1}$ + Nitrogen 10 kg ha$^{-1}$. The superiority of biochar with respect to the organic carbon content might be due to the huge surface area of biochar, which in turn provides micropores for beneficial microorganisms habitat thereby increasing a soil organic carbon content. High amount of organic carbon in the added biochar might have resulted in increased organic carbon content of soil at harvest. This was in corroboration with the finding of Nigussie *et al.* (2012) [10]. Similarly increase the organic carbon content in the surface of soil was mainly due to the accumulation of organic residue over a period of time. This was in accordance with the finding of Alok Tiwari *et al.* (2002) [1].

### Available nitrogen

The highest available nitrogen (Table 4) was observed in soil after harvest of blackgram with soil application of biochar @ 10 t ha$^{-1}$ + FYM @ 10 t ha$^{-1}$ and nitrogen @ 20 kg ha$^{-1}$(231.52 kg ha$^{-1}$) and it was on par with treatment biochar 10 t ha$^{-1}$ + FYM 10 t ha$^{-1}$ + Nitrogen 10 kg ha$^{-1}$. The increased available nitrogen status due to the biochar can be attributed to the essential role of biochar in nutrient cycling and thus affecting N retention in soil. Biochar efficiently absorb ammonia ($NH_3$) and act as a binder for ammonia in soil, therefore have the potential to decrease ammonia volatilization from soil surfaces. Similar result noticed by Asai *et al.* (2009) [2] and reported that application of biochar modify the physical environment of soil and dynamics of soil nutrients. Similarly the highest of value of available N was due to incorporation of FYM once in 3 years over a period of time might be attributed to enhanced mineralization and accumulation of N in surface soil layer.

### Available phosphorus

The highest available phosphorus was observed with the soil application of biochar @ 10 t ha$^{-1}$ + FYM @ 10 t ha$^{-1}$ and nitrogen @ 20 kg ha$^{-1}$(22.19 kg ha$^{-1}$) and it was on par with treatment biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$. The increase in phosphorus in soils treated with biochar might be due to increased microbial population, which solubilize insoluble phosphorus thereby, increase its availability. Similar result observed by Blackwell *et al.* (2010) [5]. The increase in availability of phosphorus in biochar treated soils might be due to the direct addition of phosphorus by the biochar and also changes in soil micro dynamics. Similarly the incorporation of FYM along with inorganic P increased the availability of P and this may be due to reduction in fixation of water soluble P, increased mineralization of organic P due to microbial action and enhanced the availability of phosphorus.

**Available potassium**

The significantly highest available potassium (Table 4) was observed with the application of biochar @ 10 t $ha^{-1}$ + FYM @ 10 t $ha^{-1}$ and nitrogen @ 20 kg $ha^{-1}$(348.20 kg $ha^{-1}$) and it was on par with treatment biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$. The increase in available K in soils treated with biochar might be due to the increase in surface charge of soils which hold positively charged ions and minimizes the leaching losses (Sukartono *et al.* 2011) [16]. Similar result reported by (Bandara *et al.* 2015) [4] that biochar release bases, such as $K^+$, $Ca^+$, and $Mg^{2+}$ thereby, increasing the availability of nutrients. Similarly the higher value of potassium due to FYM may be ascribed to the reduction of K fixation and release of K due to interaction of organic matter with clay Tandon, (1987) [17].

**Physical properties**

The bulk density of soil at harvest of crop was found non-significant by various treatment, there was a numerical reduction in bulk density in the treatment $T_8$ and $T_9$ (Table 5). The decrease in bulk density due to biochar application has been associated with the high porosity, which when applied to soil increase the total pore volume reported by Mukherjee *et al.* (2013) [9]. The significantly increased water holding capacity was recorded with soil treated with biochar @ 10 t $ha^{-1}$ + FYM @ 10 t $ha^{-1}$ and nitrogen @ 20 kg $ha^{-1}$ and it was found to be on par with the treatments biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$. Whereas the lowest water holding capacity was observed in control .The increasing water holding capacity of soil due to biochar because it has high specific surface area, extensive pore structure and more total porosity (micro and macro pores). Hearth *et al.* (2013) [8] reported that biochar application increased the water retention capacity of the soil because it increase soil porosity and also due to adsorptive nature of biochar. The improvement in the soil physical properties might due to increased organic matter and improved soil structure due to addition of FYM reported by Babhulkar *et al.* (2000) [3].

**Biological properties**

The significantly highest soil microbial biomass carbon (Table 6) was recorded in the treatment soil application of biochar @ 10 t $ha^{-1}$ + FYM @ 10 t $ha^{-1}$ and nitrogen @ 20 kg $ha^{-1}$ and it was found to be on par with the application of biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$. Whereas the lowest soil microbial biomass carbon was reported in treatment control. Positive effect of biochar was observed mainly due to a wide range of compounds on its surface immediately after pyrolysis (Painter 2001) [11]. These include compounds that are easily metabolized by microbes, such as sugars and aldehydes. Similarly Chakraborty *et al.* (2011) [6] reported that urea along with FYM increased soil microbial biomass carbon as FYM supplied readily available organic matter in addition to increasing root biomass and root exudates due to greater crop growth.

**Pearson's correlation coefficient**

The correlation matrix (Table 7) showed a positive and significant relationship between yield and various soil properties. The available P (0.839**) was highly correlated with yield of blackgram followed by available N (0.785**), organic carbon (0.735**) and available K (0.713**) indicating their contribution in improving yield of blackgram. Among other soil properties, organic carbon negatively correlated with bulk density (r=0.547**) and positively correlated with water holding capacity (r=0.831**) followed by soil microbial biomass carbon (SMBC) (r=0.581**). Similarly Chan *et al.* (2008) [7] and Zwieten *et al.* (2010) [20] also reported the increase in available phosphorus after the application of biochar.

**Conclusion**

It is concluded that, the soil application of biochar @ 10 t $ha^{-1}$ along with FYM @ 10 t $ha^{-1}$ and nitrogen @ 10 kg $ha^{-1}$ favourably influenced the yield of blackgram and slight improvement in soil properties.

**Table 1:** Chemical properties of biochar

| S. No. | Chemical properties of biochar | |
|---|---|---|
| 1. | pH (1:2.5) | 8.72 |
| 2. | EC ($dSm^{-1}$) | 0.59 |
| 3. | Total carbon (%) | 73.0 |
| 4. | Total N (%) | 0.36 |
| 5. | Total P (%) | 0.17 |
| 6. | Total K (%) | 1.12 |
| 7. | C:N ratio | 202.77 |

**Table 2:** Yield of blackgram as influenced by various treatments.

| Treatment | Yield of Black gram (kg $ha^{-1}$) | |
|---|---|---|
| | Seed | Straw |
| $T_1$- Control | 392 | 610 |
| $T_2$- FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 518 | 733 |
| $T_3$- FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 769 | 972 |
| $T_4$- FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 641 | 832 |
| $T_5$- FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 771 | 975 |
| $T_6$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 762 | 954 |
| $T_7$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 778 | 984 |
| $T_8$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 767 | 966 |
| $T_9$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 788 | 994 |
| SE (m)± | 7.5 | 10.1 |
| CD at 5% | 22.6 | 30.4 |

**Table 3:** Chemical properties of soil after harvest of blackgram

| Treatments | pH | EC ($dSm^{-1}$) | O C ($g\ kg^{-1}$) |
|---|---|---|---|
| $T_1$- Control | 7.95 | 0.28 | 4.26 |
| $T_2$- FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 7.94 | 0.26 | 4.63 |
| $T_3$- FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 7.93 | 0.26 | 4.71 |
| $T_4$- FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 7.94 | 0.25 | 4.73 |
| $T_5$- FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 7.93 | 0.25 | 4.91 |
| $T_6$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 7.94 | 0.29 | 4.75 |
| $T_7$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 7.94 | 0.29 | 4.92 |
| $T_8$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ +Nitrogen 10 kg $ha^{-1}$ | 7.93 | 0.30 | 4.88 |
| $T_9$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 7.92 | 0.30 | 4.95 |
| SE (m)± | 0.03 | 0.02 | 0.06 |
| CD at 5% | NS | NS | 0.19 |

**Table 4:** Fertility status of soil after harvest of blackgram as influenced various treatment

| Treatment | Available Nutrients (kg $ha^{-1}$) | | |
|---|---|---|---|
| | N | P | K |
| $T_1$- Control | 202.79 | 16.62 | 330.2 |
| $T_2$- FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 204.88 | 18.58 | 334.2 |
| $T_3$- FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 217.42 | 20.50 | 335.8 |
| $T_4$- FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 208.22 | 19.80 | 336.3 |
| $T_5$- FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 223.27 | 20.70 | 338.1 |
| $T_6$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 210.73 | 20.29 | 339.3 |
| $T_7$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 227.87 | 21.04 | 341.2 |
| $T_8$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 225.70 | 21.73 | 344.0 |
| $T_9$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 231.52 | 22.19 | 348.2 |
| SE (m)± | 1.98 | 0.37 | 2.76 |
| CD at 5% | 5.96 | 1.34 | 8.32 |

**Table 5:** Bulk density and water holding capacity of soil as Influenced by various treatments

| Treatments | Bulk Density ($Mg\ m^{-3}$) | Water Holding Capacity (%) |
|---|---|---|
| $T_1$- Control | 1.47 | 38.33 |
| $T_2$- FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 1.46 | 40.33 |
| $T_3$- FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 1.46 | 42.66 |
| $T_4$- FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 1.45 | 42.33 |
| $T_5$- FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 1.45 | 44.00 |
| $T_6$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 1.46 | 42.66 |
| $T_7$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 1.45 | 44.66 |
| $T_8$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 1.44 | 44.66 |
| $T_9$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 1.44 | 47.33 |
| SE (m) ± | 0.01 | 1.23 |
| CD at 5% | NS | 3.70 |

**Table 6:** Soil Microbial Biomass Carbon in soil as influenced of various treatments at flowering stage

| Treatment | SMBC( mg $kg^{-1}$ ) |
|---|---|
| $T_1$- Control | 174.33 |
| $T_2$- FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 185.27 |
| $T_3$- FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 194.34 |
| $T_4$- FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 188.01 |
| $T_5$- FYM 10 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 196.52 |
| $T_6$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 190.04 |
| $T_7$- Biochar 5 t $ha^{-1}$ + FYM 5 t $ha^{-1}$ + Nitrogen 20 kg $ha^{-1}$ | 201.34 |
| $T_8$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ + Nitrogen 10 kg $ha^{-1}$ | 200.09 |
| $T_9$- Biochar 10 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ +Nitrogen 20 kg $ha^{-1}$ | 204.46 |
| SE (m)± | 2.91 |
| CD at 5% | 8.78 |

**Table 7:** Pearson's correlation coefficient of yield with various soil properties

| | Yield | OC | Avail. N | Avail. P | Avail. K | B.D. | WHC | SMBC |
|---|---|---|---|---|---|---|---|---|
| Yield | 1 | | | | | | | |
| OC | 0.735** | 1 | | | | | | |
| Avail N | 0.785** | 0.784** | 1 | | | | | |
| Avail P | 0.839** | 0.839** | 0.736** | 1 | | | | |
| Avail K | 0.713** | 0.628** | 0.745** | 0.699** | 1 | | | |
| Bulk Density | -0.441* | -0.547** | -0.532** | 0.347 | 0.275 | 1 | | |
| WHC | 0.562** | 0.831** | 0.592** | 0.701** | 0.666** | -0.317 | 1 | |
| SMBC | 0.781** | 0.581** | 0.735** | 0.663** | 0.518** | -0.425* | 0.426* | 1 |

* Significant at 5% level of significance, ****** Significant at 1% level of significance

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