Journal of Applied and Natural Science 9 (4): 2043 -2046 (2017)

JANS

Effect of rice husk biochar, carpet waste, farm yard manure and plant growth promoting rhizobium on the growth and yield of rice (*Oryza sativa*)

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Received: November 22, 2016; Revised received: April 17, 2017; Accepted: September 20, 2017

Abstract: The present investigation was aimed for improving growth and yield of crop using waste products of different activities and also useful in ecological stability of soil environment. This objective is not only an economic option for poor farmer but also an effective strategy for increasing yield.The experiment was conducted in the organic farming plot of the Institute of Agricultural Sciences, BHU,Varanasi during kharif season of rice crop in 2014. The field experiment was laid out in randomized block design (RBD) with 10 treatments and three replications. Application of graded level of biochar, carpet waste farm yard manure (FYM) and plant growth promoting rhizobium (PGPR) was found to significantly enhance the grain andstraw yield of rice by 57.70% and 56.08% over control, respectively.

Keywords: Carpet waste, FYM, PGPR, Rice, Rice husk biochar

INTRODUCTION

Rice is the staple food for over half the world's population. Approximately 480 million metric tons of milled rice is produced annually. China and India alone account for approximate 50% of the rice grown and consumed (Muthayya *et al.,* 2014). In India, it occupies43.86 million ha of land and produces about 104.80 million tons ofgrain with the productivity of 2.39tones ha^{-1} (Anonymous, 2015).However, this is not enough to feed the ever-increasing population, and there is need to increase the production to keep pace with population growth.

Biochar is carbon rich solid product obtained after heating biomass, such as wood, manure or leaves under limited supply or absence of oxygen. Biochar application has received a growing interest as a sustainable technology to improve highly weathered or degraded tropical soils (Lehmann and Rondon, 2006). Biochar application can enhance plant growth by improving soil chemical characteristics (i.e. nutrient retention, nutrient availability), soil physical characteristics (i.e. bulk density, water holding capacity, permeability), and soil biological properties, all contributing to an increased crop productivity (Lehmann and Rondon, 2006; Yamato *et al.,* 2006). In addition, biochar is highly recalcitrant to microbial decomposition and thus guarantees a long term benefit for soil fertility (Steiner *et al.,* 2007). Biochar has a fantastic quality of absorbance and when applied in soil, it absorb moisture, plant nutrient, agricultural chemicals and thereby reduce loss of nutrients through leaching and surface runoff of water. Biochar is a relatively low density material that helps in lowering the bulk density in heavy texture soil along with increase in aeration and root penetration and thus the water holding capacity. These actual effects of biochar application, however, depend on various factors such as the soil fertility and the water balance at a given site, and possibly even the cultivated genotype.

Farmyard manure is easily available, cheap, proven source of nutrition and has been traditionally used by farmers (Nanda et al., 2016).PGPR consists of a diverse type of rhizobacteria known to stimulate plant growth directly either by synthesizing hormones such as indole acetic acid or by promoting nutrition, by phosphate solubilisation or generally by accelerating mineralization process. They can also stimulate growth indirectly by acting as bio control agent by protecting the plant against soil born fungal pathogens or deleterious bacteria. Some PGPR suppress pathogen by synthesizing antifungal metabolites (Vassilev *etal.*, 2006). Application of FYM along with PGPR improved organic carbon, available N, P and K content in soil when applied in mung bean (Das and Singh, 2014).Positive interaction between biochar and PGPR resulted in improved growth attributes and biomass yield in switch grass (Shanta, 2012).

Waste products like biochar, Carpet waste, etc.can be important for improving crop
growth and yield and also in the waste management. Organic carbon pools in Indian soils is declining due to heavy and imbalanced incorporation of chemical fertilizers and ignorance or unavailability or inaccessibility

of the organic matter. Considering all these facts in Indian context there is a need to study the combined effect of Biochar, FYM, Carpet waste and PGPR as a source of organic material to soil.

MATERIALS AND METHODS

The experiment was carried out at the Organic farming plot of the Institute of Agricultural Sciences, BHU, Varanasi.Three replications of each treatment were maintained in the experiment. So there were 27 experimental plots along with three control plots (without any treatment). The experiment was conducted in Randomized Block Design.To determine the initialphysico -chemical properties of soil representative soil samples were collected from five different places before conducting the experiment from the depth of 0-20 cm in sandy clay loam texture soil with pH value of 7.42, EC - 0.170 $dSm^{-1}$and organic carbon 0.45%. The initial soil was low in available N (258.55 kg ha^{-1}), medium in available P (14.27 kg ha^{-1}) and medium in available K (223.45 kg ha^{-1}).Pre-Prepared Biochar was collected from Shree ram rice mill jasuri, Chandauli**,** Uttar Pradesh in the month of June 2014.

RESULTS AND DISCUSSION

Effect of treatment on growth of rice

Effect on plant height of rice: The data pertaining to effect of biochar and PGPR on height of plant is presented in table 1. It is evident from the table that height of plant (30 DAT) varied from 77.5 to 98.6. It was higher in treatment T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1}+ PGPR) 98.6cm followed by T_9 (BC_1+ CW_1+ FYM_1 t ha^{-1}+ PGPR) 98.1cm. Significant differences were found between the treatments after application of PGPR in the plot. The inoculation with PGPR showed significantly higher plant height (98.6cm) at 30 DAT than uninoculated treatment (84.1cm). The treatment T_7 (BC_1+ CW_1 t ha^{-1} + PGPR) was found 90.9cm plantheightfollowed by T_2 (BC_1+ CW_1 t ha^{-1}) 80.7cm and treatment T_6 (PGPR) was found 87.0cm followed by T_1 (control) 77.5cm. However, the treatment T_2 (BC_1+ CW_1 t ha^{-1}), T_3 (BC_2+ CW_1 t ha^{-1}) and T_9 (BC_1+ CW_1 + FYM_1 t ha^{-1} + PGPR), T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) were found statically at par to each other. Almost similar trend was noticed with the plant height recorded at 60 DAT.

Mathivanan*et al.* (2005) reported that application of PGPR significantly increased the plant height over control. The increase in plant height may be attributed due to adequate supply of nutrients by the PGPR. Abbasi *et al.* (2011) have also reported that inoculation of PGPR in wheat increase shoot length by 25% over the un-inoculated control.

Effect on chlorophyll content: Data pertaining to the chlorophyll content (SPAD value) in leaf as influenced by biochar, carpet waste, FYM and PGPR application is give in table 1. There was a significant increase in chlorophyll content at 30 DAT with the application of biochar, carpet waste, FYM and PGPR. The maximum chlorophyll content (36.2) in leaf was found in treatment T_{10} (BC_2+ CW_1+ FYM_1 t ha^{-1}+PGPR) followed by T_9 (BC_1+ CW_1+ FYM_1 t ha^{-1}+PGPR). The minimum chlorophyll content (26.5) was found in treatment T_1 (control). The application of biochar and carpet waste in treatment T_2 (BC_1&CW_1) increase chlorophyll content 1.50% over the control,while T_6 (PGPR) increased 2.64%, and T_{10} (BC_2+ CW_1+ FYM_1 t ha^{-1}+PGPR) increased 36.60%.Decrease in chlorophyll content (leaf SPAD value) with biochar has been reported by Asai *et al*. (2009) in rice, possibly due to reduction in the availability of soil nitrogen to the plant because of its high C:N ratio. The inoculation with PGPR showed significantly higher chlorophyll content (36.2) than without its inoculation (27.5). The increase in chlorophyll content may be attributed to adequate supply of nitrogen by carpet waste and PGPR. Almost similar trend was observed in chlorophyll content recorded at 60 DAT.

Effect on number of tillers per hill: A critical perusal of the data presented in Table 1 revealed that a significant increase was found in number of tillers at 30 DAT with the application ofBC, CW FYM & PGPR. Application of PGPR and different doses of biochar resulted significant increase in number of tillers (30 DAT). The maximum number of tillers (28.3) was noted in T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1}+ PGPR) and minimum number of tillers (14.2) in T_1(control) at 30 DAT. The application of biochar and carpet waste in treatment T_2 (BC_1+ CW_1 t ha^{-1})increases number of tillers 13.38% over the control, whileT_6(PGPR) increased 69.01%, T_4 (BC_1+ CW_1+ FYM_1 t ha^{-1}) increased 71.83% and T_{10} (BC_2+ CW_1+ FYM_1 t ha^{-1}+PGPR) increased 99.29%.However, the treatment T_2 (BC_1+ CW_1 t ha^{-1}), T_3 (BC_2+ CW_1 t ha^{-1}) and T_9 (BC_1+ CW_1+ FYM_1 t ha^{-1}+PGPR) and T_{10} (BC_2+ CW_1+ FYM_1 t ha^{-1}+PGPR)

Table 1. Details of treatments followed in the plot.

Treatments	Details of treatments
T_1	Control
T_2	Biochar + carpet waste (1+1 t) ha^{-1}
T_3	Biochar + carpet waste (2+1 t) ha^{-1}
T_4	Biochar + carpet waste+ FYM (1+1+1 t) ha^{-1}
T_5	Biochar + carpet waste + FYM (2+1+1 t) ha^{-1}
T_6	PGPR
T_7	Biochar + carpet waste (1+1 t) ha^{-1}+ PGPR
T_8	Biochar + carpet waste (2+1 t) ha^{-1}+ PGPR
T_9	Biochar + carpet waste+ FYM (1+1+1 t) ha^{-1} + PGPR
T_{10}	Biochar + carpet waste + FYM (2+1+1 t) ha^{-1}+ PGPR

PGPR: Plant Growth Promoting Rhizobacteria (*Rhizobium* + *Azotobacterchroococcum* HUAZ-1 +*Pseudomonas fluoreseans* BHUPSB-06 + *Paenibacilluspolymyxa* BHUPSB-

Table 2. Effect of biochar, carpet waste, FYM and PGPR consortium on plant growth of rice at different intervals.

	30 DAT			60 DAT		
Treatment	**Height plant^{-1} (cm)**	**Chlorophyll content (SPAD value)**	**No. of tillers hill^{-1}**	**Height plant^{-1} (cm)**	**Chlorophyll content (SPAD value)**	**No. of tillers hill^{-1}**
T_1	77.5	26.5	14.2	94.7	25.4	19.7
T_2	80.7	26.9	16.1	96.8	25.5	25.6
T_3	82.5	27.6	19.2	96.9	25.4	27.2
T_4	87.9	29.5	24.4	101.4	29.4	30.6
T_5	84.1	27.5	23.2	98.4	25.0	26.4
T_6	87.0	27.2	24.0	106.2	26.8	28.6
T_7	90.9	29.5	25.2	107.3	27.5	30.7
T_8	94.4	29.0	27.4	106.5	26.3	32.5
T_9	98.1	30.7	27.8	111.6	30.5	34.4
T_{10}	98.6	36.2	28.3	116.4	33.2	36.3
SEm±	4.089	1.373	1.315	3.991	1.275	1.669
CD at 5%	11.826	3.972	3.805	11.543	3.689	4.827

Table 3. Effect of biochar, carpet waste, FYM and PGPR consortium grain and straw yield of rice at harvesting stage.

Treatment		**Grain yield (q ha^{-1})**	**Straw yield (q ha^{-1})**
T_1	Control	22.7	33.7
T_2	Biochar+ carpet waste(1+1 t) ha^{-1}	24.5	36.4
T_3	Biochar+ carpet waste(2+1 t) ha^{-1}	25.8	38.5
T_4	Biochar+ carpet waste+ FYM(1+1+1 t) ha^{-1}	29.4	42.4
T_5	Biochar+ carpet waste + FYM(2+1+1 t) ha^{-1}	31.2	44.7
T_6	PGPR	24.3	36.8
T_7	Biochar+ carpet waste(1+1 t) ha^{-1}+PGPR	26.7	39.3
T_8	Biochar+ carpet waste(2+1 t) ha^{-1}+PGPR	27.9	41.8
T_9	Biochar+ carpet waste+ FYM(1+1+1 t) ha^{-1}+PGPR	33.6	48.4
T_{10}	Biochar+ carpet waste + FYM(2+1+1 t) ha^{-1}+PGPR	35.8	52.6
SEm±		1.515	2.218
CD at 5%		4.383	6.415

were found statically at par to each other.The inoculation with PGPR showed significantly higher number of tillers (28.3) at 30 DAT than without its inoculation (23.2). Almost similar trend was noticed with the number of tillers recorded at 60 DAT.Inoculation with PGPR increase the number of tillers in wheat was reported by Zahir *et al.* (2003) and Cakmakci *et al.* (2001).

Effect of biochar, carpet waste, FYM and PGPR on grain and straw yield of rice at harvest

Effect on grain yield: A critical perusal of the data presented in table 2 revealed that the grain yield of rice was ranging from 22.7 qha^{-1} to 35.8 qha^{-1} and it has increased significantly with the application of graded levels ofBC, CW, FYM& PGPR. The maximum grain yield (35.8 qha^{-1}) was recorded in the treatment T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) which were 14.74% higher than treatment T_5 (BC_2+ CW_1 + FYM_1 t ha^{-1}). The treatment T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) was found 57.70% higher over the treatment T_1 (control). The treatment T_7 (BC_1+ CW_1 t ha^{-1} + PGPR) gave 26.7 qha^{-1}grain yield which was 8.97% higher over the T_2 (BC_1+ CW_1t ha^{-1}). Treatment T_6 (PGPR) gave7.04% higher grain yield over the T_1 (control).However, the treatment T_2 (BC_1+ CW_1 t ha^{-1}), T_3 (BC_2+ CW_1t ha^{-1}) and T_9 (BC_1+ CW_1 + FYM_1 t ha^{-1} + PGPR), T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) were found statically at par to each other.

Rondon *et al.*, (2007) reported that bean yield increased by 46% and biomass production by 39% over the control at application of 60g biochar per kg soil. Thakuria *et al.* (2004) reported that inoculation of different PGPR can increase rice yield from 10 to 76% over control in which *Pseudomonas aeruginosa* and *P. fluorescens*can increase rice yield by 49.2% and 23.01% respectively, over control.

Effect on straw yield: A critical perusal of the data presented in table 2 revealed that the application of BC_2+ CW_1+ FYM_1 t ha^{-1}+PGPR resulted in significantly higher straw yield by 56.08% than the straw yield obtained from the treatment T_1 (control). The maximum straw yield (52.60 qha$^-$1) was recorded in the treatment T_{10} (BC_2+ CW_1+ FYM_1 t ha^{-1}+PGPR) which were 17.67%higher than treatment T_5 (BC_2+ CW_1+ FYM_1 t ha^{-1}). The treatment T_7 (BC_1+ CW_1 t ha^{-1}+PGPR) gave39.30 q ha^{-1} straw yield which was 7.96%higher over the T_2 (BC_1+ CW_1 t ha^{-1}).Treatment T_6(PGPR) gave9.19% higher over T_1 (control). Increase in the chlorophyll content in leaf thus increased the photosynthesis rate and ultimately photosynthetic products increased the biomass of plant. Significant increase in straw yield was might be due to the availability of all essential elements to the rice crop in sufficient amount by the FYM, carpet waste and PGPR application.Das and Saha (2005) have found an increase in rice yield by 23.7% due to combined inoculation of*Azotobacter* strain DS_3 +*Azospirillum* strain DM_{10}.

Conclusion

Application of graded level of biochar, carpet waste FYM and PGPR was found to significantly effective to enhance the grain and straw yield of rice. Application of biochar + carpet waste + FYM (2+1+1t) ha^{-1}& PGPR was found 57.70% higher over the treatment T_1 (control). Application of PGPR consortium (*Azospirillium* + *Azotobacterchroococcum* HUAZ-1 + *Paenibacilluspolymyxa* BHUPSB-16) (T_6) enhanced maximum grain yield 35.8 q ha^{-1} which7.04 % higher over the T_1 (control). Application of BC_2+ CW_1 + FYM_1 t ha^{-1}+ PGPR resulted in significantly higher straw yield (52.6 q ha^{-1})which was56.08 % than the straw yield obtained from the treatment T_1 (control). Application of PGPR (T_6) was found 9.19 %higher over the T_1 (control).

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