JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Sept. 2016. Vol. **10**(3), p. 2427-2431

The Assessment of Rice Husk Biochar, Carpet Waste, FYM and PGPR on Growth and Yield of Mungbean (*Vigna radiata* L.)

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(Received: 11 June 2016; accepted: 01 August 2016)

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. Although, this objective is either an economic option for poor farmer or 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 mungbean crop in 2014. The field experiment was laid out in Randomized Block Design having 10 treatments and replicated thrice. Application of graded level of biochar, carpet waste FYM and PGPR was found to significantly enhance the straw and grain yield of mungbean. Application of BC_2, CW_1 FYM_1 and PGPR was found 60.17% higher over the control treatment. Application of BC_2 + CW_1 + FYM_1 t ha^{-1} + PGPR resulted in significantly higher straw yield by 54.85% then the straw yield obtained from the control treatment.

Keywords: Rice Husk Biochar, Carpet waste, FYM, PGPR and Mungbean.

Mungbean (*Vigna radiata* L. Wilezek) is the third most important pulse crop cultivated in India covering an area of 2.39 mha, with production of 0.89 million tones and an average productivity of 498 kg ha^{-1} (Anonymous 2015). Mungbean contains about 24 per cent protein, this being about two third of the protein content of soybean, twice that of wheat and thrice that of rice.

Biochar is a carbon rich solid product obtained after heating biomass, such as wood, manure or leaves under limited supply or absence of oxygen (Lehmann and Joseph, 2009). In the recent years, biochar is gaining importance as a good source of amendment because it helps in stabilizing photosynthetic carbon. Since, it has a fantastic quality of absorbance and when applied in soil, it absorbs moisture, plant nutrients and agricultural chemicals, and thereby reduces loss of nutrients through leaching and surface runoff of water. Carpet waste is source of multi nutrient to supply the adequate amount of nutrient. It contents higher amount of nitrogen but phosphorus and potassium have very less amount.

Much of the effects of FYM on soil and crop yield are due to its humus content, which serves as a slow release source of plant nutrient. The efficiency of FYM can be increased by the addition of phosphate fertilizers (Basir *et al*, 2008). Plant growth promoting rhizobacteria (PGPR) represent a wide range of soil bacteria which, when applied in association with a host plant, result in stimulation of plant growth of their host plant (Vessey, 2003).

So waste products like biochar, Carpet etc. become important for improving crop growth and yield which need for evaluation. These discoveries will open new avenues and enhance our understanding which economically solution of limited crop production in different types of soil.

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MATERIALS AND METHODS

The experiment was carried out at the Research Farm, Institute of Agricultural Sciences, Banaras Hindu University and 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 initial physico-chemical properties of soil representative soil samples were collected from five different places before conducting the experiment from the depth of 0-20 cm. The soil belongs to sandy clay loam texture class. The soil had a pH 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_2O_5 14.27 kg ha^{-1} and medium in available K_2O 223.45 kg ha^{-1}.

RESULTS AND DISCUSSION

Effect on number of nodule per plant

The data pertaining to effect of biochar and PGPR on number of nodules per plant are presented in table 1. It evident from the table that no. of nodule per plant varied from 18.33 to 40. It was higher 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). Significant differences were found between the treatments after application of PGPR in the plot. The maximum no. of nodule per plant (45) was recorded in the treatment T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) which was 36.37% 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) was found 27 no. of nodule per plant which was 19.10% higher over the T_2 (BC_1+ CW_1 t ha^{-1}) and treatment T_6 (PGPR) was found 29.13% higher over the T_1 (control). 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. Hamaoui *et al.* (2001) also reported that inoculation with PGPR significantly enhance nodulation by native *Rhizobia* in chickpea and faba bean. According to Verma *et al.*, (2010) and Petersen *et al.*, (1996), some PGPR strains from a range of genera, enhance legume growth, nodulation and nitrogen fixation when inoculation of *rhizobia*. Similar result were obtained by Nishijima *et al*., (1988) who reported that inoculation of legumes with root colonizing bacteria (PGPR) and *Rhizobium* affect symbiotic nitrogen fixation by enhancing root nodule number or mass.

Effect on chlorophyll content

Chlorophyll content (SPAD value) in leaf significantly influenced at flowering stage with the application of biochar, carpet waste, FYM and PGPR (table 2). The maximum chlorophyll content (56.50) 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 (38.77) was found in treatment T_1 (control). The application of biochar and carpet waste in treatment T_2 (BC_1 & CW1) increase chlorophyll content 9.62% over the Control, while T_6 (PGPR) increased 15.88%, and T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) increased 45.73%. 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.

Effect on fresh weight of plants

A critical perusal of the data presented in Table **2** and revealed that a significant increase was found in fresh weight at 45 DAS with the

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 (*Rhizobiutn* + *Azotobacter chroococcum* HUAZ-1 +*Pseudomonas fluoreseans* BHUPSB-06 + *Paenibacillus polymyxa* BHUPSB-16) application of BC, CW FYM & PGPR. Application of PGPR and different dose of biochar resulted significant increase in fresh weight (45 DAS). The maximum fresh weight (122.67 g) was noted in T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) and minimum fresh weight (76.33 g) in T_1 (control) at 45 DAS. The application of biochar and carpet waste in treatment T_2 (BC_1+ CW_1 t ha^{-1}) increase fresh weight over 17.47% the control while T_6 (PGPR) increased 28.82%, T_4 (BC_1+ CW_1 + FYM_1 t ha^{-1}) increased 34.94% and T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) increased 60.71%. 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) were found statically at par to each other. PGPR have also been reported to promote plant growth by reducing population of root colonizing phytopathogens (Sindhu *et al*., 1999, Weller, 2007). Malik *et al*., (2014) found that Mungbean yield (number of pods, grain and biological yield i.e. fruit + stem) increased by the addition of *Rhizobium* inoculation.

Table 1. Effect of biochar, carpet waste, FYM and PGPR consortium chlorophyll content of mungbean at flowering stage (45 DAS)

	Treatments	chlorophyll contain plant^{-1} at flowering stage (45 DAS)	Nodule number plant^{-1} at flowering stage(45 DAS)
T_1	Control	38.77	18.33
T_2	BC_1+ CW_1 t ha^{-1}	42.50	22.67
T_3	BC_2+ CW_1 t ha^{-1}	44.57	23.00
T_4	BC_1+ CW_1 + FYM_1 t ha^{-1}	48.23	27.67
T_5	BC_2+ CW_1 + FYM_1 t ha^{-1}	50.23	29.33
T_6	PGPR	44.93	23.67
T_7	BC_1+ CW_1 t ha^{-1} + PGPR	46.50	27.00
T_8	BC_2+ CW_1 t ha^{-1} + PGPR	48.13	30.33
T_9	BC_1+ CW_1 + FYM_1 t ha^{-1} + PGPR	54.07	37.67
T_{10}	BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR	56.50	40.00
	SEm±	1.93	1.47
	CD at 5%	5.59	4.26

Table 2. Effect of biochar, carpet waste, FYM and PGPR consortium on plant^{-1} fresh weight and dry weight of mungbean at flowering stage (45 DAS)

	Treatments	Weight plant^{-1}	
		Fresh (g)	Dry (g)
T_1	Control	76.33	15.17
T_2	BC_1+ CW_1 t ha^{-1}	89.67	18.87
T_3	BC_2+ CW_1 t ha^{-1}	94.67	19.90
T_4	BC_1+ CW_1 + FYM_1 t ha^{-1}	103.00	22.93
T_5	BC_2+ CW_1 + FYM_1 t ha^{-1}	106.33	23.97
T_6	PGPR	98.33	20.33
T_7	BC_1+ CW_1 t ha^{-1} + PGPR	105.33	22.90
T_8	BC_2+ CW_1 t ha^{-1} + PGPR	109.67	23.77
T_9	BC_1+ CW_1 + FYM_1 t ha^{-1} + PGPR	119.33	26.47
T_{10}	BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR	122.67	27.63
	SEm±	4.696	1.178
	CD at 5%	13.582	3.407

Table 3. Effect of biochar, carpet waste, FYM and PGPR consortium grain and straw yield of mungbean

	Treatment	Grain yield q ha^{-1}	straw yield q ha^{-1}
T_1	Control	9.09	40.00
T_2	BC_1+ CW_1 t ha^{-1}	9.72	44.33
T_3	BC_2+ CW_1 t ha^{-1}	9.94	46.67
T_4	BC_1+ CW_1 + FYM_1 t ha^{-1}	10.53	54.44
T_5	BC_2+ CW_1 + FYM_1 t ha^{-1}	10.83	56.78
T_6	PGPR	10.58	45.00
T_7	BC_1+ CW_1 t ha^{-1} + PGPR	11.19	48.70
T_8	BC_2+ CW_1 t ha^{-1} + PGPR	12.19	51.45
T_9	BC_1+ CW_1 + FYM_1 t ha^{-1} + PGPR	14.14	58.81
T_{10}	BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR	14.56	61.94
SEm±	0.552	1.484	
CD at 5%	1.597	4.293	

Effect on dry weight of plants

Application of different BC, CW FYM & PGPR treatments showed a significant impact on dry weight of plants at 45 DAS which was varied from 15.17 to 27.63 g (table 2). Application of PGPR and different dose of biochar resulted significant increase dry weight (45 DAS). The maximum dry weight (27.63 g) was noted in T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) and minimum dry weight (15.17g) in T_1 (control) at 45 DAS. The application of biochar and carpet waste in treatment T_2 (BC_1+ CW_1 t ha^{-1}) increase dry weight over 24.39% the control while T_6 (PGPR) increased 34.01%, T_4 (BC_1+ CW_1 + FYM_1 t ha^{-1}) increased 51.15% and T_{10} (BC_2, CW1 FYM_1 & PGPR) increased 82.13%. 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. Findings of Malik *et al*., (2014) supported such results.

Effect on grain yield of plants at harvest

Grain yield of mungbean significantly increased with the application of graded level BC, CW, FYM & PGPR (table 3). The maximum grain yield (14.56 q ha^{-1}) was recorded in the treatment T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) which were 34.44% 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 60.17% higher over the treatment T_1 (control). The treatment T_7 (BC_1+ CW_1 t ha^{-1} + PGPR) was found 11.19 q ha^{-1} grain yield which was 15.12% higher over the T_2 (BC_1+ CW_1 t ha^{-1}) and treatment T_6 (PGPR) was found 16.39% higher over the T_1 (control). %. 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.

Ronden *et al*., (2007) reported that bean yield increased by 46% and biomass production by 39% over the control at 60g biochar per kg soil. Similar results were obtained by Hazarika *et al.*, (2000) who inoculated *V. radiata* with *Glomus mosseae*, *G. fasciculatum* or *Rhizobium*, or *Rhizobium* combined with either of the two *Glomus spp*., before sowing. All treatments significantly stimulated the growth and straw yield of *V. radiata*. Javaid *et al.*, (2010) reported that FYM, plants co-inoculated with *B. japonicum* and EM exhibited highest and significantly greater shoot biomass, and number and biomass of pods as compared to all other treatments. The present study concludes that soybean yield can be significantly enhanced by the application of *B. japonicum* and EM in farmyard manure amendment.

Effect on straw yield of plants at harvest

Application of BC2+ CW_1 + FYM_1 t ha^{-1} + PGPR resulted in significantly higher straw yield by 54.85% then the straw yield obtained from the control treatment (Table 3). The maximum straw yield (61.94q ha^{-}1) was recorded in the treatment T_{10} (BC_2+ CW_1 + FYM_1 t ha^{-1} + PGPR) which were

9.08% 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) was found 48.70 q ha^{-1} straw yield which was 9.85% higher over the T_2 (BC_1+ CW_1 t ha^{-1}) and treatment T_6 (PGPR) was found 12.5% higher over the T_1 (control).

Increase in the chlorophyll content in leaf thus increase the photosynthesis rate and ultimately photosynthetic products so increase biomass of plant. Significant increase in straw yield might be due to the availability of all essential elements to the mungbean crop in sufficient amount by the FYM, carpet waste and PGPR application. Similar results were obtained by Hazarika *et al.*, (2000) who inoculated *V. radiata* with *Glomus mosseae, G. fasciculatum* or *Rhizobium,* or *Rhizobium* combined with either of the two *Glomus spp*., before sowing. All treatments significantly stimulated the growth and straw yield of *V. radiata*.

ACKNOWLEDGEMENT

The authors are thankful to the Head, Department of Soil Science & Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh for providing necessary facilities to conduct this research work.

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