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Influence of Rice Husk Biochar Application on Nitrogen Use Efficiency by Wheat Plants Grown on Mediterranean Soils

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Introduction

Agricultural soils in south Mediterranean Sea (e.g., Egypt) are classified as drylands which defined by high aridity index, high rates of organic matter depletion and accelerating soil salinity problems [1]. In Egypt, although, there is about 30–35 million ton of agricultural wastes are generated annually, only 20 % are used in organic fertilizer and fodder production [2] and the rest of waste amount is needed to précised management. Biochar, as one of stable sources of organic carbon, is considered as one of the option for agricultural waste management and recycling as soil amendment. Therefore, using stable soil conditioners such as rice husk biocher was considered as an attempt for (1) controlling fertilizer nitrogen loss and thereafter increasing the bioavailability of N to grown crops and (2) testing its role in reducing vulnerable effects of salinity on plant growth. In the current study, rice husk biochar (RHB) was produced by slow pyrolysis method [3]. Greenhouse experiments were carried out to study the effect of rice husk (RH) and rice husk biochar (RHB) application by rate of 30 ton ha^{-1} to alluvial soil samples collected from agricultural experiment station in the Northwestern Nile Delta, Egypt (see Table 1) for some RH, RHB and soil properties), and the seeds of wheat plants (Sakha 104 local cultivar) were emerged after adding third of N, all of P_2O_5 and K_2O by rates 60, 70 and 120 in the form of ammonium sulfate, single super phosphate and potassium sulfate, respectively. Then, two thirds of N was applied after 45 and 65 day of plant emergence.

Table 1. some characteristics of rice husk (RH), rice husk biochar (RHB) and soil used in the study

	OC, %	Total N, %	TP, %	TK, %	TFe, mg/kg	TMn, mg/kg	TZn, mg/kg	TCu, mg/kg
RH	27.9	1.19	0.4	0.62	233.4	78.6	41.6	16
RHB	36.6	0.52	0.54	88	248.2	90.6	50	17.6

	EC, dS/m	pH	OC, %	min.N, mg/kg	DTPA-extractable Micronutrients, mg/kg			
					Fe	Mn	Zn	Cu
Soil	6.23	7.81	2.9	104.6	3.17	2.93	2.58	0.14

The plants were irrigated by fresh water (S0) till 40 day of planting then irrigated by two levels of saline water had sodium chloride salinity equivalent 5 (S1) and 10 (S2) dSm^{-1} of electrical conductivity. At harvest, total weight of plants and grain weight were recorded, plant height, and number of spikes were measured. After oven drying of plants, N, Na and K in grains and straw were determined using ICAP Thermo model 6000 Series. Top 20-cm soil samples were withdrawn using soil tub to extract and distillate the remaining available nitrogen by 2.0 M KCl solution [4, 5]. Statistical analysis for all measured parameters was done using Costat software.

Results and Discussions

The results in Table (2) showed that grain and straw yield were highly affected by the application of both RH and RHB in all salinity treatments. Under non saline conditions (S0), RH addition increased grain and straw yield by about 60 and 33.3% whereas RHB application increased it about 10.4 and 2.5%, respectively. RH addition also increased the yield of grain (by 23.5 and 13.7%) and straw (by 17.1 and

3.9%) under the two salinity levels (S1 and S2) of irrigation water, respectively. RHB application only increased grain yield by about 17.3% and decreased straw yield by 3.3% in the pots irrigated with S1 water comparing with RHB-non treated pots. In S2-irrigated soils, RHB addition led to decrease both grain and straw yield by 2.9 and 4.74%, respectively. These findings are agreed with the results obtained by Zwieten et al. (2009) when applied papermill biochar in wheat plants grown in calcareous soils under greenhouse conditions [6]. It is observed that application of RHB increased the plant height and decreased the number of spikes per plant in all salinity treatments comparing with RH. Sodium percent in wheat straw in RHB treatments was greater than RH and non amended soil samples under all irrigation salinity levels (Table 2). These results reflect the higher content of Na in RHB and RH, and subsequent corresponded higher Na uptake, comparing to non amended soils. RHB was more beneficial in potassium uptake only under fresh irrigation water conditions where K content in grain increased about 35% more than in plants grown on non amended soil.

Table 2. Effect of RH and RHB application on the yield components and contents of Na, K and N in grains and straw of wheat plants irrigated with different saline water

Treatment	Grain yield (ton/ha)	Straw yield (ton/ha)	Plant height, cm	Spike No/pot	Na in straw, %	Na in grains, %	K in straw, %	K in grains, %	N in Grains, %	N in Straw, %
S0	2.99	8.45	82.67	34.67	0.21	0.07	1.93	0.45	1.14	1.17
S0 + RH	4.79	11.27	84.67	42.33	0.27	0.12	2.43	0.48	1.24	1.38
S0 + RHB	3.30	8.66	85.67	32.33	0.33	0.07	2.60	0.45	1.16	1.40
S1	3.67	8.65	74.33	38.33	0.56	0.13	2.67	0.47	1.14	1.42
S1 + RH	4.79	10.13	80.00	37.33	0.62	0.10	2.77	0.46	1.26	1.49
S1 + RHB	4.30	8.36	81.33	35.33	1.06	0.11	2.27	0.44	1.13	1.28
S2	3.83	8.66	78.00	34.67	1.30	0.12	1.80	0.46	1.23	1.16
S2 + RH	4.36	8.99	78.67	38.33	1.33	0.16	2.43	0.53	1.37	1.44
S2 + RHB	3.72	8.25	81.00	31.00	1.34	0.14	1.90	0.45	1.20	1.19

Nitrogen content in both wheat grain and straw slightly changed as a result of application RH and RHB. The highest N percents in grains and straw were obtained fro plant grown on RH-amended with all salinity levels of irrigation water. Whereas RHB application did not has significant effect on N content (Table 2). After plant harvest, the results of available mineral nitrogen (NH_4^+ + NO_3^-) in soil in the top 20-cm soil showed that RHB application saved more N in soil comparing to RH- and non-amended soils (Fig. 1) where about 35.3, 45.2 and 50.4% of mineral N in soils irrigated by S0, S1 and S2 water salinity, respectively, were remained in soil more than those occurred in corresponded non-amended soils. In contrast, concentrations of N in RH- amended soil were less than those in non-amended one with all corresponded salinity levels of water (Fig. 1) by about 15, 2.5 and 8.5%. These results indicate that studies of RHB application should be extended to the next growth seasons to explain its role in mineral fertilizer nitrogen conservation to the followed crops and its subsequent impact on crop production economies and further studies are needed to explore the role of different biochar sources as soil amendment for saline soils in arid areas.

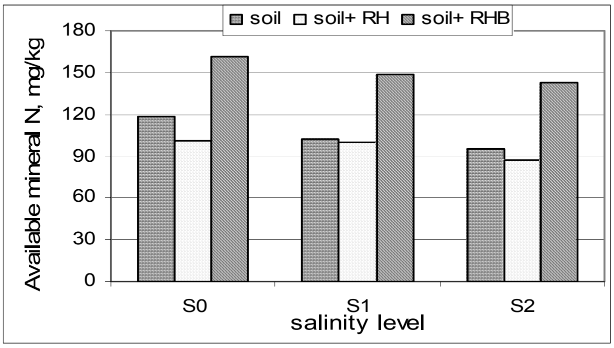

Figure 1. Soil mineral available N (NH_4^+ + NO_3^-) as a results of RH and RHB application to wheat grown on soil irrigated with different saline water.

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