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EFFECT OF RICE HUSK ASH AMENDMENT ON DROUGHT TOLERANCE AND NUTRITION OF WHEAT

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ABSTRACT

Drought is one of the stresses that affect the growth and yield of wheat. Silicon might alleviate this environmental stress and improve wheat yield. Based on this hypothesis, an experiment was conducted at the Soil Science Field Laboratory, Bangladesh Agricultural University, Mymensingh, to unfold the effects of Silicon (Si) on wheat using rice husk ash (RHA) as a source of Si. The experiment was laid out in a Split Plot Design with irrigation in the main plots and RHA amendments in the subplots. The water management treatments were irrigated and rainfed, and four levels of RHA viz. RHA_0-control, RHA_1-1.25, RHA_2-2.50 and RHA_3-5.00 t/ha were accommodated in the subplots with three replications. All the experimental plots received recommended doses of nutrients (N, P, K and S). Results showed that the interaction effect of irrigation and RHA treatments significantly affected wheat yield and yield contributing characteristics. The treatment IR RHA_3 (5.0 t/ha RHA with irrigation) produced the highest grain yield of 0.819 t/ha (32.5% increase over control) and straw yield of 1.55 t/ha (51% increase over control). The lowest grain yield and straw yield (0.62 and 1.16 t/ha, respectively) were found in control (RHA_1). Under non-irrigated conditions, RHA amendment increased grain and straw yields up to 8.6 and 35.5%, respectively, compared to control. The nutrient and Si content in wheat was also markedly influenced by the interaction effect of irrigation and RHA amendments. Available soil Si content increased with increasing RHA amendment. So, the application of 5.0 t/ha RHA could be a preventive measure for growing wheat in water stress areas of Bangladesh.

Key words: Drought, Silicon, rice husk ash (RHA), wheat, yield.

Introduction

Drought is one of the major problems in wheat cultivation in Bangladesh as it is grown during the dry winter and irrigation dependent. Seasonal drought cause yield loss of wheat; the extent of loss is viable in different regions of Bangladesh and between the years. A recent study on crop nutrition shows that micronutrients and macronutrients are essential for crop growth and development (Ahmad *et al*., 2016). Besides the nutrients, silicon (Si) is also needed for better growth and yield of wheat. However, its utility is still debatable due to the lack of evidence demonstrating its role in plant metabolism (Richmond *et al*., 2003). The Association of American Plant Food Control Officials (AAPFCO) has recognized Si as a "quassi essential" or "beneficial substance" based on its functionality on many crops. Si is regarded as the second most abundant element on earth's crust but it is not available for plants as it is found in polymerized form in nature. Plants can only absorb Si in the form of mono silicic acid (H_2SiO_4). Silicon increases drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under high transpiration rates (Hattori *et al*, 2005). Application of Si forms a silica cuticle double layer on leaf epidermal tissues that is responsible for higher water potential under low water condition (Matoh *et al.,* 1991). Application of Si could be a good solution as it develops drought tolerance of wheat as well as increase growth and yield of wheat. But Si is not yet available and marketed in Bangladesh as fertilizer. The alternative source of Si is a good solution from this perspective. Rice Husk Ash produced in farmer's kitchen is very rich in Si and many other nutrients. Therefore, the research was designed with the following objectives: i) to study the effect of rice husk ash amendment on growth and yield of wheat, ii) to see the effect of rice husk ash on the nutrients and silicon content in wheat and iii) to evaluate the effect of rice husk ash amendment on the drought tolerance in wheat.

Materials and Methods

A field experiment was carried out at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh on the year of 2018 to study the effects of Rice Husk Ash (RHA) on drought tolerance and nutrition of wheat (BARI Gom28). The experimental soil belongs to the Sonatala soil series under the AEZ of Old Brahmaputra Floodplain. Characteristically, the soil was silt loam having pH 6.20, organic matter content 1.18%, total N 0.075%, available P 17.6 ppm, exchangeable K 0.13 me 100/g soil, available S 13.76 ppm, exchangeable Na 0.297 me 100/g soil, exchangeable Ca 6.09 me 100/g soil, and CEC 14.02 me 100/g soil. The experiment was designed with 2 blocks (B1=Non-irrigated, B2=Irrigated) along with 4 treatments and laid out in RCBD with three replications. The unit plot size was 4 m x 2.5 m. The treatments used in the experiment were T_0=Rice Husk Ash 0 kg/ha, T_1= Rice Husk Ash 1.25 kg/ha, T_2= Rice Husk Ash 2.5 kg/ha, T_3= Rice Husk Ash 5 kg/ha. The recommended fertilizer doses applied for the experiment were Urea 250kg/ha, TSP 150 kg/ha, MoP 180 kg/ha, Gypsum 94 kg/ha respectively. In the meantime, Rice Husk Ash (RHA) a supplementary for Si was applied for 4 treatments in two installments (0.625 kg, 1.25 kg, 2.5 kg). 1st dose of ash was applied on 27 December 2018 and the 2nd dose was applied on 15 January 2019. Intercultural operations were done as and when necessary. The crop was harvested at full maturity on 24 March 2019. Samples were collected randomly from plots sized $2m^2$ to record the yield contributing characters. Grain and straw samples were collected, dried, ground, sieved and kept for chemical analysis. All the data were statistically analyzed and mean comparison was made by Duncan's Multiple Range Test (DMRT). The analysis of different yield characters as well as for different nutrient concentration was made by the program Minitab-19.

Results and Discussion

Yield contributing characters like plant height, spike length, spikelet, field grain and 1000 grain weight were analyzed and found statistically non-significant results for plant height, spike length and 1000 grain weight respectively in case of irrigation section. On the contrary, spikelets/spike and filled grains/spike showed statistically significant results. For the number of spikelets/spike, the highest was found in IR (Irrigated) and the lowest was found in NIR (Non-Irrigated). In case of filled grain, IR (Irrigated) had the highest value and NIR (Non-Irrigated) had the lowest. However, RHA application, plant height showed non-significant results whereas spike length, spikelets/spike, field grain, 1000 grain weight showed statistically significant results. The highest value for significant results *viz.* spike length, spikelets/spike, field grain, 1000 grain weight were 9.04, 15.29, 34.30, 45.49 found in RHA_3 respectively and the lowest value was obtained in RHA_1 with the values of 7.70, 12.74, 25.83. Whereas their interaction effects showed results non-significant (Table 1).

There was significant effect of ash on grain yield and straw yield of wheat (BARI Gom28) in respect of irrigation water management system. The grain yield as well as straw yield found highest both in irrigated field. On the contrary, non-irrigated condition showed decreased values both in grain and straw yield. There was a significant increase over control in both cases as there were production of 16 and 14% grain and straw yield over control recognized as non-irrigated field. Again the RHA application provided a statistically significant result in both grain yield and straw yield. It was found that the highest amount of grains and straws were produced both in RHA_3 with the values of 0.819 and 1.548 t/ha respectively. The lowest value was obtained in RHA_0 and there was 7, 14, 17% and 13, 18, 35% increase over control in respect of grain yield and straw yield. However, grain yield and straw yield also found statistically significant results in their interaction section. IR RHA_3 (Irrigated, Ash 5 t/ha) gave the highest yield in the field of grain yield with 32.5% increase over control and 51% increase in straw yield respectively. The lowest grain yield along with straw yield was produced from NIR RHA_2 (irrigated, ash 2.5 t/ha), NIR RHA_1 (irrigated, ash 1.25 t/ha) with an increase of 4.5% and 13.3% respectively as illustrated in Table 2. K content of BARI Gom28 was significantly influenced due to the effect of irrigation condition. K was found high in irrigated field with a value of 0.37%. Among other nutrient contents, N (1.96%), P (0.95%), S (0.39%) found highest in irrigated field though the results were not statistically influenced. Besides, RHA application gave statistically significant results for N and K with their highest values 2.11, 0.34% found in

T_3. In contrast, P and S content were found non-significant in RHA application. In case of their interactions, K showed statistically significant results only whereas N, P and S found non-significant. IR RHA_3 (Irrigated, Ash 5 t/ha) gave the highest values in all cases. The lowest value of N (1.74%), P (0.88%), K (0.27%), S (0.10%) was obtained from IR RHA_0 (irrigated, ash 0 t/ha), NIR RHA_2 (non-irrigated, ash 2.5 t/ha), NIR RHA_0 (non-irrigated, ash 0 t/ha) respectively as presented in Table 3.

Table 1 Effect of irrigation and RHA amendment on the yield contributing

Treatment	Plant height (cm)	Spike length (cm)	Spikelets/spike (No.)	Filled grains/spike (No.)	1000 grain weight (g)
Irrigation					
NIR	81.92±0.78	8.54±0.14	13.99±0.34b	28.92±1.10b	43.23±0.56a
IR	82.30±0.70	8.64±0.22	15.10±0.39a	33.20±1.45a	43.45±0.86a
P value	0.713	0.508	0.002	0.003	0.810
Ash					
RHA_0	81.42±0.88	7.70±0.18b	12.74±0.36b	25.83±1.25b	41.63±0.66a
RHA_1	83.49±0.47	8.84±0.14a	15.21±0.38a	33.08±1.52a	42.62±0.58ab
RHA_2	83.04±0.89	8.77±0.15a	14.93±0.42a	31.04±1.82a	43.62±1.03ab
RHA_3	83.50±1.38	9.04±0.16a	15.29±0.32a	34.30±1.60a	45.49±1.12b
P value	0.175	0.000	0.000	0.001	0.041
Irrigation x Ash					
NIR RHA_0	81.46±1.84	7.93±0.29bc	12.42±0.63c	25.48±2.49d	41.48±1.07a
NIR RHA_1	82.56±0.46	8.72±0.19ab	14.61±0.39ab	30.70±1.52abcd	41.84±0.55a
NIR RHA_2	83.84±0.96	8.54±0.12ab	14.12±0.31abc	27.32±1.59bcd	43.64±2.20ab
NIR RHA_3	79.83±2.12	8.96±0.12a	14.81±0.31ab	32.19±1.11abcd	44.16±1.89ab
IR RHA_0	81.37±0.72	7.47±0.12c	13.07±0.37bc	26.17±1.23cd	41.77±0.78a
IR RHA_1	84.42±0.14	8.95±0.13a	15.82±0.46a	35.46±1.90ab	43.39±0.88ab
IR RHA_2	82.24±1.57	9.01±0.21a	15.74±0.33a	34.76±0.51abc	43.60±0.66ab
IR RHA_3	81.18±2.14	9.11±0.33a	15.79±0.43a	36.42±2.65a	46.83±0.95b
P value	0.632	0.182	0.697	0.324	0.419

Table 2 Effect of irrigation and RHA amendment on the yields (grain & straw) of BARI Gom28

Treatment	Grain Yield (t/ha)	% increase over control	Straw yield (t/ha)	% increase over control
Irrigation				
NIR	0.645.5±8.6b		1.187±40b	
IR	0.746±21a	16	1.351±44a	14
P value	0.000		0.000	
Ash				
RHA_0	0.636±9.7c		1.090±30.3d	
RHA_1	0.679±18b	7	1.229±32c	13
RHA_2	0.723±36a	14	1.290±55b	18
RHA_3	0.745±34a	17	1.469±37a	35
P value	0.000		0.000	
Irrigation x Ash				
NIR RHA_0	0.618±6c		1.025±12e	
NIR RHA_1	0.647±22bc	4.7	1.161±12d	13.3
NIR RHA_2	0.646±12bc	4.5	1.172±22d	14.3
NIR RHA_3	0.671±17bc	8.6	1.389±19b	35.5
IR RHA_0	0.653±12bc	5.7	1.154±17d	12.6
IR RHA_1	0.711±11b	15	1.296±17c	26.4
IR RHA_2	0.801±17a	29.6	1.407±29b	37.3
IR RHA_3	0.819±13a	32.5	1.548±7a	51
P value	0.001		0.033	

Table 3 Effect of irrigation and RHA amendments on nutrient contents in grain of BARI Gom28

Treatment	%N	%P	%K	%S
Irrigation				
NIR	1.89±0.05	0.87±0.04	0.30±0.0152b	0.34±0.06
IR	1.96±0.06	0.95±0.03	0.37±0.0081a	0.39±0.03
P value	0.274	0.234	0.000	0.404
Ash				
RHA_0	1.75±0.05b	0.86±0.038	0.36±0.012a	0.24±0.067
RHA_1	1.89±0.04ab	0.89±0.042	0.32±0.019a	0.36±0.11
RHA_2	1.99±0.06a	0.91±0.065	0.32±0.025a	0.42±0.033
RHA_3	2.11±0.07a	0.98±0.086	0.34±0.025a	0.46±0.030
P value	0.003	0.633	0.037	0.099
Irrigation x Ash				
NIR RHA_0	1.76±0.09	0.87±0.16	0.27±0.008ab	0.10±0.042
NIR RHA_1	1.85±0.03	0.89±0.037	0.29±0.025cd	0.39±0.038
NIR RHA_2	1.9±0.117	0.88±0.11	0.28±0.014d	0.42±0.047
NIR RHA_3	2.03±0.09	0.84±0.056	0.38±0.014cd	0.46±0.19
IR RHA_0	1.74±0.06	0.88±0.056	0.33±0.008bc	0.27±0.11
IR RHA_1	1.92±0.08	0.90±0.086	0.36±0.008ab	0.37±0.044
IR RHA_2	2.01±0.03	0.93±0.092	0.37±0.008ab	0.44±0.057
IR RHA_3	2.18±0.09	1.07±0.024	0.39±0.008a	0.49±0.029
P value	0.785	0.720	0.000	0.103

Table 4 Effect of irrigation and RHA application on Si contents in wheat grain and postharvest soils

Treatment	Si content (Grain)	Si content (Postharvest Soil)
Irrigation		
NIR	0.45±3b	16.79±0.92b
IR	0.59±0.1a	22.09±1.34a
P value	0.000	0.000
Ash		
RHA_0	0.45±0.47c	16.01±0.65b
RHA_1	0.48±0.44bc	19.23±2.44ab
RHA_2	0.54±0.38b	20.61±2.43a
RHA_3	0.61±0.18a	21.82±1.96a
P value	0.000	0.000
Irrigation x Ash		
NIR RHA_0	0.35±0.16c	14.59±2.14
NIR RHA_1	0.39±0.43c	16.29±2.01
NIR RHA_2	0.46±0.32bc	17.71±2.04
NIR RHA_3	0.59±0.22a	18.61±1.10
IR RHA_0	0.55±0.26ab	17.62±0.8
IR RHA_1	0.56±0.21ab	22.18±3.48
IR RHA_2	0.62±0.04a	23.51±2.25
IR RHA_3	0.65±0.12a	25.03±2.54
P value	0.060	0.060

Si content for both grain and postharvest soil found significant due to the effect of irrigation condition. Si was increased in case of IR (irrigated condition) compared to NIR (rainfed condition). In case of RHA, the value showed significant results of Si (grain and postharvest soil) ranged from 0.45 to 0.61 ppm and 16.01 to 21.82 ppm respectively. The highest amount of Si found in the interaction section in IR RHA_3 (Irrigated, Ash 5 t/ha) and IR RHA_1 (irrigated, ash 1.25 t/ha) in respect of grain and straw a shown in Table 4.

Si application increases crop production (Tahir *et al*., 2012). Many effective mechanisms, including water content, can be boosted by silicate application (Singh *et al*., 2021). Silicate not only provides rigidity and strengthens the cell wall but produced elasticity in the cell elongation process. Hattori *et al*. (2008) found that silicate plays a vital role in cell division and cell expansion with the help of its effects on RNA and DNA synthesis. Yadav *et al*. (2015) reported that the grain yield of the wheat could be improved by foliar application of silicon. It has also been reported that silicon can improve the defense system as an antioxidant and provide protection to the photosynthetic pigments (Ashraf *et al*., 2010). Silicon is accumulated in leaf and chaff, with very little amount entering in seed and creates a significant effect in maintaining nutrients concentration in leaves and soil. Lux *et al*. (2003) proposed that Si plays an essential role in water transportation and enhancing the development of roots under drought stress conditions in sorghum crops. The available Si content in the postharvest soil increased with increasing RHA application. Moreover, the increased Si content in grain with increasing RHA amendments in both irrigated and non-irrigated conditions indicates the effect of Si on the drought tolerance in wheat.

Conclusion

The present study evaluated the effects of rice husk ash as Si amendment on drought tolerance and nutrition of wheat in the Soil Science field laboratory at Bangladesh Agricultural University, Mymensingh. The non-irrigated field showed a decreased result in all parameters compared to the irrigated field. RHA amendment increased the performance of all the parameters compared to their respective control. From the entire observation, it is distinct that the RHA amendment has the potential to improve the performance of all the parameters under non-irrigated water stress conditions.

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