Int.J.Curr.Microbiol.App.Sci (2018) *7*(3): 899-906

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 03 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.703.105

Potential Use of Rice Husk Ash for Enhancing Growth of Maize (*Zea mays*)

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Keywords

Rice husk ash, Maize growth

Article Info

Accepted:
10 February 2018
Available Online:
10 March 2018

A B S T R A C T

Rice husk ash can be a substitute for inorganic fertilizers or can be used in combination along with inorganic fertilizers, as an amendment to acidic soils, as a carrier for biofertilizers, etc. It can increase the pH in acid soils and there by nutrient availability and can affect the hydro-physical properties. The magnitude of these effects depends on the characteristics of the rice husk ash (RHA) and the soil, the RHA dosage, and the interaction between soil and RHA (Gonçalves and Bergmann, 2007). Rice husk with pH and EC of 8.94 and 1.08 dS m^{-1} was taken for an experiment with maize under pot culture conditions. The maximum leaf area (45.5cm^2) of maize was observed in the treatment with 100% NP+ 25% K + 15 t ha^{-1} RHA whereas the maximum SPAD chlorophyll value (45.5) was observed in the treatment with 100% NP+75% K +5 t ha^{-1} RHA. The higher plant height (76.6 cm) was observed in the treatment with 100% NP+50% K +10 t ha^{-1} RHA and the highest shoot root ratio (5.54) was observed in the treatment with 100% NPK. Substitution of rice husk ash @ 10 t ha^{-1} along with 50 % of recommended K can enhance maize growth and growth parameters.

Introduction

Rice husk ash produced industrially during combustion of rice husk for various purposes such as power generation is a mixture of ash, charred hull and fresh rice husk at different proportions. It is light in weight, has low bulk density, increases the soil pH, improves the aeration in the crop root zone and also increases the water holding capacity and level of exchangeable potassium and magnesium (AICOAF, 2001). Annually, for an average production of 120 million tonnes of paddy, about 24 million tonnes of the husk is produced during milling. This generates about 4.4 million tonnes of rice husk ash (RHA) (15% of rice husk) annually (Gonçalves and Bergmann, 2007). This large residue volume poses a serious threat to environment with regard to waste disposal. The chemical constituents include silica, calcium, magnesium, phosphorus, potassium, sodium, iron, carbon and nitrogen. Amount of nutrients vary with the temperature and time which the husk is burnt. Priyadharshini *et al.*, (2009) found that RHA application @ 4.5 t ha^{-1} results the high number of nodules and nodule weight and significantly higher yield in cowpea. Abukari (2014) found that combined treatment of 4 t ha^{-1} RHA+ 90 kg N recorded

the highest maize grain yield of 2.84 t ha^{-1} and the control, the lowest (0.8 t ha^{-1}). The yield of maize crop with a dosage of 3 t ha^{-1} RHA was 5.75 t ha^{-1} and that of control plot was 0.34 t ha^{-1} (Nwite *et al.,* 2011). Thind *et al.,* (2012) recorded that application of rice husk ash at 10 t ha^{-1} to wheat increased the grain yield of wheat by 25 percent.

Muntohar *et al.,* (2002) found that RHA reduces the swelling potential of the soil when applied along with lime. Onwudike *et al.,* (2015), found that RHA @ 5 t ha^{-1}, the bulk density of the soil decreased from 1.44 g cm^{-3} to 1.39 g cm^{-3}, whereas the total porosity and moisture content increased from 45.7% and 129.4 g kg^{-1} to 47.5% and 134.2 g kg^{-1} respectively. Application of 10 t $ha^{-1}$of RHA to either rice or wheat for three years supplied a total of 58 kg P ha^{-1}. Application of RHA to both rice and wheat compared with their application either to wheat or rice showed greater effects in increasing the Olsen-P and Pi fractions in the surface soil layer (Singh *et al.,* 2013).

Materials and Methods

pH and EC was determined at 1:5 ratio as per Jackson (1973). Bulk density, particle density and porosity were determined with cylinder method (Tan, 1998). Water soluble and NH_4Ac –extractable Ca, Mg, Na, K were determined as per Jackson (1973). Soil available N, P and K were determined as per Subbiah and Asija (1956), Olsen *et al.,* (1954) and Stanford and English (1949), respectively. Total N, P and K in maize plant were determined as per Humphries (1956), Jackson (1973) and Toth and Prince (1949), respectively. The experiment was conducted seven treatments viz., T_1 - Absolute control, T_2 – 100% NPK, T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4– 100% NP + 75% K + 5 t ha^{-1} RHA, T_5 - 100% NP + 50% K +10 t ha^{-1} RHA, T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA and T_7 - 100% NP + 20 t ha^{-1} RHA in three replications under Completely Randomised Design. The test crop was maize (TNAU maize hybrid CO6).

Five kilograms of soil (Brown non calcareous) was taken in a plastic pot and the treatments were imposed. Maize seeds were sown on 27.02.2017, treatments were imposed and harvested after 45 days after sowing. The parameters recorded were, leaf area and plant height during 15, 30 and 45 days after sowing, shoot weight, root weight, root length and root volume at 45 days after sowing. SPAD meter readings were recorded during 15, 30 and 45 days using Chlorophyll Meter (SPAD 502) designed by the Soil Plant Analytical Development (SPAD) section, Minolta, Japan. The Minolta SPAD-502 measures chlorophyll content as ratio of transmittance of light at wavelength of 650 nm and 940 nm. Three readings were taken from each replication and the average value computed using method described by Minolta (1989).

Results and Discussion

Characteristics of initial soil

Initial soil was analysed for pH, EC, bulk density, particle density, $KMnO_4$-N, Olsen-P and NH_4Ac-K. The pH of the initial soil was 6.5. Electrical Conductivity was 0.17 dS m^{-1}. Bulk density and Particle density of the soil were 1.25 and 1.60 Mg m^{-3} respectively. $KMnO_4$-N, Olsen-P and NH_4Ac-K were 224, 39.0 and 656 kg ha^{-1} respectively.

pH and EC of RHA were found to be 8.94 and 1.08 dS m^{-1}. Bulk density, particle density and porosity were found to be 0.22 Mg m^{-3}, 0.23 Mg m^{-3} and 4.35 % respectively. Water soluble Ca, Mg, Na and K were 300, 60, 362 and 740 mg kg^{-1}. NH_4Ac –extractable Ca, Mg, Na and K were 2750, 150, 333 and 2722 mg kg^{-1}.

Effect of RHA on plant growth parameters

Leaf Area

The leaf area during 15 DAS varied from 35.5 and 46.4 cm^2. The highest leaf area (46.4cm^2) was observed in the treatment with 100% NP+ 50% K + 10 t ha^{-1}. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4– 100% NP + 75% K + 5 t ha^{-1} RHA and T_5 - 100% NP + 50% K +10 t ha^{-1} RHA were significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

On 30th day, the leaf area varied from 178.9 to 323.7cm^2. The maximum value (323.7cm^2) was observed in the treatment with 100% NP+50% K+10 t ha^{-1}. The treatments T_4 – 100% NP + 75% K + 5 t ha^{-1} RHA, T_5– 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K +15 t ha^{-1} RHA were significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The leaf area on 45 DAS varied from 221.8 and 396.0cm^2. The highest leaf area (396.0cm^2) was observed in the treatment with 100% NP, 25% K and 15 t ha^{-1} RHA. The treatments T_4 –100% NP + 75% K + 5 t ha^{-1} RHA, T_5– 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K +15 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The mean value of leaf area varied from 146.6 and 251.3cm^2. The maximum leaf area (251.3cm^2) was observed in the treatment with 100% NP+25% K+15 t ha^{-1} RHA. The treatments T_4 –100% NP + 75% K + 5 t ha^{-1} RHA, T_5– 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K +15 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

Similar findings with application of rice husk biochar on enhancement of leaf width and leaf length of spinach was observed by Milla *et al.*, (2013).

Chlorophyll content

The SPAD chlorophyll values on 15 DAS varied from 32.4 and 42.8. The highest chlorophyll content (42.8) was observed in the treatment with 100% NP + 20 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{-1} RHA, T_5– 100% NP + 50% K + 10 t ha^{-1} RHA,T_6 - 100% NP + 25% K +15 t ha^{-1} RHA and T_7 - 100% NP + 20 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

On 30th day, the SPAD chlorophyll values varied from 36.0 to 45.5. The maximum value (45.5) was observed in the treatment with 100% NP+75% K + 5 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA and T_4 –100% NP + 75% K + 5 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control. The SPAD chlorophyll values on 45 DAS varied from 39.4 and 48.9. The highest chlorophyll content (48.9) was observed in the treatment with 100% NP+75% K + 5 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA and T_4 –100% NP + 75% K + 5 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control (Table 1).

The mean value of SPAD chlorophyll values varied from 35.9 and 45.3. The maximum chlorophyll content (45.5) was observed in the treatment with 100% NP+75% K +5 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{-1} RHA and T_5– 100% NP + 50% K + 10 t ha^{-1} RHA significantly differ from others and found to be on par.

Table.1 Effect of treatments of leaf area and SPAD chlorophyll of Maize

Treatments	Leaf area (cm^2)				SPAD chlorophyll readings			
	15 DAS	30 DAS	45 DAS	Mean	15 DAS	30 DAS	45 DAS	Mean
T_1 - Absolute control	35.5	178.9	221.8	**146.6**	32.4	36.0	39.4	**35.9**
T_2 – 100% NPK	41.1	275.5	336.4	**217.7**	38.5	40.7	45.1	**41.4**
T_3 – 100% NPK + 5 t ha^{-1} RHA	42.1	283.1	339.7	**221.6**	39.5	43.5	47.5	**43.5**
T_4– 100% NP + 75% K + 5 t ha^{-1} RHA	43.3	303.1	369.0	**238.5**	41.5	45.5	48.9	**45.3**
T_5 - 100% NP + 50% K +10 t ha^{-1} RHA	46.4	323.7	378.7	**249.6**	42.1	42.3	45.1	**43.2**
T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA	41.4	316.6	396.0	**251.3**	42.2	40.8	40.6	**41.2**
T_7 - 100% NP + 20 t ha^{-1} RHA	39.1	263.1	292.2	**196.9**	42.8	39.9	40.4	**41.0**
Mean	**41.3**	**277.7**	**333.4**		**39.9**	**41.2**	**43.9**	
SEd	2.20	15.57	25.58		1.73	1.14	1.17	
CD (p=0.05)	4.72	33.40	54.86		3.71	2.44	2.51	

Table.2 Effect of treatments on plant height and root and shoot parameters and total dry matter of maize

Treatments	Plant height (cm) at days after sowing				Root and shoot parameters and total dry matter (per plant) at 45 Day after sowing					
	15	30	45	Mean	Shoot weight (g)	Root weight (g)	Total Dry matter (g)	Root length (cm)	Root volume (cm^3)	Shoot/ Root ratio
T_1 - Absolute control	29.3	65.4	72.5	**55.8**	5.6	1.66	7.9	28.0	4.7	3.40
T_2 – 100% NPK	32.0	85.1	94.8	**70.6**	11.8	2.13	13.9	33.5	10.7	5.54
T_3 – 100% NPK + 5 t ha^{-1} RHA	32.4	89.7	95.5	**72.5**	12.5	3.14	15.6	36.8	11.3	3.98
T_4– 100% NP + 75% K + 5 t ha^{-1} RHA	32.7	91.2	96.3	**73.4**	13.6	3.49	17.1	37.2	12.0	3.89
T_5 - 100% NP + 50% K +10 t ha^{-1} RHA	34.7	92.3	102.8	**76.6**	13.8	3.57	17.3	43.0	14.0	3.85
T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA	31.6	91.7	94.0	**72.4**	12.1	3.18	14.6	42.2	10.0	3.79
T_7 - 100% NP + 20 t ha^{-1} RHA	30.5	81.3	84.0	**65.3**	10.0	2.89	12.5	37.3	7.3	3.46
Mean	**31.9**	**85.2**	**91.4**		**11.3**	**2.86**	**14.1**	**36.9**	**10.0**	**4.00**
SEd	0.77	2.22	4.60		0.82	0.16	0.88	2.29	0.59	0.42
CD (p=0.05)	1.65	4.76	9.87		1.77	0.34	1.88	4.92	1.27	0.90

The lowest value was recorded in absolute control. Leaf chlorophyll content was enhanced with the application of rice husk biochar to spinach (Milla *et al.*, 2013).

Plant height

The plant height on 15 DAS varied from 29.3 and 34.7 cm. The highest plant height (34.7 cm) was observed in the treatment with 100% NP+ 50% K+ 10 t ha^{-1} RHA. The treatment T_5– 100% NP + 50% K + 10 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

On 30th day, the plant height varied from 65.4 to 92.3 cm. The maximum value (92.3 cm) was observed in the treatment with 100% NP + 50% K +10 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{-1} RHA, T_5– 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The plant height on 45 DAS varied from 72.5 and 102.8 cm. The highest plant height (102.8 cm) was observed in the treatment with 100% NP + 50% K +10 t ha^{-1} RHA. The treatments T_2 – 100% NPK, T_3 - 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{1} RHA, T_5 - 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The mean value of plant height varied from 55.8 and 76.6 cm. The maximum mean plant height (76.6 cm) was observed in the treatment with 100% NP+50% K +10 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{-1} RHA,T_5– 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

Fawzy *et al.,* (2005) showed that potassium fertilizer had a significant effect on the fresh weights of leaves and stems, early and total yield of sweet pepper plants. This result is supported by Chen *et al., (*1996) on eggplant and Al-Karaki (2000) and Gupta and Sengar (2000) on tomato plant who mentioned that increasing vegetative growth is due to increasing potassium fertilizer levels. Along with potassium RHA could have supplied sufficient Si to maize crop. The RHA application to rice nurseries seems to be an efficient way of recycling plant Si and have agronomic and environmental benefits, especially in developing countries (Sistani *et al.*, 1997).

Shoot and root parameters

The shoot weight varied from 6.3 and 13.8g. The highest shoot weight (13.8g) was observed in the treatment with 100% NP+ 50% K + 10 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{-1} RHA and T_5– 100% NP + 50% K + 10 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The root weight varied from 1.56 g and 3.57 g. The highest root weight (3.57 g) was observed in the treatment with 100% NP+ 50% K+ 10 t ha^{-1} RHA. The treatments T_4 – 100% NP + 75% K + 5 t ha^{-1} RHA and T_5– 100% NP + 50% K + 10 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The total dry matter varied from 7.9 and 17.3g. The highest total dry matter (17.3 g)

was observed in the treatment with 100% NP+ 50% K + 10 t ha^{-1} RHA. The treatments T_3 – 100% NPK + 5 t ha^{-1} RHA, T_4 –100% NP + 75% K + 5 t ha^{-1} RHA and T_5– 100% NP + 50% K + 10 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The root length varied from 28.0 and 43.0 cm. The highest root length (43.0 cm) was observed in the treatment with 100% NP+ 50% K +10 t ha^{-1} RHA. The treatmentsT_5– 100% NP + 50% K + 10 t ha^{-1} RHA and T_6 - 100% NP + 25% K + 15 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The root volume varied from 4.7 and 14.0 cm. The highest root volume (14.0 cm) was observed in the treatment with 100% NP+ 50% K + 10 t ha^{-1} RHA. The treatmentT_5 – 100% NP + 50% K + 10 t ha^{-1} RHA significantly differ from others and found to be on par. The lowest value was recorded in absolute control (Table 2).

The shoot to root ratio varied from 3.40 and 5.54. The highest shoot root ratio (5.54) was observed in the treatment with 100% NPK. The treatment T_2 – 100% NPK significantly differ from others and found to be on par. The lowest value was recorded in absolute control.

The simulative effect may be due to the role of potassium on production of enzyme activity and enhanced translocation of assimilative and photosynthesis (El-Desuki *et al.,* 2006). Similar results were recorded in cowpea (Priyadharshini *et al.,* 2009) and wheat (Thind *et al.,* 2012). Onwudite *et al.,* (2015) have also demonstrated that ashes of agro-wastes increase crop yield.

Rice husk ash found to be used in combination along with inorganic fertilizers to enhance crop production. It can enhance nutrient availability and can affect the hydro-physical properties. In the present study, it was observed that application of RHA in combination N and P fertilizer enhances chlorophyll content, plant height, shoot weight, root length, root weight, root volume and total dry matter content of maize. It can be concluded that substituting rice husk ash @ 10 t ha^{-1} along with 50 % of recommended K can enhance maize growth.

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How to cite this article:

Saranya, P., C.M. Sri Gayathiri and Sellamuthu, K.M. 2018. Potential Use of Rice Husk Ash for Enhancing Growth of Maize (*Zea mays*). *Int.J.Curr.Microbiol.App.Sci.* 7(03): 899-906.
doi: https://doi.org/10.20546/ijcmas.2018.703.105