

Effect of Rice Straw and Husk Biochar on Vegetative Growth and Yield Attributes of *Oryza sativa* L

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Abstract: A research was conducted to evaluate the growth and yield of rice as influenced by rich straw and husk biochar along with chemical fertilizer. The experiment was done with six treatments. T1- recommended chemical fertilizer, T2- Rice straw (1.0 t/ha), T3-Rice husk biochar (1.0 t/ha), T4-Rice straw (0.5 t/ha) + Rice husk biochar (0.5 t/ha), T5-Rice straw (1.0 t/ha) + Rice husk biochar (0.5 t/ha) and T6-Rice straw (1.0 t/ha) + Rice husk biochar (1.0 t/ha). Recommended chemical fertilizer was incorporated to all the treatments. During the vegetative periods, the growth parameters were recorded and finally yield analysis was done. Rice plants treated in rice straw (1.0 t/ha) and husk biochar (1.0 t/ha) along with chemical fertilizer had significantly ($P < 0.05$) higher mean values of leaf area (185.93 cm²), number of tillers (4.0), number of roots per plant (105.33) and also dry weights of shoots (5.15 g) and roots (4.27 g) per plant when comparing chemical fertilizer alone. Average number of grains (187.67), number of filled grains (170.33) and filled grain weight per panicle (3.142 g) was also considerably increased in rice straw (1.0 t/ha) and husk biochar (1.0 t/ha) treatment followed by husk biochar (1.0 t/ha) treatment than those in the control. There were no significant difference ($P > 0.05$) in 100 seed weight between them. Hence, it can be concluded that addition of rice straw (1.0 t/ha) and husk biochar (1.0 t/ha) along with chemical fertilizer to rice field is feasible to increase the grain yield under local conditions.

Key words: Biochar, Rice straw, Rice husk, Rice, Seed weight

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for millions people in Asia. Per capita rice consumption is around 100 kg per year (Somaratne, 2010). In rice cultivation, fertilizer application is an essential practice to obtain potential yield therefore effective way of fertilizer application is an important (Gamage et al., 2012) to maximize the crop production. But the excess use of chemical fertilizer causes under ground water pollution and destroys soil biota (Somaratne, 2010). Organic fertilizers are good source of plants nutrients which are essential for improvement of soil fertility and crop yield (Oladipo et al., 2005).

In Sri Lanka, rice straw and husk is available as waste annually which can be utilized to improve soil. Paddy straw is an obtainable in large quantity. It has high C:N ratio therefore

can be used with other organic materials to improve soil water retention and nutrients. Rice husk can also be used as organic material in rice cultivation to reduce environmental problem. The partially burned rice husk (husk biochar) enhances the water holding capacity (Milla et al., 2013) and increases available potassium and magnesium (Gaskin et al., 2010). This experiment was carried to study the effect of rice straw and husk biochar along with inorganic fertilizers on vegetative growth and panicle performance of rice.

MATERIALS AND METHODS

The experiment was done in 2014-2015 at the Agricultural Research Station, Sammanthurai in Eastern region of Sri Lanka. The soil type is non-calcic brown soil and the Latitude between 7^o 22N and

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Longitude 81°48E. The mean temperature is 30°C and annual rain fall is 1400 mm.

Rice variety used in this study was At 307 which is a high yielding variety and recommended for cultivation in island wide. It was laid out in RCBD with three replications. The treatments were as follows:

T1 - Chemical fertilizers only

T2 - 1.0 t/ha rice straw + chemical fertilizer

T3 - 1.0 t/ha rice husk biochar (RHB) + chemical fertilizers

T4 - 0.5 t/ha rice straw + 0.5 t/ha RHB + chemical fertilizers

T5 - 1.0 t/ha rice straw + 0.5 t/ha RHB + chemical fertilizers

T6 - 1.0 t/ha rice straw + 1.0 t/ha RHB + chemical fertilizers

The size of plots was 1.5 m x 1.5 m. Decayed rice straw and husk biochar were incorporated with soil before one month of seeding for decaying. Rice variety, At 307 was used in this experiment and required seed rate of rice per plot is 35 g. Triple super phosphate (55 kg/ha) and zinc sulphate (5 kg/ha) were applied prior to sowing. The recommended fertilizer mixture containing 225 kg/ha urea and 60 kg/ha Muriate of potash was applied after sowing.

All agronomic practices were carried out as recommended by the Department of Agriculture. Growth parameters were taken at 15 days interval after sowing upto 60 days. Each parameter was recorded in randomly selected plants. Samples were placed in oven at 105 °C to record dry weight of shoot and root. In each treatment, leaf area was measured by portable leaf area meter (L-1 3000 c).

Data were analyzed using SAS. Tukey's test was done at 5% significant level to compare the difference among treatment mean values.

RESULTS AND DISCUSSION

Leaf area

There was significant difference in Leaf area among the treatments at 45 and 60 days after planting (DAP). Statistical analysis showed that there were no significant differences ($P > 0.05$) on average leaf area at 15 and 30 DAP (Table 1). At 60 DAP, treatment T1 had significantly ($P < 0.05$) lower value in leaf area than other treatments. Agusalim et al. (2010) revealed that addition of rice husk biochar increased the number of rice tillers compared to untreated soil. It correlated with number of leaves. The higher leaf number attributes to higher leaf area. The maximum leaf number of was recorded in T6 followed by in T3.

Number of tillers

The results showed that there were significant variations ($P < 0.05$) in mean number of tillers among the treatments at 45 and 60 DAP (Table 2). Higher number of tillers was recorded in T6 than the other treatments except T3. Mean number of tillers ranged from 2.8 to 4.0. (Gamage et al., 2012) showed that incorporation of rice husk charcoal to the rice field improved soil fertility to give more yield of rice.

Number of roots

The result showed that the number of roots was remarkably differed ($P < 0.05$) among the treatments (Table 3). No significant difference in number of roots was recorded among the treatments at 15 DAP thereafter significant differences were observed.

At 30 DAP, maximum mean number (23.16) of root was recorded in T6 followed by 22.83 in T3 and 21.83 cm in T2 while minimum number of root of 18.33 was recorded in T1. After 15 DAP, there was significant variation ($P < 0.05$) on number of roots between the treatments T1 and T6. After 30

DAP, number of roots was high in RHB treated soil compared with untreated soil. At 60 DAP, the highest mean number of roots (105.33) was recorded in T6. It may be due to combined application of rice straw and husk biochar which improves soil properties for better root system. Solaiman et al. (2010) reported that biochar amended soil has high nutrient uptake.

Table 1: Effect of rice straw and husk biochar on the leaf area at different growing periods.

Treatments	Leaf area (cm ²) per plant			
	15 DAP	30 DAP	45 DAP	60 DAP
T1	3.09±0.26	25.72±2.83	110.15±5.01ab	122.73±6.18c
T2	3.23±0.15	31.16±1.69	110.48±2.14ab	157.20±7.26b
T3	2.74±0.56	31.28±3.53	112.31±3.73ab	174.57±2.38a
T4	2.83±0.78	27.84±5.90	106.50±4.95b	159.68±6.96b
T5	2.71±0.23	30.54±3.01	110.43±1.36ab	164.37±5.65ab
T6	3.19±1.38	40.95±0.38	124.03 ±7.87a	185.93±5.45a
F test	ns	ns	*	*
CV%	33.9	18.8	7.4	9.9

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Table 2: Effect of rice straw and husk biochar on tiller numbers at different growing periods.

Treatments	Number of tillers per hill		
	30 DAP	45 DAP	60 DAP
T1	0.00±0.00	2.50±0.41b	2.83±0.81c
T2	0.50±0.29	2.60±0.33b	3.00±0.33bc
T3	0.30±0.33	3.17±0.76ab	3.67±0.33ab
T4	0.17±1.20	2.67±0.44b	3.33±0.20b
T5	0.17±0.44	2.67±0.39b	3.33±0.60b
T6	0.10±2.33	3.67±0.49a	4.00±0.51a
F test	ns	*	*
CV%	17.2	16.2	15.6

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Length of roots

Table 4 shows the root lengths of rice plant during the growing periods from 15 DAP to 60 DAP in each treatment. There were no considerable variations ($P>0.05$) in longest

root length at the different growing periods except at 30 DAP. Agusalim et al. (2010) mentioned that rice husk biochar enhances plant growth by improving the soil properties.

Table 3: Effect of rice straw and husk biochar on number of roots per plant at different growing periods.

Treatments	Number of roots per plant			
	15 DAP	30 DAP	45 DAP	60 DAP
T1	7.33±1.88	18.33±1.48b	44.33±1.45bc	85.83±0.60b
T2	6.33±0.60	21.83±0.73ab	47.00±1.44ab	89.17±0.92b
T3	5.66±0.17	22.83±2.46ab	56.00±2.02ab	97.17±1.45ab
T4	5.00±0.76	19.00±0.76ab	53.33±1.01ab	98.67±0.83ab
T5	5.83±1.33	19.16±0.73ab	56.67±1.20ab	97.67±1.36ab
T6	8.66±0.17	23.16±0.17a	59.67±1.30a	105.33±0.3a
F test	ns	*	*	*
CV%	17.9	7.9	5.7	3.3

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Table 4: Effect of rice straw and husk biochar on root length of rice plant at different growing periods.

Treatments	length of longest roots (cm)			
	15 DAP	30 DAP	45 DAP	60 DAP
T1	3.66±0.44	6.66±0.92ab	9.53±0.32	9.43±0.39
T2	3.53±0.15	5.58±0.68b	9.78±0.06	9.65±0.26
T3	3.75±0.20	6.83±0.33ab	9.63±0.24	9.53±0.15
T4	3.36±0.34	5.83±0.60b	9.66±0.33	9.51±0.29
T5	3.16±0.44	7.16±0.33ab	9.38±0.17	9.33±0.38
T6	4.25±0.31	8.33±0.44a	10.01±0.16	9.97±0.30
F test	ns	*	ns	ns
CV%	14.2	15.5	4.4	5.9

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Dry weight of shoots

The dry weights of shoots during the growing period from 15 to 60 DAP are presented in Table 5. There were no significant differences in dry weights of shoots at 15, 30 and 45 DAP. Significant difference was noted between the treatments at 60 DAP and T6 had high value of leaf area and dry weight of shoot. Khan and Khalil (2010) stated that leaf area determines dry matter production of crops.

Dry weight of roots

The dry weight of roots were recorded during the growing period from 15 to 60 DAP as given in Table 6. No significant variations ($P>0.05$) were observed in dry weights of roots at 15 DAP to 45 DAP. But at 60 DAP, there was remarkable difference among treatments. T6 had higher dry weight of roots among the treatments. Organic materials added to soil may increase soil properties for better root system.

Table 5: Effect of rice straw and husk biochar on dry weight of shoots at different growing periods.

Treatments	Dry weight of shoots			
	15 DAP	30 DAP	45 DAP	60 DAP
T1	0.02±0.00	0.43±0.12	1.55 ±0.54	3.37±0.12c
T2	0.02±0.00	0.25±0.09	1.55±0.23	3.98±0.25bc
T3	0.02±0.00	0.55±0.04	1.70±0.44	4.91±0.39ab
T4	0.02±0.00	0.32±0.02	1.64 ±0.52	4.15±0.08bc
T5	0.02±0.00	0.52±0.11	1.52±0.24	4.41±0.29ab
T6	0.03±0.00	0.51±0.05	1.89±0.29	5.15±0.32a
F test	ns	ns	ns	*
CV%	23.1	17.2	13.8	11.4

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Table 6: Effect of rice straw and husk biochar on dry weight of roots at different growing periods.

Treatments	Dry weight of roots			
	15 DAP	30 DAP	45 DAP	60 DAP
T1	0.024 ±0.01	0.107±0.03	0.78±0.33	2.96±0.37bc
T2	0.018±0.00	0.049±0.01	0.35±0.10	3.41±0.21c
T3	0.023±0.00	0.095±0.02	0.55±0.14	3.97±0.12ab
T4	0.011±0.00	0.102±0.00	0.82±0.23	3.59±0.17b
T5	0.019±0.00	0.090±0.01	0.93±0.34	3.84±0.20ab
T6	0.013±0.00	0.149±0.05	1.24±0.58	4.27±0.40 a
F test	ns	ns	ns	*
CV%	58.7	50.2	76.3	13.6

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Yield attributes

The results revealed that number of spikelets per panicle and number of empty grains per panicle were not shown any significant variations ($P>0.05$) among the treatments (Table 7) but total number of grains per panicle showed considerable difference among them. T1 and T2 varied significantly ($P<0.05$) in total number of filled grains per panicle with other treatments and T6 had high value among the treatments. The lowest

number of filled grain per panicle was recorded in T1 treatment without rice straw and husk biochar incorporation.

The result revealed that the total weight of filled grains per panicle was significantly ($P<0.05$) varied among the treatments (Table 8). Hundred seed weight was showed no remarkable difference among them. No significant difference ($P>0.05$) was observed in total weight of filled grains per panicle between T1 and T2. T6 had high

grain weight per panicle among the treatments. Zhang et al. (2010) and Shackley et al. (2012) reported that rice husk biochar increased rice yield. The 1000 grain weight was higher in composted rice straw with NPK fertilized plants than that of composted rice straw (Son et al., 2013). In present study, the numbers of tillers, number of filled

grains per panicle, grain weight per panicle and hundred grain weight increased in rice straw and husk biochar treated soil. Asaduzzaman and Pramanik (2005) reported that the grain yield increased by about 5% over control for addition of 10 t/ha rice straw.

Table 7: Effect of rice straw and husk biochar on numbers of spikelets per panicle and grains per panicle in each treatment.

Treatments	Number of spikelets per panicle	Total number of grains per panicle	Number of empty grains per panicle	Total number of filled grains per panicle
T1	11.67	169.33c	13.00	156.67c
T2	10.67	173.33c	15.00	158.33c
T3	11.33	184.33ab	16.33	168.00ab
T4	11.00	179.00b	15.67	163.33b
T5	11.00	181.67ab	16.00	165.67ab
T6	12.00	187.67a	15.33	170.33a
F test	ns	*	ns	*
CV %	8.2	2.9	10.6	3.1

Mean with the same letter in each column are not significantly different at 5% level using Tukey's test. F test: ns- non significant, *-significant.

Table 8: Effect of rice straw and husk biochar on grain weight of rice.

Treatments	Total weight of filled grains per panicle (g)	Weight of 100 seeds (g)
T1	2.870 c	1.831
T2	2.901 c	1.833
T3	3.116 ab	1.854
T4	3.011 bc	1.843
T5	3.057 b	1.845
T6	3.142 a	1.846
F test	*	ns
CV %	4.8	4.8

Mean with the same letter in each column are not significantly different at 5% level using Duncan's test. F test: *-significant.

CONCLUSION

Rice straw and paddy husk are abundant in rice producing area and it can be used to improve soil properties in rice field. In this experiment, addition of rice straw and hush biochar showed better crop performance during their growing periods. The results revealed that rather than applying chemical fertilizer alone, incorporation of rice straw (1.0 t/ha) and husk biochar (1.0 t/ha) along with chemical fertilizer is possible to increase the grain weight per panicle for better yield under local conditions.

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