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Effect of Brown Manuring on Growth, N Uptake and Yield of Direct Seeded Rice (*Oryza sativa* L.)

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ABSTRACT

On farm trial's was conducted at farmer's field during *kharif* season 2017 – 18 and 2018 – 19 in Deoghar district of Jharkhand to assess the effect of brown manuring on yield and nutrient status of soil and plant after harvest of direct seeded rice in upland condition. The trial was conducted in Randomized Block Design (RBD) with ten replications and four treatments. Here treatments are technological options were as control viz., Farmer's Practice - Broadcasted rice along with manual weeding, Technological option 1 - Line sowing of rice + Dhaincha in between rice rows followed by incorporation in soil at 30 DAS with weeder, Technological option 2 - Line sowing of rice + Broadcasting of Dhaincha followed by spray of 2, 4–D Na Salt @ 0.5 kg ha^{-1} at 30 DAS and Technological option 3 - Line sowing of rice with application of Nominee Gold 100 ml ha^{-1} at 20 DAS. Results revealed that growth, yield attributes, weed density/ weed dry matter, soil fertility status and nitrogen uptake were significantly influenced with the technological options tested in the trial. The Technological option - 2 i.e., line sowing of rice + broadcasting of Dhaincha seeds followed by application of 2, 4–D Na Salt @ 0.5 kg ha^{-1} at 30 DAS resulted in significantly higher grain yield (26.7 q ha^{-1}), straw yield (39.1 q ha^{-1}), N uptake in grain and straw was 35.78 kg ha^{-1} and 22.28 kg ha^{-1}, respectively also found better soil fertility status after harvest of crop. However, higher net return (Rs ha^{-1} 28,875) and benefit cost ratio (2.62) was also observed followed by technological option 1.

Keywords DSR, Brown manuring, Nitrogen uptake, Yield, Economics.

INTRODUCTION

Rice is the main staple food crop of India; during the year (2019–20) India produced 118.43 million tones of rice from 43.78 million hectare of the land (Anonymous 2020). Currently, direct seeded rice in Asia occupies about 29 Million hectare which approximately 21% of the total rice area in the region. Countries like USA and Australia extensively practicing direct seeding of rice are with profitable results as it avoids all the penalties entailed in transplanting. In Jharkhand, rice is the main crop with cultivable area 1.48 m ha. It is grown under varying agro climatic condition rain-fed upland, rain-fed medium land, low lands terraces with irrigation facility. Direct seeded rice under no/reduced tillage is an efficient resource conserving technology holding good promise in coming days because of the following advantages over transplanting of rice viz., Labor required for nursery raising or uprooting and transplanting of seedlings

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are saved to the extent of about 40%, Saving of water (up to 60%) as nursery raising, Puddling, seepage and percolation are eliminated. Fertilizer use efficiency is increased because of application of fertilizer in the root zone, Early maturity (10 - 15 days) helping in timely sowing of succeeding crops, Energy saving (up to 60%) because of elimination of field preparation for nursery raising, Puddling and reduced water application for irrigation, Reduction in methane emission and global warming potential. System productivity is enhanced and cost of cultivation is reduced by about Rs ha^{-1} 6000 - 7000 in direct - seeded rice method. Weeds are the biggest constraint; because of the absence of flooding during early stages, all types of weeds such as grasses, non-grasses and sedges emerge simultaneously at high density with rice seedlings. Ultimately it reduces up to 50 - 80% yield in direct seeded upland rice (Sangra *et al*. 2018). The weed presence is higher in direct - seeded method than in transplanted rice cultures mainly because of differences in land preparation.

Brown manuring is similar to green manuring, except the fact that rice and Dhaincha are grown together and when these Dhaincha plants overtake the rice plants in height of 30 days of co-culture, a weedicide 2, 4 – D is applied to kill these Dhaincha plants. After 4–5 days of spraying Dhaincha plants will appear brown and then start drying. As it is a selective herbicide, it kills only Dhaincha plants. This is called knocking down effect. Brown manuring is usually recommended for the rice which is directly seeded. If the rice is broadcasted then at the time of beusaning dead Dhaincha plant parts will be incorporated in soil, whereas, in case of line sowing at the time of weeding it mixes in the soil supplying the nitrogen and other nutrients to rice (Sarangi and Sadangi 2015). Among the nutrients nitrogen, phosphorus and potassium are limiting ones and nitrogen is the first nutrient to become limiting due to crop – weed competition. Brown manuring of Dhaincha suppressed the weed flora as a result increased the availability of nutrients to the crop thereby reducing the nutrient uptake by weeds and producing better crop yield. In order to devise a strategy for direct seeded rice, studies need to be done on brown manuring in combination with herbicides. Since not much work have been done in this field, this research is designed to address the problem of making direct seeded rice popular among farmers with the objective of evaluating the effect of brown manuring practices on soil fertility as well as controlling weeds in direct seeded rice.

MATERIALS AND METHODS

The trial was layout with four (4) treatments viz., Farmer's Practice - Broadcasted rice along with manual weeding, Technological option 1 - Line sowing of rice + Dhaincha in between rice rows followed by incorporation in soil at 30 DAS with weeder, Technological option 2 - Line sowing of rice + Broadcasting of Dhaincha followed by spray of 2, 4–D Na Salt @ 0.5 kg ha^{-1} at 30 DAS and Technological option 3 - Line sowing of rice with application of Nominee Gold 100 ml ha^{-1} at 20 DAS with maintaining ten (10) replications as one block of 10 m^2 plot size in Randomized Block Design considering each location (farmer). Vandana rice variety was taken as test crop and standard agronomic procedures were also followed during the trial. Observations on growth parameters were taken from five randomly selected plants. Plant heights were recorded at 60 DAS. No. of effective tillers were recorded at maturity of plants. No. of tillers was measured in per meter sq area of plots. Well developed dried 1000 seeds were counted randomly from the produce of each plot. After this, their weight was recorded separately in grams with the help of electronic balance. The plants were cut at ground level from the net plot area brought to threshing floor and dried for three days before threshing. After threshing grains were cleaned and sun dried for another two days. Then the grain weight of each net plot was recorded and converted to q ha^{-1}. Straw obtained after threshing the grain of individual plot was kept separately and weight was recorded and used for estimating straw yield in kg ha^{-1}.

Initial and post harvest fertility status of soil

The trial was conducted in 10 farmers plot of Deoghar district. The initial soil fertility status of the experimental field was given in Table 1.

Initial and post harvest soil samples were taken randomly from different places in each plot. These samples were dried, grind and passed through 0.2

Table 1. Initial soil fertility status in plots.

Sl No.	pH	EC (dSm^{-1})	OC (%)	N ($kg\ ha^{-1}$)	P_2O_5 ($kg\ ha^{-1}$)	K_2O ($kg\ ha^{-1}$)
1	5.6	0.43	0.47	268.3	10.1	123.5
2	5.6	0.51	0.48	274.2	9.7	130.2
3	5.5	0.45	0.48	270.5	8.2	127.4
4	5.7	0.56	0.50	281.6	10.4	118.7
5	5.7	0.42	0.49	263.1	10.8	125.3
6	5.6	0.49	0.50	270.2	9.3	131.0
7	5.8	0.47	0.47	273.4	8.6	128.3
8	5.5	0.46	0.51	282.7	10.2	116.5
9	5.6	0.52	0.52	287.2	11.3	120.3
10	5.8	0.48	0.50	283.1	10.6	123.6

mm sieve for the purpose of chemical analysis. pH and EC of soils were measured in 1:2.0 (Soil: Water) suspension with the help of glass electrode digital pH meter and conductivity bridge as described by (Jackson 1973). Organic carbon was estimated by chromic acid wet digestion method given by (Walkley and Black 1934). Available nitrogen was estimated by distilling soil with alkaline potassium permanganate and determining the ammonia liberated as per method suggested by (Subbiah and Asija 1956). For available P estimation soil was extracted with Bray P1extractant (0.03N NH_4F in 0.025N HCl solution) and was determined (Bray and Kurtz 1945) as described by (Jackson 1973) on double beam spectrophotometer. Available potassium was determined by flame photometer after extraction of soil with neutral normal ammonium acetate (Hanway and Heidal 1952) in soil to solution ratio 1:5 (w/v).

Nutrient content (%) and uptake by plant

After harvesting, grain and straw samples of rice were oven dried at 60 – 65^0 C until constant weight was obtained. All the samples were ground separately and passed through 40 mesh sieve and subjected to chemical analysis for determining the nitrogen by Kjeldahl's method (Jackson 1973). N uptake by rice crop were computed from their respective nutrient concentrations in grains and straw by using expression: Nutrient uptake ($kg\ ha^{-1}$) = Concentration (%) of nutrient x Yield ($q\ ha^{-1}$). Uptake by grains and straw were combined to give total uptake by crops and the values were expressed in $kg\ ha^{-1}$.

Statistical data were analyzed by the technique of 'Analysis of variance'. Test of significance of the treatment differences was done on the basis of 'F' test. The significant differences between treatments were compared with the critical differences at 5 % level of probability as per method described in (Panse and Sukhatme 1985). The economics was calculated through mean total cost of cash inputs in rice cultivation, mean gross returns, mean net returns and the benefit-cost ratio (B:C ratio) based on the data collected at farmer's field during personal interviews of the participating farmers. The minimum support price declared by GoI for the year 2018–19 (Rs 1750 per q) was considered as selling price of rice. The extension gap, technology gap and technology index were calculated using following equation as suggested by (Yadav *et al*. 2004). The potential yield of rice variety Vandana is 30.0 $q\ ha^{-1}$.

Extension gap = Yield under particular practice - Farmer's practice yield

Technology gap = Potential yield - Yield under farmer's practice

$$\text{Technology index} = \frac{\text{Potential yield - yield under particular practice}}{\text{Particular yield}} \times 100$$

RESULTS AND DISCUSSION

Yield, yield attributing characters and soil health

Line sowing of rice + Dhaincha by incorporation in soil at 30 DAS with weeder (TO_1) or line sowing of rice after broadcasted Dhaincha followed by 2, 4–D @ 0.5 kg ha^{-1} at 30 DAS ($T0_2$) or line sowing of rice with application of Nominee Gold 100 ml ha^{-1} at 20

Table 2. Yield ($q\ ha^{-1}$) and yield attributing characters of DSR as affected by brown manuring techniques.

Technology option	Yield component					
	Plant height (cm)	No. of effective tillers m^{-2}	No. of grains per spike	Test wt (1000 grain wt in g)	Yield ($q\ ha^{-1}$)	Straw yield ($q\ ha^{-1}$)
FP	78.78	134.0	104.2	24.3	19.6	27.3
TO_1	86.08	161.7	113.4	25.7	25.8	36.7
TO_2	88.65	168.3	115.8	25.3	26.7	39.1
TO_3	80.66	149.6	109.9	26.8	23.4	32.4
CD at 5%	3.17	8.68	3.75	NS	2.12	3.67
CV %	9.26	13.90	8.28	2.63	11.56	12.48

Table 3. Effect of brown manuring on total weed density and weed dry weight in DSR.

Treatments	Total weed density (m^{-1}) at harvest	Total weed dry weight (g m^{-1}) at harvest
FP	126.6	282.5
TO_1	56.3	124.8
TO_2	42.7	98.4
TO_3	46.3	103.7
CD at 5%	9.63	14.25
CV %	8.88	6.11

DAS (TO_3) significantly increased the grain yield of rice as well as yield attributing characters such as plant height, no. of effective tillers and no. of grains per spike as compared to farmer's practice, except test weight of 1000 grains (Table 2). Plant height is an important parameter that can be used to study the effect of different treatments on crop growth. Highest grain yield (26.7 q ha^{-1}), straw yield (39.1 q ha^{-1}) and yield attributing characters such as plant height (88.65 cm), number of effective tillers meter-2 (168.3), number of grains per spike (115.8) were recorded in technological options TO_2 i.e., brown manuring (Table 2) and it was significantly superior to all of the treatments as well as farmers practice. Increase in yield with brown manuring over farmer's practice may be due to the supply of plant nutrients in proper quantity and proportion. Beneficial effect of brown manuring on grain yield as well as yield attributing characters might be due to increased nutrient uptake and beneficial impact of organic material addition through brown manuring on physical, chemical and biological properties of soil. Results are in accordance with (Saha *et al*. 2020) and (Roy *et al*. 2001).

Total weed density and weed dry weight

Effect of different treatments on total weed density at harvest and weed dry weight are presented in Table 3. Line sowing of paddy after broadcasted Dhaincha followed by 2, 4 – D @ 0.5 kg ha^{-1} at 30 DAS (Brown manuring) recorded lowest weed density (42.7) and total weed dry matter accumulation (98.4) followed by TO_3. Both the treatment was found at par in controlling weed in the direct seeded rice. Results are in accordance with (Kumari and Kaur 2016).

Table 4. N content (%) and N uptake (kg ha^{-1}) by rice as affected by brown manuring techniques.

Treatments	N content (%)		N uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw
FP	1.13	0.60	22.15	16.38
TO_1	1.32	0.59	34.06	21.65
TO_2	1.34	0.57	35.78	22.28
TO_3	1.21	0.52	28.32	16.85
CD at 5%	0.03	NS	3.45	2.80
CV %	5.50	2.30	6.26	7.81

Nitrogen uptake by crop

N content and uptake by rice grain and straw was presented in (Table 4). Line sowing of rice after broadcasted Dhaincha followed by 2, 4–D @ 0.5 kg ha^{-1} at 30 DAS ($T0_2$) resulted into highest nitrogen uptake by rice grain and straw (35.78 and 22.28 kg ha^{-1}, respectively) followed by TO_1 i.e., sowing of rice + Dhaincha by incorporation in soil at 30 DAS with weeder were statistically at par.

Soil fertility status after harvest of rice crop

Pooled data of soil fertility status of DSR field are presented in Table 5. It indicates that soil pH and electrical conductivity were not influenced by the application of dhaincha as brown manuring or 2, 4–D/ Nominee Gold during both the year of trial. However, organic carbon content of soil after harvest of rice was increased as compared to Farmer's Practice in all treatments. Application of brown manuring (Line sowing of rice + Dhaincha along with 2, 4-D recorded highest organic carbon (0.62%) content in the soil after harvest of rice. This might be due to addition of organic matter in brown manuring treatment due to incorporation of Dhaincha.

It was found that Technology option 1 and 2 significantly increased the available N and K_2O status of

Table 5. Soil fertility status after harvest of direct seeded rice.

Treatments	Ph	EC (dSm^{-1})	OC (%)	Av N (kg ha^{-1})	Av P_2O_5 (kg ha^{-1})	Av K_2O (kg ha^{-1})
FP	5.81	0.47	0.51	281.2	13.8	135.1
TO_1	5.89	0.56	0.59	298.4	15.1	143.5
TO_2	5.97	0.47	0.62	310.9	16.4	151.2
TO_3	5.85	0.53	0.53	289.1	14.3	137.6
CD at 5%	NS	NS	0.04	13.48	NS	9.73
CV %	5.62	4.20	1.43	9.07	8.66	13.30

Table 6. Economics analysis of rice under different treatments.

Technology option	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C ratio
FP	18,700	34,300	15,600	1.83
TO_1	20,100	45,150	25,050	2.24
TO_2	17,850	46,725	28,875	2.62
TO_3	18,500	40,950	22,450	2.21

Table 7. Gap analysis under DSR techniques in rice.

Treatments	Extension gap (q ha^{-1})	Technology gap (q ha^{-1})	Technology index (%)
FP	-	10.40	34.65
TO_1	6.20	4.20	14.12
TO_2	7.10	3.30	11.04
TO_3	3.80	6.60	22.26

soil after harvest of rice (Table 5). Significantly higher available N (310.9 kg ha^{-1}) and K_2O (151.2 kg ha^{-1}) was recorded under Technology option - 2, however in case of available P_2O_5 the observed difference was non-significant among both technological options. This may be due to incorporation of dhaincha after mineralization and rapid conversion of plant nutrients in available form. These results are in agreement with (Kumar *et al*. 2018) and (Baishya *et al.* 2015).

Economics and gap analysis

Data presented in Table 6 indicates that TO_1 and TO_2 significantly increased the gross return, net return and benefit-cost ratio of rice over farmer's practice during two years of trial. Technology option 2 resulted in significantly highest gross return (Rs. 46,725 ha^{-1}), net return (Rs 28,875 ha^{-1}) and B: C ratio (2.62). This might be due to use of dhaincha as brown manuring form reduces the weed population in the early stage, increases the soil organic carbon content and supplying required nitrogen for the rice plants. The lowest cost of cultivation were recorded in TO_2 (Rs 17,850) followed by TO_3 (Rs 18,500).

The extension gap recorded under TO_2 were 7.10 q ha^{-1}, respectively which emphasises the need to educate the farmers through various means for adoption of Dhaincha practices as well as brown manuring techniques in DSR rice cultivation (Table 7). The highest technology gap was recorded under FP (10.4 q ha^{-1}) however, lowest technology gap was recorded under TO_2 i.e., brown manuring techniques (3.30 q ha^{-1}). The highest technology gap recorded under farmer's practice is in accordance with (Jha *et al.* 2021). The lowest technology gap under brown manuring techniques reflects the suitability of DSR for rice cultivation over current farmer's practices and recommendation of dhaincha application. Similar observation under technology index was found and lowest value was recorded under TO_2 (11.04%). The observation recorded under technology index showed the feasibility of brown manuring techniques at farmer's field. Lower technology index and technology gap was observed under recommended practices over farmer's practice in mustard was reported by (Kalita *et al*. 2019).

CONCLUSION

On the basis of present trial conducted during the year 2017 - 18 and 2018 - 19 it can be concluded that brown manuring techniques (Line sowing of rice + Dhaincha in between rice rows followed by incorporation in soil at 30 DAS with weeder / Line sowing of rice + Broadcasting of Dhaincha followed by spray of 2, 4–D Na Salt @ 0.5 kg ha^{-1} at 30 DAS had significant influence on yield and yield attributing characters of rice and recorded highest values of these parameters as compared to farmer's practice. Highest net return along with B:C ratio of 2.62 was also recorded under DSR techniques. Reduction in cost of cultivation over farmers practice in brown manuring is another benefit farmers are getting in DSR. Comparatively lower technology gap (3.30 q ha^{-1}) and lower technology index (11.04 %) observed under DSR techniques suggests it's feasibility at farmer's field. It is suggested the technology is more suitable for risk prone agro-ecosystems in which direct seeding of rice is done. As most of the Indian rice growers are resource poor, the technology can add more benefit with very marginal input cost.

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