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Performance of direct seeded rice as influenced by mulching, nitrogen levels and weed management practices in eastern part of Uttar Pradesh

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Abstract
A field experiment was carried out in the year 2014 and 2015 at experimental field of Banaras Hindu University, Varanasi, Uttar Pradesh, to evaluate the performance of direct seeded with different mulching, nitrogen levels and weed management practices. Twenty-four treatment combinations consisting of two mulching *viz.* no mulch and live mulching (brown manuring with *sesbania*) and nitrogen levels (120 kg ha^{-1}, 150 kg ha^{-1} and 180 kg ha^{-1}) in main plot and four weed management practices *viz.* weedy check, two hand weeding at 20 and 40 DAS; azimsulfuron @ 30 g/ha + bispyribac-sodium @ 25 g/ha at 10-15 DAS; pendimethalin @ 1 kg/ha at 1-3 DAS *fb* bispyribac-sodium @ 25 g/ha 15-20 DAS were allocated to sub plots. Effect of mulching resulted in significantly higher grain yield which results in higher net returns and B: C ratio for both the years. Under various nitrogen levels, application of 150 kg ha^{-1} nitrogen fertilizer resulted in maximum grain yield, net return and B:C ratio. Amongst weed management practices, maximum grain yield and net returns for both the years was recorded under treatment pendimethalin *fb* bispyribac- sodium @ 25 g/ha which was significantly superior over rest of weed management practices. Weedy check recorded lowest grain yield and net return. Highest B:C ratio in 2014 was observed from the treatment azimsulfuron @ 30 g/ha + bispyribac-sodium @ 25 g/ha, while in 2015 it was found to be highest with treatment pendimethalin *fb* bispyribac-sodium @ 25 g/ha.

Keywords: Direct seeded rice, herbicides, Nitrogen, weed management

Introduction
Rice *(Oryza sativa* L.) is the most important and extensively grown crop in tropical and subtropical regions of the world and a staple food for more than 70% of the world population. India has the largest area under rice cultivation in the world and is the second largest producer of rice after China, contributing about 20% of the world rice production (Singh *et al*., 2012) [14]. In India, rice is grown over an area of 43 million hectares with total production of 95 million tonnes amounting to 40% of the total food production (Kumar *et al.*, 2017) [8]. The demand for food grains in India is increasing day by day and the requirement by the year 2025 is estimated to be increased by 40 per cent as compared to 2003-04. To sustain present food self-sufficiency and to meet future food requirements, there is need to increase rice productivity by 3 per cent per annum.
Direct seeded rice is a viable alternative over transplanting in rescuing farmers (Farooq *et al*., 2011) [4]. Direct seeded rice is replacing traditional transplanting in areas with good drainage and water control (Balasubramanian and Hill, 2002) [2]. It needs only 34% of the total labour requirement and saves 29% of the total cost of transplanted crop (Ho and Romli, 2000) [6]. The additional benefits of DSR would be water conservation, soil temperature moderation and buildup of soil organic carbon status due to residue retention at the surface. This practice of residue retention will facilitate integrated nutrient management, weed suppression and will have direct bearing on the nutritional status of soil (Shoran *et al.*, 2005) [13].
The sustainability of the system, however, is threatened by heavy weed infestation as this system is prone to weed competition (Chauhan, 2012; Mahajan and Chauhan, 2013) [3, 9]. They are the prime yield limiting biotic constraints that compete with rice for moisture, nutrients and light. Weed competition reduced the grain yield by 50-60% in direct seeded rice. Losses can be severe in DSR as the rice and weed seedlings are at similar growth stages. The use of only one method of weed control in a DSR crop may not be successful for raising a good crop.

Manual weeding has become difficult because of labour scarcity and increased cost (Rao *et al*., 2007) [12]. Chemical control is the most effective, economic and practical way of weed management (Marwat *et al*., 2006; Hussain *et al*., 2008; Anwar *et al*., 2012) [11, 7, 1] during periods of labour shortage when weeding coincides with other farm work. Therefore, crop management technologies that help to reduce the competitive effects of weeds on crops and economical are needed.

Mulching is a technique to reduce weed problems in direct seeded rice. Mulching helps to maintain optimum surface soil moisture for germination and rooting of the crop and helps in controlling weeds. *Sesbania* can be grown as live mulch with rice. Brown manuring is simply a no-till version of green manuring, in which selective herbicide 2, 4 –D @ 400-500 g/ha is applied to knockdown and desiccate the *Sesbania* nearly at blooming (30- 40 days) stage. Integration of suitable herbicides (pre and post-emergence) (Singh, 2009) [15] or/and *Sesbania* co-culture (Maity and Mukherjee, 2011) [10] helped in effective reduction of crop-weed competition by reducing weed population and their biomass in direct seeded rice and improved yield attributes thus ultimately led to higher yield and net return. Manipulation of crop fertilization is a promising approach to reduce weed infestation and may contribute to long-term weed management. Fertilizer management should be aimed at maximizing nutrient uptake by crop and minimizing nutrient availability to weeds. The effect of crop density on weed suppression could be influenced by N rates. At low soil N rates the effect of high crop density could be more because weeds grow more slowly at low-N rates. Conversely, high-N rates could result in an earlier onset of size-asymmetric competition and therefore increase the effect of high crop density on weed suppression. It is important to understand weed responses to N rates for the development of strategies that reduce N availability to weeds.

Therefore, with inclusion of live mulch under different nitrogen levels, application of herbicides in combination or sequence can be useful.

Method and Materials

The experiment was laid out in split-plot design with three replications. The mulching (no mulch and live mulch *i.e*. brown manuring with *sesbania*) and nitrogen doses (120, 150 and 180 kg ha^{-1}) were assigned to main plots and weed management practices (weedy; two hand weeding at 20 and 40 DAS; azimsulfuron @ 30 g/ha + bispyribac-sodium @ 25 g/ha at 10-15 DAS; pendimethalin @ 1 kg/ha at 1-3 DAS fb bispyribac-sodium @ 25 g/ha 15-20 DAS) in sub plots. Rice variety Sarjoo 52 was sown in the last week of June. Seed of *sesbania* was sown in between rows just after seeding of rice for brown manuring and was knock down at 25 DAS with the help of 2,4 D. Spray of herbicides was done by using knap sack sprayer with flat fan nozzle with their respective doses at appropriate stages:

A uniform dose of 60 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied in all the treatments through single super phosphate and murate of potash, respectively. Nitrogen doses of 120, 150 and 180 kg/ha were given as per treatment through urea. Half of total nitrogen and full dose of phosphorus, and potassium were applied to rice crop as basal application before sowing. Remaining half dose of nitrogen in the form of urea was top dressed in two equal splits, at active tillering and panicle initiation stage during both the years. The net return was worked out by using following formula:

Net return (Rs. ha^{-1}) = Gross return (Rs. ha^{-1}) – Cost of cultivation (Rs. ha^{-1})

Whereas, benefit cost ratio (B:C ration) was worked out on the basis of gross return (Rs.ha^{-1}) and cost of cultivation (Rs.ha^{-1}).

$$\text{B:C ratio} = \frac{\text{Gross return (`ha}^{-1})}{\text{Cost of cultivation (`ha}^{-1})}$$

The data obtained by various observations during the course of investigation were subjected to statistical analysis for determining the significance of difference as described by Snedecor and Cochran (1968) [17].

Result and Discussion

Grain Yield

The effect of mulching, nitrogen levels and weed management practices on grain yield of direct seeded rice was found to be significant during both the years of investigation. Maximum grain yield, 4.20 and 4.54 t ha^{-1} was recorded under live mulching with *sesbania* in 2014 and 2015, respectively (Table 1).

Under nitrogen levels, 150 kg ha^{-1} produced highest grain yield of 4.13 and 4.41 t ha^{-1} which was statistically at par with 180 kg ha^{-1} (4.05 and 4.32 t ha^{-1}) for 2014 and 2015, respectively. Lowest grain yield was recorded from 120 kg $ha-^{1}$ for both the years. Further, it was observed that weed management practices produced significant variation in relation to grain yield of direct seeded rice in both the years of investigation.

The maximum grain yield in the year of 2014 (4.75 t $ha-^{1}$) was registered under pendimethalin *fb* bispyribac- sodium @ 25 g/ha which was significantly superior over rest of weed management practices. This was followed by two hand weeding at 20 and 40 DAS (4.44 t $ha-^{1}$). In the second year of experiment (2015) it was observed that maximum and significantly superior grain yield was produced from the treatment pendimethalin *fb* bispyribac- sodium @ 25 g/ha (4.82 t $ha-^{1}$). This was followed by two hand weeding at 20 and 40 DAS (4.42 t $ha-^{1}$) and azimsulfuron @ 30 g/ha + bispyribac- sodium @ 25 g/ha (4.46 t $ha-^{1}$) treatments. Both these treatments were statistically at par with each other. Minimum grain yield was observed under weedy check for both the years. Optimum supply of nitrogen dose and better and timely weed management results in higher yield attributes ultimately resulting in higher yield.

Maximum harvest index was recorded under live mulching for 2014 and 2015 respectively. This might be due to the lower weed competiton in live mulch treatment as Sesbania (as live mulch) reduces the poplation of weeds by reducing nutrient availability to the weeds. (Singh *et al*., 2009) [16].

Under various nitrogen levels, maximum harvest index was recorded with application of 150 kg ha^{-1} (43.16 %) which was statistically at par with 180 kg ha^{-1} (42.99 %) for the year 2014. In the second year of investigation, *i.e*. 2015, maximum and statistically superior harvest index was recorded with150 kg ha^{-1} (43.53 %). Lowest harvest index was recorded with 120 kg ha^{-1} for both the years. Under weed management practices, in the year 2014 maximum harvest index was recorded with pendimethalin *fb* bispyribac- sodium @ 25 g/ha which was significantly superior over other treatments. This was followed with two hand weeding at 20 and 40 DAS.

Net return and B: C ratio

Brown manuring with sesbania recorded highest net return (33109.42 and 38178.42) for the years 2014 and 2015, respectively. This might be due to the positive effect of brown manuring on fertility of the soil which ultimatly increases the microbial population near the root zone and hence increases the avaibility of the nutrients. These findings are in close agreement with the results of Gopal *et al*., 2010[5]. B: C ratio for both the years was also found to be higher under mulch treatment when compared to no mulch treatment. Maximum net return and highest B:C ratio was recorded with 150 kg ha^{-1} various nitrogen levels.

Under weed management practices, treatment pendimethalin *fb* bispyribac- sodium @ 25 g/ha recorded highest net return in for both the years which was followed by treatment azimsulfuron @ 30 g/ha + bispyribac- sodium @ 25 g/ha. However, for the year 2014 treatment azimsulfuron @ 30 g/ha + bispyribac- sodium @ 25 g/ha recorded highest B:C ratio (2.17), while in the year 2015 pendimethalin fb bispyribac- sodium @ 25 g/ha treatment (2.42) recorded highest B:C ratio. Saving in labour, power and capital in direct seeded rice resulted in reduction in overall cost of production, thus leading to maximum net return and benefit: cost ratio.

Table 1: Influence of mulching, nitrogen levels and weed management practices on yield (t ha^{-1}), net return and B:C ratio of direct seeded rice

Treatments	Grain yield (t ha^{-1})		Harvest index (%)		Net return (Rs. ha^{-1})		B:C ratio	
	2014	2015	2014	2015	2014	2015	2014	2015
Mulching								
No mulch	3.67	41.99	42.37	3.75	26527.92	27620.92	1.91	1.95
Live mulch (Brown manuring with *Sesbania*)	4.20	43.34	43.49	4.54	33109.42	38178.42	2.09	2.27
SEm±	0.04	0.07	0.06	0.04	-	-	-	-
CD (P=0.05)	0.13	0.27	0.18	0.14	-	-	-	-
Nitrogen level (kg/ha)								
120	3.65	42.05	42.21	3.74	26341.08	27655.08	2.00	1.95
150	4.13	43.16	43.53	4.41	32502.32	36590.32	2.03	2.23
180	4.05	42.99	43.23	4.31	30940.12	34781.12	1.99	2.15
SEm±	0.04	0.06	0.06	0.04	-	-	-	-
CD (P=0.05)	0.13	0.18	0.18	0.14	-	-	-	-
Weed management practices								
Weedy	2.20	36.07	41.69	3.01	7780.42	18856.42	1.90	1.70
Two hand weeding (20 and 40 DAS)	4.44	43.70	42.79	4.42	33064.42	33087.42	1.83	1.98
Azimsulfuron @ 30 g/ha + Bispyribac- sodium @ 25 g/ha	4.35	43.41	42.58	4.36	37188.17	37634.17	2.17	2.33
Pendimethalin *fb* Bispyribac- sodium @ 25 g/ha	4.75	44.90	44.63	4.82	41241.68	42383.68	2.13	2.43
SEm±	0.03	0.06	0.04	0.03	-	-	-	-
CD (P=0.05)	0.08	0.18	0.12	0.07	-	-	-	-

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