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Research Communication

Influence of nitrogen and weed-management practices on crop-growth indices and productivity of dry direct-seeded rice (*Oryza sativa*)

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ABSTRACT

A field study was carried out during the rainy (*kharif*) season of 2019–20 at ICAR-Indian Agricultural Research Institute, New Delhi, to study the effect of nitrogen and weed management practices in dry direct-seeded rice (*Oryza sativa* L.) for obtaining higher productivity and crop growth. The experiment was laid out in a split-plot design, taking 3 nitrogen treatments, i.e. No N (P and K only), recommended dose of fertilizer (RDF–N : P : K = 80 : 17 : 33 kg/ha) (3 splits of nitrogen application–50% basal + 25% at tillering + 25% at panicle-initiation stage), 50% N from FYM + 50% N as real-time nitrogen management (top-dressing) as per leaf colour chart (LCC) up to panicle-initiation stage in main plots. Four weed-management treatments, viz. unweeded control, weed-free control, Pendimethalin @ 1.5 kg a.i./ha as pre-emergence followed by (*fb*) brown manuring with *Sesbania bispinosa* (Jacq.) W. Wight; Syn. *S. aculeata* [(Willd.) Pers.] (knocking down *Sesbania* by Bispyribac- Na 25 g a.i./ha at 25 days after sowing (DAS), Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* Bispyribac -Na @ 25 g a.i./ha at 25 DAS in subplots with 3 replications. Result revealed that, Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* brown manuring with *Sesbania bispinosa* significantly increased grain yield (2.78 t/ha) as well as growth indices like leaf-area index (1.8 and 4.4 at 40 DAS and 70 DAS, respectively), crop-growth rate (1.9 g/m^2/day, 8.8 g/m^2/day at 40 DAS and 70 DAS, respectively), relative growth rate (145.3 mg/g/day and 54.5 mg/g/day 40 DAS and 70 DAS, respectively), net assimilation rate (0.40 g/m^2/day 3.49 g/m^2/day at 40 DAS and 70 DAS, respectively) and dry-matter accumulation (185.6 g/m^2, 591.6 g/m^2 and 1,144 g/m^2 at 40 DAS, 70 DAS and harvesting, respectively) to the other treatments. In case of N-management practices, combined use of FYM and LCC-based N management gave the highest grain yield (3.25 t/ha), growth indices like leaf-area index (1.69 and 4.0 at 40 DAS and 70 DAS respectively) crop-growth rate (1.8 g/m^2/day, 8.2 g/m^2/day at 40 DAS and 70 DAS, respectively), relative growth rate (145.1 mg/g/day and 55.1 mg/g/day at 40 DAS and 70 DAS, respectively) and dry-matter accumulation (168.5 g/m^2, 523.2 g/m^2 and 958 g/m^2 at 40 DAS, 70 DAS and harvesting, respectively) comparable with RDF application and significantly higher than the plot without N.

Key words: Dry direct-seeded rice, Brown manuring, Leaf-colour chart, Real-time N management

Rice (*Oryza sativa* L.) is a principal source of food for more than half of the world's population and more than 90% of rice worldwide is grown and consumed in Asia. In India it is grown on 43.78 million ha, with an average annual production of 118.43 million tonnes (DAC & FW, 2020). Dry Direct-seeded rice (DDSR) is an effective alternative to transplanted rice. Dry seeding of rice avoids the need for ponding water vis-à-vis transplanting, requiring ~36% less water (Mohammad *et al*., 2018), ~60% less labour (Kumar and Ladha, 2011). Yield potential of direct-seeded rice is comparable to the transplanted rice under optimal water, nutrient and weed-management conditions (Narolia *et al*., 2014). The battle against weed is never ending and often the costliest agronomic input for successful crop production (Das *et al.,* 2012). Weeds compete with direct-seeded rice (DSR) for moisture, light, space and nutrients throughout the growing season (Singh and Singh, 2010). Ramzan (2003) reported yield reduction up to 48, 53 and 74% in transplanted, direct-seeded in flooded conditions and dry direct-seeded soils, respectively. Severe

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crop-weed competition is the crux of the problem affecting N-use efficiency which reduces yields considerably. Traditional nitrogen (N) management may not solve the problem of low N recovery (30–40%) which is a great concern in upland conditions (Ghosh, 2018). Therefore, improving fertilizer N-use efficiency in rice is vital to achieve high grain yields (Gupta *et al.,* 2011). The real time N–management approach by use of leaf colour chart (LCC) can help avoid excessive use of N fertilizer by synchronizing time of fertilizer application with plant need (Ali *et al*., 2015). Hence, keeping the above facts in view, the present investigation was undertaken to assess the effect of multiple herbicidal and nitrogen-management interventions on productivity and profitability of dry direct seeded rice in eastern India.

The experiment was conducted at the Central Rainfed Upland Rice Research Station Hazaribagh, Jharkhand (ICAR-National Rice Research Institute, Cuttack, Odisha) situated at (23°56′34″ N and 85°21′46″ E with an altitude of 614 m mean sea-level) during the rainy (*kharif*) season of 2019. The climate is warm and humid with the mean minimum and maximum temperature of 13.7°C and 31.4°C respectively. The normal rainfall of the district is 1,027.5 mm and 79% of the total rainfall received from June to December. The soil of the experimental field was silty loam, medium in organic C, low in available N, medium in available P and high in available K, with a *p*H of 5.4. The experiment was laid out in a split-plot design, taking 3 nitrogen treatments, i.e. No N [recommended dose of fertilizer (RDF) of P and K only], RDF (N: P_2O_5: K_2O = 80 : 17 : 33 kg/ha) (3 splits of nitrogen application–50% basal + 25% at tillering + 25% at panicle-initiation stage), 50% N from FYM + 50% N as real time nitrogen management (top-dressing) as per LCC up to panicle- initiation stage in main plots. Four weed-management treatments viz. un-weeded control, weed-free control, Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* brown manuring with *Sesbania bispinosa* (Jacq.) W. Wight; syn. *S. aculeata* (Willd.) Pers. (knocking down *Sesbania* by Bispyribac-Na 25 g a.i./ha at 25 DAS), Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* Bispyribac -Na @ 25 g a.i./ha at 25 DAS in subplots with 3 replications. Rice variety 'CR Dhan 202' was used in our study.

Leaf blades were separated from the leaf sheath and leaf area was measured at different crop-growth stages (0–40 DAS and 40–70 DAS) with the help of leaf-area meter (LI COR-3100). Leaf-area index (LAI) was estimated as per Watson (1947).

Dry-matter accumulation was recorded at periodic intervals of 40 DAS, 70 DAS and harvesting. For this, second row was earmarked for collecting the plant samples from each plot. Two spots of 1 m^2 area were randomly selected and the samples were taken by cutting at ground level. The collected plant samples were sun-dried and kept in an electric oven at 65°C for complete drying and their weight was recorded when samples attained a constant weight.

Crop-growth rate (CGR), relative crop-growth rate (RGR) and net assimilation rate (NAR) were worked out as per Watson (1958), Blackman (1919) and Heath and Gregory (1938), respectively.

The research findings pertaining to grain yield, crop-growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf-area index (LAI) and dry-matter accumulation (DMA) were studied under different nitrogen and weed-management practices. The plot treated with 50% N from FYM + 50% N as real-time nitrogen management (top-dressing) as per LCC up to panicle-initiation stage gave the highest grain yield (3.25 t/ha) which was at par with the application of recommended dose of fertilizer (3.15 t/ha). Both the treatments resulted in significantly higher than the plot without N application (1.56 t/ha) (Tables 1 and 2). This might be owing to enhanced photosynthetic activity and translocation of photosynthates by providing nutrients according to crop needs in real time which led to increased grain-filling as well as number of filled grains (Singh *et al.,* 2002). The FYM might have act as a surface mulch which escaped initial moisture stress by reducing evaporation losses from soil surface and conserving moisture resulting in greater availability of nutrients to crop and increasing the yield subsequently in rainfed upland condition.

Highest values of LAI (1.69 and 4.0 at 40 DAS and 70 DAS respectively), CGR (1.8 and 8.2 g/m^2/day at 40 DAS and 70 DAS, respectively), RGR (145.1 and 55.1 mg/g/day at 40 DAS and 70 DAS, respectively) and DMA (168.5, 523.2 and 958 g/m^2 at 40 DAS, 70 DAS and harvesting stage respectively) were observed in the plot treated with 50% N from FYM + 50% N as real time nitrogen management (top dressing) as per LCC up to panicle-initiation stage. The possible reason could be the higher supply of N according to crop needs unlike RDF method of fixed time N application. In addition, FYM enhanced the nutrient availability for longer period which resulted in an increased leaf area, plant height, number of tillers and higher grain yield. Bana *et al*., (2016) also reported better growth rates and assimilation of biomass under manure treatments.

Among weed-management practices, yield obtained in the plot treated with Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* brown manuring with *Sesbania bispinosa* (2.78 t/ha) was at par with the plot treated with pre-emergence application of Pendimethalin *fb* Bispyribac-Na (2.70 t/ha). Both the treatments resulted in significantly higher yield than the un-weeded control plot (2.06 t/ha) (Table 1). Weed growth was low under *Sesbania*-treated plot because

Table 1. Effect of nutrient-and weed-management practices on leaf-area index (LAI), dry-matter accumulation (DMA), yield and yield attributes of rice

Treatment	LAI		DMA (g/m^2)			Grain yield (t/ha)	Effective tillers/ m^2	Filled grain/ panicle	1,000-grain weight (g)
	40 DAS	70 DAS	40 DAS	70 DAS	Harvesting				
Nitrogen management (N)									
No N (P and K only)	1.58	3.9	161.6	481.7	838.0	1.56	186.7	80.8	20.8
RDF (N: P: K, 80 : 17 : 33 kg/ha)	1.61	3.9	163.9	521.7	943.7	3.15	197.7	89.1	22.0
50% N through FYM + 50% N through RTNM (LCC) RTNM (LCC)	1.69	4.0	168.5	523.2	958.0	3.25	200.1	92.8	22.1
SEm±	0.005	0.2	2.5	3.1	4.3	0.07	3.1	2.5	0.3
CD (P=0.05)	0.02	NS	NS	11.3	12.9	0.26	9.4	7.9	1.0
Weed management (W)									
Unweeded control	1.2	2.4	96.1	252.7	496.3	2.06	103.1	76.1	19.7
Weed-free control	1.9	4.7	194.6	615.9	1,017.8	3.09	232.7	97.6	22.5
Brown manuring	1.8	4.4	185.6	591.6	1,144.2	2.78	222.8	91.7	22.3
Pendimethalin *fb* Bispyribac- Na	1.7	4.3	182.4	575.2	1,128.1	2.70	220.7	84.8	22.0
SEm±	0.009	0.1	2.6	3.2	5.5	0.08	3.3	1.6	0.2
CD (P=0.05)	0.03	0.2	7.1	12.6	15.4	0.24	9.8	4.8	0.6
Interaction (N × W)									
Sub-plot at same main-plot									
SEm±	0.01	0.03	3.2	4.2	4.3	0.2	5.7	1.1	0.33
CD (P=0.05)	0.04	0.08	9.6	11.5	12.8	0.5	NS	3.3	0.97
Mainplots at same/different subplot									
SEm±	0.01	0.04	1.8	3.6	3.9	0.1	5.7	1.08	0.37
CD (P=0.05)	0.3	1.0	6.6	12.1	11.7	0.4	NS	3.4	1.2

DAS, Days after sowing; RDF, Recommended dose of fertilizer; RTNM, real-time nitrogen management; *fb*, followed by

Table 2. Crop-growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) of rice variety 'CR Dhan 202' at different growth stages as influenced by nutrient-and weed-management practices

Treatment	CGR ($g/m^2/day$)		RGR (mg/g/day)		NAR ($g/m^2/day$)	
	0–40 DAS	40–70 DAS	0–40 Days	40–70 DAS	0–40 DAS	40–70 DAS
Nitrogen management (N)						
No N (P and K only)	1.81	8.02	140.3	51.7	0.36	3.27
RDF (N: P: K, 80 : 17 : 33 kg/ha)	1.82	8.02	143.8	54.6	0.38	3.31
50% N through FYM + 50% N through RTNM (LCC)	1.85	8.20	145.1	55.1	0.39	3.34
SEm±	0.002	0.02	0.6	0.15	0.07	0.021
CD (P=0.05)	0.006	0.08	2.2	0.6	NS	NS
Weed management (W)						
Unweeded control	1.26	4.8	128.0	49.3	0.15	2.64
Weed- free control	2.39	10.0	160.9	59.7	0.63	3.68
Brown manuring	1.90	8.8	145.3	54.5	0.40	3.49
Pendimethalin *fb* Bispyribac-Na	1.76	8.7	138.4	52.4	0.33	3.42
SEm±	0.008	0.02	3.1	1.3	0.04	0.02
CD (P=0.05)	0.02	0.08	9.0	2.7	0.12	0.08
Interaction (N × W)						
Subplot at same main-plot						
SEm±	0.01	0.03	2.2	0.43	0.02	0.02
CD (P=0.05)	0.04	0.1	5.4	NS	NS	0.05
Main-plots at same/different subplot						
SEm±	0.01	0.03	2.0	0.39	0.01	0.02
CD (P=0.05)	0.03	0.1	4.5	NS	NS	0.09

DAS, Days after sowing; RDF, Recommended dose of fertilizer; RTNM, real-time nitrogen management; *fb*, followed by of its smothering effect both at initial and at later stage of crop growth. After knocking down *Sesbania,* its residues act as surface mulch which restricted penetration of solar radiation on soil surface which resulted in reduced germination of weed seeds. *Sesbania* is a fast-growing crop with high biomass production that could have fixed atmospheric N in the soil and provided the same through its residues after decomposition which helped in better crop growth and higher grain yield (Maity and Mukherjee, 2011).

Yield attributes like effective tillers/m^2 (222.8), filled grains/panicle (91.7), 1,000 grain weight (22.8 g) were significantly higher in plot treated with Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* brown manuring with *Sesbania bispinosa* than unweeded control plot (Table 1).

All the crop-growth indices like LAI (1.8 and 4.4 at 40 DAS and 70 DAS respectively), CGR (1.9 g/m^2/day and 8.8 g/m^2/day at 40 DAS and 70 DAS respectively), RGR (145.3 and 54.5 mg/g/day 40 DAS and 70 DAS respectively), NAR (0.40 and 3.49 g/m^2/day at 40 DAS and 70 DAS respectively) and DMA (185.6, 591.6 and 1,144 g/m^2 at 40 DAS, 70 DAS and harvesting stage respectively) were highest for plot treated with Pendimethalin @ 1.5 kg a.i./ha as pre-emergence *fb* brown manuring with *Sesbania bispinosa* were at par with the plot treated with pre-emergence application of Pendimethalin *fb* Bispyribac-Na which was significantly higher than unweeded control plot. *Sesbania* fixes atmospheric N and provides nutrients to the crop during its initial growth as well as after its decomposition. Further, it has smothering effect which suppresses the germination of weed seeds and their subsequent growth.

Therefore, LCC-based N management along with application of pre-emergence herbicide, pendimethelin *fb* brown manuring with Bispyribac-Na may be used for sustainable productivity as well as improving crop-growth indices in cultivation of dry direct-seeded rice.

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