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Effect of leaf colour chart based nitrogen and weed management on direct seeded rice

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Abstract
A field experiment was conducted during *kharif*, 2016 and 2017 in sandy clay loam soils of experimental field at Banaras Hindu University, Varanasi, Uttar Pradesh to find out the effect of leaf colour chart based nitrogen and weed management practices on growth and yield of direct seeded rice. The experiment was laid out in split plot design with four main plot treatments and five sub plot treatments which were replicated thrice. It was found that superior performance of rice in terms of minimum weed density, dry weight and maximum weed control efficiency, growth, yield attributes and yield was observed with application of nitrogen @ LCC $\leq$ 5 (N_4). Among weed management practices application of Pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS (W_4) which was comparable with two hand weedings at 20 and 40 DAS (W_1) while weedy check (W_0) recorded lowest weed control efficiency, yield and yield attributes.

Keywords: direct seeded rice, LCC, weeds, herbicides, yield

Introduction
Declining profitability of transplanted rice due to increasing production costs and plateauing yield levels have encouraged rice farmers to shift from traditional transplanting to direct seeding. Direct seeded rice, which does not require puddling and drudgery of transplanting the young rice seedlings, provide an option to resolve the edaphic conflict and enhance the sustainability of rice and subsequent cropping system. However, it offers many advantages such as more efficient water use, high tolerance to water deficit, less methane gas emission, reduced cultivation cost, prevents the formation of hard pan in sub-soil and minimizes labour input (Balasubramanian and Hill, 2002) [3].

Direct seeding of rice in the Indo-Gangetic plains has begun and farmers are finding the new technology attractive. In spite of the weed menace, farmers in eastern U.P. and Bihar opt for dry-DSR when it is difficult for them to complete rice transplanting in time or water supplies are uncontrolled such as low or upland rice ecologies (Singh *et al*. 2010) [9]. In dry DSR, the dominant form of N is nitrate and the alternate moist and dry soil conditions prevalent in this system can stimulate nitrification and denitrification processes resulting in a loss of N through N_2 and N_2O. So, fractional application of nitrogen in right amount and proportion, and when it is needed the most seems to be a practical proposition. The LCC is an easy-to-use and inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator of the plant N status (Alam *et al.* 2005) [1] used to guide the application of fertilizer N to maintain an optimal leaf N content for achieving high rice yield with effective N management.

Weeds pose a serious problem in direct seeded rice production system due to the prevalence of congenial atmosphere for its growth durin*g* monsoon season and uncontrolled weed growth reported to reduce yield up to 30.2% (Singh *et al*. 2005) [10]. Effective weed control facilitates higher absorption of applied nutrients by crop. Thus, increase the efficiency of fertilizers application to the crops (Amarjit *et al.* 2006) [2]. Continuous use of these herbicides year after year may also lead to weed flora shift and development of herbicide resistance in certain weeds in the course of time. Therefore, it is essential to develop and evaluate new and alternate herbicides to widen application window and weed control spectrum.

Material and Methods
A field experiment was conducted during rainy (*Kharif*) season of 2016 and 2017 at Agricultural Research Farm, Department of Agronomy, Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The soil was Gangetic alluvial having Sandy clay loam in texture with pH 7.80. It was moderately fertile, being low in available organic carbon (0.33%), available N (154.60 kg ha^{-1}), and medium in available P (12.10 kg ha^{-1}) and K (210.51 kg ha^{-1}). The experiment was laid out in split-plot design with three

replications. The nitrogen management subjected to main plots while weed management in sub plots. A combination of 20 treatments consisting of 4 nitrogen management, viz., N_1: RDN (120 kg N ha^{-1}), N_2: LCC $\leq$ 3, N_3: LCC $\leq$ 4, N_4: LCC $\leq$ 5 and 5 weed management treatments viz., W_0: Weedy check, W_1: Two hand weedings at 20 and 40 DAS, W_2: Pendimethalin @ 1 kg a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS, W_3: Flufenacet @ 120 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS, W_4: Pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS. Recommended dose of N, P and K were applied at 120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 40 kg K_2O ha^{-1}. Full dose of phosphorus and potash were applied as basal application and nitrogen was applied as treatment wise. Dry seed of 'HUR 105' variety of rice at 30 kg ha^{-1} was used for seeding of rice. Sowing was done manually with the help of spade at a spacing of row 20 cm. The required quantity of pre-emergence and post-emergence herbicides was sprayed as per treatment using spray volume of 500 litres of water ha^{-1} with the help of knap sack sprayer fitted with flat fan nozzle. The data on weeds were subjected to square-root transformation ($\sqrt{x+0.5}$) to normalize their distribution.

Results and Discussion

Weed Flora

Major weed flora species infesting in the direct seeded rice as observed in weedy check plots were, grasses, sedges and broad-leaved weeds. The critical analysis of data on relative composition of weed species indicated that *Echinochloa colona*, *Echinochloa crussgalli* and *Cyanodon dactylon* among grasses, *Cyperus rotundus* and *Cyperus iria* among sedges and *Eclipta Alba* and *Caesulia auxillaris* among broad leaved weed were dominant throughout the crop growth period.

Effect on weeds

Weed density

Irrespective of nitrogen and weed management practices, weed density and dry weight of weeds were higher in 2017 than in 2016. The crop experienced severe weed competition during 2017, which might be due to favourable weather conditions leading to vigorous growth of weeds.

Statistically detectable disparities were noticed with respect to weed density (Table 1). Among nitrogen management treatments, LCC $\leq$ 5 (N_4) was effective in controlling broad spectrum of weeds *i.e.*, grasses, sedges and broad leaved weeds Maximum weed population was found in case of N_1-RDN (120 kg N ha^{-1}) during both the years of study. This might be due to the fact that in all LCC treatments equal and liberal amounts of nitrogen were applied with more number of splits at critical growth stages and made timely availability of nitrogen as per need of the plant. These results are in conformity with the findings of Sen *et al*. (2011) [7].

All the weed management practices showed significant effect on weeds and had less weed growth as compared to weedy check (W_0) which recorded maximum weed population. The lowest total weed density among the herbicide treatments was registered with two hand weedings at 20 and 40 DAS and application of pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS (W_4) and significantly superior to rest of the herbicide treatments and weedy check (T_1). Better performance exhibited by W_4 in reducing the total weed density might be due to the reason that it was able to control both grassy as well as sedges effectively at 60 DAS. These

Results are corroborating with the study of McDonald and Dernoeden (2006) [5] who reported that bispyribac sodium can selectively control annual grasses and also in conformity with Upasani and Barla (2014) [11].

Weed dry weight

Total weed dry weight was significantly influenced by different nitrogen and weed management practices. Application of nitrogen @ LCC $\leq$ 5 (N_4) recorded minimum weed dry weight and the maximum weed dry weight was recorded with the application of N_1-RDN (120 kg N ha^{-1}) at 60 DAS during both the years of study. Higher dry weight of weeds in RDN (¼ at basal+ ½ at maximum tillering+ ¼ at panicle initiation stage) under splits involving part of nitrogen at sowing might be attributed to vigorous growth of weeds due to nitrogen supply at sowing, which consequently resulted in higher dry weight of weeds at different stages of growth. These findings are similar with the results reported by Sharma *et al*. (2007) [8].

Among weed management practices, minimum total weed dry weight was recorded under two hand weedings at 20 and 40 DAS followed by pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS (W_4). The next best treatment was Pendimethalin @ 1 kg a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS (W_2). Maximum weed dry weight recorded in weedy plots in respect to other treatment. Superior performance of herbicides in reducing the weed dry weight due to sequential application compared to alone application has been reported Narolia *et al*. 2014 [6].

Weed control efficiency

Under different nitrogen treatments, application of nitrogen @ LCC $\leq$ 5 (N_4) recorded highest weed control efficiency (35.68 and 39.44, respectively) due to lower dry matter accumulation of weeds at all the stages of crop growth during both the years of study (Table 1). Application of N_1-RDN (120 kg N ha^{-1}) had minimum weed control efficiency (21.06 and 20.18, respectively) than other nitrogen treatments due to higher dry weight of weeds.

Among different weed management practices, two hand weedings at 20 and 40 DAS (44.15 and 45.43, respectively) recorded higher weed control efficiency followed by pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS (39.70 and 40.39, respectively) which might be due to lower weed dry matter accumulation during both the years of study. The highest weed control efficiency associated with pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS might be due to the fact that the successive application of two herbicides at an interval of 20 days created an adverse reduction in total weed dry matter. The results of the present investigation was in conformity with those reported by Narolia *et al*. (2014) [6] who also obtained significant increase in weed control efficiency with sequential application of herbicides.

Table 1: Effect of Leaf colour chart based nitrogen and weed management on total density of weeds, dry weight and WCE at 60 DAS of direct seeded rice

Treatments	Total weed density (No. m^{-2})		Weed dry weight (g m^{-2})		WCE (%)	
	2016	2017	2016	2017	2016	2017
Nitrogen management						
N_1: RDN (120 kg N ha^{-1})	19.01 (367.26)	20.24 (416.17)	8.84 (78.74)	9.64 (94.04)	21.06	20.18
N_2: LCC $\leq$ 3	18.68 (352.58)	20.06 (405.52)	8.60 (73.87)	9.35 (87.66)	25.94	25.60
N_3: LCC $\leq$ 4	17.66 (316.21)	19.10 (369.41)	8.14 (66.30)	8.64 (75.21)	33.53	36.17
N_4: LCC $\leq$ 5	16.42 (281.90)	18.12 (337.98)	7.91 (64.16)	8.34 (71.35)	35.68	39.44
SEm $\pm$	0.26	0.36	0.12	0.14	--	--
CD (P=0.05)	0.90	1.24	0.42	0.50	--	--
Weed management practices						
W_0: Weedy check	22.26 (495.89)	23.78 (565.39)	10.00 (99.75)	10.86 (117.82)	0.00	0.00
W_1: Two hand weedings at 20 and 40 DAS	14.86 (224.51)	16.75 (283.33)	7.44 (55.71)	8.02 (64.29)	44.15	45.43
W_2: Pendimethalin @ 1 kg a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	17.92 (321.85)	19.17 (368.13)	8.11 (65.65)	8.54 (73.13)	34.19	37.93
W_3: Flufenacet @ 120 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	18.41 (340.27)	19.60 (384.90)	8.54 (72.58)	9.18 (84.87)	27.24	27.97
W_4: Pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	16.27 (264.92)	17.60 (309.60)	7.77 (60.15)	8.37 (70.23)	39.70	40.39
SEm $\pm$	0.21	0.12	0.11	0.08	--	--
CD (P=0.05)	0.60	0.34	0.31	0.24	--	--

Effect on crop

Significantly taller plants were recorded under nitrogen application @ LCC $\leq$ 5 (N_4) than other nitrogen management treatments during both the years of experimentation (Table 2). Maximum dry matter accumulation 25 cm^{-1} row length and higher number of tillers at 60 DAS were recorded with nitrogen management @ LCC $\leq$ 5 (N_4) which was comparable with LCC $\leq$ 4 (N_3). As the growth parameters of plant dependent upon its metabolic activities and its corresponding growth. With higher leaf area and chlorophyll content the plant could exhibit higher photosynthetic activities which ultimately led to greater dry matter production and more number of tillers. These results were in conformity with the findings of Sen *et al*. (2011) [7].

Amongst various weed management treatments, hand weeding twice at 20 and 40 DAS and the application of pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS increased growth attributes during both the years of experimentation. Effective suppression of weed growth throughout the critical period of crop-weed competition might have enabled direct seeded rice to bear promising architecture for growth attributes. These findings are reported by Zahoor Ahmad Ganie *et al*. 2014 [12].

Table 2: Effect of Leaf colour chart based nitrogen and weed management on growth parameters at 60 DAS of direct seeded rice

Treatments	Plant height (cm)		Number of tillers (m^{-1} row length)		Dry matter production (g/25 cm row length)	
	2016	2017	2016	2017	2016	2017
Nitrogen management						
N_1: RDN (120 kg N ha^{-1})	64.91	64.13	71.32	67.89	21.69	19.77
N_2: LCC $\leq$ 3	67.78	66.51	74.36	72.32	24.47	23.14
N_3: LCC $\leq$ 4	69.93	69.18	76.85	75.46	29.72	28.26
N_4: LCC $\leq$ 5	75.28	74.70	80.06	78.49	35.78	34.12
SEm $\pm$	0.52	0.38	1.18	1.48	0.71	0.37
CD (P=0.05)	1.79	1.30	4.08	5.12	2.45	1.28
Weed management practices						
W_0: Weedy check	59.71	58.13	61.62	59.95	19.33	17.94
W_1: Two hand weedings at 20 and 40 DAS	76.25	75.70	83.81	81.75	34.50	32.38
W_2: Pendimethalin @ 1 kg a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	70.14	69.40	77.51	76.14	29.01	27.97
W_3: Flufenacet @ 120 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	65.16	64.00	71.87	69.90	23.36	22.12
W_4: Pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	76.11	75.93	83.44	79.97	33.37	31.20
SEm $\pm$	0.48	0.36	1.11	1.17	0.50	0.58
CD (P=0.05)	1.39	1.04	3.21	3.38	1.44	1.67

Effect on crop yield

Application of LCC $\leq$ 5 (N_4) was recorded maximum grain and straw yield than other nitrogen treatments (Table 3). The increased harvest index, grain and straw yield was perhaps as a result of better availability of nutrient as need based and reduced weed density, dry weight and better weed control efficiency. These findings were in conformity with the results of Kumawat *et al.* (2017) [4]. The minimum harvest index, grain and straw yield was recorded under nitrogen application of N_1-RDN (120 kg N ha^{-1}).

Amongst various weed management treatments, hand weeding twice at 20 and 40 DAS resulted in significantly higher harvest index, grain and straw yield and was comparable with application of pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS (Table 3) than other weed management treatments. The increase in

harvest index, grain and straw yield might be due to the reason that the sequential application of two herbicides having distinct mode of actions created a rather weed free environment by effectively suppressing a broad-spectrum of weed population and consequently weed dry matter. Prevalence of weed free crop growing environment might have enabled congenial conditions for production of higher growth stature and better yield structure which might have eventually resulted in higher yields. Similar views were also expressed by Narolia *et al*. (2014) [6].

Table 3: Effect of Leaf colour chart based nitrogen and weed management on Grain yield, Straw yield and Harvest index in direct seeded rice

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Harvest Index (%)	
	2016	2017	2016	2017	2016	2017
Nitrogen management						
N_1: RDN (120 kg N ha^{-1})	3515.15	3122.91	5471.86	5350.65	38.80	36.04
N_2: LCC ≤ 3	3688.31	3316.02	5645.02	5428.57	39.18	37.50
N_3: LCC ≤ 4	3826.84	3696.97	5437.23	5423.84	39.37	39.53
N_4: LCC ≤ 5	4277.78	4025.97	6025.97	5922.08	40.74	39.72
SEm ±	97.91	59.70	70.21	63.26	0.95	0.58
CD (P=0.05)	338.82	206.59	242.95	218.90	3.27	2.02
Weed management practices						
W_0: Weedy check	2532.47	2186.15	4956.71	4745.17	33.61	31.31
W_1: Two hand weedings at 20 and 40 DAS	4827.75	4574.63	6093.07	6006.49	43.25	42.60
W_2: Pendimethalin @ 1 kg a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	3733.77	3463.20	5692.64	5562.77	39.35	38.33
W_3: Flufenacet @ 120 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	3387.45	3084.42	5422.08	5357.14	38.37	36.52
W_4: Pyrazosulfuron @ 20 g a.i ha^{-1} (PE) *fb* bispyribac @ 25 g a.i ha^{-1} at 15-20 DAS	4653.68	4393.94	6060.61	5984.85	43.04	42.22
SEm ±	76.89	70.45	68.19	54.23	0.91	0.68
CD (P=0.05)	221.49	202.94	196.42	156.22	2.62	1.97

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