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Leaf colour chart-based nitrogen and weed management impacts on weeds, yield and nutrient uptake in dry direct-seeded rice

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ABSTRACT

A field experiment was conducted during *Kharif* (rainy season) 2016 and 2017 in sandy clay loam soils of experimental field at Banaras Hindu University, Varanasi, Uttar Pradesh India to find out the effect of leaf colour chart-based nitrogen and weed management practices on nutrient uptake and yield of direct-seeded rice. Minimum weed index, nutrient content and uptake by weeds and maximum weed control efficiency, yield and nutrient content and uptake by grain and straw were observed with application of nitrogen leaf colour chart LCC $\leq$ 5. Application of pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS recorded minimum weed index, nutrient content and uptake by weeds and maximum weed control efficiency, rice yield and nutrient content and uptake by rice grain and straw, which was comparable with two hand weedings at 20 and 40 DAS.

INTRODUCTION

Rice cultivation by direct-seeding is viewed as both cost and labour saving practice. Nitrogen is the most widely used fertilizer nutrient in rice and its consumption has increased substantially in the past decades. The quantity of rice grain produced per unit of applied N fertilizer (partial factor productivity) has constantly decreased to very low values (Dobermann *et al.* 2002). It has been observed that more than 60% of applied nitrogen is lost due to lack of harmonization between the nitrogen demand and nitrogen supply. Since farmers generally prefer to keep leaves of the crop dark green, it leads to more application of fertilizer N resulting in low use efficiency. The spectral properties of leaves should be used in a more coherent manner to guide need based N application at the right time and in right dose as it is critical for healthy plant environment (Tauseef *et al.* 2017). Thus, the International Rice Research Institute (Philippines) developed a leaf color chart (LCC) that helps to guide farmers for real-time nitrogen management in rice farming which is inexpensive, and easily affordable by most resource poor rice farmers (Islam *et al.* 2004).

In direct-seeded rice (DSR), weeds are a major biotic stress to rice production as they increase production costs and cause yield loss (Rao *et al.* 2007). Weeds reduce rice yield up to 40-100% in direct-seeded rice (Choubey *et al.* 2001). The shift from transplanted to DSR results in more hostile weed flora and increased dependence on herbicides, owing to increasing labour problem and in view of time consuming, burdensome and less effective nature of cultural and mechanical methods of weed control (Rao and Ladha 2014). Herbicide-based weed management is the smartest and viable option of weed control in DSR. It reduces the total energy requirement for rice cultivation. To have a broad-spectrum weed control in single application, herbicide mixtures (both concocted and tank) were tried and found to be effective (Rao and Nagamani 2010). Fractional application of nitrogen in right amount and proportion together with weed control practices facilitates higher absorption of applied nitrogen and thus increasing effectiveness of fertilizer nitrogen (Amarjit *et al.* 2006). The objectives include the effect of real time nitrogen application and weed management treatments on weed growth, NPK uptake by weed and the crop under different treatments.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*Kharif*) season of 2016 and 2017 at Institute of Agricultural sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. 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), and medium in available P (12.10 kg/ha) and K (210.51 kg/ha).

The experiment was laid out in a split-plot design replicated thrice with four nitrogen management treatments, *viz*. recommended dose of nitrogen (RDN) (120 kg N/ha), LCC ≤ 3, LCC ≤ 4, LCC ≤ 5 as main plots and 5 weed management treatments, *viz*. weedy check, two hand weedings at 20 and 40 DAS, pendimethalin 1.0 kg/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS, flufenacet 120 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS, pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 as sub-plots. Full dose of phosphorus (60 kg P/ha) and potash (40 kg K/ha) were applied as basal application and nitrogen was applied as per treatment. The leaf colour chart consisteds of 6 colour shades ranging from light yellowish green to dark green strips fabricated with veins resembling that of rice leaves. LCC readings were taken at 7 days interval starting from 10 days after sowing till emergence of heading stage. Ten disease free hills were selected at random from sampling area in each plot. From each hill top, most fully expanded leaf was selected and LCC readings were taken by placing the middle part of the leaf on the chart and leaf colour was observed by keeping the sun blocked by body as sunlight affects leaf colour reading. Whenever, the green colour of more than 5 out of 10 leaves were observed equal to or below a set critical limit of LCC score, nitrogen was applied as per treatment.

The dry seed of *'HUR 105'* variety of rice at 30 kg/ha was sown manually with the help of spade at a row spacing of 20 cm. The pre-emergence and post-emergence herbicides were sprayed as per treatment using spray volume of 500 L of water/ha using knap sack sprayer fitted with flat fan nozzle. Weed samples were collected by placing a quadrate (50 x 50 cm) randomly at two places in each plot at 20, 40, 60, 80 DAS and at harvest. The data on weeds were subjected to square-root transformation ($\sqrt{x+0.5}$) to normalize their distribution. The weed index (WI) was calculated based on the rice grain yield obtained from treatments using the formula as suggested by Gill and Vijaykumar (1969).

The plant samples of rice utilized for recording dry matter production at harvest and weed samples at 60 DAS were ground in a Willey mill to pass through 40 mesh sieve. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen and phosphorus were estimated by Micro Kjeldahl's method (Jackson 1973), Vanadomolybdate phosphoric yellow colour method (Jackson 1973) respectively, and potassium was determined by Flame photometer method (Jackson 1973) and it was expressed in per cent.

RESULTS AND DISCUSSION

Weed flora, weed control efficiency, weed index and nutrient uptake by weeds

Major weed flora species infesting in the direct-seeded rice as observed in weedy check plots were *Echinochloa colona* (45.09%), *Echinochloa cruss-galli* (48.14%) and *Cyanodon dactylon* (39.25%) among grasses, *Cyperus rotundus* (62.92%) and *Cyperus iria* (58.22%) among sedges and *Eclipta alba* (45.02%) and *Caesulia auxillaris* (54.98%) among broad-leaved weeds.

Under different leaf colour chart based nitrogen schedules, LCC ≤5 recorded the highest weed control efficiency, lower weed index (11.39 and 11.99)

Table 1. Effect of leaf colour chart-based nitrogen management and weed management treatments on grain yield, straw yield and weed control efficiency in dry direct-seeded rice

Treatment	Grain yield (t/ha)		Straw yield (t/ha)		Weed control efficiency (%)		Weed index	
	2016	2017	2016	2017	2016	2017	2016	2017
Nitrogen management								
RDN (120 kg N/ha)	3.51	3.12	5.47	5.35	23.62	25.39	27.19	31.73
LCC ≤ 3	3.69	3.32	5.64	5.43	30.48	29.49	23.60	27.51
LCC ≤ 4	3.83	3.70	5.44	5.42	33.67	33.63	20.73	19.19
LCC ≤ 5	4.28	4.03	6.03	5.92	35.60	35.49	11.39	11.99
LSD (p=0.05)	0.34	0.21	0.24	0.22	-	-	-	-
Weed management								
Pendimethalin 1.0 kg/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	3.73	3.46	5.69	5.56	34.88	32.88	22.66	24.30
Flufenacet 120 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	3.39	3.08	5.42	5.36	30.98	29.01	29.83	32.58
Pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	4.65	4.39	6.06	5.98	42.06	45.45	3.61	3.95
Two hand weedings at 20 and 40 DAS	4.83	4.57	6.09	6.01	46.28	47.66	0.00	0.00
Weedy check	2.53	2.19	4.96	4.74	0.00	0.00	47.54	52.21
LSD (p=0.05)	0.22	0.20	0.20	0.16	-	-	-	-

LCC: Leaf colour chart; RDN: Recommended dose of nitrogen

(**Table 1**) and minimum nutrient (N, P and K) content and depletion by weeds (**Table 2**) due to lower weed biomass at all the stages of crop growth during both the years. The RDN (120 kg/ha) registered lower weed control efficiency due to higher weed biomass (Nair *et al.* 2002, Chaudhary *et al*. 2011 and Singh *et al*. 2005).

The highest weed control efficiency, minimum weed index (3.61 and 3.95) and lower NPK depletion by weeds were recorded with pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS during both the years (**Table 1**) due to its effective control of complex weed flora, *viz*. grasses, sedges and broad-leaved weeds as it encouraged the earlier crop canopy closure/coverage. These results were in conformity with the findings of Devi and Singh (2018), Ghosh *et al.* (2017) in reference to nutrient content (%) and uptake (kg/ha), grain and straw yield of rice.

Application of LCC ≤ 5 recorded maximum nutrient content in grain and straw (**Table 3**) and maximum grain and straw yield than other nitrogen treatments (**Table 1**). 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, biomass and better weed control efficiency. These findings were in conformity with the results of Kumawat *et al.* (2017). The lower total N uptake with fixed schedule recommended N application method than with LCC managed N could be associated with suboptimal rates of N application in the recommendation, which could have limited rice

Table 2. Effect of leaf colour chart-based nitrogen and weed management on NPK removal by weed at harvest in direct-seeded rice

Treatment	N removal (kg/ha) by weed		P removal (kg/ha) by weed		K removal (kg/ha) by weed	
	2016	2017	2016	2017	2016	2017
Nitrogen management						
RDN (120 kg N/ha)	5.88(35.1)	6.85(50.4)	3.18(10.1)	3.91(16.3)	6.51(42.9)	7.30(56.6)
LCC ≤ 3	5.46(29.9)	6.55(44.5)	2.73(7.4)	3.39(12.1)	6.10(37.0)	7.05(50.2)
LCC ≤ 4	5.16(27.6)	6.16(38.1)	2.55(6.8)	3.11(10.2)	5.74(33.6)	6.73(45.3)
LCC ≤ 5	4.86(24.9)	5.67(32.7)	2.37(5.7)	2.59(7.0)	5.44(31.4)	6.32(41.0)
LSD (p=0.05)	0.12	0.15	0.06	0.08	0.14	0.16
Weed management						
Pendimethalin 1.0 kg/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	5.14(26.1)	6.15(37.8)	2.49(5.9)	2.94(8.5)	5.94(35.1)	6.77(45.6)
Flufenacet 120 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	5.42(28.9)	6.56(42.7)	2.73(7.0)	3.47(12.1)	6.15(37.6)	7.01(49.1)
Pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	4.53(20.8)	5.26(27.7)	2.25(4.8)	2.40(5.3)	5.00(25.0)	5.96(35.2)
Two hand weedings at 20 and 40 DAS	4.37(19.0)	5.30(28.4)	2.02(3.7)	2.34(5.1)	5.14(27.5)	5.74(33.0)
Weedy check	7.24(52.1)	8.27(70.5)	4.05(16.1)	5.11(26.1)	7.50(56.1)	8.78(78.4)
LSD (p=0.05)	0.09	0.11	0.04	0.05	0.09	0.11

Data were subjected to square root transformation $\sqrt{x+0.5}$. Figures in parenthesis are original values

Table 3. Effect of leaf colour chart-based nitrogen and weed management on nutrient uptake by grain and straw in direct-seeded rice

Treatment	N uptake (kg/ha)				P uptake(kg/ha)				K uptake(kg/ha)			
	2016		2017		2016		2017		2016		2017	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Nitrogen management												
RDN (120 kg N/ha)	40.4	31.9	34.3	30.6	8.6	12.1	7.4	10.1	16.9	67.6	13.7	68.6
LCC ≤ 3	43.7	34.0	36.4	31.9	9.8	13.0	7.6	11.5	18.3	79.6	14.3	75.0
LCC ≤ 4	47.7	33.8	44.2	32.7	11.4	12.7	9.0	11.7	20.0	81.5	16.3	77.7
LCC ≤ 5	59.0	47.3	52.3	43.7	14.1	17.1	11.6	15.8	24.5	100.2	21.5	94.4
LSD (p=0.05)	10.5	6.0	7.1	6.4	2.7	1.9	2.0	2.6	3.2	15.2	3.0	10.0
Weed management												
Pendimethalin 1.0 kg/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	46.8	38.2	40.1	36.0	11.1	15.0	9.1	13.9	19.9	83.1	15.9	81.0
Flufenacet 120 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	40.2	33.2	33.4	31.5	7.1	9.3	5.5	8.3	14.8	72.1	11.0	69.3
Pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS	62.0	44.1	56.7	42.2	15.5	17.7	12.5	16.3	26.2	91.3	22.3	88.3
Two hand weedings at 20 and 40 DAS	66.4	47.5	59.7	44.5	17.3	19.6	14.6	17.7	28.3	101.7	24.4	98.3
Weedy check	23.1	20.9	19.1	19.2	3.9	7.0	2.7	5.3	10.3	63.0	8.8	57.6
LSD (p=0.05)	9.1	5.4	6.5	5.1	2.1	2.1	1.3	2.4	4.4	14.3	2.6	16.1

growth. Increase in P and K uptake with increased dose of N added evidence to the fact that N application has synergistic effect on the uptake of other nutrients besides N which was due to increase in biomass of the crop with increased N application. The results were in close proximity to Gupta *et al.* (2011) and Nachimuthu *et al.* (2007).

Amongst various weed management treatments, hand weeding twice at 20 and 40 DAS resulted in significantly higher grain and straw yield and higher N, P and K uptake by grain and straw of rice and was comparable with application of pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS than other weed management treatments (**Table 1**). Higher values for the uptake of N, P and K by crop under relatively weed free crop growing conditions was also reported earlier by Devi and Singh (2018). The increase in grain and straw yield in those two treatments might be due to the creation of 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 as expressed by Narolia *et al.* (2014).

Thus, it may be concluded that, application of LCC $\leq$ 5 and sequential application of pyrazosulfuron 20 g/ha (PE) *fb* bispyribac 25 g/ha at 15-20 DAS recorded the maximum weed control and grain yield in dry direct-seeded rice in Eastern Uttar Pradesh.

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