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Effect of nitrogen fertilizer and weed management practices on weed growth and crop yield of zero-till transplanted rice

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ABSTRACT

The application of N at recommended or higher dose (33% higher than recommended) effectively enhanced the growth and yield of rice crop by suppressing the weed growth in zero-till transplanted rice. Hand weeding thrice at 25, 55 and 75 days after transplanting (DAT) was the best in reducing weed growth and ultimately increased the grain yield of zero-till transplanted rice. Among the herbicidal methods, tank mix application of bispyribac-Na + 2,4-D minimized the weed growth at early stage and enhanced rice grain yield.

Rice is the most important staple crop for more than half of the population in India. The most common growing method of rice is manual transplanting of seedlings in puddled soils, creating a hard pan below the plough layer. This practice involves huge amount of water (3000-5000 L of water to produce 1 kg rice) (Bouman *et al.* 2002), which is becoming increasingly scanty. Continuous practice of puddling deteriorates soil health and also emits greenhouse gases emission, particularly methane. On the other hand early heavy rainfalls during rice seeding also hamper the proper crop establishment. These above situations have compelled scientists and researchers to test zero-till transplanted rice cultivation. Weeds are recognized as the major biological constraints to the production of rice under zero-till condition (Singh *et al*. 2008 Ghosh *et al.* 2016). Many agronomic aspects of land management influence the composition, density and diversity of a community of weeds; particularly nitrogen (N) fertilization alters soil fertility affecting not only crop growth, but also diversity and growth of associated weeds (O'Donovan *et al.* 1997, Rao and Matsumoto 2017). Weeding in Asia is commonly done by labour; however, due to unavailability of labour at critical time and higher cost, herbicides are considered to be an alternative to hand weeding (HW) (Rao and Matsumoto 2007). Hence, the present investigation was undertaken to study the effect of different N and weed management practices on weed growth and performance of rice crop in zero-till transplanted condition.

A field experiment was carried out during rainy season of 2013 at experimental farm of ICAR-Directorate of Weed Research, Jabalpur (23°132' N, 79°582'E, and 390 m above mean sea level), Madhya Pradesh. The soil was clay loam in texture, neutral (7.2) in reaction, medium in organic carbon (0.79%), available nitrogen (312 kg/ha) and phosphorus (18 kg P_2O_5/ha) but high in available potassium (291 kg K_2O/ha). The experiment was laid out in a split-plot design with five N levels as main factor (0, 40, 80, 120 and 160 kg N/ha) and four weed management methods as sub-factors. The weed management practices comprised of single post-emergence (POST) herbicide (fenoxaprop-p-ethyl at 60 g/ha), tank mix application of POST herbicides (bispyribac-Na + 2,4-D at 25 + 500 g/ha), conventional hand weeding (HW) practice and weedy check for comparison. The area of each plot was 60 m² (5 × 12 m). Nitrogen was applied in the form of urea as per treatment and a basal dose of P_2O_5 and K_2O at 60 kg/ha each were applied through single super phosphate and muriate of potash, respectively. Nitrogen was applied in three equal splits, as basal, maximum tillering and panicle initiation stage. The 25 days old seedlings of rice cv. *Kranti* was transplanted in zero-till condition (without puddling) with spacing of 20 x 10 cm during third week July. The herbicides were applied with a knapsack sprayer filted with flat-fan nozzles at 25 days after transplanting (DAT) with spray volume of 500 L/ha, and HW was done at 25, 55 and 75 DAT for conventional approach. Data were collected randomly from each plot for three replications. For weed density, permanent quadrates (2 × 2 m) were earmarked in each plot after rice transplanting and then weed data were taken from these areas before and 25 days after application of POST herbicides. For weed biomass, weeds were cut at ground level and washed with tap water, sun dried, hot-air oven-dried at 70°C for 48 h, and then weighed. Plant height and tiller number of rice were documented at 50 DAT; and panicle number and grain yield of rice were recorded at harvest. The data of actual weed density were transformed by square root transformation before analysis. The statistical analysis of data was done using SAS Windows Version 9.4. The means were compared based on the least significant difference (LSD) test at 0.05 probability level.

Weed flora

The dominant weeds associated with rice were *Echinochloa colona* (L.) Link, *Dinebra retroflexa* (Vahl) Panzer, *Cyperus iria* (L.), *Alternanthera sessilis* R.Br. and *Commelina benghalensis*. However, other weed flora consists of *Ludwigia parviflora* (L.), *Eclipta alba* (L.) Hassk, *Caesulia axillaris* and (L.). and *Physalis minima*.

Effect on weed density and biomass

Throughout the crop growth period, different nutrient management practices with varying level of N had no significant effect on the total weed density in rice, whereas, different weed management practices significantly lowered down the total weed density at 50 DAT in rice (**Table 1**). As compared to HW (one HW out of three HW), the application of herbicides *i.e.* bispyribac-Na + 2,4-D and fenoxaprop-p-ethyl at 25 DAT effectively minimized the total weed density at 50 DAT in zero-till transplanted rice. At early crop growth stage (50 DAT), among the different N management practices, the application of N at lower dose (40 and 80 kg/ha) restricted the growth of rice crop (data not presented) and facilitated the weed growth which ultimately resulted higher biomass accumulation of total weeds in rice. The plots received N at lower dose was insufficient to supply N for proper growth of rice crop. On the other hand, N application at recommended and higher dose (120 and 160 kg/ha) enhanced the crop growth and eventually suppressed the growth of weeds. Under control situation (0 kg N/ ha), the availability of N was inadequate for the proper growth of both crop and weeds. At harvest, biomass accumulation by total weeds was the maximum when N was applied at 2/3 of recommended dose. As compared to recommended dose (120 kg/ha), when N was applied at 33% higher rate significantly lowered down the biomass accumulation of total weeds by increasing the growth

Table 1. Effect of nitrogen fertilizer and weed management practice on weed density and biomass, plant growth and grain yield in zero-till transplanted rice

Treatment	Weed density (no./m^2)		Weed biomass (g/m^2)		Plant height (cm) at 60 DAT	Tiller no./m^2 at 60 DAT	Panicle no./m^2	Grain yield (t/ha)
	25 DAT	50 DAT	50 DAT	Harvest				
Nitrogen management								
40 kg/ha	12.0 (143)	9.0 (80)	221	233	72.2	246	222	1.51
80 kg/ha	12.0 (143)	10.1 (101)	275	439	71.8	233	237	1.70
120 kg/ha	12.0 (143)	9.7 (93)	181	363	70.8	277	253	1.91
160 kg/ha	13.7 (188)	10.2 (103)	194	195	71.6	273	251	1.94
Control	12.3 (151*)	10.3 (107)	182	189	71.5	228	203	1.11
LSD (p=0.05)	NS	NS	48.9	122.4	NS	24.3	26.6	0.16
Weed management								
Bispyribac-Na + 2,4-D (25 + 500 g/ha at 25 DAT)	12.7 (160)	8.4 (69)	51	318	71.1	249	242	1.91
Fenoxaprop-p-ethyl (60 g/ha at 25 DAT)	11.8 (140)	8.1 (65)	321	361	71.3	259	240	1.74
Hand weeding thrice (at 25, 50 and 75 DAT)	13.0 (169)	11.0 (120)	114	61	70.9	255	236	1.98
Weedy	12.0 (144)	11.5 (133)	356	396	73.1	242	214	0.89
LSD (p=0.05)	NS	1.3	66.3	94.1	NS	NS	18.3	0.17

*Original figures in parentheses were subjected to square-root transformation $\sqrt{x+0.5}$ before statistical analysis; DAT-Days after transplanting of rice crop. At early crop growth stage, as compared to weedy, the tank mix application of bispyribac-Na + 2,4-D at 25 DAT significantly reduced the total weed dry biomass by 86% in zero-till transplanted rice. On the other hand, HW thrice performed better than the herbicides in reducing biomass accumulation by weeds. It may be due to that, the effect of herbicides in reducing germination and growth of weeds was not enough for subsequent weed flashes (emerged after herbicide application).

Crop growth and yield

Different N and weed management practices had no significant effect on plant height of rice at 60 DAT. With the increment of N dose, the tiller and panicle number of rice increased. Significantly higher tiller and panicle number was recorded in the plots receiving the N at recommended dose or 33% higher than the recommended dose indicating that lower N dose was not adequate for proper growth of rice crop. On the other hand, different weed management had no significant effect on tiller production by rice crop at 60 DAT, but the panicle number/m^2 varied significantly with weed management methods. The application of N at recommended or higher dose (33%) significantly increased the grain yield of rice. Amongst weed management practices, the maximum yield was recorded with hand weeding thrice (at 25, 55 and 75 DAT) and it was at par with bispyribac-Na+2,4-D at 25+500 g/ha at 25 DAT. Ghosh *et al*, (2017) also found that the tank mix application of bispyribac-Na + azimsulfuron effectively decreased the growth of diverse weed flora in zero-till direct-seeded rice and subsequently enhanced the rice grain yield. In the current experimentation, crop was transplanted in zero-till condition and the field topography was medium upland in nature, as a result it was very difficult to maintain the standing water in the zero-till condition. And also, the field was heavily infested with weeds, and weeds were germinated in repeated flushes, as a result the performance of rice crop was meagre and resulted in lower rice grain yield.

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