

Original Research Article

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Effect of Nitrogen and Weed Management on Nutrient Removal by Weed in Direct Seeded Rice

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ABSTRACT

A study was carried out during *Kharif* 2015 and 2016 to evaluate the effect of four nitrogen and six weed management practices on drymatter and nutrient removal by weed in direct seeded rice on a sandy loam soil at the Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiment was laid out in split plot design with 3 replications. The results revealed that the application of $\frac{1}{4}$ N basal + $\frac{1}{4}$ N at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage + $\frac{1}{4}$ N at heading stage was significantly superior in reducing total weed dry matter (g m^{-2}) at all the stages of observation and NPK removal by weeds at 60 DAS and at harvest than $\frac{1}{2}$ N basal + $\frac{1}{4}$ N at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage and $\frac{1}{4}$ N at basal + $\frac{1}{2}$ N at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage. However, it was at par with $\frac{1}{3}$ N at basal + $\frac{1}{3}$ N at active tillering stage + $\frac{1}{3}$ N at panicle initiation stage. Amongst weed management practices hand weeding twice at 20 and 40 DAS followed by bispyribac at 25 g a.i. ha^{-1} + azimsulfuron at 17.5 g a.i. ha^{-1} + NIS (0.25 %) at 15-20 DAS proved most effective in reducing weed drymatter and nutrient removal by weeds as compared to other herbicidal treatments. Application of oxadiargyl at 90 g a.i. ha^{-1} (PE) fb bispyribac at 25g a.i. ha^{-1} + NIS (0.25%) at 15-20 DAS had minimum efficacy in these respect during both the years.

Keywords

Direct seeded rice,
Nutrient removal,
weed management,
weed drymatter

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Introduction

In recent years there has been a shift from transplanting to direct seeding. This shift was principally driven by water scarcity issues and expensive labour component for transplanting under acute farm labour shortage (Chauhan, 2012). Direct seeding of rice has the potential to provide several benefits to farmers and the environment over conventional practices of puddling and transplanting. Direct seeding helps reduce water consumption by about 30% (0.9 million liters acre⁻¹) as it eliminates

raising of seedlings in a nursery, puddling, transplanting under puddled soil and maintaining 4-5 inches of water at the base of the transplanted seedlings (Joshi *et al.*, 2013). Despite several advantages of DSR, it is subjected to much higher weed pressure than the conventional puddled transplanted rice systems (Chauhan, 2012), in which weeds are suppressed by standing water and transplanted rice seedlings. Aerobic soil conditions and alternate wetting and drying in DSR are conducive to the germination and growth of weeds, causing grain yield losses of up to

80%. Thus, an efficient and timely weed control is crucial for the success of DSR. In order to control weeds, farmers use both pre and post emergence herbicides (Mahajan *et al.*, 2013). Weeds interfere with normal crop growth by competing for available nutrients, light and water. Uncontrolled weeds reduce the grain yield by 96% in dry direct-seeded rice and 61% in wet direct seeded rice (Maity and Mukerjee, 2008). Nitrogen is a key nutrient in determining the level of crop productivity. The efficiency of applied nitrogen is very low and varies from 20 to 25% in upland rice crop due to the oxidized condition prevailing in uplands and concomitant heavy nitrogen loss through percolating water. Hence, fractional application of nitrogen in right amount and proportion, and when it is needed the most seems to be a practical proposition. Weed control also facilitates higher absorption of applied nutrient, thus increases the efficiency of fertilizers application to the crops (Amarjit *et al.*, 2006). Split application is one of strategies for efficient use of N fertilizers throughout the growing season by synchronizing with plant demand, reducing denitrification losses and improved N uptake by crop.

Materials and Methods

A field experiment was conducted during rainy (*kharif*) season of 2015 and 2016 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 7.60. It was moderately fertile, being low in available organic carbon (0.40%), available N (198.38 kg ha⁻¹), and medium in available P (17.78 kg ha⁻¹) and K (216.32 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 24 treatments consisting of 4 nitrogen management, viz. N₁ - ½ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage, N₂ - ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage, N₃ - 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage and N₄ - ¼ N basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage + ¼ N at heading stage and 6 weed management treatments, viz. W₀ - Weedy check, W₁- Two hand weedings at 20 and 40 DAS, W₂ - Pendimethalin 1.0 kg a.i ha⁻¹ (PE) fb Bispyribac at 25 g a.i ha⁻¹ + NIS (0.25%) at 15-20 DAS, W₃ - Bispyribac at 25 g a.i. ha⁻¹ + Pyrazosulfuron at 20 g a.i. ha⁻¹ + NIS (0.25%) at 15-20 DAS, W₄ - Oxadiargyl at 90 g a.i. ha⁻¹ (PE) fb Bispyribac at 25g a.i. ha⁻¹ + NIS (0.25%) at 15-20 DAS and W₅ - Bispyribac at 25 g a.i. ha⁻¹ + Azimsulfuron at 17.5 g a.i. ha⁻¹) + NIS (0.25 %) at 15-20 DAS. A uniform dose of 150 kg N ha⁻¹, 60 kg P₂O₅ ha⁻¹ and 60 kg K₂O ha⁻¹ were applied in all the plots.

Full dose of phosphorus and potash were applied as basal application and nitrogen was applied as treatment wise. 'HUR 105' variety of rice @ 35 kg ha⁻¹ was used for seeding of rice. The required quantity of pre-emergence and post-emergence herbicides was sprayed as per treatment using spray volume of 600 litres of water ha⁻¹ with the help of knap sack sprayer fitted with flat fan nozzle.

Results and Discussion

Grassy weeds were predominant in DSR followed by sedges and broad leaved weeds, respectively. The dominant weed species observed in the experimental field were *Echinochloa crus-galli*, *Echinochloa colona*, *Cynodon dactylon*, *Cyperus rotundus*, *Cyperus iria*, *Eclipta alba* and *Caesulia axillaris* during both the years of study.

Effect on weed dry matter (g m^{-2})

Data clearly revealed that among nitrogen treatments, significantly lowest of total dry matter of weeds was observed with application of $\frac{1}{4}$ N at basal + $\frac{1}{4}$ N at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage + $\frac{1}{4}$ at heading stage which was at par to $\frac{1}{3}$ N at basal + $\frac{1}{3}$ N at active tillering stage + $\frac{1}{3}$ N at panicle initiation stage at all stage of observation during both the years of study. Whereas, maximum weed dry weight was recorded when nitrogen was applied as $\frac{1}{4}$ N at basal + $\frac{1}{2}$ N at active tillering stage + $\frac{1}{4}$ at panicle initiation stage. Application of $\frac{1}{4}$ N at basal + $\frac{1}{4}$ at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage + $\frac{1}{4}$ at heading stage was the most effective treatment among all the nitrogen treatments in minimizing dry matter of weeds at all the stage of observation during both the years of experimentation. The higher dry weight of weeds under splits involving more nitrogen application at sowing might be attributed to vigorous growth of weeds due to excess nitrogen supply at sowing, which consequently resulted in higher dry weight of weeds at different stages of growth. Similar findings were given by Sanusan *et al.*, (2010).

Among weed management practices, application of bispyribac at $25 \text{ g a.i. ha}^{-1}$ + azimsulfuron at $17.5 \text{ g a.i. ha}^{-1}$ + NIS (0.25 %) at 15-20 DAS was most effective in minimizing the total weed dry matter at all the crop growth stages and was found significantly superior to all the weed management practices next to the treatment two hand weeding at 20 and 40 DAS. Application of bispyribac at $25 \text{ g a.i. ha}^{-1}$ + pyrazosulfuron at $20 \text{ g a.i. ha}^{-1}$ + NIS (0.25%) at 15-20 DAS was the next best treatment to minimise the weed dry matter and found superior to other treatments at all the stages during both the years. Both these weed management treatments were better than other weed management practices in minimizing dry

weight of weeds in both the years of experimentation. Weedy check resulted in maximum weed dry matter at all the stages of crop growth during both the years. Tank mix application of azimsulfuron with bispyribac-sodium effectively reduced the dry biomass of *Cyperus* spp. These findings may be supported by Ghosh *et al.*, (2017).

Effect on nutrient (N, P, K) removal by weeds (Kg ha^{-1})

Nitrogen removal (Kg ha^{-1})

Nitrogen treatments differed significantly in nitrogen removal by weeds during both the years at 60 DAS and at harvest stage of direct seeded rice. The minimum nitrogen removal was recorded by application of $\frac{1}{4}$ N at basal + $\frac{1}{4}$ at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage + $\frac{1}{4}$ at heading stage which was significantly less than all other nitrogen treatments except the application of $\frac{1}{3}$ N at basal + $\frac{1}{3}$ N at active tillering stage + $\frac{1}{3}$ N at panicle initiation stage. These two treatments were at par with each other. Data also showed that nitrogen application of $\frac{1}{4}$ N at basal + $\frac{1}{2}$ N at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage had maximum nitrogen removal by weeds during both the years of study at 60 DAS and at harvest stage of direct seeded rice. This is in agreement with the findings of Sweeney *et al.*, 2008. Among weed management practices, application of bispyribac at $25 \text{ g a.i. ha}^{-1}$ + azimsulfuron at $17.5 \text{ g a.i. ha}^{-1}$ + NIS (0.25 %) at 15-20 DAS established their superiority in minimizing the nitrogen removal by weeds which was significantly superior to other weed management treatments but it was next best to the two hand weeding at 20 and 40 DAS. Bispyribac at $25 \text{ g a.i. ha}^{-1}$ + pyrazosulfuron at $20 \text{ g a.i. ha}^{-1}$ + NIS (0.25%) at 15-20 DAS was the next best treatment in minimizing the removal of nitrogen by weeds during both the years at both the stages of crop growth.

Table.1 Effect of nitrogen management and weed management practices on total weed dry matter (g. m⁻²) at different growth stages of direct seeded rice

Treatments	15 DAS		30 DAS		60 DAS		90 DAS		Harvest	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nitrogen management										
N ₁ - ½ at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage	5.34 (28.38)	5.73 (32.64)	6.57 (44.27)	7.38 (55.74)	8.48 (72.23)	9.18 (84.84)	9.99 (108.28)	11.34 (129.30)	9.83 (87.65)	10.83 (118.07)
N ₂ - ¼ N at basal + ½ N at active tillering stage + ¼ at panicle initiation stage	5.53 (30.50)	5.92 (35.03)	6.87 (48.27)	7.75 (61.34)	8.79 (77.60)	9.51 (91.10)	10.40 (115.58)	11.82 (139.41)	10.17 (104.02)	11.20 (126.46)
N ₃ - 1/3 N at basal + 1/3 N at active tillering stage + 1/3 n at panicle initiation stage	5.15 (26.46)	5.53 (30.47)	6.31 (40.89)	7.06 (51.11)	8.17 (67.11)	8.88 (79.37)	10.74 (100.39)	10.90 (119.71)	9.49 (90.67)	10.52 (110.53)
N ₄ - ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage	5.07 (25.42)	5.39 (28.86)	6.14 (38.59)	6.82 (47.62)	8.00 (64.32)	8.71 (76.42)	9.81 (96.71)	10.58 (112.93)	9.36 (87.97)	10.28 (106.30)
SEm±	0.059	0.057	0.076	0.074	0.090	0.090	0.102	0.154	0.105	0.112
CD (P=0.05)	0.203	0.197	0.263	0.255	0.310	0.311	0.354	0.533	0.365	0.387
Weed management practices										
W ₀ - Weedy check	6.10 (36.92)	6.56 (42.75)	9.01 (80.97)	9.94 (98.56)	10.14 (102.49)	11.04 (118.77)	12.02 (144.12)	13.43 (167.16)	11.65 (135.38)	12.84 (160.83)
W ₁ - Two hand weeding at 20 and 40 DAS	5.95 (34.75)	6.27 (38.91)	5.19 (26.50)	5.89 (34.25)	7.36 (53.75)	7.79 (63.25)	9.22 (84.75)	9.96 (99.00)	8.60 (73.50)	9.44 (88.75)
W ₂ - Pendimethalin at 1.0 kg a.i. ha ⁻¹ (PE) fb Bispyribac at 25 g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	4.76 (22.41)	5.09 (25.48)	6.32 (39.50)	7.07 (49.64)	8.27 (68.04)	9.04 (81.38)	10.18 (103.32)	11.06 (122.18)	9.64 (92.57)	10.63 (112.70)
W ₃ - Bispyribac at 25 g a.i. ha ⁻¹ + Pyrazosulfuron at 20 g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	5.04 (24.72)	5.44 (29.16)	6.00 (35.56)	6.79 (45.88)	8.04 (64.30)	8.80 (77.02)	9.93 (98.25)	10.76 (115.70)	9.37 (87.40)	10.34 (106.64)
W ₄ - Oxadiargyl at 90 g a.i. ha ⁻¹ (PE) fb Bispyribac at 25g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	4.81 (22.97)	5.16 (26.21)	6.59 (43.01)	7.32 (53.25)	8.48 (71.58)	9.22 (84.64)	10.41 (108.09)	11.34 (128.43)	9.86 (96.99)	11.01 (121.03)
W ₅ - Bispyribac at 25 g a.i. ha ⁻¹ + Azimsulfuron at 17.5 g a.i. ha ⁻¹ + NIS (0.25 %) at 15-20 DAS	4.98 (24.13)	5.33 (27.99)	5.73 (32.49)	6.52 (42.20)	7.88 (61.73)	8.54 (72.55)	9.65 (92.92)	10.40 (108.07)	9.17 (83.82)	9.99 (99.58)
SEm±	0.063	0.061	0.080	0.077	0.087	0.109	0.100	0.119	0.103	0.109
CD (P=0.05)	0.179	0.174	0.228	0.221	0.247	0.312	0.284	0.339	0.295	0.313

Table.2 Effect of nitrogen management and weed management practices on NPK removal (kg ha⁻¹) of weed at 60 DAS in direct seeded rice

Treatments	N removal (kg ha ⁻¹)		P removal (kg ha ⁻¹)		K removal (kg ha ⁻¹)	
	2015	2016	2015	2016	2015	2016
Nitrogen management						
N ₁ - ½ at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage	15.17	22.99	3.18	5.02	21.50	28.18
N ₂ - ¼ N at basal + ½ N at active tillering stage + ¼ at panicle initiation stage	17.51	26.40	4.06	6.60	23.31	31.09
N ₃ - 1/3 N at basal + 1/3 N at active tillering stage + 1/3 n at panicle initiation stage	13.32	19.79	2.18	3.61	19.50	24.46
N ₄ - ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage	11.84	18.18	2.03	3.25	18.29	22.29
SEm±	0.384	0.527	0.064	0.105	0.613	0.653
CD (P=0.05)	1.328	1.824	0.216	0.364	2.121	2.259
Weed management practices						
W ₀ - Weedy check	25.15	37.81	6.34	9.99	31.21	43.86
W ₁ - Two hand weedings at 20 and 40 DAS	9.51	13.56	1.28	2.15	15.01	17.54
W ₂ - Pendimethalin at 1.0 kg a.i. ha ⁻¹ (PE) fb Bispyribac at 25 g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	13.51	20.83	2.56	4.13	20.03	25.17
W ₃ - Bispyribac at 25 g a.i. ha ⁻¹ + Pyrazosulfuron at 20 g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	12.50	19.31	2.26	3.66	18.78	23.67
W ₄ - Oxadiargyl at 90 g a.i. ha ⁻¹ (PE) fb Bispyribac at 25g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	14.67	22.30	2.92	4.66	21.20	27.03
W ₅ - Bispyribac at 25 g a.i. ha ⁻¹ + Azimsulfuron at 17.5 g a.i. ha ⁻¹ + NIS (0.25 %) at 15-20 DAS	11.43	17.21	1.80	3.10	17.68	21.78
SEm±	0.400	0.550	0.062	0.100	0.650	0.683
CD (P=0.05)	1.144	1.571	0.179	0.285	1.858	1.953

Table.3 Effect of nitrogen management and weed management practices on NPK removal (kg ha⁻¹) of weed at Harvest in direct seeded rice

Treatments	N removal (kg ha ⁻¹)		P removal (kg ha ⁻¹)		K removal (kg ha ⁻¹)	
	2015	2016	2015	2016	2015	2016
Nitrogen management						
N ₁ - ½ at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage	30.55	44.18	7.84	11.02	37.96	50.15
N ₂ - ¼ N at basal + ½ N at active tillering stage + ¼ at panicle initiation stage	35.46	51.33	9.86	15.64	41.22	54.43
N ₃ - 1/3 N at basal + 1/3 N at active tillering stage + 1/3 n at panicle initiation stage	25.99	37.04	5.78	10.50	34.96	45.96
N ₄ - ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage +¼ at heading stage	23.42	35.18	5.23	9.57	33.54	42.70
SEm±	0.704	0.893	0.155	0.318	0.729	1.040
CD (P=0.05)	2.437	3.090	0.536	1.100	2.521	3.599
Weed management practices						
W ₀ - Weedy check	50.22	71.78	15.17	26.87	54.45	75.10
W ₁ - Two hand weedings at 20 and 40 DAS	19.08	27.68	3.59	5.24	27.61	34.21
W ₂ - Pendimethalin at 1.0 kg a.i. ha ⁻¹ (PE) fb Bispyribac at 25 g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	27.26	39.64	6.44	9.37	35.86	45.74
W ₃ - Bispyribac at 25 g a.i. ha ⁻¹ + Pyrazosulfuron at 20 g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	25.15	36.54	5.84	8.33	33.73	43.95
W ₄ - Oxadiargyl at 90 g a.i. ha ⁻¹ (PE) fb Bispyribac at 25g a.i. ha ⁻¹ + NIS (0.25%) at 15-20 DAS	29.66	44.14	7.28	13.58	37.75	50.89
W ₅ - Bispyribac at 25 g a.i. ha ⁻¹ + Azimsulfuron at 17.5 g a.i. ha ⁻¹ + NIS (0.25 %) at 15-20 DAS	22.49	31.80	4.63	6.70	32.06	39.98
SEm±	0.699	0.839	0.144	0.335	0.759	0.982
CD (P=0.05)	1.997	2.398	0.412	0.956	2.168	2.806

Application of oxadiargyl at 90 g a.i. ha⁻¹ (PE) fb bispyribac at 25g a.i. ha⁻¹ + NIS (0.25%) at 15-20 DAS treatment was the least effective in reducing the nitrogen removal by weeds during both the years. However, all the weed management treatments were significantly superior to weedy check in this respect during both the years at 60 DAS and at harvest stage of direct seeded rice crop. Significantly reduced nutrient depletion by weeds as weed infestation and their dry matter accumulation in these treatments were significantly lower than other treatments. This fact is in conformity with the findings of Angiras and Rana (1999).

Phosphorus removal (Kg ha⁻¹)

Nitrogen treatments caused significant variation in phosphorus removal by weeds during both the years and ¼ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage + ¼ N at heading stage proved significant superiority in minimizing the phosphorus removal by weeds during both the years than the application of ½ at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage and ¼ N at basal + ½ N at active tillering stage + ¼ N at panicle initiation stage. However, it was at par with the application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage at both the stages of crop growth during both the years.

Amongst weed management practices, bispyribac at 25 g a.i. ha⁻¹ + azimsulfuron at 17.5 g a.i. ha⁻¹ + NIS (0.25 %) at 15-20 DAS was most effective in reducing the phosphorus removal by weeds next to the two hand weedings at 20 and 40 DAS and was significantly superior to rest of the weed management treatments during both the years. The next best treatment was the application of bispyribac at 25 g a.i. ha⁻¹ + pyrazosulfuron at 20 g a.i. ha⁻¹ + NIS (0.25%) at 15-20 DAS at

60 DAS and at harvest during both the years of study. The highest removal of phosphorus by weeds was recorded under the application of oxadiargyl at 90 g a.i. ha⁻¹ (PE) fb bispyribac at 25g a.i. ha⁻¹ + NIS (0.25%) at 15-20 DAS during both the years. However, all the weed management treatments had significantly lower removal of phosphorus by weeds as compared to weedy check during both the years of experimentation. Significantly reduced nutrient depletion by weeds as weed infestation and their dry matter accumulation in these treatments were significantly lower than other treatments. This fact is in conformity with the findings of Angiras and Rana (1999).

Potassium removal (Kg ha⁻¹)

The data revealed that amongst nitrogen management treatments, the minimum potassium removal was recorded with the application of ¼ N at basal + ¼ at active tillering stage + ¼ N at panicle initiation stage + ¼ at heading stage which was at par with the application of 1/3 N at basal + 1/3 N at active tillering stage + 1/3 N at panicle initiation stage and significantly lower than application of ½ N at basal + ¼ N at active tillering stage + ¼ N at panicle initiation stage and ¼ N at basal + ½ N at active tillering stage + ¼ at panicle initiation stage during both the years of experimentation.

Among weed management treatments, application of bispyribac at 25 g a.i. ha⁻¹ + azimsulfuron at 17.5 g a.i. ha⁻¹ + NIS (0.25 %) at 15-20 DAS recorded minimum potassium removal by weed which was the second best after two hand weedings at 20 and 40 DAS treatment and significantly lower than the remaining herbicide application treatments during both the years. The maximum potassium removal was recorded with the application of oxadiargyl at 90 g a.i. ha⁻¹ fb bispyribac at 25 g a.i. ha⁻¹ + NIS

(0.25%) at 15-20 DAS. However, all the weed management treatments were significantly superior to weedy check in suppressing potassium removal by weeds during both the years at 60 DAS and at harvest stage of direct seeded rice. Significantly reduced nutrient depletion by weeds as weed infestation and their dry matter accumulation in these treatments were significantly lower than other treatments. This fact is in conformity with the findings of Angiras and Rana (1999).

Application of $\frac{1}{4}$ N at basal + $\frac{1}{4}$ N at active tillering stage + $\frac{1}{4}$ N at panicle initiation stage + $\frac{1}{4}$ N at heading stage and $\frac{1}{3}$ N at basal + $\frac{1}{3}$ N at active tillering stage + $\frac{1}{3}$ N at panicle initiation stage were equally effective in minimizing weed dry weight and N, P, K depletion by weeds. Application of bispyribac at 25 g a.i. ha⁻¹ + azimsulfuron at 17.5 g a.i. ha⁻¹ + NIS (0.25 %) at 15-20 DAS and hand weeding twice at 20 and 40 DAS were recorded lower weed dryweight and nutrient depletion by weeds in direct seeded rice.

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