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Effect of Sequential Application of Herbicides on Weed Management, Productivity and Nutrient Uptake of Direct Seeded Rice

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***Abstract*:** The investigation was carried out at Bihar Agricultural University, Sabour, Bhagalpur (Bihar) during *kharif*, 2018 to find the impact of chemical weed management on complex weed flora and productivity of direct seeded rice. The dominant weeds in field were *Cyperus rotundus, Echinochloa spp, Eleusine indica* and *Caesulia axillaries*. The lowest weed population, dry weight, highest percent weed control efficiency and productivity of rice were recorded by the hand weeding treatment. Among all the herbicidal treatments, the lowest weeds count, weeds dry weight and highest percent weed control efficiency, high productivity and nutrient uptake of rice were recorded under treatment pyrazosulfuron @ 25 g a.i. ha^{-1} PE fb pyrazosulfuron @ 20 g a.i. ha^{-1} + bispyribac-Na @ 20 g a.i. ha^{-1} at POE which can be recommended to the farmers.

***Keywords*:** Weed flora, Direct seeded rice, Weed population, Weed control efficiency, Nutrient uptake

Rice (*Oryza sativa* L.) is the staple food for more than 60% of the world population, providing energy for about 40% of the world population where every third person on earth consumes rice every day in one form or other (Datta and Khushi 2002). Among several reasons for low rice productivity, the losses due to weeds are one of the most important. Weeds are most severe and widespread biological constrains to crop production in India and weeds alone cause 33% of losses out of total losses due to pests (Verma et al 2015). Direct-seeded rice (DSR) has several advantages over puddled transplanted rice like easier planting, timely sowing, less drudgery, early crop maturity by 7-10 days, less water requirement, better soil physical condition for next crop and low production cost and more profit (Kumar and Ladha, 2011). DSR is severely affected by weed population in *kharif* season which indicates that timely management of weeds is essential for better performance. In the initial stages of the crop, weeds can be effectively controlled by pre-emergence herbicides. However, in later stages of crop, weeds can obstruct the growth and development of crop. Therefore, the present experiment was conducted to find out the effective herbicides or herbicide mixtures for weed control in direct seeded rice.

MATERIAL AND METHODS

A field experiment was conducted at Agriculture research farm, Bihar Agricultural University, Sabour, Bhagalpur, Bihar (longitude 87°2'42" East and latitude 25°15'40" North at altitude of 46 meters above *mean* sea level in the heart of the vast Indo-Gangetic plains of North India) during *Kharif season* of 2018. The soil of the experimental site was loamy sand in texture having normal soil reaction (pH 7.27) and electrical conductivity (0.27 dSm^{-1}), low in organic carbon (0.46%) & available N (180.61 kg/ha) and medium in available P (22.65 kg/ha) and K (206.88 kg/ha). The experiment comprised of 11 weed management practices (Table 1). The experiment was laid out in randomized block design with three replications. Rice variety *'Sabour Sampannadhan'* (BRR0059) was sown on 16th June 2018 using tractor drawn conventional drill with seed rate of 30 kg /ha in rows spaced at 20 cm. The recommended dose of fertilizers and plant protection measures for insect-pest and disease control were applied. The data on weed density were transformed using square root transformation. Yield and yield attributes were recorded at the time of harvesting.

RESULTS AND DISCUSSION

Weed population: Hand weeding treatments shown significantly lower weeds at all growth stages over rest of the treatments the main reason behind this is timely uprooting of weed species. The significantly higher weed population was obtained in weedy check at 15, 30, 45 and 60 DAS which was significantly superior compared to rest of the treatments at all of the crop growth stages. It was mainly due to uninterrupted growth of all the three types of weeds. This is in conformity with the findings of Chauhan (2013). Among the herbicide

applied treatments at 15, 30, 45 and 60 DAS, the minimum weed population of total weeds was recorded. Among the all herbicidal treatments, the minimum weed population was recorded under T_5 (pyrazosulfuron @ 25 g a.i. ha^{-1} PE fb bispyribac-Na @ 20 g a.i. ha^{-1} + pyrazosulfuron @ 20 g a.i. ha^{-1} POE) which was at par with T_4(pyrazosulfuron @ 25 g a.i. ha^{-1} PE fb bispyribac-Na @ 25 g a.i. ha^{-1} POE). This is probably because of capability of the herbicide to impact the cell division, cell growth and competition among the weeds and crop might have resulted in death of some weeds. Herbicidal mixtures decreased the weed density compared to the either solo application of pre or post emergence herbicides. The significant effect of herbicides in combination with hand weeding can be ascribed to the broad spectrum weed control as the herbicides have controlled specific weeds. These results are in conformity with the findings of Tiwari et al (2013).

Weed dry weight: Among the all herbicidal treatments, the minimum weed dry weight (4.91 g m^{-2}) was under T_1 (pyrazosulfuron @ 25 g a.i. ha^{-1} PE) at 15 days after sowing and which was statistically at par with T_2 , T_3 , T_4 , and T_5. The maximum dry weight (7.53 g m^{-2}) of weed was d with T_9 (halosulfuron @ 67.5 g a.i. ha^{-1} + azimsulfuron @ 30 g a.i. ha^{-1} POE). In rest of the growth stages (30, 45 and 60 DAS), the minimum weed dry weight was obtained under T_5 which was statistically at par with T_4 and was significantly superior over rest of the treatments. The maximum dry weight of total was obtained with T_2 (pendimethalin @ 1000 g a.i. ha^{-1} PE). The application of herbicides can be attributed to their efficacy to control wide spectrum of weeds. The integration of herbicides which resulted in broad spectrum weed control over the other treatments was because pre emergence herbicides eliminated the early emerged weeds and post emergence herbicides controlled the later germinated weeds which resulted in lowest weed population as well as weed dry weight. These results are in conformity with the findings of Patel et al. (2018) where application of pyrazosulfuron-ethyl 25 g ha^{-1} fb bispyribac-sodium salt 50 g ha^{-1} at 30 DAS suppressed the weed population and dry weight over control.

Among herbicide applied treatments, the highest WCE was recorded (84.88%) under T_5 at 45 days after sowing whereas minimum WCE (61.94%) was obtained with treatment T_2. The maximum WCE was obtained (87.09%) under T_5 treatment at 60 days after sowing and minimum weed control efficiency (69.00 per cent) was recorded in the treatment T_2. The reducing trend of WCE is because of the decrease of weed dry matter in herbicides treated with advancement of time which is due to decrease in weed dry matter over rest of the weed treatment. The highest WCE with hand weeding was also observed by Singh et al (2014).

Among the different weed treatment, the lowest weed index (1.69%) was with the treatment T_5 followed by T_4

Table 1. Effect of chemical weed management practices on total weed population (no. m^{-2}) at various crop growth stages of direct seeded rice

Treatments	Description	15 DAS	30 DAS	45 DAS	60 DAS
T_1	Pyrazosulfuron @ 25 g a.i. ha^{-1} PE	5.87 (34.03)	7.66 (58.23)	8.48 (71.42)	7.78 (60.05)
T_2	Pendimethalin @ 1000 g a.i. ha^{-1} PE	6.04 (35.93)	7.98 (63.25)	9.02 (80.94)	8.31 (68.59)
T_3	Pyrazosulfuron @ 25 g a.i. ha^{-1} PE fb 2,4-DEE @ 750 g a.i. ha^{-1} POE	6.48 (41.44)	6.98 (48.32)	8.41 (70.30)	7.71 (58.98)
T_4	Pyrazosulfuron @ 25 g a.i. ha^{-1} PE fbbispyribac-Na@ 25 g a.i. ha^{-1} POE	6.34 (39.82)	5.76 (32.70)	6.63 (43.42)	5.42 (28.92)
T_5	Pyrazosulfuron @ 25 g a.i. ha^{-1} PE fbbispyribac-Na@ 20 g a.i. ha^{-1} + pyrazosulfuron @ 20 g a.i. ha^{-1} POE	6.22 (38.26)	5.41 (29.02)	6.20 (38.05)	5.13 (25.90)
T_6	Bispyribac-Na@ 25 g a.i. ha^{-1} POE	8.58 (73.10)	7.28 (52.54)	8.21 (66.95)	7.48 (55.57)
T_7	Bispyribac sodium@ 20 g a.i. ha^{-1}. + pyrazosulfuron @ 20 g a.i. ha^{-1} POE	8.56 (72.64)	6.86 (46.52)	7.64 (57.91)	6.81 (46.0)
T_8	Ethoxsulfuron @ 15 g a.i. ha^{-1} + pyrazosulfuron @ 20 g a.i. ha^{-1} POE	8.87 (78.27)	7.15 (50.64)	7.91 (62.09)	7.06 (49.34)
T_9	Halosulfuron @ 67.5 g a.i. ha^{-1} + azimsulfuron @ 30 g a.i. ha^{-1} POE	8.55 (72.64)	6.42 (40.67)	7.11 (50.22)	6.14 (37.46)
T_{10}	Hand weeding (15,30 and 45 DAS)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_{11}	Weed check	9.61 (91.16)	11.16 (124.07)	12.24 (149.29)	11.57 (133.41)
CD (p=0.05)		(0.39)	(0.43)	(0.51)	(0.54)

Data in parenthesis were transformed to $\sqrt{x}$+ 0.5 before analysis. The figures in parentheses are the original values

(7.58%) weed management practices. Improved WCE and season long broad-spectrum control of these weed management practices bring about in reduced weed index significantly. These results were supported by Maity and Mukherjee (2008). At the maturity stage, among all herbicides treatments the significantly maximum number of effective tillers (293.7 m^{-2}) were in T_5which was at par with T_4, T_9, T_7 and T_6 and minimum number of effective tillers were recorded in T_2 (236.7 m^{-2}). Irrespective of growth stages, significantly the maximum number of tillers of rice was observed in hand weeding (T_{10}) and minimum number of tillers was observed in weedy check (T_{11}). Highest LAI was observed at 90 DAS in the hand weeding treatment T_{10} (4.84) which were comparable with treatments *viz,* T_4, T_5, T_6, T_7 and T_9 which was due to intercultural operations helping more aeration of the soil. Minimum competition and better WCE which has led to well growth and development finally improved the LAI of the concerned treatments. Lowest LAI with weedy check was reported by Singh et al (2014). Among the herbicide applied treatments, maximum dry matter (1025.7 g m^{-2}) was obtained with T_5 at maturity and minimum was with T_2 (876.3g m^{-2}). It is probably because of application of Pyrazosulfuron as a pre-emergence herbicide and in combination with bispyribac-Na as a post emergence herbicide which resulted in greater reduction of weed population which in turn made the plant-weed competition lowest compared to rest of the treatments. This finding was in conformity with Ramachandran and Balasubramanian (2012).

Among all the herbicide applied treatments, the

Table 2. Effect of chemical weed management practices on total weed dry weight (g/m^2) at various crop growth stages of direct seeded rice

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
T_1	4.91 (23.62)	6.17 (37.56)	6.74 (44.87)	6.90 (47.05)
T_2	5.21 (26.61)	6.54 (42.32)	7.00 (48.57)	7.04 (49.02)
T_3	5.15 (26.13)	5.63 (31.31)	6.17 (40.94)	6.32 (39.50)
T_4	5.08 (25.37)	4.14 (16.70)	4.67 (21.56)	4.82 (24.88)
T_5	5.13 (25.91)	3.82 (14.17)	4.44 (19.29)	4.57 (20.42)
T_6	7.12 (50.18)	5.24 (26.93)	5.78 (32.92)	5.93 (34.70)
T_7	6.81 (45.83)	4.92 (24.04)	5.62 (30.98)	5.86 (33.90)
T_8	7.10 (49.98)	5.53 (30.31)	6.09 (36.65)	6.22 (38.22)
T_9	7.35 (53.59)	4.56 (19.94)	5.28 (27.37)	5.40 (28.72)
T_{10}	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_{11}	8.47 (71.31)	11.23 (104.00)	11.32 (127.62)	12.68 (158.13)
CD (P=0.05)	0.32	0.40	0.24	0.27

See Table 1 for details .Data in parenthesis were transformed to √x+ 0.5 before analysis. The figures in parentheses are the original values

Table 3. Effect of chemical weed management practices on weed index and weed control efficiency of direct seeded rice

Treatments	Weed index	Weed control efficiency (%)			
		15 DAS	30 DAS	45 DAS	60 DAS
T_1	34.48	66.88	63.88	64.83	70.25
T_2	36.39	62.68	59.31	61.94	69.00
T_3	29.13	63.36	69.89	70.55	75.02
T_4	7.58	64.42	83.94	81.54	84.27
T_5	1.69	63.67	86.38	84.88	87.09
T_6	22.75	29.63	74.11	74.20	78.06
T_7	18.06	35.73	76.88	75.65	78.56
T_8	28.42	29.91	70.86	71.28	75.83
T_9	15.06	24.85	80.83	78.55	81.84
T_{10}	0.00	100.00	100.00	100.00	100.00
T_{11}	50.95	0.00	0.00	0.00	0.00

Table 4. Effect of chemical weed management on growth and yield attributes at maturity of direct seeded rice

Treatments	Tillers (m^{-2}) at maturity	Leaf area Index at 90 DAS	Dry matter accumulation ($g\ m^{-2}$) at maturity	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
T_1	251.7	4.41	878.7	3.60	4.99
T_2	236.7	4.36	876.3	3.50	5.01
T_3	258.3	4.38	907.7	3.90	5.26
T_4	281.3	4.73	1002.0	5.08	6.35
T_5	293.7	4.75	1025.7	5.41	6.67
T_6	268.7	4.50	990.0	4.25	5.90
T_7	273.0	4.69	992.7	4.51	6.06
T_8	252.0	4.39	928.3	3.94	5.37
T_9	278.7	4.66	998.7	4.67	6.20
T_{10}	307.3	4.84	1058.0	5.50	6.69
T_{11}	194.7	3.82	873.0	2.70	3.97
CD (p=0.05)	33.3	0.32	13.3	0.82	1.31

Table 5. Effect of chemical weed management practices on nutrient uptake by grain and straw in direct seeded rice

Treatments	Nitrogen $kg\ ha^{-1}$			Phosphorous $kg\ ha^{-1}$			Potassium $kg\ ha^{-1}$		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	56.86	19.95	76.82	10.21	9.30	19.51	12.44	70.45	82.89
T_2	55.49	19.96	75.45	9.99	9.41	19.41	12.07	69.49	81.56
T_3	58.57	22.77	81.34	11.02	9.71	20.73	13.34	73.04	86.39
T_4	75.01	23.01	98.02	14.54	11.81	26.36	17.59	88.92	106.98
T_5	78.34	25.33	103.67	15.48	12.45	27.93	18.77	94.26	110.03
T_6	66.64	23.02	89.66	12.23	11.08	23.31	14.69	81.89	96.58
T_7	68.93	22.72	91.65	12.85	11.24	24.08	15.57	84.19	99.76
T_8	55.46	22.56	78.02	11.19	10.04	21.23	13.59	74.35	87.94
T_9	69.57	25.66	95.23	13.27	11.67	24.94	16.06	86.02	102.08
T_{10}	80.09	28.26	108.35	15.57	12.48	28.05	18.96	92.37	111.34
T_{11}	39.74	15.09	54.84	7.66	7.29	14.96	9.32	56.32	65.65
CD (p=0.05)	12.30	4.88	15.15	2.39	2.29	3.54	2.82	17.95	18.57

significantly higher grain yield of (5.41 $t\ ha^{-1}$) was produced with T_5 which was significant at par T_4 (5.08 $t\ ha^{-1}$) and T_9 (4.67 $t\ ha^{-1}$). The increased grain yield in these treatments is because of weed density and better WCE along with betterment in yield attributes like number of effective tillers per m^2, panicles length, number of grains per panicle and test grain weight. This corroborates with the findings of Singh et al (2005). The treatment T_5 obtained significantly higher straw yield of (6.69 $t\ ha^{-1}$) which was at par with T_4, T_6, T_7, T_8 and T_9. The minimum straw yield was recorded in T11 (3.97 $t\ ha^{-1}$) (weedy check). Similar findings were observed by Pratap et al (2017).

Nutrient uptake: Among the different treatments, maximum uptake of 108.35, 28.05 and 111.34 $kg\ ha^{-1}$ N, P and K respectively was observed with hand weeded plot. The lowest N, P and P uptake was recorded in weedy check plots. The high uptake of nutrients is because of less crop weed competition along with higher nutrient absorption which has led to in higher N, P and K content in grain and straw. Among all herbicidal treatments, the higher value of N (103.67 $kg\ ha^{-1}$), P (27.93 $kg\ ha^{-1}$) and K (110.03 $kg\ ha^{-1}$) was registered in T_5 followed by T_4.

CONCLUSION

Weed management in direct seeded rice is very difficult because of presence of complex weed flora. Usage of herbicidal combinations could be the solution as it controls the all types of weeds effectively and prevents the development of herbicide resistance in weeds. This study was carried out to find the suitable herbicidal combinations in

direct seed rice as research on herbicidal combinations in direct seeded rice in India are limited. Based on findings of investigation for one year, it may be concluded that application of pyrazosulfuron @ 25 g a.i. ha^{-1} PE fb bispyribac-Na @ 20 g a.i. ha^{-1} + pyrazosulfuron @ 20 g a.i. ha^{-1} PoE was equally effective to hand weeding thrice in controlling the weeds, improved yield and economically viable option in DSR.

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