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Effect of Sowing time and weed management practices on weed dynamics, productivity, and economics of direct-seeded rice

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ABSTRACT

Weed management is an integral part of direct seeded rice technology owing to a very high weed infestation. Thus, in order to control the diverse weed flora using the most appropriate herbicide and devise the most effective date of sowing in the DSR, a two-year field experiment was conducted during the *kharif* season of 2019 and 2020 at Zonal Agricultural Research station Powarkheda, Narmadapuram, JNKVV Jabalpur. The field experiment was laid out in split plot design with three main plot treatments and five sub plot treatments and replicated thrice. The results revealed that late sowing of DSR on 20th July and post emergence application of bispyribac sodium 25 g/ha had lesser weed density; weed dry weight and higher weed control efficiency (56.42% and 66.19 %) among all other treatments. However, plant growth characters, yield attributes and grain yield were higher with the early sowing of DSR on 20th June and early post emergence application of bispyribac sodium 25g/ha. The early sowing on 20th June along with the application of bispyribac sodium 25g/ha resulted in highest net monetary returns (83901 Rs/ha) which also increased the B:C ratio (3.1). Thus, it was concluded that the early sowing of direct seeded rice along with early post emergence application of bispyribac sodium can control the weeds and increase the grain yield and can prove to be a promising technology adopted by the farmers.

Key words: *B:C ratio, Bispyribac sodium, Net monetary returns, Weed management, Weed control efficiency*

Introduction

Rice (*Oryza sativa* L.) Plays a pivotal role in Indian agriculture and is staple food for more than 60 per cent of population. It is grown over 45.07 m ha with 122.27 million tones production and 2713 kg/ha productivity (Anonymous, 2021). In India, rice is generally grown by transplanting in puddle soils. Although, the conditions for higher productivity are more conducive in transplanted rice but it is labour intensive and requires huge amount of water. Raising seedlings, puddling of field, followed by transplanting involve high labour cost. Transplanting of rice is associated with various constraints like late transplanting due to non-availability of water and labours at peak time which causes low plant population and ultimately reduction in yield. Thus, puddled transplanted rice-based production systems are high energy and cost intensive, and result in a less profitable production system (Jat *et al*., 2012; Kumar *et al.*, 2021). In consequence, there is an imperative need to identify possible suitable crop establishment methods, specifically for rice production systems, to reduce the adverse impacts of cli-

mate change and increase productivity and profitability (Zewde *et al*., 2018; Jat *et al.,* 2019).

Direct seeded rice (DSR) are being tried over the existing unaerobic systems (puddle), which is labour saving, ensures timely sowing and early maturity (7-10 days) of crop and reduced production cost, improves soil physical conditions for the succeeding crops with less methane emission. Therefore, the direct seeded rice may solve the problem of existing practices. This system has significant potential to reduce the environmental footprint and increase production (Yadav *et al.,* 2020). Consequently, maintained productivity and sustained environmental quality could be achieved through improved production (Gathala *et al.*, 2020; Nandan *et al*., 2021).

Heavy weed infestation is one of the major constraints in direct seeded rice causing severe yield losses. Weeds emerge simultaneously with germinating rice seedling, resulting in severe competition for nutrients, moisture, light and space. The yield losses due to weeds vary 40-100 per cent in direct seeded rice (Choubey *et al*., 2001). Weed management in direct seeded rice can be accomplished by mechanical, cultural and chemical methods. Hence, for direct seeded rice, the chemical method of weed management is best suited as it can take care of weeds right from beginning of crop growth and it cost effective.

Sowing time is a non-monetary input, but greatly affects the productivity of rice. Several studies have shown that sowing of rice after onset of monsoon gave higher grain yield due to less infestation of weeds. However, very late sowing could reduce the vegetative and reproductive growth period of rice, resulting into lower crop yield (Kumar *et al*., 2012). Alternation in sowing time and effective weed control methods can decrease losses due to weeds to improve the productivity of direct seeded rice. Therefore, an attempt was made to study the effect of sowing time and weed control methods for improving the productivity of direct seeded rice.

Materials and Methods

The field experiments were conducted during *kharif* 2019 and 2020 at the Zonal Agricultural Research station Powarkheda, Narmadapuram, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in 21º50′ North latitude and 76º43′ East longitude with 229 meter above the mean sea level. The soil of the experimental field was sandy clay loam in texture. It was medium in organic carbon (0.60 %), available nitrogen (236.00 kg/ha), available phosphorus (16.65 kg/ha) and available potassium (463.00 kg/ha) contents. The soil was neutral in reaction (pH 7.45) and soluble salt concentration (0.38 ds/m) was also below harmful limit. The experiment was carried out in split plot design with three dates of sowing time i.e., D1-20th June, D2-05th July, D3-20th July in main plots and weed management practices i.e. W1-Butachlor PE (1 kg/ha), W2-Butachlor PE (1 kg/ha) fb fenoxaprop-p-ethyl POE (100 g/ha), W3-Bispyribac sodium POE (25 g/ha), W4-Hand weeding (20 and 40 DAS), W5-Weedy check in sub plots. All the treatments were randomized and replicated three times during both the years. Rice cultivar "PS 4" was sown at 20 cm apart using 70 kg seed/ha. Data on weed density and dry matter were recorded at 90 DAS with the help of quadrate (0.5 m x 0.5 m) placed at two places per plot and then converted to per square meter. Data on weed density and dry weight was subjected to square root transformation before analysis. Log (X+1) transformation was used to analyze the data in respect of weeds. The economics of different treatments were worked out in terms of cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR) and benefit-cost ratio (B:C ratio) on per hectare area basis to ascertain the economic viability of treatments.

Results and Discussion

Effect on weeds

Echinochloa colona among grasses, *Commelina benghalensis* and *Alternanthera sessilis* among broad leaved and *Cyperus rotundus* among sedges were predominant weed species in the experimental site during both the years. Similar weed flora in rice has also been reported by Verma *et al.* (2022) and Duary *et al.* (2015).

Sowing time and weed management practices had significant influence on weed population (Table 1). Data recorded on density of total weeds at 90 DAS, the lowest density was found in case of 20th July sowing (6.36/m^2). Whereas, sowing was done on 20th June and 5th July, recorded higher weed density. Due to high photoperiods with favorable weather condition for germination, thereby weeds emerged and established more in early and medium sown dates (Upasni *et al*., 2010). Among the weed control treatments, the density of total weeds was

higher under weedy check plot (9.84/m^2), where weed control was not done. Whereas, herbicidal treated plots receiving butachlor 1 kg/ha was recorded higher density (7.53/m^2) than butachlor 1 kg/ha *fb* fenoxaprop-p-ethyl 100 g/ha and the minimum was recorded under bispyribac sodium 25 g/ha (5.61/m^2) and proved significantly superior over other herbicidal treatments except hand weeding twice. This confirms the findings of Raghvendra *et al*. (2015).

Sowing time and weed control practices significantly influenced on the dry weight of total weeds at 90 DAS (Table 1). The dry weight of total weeds was recorded maximum in case of 20th June sowing (7.54 g/m^2). However, it was reduced appreciably in plots, where sowing was done on 5th July (7.40 g/m^2) and 20th July (7.28 g/m^2). All the weed control treatments significantly influenced on the dry weight of total weeds. Among the weed control treatments, the dry weight of total weeds was found maximum under weedy check plot (11.6 g/m^2), However, it was significantly reduced in plots receiving butachlor 1 kg/ha(7.39g/m^2) and butachlor 1 kg/ha^1 *fb* fenoxaprop-p-ethyl 100 g/ha(7.18g/m^2). While the minimum weed dry weight was recorded under bispyribac sodium 25 g/ha (6.77g/m^2) and proved significantly superior over other herbicidal treatments exclude hand weeding twice. This may

Table 1. Influence of sowing date and weed control treatments on weed density and dry weight (mean of two years)

Treatments	Rate of application (kg/ha)	Total weed density of (no./m^2) 90 DAS	Total weed dry weight (g/m^2) 90 DAS	WCE (%) 90 DAS
D_1: Early sowing (20th June)	-	7.62 (57.55)	7.91 (62.10)	53.74
D_2: Timely sowing (05th July)	-	7.18 (51.05)	7.78 (60.03)	55.28
D_3: Late sowing (20th July)	-	6.62 (43.28)	7.68 (58.51)	56.42
SEm (±)		0.04	0.01	-
CD (5%)		0.17	0.04	-
T1: Butachlor PE	1.0	7.55 (56.44)	7.39 (54.11)	59.69
W2: Butachlor PE (1 kg/ha) fb fenoxaprop-p-ethyl POE (100 g/ha)	1.0 + 0.1	6.66 (43.83)	7.19 (51.14)	61.90
T3: Bispyribac sodium early POE	0.025	5.65 (31.39)	6.77 (45.37)	66.19
T4: Hand weeding (20 and 40 DAS)	-	5.06 (25.14)	4.08 (16.17)	87.94
T5: Weedy check	-	9.82 (95.89)	11.61 (134.26)	00.0
SEm (±)		0.07	0.03	-
CD (5%)		0.22	0.08	-

Original values are given in parentheses and transformed values are given in non-parenthesis

Table 2. Influence of sowing date and weed control treatments on growth parameters and grain yield (mean of two years)

Treatments	Rate of application (kg/ha)	Plant height (cm) 90 DAS	No. of tillers/ meter row length 90 DAS	Leaf area index 90 DAS	Grain yield (kg/ha)
D_1: Early sowing (20th June)	-	78.89	70.79	2.79	3508
D_2: Timely sowing (05th July)	-	75.99	66.25	2.78	3142
D_3: Late sowing (20th July)	-	72.38	63.71	2.58	1964
SEm (±)		0.15	0.26	0.01	82.9
CD (5%)		0.57	1.01	0.05	325.6
T1: Butachlor PE	1.0	75.84	62.41	2.60	2165
W2: Butachlor PE (1 kg/ha) fb fenoxaprop-p-ethyl POE (100 g/ha)	1.0 + 0.1	79.91	76.59	2.77	3257
T3: Bispyribac sodium early POE	0.025	83.65	80.94	3.53	3415
T4: Hand weeding (20 and 40 DAS)	-	83.96	81.69	3.54	3755
T5: Weedy check	-	55.41	32.94	1.15	1762
SEm (±)		0.39	0.30	0.02	205.9
CD (5%)		1.15	0.88	0.06	634.7

be due to application of treatments at pre emergence and 25 DAS post emergence. Due to timely suppression of intercultural tools weeds are uprooted and killed (Yogananda *et al.,* 2021 and Parthipan *et al.*, 2016).

The weed control efficiency was maximum in case of 20thJuly sowing (56.42%)being at par to 5thJuly sowing (55.28%). However, it was reduced significantly in plots where sowing was done on 20th June (53.74%). The weed control efficiencywas found minimum under weedy check plot (0.00), where weed control was not done. While, the maximum was recorded under bispyribac sodium 25 g/ha (66.19%) and proved statistically superior over other herbicidal treatment except hand weeding twice (87.94%). This was attributed to removal of weeds which reduced the biomass production under these treatments.

Effect on crop

Sowing time and different weed control treatments significantly influenced the growth parameters (plant height, number of tillers and leaf area index) and grain yield of direct seeded rice (Table 2).

Data recorded on plant height indicated that, highest plant height was observed in case of 20th June sowing (78.89 cm). Whereas, it was reduced appreciably in plots, where sowing was done on 5th July and 20th July. The plant height was found maximum under the application of bispyribac sodium 25 g/ha (83.65 cm) and proved significantly superior over other herbicidal treatment except hand weeding twice (83.96 cm). However, it was significantly reduced in plots receiving butachlor 1 kg/ha *fb* fenoxaprop-p-ethyl 100 g/ha and butachlor 1 kg/ha and found minimum under weedy check plot (55.41 cm). These findings are in agreement with the findings of Walia *et al.,* 2014.

The number of tillers was recorded maximum in case of 20th June sowing (70.79). However, it was reduced appreciably in plots, where sowing was done on 5th July and 20th July. Among different weed control treatments, the number of tillers was found maximum under the application of bispyribac sodium 25 g/ha (80.94) and proved significantly superior over other herbicidal treatment except hand weeding twice. However, it was significantly reduced in plots receiving butachlor 1 kg/ha *fb* fenoxaprop-p-ethyl 100 g/ha and butachlor 1 kg/ha and recorded minimum under weedy check plot (32.94). These findings were in conformity to those of Kaur and Singh, 2015.

The results related to leaf area index reveals that 20th June sown crop recorded higher LAI(1.38) than the late sown condition. The late sowing i.e. 05th July and 20th July recorded lower LAI. Among weed control treatments, maximum LAI were noted with the hand weeding twice at 20 and 40 DAS followed by

Table 3. Influence of sowing date and weed control treatments on economics (mean of two years)

Treatments	Rate of application (kg/ha)	Gross monetary returns (Rs/ha)	Net monetary returns (Rs/ha)	B:C ratio
D_1: 20th June				
T1: Butachlor PE	1.0	79534	42010	2.1
T2: Butachlor PE *fb* fenoxaprop-p-ethyl POE	1.0 + 0.1	106481	67037	2.7
T3:Bispyribac sodium early POE	0.025	122875	83901	3.1
T4: Hand weeding (20 and 40 DAS)	-	129254	83030	2.8
T5: Weedy check	-	66536	29912	1.8
D_2: 5th July				
T1: Butachlor PE	1.0	67338	29814	1.8
T2: Butachlor PE *fb* fenoxaprop-p-ethyl POE	1.0 + 0.1	104514	65070	2.6
T3:Bispyribac sodium early POE	0.025	120062	81088	3.1
T4: Hand weeding (20 and 40 DAS)	-	126160	79936	2.7
T5: Weedy check	-	50850	14226	1.4
D_3: 20th July				
T1: Butachlor PE	1.0	44532	7008	1.2
T2: Butachlor PE *fb* fenoxaprop-p-ethyl POE	1.0 + 0.1	65212	25768	1.6
T3:Bispyribac sodium early POE	0.025	68673	29699	1.7
T4: Hand weeding (20 and 40 DAS)	-	86108	39884	1.8
T5: Weedy check	-	40828	4204	1.1

application of bispyribac sodium 25 g/ha (1.82). While the minimum LAI was observed under weedy check plot (0.77).

Late sown crop on 05th and 20th July resulted significant yield reduction as compared to sown crop on 20th June sowing. The higher grain yield in early sown rice on 20th June (3508 kg/ha) may be attributed to better plant growth leading to significantly more growth parameters and yield attributes just because of better partitioning of photosynthates compared to delayed sowing dates. Among the weed control treatments, the lowest grain yield (1762 kg/ha) was noted under weedy check plot in which weeds were allowed to grow throughout the crop season. This resulted due to severe crop-weed competition for available growth resources which resulted in the inferior growth and yield attributing characters. However, the highest grain yield was recorded with the application of bispyribac sodium 25 g/ha (3415 kg/ha) except hand weeding. The enhanced yields under these treatments was because of elimination of weeds which helped in enhancing the availability of nutrients, space, sunlight and water resulting in better growth and development of crop plants (Verma *et al*., 2022; Satapathy *et al*., 2022).

Economics

Early sowing of direct seeded rice on 20th June proved most beneficial giving maximum gross income, net income and B:C ratio. Late sowing adversely influenced the yield and there by net income. Among weed control methods, maximum net return (Rs 83900/ha) and benefit: cost ratio (3.1) was recorded with application of bispyribac sodium 25 g/ha (Table 3).

Conclusion

It was concluded that direct seeded rice should be sown on 20th June and application of bispyribac sodium 25 g/ha as it not only gives effective weed control but produces higher yield with highest net profit.

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