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EVALUATION OF CROP ESTABLISHMENT TECHNIQUES AND WEED MANAGEMENT TACTICS ON WEED POPULATION DYANAMICS AND CROP PRODUCTIVITY IN WET DIRECT SEEDED WINTER RICE

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ABSTRACT

In the *sali* season of 2022, a field experiment was conducted at Assam Agricultural University-Assam Rice Research Institute in Titabar, Assam. The aim was to find out the efficacy of different establishment techniques and weed management strategies for controlling weed population in wet direct seeded rice (DSR). The experiment was designed using a split plot layout with three replications. The study considered three establishment techniques namely broadcasting , drum seeding and line sowing and six different weed management practices *viz.*, hand weeding at 20, 40 and 60 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS , weed free check and weedy check. Drum seeding technique recorded lower weed population/m^2 and weed dry weight along with highest weed control efficiency and weed control index at all the growth stages followed by line sowing and broadcasting. Drum seeding technique also recorded the highest grain yield (43.07 q/ha) and straw yield (68.79 q/ha) among all the establishment techniques. Among weed management practices, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS resulted significantly lower weed population/m^2, weed dry weight along with higher weed control efficiency and weed control index at all the growth stages next to weed free check. The highest grain (47.50 q/ha) and straw yield (75.11 q/ha) was recorded under weed free check which was followed by the treatment of pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS (44.37 q/ha grain and 71.80 q/ha straw yield) with harvest Index of 38.15%.

Key words : Bispyribac-Na, Drum seeding, Pyrazosulfuron-ethyl, Weed management, Weed control efficiency, Weed control index.

Introduction

Rice (*Oryza sativa* L.) holds a crucial position as one of the world's primary and extensively cultivated staple foods, catering to a significant portion of the global population. The cultivation occurs in both the *kharif* and *Rabi* seasons across a range of ecological and climatic conditions in India, alongside various socio-economic diversities. The concept of direct seeding for rice is emerging as a promising alternative to traditional transplanting methods. The significance of direct-seeded cultivation in rice farming has risen due to a shortage of agricultural labor, as well as the elevated water demand and increased production costs associated with transplanted rice (Azmi and Baki, 2007). This approach involves planting pre-germinated rice seeds directly in the field, either manually or using mechanical equipment, thus eliminating the need for transplanting seedlings from nursery beds. The adoption of direct-seeded rice is gaining momentum due to factors such as increased groundwater depletion, rising pumping costs, labour and time constraints and the desire to reduce transplanting shock on the crop. Controlling weed growth in DSR, especially in its initial stages, poses a significant challenge because stagnant water hampers crop emergence and there is a shortage of seedlings (Shekhawat *et al*., 2022). Approximately, 90% of yield loss can be attributed to severe weed interference, making weeds the foremost biological obstacle to DSR production (Chauhan and Johnson, 2011; Shekhawat *et al*., 2022). Weed emergence closely aligns with that of the crop in wet-seeded rice, intensifying competition with rice plants. Consequently, effective herbicide-based weed management becomes increasingly vital (Singh and Singh, 2010). Various herbicides have been utilized to tackle weed growth in DSR crops. However, relying solely on one herbicide treatment may not yield satisfactory results due to the limited range of weed control offered by these chemicals (Narayana *et al*., 1999). To tackle this issue, it's imperative to adopt advanced herbicides or their combinations. This strategy guarantees precise and effective control of various weed species in direct seeding for rice cultivation. Therefore, this research was undertaken to examine various weed management practices and establishment techniques aimed at effectively controlling and reducing weed population, while concurrently improving rice productivity in wet direct-seeded condition.

Materials and Methods

The research took place at the Assam Agricultural University-Assam Rice Research Institute, located in Titabar, Assam (26º43' N, 94º12' E, 86.6 m above msl) throughout *sali* season of 2022. The soil was classified as clay loam, with a pH level of 4.97 (acidic), organic carbon content at 0.56% (medium), available nitrogen at 242.41 kg/ha (low), available phosphorus at 24.16 kg/ha (medium) and available potassium at 154.23 kg/ha (medium). The total rainfall recorded during the growth period amounted to 1043.10 mm. Three establishment techniques namelybroadcasting, drum seeding, line sowing and six different weed management practices *viz*., hand weeding at 20, 40 and 60 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS, weed free check and weedy check. The experimental layout followed a split-plot design, consisting of three replications. Timely application of recommended dose of nutrient fertilizer was done, which was 60 kg N/ha as urea, 20 kg P_2O_5/ha through SSP and 40 kg K_2O/ha through MOP was applied uniformly. Where half of the N, entire dose of P_2O_5 and K_2O were applied to the crops as basal dose and remaining 50 % of N was applied in two splits *i.e*., 25% at active tillering stage and remaining 25% at panicle initiation stage. The rice variety chosen was Numali with a maturation period of 135-140 days. Seed rate of 100 kg/ha was taken for broadcasting, 35 kg/ha for drum seeding and 75 kg/ha for line sowing. Herbicides were applied with knap-sack sprayer delivering a spray volume of 600 litres/ha through flat-fan nozzle. Weed species observed in the weedy check treatment plots of the experimental field were recorded at 30, 60 and 90 DAS, as well as at harvest. Subsequently, they were analyzed to understand the diversity of weed populations in the wet seeded plots during the *sali* season. All the weed parameters *viz*., weed flora, weed population/m^2, weed dry weight (g/m^2), weed control efficiency (WCI), weed control Index (WCI) and weed Index (WI) were recorded at an interval of 30, 60, 90 DAS and at harvest, respectively. Meanwhile, the grain and straw yield along with harvest index were recorded during harvest of the crop. The data recorded in the experiment for each parameter were subjected to analysis of variance for split-plot design (SPD) given by Panse and Sukhatme (1954).

The formulae used are as follows:

$$\mathrm{WCE}\,(\%) = \frac{\text{Weed population } (\text{no.}/\text{m}^2) \text{ in control plot} - \text{Weed density } (\text{no.}/\text{m}^2) \text{ in treated plot}}{\text{Weed population } (\text{no.}/\text{m}^2) \text{ in control plot}} \times 100$$

$$\mathrm{WCI}\,(\%) = \frac{\text{Weed dry matter } (\text{g}/\text{m}^2) \text{ in control plot} - \text{Weed dry matter } (\text{g}/\text{m}^2) \text{ in treated plot}}{\text{Weed dry matter } (\text{g}/\text{m}^2) \text{ in control plot}} \times 100$$

$$\mathrm{WI}\,(\%) = \frac{\text{Yield from weed free plot} - \text{Yield from treated plot}}{\text{Yield from weed free plot}} \times 100$$

Results and Discussion

The predominant weed species observed in the experimental plot in association with the direct-seeded rice includes grasses like *Eleusine indica* (L.), *Setaria pumila* (Poir), *Panicum repens* (L.), *Eragrostis unioloides*, *Echinochloa crusgalli, Cynodon dactylon* (L.) Pers. and *Leersia hexandra* Sw, broad leaf weeds like, *Ageratum conyzoides* (L.), *Ludwigia palustris* (L.), *Phyllanthus fraternus* (L.) and *Alternanthera philoxeroides* (L.) and sedges like *Fimbristylis*

Table 1 : Effect of establishment techniques and weed management strategies on weed population and dry weight at different intervals.

Treatment	Weed population (no./m^2)				Weed dry weight (g/m^2)			
	30 DAS	60DAS	90DAS	At harvest	30 DAS	60DAS	90DAS	At harvest
Establishment techniques								
Broadcasting	4.46(24.11)	5.39(34.69)	5.97(43.39)	6.75(50.49)	4.13(20.82)	4.89(29.09)	5.42(37.01)	8.07(69.78)
Drum seeding	4.00(20.05)	4.66(26.73)	5.20(33.56)	6.02(40.85)	3.35(15.05)	4.56(25.67)	5.05(32.75)	7.69(64.22)
Line sowing	4.18(21.73)	5.05(30.81)	5.49(37.22)	6.41 (45.98)	3.71(17.49)	4.75 (27.54)	5.23(34.62)	7.86(66.53)
SEm ±	0.03	0.04	0.04	0.07	0.06	0.02	0.04	0.03
CD (P=0.05)	0.11	0.15	0.14	0.28	0.25	0.07	0.17	0.11
Weed management practices								
Hand weeding at 20, 40 and 60 DAS	6.11(37.06)	5.24(27.22)	6.01(35.74)	6.44(41.17)	4.65(21.66)	5.00(24.60)	5.34(28.30)	7.65(58.30)
Pyrazosulfuron-ethyl @ 30g /ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS	3.63(12.78)	6.02(35.99)	6.38(40.72)	6.83(46.59)	3.21(10.04)	5.56(30.48)	6.03(35.90)	8.10(65.13)
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS	4.20(17.15)	4.91(23.76)	5.38(28.60)	5.51(29.98)	3.88(14.62)	4.54(20.24)	4.81(22.72)	7.27(52.39)
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS	3.53(12.09)	4.52(20.38)	4.86(23.62)	4.96(24.51)	3.19(9.89)	4.01(15.66)	4.31(18.14)	6.98(48.36)
Weed free check	0.71(0.00)	0.71(0.00)	0.71(0.00)	3.68(13.10)	0.71(0.00)	0.71(0.00)	0.71(0.00)	4.80(22.65)
Weedy check	7.48(55.57)	8.79(77.11)	10.00(99.66)	10.94(119.29)	7.39(54.51)	8.60(73.63)	10.20(103.71)	12.44(154.22)
SEm ±	0.10	0.10	0.11	0.10	0.15	0.08	0.08	0.07
CD (P=0.05)	0.30	0.29	0.31	0.29	0.42	0.22	0.22	0.20

*Square root transformed $\sqrt{[(x+0.5)]}$ value, where x = observed value

The original values are presented in the parentheses.

dichotoma, *Cyperus iria* (L.) and *Cyperus rotundus* (L.). Similar weed species under direct seeded rice were also reported by Sindhu *et al*. (2010) and Verma *et al*. (2022).

The lowest weed population and weed dry matter was observed under drum seeding at 30, 60, 90 DAS and at harvest among the various establishment techniques. This might be due to remark a blyelevated plant densities achieved through uniform seed-to-seed spacing. This approach led to the development of a broader crop canopy, facilitating increased uptake of available minerals and nutrients from the soil. Consequently, the enhanced nutrient utilization effectively suppressed weed growth, resulting in diminished weed population and reduced weed dry weight. This was in conformity with the findings of Nayak *et al.* (2014). Among different weed management practices, weed free check resulted the lowest weed population and weed dry weight at 30, 60, 90 DAS and at harvest which was followed by pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS. However, at 30 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS was statistically at par with pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS. This might be due to the initial suppression of weed population by the pre-emergence application of

Table 2 : Effect of establishment techniques and weed management strategies on weed control efficiency, weed control index and weed index.

Treatment	Weed control efficiency (WCE) (%)				Weed control index (WCI) (%)				Weed Index (%)
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	
Establishment techniques									
Broadcasting	57.61	55.95	59.39	59.94	61.64	61.61	65.02	55.24	25.61
Drum seeding	63.08	63.50	63.85	63.44	70.62	64.14	67.80	57.85	15.91
Line sowing	60.67	60.27	62.39	61.66	68.15	62.18	66.39	56.83	20.45
SEm ±	-	-	-	-	-	-	-	-	0.93
CD (P=0.05)	-	-	-	-	-	-	-	-	3.66
Weed management practices									
Hand weeding at 20, 40 and 60 DAS	33.09	64.40	64.18	65.53	58.87	66.45	72.65	62.24	21.17
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac -Na @ 25 g/ha at 25 DAS	76.99	52.83	59.32	61.06	80.70	58.43	65.30	57.72	27.05
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS	69.05	68.79	71.35	74.88	73.06	72.40	78.04	65.99	12.03
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac -Na @ 25 g/ha at 25 and 45 DAS	78.32	73.42	76.42	79.58	81.01	78.60	82.45	68.60	5.83
Weed free check	100.00	100.00	100.00	89.02	100.00	100.00	100.00	85.30	0.00
Weedy check	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.86
SEm ±	-	-	-	-	-	-	-	-	1.57
CD (P = 0.05)	-	-	-	-	-	-	-	-	4.54

pyrazosulfuron-ethyl. This herbicide likely inhibited weed growth during the crucial early stages of crop development. Subsequently, the control of weed population and reduction in weed dry weight were further facilitated by the application of bispyribac-Na as a post-emergent herbicide. This sequential approach effectively minimized the density of weeds per square meter and decreased the overall weed dry weight, ultimately contributing to improved weed management outcomes. Similar findings were reported by Kotresh *et al.* (2022) and Verma *et al.* (2022).

Among the various establishment strategies, drum seeding recorded the highest WCE and WCI at all the growth stages compared to line sowing and broadcasting. The reduction in weed population and dry weight under drum seeding technique may be attributed to the uniform spacing, leading to higher plant densities that suppress weed growth. Similar findings were reported by Nayak *et al.* (2014) and Karki *et al.* (2022). On the other hand, under different weed management practices, weed free check recorded the highest WCE and WCI due to lower number of weeds/m^2 and continuous weeding practices. However, it was closely followed by application of pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS at all the growth stages. This might be due to overall suppression of weed population during initial growth stages and subsequently throughout the growth period which ultimately resulted lower weed dry weight. Similar findings were reported by Channabasavanna *et al.* (2014), Vigneshwaran (2020), Kotresh *et al.* (2022) and Verma *et al.* (2022).

The weed index showed a notable decrease under the weed-free check compared to the other treatments. This result correlated with the findings of Hia *et al.*

Table 3 : Effect of establishment techniques and weed management strategies on grain yield, straw yield and harvest index.

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Establishment techniques			
Broadcasting	32.62	60.64	34.06
Drum seeding	43.07	68.79	38.18
Line sowing	36.90	65.54	35.34
SEm ±	0.29	0.60	-
CD (P=0.05)	1.14	2.36	-
Weed management practices			
Hand weeding at 20, 40 and 60 DAS	37.27	63.57	36.78
Pyrazosulfuron-ethyl @ 30g /ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS	34.47	59.07	36.70
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS	41.48	68.31	37.70
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS	44.37	71.80	38.15
Weed free check	47.50	75.11	38.49
Weedy check	20.06	52.09	27.33
SEm ±	0.37	0.40	-
CD (P = 0.05)	1.07	1.15	-

DAS= Days after sowing, *fb* = followed by

(2017). Next to weed free check, the lowest weed index was obtained under application of pyrazosulfuron ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS. The enhanced growth and yield attributes of rice could be attributed to the efficient management of weeds through diverse herbicidal combinations, leading to reduced competition from weeds. This, in turn, potentially allowed the crop to optimize the uptake and utilization of essential resources including minerals, nutrients, moisture, sunlight, and space. Conversely, the weed index value markedly increased under the weedy check due to enhanced competition from uncontrolled weed growth for soil nutrients, moisture and light, as evidenced by diminished crop vigour, growth, and yield components. Top of Form Similar findings were observed by Vigneshwaran (2020).

Among the establishment techniques, highest grain yield of 43.07 q/ha and straw yield of 68.79 q/ha was observed under drum seeding followed by line sowing and broadcasting. Extended and more favorable environmental conditions throughout the crop growth period provided rice crop with enhanced opportunities for overall growth and development. Consequently, this led to improvements in yield-contributing traits, accompanied by increased nutrient translocation from source to sink, ultimately maximizing yield potential. Similar results were reported by Larry *et al.* (2012) and Nayak *et al*. (2014). Among weed management practices, highest grain of (47.50 q/ha) and straw yield (75.11 q/ha) was recorded under weed free check which was followed by the treatment of pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS (44.37 q/ha grain and 71.80 q/ha straw yield). The observed phenomenon could be attributed to the effective and dynamic suppression of weed growth during the critical phase of crop-weed competition. This allowed the crop to optimize the translocation of photosynthates from the source to the sink, thereby maximizing yield-contributing traits and achieving a higher grain-filling percentage in weed-free plots compared to other plots. This was in accordance with the findings of Mahbub *et al.* (2022) and Mukherjee *et al.* (2022).

Conclusion

The approach of **c**ombined application of drum seeding treatment along with pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS effectively controls weed population throughout the entire rice cultivation period, thus promoting optimal conditions for crop growth and maximizing productivity in wet direct seeded winter rice.

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