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Date of Transplanting and Integrated Weed Management Effects on Growth and Yield of Black Rice (*Oryza sativa* L.) under SRI

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ABSTRACT

Background: The date of transplanting which is related to the climatic condition is one of the major factor affecting the growth and yield of black rice. Weeds also pose serious threat to rice in SRI condition if not controlled during critical period of weed competition. Therefore, efficient integrated weed management practices are required in SRI. The experiment was carried out to assess the effect of date of transplanting and integrated weed management on black rice.

Methods: The experiment was conducted in the experimental farm of SASRD, NU, Medziphema campus during *kharif* season of 2019 and 2020. The experiment was laid out in split plot design with three dates of transplanting in the main plots and five integrated weed management treatments in the sub-plots with 15 treatment combinations and three replications.

Result: Minimum weed population and dry weight were recorded with transplanting black rice on 15th June. It also gave significantly highest growth attributes and yield of black rice. Among the integrated weed management, Pretilachlor 0.75 kg/ha t 3 DAT *fb* handweeding at 40 DAT recorded significantly lowest weed population and dry weight and highest plant height, number of green leaves plant^{-1}, dry matter accumulation and yield of black rice.

Key words: Black rice, Date of transplanting, Pretilachlor, Weed management.

INTODUCTION

India is the world's second largest rice producer and consumer next to China. It contributes 43 per cent of total food grain production and 46 per cent of total cereal production in India. Rice is cultivated in an area of 43.78 million hectares with an annual production of 118.4 million tonnes and productivity of about 2.7 tonnes per hectare (Annual Report. 2020-21, Department of Agriculture, Cooperation and Farmer's Welfare). Black rice is a special type of rice species *Oryza sativa* L. which is black in colour, glutinous, packed with high level of nutrients and mainly cultivated in Asia. In India, black rice is cultivated only in few areas such as northeast, West Bengal, Jharkhand and Odisha. In northeast, it is especially grown in Manipur. In order to obtained higher paddy yields, sowing at optimum time is important. The sowing date of the rice crop is important for three major reasons. Firstly, it ensures that vegetative growth occurs during a period of satisfactory temperature and high levels of solar radiation. Secondly, the optimum sowing date for each cultivar ensures that the cold sensitive stage occurs when the minimum night temperatures are historically the warmest. Thirdly, sowing on time guarantees that grain filling occurs when milder autumn temperatures are more likely, hence good grain quality is achieved (Farrell *et al*., 2003). Out of several factors responsible for low yield, severe infestation of weeds in SRI cultivation is also considered to be one of the major obstacles in achieving higher yield. When rice fields are not flooded continuously and plants are widely spaced as recommended under SRI, weeds get a better chance to grow. Weeds become detrimental to crops by changing the pH of soil, decreasing the nutrient availability, which in turn reduces straw yield by 13-38% and grain yield by 25-47% (Manandhar *et al*., 2007; Nivetha *et al*., 2017; Paul *et al*., 2019 and Tasmin *et al*., 2019). Therefore, efficient weed management practices are required under SRI. Keeping the above points in view, an experiment was conducted to assess the effect of date of transplanting and integrated weed management on growth and yield black rice.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of 2019 and 2020 in the experimental research farm of the School of Agricultural Science and Rural Development (SASRD), Medziphema campus, Nagaland University located at 20°45′43″N latitude and 93°53′04″E longitude with

an elevation of 310 m above mean sea level. The soil condition of the experimental site was clayey loam in texture with a pH of 4.85, high in organic carbon (1.21%), low in available nitrogen (253.12 kg ha^{-1}), low in available phosphorus (18.43 kg ha^{-1}) and medium in available potassium (142.62 kg ha^{-1}). The experiment was laid out in split plot design with three dates of transplanting *viz*. D_1- 15th June, D_2- 30th June and D_3- 15th July in the main plots and five integrated weed management treatments *viz*. W_1- Weedy check, W_2- Conoweeding at 20 and 40 DAT, W_3- Pretilachlor 0.75 kg/ha at 3 DAT *fb*handweeding at 40 DAT, W_4- Pretilachlor @0.75 kg ha^{-1} at 3 DAT *fb*conoweeder @ 40 DAT and W_5-Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb*Bispyribac-Na @ 25 g a.i ha^{-1} at 20 DAT in the sub-plots with 15 treatment combinations and replicated thrice. The plot size was 4 m × 3 m. Cultivar used was Chakhao Poireiton. The recommended dose of fertilizer (RDF) at 50:30:20 kg NPK ha^{-1} was applied. Half dose of N and full dose of P and K were applied as basal during transplanting while the other half of N were top-dressed during tillering and flowering in further two equal halves. Transplanting was done at one seedling hill^{-1} with a spacing of 25 cm × 25 cm using 12 days old seedling. As per the treatment, pretilachlor (50% EC) @ 0.75 kg ha^{-1} at three days after transplanting and bispyribac-Na (10% SL) @ 20 g a.i ha^{-1} at twenty days after transplanting were applied in respective plots with the help of knapsack sprayer fitted with flat fan nozzle using spray volume of 500 L/ha. Data were statistically analysed using the technique of Analysis of Variance as described by Gomez and Gomez (2010). The significance differences were tested by 'F' test at 5% probability level. The weed data was subjected to square root transformation with the help of the formula, $\sqrt{x + 0.5}$, where x is the actual weed count.

Results and Discussion

Weed population and weed dry weight

Black rice transplanted on 15th June recorded significantly lowest total weed population and dry weight while highest population was recorded under 15th July transplanting date which could be due to availability of higher moisture with the onset of monsoon (Table 1). Early transplanting of black rice might have provided better environmental condition for the crop to establish and overcome the weed that led to better growth and competitive ability of crop and ultimately reduces the utilization of resources by weeds like moisture, nutrients, light and space resulting in lower weed population. The results are in close conformity with the findings of Rajaput (2013), Ghandor *et al*. (2017) and Kumar *et al*. (2017).

Integrated weed management influenced the total weed population and dry weight of weeds significantly. Weedy check gave significantly maximum population and dry weight of weeds in both the years (Table 1). The higher total weed population and dry weight could be due to higher weed intensity and its dominance in utilizing the resources like nutrients, moisture, light *etc*. Similar results were reported by Mondal *et al*. (2019) and Parihar *et al*. (2020). Application

Table 1: Effect of date of transplanting and integrated weed management on total weed population and dry weight (g m^{-2}) at 60 DAT.

Treatment	Total weed population (no. m^{-2})			Total dry weight of weeds (g m^{-2})		
Date of transplanting	2019	2020	Pooled	2019	2020	Pooled
D_1- 15th June	10.08 (123.56)	10.24 (126.18)	10.16 (124.87)	8.48 (98.73)	8.37 (98.37)	8.42 (98.55)
D_2- 30th June	11.77 (160.51)	11.91 (164.57)	11.84 (162.54)	9.77 (124.18)	9.70 (124.13)	9.73 (124.16)
D_3- 15th July	12.79 (187.76)	13.03 (194.11)	12.91 (190.94)	11.24 (159.17)	11.19 (159.75)	11.21 (159.46)
SEm±	0.26	0.17	0.15	0.07	0.13	0.07
CD (P=0.05)	1.02	0.66	0.50	0.29	0.51	0.24
Integrated weed management						
W_1- Weedy check	20.56 (424.22)	20.87 (436.98)	20.71 (430.60)	20.57 (425.13)	20.74 (432.26)	20.66 (428.70)
W_2- Cono weeding at 20 and 40 DAT	11.23 (127.31)	11.18 (126.65)	11.21 (127.01)	8.29 (70.00)	8.30 (69.77)	8.30 (69.89)
W_3- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT fb Hand weeding at 40 DAT	6.76 (46.11)	7.17 (51.84)	6.97 (48.97)	5.51 (31.02)	5.23 (27.90)	5.37 (29.46)
W_4- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT fbcono weeder at 40 DAT	10.62 (114.24)	10.61 (114.19)	10.61 (114.22)	7.91 (63.29)	7.82 (62.13)	7.87 (62.71)
W_5- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT fb Bispyribac-Na @ 25 g a.i. ha^{-1} at 20 DAT	8.57 (74.44)	8.81 (78.45)	8.69 (76.45)	6.86 (47.36)	6.65 (45.02)	6.76(46.19)
SEm±	0.21	0.24	0.16	0.17	0.15	0.11
CD (P=0.05)	0.62	0.71	0.46	0.49	0.43	0.32

Original values were subjected to square root transformation. Figures in parenthesis are the original values.

of pre-emergence herbicides pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb*handweeding at 40 DAT recorded significantly lowest total weed population and dry weight which was followed by pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb*Bispyribac-Na @ 25 g a.i. ha^{-1} at 20 DAT. The lower population and dry weight of weeds with these treatments could be due to inherent capability of the herbicides to affect the cell division, cell growth and hindering the germination of weeds during initial stage followed by hand removal of weeds at later stage. The results were in conformity with the findings of Jadhav *et al*. (2016), Phukan and Deka (2021) and Reddy and Ameena (2021).

Growth attributes

Data pertaining to plant height (cm), number of green leaves plant^{-1} and dry matter accumulation (g plant^{-1}) (Table 2) revealed that transplanting of black rice on 15th June recorded maximum plant height, number of green leaves plant^{-1} and dry matter accumulation which was followed by transplanting on 30th June while significantly lowest values were observed under 15th July. Early date of transplanting might have ensured the vegetative growth to take place during a period of satisfactory temperature and higher level of solar radiation (Patel *et al*., 2019). Similar results were obtained by Tiwari *et al*. (2018); Singh *et al*. (2021) and Yumnam *et al*. (2021).

Significantly highest plant height, number of green leaves plant^{-1} and dry matter accumulation were recorded with application of pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb*handweeding at 40 DAT and it was followed by pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* Bispyribac-Na @ 25 g a.i. ha^{-1} at 20 DAT (Table 2). This may be attributed to the effective control of weeds at critical stages of crop weed management resulting in increased availability of nutrients and accumulation of photosynthates. Similar findings were reported by Ansari *et al*. (2017), Suseendran *et al*. (2020) and Sanodiya and Singh (2021). Minimum values were recorded under weedy check in both the years due to heavy competition with weed flora.

Yield

The differences in grain and straw yield among the date of transplanting were found to be significant (Table 3a). The grain and straw yield recorded under 15th June transplanting date was found to be significantly highest and was followed by 30th June. The higher yield in early planted crops could be due to optimum period available for growth and development which leads to more storage of photosynthates in grain as well as better yield related traits observed under earlier planted crop than the later crop. The results are in corroboration with those of Vishwakarma *et al*. (2016), Dileep *et al*. (2018) and Kumari and Prasad (2021).

Weedy check recorded significantly lowest yield during both the years (Table 3a). Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* h and weeding at 40 DAT recorded significantly highest grain and straw yield as compared to the rest of the treatments. This was followed by pretilachlor @ 0.75 kg ha^{-1} at

Table 2: Effect of date of transplanting and integrated weed management on plant height (cm), number of green leaves plant^{-1} and dry matter accumulation (g plant^{-1}) at 90 DAT of black rice.

Treatment	Plant height (cm) at 90 DAT			Number of green leaves plant^{-1} at 90 DAT			Dry matter accumulation (g plant^{-1}) at 90 DAT		
Date of transplanting	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
D_1- 15th June	134.92	133.84	134.38	41.96	41.04	41.50	43.71	44.41	44.06
D_2- 30th June	126.95	126.39	126.67	36.21	36.03	36.12	36.21	34.70	35.45
D_3- 15th July	121.20	119.92	120.56	29.65	28.53	29.09	27.76	26.60	27.18
SEm±	1.74	1.86	1.27	1.37	1.13	0.89	1.10	0.75	0.66
CD (P=0.05)	6.83	7.30	4.15	5.39	4.42	2.89	4.31	2.94	2.17
Integrated weed management									
W_1- Weedy check	103.36	102.32	102.84	21.04	19.88	20.46	14.27	13.41	13.84
W_2- Cono weeding at 20 and 40 DAT	121.77	121.32	121.55	29.49	28.84	29.16	30.97	29.18	30.08
W_3- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* Hand weeding at 40 DAT	149.02	148.20	148.61	51.09	50.64	50.87	54.69	56.54	55.61
W_4- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* cono weeder at 40 DAT	126.47	125.55	126.01	34.37	33.60	33.99	34.13	32.83	33.48
W_5- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* Bispyribac-Na @ 25 g a.i. ha^{-1} at 20 DAT	137.84	136.19	137.02	43.70	43.04	43.37	45.41	44.20	44.80
SEm±	2.97	3.28	2.21	1.87	1.66	1.25	1.25	1.45	0.96
CD (P=0.05)	8.68	9.59	6.30	5.46	4.83	3.55	3.64	4.24	2.72

Table 3(a): Effect of date of transplanting and integrated weed management on grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}).

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})		
Date of transplanting	2019	2020	Pooled	2019	2020	Pooled
D_1- 15th June	2030.12	2132.15	2081.13	4063.24	4119.96	4091.60
D_2- 30th June	1621.67	1736.03	1678.85	3799.64	3881.81	3840.73
D_3- 15th July	1441.17	1550.98	1496.07	3532.01	3633.59	3582.80
SEm±	33.84	38.81	25.75	61.63	57.55	42.16
CD (P=0.05)	132	152	83	241	225	137
Integrated weed management						
W_1- Weedy check	1163.48	1264.10	1213.79	3286.65	3188.18	3237.42
W_2- Cono weeding at 20 and 40 DAT	1593.55	1698.62	1646.09	3635.67	3754.52	3695.10
W_3- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT fb Hand weeding at 40 DAT	2124.09	2245.04	2184.57	4300.69	4419.01	4359.85
W_4- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT fb cono weeder at 40 DAT	1696.36	1797.74	1747.05	3780.17	3896.78	3838.48
W_5- Pretilachlor @ 0.75 kg ha^{-1} at 3 DAT fb Bispyribac-Na @ 25 g a.i. ha^{-1} at 20 DAT	1910.78	2026.42	1968.60	3988.30	4133.76	4061.03
SEm±	37.93	42.68	28.55	81.08	75.01	55.23
CD (P=0.05)	110	124	81	236	218	157

Table 3(b): Interaction effect of date of transplanting and integrated weed management on grain yield (kg ha^{-1}).

Treatment	Grain yield (kg ha^{-1})		
	2019	2020	Pooled
D_1W_1	1340.20	1410.03	1375.12
D_1W_2	1917.11	2015.63	1966.37
D_1W_3	2527.54	2655.04	2591.29
D_1W_4	2068.23	2168.36	2118.30
D_1W_5	2297.54	2411.67	2354.61
D_2W_1	1181.91	1303.69	1242.80
D_2W_2	1487.86	1592.39	1540.13
D_2W_3	2106.44	2232.96	2169.70
D_2W_4	1528.16	1629.83	1579.00
D_2W_5	1803.99	1921.25	1862.62
D_3W_1	968.34	1078.59	1023.47
D_3W_2	1375.70	1487.83	1431.76
D_3W_3	1738.30	1847.13	1792.71
D_3W_4	1492.69	1595.03	1543.86
D_3W_5	1630.81	1746.34	1688.57
SEm± (D×W)	65.69	73.93	49.45
SEm± (W×D)	56.16	64.08	42.60
CD (P=0.05) (D×W)	191	215	140
CD (P=0.05) (W×D)	186	213	128

3 DAT *fb* Bispyribac-Na @ 25 g a.i. ha^{-1} at 20 DAT. Application of pre-emergence herbicides pretilachlor interfered with the growth and development of weeds by inhibiting the cell division and effectively controlled the germinating weeds or emerging weeds during early stages of crop growth followed by hand weeding at later stage and maintain the crop free from crop weed competition for nutrients, space and light resulting in higher number of tillers, number of panicles, grains panicle^{-1} and ultimately yield. Similar findings were reported by Paul *et al*. (2019); Tasmin *et al*. (2019); Salam *et al*. (2020) and Bhattacharya *et al*. (2022).

Interaction effect of date of transplanting and integrated weed management on grain yield was found to be significant (Table 3b). Transplanting of black rice on 15th June along with application of pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* h and weeding at 40 DAT recorded significantly highest grain yield in both the years while transplanting on 15th July in combination with weedy check gave the lowest yield. Similar results were reported by Mubeen *et al*. (2014).

Conclusion

From the above experiment, it can be concluded that black rice should be transplanted on 15th June along with application of pre-emergence herbicides pretilachlor @ 0.75 kg ha^{-1} at 3 DAT *fb* Hand weeding at 40 DAT for efficient weed management and higher productivity.

Conflict of interest

All authors declared that there is no conflict of interest.

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