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Research Paper

Efficacy of integrated weed management practices on weed dynamics and productivity of black rice in Nagaland

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ABSTRACT

A field experiment was conducted during *kharif* season of 2021 and 2022 at the experimental site of School of Agricultural Sciences (SAS) Nagaland University, Medziphema. Main plot comprised of four integrated weed management namely W_1, weedy check (control); W_2, hand weeding (15 and 30 DAS); W_3, pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS; and W_4, pretilachlor @ 1.0 kg/ha (PE) + bispyribac sodium @ 25 g/ha (PoE) at 20 DAS while four genotypes, viz. C_1, Chakhao Poireiton (Check); C_2, Chakhao Amubi; C_3, Wairi Chakhao and C_4, Khurukhul Chakhao under sub-plot and was laid out in split-plot design (SPD). A total of 11 different species of grasses, sedges and broad-leaved weeds was recorded from experimental field. At 60 DAS 2 hand weeding at 15 and 30 DAS recorded the lowest density and biomass of grasses, sedges and broad-leaved weed which was closely followed with application of pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS. Chakhao Poireiton and Wairi Chakhao among the genotypes recorded the lowest weed density and biomass respectively. Highest weed control efficiency and lowest weed index was revealed with two hand weeding at 15 and 30 DAS. Weedy check (control) recorded lowest growth, yield attributes and yield while maximum result was exhibited with two hand weeding at 15 and 30 DAS and was closely with application of pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS. Among genotypes, Chakhao Poireiton and Wairi Chakhao recorded the highest and lowest growth, yield attributes and yield respectively.

Key words: Black rice, Chakhao, Pretilachlor, Weeding, Yield

Rice (*Oryza sativa*) is the most popular food worldwide and is considered as a staple food due to its nutritional value. Black rice, also called purple rice or forbidden rice, is a type of rice from the genus *Oryza sativa*, some of which are glutinous rice. It is primarily black in colour due to its anthocyanin's levels (Yamuangmorn and Prom-u-Thai *et al*., 2021). Due to consumer demand, farmers are now interested in black rice due to its high anthocyanin content, carbohydrates, lipids, proteins, dietary fibers and minerals (Sah and Kushwaha 2016). Comparing the different rice cultivation methods adopted weeds flourish fast in direct seeded rice (DSR). Weeds are more prevalent in DSR than transplanted rice due to the simultaneous emergence of rice and weeds and the absence of standing water in the early stages of rice growth and hence, weed management is a major obstacle to the success of upland direct seeded rice (DSR) (Rathika *et al.,* 2020). Farmers use a wide array of weed management methods (manual, mechanical, herbicides etc.) to reduce weeds in the fields. However, weeds in cereal crops are so complex and diverse that no single method can control them effectively (Raj *et al.,* 2022). Different varieties of rice used for cultivation vary in their ability to compete with weeds due to their varied morphological characteristics such as plant height, tillering ability, canopy structure and relative growth rate etc. (Kumar *et al.,* 2020) and additionally weed competitive genotypes are characterized by increased early vigour, higher leaf area, biomass accumulation, rapid ground cover by canopy, more tillering ability, taller plants and allelopathy (Dhillon *et al*., 2021). However, the weed control ability of rice genotypes may vary according to the different weed management practices adopted and therefore, in this region, the selection of the best black rice genotype and weed management practices are essential to the successful cultivation of the black rice genotype in a weed-free environment during the critical period of

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growth. Hence, the present study was conducted to evaluate the efficacy of integrated weed management on weed dynamics and productivity of black rice genotypes in Nagaland.

MATERIALS AND METHODS

The experiment was conducted at the experimental site of School of Agricultural Sciences (SAS), Nagaland University, Medziphema during the *kharif* season of 2021 and 2022 to study the efficacy of integrated weed management practices on weed dynamics and productivity of black rice genotypes in Nagaland. Humid summers and cold winters are the climatic conditions of the region. Throughout the cropping season the total rainfall received in the year 2021 and 2022 was 829.9 mm and 1,070.8 mm respectively from July to December while average maximum temperature recorded the highest in the month of August at 34.4°C and 34.1°C for the year 2021 and 2022 and lowest temperature recoded in the month of December at 11.4°C and for 12.0°C for 2021 and 2022, respectively. The texture of the soil was clayey loam and strongly acidic (*p*H 4.75), high organic carbon (1.49%), low in available N (252.09 kg/ha), high in available P (34.51 kg/ha) and medium in available K (148.63 kg/ha).

The main plot consisted of four integrated weed management, viz. W_1, Weedy check (Control); W_2, hand weeding (15 and 30 DAS); W_3, pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS and W_4, pretilachlor @ 1.0 kg/ha (PE) + bispyribac sodium @ 25 g/ha (PoE) at 20 DAS while subplot consisted of four genotypes, viz. C_1, Chakhao Poireiton (Check), C_2, Chakhao Amubi, C_3- Wairi Chakhao and C_4- Khurukhul Chakhao and laid out in Split plot design (SPD). The plot size of each experimental unit was 4 m × 3m where 80 kg/ha of seed rate was directly sown and a distance of 20 cm was maintained row to row and 10 cm for plant to plant. Well decomposed farm yard manure (FYM) @ 2.5 t/ha was broadcasted uniformly and incorporated during the land preparation. Irrespective of treatment fertilizers were applied in the form of Urea (130 kg/ha), Single super phosphate (250 kg/ha) and Muriate of potash (66 kg/ha) where Urea was applied in split doses before sowing and at tillering while full dose of SSP and MOP was applied over the entire plot before sowing. Herbicides as per treatment was applied with the help of flat fan nozzle fitted knapsack sprayer. The density of grasses, sedges and broad-leaved weeds from each plot was randomly collected with the help of a quadrate of $1/m^2$ where square root transformation was subjected to the data collected. The collected data on various parameters was analyzed of variance technique as per split plot design. The treatment means were compared with critical difference at 5% level of significance.

RESULTS AND DISCUSSION

Effect of integrated weed management and rice genotypes on weeds

Altogether 11 species of weeds were identified and recorded from the experimental field. *Digiteria sanguinalis*, *Cynodon dactylon* and *Eleusine indica* and among grasses, *Cyperus iria* and *Cyperus rotundus* among sedges while *Phyllanthus niruri*, *Borreria latifolia*, *Commelina benghalensis*, *Alternanthera sessilis, Mollugo pentaphylla* and *Ageratum conyzoides* among broad leaved weed were dominantly observed under study. Weed density and dry weight of grasses, sedges and broad-leaved weed differed significantly due to the effect of integrated weed management treatments at 60 DAS in both the years of study. Highest density and dry weight of weeds as depicted in Table 1 were obtained under control which is because no weed management measures were applied. However, hand weeding at the critical stages (15 and 30 DAS) proved to show positive response in maintaining the lower weed density as well as dry weight. The result from the study also responded similarly with hand weeding at 15 and 30 DAS exhibiting the lowest weed density and dry weight at 60 DAS. This was in close similarity with the sequential application of pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS. It may have been due to broad spectrum weed control by the herbicide and timely hand weeding thereafter which was also noted by (Soujanya *et al.,* 2020).

The four genotypes under study also exerted significant results on weed density and dry weight at 60 DAS (Table 1). Among the black rice genotypes, study revealed that Wairi Chakhao exhibited highest density and dry weight of weed at 60 DAS while further data resulted that Chakhao Poireiton proved to show significantly lowest density and dry weight at 60 DAS which was statistically at par with Chakhao Amubi. Genotypes generally differ in their weed competitive abilities owing to the diverse morphological characteristics such as plant height, canopy cover, relative rate of growth etc. which agree with that of Kumar *et al*., (2020).

Weed control efficiency and weed index showed variation with regard to the integrated weed management treatments as well as the four black genotypes in both the years of experiment (Table 1). Highest control of weeds was successfully achieved with two hand weeding at 15 and 30 DAS. The increased weed control efficiency and lower weed index were achieved due to decreased weed density and biomass and it was possible by strategies of successful management of weeds during the critical stages by hand weeding (15 and 30 DAS). A similar result was also reported by (Hashim *et al*., 2022) and (Verma *et al.,* 2023). This was closely followed with sequential application of pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS which

Table 1. Effect of integrated weed management and different genotypes on population and dry weight of grasses, sedges and broad-leaved weed, weed control efficiency at 60 DAS (%) and weed index (%) (pooled data of 2 years)

Treatment	Population (no./m^2)			Dry weight (g/m^2)			Weed control efficiency (%)	Weed index (%)
	Grasses	Sedges	BLW	Grasses	Sedges	BLW		
Weed Management								
W_1, Weedy check (Control)	13.71 (194.00)	9.34 (87.00)	10.66 (114.00)	15.05 (230.49)	8.26 (67.90)	10.38 (108.24)	0	42.44
W_2, Hand weeding (15 and 30 DAS)	6.83 (51.67)	4.90 (24.00)	6.23 (39.50)	5.29 (32.59)	4.89 (23.68)	5.83 (34.43)	77.70	0
W_3, Pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS	9.36 (90.00)	6.43 (41.67)	8.14 (67.67)	8.08 (67.40)	6.27 (39.17)	7.53 (57.41)	59.68	9.71
W_4, Pretilachlor @ 1.0 kg/ha (PE) + bispyribac sodium @ 25 g/ha (PoE) at 20 DAS	9.84 (97.50)	6.58 (44.00)	8.10 (66.67)	8.33 (70.61)	6.43 (41.21)	7.27 (53.55)	59.33	32.14
SEm±	0.34	0.07	0.08	0.32	0.06	0.12	–	–
CD (P=0.05)	1.04	0.22	0.26	0.98	0.17	0.38	–	–
Genotype								
C_1, Chakhao poireiton	7.89 (68.83)	6.09 (39.83)	6.83 (49.17)	7.16 (63.41)	6.01 (37.39)	6.51 (45.17)	64.11	16.79
C_2, Chakhao amubi	9.43 (99.00)	6.59 (46.00)	7.98 (66.33)	8.87 (95.55)	6.30 (40.85)	7.51 (59.17)	51.90	19.08
C_3, Wairi chakhao	11.76 (146.17)	7.65 (60.50)	9.73 (96.67)	10.96 (133.61)	7.01 (50.03)	8.98 (83.53)	34.31	25.56
C_4, Khurukhul chakhao	10.65 (119.17)	6.92 (50.33)	8.60 (75.67)	9.76 (108.53)	6.52 (43.69)	8.01 (65.77)	46.39	22.87
SEm±	0.29	0.15	0.10	0.27	0.10	0.12	–	–
CD (P=0.05)	0.82	0.42	0.30	0.75	0.27	0.34	–	–

may have been because application of pretilachlor at initial days inhibited cell division and weed germination followed by removal with hands at later stages also helped in maintaining lesser weed density and biomass which was in conformity with the findings of (Phukan and Deka 2021). Lower weed index clearly indicated higher yield while higher weed control efficiency indicated lower weed density compared to the other plots. Further, lowest weed control efficiency and highest weed index was resulted with weedy check in both the years of experiment.

Effect of integrated weed management and genotypes on productivity of black rice

The growth of a plant is characterized by several key factors like plant height, number of tillers, number of panicles and dry matter production. Parameters pertaining to growth of rice, yield attributes and yield illustrated significant results as influenced by integrated weed management (Table 2). Significantly maximum height of the crop was obtained under the treatment where hand weeding was done at 15 and 30 DAS. This was closely followed with sequential application of pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS. The lower weed density and dry weight under these treatments may have provided congenial conditions for the utilization of multiple inputs required for growth more effectively resulting in higher height of the crop which was also in close agreement with the study of (Verma *et al*., 2022). Yield of a rice crop results from the combination of the number of productive tillers and number of filled grains per panicle (Mani *et al.,* 2023). Hand weeding twice at 15 and 30 DAS also proved to show similar result with weight of panicles, grain and straw yield of crop in both the years (Table 2). Further, treatment under control where no weeds were removed both by manual and herbicides revealed lowest result significantly in both the years. Additionally, grain filling % showed no significant effect under the influence of integrated weed management. Plant height, weight of panicles, grain and straw yield was significantly influenced with the four black rice genotypes under study in both the years.

Table 2. Effect of integrated weed management and different genotypes on growth, yield attributes and yield

Treatment	Plant height at 60 DAS (cm)	Weight of panicles (g)	Grain filling %	Grain yield (kg/ha)	Straw yield (kg/ha)
Weed management					
W_1, Weedy check (Control)	55.75	1.14	91.08	1,077.33	2,989.04
W_2, Hand weeding (15 and 30 DAS)	84.18	2.64	91.67	1,871.75	4,053.08
W_3, Pretilachlor @ 1.0 kg /ha (PE) *fb* HW at 40 DAS	73.49	1.85	89.14	1,690.04	3,718.08
W_4, Pretilachlor @ 1.0 kg/ha (PE) + bispyribac sodium @ 25 g/ha (PoE) at 20 DAS	65.82	1.56	88.60	1,270.17	3,378.67
SEm±	0.89	0.02	0.76	20.97	36.94
CD (P=0.05)	2.73	0.07	NS	64.62	113.81
Genotype					
C_1, Chakhao poireiton	71.98	1.88	90.11	1,557.50	1,553.92
C_2, Chakhao amubi	70.32	1.84	89.30	1,514.63	1,508.67
C_3, Wairi chakhao	67.72	1.71	90.59	1,393.42	1,389.17
C_4, Khurukhul chakhao	69.22	1.75	90.49	1,443.75	1,440.92
SEm±	0.72	0.02	0.82	15.16	21.42
CD (P=0.05)	2.03	0.06	NS	43.11	62.52

Chakhao Poireiton proved to result in significantly maximum height of crop, weight of panicle and straw yield which was at par with Chakhao Amubi statistically while minimum height, weight of panicle and straw yield was observed statistically under Wairi Chakhao treatment. However, the four genotypes showed no significant effect on grain filling % in both the years.

Effect of integrated weed management and genotypes on economics

The economic study on treatment combination of black rice was influenced by integrated weed management and different genotypes of black rice (Table 3). The data revealed that treatment combination of hand weeding at 15 and 30 DAS and genotype Chakhao Poireiton exhibited

Table 3. Effect of treatment combination on net returns and Benefit: cost ratio of black rice production

Treatment	Net returns (₹/ha)			Benefit: cost ratio		
	2021	2022	Mean	2021	2022	Mean
W_1C_1	57,813.15	58,881.49	58,347.32	1.60	1.63	1.62
W_1C_2	55,721.49	58,033.49	56,877.49	1.55	1.61	1.58
W_1C_3	46,097.49	48,017.82	47,057.65	1.28	1.33	1.31
W_1C_4	49,742.15	50,777.15	50,259.65	1.38	1.41	1.39
W_2C_1	113,010.15	113,401.82	113,205.99	2.35	2.36	2.36
W_2C_2	107,928.49	108,114.15	108,021.32	2.25	2.25	2.25
W_2C_3	99,317.82	99,683.82	99,500.82	2.07	2.08	2.07
W_2C_4	102,030.15	102,536.82	102,283.49	2.12	2.13	2.13
W_3C_1	102,083.15	102,548.49	102,315.82	2.46	2.47	2.47
W_3C_2	100,127.82	101,187.15	100,657.49	2.42	2.44	2.43
W_3C_3	91,197.15	91,708.15	91,452.65	2.20	2.21	2.21
W_3C_4	95,375.49	95,622.49	95,498.99	2.30	2.31	2.30
W_4C_1	75,679.82	76,352.82	76,016.32	2.02	2.03	2.03
W_4C_2	70,188.82	70,728.15	70,458.49	1.87	1.88	1.88
W_4C_3	58,345.15	58,520.15	58,432.65	1.55	1.56	1.56
W_4C_4	64,832.15	65,047.49	64,939.82	1.73	1.73	1.73

Table 4. Correlation coefficients studies for among growth, yield attributes, yield, weed density and weed biomass under study

Treatment	Plant height (cm)	Weight of panicle (g)	Grain filling (%)	Straw yield (kg/ha)	Grasses (no./m^2)	Sedge (no./m^2)	Broad leaved weed (no./m^2)	Grasses (g/m)	Sedge (g/m)	Broad leaved weed (g/m^2)
Plant height (cm)	1									
Weight of panicle (g)	0.973**	1								
Grain filling %	0.143	0.224	1							
Straw yield (kg/ha)	0.989**	0.948**	0.095	1						
Grasses (no./m^2)	-0.882**	-0.857**	0.017	-0.884**	1					
Sedge (no./m^2)	-0.930**	-0.878**	0.021	-0.944*	0.929**	1				
Broad leaved weed (no./m^2)	-0.862**	-0.878**	0.058	-0.880**	0.954**	0.957**	1			
Grasses (g/m^2)	-0.905**	-0.861**	0.096	-0.908**	0.907**	0.968**	0.942**	1		
Sedge (g/m^2)	0.956**	-0.924**	-0.041	-0.961**	0.931**	0.993**	0.948**	0.963**	1	
Broad leaved weed (g/m^2)	-0.870**	-0.829**	0.122	-0.881**	0.960**	0.971**	0.987**	0.971**	0.958**	1

Note: **determines significant at 1% level

highest net returns in both the years of study while lowest was incurred under weedy check (control) in combination with genotype Wairi Chakhao. The lower net returns under control might be because of significant reduction of yield by virtue of no weed control in the entire crop growth period which was also in harmony with the findings of (Barla *et al*., 2021) and (Satapathy *et al.,* 2020). Further, treatment combination of pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS and Chakhao Poireiton recorded maximum B:C ratio in both the years. The lower cost involved in the treatment in comparison with manual hand weeding alongside with increased yield under the treatment may have aided in higher B:C ratio. Similar findings are also in agreement with the study of (Salam *et al.,* 2020).

Correlation between different parameters

Study on correlation revealed a positive and significant correlation between growth, yield attributes and yield of black rice (Table 4). Plant height was highly and significantly correlated with weight of panicle (r = 0.97) and straw yield (r = 0.98) of black rice while weight of panicle also revealed a positive and significant correlation with straw yield (r =0.94). However, a low and significant correlation was observed with grain filling % with the rest of the characters. With regard to weed characters it was revealed that weed density and biomass revealed significant but highly significant correlation with growth, yield attributes and yield of crop. However, weed density of grasses, sedges and broad-leaved weed observed a highly positive and significant correlation with weed biomass.

Therefore, although two hand weeding at 15 and 30 DAS in conjunctive with genotype Chakhao Poireiton recorded highest growth, yield attributes, yield, WCE and net returns of black rice provided with reduced weed density and biomass but since the highest B:C ratio was incurred with pretilachlor @ 1.0 kg/ha (PE) *fb* HW at 40 DAS and Chakhao Poireiton. Thus, it may be recommended for profitable cultivation of black rice in Nagaland condition.

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