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Growth, Yield and Economics as Influenced by Integrated Weed Management and Cultivars of Black Rice under Nagaland Condition

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ABSTRACT

An experimental investigation was conducted during the *kharif* season of 2021 and 2022 at the experimental site of the School of Agricultural Sciences (SAS), Nagaland University, Medziphema. The main plot included four integrated weed management measures, namely Weedy check (control), Hand weeding (15 and 30 DAS), Pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS and Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25 g ha^{-1} (PoE) at 20 DAS while four cultivars namely Chakhao Poireiton (Control), Chakhao Amubi, Wairi Chakhao and Khurukhul Chakhao under the sub-plot and laid out in Split plot design (SPD). At 40 DAS, both total weed population and dry weight was recorded with hand weeding at 15 and 30 DAS and was followed by the application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS. Among cultivars, Chakhao Poireiton and Wairi Chakhao registered lowest and highest total weed population and dry weight respectively. Weedy check (control) recorded the lowest growth, yield and economics while the maximum result was obtained with hand weeding at 15 and 30 DAS and was closely followed with application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS. Among the cultivars, Chakhao Poireiton and Wairi Chakhao recorded the highest and lowest growth, yield and economical studies in both the years respectively.

Keywords Black rice, Cultivar, Hand weeding, Pretilachlor, Weed.

INTRODUCTION

Rice (*Oryza sativa* L.), essential for the diet of half the world's population, is fundamental in the fight against food insecurity, especially in economically vulnerable countries Dass *et al.* (2016), Wasaya *et al.* (2022). India, which contributes 21% to global rice production, faces the challenge of meeting a projected demand of 130 million tonnes by 2025 for national food security and the United Nations Sustainable Development Goals Choudhary *et al.* (2022). Black rice, a special type of rice species is remarkably known for its color, packed aroma along with a lot of nutritive and health benefits is mainly grown in Asia. The Manipur black rice "Chakhao" which translates to "delicious" is gaining a lot of interest and has the ability to alternate the white rice keeping the multiple benefits mentioned. Of many constraints hindering the full potential of its production weed infestation

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with the rice crop plays a vital role reducing the yield miserably. Integrated weed management being a comprehensive approach that combines effective, reliable and practical weed control methods can contribute to enhanced control of weed to some extent. Additionally, rice varieties differing in their competitive ability against weeds due to their different morphological characteristics, namely plant height, tillering ability, canopy structure and relative growth rate Kumar *et al.* (2020). Therefore, selection of suitable weed management methods along a high competing variety with suitable morphological traits is a requirement to unfold the outmost cultivation of rice crop reducing the yield reductions.

MATERIALS AND METHODS

The present study was conducted in the experimental farm of School of Agricultural Sciences (SAS), Nagaland University, Nagaland during the *kharif* season of 2021 and 2022. It was laid out in Split plot design (SPD) where four treatments namely W_1- Weedy check (Control), W_2- Hand weeding (15 and 30 DAS), W_3- Pretilachlor @ 1.0 kg ha_{-1} (PE) *fb* HW at 40 DAS and W_4- Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25g ha^{-1} (PoE) at 20 DAS in the main plot while sub-plot consisting of four cultivars viz. C_1- Chakhao Poireiton (Check), C_2- Chakhao Amubi, C_3- Wairi Chakhao and C_4- Khurukhul Chakhao. During the cropping season (2021 and 2022) total rainfall received was 829.9 mm and 1070.8 mm respectively from July to December. A uniform application of well decomposed FYM was done in the entire trial area where 80 kg ha^{-1} seeds were used for sowing which was done on 8th July and 6th July in 2021 and 2022 respectively. Fertilizers was applied irrespective of the treatment in the form Urea, SSP and MOP where split dose of Urea and full dose of SSP and MOP was applied. With the help of flat fan nozzle fitted knapsack sprayer herbicides were applied as per the treatment requirement. The leaf area index (LAI) was measured at 30 DAS removing all the leaves from each of the 5 randomly selected plants in each plot and passing them individually on a stationary leaf area meter device. Yield from the net plot (4 × 3= 12 m^2) were harvested sundried followed by weighing the biological yield using the following formula.

$$\text{Biological yield (kg ha}^{-1}) = \frac{\text{Weight of the grain+straw per plot (kg)}}{\text{Size of the plot(m}^2)} \times 10000$$

For measuring the weed population and dry weight 1 m^2 quadrate was randomly placed in each plot and data were recorded which was subjected to square root transformation respectively. Significant differences between the treatment mean were compared with 5 % level of probability of critical differences.

RESULTS AND DISCUSSION

Weed studies

Effect of integrated weed management on weed: In both the years of experiment variations on data with regards to total weed population and dry weight of weed at 40 DAS was significantly affected by integrated weed management (Table 1). Weedy check had the maximum weed population as well as dry weight owing to the fact that weeds were left unchecked throughout the cropping period. Further, the result from data exhibited lowest weed population and dry weight with hand weeding at 15 and 30 DAS and was closely followed with application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS which was at par with pretilachlor @ 1.0 kg ha^{-1} (PE) + bispyribac sodium @ 25g ha^{-1} (PoE) at 20 DAS respectively. The timely control of weeds at the critical stages manually as well as with the herbicides making it evident that the treated plots showed significant results in comparison with control Suryakala *et al.* (2019) has also confirmed a close result from his findings.

Effect of cultivars on weed: Results pertaining to total weed population and dry weight also revealed variable results on the different cultivars in both the years of experiment. Cultivar Chakhao Poireiton resulted in the minimum total weed population and dry matter and was closely followed with Chakhao Amubi. Schreiber *et al.* (2018) from his study also revealed that the rice cultivars which had increasing and early ground cover proved to reduction of weed population and dry matter ultimately. Additionally, Wairi Chakhao significantly resulted to highest total weed population and dry matter in both the years. Suppressing ability of taller rice cultivars over the weeds showed an impactful effect over the shorter

Table 1. Effect of integrated weed management and different cultivars on total weed population and dry weight at 40 DAS.

Treatments	Total weed population (no. m^{-2})			Total dry weight (g m^{-2})		
	2021	2022	Pooled	2021	2022	Pooled
Weed management						
W_1 -Weedy check (Control)	17.32 (301.67)	16.89 (287.00)	17.11 (294.33)	13.36 (178.87)	13.13 (173.23)	13.24 (176.05)
W_2 - Hand weeding (15 and 30 DAS)	9.49 (94.67)	9.32 (90.00)	9.41 (92.33)	7.79 (62.35)	7.56 (58.72)	7.68 (60.53)
W_3 -Pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS	12.80 (168.00)	12.55 (161.00)	12.67 (164.50)	10.10 (103.76)	10.01 (102.03)	10.06 (102.90)
W_4 -Pretilachlor @ 1.0 kg ha^{-1} (PE) + bispyribac sodium @ 25g ha^{-1} (PoE) at 20 DAS	13.06 (172.33)	12.74 (164.67)	12.90 (168.50)	10.29 (106.86)	10.15 (104.02)	10.22 (105.44)
SEm ±	0.22	0.22	0.16	0.20	0.18	0.13
CD (p=0.05)	0.77	0.77	0.49	0.68	0.61	0.41
Cultivar						
C_1- Chakhao Poireiton (Check)	10.76 (127.33)	10.72 (124.00)	10.74 (125.67)	8.70 (80.91)	8.56 (77.88)	8.63 (79.39)
C_2 -Chakhao Amubi	12.70 (168.67)	12.36 (160.67)	12.53 (164.67)	10.15 (106.43)	9.83 (100.44)	9.99 (103.44)
C_3 -Wairi Chakhao	15.42 (244.67)	15.16 (237.00)	15.29 (240.83)	11.96 (146.33)	11.93 (145.82)	11.94 (146.08)
C_4 -Khurukhul Chakhao	13.79 (196.00)	13.26 (181.00)	13.53 (188.50)	10.72 (118.17)	10.53 (113.86)	10.63 (116.02)
SEm ±	0.27	0.25	0.18	0.20	0.18	0.13
CD (p=0.05)	0.79	0.72	0.52	0.59	0.52	0.38

Square root transformation was subjected to original values. Figures in parenthesis are the original value.

cultivars in the experimental plots Afroz *et al.* (2019) also confirmed similar results.

Important value index (%): Based on data depicted in Table 2, among the 11 species the highest important value index (IVI) at 40 DAS were *Digiteria sanguinalis, Cyperus iria* and *Borreria latifolia* as it was found dominant in almost all the plots and in most number and it clearly showed the importance of *Digiteria sanguinalis* on these plots in the experimental area while the least were *Phyllanthus niruri, Commelina benghalensis* and *Alternanthera sessilis* which was found in lesser number and was not found in all the plots in comparison to the other weed species under treatment. Hence *Digiteria sanguinalis* was found to be the most dominant weed species in the concerned

Table 2. Important value index (%) at 40 DAS of the dominant weed species in the year 2021 and 2022.

Sl. No.	Type	Family	Species	IVI (%)	
				2021	2022
1	Grass	Poaceae	*Digiteria sanguinalis*	83.10	89.89
2		Poaceae	*Cynodon dactylon*	19.87	18.79
		Poaceae	*Eleusine indica*	18.33	17.76
3	Sedges	Cyperaceae	*Cyperus iria*	35.15	35.51
4		Cyperaceae	*Cyperus rotundus*	19.46	19.55
5	Broad-leaved weed	Amaranthaceae	*Alternanthera sessilis*	17.76	17.76
6		Molluginaceae	*Mollugo pentaphylla*	22.87	22.97
7		Rubiaceae	*Borreria latifolia*	27.77	28.16
8		Commelinaceae	*Commelina benghalensis*	16.42	16.27
9		Asteraceae	*Ageratum conyzoides*	20.52	20.24
10		Phyllanthaceae	*Phyllanthus niruri*	13.76	13.11

Table 3. Effect of integrated weed management and different cultivars on plant height, LAI, number of plants and dry matter accumulation at 30 DAS.

Treatment	Plant height (cm) at 30 DAS			LAI at 30 DAS			Number of plants (m^{-2}) at 30 DAS			Dry matter accumulation (g $plant^{-1}$) at 30 DAS		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Weed managemen												
W_1 -Weedy check (Control)	42.66	43.91	43.29	0.40	0.42	0.41	49.33	49.58	49.46	1.97	1.98	1.97
W_2 - Hand weeding (15 and 30 DAS)	70.65	72.03	71.34	1.13	1.15	1.14	49.67	49.67	49.67	2.80	2.83	2.82
W_3 -Pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS	61.13	62.50	61.82	1.01	1.05	1.03	49.58	49.67	49.63	2.53	2.62	2.57
W_4 -Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25g ha^{-1} (PoE) at 20 DAS	49.61	51.28	50.45	0.85	0.86	0.86	49.42	49.58	49.50	2.18	2.20	2.19
SEm ±	0.88	1.10	0.71	0.01	0.02	0.01	0.09	0.12	0.07	0.03	0.05	0.03
CD (p=0.05)	3.06	3.81	2.17	0.04	0.06	0.03	NS	NS	NS	0.12	0.17	0.09
Cultivar												
C1- Chakhao Poireiton (Check)	58.28	59.81	59.05	0.88	0.89	0.88	49.83	49.92	49.88	2.47	2.49	2.48
C2 -Chakhao Amubi	56.71	57.98	57.34	0.86	0.88	0.87	49.50	49.58	49.54	2.39	2.43	2.41
C3 -Wairi Chakhao	53.35	54.81	54.08	0.81	0.84	0.83	49.17	49.42	49.29	2.28	2.32	2.30
C4 -Khurukhul Chakhao	55.71	57.13	56.42	0.85	0.87	0.86	49.50	49.58	49.54	2.34	2.38	2.36
SEm ±	0.81	0.90	0.60	0.01	0.01	0.01	0.16	0.16	0.11	0.04	0.04	0.03
CD (p=0.05)	2.36	2.62	1.72	0.04	0.04	0.03	NS	NS	NS	0.11	0.11	0.07

PE- Pre emergence, PoE- Post emergence, NS- Non significant at 5 %.

study site. Solfiyeni *et al.* (2016) also corroborated that lesser weed density value of species indicates species being lower in comparison than the others and that this type is having a narrow distribution in the experimental site.

Growth parameters

Effect of integrated weed management on growth parameters: Data pertaining to growth attributes (Table 3) in both the years of experiment revealed a significant result as influenced by integrated weed management where maximum plant height, LAI and dry matter accumulation at 30 DAS was exhibited with two hand weeding at 15 and 30 DAS and was closely followed with pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS. This possibility may be due to the increase in plant growth due to less weed competition during the early stages of plant development, which favors its ability to access nutrients and light, which leads to the efficient accumulation of photosynthesis. A similar opinion was expressed by Sen *et al.* (2020) and Shahane and Behera (2023). Further, weedy check treatment where weeds were not controlled all growing season resulted to minimum data on plant height, LAI and dry matter accumulation at 30 DAS significantly in both the years.

Effect of cultivars on growth parameters: Likewise, with context to different cultivars (Table 3) it showed a variable effect on plant height, LAI and dry matter accumulation at 30 DAS where highest results were observed with Chakhao Poireiton which was at par with Chakhao Amubi significantly. Further, Wairi Chakhao showed minimum results on the growth parameters. Such differences among the different varities might be attributed due to their respective parental origin and genetic inheritance Grace *et al.* (2018) also reported mutual results from the study conducted. However, number of plant (m^{-2}) did not show any significant effect on integrated weed management and different cultivars in both the years of

experiment.

Yield

Effect of integrated weed management and cultivars on yield: The experiment conducted in the two years (Table 4) showed a significant variation on the biological yield as influenced by integrated weed management where hand weeding at 15 and 30 DAS resulted to maximum biological yield and was closely followed with pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS which may have been due to effective control of weeds throughout the critical period of crop weed competition providing a congenial environment for moisture, light and nutrients for the crops resulting in higher growth and yield of crop eventually. A similar result is also in the conformity with those of Kumawat *et al.* (2017). Data also recorded lowest biological yield significantly with weedy check treatment in both the years which might be due to high weed interference resulting in higher density and dry weight of weed similar views are in corroboration with those of Kumari *et al.* (2023b). Similarly, biological yield was also significantly affected with different cultivars in both the years where Chakhao Poireiton showed maximum biological yield and was at par with Chakhao Amubi respectively. Further, Wairi Chakhao exhibited the lowest biological yield in both the years.

Economic

Effect of integrated weed management and cultivars on economics: The data on gross and net returns (Table 4) as recorded from the two years data revealed that two hand weeding at 15 and 30 DAS incurred the maximum gross as well as net returns respectively and was closely followed with pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS. By virtue, plots where weeds were timely controlled gave a positive and higher yield returns and higher returns ultimately. Similar results are in harmony with those of Barla *et al.* (2021). Further, weedy check recorded minimum gross and net returns in both the years. Further, in terms of cultivars Chakhao Poireiton and Wairi Chakhao incurred highest and lowest gross and net returns respectively from the two years observation of data.

Table 4. Effect of integrated weed management and different cultivars on biological yield, gross returns and net returns of black rice.

Treatment	Biological yield (kg ha^{-1})			Gross return (₹ ha^{-1})			Net returns (₹ ha^{-1})		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Weed Management									
W_1 -Weedy check (Control)	4018.33	4114.42	4066.38	88383.75	89967.67	89175.71	52343.57	53927.49	53135.5
W_2 - Hand weeding (15 and 30 DAS)	5875.25	5974.42	5924.83	153611.83	153974.33	153793.08	105571.65	105934.15	105752.9
W_3 -Pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS	5389.42	5426.83	5408.13	138636.08	139206.75	138921.42	97195.90	97766.57	97481.2
W_4 -Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25g ha^{-1} (PoE) at 20 DAS	4619.67	4678.00	4648.83	104791.67	105192.33	104992.00	67261.49	67662.15	67461.8
SEm±	60.55	48.79	38.88	88383.75	89967.67	89175.71	52343.57	53927.49	53135.5
CD at 5%	209.53	168.84	119.80	153611.83	153974.33	153793.08	105571.65	105934.15	105752.9
Cultivar									
C_1- Chakhao Poireiton (Check)	5149.83	5233.25	5191.54	127909.25	128558.83	128234.04	91869.07	92518.65	92193.9
C_2 -Chakhao Amubi	5069.67	5152.33	5111.00	124254.33	125278.42	124766.38	88214.15	89238.24	88726.2
C_3 -Wairi Chakhao	4757.92	4829.50	4793.71	114502.08	115245.17	114873.63	78461.90	79204.99	78833.4
C_4 -Khurukhul Chakhao	4925.25	4978.58	4951.92	118757.67	119258.67	119008.17	82717.49	83218.49	82968.0
SEm±	62.46	67.44	45.96	127909.25	128558.83	128234.04	91869.07	92518.65	92193.9
CD at 5%	182.31	196.84	130.69	124254.33	125278.42	124766.38	88214.15	89238.24	88726.2

PE- Pre emergence, PoE- Post emergence.

CONCLUSION

The two years experiment concluded with hand weeding at 15 and 30 DAS along with cultivar Chakhao Poireiton resulting in highest growth, yield and economic returns also exhibiting the minimum total weed population and dry weight respectively. However, keeping the view of high labor requirement in carrying out the hand weeding making it difficult for the farmers both financially and physically it may be suggested that pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS along with cultivar Chakhao to be recommended for cultivation in Nagaland conditions. However, further research can also be recommended for the treatments to result in its outmost potential.

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