RESEARCH ARTICLE Agricultural Science Digest, Volume 45 Issue 5: 826-832 (October 2025)

Evaluation of Growth, Phenology, Yield and Weed Dynamics as Influenced by Integrated Weed Management in Black Rice Cultivars under Nagaland Condition

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10.18805/ag.D-6198

ABSTRACT

Background: Black rice a special type of rice species known in multiple ways through its beneficial nutrients and health needs and are in need to be cultivated to its outmost potential. Cultivation of weed suppressible variety along with integrated weed management can be considered for high outcome of yield.

Methods: A farm trial during *kharif* season of 2021 and 2022 was laid out in split plot design (SPD) on the experimental field of School of Agricultural Sciences (SAS), Nagaland University, Nagaland consisting of four integrated weed management in the main plot while sub-plot consisting of four cultivars respectively.

Result: Grasses, sedges and broad-leaved weeds with a total of 11 species were identified and recorded dominant. Lowest depletion of nutrients by weed was observed with hand weeding at 15 and 30 DAS with cultivar Chakhao Poireiton and was followed with application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS. Hand weeding at 15 and 30 DAS along with cultivar Chakhao Poireiton exhibited highest plant height, LAI and biological yield and was closely followed with application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS with Chakhao Poireiton, while similar results were also observed with the phenological studies. Further, weedy check recorded lowest plant height and LAI. However, plant population showed no significant variation with context to integrated weed management and different cultivars in both the years. Additionally, correlation studies revealed a strong negative correlation between plant height and nutrient depletion by weeds.

Key words: Black rice, Chakhao, Cultivars, Poireiton, Weed.

INTRODUCTION

Rice (*Oryza sativa* L.) which belongs to the family of Poaceae is an important and extensively grown crop due to its need as a daily food for one of every three individuals on the earth. Of many different varieties of rice known the Black rice variety although having a history of heritage is considered as underutilized crop owing to its limited consumption (Jha *et al.,* 2017). The Manipur black rice also known as Chakhao which has already been awarded the GI tag in the April of 2020 (Moirangthem *et al.,* 2020) is gaining attention to its great nutritive, curative benefits, anti-carcinogenic, anti-inflammatory and anti-oxidative properties. The aromatic, glutinous and purplish black colour of black colour is mainly owing to pigment anthocyanin. Rice is being cultivated in India over a wide range of area with different establishment methods. Irrespective of the establishment methods, it is very well known that the major losses in yield is reported by weed infestation of rice crops (Sheeja and Elizabeth, 2017). Reduction in yield of rice due to weeds in the direct seeded rice field has been reported to about 40-100% (Shekhawat *et al.,* 2020). Control of weeds during critical conditions of crop weed competition in direct seeding of rice (DSR) can be carried out by various physical, chemical or cultural practices (Banik *et al.,* 2020). Additionally, during the crop weed competition, growing of appropriate cultivars is also a need due to its diverse morphological traits, structure of canopy, duration of growth and relative growth rate. Cultivars of rice having weed suppressing characters are an important aspect to manage weed infestations (Kumar *et al.,* 2016). It is for a fact that the cultivars of black rice could provide food security apart from its contribution to interesting diet with many medicinal properties.

Therefore, conservation of such cultivars is of great importance by carrying out the cultivation through the adoption of better agronomic practices. Keeping in view the need of the above context, an experiment entitled "Evaluation of growth, phenology, yield and weed dynamics

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How to cite this article: Chishi, H.M., Nongmaithem, D., Khoisnam, N., Bijayalakshmi, S., Tzudir, L., Yadav, R. and Malemnganbi, T. (2025). Evaluation of Growth, Phenology, Yield and Weed Dynamics as Influenced by Integrated weed Management in Black Rice Cultivars under Nagaland Condition. *Agricultural Science Digest*. **45(5):** 826-832. doi: 10.18805/ag.D-6198.

Submitted: 14-09-2024 **Accepted:** 23-01-2025 **Online:** 17-02-2025

as influenced by integrated weed management in black rice cultivars under Nagaland condition" was carried out.

MATERIALS AND METHODS

An experiment entitled "Evaluation of growth, phenology, yield and weed dynamics as influenced by integrated weed management in black rice cultivars under Nagaland condition" was carried out on the experimental field of the School of Agricultural Sciences, Nagaland University, Medziphema during the *kharif* season of 2021 and 2022. The region of the experiment conducted is sub-tropical consisting of hot and humid summers and cold winters. Throughout the growing season, the total rainfall received in 2021 and 2022 was 829.9 mm and 1070.8 mm, respectively from July to December, while the average maximum temperature recorded in August at 34.4°C and 34.1°C for 2021 and 2022 and the lowest temperature recorded in December at 11.4°C and 12.0°C for 2021 and 2022, respectively. The soil structure was clayey loam and strongly acidic in reaction (pH 7.3), high in organic carbon (1.49%), low in available N (252.09 kg ha^{-1}), high in available P (34.51 kg ha^{-1}) and medium available K (148.63 kg ha^{-1}). The experiment was laid out in split plot design (SPD) 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^{-1} (PE) *fb* HW at 40 DAS and W_4- pretilachlor @ 1.0 kg ha^{-1} (PE) + bispyribac sodium @ 25 g ha^{-1} (PoE) at 20 DAS followed by 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. A distance of 20 cm × 10 cm plant to plant and row to row was maintained using 80 kg ha^{-1} while maintaining 4 m × 3 m individual plot size. Nitrogen in split doses at sowing and panicle initiation and full doses of phosphorous and potassium at sowing in the form of Urea, SSP and MOP (60-40-40 kg NPK ha^{-1}) was applied uniformly over the experimental field area. Herbicides per treatment were applied with a knapsack sprayer equipped with a flat fan nozzle. Grasses, sedges and broad-leaved weed density from each plot were collected randomly using a 1 m^2 quadrate where the square root transformation was subjected to the collected data. The data collected for different parameters were analyzed using the variance technique as per the split plot design proposed by (Gomez and Gomez, 1984). Treatment means were compared with a critical difference at a 5% significance level.

RESULTS AND DISCUSSION

Weed studies

A total of 11 weed species namely 3 grasses, 2 sedges and 6 broad leaved weeds were identified and noted from the experimental field. Some of the dominant species were *Digitaria sanguinalis*, *Cynodon dactylon*, *Cyperus iria*, *Cyperus rotundus*, *Borreria latifolia*, *Phyllanthus niruri*, *Commelina benghalensis* and *Alternanthera sessilis*.

Results on nutrient depletion by weeds showed a significant difference with regard to integrated weed management in both the years of experiment (Table 1). Data revealed that lowest depletion of nitrogen, phosphorous as well as potassium was exhibited under two hand weeding at 15 and 30 DAS and it was followed with sequential application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS. (Hassan and Upasani, 2015) and (Nazir *et al.,* 2022) from their findings revealed mutual results leading to lowest depletion nutrients by weeds due to timely control of weeds at the critical stages maintaining a feasible environment for the crops to grow rather than the weeds respectively. Further, weedy check recorded the maximum depletions of the nutrients in both years. Similar findings were also observed by (Sharma *et al.,* 2018) and (Shanmugapriya *et al.,* 2021) where highest removal of nutrients from weedy check may be due to numerous weed growth in these plots that was left unchecked leading to higher weed population as well as dry matter.

Growth and yield parameters

Variations in data concerned with plant height at harvest, LAI at 60 DAS and biological yield as influenced by integrated weed management in both the years of experiment showed significant results where it was noted that maximum height (110.7 cm), LAI (1.96) and biological yield (5924.83 kg ha^{-1}) was recorded significantly with two hand weeding at 15 and 30 DAS. Congenial environment owing to lesser crop-weed competition and timely removal of weeds leading to lesser requirement of limited resources favored a better growth of crop with increased canopy development (Mahanta *et al.,* 2019) also confirmed similar opinions from the study conducted. This was closely followed with application of pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS and it may have been due to herbicidal effect that controlled the weeds at early stages while manual weeding at later stages respectively. Mutual results were also confirmed with (Sanodiya and Singh, 2021) and (Bhattacharya *et al.,* 2022). Further, weedy check showed minimum plant height (87.68 cm), LAI (0.86) and biological yield (4066.38 kg ha^{-1}) respectively in both the years. Similarly, data pertaining to plant height, LAI and biological yield showed variations with different cultivars under study where it was observed that cultivar Chakhao Poireiton exhibited the maximum plant height, LAI and biological yield and was at par with Chakhao Amubi (Table 2). Further, cultivar Wairi Chakhao observed minimum growth and yield attributes in both the years of experiment which was at par with Khurukhul Chakhao. Such differences among the cultivars might have been due to the fact that taller cultivars as well as bigger leaves had the potential smothering effect over the weeds. Schreiber *et al.* (2018) from his study also described similar results. However, result observed from plant population under study did not show any significant differences with context to integrated weed management as well as different cultivars under study in both the years.

Table 1: Effect of integrated weed management and different cultivars of black rice on nutrient depletion by weeds.

Treatment	Nitrogen (kg ha^{-1})			Phosphorous (kg ha^{-1})			Potassium (kg ha^{-1})		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Weed management									
W_1- Weedy check (Control)	30.85	30.94	30.89	19.98	20.23	20.11	55.73	55.40	55.57
W_2- Hand weeding (15 and 30 DAS)	4.84	4.39	4.62	1.83	1.71	1.77	3.72	3.37	3.55
W_3- Pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS	9.89	9.92	9.91	3.77	3.47	3.62	17.89	17.14	17.52
W_4- Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25 g ha^{-1} (PoE) at 20 DAS	11.69	11.71	11.70	7.24	6.99	7.12	18.76	18.60	18.68
SEm±	0.59	1.13	0.64	0.25	0.44	0.25	0.82	1.51	0.86
CD at 5%	2.06	3.91	1.97	0.88	1.53	0.79	2.82	5.21	2.64
Cultivar									
C_1- Chakhao poireiton	10.10	9.58	9.84	5.75	5.40	5.57	16.76	16.25	16.50
C_2- Chakhao amubi	13.28	14.47	13.88	7.48	7.85	7.66	22.19	22.56	22.38
C_3- Wairi chakhao	18.30	17.32	17.81	11.15	10.41	10.78	32.02	30.16	31.09
C_4- Khurukhul chakhao	15.59	15.58	15.59	8.45	8.76	8.60	25.13	25.53	25.33
SEm±	0.55	0.79	0.48	0.23	0.44	0.25	0.64	1.14	0.65
CD at 5%	1.61	2.31	1.37	0.66	1.29	0.71	1.87	3.31	1.85

PE- Pre emergence; PoE- Post emergence.

Table 2: Effect of integrated weed management and different black rice cultivars on plant height at harvest, LAI at 60 DAS, plant population at harvest and biological yield.

Treatments	Plant height (cm) at harvest			LAI at 60 DAS			Plant population (m^{-2}) at harvest			Biological yield (kg ha^{-1})		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Weed management												
W_1- Weedy check (Control)	87.01	88.36	87.68	0.85	0.87	0.86	48.17	48.25	48.21	4018.33	4114.42	4066.38
W_2- Hand weeding (15 and 30 DAS)	110.19	111.22	110.71	1.95	1.97	1.96	48.67	48.67	48.67	5875.25	5974.42	5924.83
W_3- Pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS	101.80	103.72	102.76	1.82	1.85	1.84	48.50	48.58	48.54	5389.42	5426.83	5408.13
W_4- Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25 g ha^{-1} (PoE) at 20 DAS	97.85	99.64	98.74	1.23	1.26	1.25	48.17	48.42	48.29	4619.67	4678.00	4648.83
SEm±	1.68	1.88	1.26	0.02	0.02	0.02	0.17	0.16	0.12	60.55	48.79	38.88
CD at 5%	5.80	6.49	3.87	0.07	0.07	0.05	NS	NS	NS	209.53	168.84	119.80
Cultivar												
C_1- Chakhao poireiton	102.04	103.21	102.63	1.51	1.53	1.52	48.58	48.75	48.67	5149.83	5233.25	5191.54
C_2- Chakhao amubi	100.48	102.09	101.28	1.48	1.50	1.49	48.42	48.58	48.50	5069.67	5152.33	5111.00
C_3- Wairi chakhao	96.10	97.40	96.75	1.42	1.44	1.43	48.17	48.17	48.17	4757.92	4829.50	4793.71
C_4- Khurukhul chakhao	98.23	100.24	99.23	1.45	1.47	1.46	48.33	48.42	48.38	4925.25	4978.58	4951.92
SEm±	1.47	1.46	1.04	0.02	0.02	0.02	0.14	0.17	0.11	62.46	67.44	45.96
CD at 5%	4.30	4.26	2.95	0.06	0.06	0.04	NS	NS	NS	182.31	196.84	130.69

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

Table 3: Effect of integrated weed management and different cultivars on phenology of black rice.

Treatment	Days to 50% flowering			Days to 50% physiological maturity			Days to maturity		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Weed management									
W_1- Weedy check (Control)	104.08	104.42	104.25	115.25	115.58	115.42	134.50	134.08	134.29
W_2- Hand weeding (15 and 30 DAS)	104.83	105.00	104.92	115.83	115.83	115.83	135.83	135.25	135.54
W_3- Pretilachlor @ 1.0 kg ha^{-1} (PE) fb HW at 40 DAS	104.58	104.92	104.75	115.58	115.58	115.58	135.42	135.50	135.46
W_4- Pretilachlor @ 1.0 kg ha^{-1} (PE) + Bispyribac sodium @ 25 g ha^{-1} (PoE) at 20 DAS	104.42	104.25	104.33	115.33	115.50	115.42	134.50	134.58	134.54
SEm±	0.17	0.18	0.12	0.16	0.17	0.12	0.50	0.67	0.42
CD at 5%	NS	NS	0.38	NS	NS	NS	NS	NS	NS
Cultivar									
C_1- Chakhao poireiton	105.58	105.50	105.54	116.75	116.67	116.71	137.92	138.00	137.96
C_2- Chakhao amubi	104.58	104.83	104.71	116.00	116.00	116.00	136.25	136.33	136.29
C_3- Wairi chakhao	103.50	103.75	103.63	114.33	114.33	114.33	131.25	131.50	131.38
C_4- Khurukhul chakhao	104.25	104.50	104.38	114.92	115.50	115.21	134.83	133.58	134.21
SEm±	0.20	0.20	0.14	0.13	0.15	0.10	0.46	0.69	0.41
CD at 5%	0.57	0.57	0.39	0.37	0.44	0.28	1.33	2.02	1.18

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

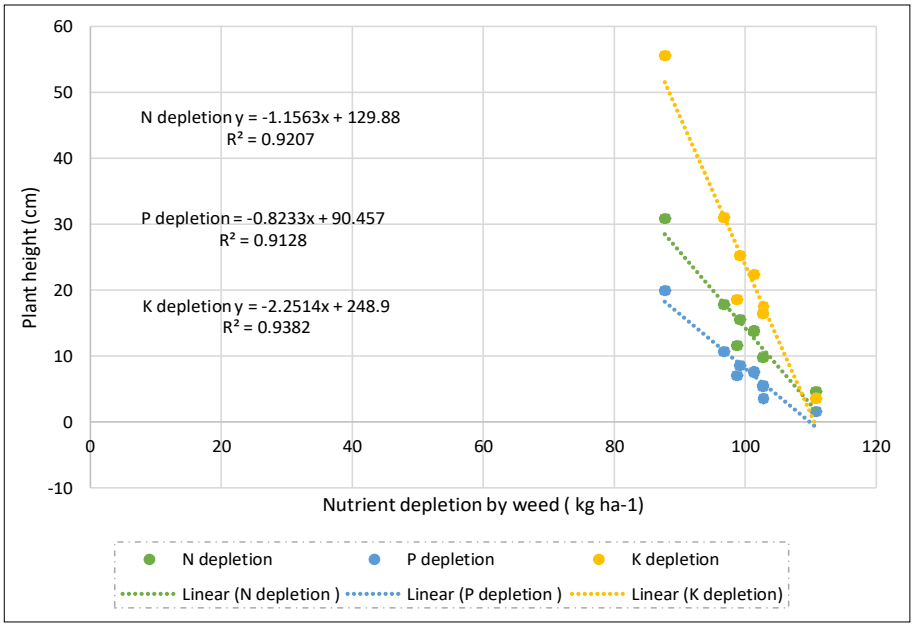


Fig 1: Relationship between plant height (cm) and nutrient (NPK) depletion (kg ha^{-1}) by weeds.

Phenological studies

The resulted depicted on Table 3 with regard to phenological studies revealed that it did not show any significant result with context to the four integrated weed management practices under study in the two years of experiment. However, pooled data of days to 50% flowering showed some variations with two hand weeding at 15 and 30 DAS recording highest number of days to 50% flowering which was at par statistically with pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS, while further data revealed minimum days to 50 % flowering was revealed with weedy check and was seen to be at par with pretilachlor @ 1.0 kg ha^{-1} (PE) + bispyribac sodium @ 25 g ha^{-1} (PoE) at 20 DAS. Results with regard to the four cultivars of black rice under study showed significant differences on phenological studies where it was seen that significantly maximum days to 50% flowering, physiological maturity as well as maturity was recorded with Chakhao Poireiton which was closely followed with Chakhao Amubi. Additionally, Wairi Chakhao revealed to minimum days to 50% flowering, physiological maturity as well as maturity of crop respectively. Such differences in phenology of crop may have been affected due to condition of environmental during pollination and flowering of the crop. Similar opinions were also revealed in the study conducted by Purwanto *et al.* (2020).

Correlation studies

Data from both the year under experimentation showed a strongly negative linear correlation between plant height and nutrient depletion by weeds with coefficient determination of 0.9207 for plant height with N depletion by weed, 0.9128 for plant height with P depletion and 0.9382 for plant height and K depletion which has been depicted in Fig 1, respectively. The result clearly revealed that control of weeds at the critical stages while maintaining a feasible environment for the crops to grow had a positive effect by reduction of weeds leading to lower depletion eventually. Similar opinions were also revealed with the findings from (Saravanane *et al.,* 2016).

CONCLUSION

Drawn from the result conducted in the two years of experiment it can be concluded that two hand weeding at 15 and 30 DAS along with cultivar Chakhao resulted in higher growth attributes, phenological studies and yield while also resulting in lower depletion of nutrients from weed studies perspective. However, keeping the fact known that hand weeding becomes a tedious work with very high labour requirement it may be suggested that pretilachlor @ 1.0 kg ha^{-1} (PE) *fb* HW at 40 DAS along with cultivar Chakhao Poireiton may be suggested to the farmers for profitable yield and income in Nagaland condition.

Conflict of interest

All the authors declare that there is no conflict of interest.

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