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RESEARCH NOTE

Non chemical weed management in organically grown direct-seeded aerobic upland rice in newly cleared forest area

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ABSTRACT

A field experiment was conducted in newly cleared forest area under organic production system at College of Agriculture (CAU-I), Kyrdemkulai, Meghalaya, India during rainy (*Kharif)* season of 2020. The objective of experiment was to evaluate timing and frequency of manual and mechanical methods of weed management on weeds, growth and yield of direct-seeded upland aerobic rice. The grain yield for both *Sahbhagi Dhan* and *Bhalum-1* rice varieties was highest in weed free and it was at par with yield in mechanical weeding twice at 23-25 and 45-50 days after seeding (DAS).The manual and mechanical weeding didn't differ significantly due to the use of higher seed rate, lower weed density and uniform distribution of inter and intra-row weeds. The mechanical weeding was found economical than manual weeding due to lesser labour and time requirements for weeding.

Keywords: Aerobic rice, Mechanical weeding, Non-chemical weed management, Organic production system, *Sahbhagi Dhan*

The rice is the staple food in Meghalaya and is grown on 1.11 lakh ha area with production and productivity of 3.04 lakh tonnes and 2740 kg/ha, respectively (Anonymous 2019). In Meghalaya, the rice is mainly grown under rainfed upland and rainfed lowland ecosystems due to significantly higher variation in rainfall across the state. The use of agrochemicals for nutrient and biotic stress management is very less in Meghalaya on account of farmers preference to traditional cultivation methods using indigenous technical knowledge (ITK) which suits the socio-economic conditions of local production system. The washing out of agrochemicals due to heavy rains, non-availability of agrochemicals on time and low seed replacement ratio with less prominence of improved varieties are few other reasons for non-adoption of agro-chemical based crop management systems. In rice production, weed management is of immense importance (Deka and Barua 2015) considering losses caused by weeds in rice, particularly in direct-seeded upland rice (Rao *et al.* 2007). The losses due to weed in direct-seeded rice were reported to be 20 to 100% (Singh *et al.* 2016). In Meghalaya, nearly 42.3% area is occupied by forests (Anonymous 2019a) and the rice cultivated area is surrounded by forest and prominence of wild vegetation and therefore, greater species diversity is common in rice cultivation. Considering both non-use of herbicides and yield losses in upland rice due to weeds, the alternative best non-chemical combinations of manual and mechanical weeding is need to be identified for managing weeds effectively and improve rice yield. Hence, a study was conducted with an objective to evaluate timing and frequency of manual and mechanical methods of weed management on weeds, growth and yield of direct-seeded upland aerobic rice.

The study was conducted during rainy (*Kharif)* season of 2020 at Research Farm of College of Agriculture (CAU-I), Kyrdemkulai, Ri-Bhoi district of Meghalaya (25^0.74' N and 91^0 81' E), India in recently cleared forest area. The climate of selected area is subtropical type with average seasonal (South West monsoon) and annual precipitation of 1424.1 and 2119.3 mm, respectively. The area selected is at the hill top where trees and wild vegetations were cleared six months before the sowing of rice by cutting trees and removing wild vegetation without burning. As the area is at the top and vegetation is cleared well ahead of sowing, soil was poor in organic carbon and acidic in reaction. The experiment was conducted in split-plot design with rice cultivars (*viz. Sahbhagi Dhan* and *Bhalum-1*) in main plots and seven weed management treatments in subplots, *viz.* control, manual weeding twice at 25-30 and 45-50 days after sowing (DAS), manual weeding thrice at 25-30, 45-50 and 60 DAS, mechanical

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weeding at 23-25 and 50 DAS, manual weeding at 25-30 DAS followed by (*fb*) mechanical weeding at 50 DAS, mechanical weeding at 23-25 DAS *fb* manual weeding at 45-50 DAS and weed free. Rice was grown as direct-seeded rice under rainfed upland aerobic conditions by sowing manually in 3rd and 4th July using 20 cm row spacing with seed rate of 60 kg/ha. The nutrients were applied using poultry manure equivalent to 120 kg nitrogen/ha and 1.5 t/ha lime was applied. Both poultry manure and lime were applied and soil incorporated before the sowing of rice. The crop was grown as rainfed crop and irrigation was not applied. In weed free plots, weeding was done 4 times and for manual weeding, treatment weeds were removed by hand and also using *khurpi* as per the treatment details. For mechanical weeding, manual operated rake was used. The standard recommended practices were followed for recording of rice growth attributes and yield data. To measure rice total biomass yield and grain yield, net plots were harvested and sun-dried in the field and then weighed. Rice grain yield was measured after cleaning and drying. For measurement of weed density and biomass, 25 × 25 cm quadrat was used and samples at three spots were taken for recording all the observations. The data recorded was statistically analyzed using F-test as per the standard statistical procedure (Gomez and Gomez 1984) and least significant difference (LSD) were used for determination of treatment significance. For analysis of weed density and biomass data, logarithmic transformation was used.

Effect on weeds

The predominent weed species in experiment field were: *Chromolaena odorata* (L.) R.M.King & H.Rob., *Elephantopus scaber* L., *Galinsoga parviflora* Cav., *Heliotropium indicum* L., *Lophatherum gracile* Brongn. (L. gracile), *Mimosa pudica* L., *Spilanthes acmella* Murr., *Sida acuta* Burm.f., *Spilanthes acmella* Murr. and *Panicum repens* L. The weed density was higher at 30 DAS in both varieties and decreased at 60 DAS. Significant and negative relation was observed between the dry matter production of rice varieties *Bhalum-1* and in *Sahbhagi Dhan* and weed biomass at 60 DAS (**Table 1**). The weed density at both observations was higher in *Sahbhagi Dhan*; while weed biomass at 30 DAS was higher in *Sahbhagi Dhan* and at 70 DAS it was higher in *Bhavum-1* rice. The variation in weed biomass at 30 DAS was mainly due to the occurred weed density; while at 70 DAS, it was mainly due to applied treatment. The highest weed density and biomass was recorded in weedy check at both 30 and 70 DAS.

Effect on rice growth and yield attributes

The greater height of *Bhalum-1* was observed at 30, 60, 90 DAS and at harvest. Among weed management treatments, weed free and manual weeding twice recorded greater rice height (**Table 2**). The highest tillers/m^2 was observed in weed free. The variation in crop growth in response to weed management treatment was reported by Deka and Barua (2015). The manual and mechanical weeding didn't show any significant difference indicating the intra row weed competition was not influencing the growth attributes of both rice varieties. The highest increase in shoot dry matter accumulation from 30 to 90 DAS was recorded in *Bhalum-1*. The manual weeding twice and mechanical weeding twice recorded higher rice dry matter accumulation than weedy check at 90 DAS.

Table 1. Weed density and biomass at 30 and 70 days after seeding (DAS) as influenced by two rice varieties and non-chemical weed management treatments

Treatment	Weed density (no./m^2)		Weed biomass (g/m^2)	
	30 DAS	70 DAS	30 DAS	70 DAS
Rice variety				
Sahbhagi Dhan	1.51 (32.7)	1.27 (19.6)	0.61 (4.3)	1.43 (27.3)
Bhalum-1	1.44(27.9)	1.21 (17.1)	0.46 (3.2)	1.52 (33.3)
LSD (p=0.05)	0.01	0.14	0.07	0.08
Weed management				
Control (farmers' practice)	1.52(33.7)	1.42 (26.5)	0.77 (6.0)	1.58 (38.3)
Manual weeding twice at 25-30 DAS and 45-50 DAS	1.44(27.7)	1.10 (12.8)	0.64 (4.5)	1.43 (27.5)
Manual weeding thrice at 25-30 DAS,45-50 DAS and 60 DAS	1.50(31.8)	1.27 (19.0)	0.46 (3.2)	1.44 (28.0)
Mechanical weeding twice at 23-25 DAS and 45-50 DAS	1.50 (31.8)	1.21 (16.5)	0.44 (2.8)	1.50 (32.0)
Manual weeding at 25-30 DAS *fb* mechanical weeding at 45-50 DAS	1.45 (28.3)	1.31 (20.8)	0.47 (3.2)	1.48 (30.7)
Mechanical weeding at 23-25 DAS *fb* manual weeding 45-50 DAS	1.51 (32.8)	1.30 (20.3)	0.53 (3.5)	1.53 (33.7)
Weed free	1.41 (25.7)	1.08 (12.5)	0.45 (3.0)	1.34 (22.2)
LSD (p=0.05)	0.06	0.11	0.13	0.07

Note: The values in parentheses are the original values

The yield attributes recorded (filled, unfilled and total spikelet number) and yield (grain and straw) were higher in *Bhalum-1* across varieties indicating its superior performance (**Table 2**). *Bhalum-1* variety had higher total grains, filled and unfilled grains than *Sahbhagi Dhan* variety. The total and filled spikelet number didn't differ significantly amongst weed management treatments in *Bhalum-1*; while in *Sahbhagi Dhan*, they were significantly higher in weed free and mechanical weeding twice. The grain yield of both *Sahbhagi Dhan* and *Bhalum-1* was highest in weed free. The variation in response of rice varieties to weed competition was reported earlier (Mahajan *et al.* 2014). The yield of both rice varieties was sub-optimal due to possible reasons such as light textured soil with acidic soil reaction, washing of manure applied due to heavy rainfall, termite infestation and incidence of blast disease. The yield in weed free check was at par with yield obtained with mechanical weeding twice and can be considered as most viable / effective options for weed management in upland direct-seeded rice. Weeding three times was at par with hand weeding twice (both in manual and mechanical) in both rice varieties which was due to initial lesser weed occurrence and at the end of the weeding time. This indicates that, hand weeding twice was adequate for effective weed management. The manual and mechanical weeding didn't differ significantly which was due to use of higher seed rate, lower weed population, use of hand hoes as mechanical weed management option and equitable distribution of weed between inter and

Table 2. Rice growth attributes, yield attributes and yield as affected by non-chemical weed management treatments in organic production system

Treatment	Rice plant height (cm)				Rice tillers/m^2 (no.)		Rice yield attributes and yield				
	30 DAS	60 DAS	90 DAS	At harvest	60 DAS	At harvest	Filled spikelets (no.)	Unfilled spikelets (no.)	Total spikelets (no.)	Grain yield (t/ha)	Straw yield t/ha
Rice variety											
Sahbhagi Dhan	40.1	56.9	78.8	87.5	540.1	273.8	50.6	16.4	67.0	0.89	1.91
Bhalum-1	42.1	61.8	91.1	96.1	524.7	268.1	60.3	18.8	79.1	1.26	2.98
LSD (p=0.05)	0.6	1.4	1.2	3.5	8.8	8.7	3.7	2.2	2.8	0.054	0.07
Weed management											
Control (farmers' practice)	39.7	55.5	81.0	86.3	534.5	260.3	38.3	19.8	58.2	0.72	1.76
Manual weeding twice at 25-30 DAS and 45-50 DAS	41.7	60.4	86.6	93.6	529.0	277.5	56.7	16.8	73.5	1.14	2.57
Manual weeding thrice at 25-30 DAS,45-50 DAS and 60 DAS	41.9	58.1	84.0	91.6	529.3	267.3	58.0	18.7	76.7	1.13	2.52
Mechanical weeding twice at 23-25 DAS and 45-50 DAS	41.7	60.8	86.5	93.4	532.2	275.3	59.8	16.5	76.3	1.16	2.60
Manual weeding at 25-30 DAS *fb* mechanical weeding at 45-50 DAS	40.5	58.3	83.6	91.6	534.8	269.3	58.7	17.0	75.7	1.12	2.51
Mechanical weeding at 23-25 DAS *fb* manual weeding 45-50 DAS	40.8	60.1	85.5	92.7	529.8	262.3	56.7	18.3	75.0	1.11	2.51
Weed free	41.9	62.1	87.5	93.6	537.2	284.7	60.0	16.2	76.2	1.18	2.64
LSD (p=0.05)	1.7	2.3	3.9	3.4	11.0	10.9	2.5	1.6	2.7	0.05	0.06

Table 3. Effects of different non-chemical weed management treatments on economics of rice cultivation in rice varieties

Treatment	Gross returns (x10^3 `/ha)	Cost of cultivation (x10^3 `/ha)	Net returns (x10^3 `/ha)	B:C ratio
Rice variety				
Sahbhagi Dhan	41.55	32.03	9.52	1.30
Bhalum-1	59.49	32.03	27.46	1.86
LSD (p=0.05)	2.22	-	2.22	0.07
Weed management				
Control (farmer practice)	33.97	25.70	8.27	1.32
Manual weeding twice at 25-30 DAS and 45-50 DAS	53.18	31.70	21.48	1.68
Manual weeding thrice at 25-30 DAS, 45-50 DAS and 60 DAS	52.86	35.70	17.16	1.48
Mechanical weeding twice at 23-25 DAS and 45-50 DAS	54.10	29.87	24.23	1.81
Manual weeding at 25-30 DAS *fb* mechanical weeding at 45-50 DAS	52.39	31.12	21.28	1.68
Mechanical weeding at 23-25 DAS *fb* manual weeding 45-50 DAS	51.98	31.12	20.86	1.67
Weed free	55.15	39.03	16.12	1.41
LSD (p=0.05)	1.85	-	1.85	0.06

intra-row. Hence, mechanical weeding was found economical than manual weeding due to greater labour, time and cost required for manual weeding. The need for mechanical weeding in the organic production systems was also stressed by Weide *et al.* (2008).

The highest gross returns were observed in weed free plot and remained at par with mechanical weeding twice (23-25 DAS and 45-50 DAS) (**Table 3**), However, the net return was highest with mechanical weeding twice (23-25 DAS and 45-50 DAS). The net returns were lowest in weed free plot amongst all treatments (except control) due to higher number of weeding that increased cultivation cost and non-proportionate yield improvement. This trend in higher net returns was reflected in B:C ratio with higher B:C ratio of 1.81 with mechanical weeding twice. The B:C ratio in weed free and manual weeding thrice (25-30 DAS, 45-50 DAS and 60 DAS) was lowest among the tested weed management treatments (except control). Across the varieties, *Bhalum-1* found superior in gross and net returns due to higher yield. In the context of the rice farmers of North East Hill region, mechanical weeding is relevant as minor light weight and small weeder can be very good alternatives to reduce drudgery associated with manual hand weeding and attain optimal economic upland rice yield in the organic farming adopting region under upland situation.

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