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RESEARCH NOTE

Comparing manual and mechanical weed management techniques for upland organic rice in acidic soil of Meghalaya: A on-farm study

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ABSTRACT

The on-farm trial was conducted at Kyrdemkulai village in Ri-Bhoi district of Meghalaya during *Kharif* (rainy) season of 2021. The objective of experiment was to compare the effectiveness of manual and mechanical methods of weed management in upland organic rice (*ArizeTej Gold*). Treatment includes, two-time manual weeding (25-30 days after sowing (DAS) and 45-50 DAS), three times manual weeding (25-30 DAS, 45-50 DAS and 60 DAS), two-time mechanical weeding with the help of manual operated star wheel weeder (23-25 DAS and 45-50 DAS), manual (25-30 DAS) followed by mechanical weeding (45-50 DAS), mechanical (23-25 DAS) followed by manual weeding (45-50 DAS) and two check, *viz.* weedy check and weed free check. These seven treatments were replicated thrice. Result showed that, three times manual weeding and weed free treatment recorded significantly higher grain yield (5–69%) and net returns (27270 ₹/ha and 27200 ₹/ha, respectively as well as lower weed population by 22-80 no./m^2 and 140-220 no./m^2, respectively over other treatments. The highest B: C ratio was recorded in mechanical weeding at 23-25 DAS followed by manual weeding at 45-50 DAS (1.50) and three-time manual weeding (1.48). It was concluded that three-time manual weeding will be best due to significantly higher yield (1.74 t/ha); while mechanical weeding *fb* manual weeding will be considered economic with B:C ratio of 1.50.

Keywords: *ArizeTej Gold*, *Heliotropium indicum*, Manual weeding, Mechanilcal weeding, Organic rice, Weed intensity

In Meghalaya, rice is staple food crop occupy first position with 13.6% area under occupation out of total agricultural land. Rice straw also contributes as a base material for mushroom production, fodder for cattle and also used in several small-scale cottage industries; hence is considered as a staple crop of peasant farmers in Meghalaya. The rice cultivation in state is known for organic production practices, acidic soil with high organic matter, increasing seed replacement ratio, promotion of traditional rice varieties and use of indigenous technical knowledge and its amalgamation with new technical knowledge (Kumar *et al.* 2016, Das *et al.* 2022). The major production constraints in organic upland rice in Meghalaya includes, soil acidity, termite infestation, blast infection, washing of manures due to runoff and soil relief and problem of weeds leading to low crop productivity (Munda *et al.* 2019). The rice production systems in Meghalaya are organic and are grown in both upland and lowland situation. The lowlands have puddling and standing water which have control over weed population; while upland organic rice production system have manual weeding as a single option for weed management. Besides that, the higher menace of weeds in upland rice (Saha *et al.* 2021, Chaudhary *et al.* (2022) and organic rice production system is reported in Gnanasoundari and Somasundaram (2014). The use of herbicides for weed control was not allowed in organic production system and hence weed management is a more time and energy taking in organic production system in absence of puddling and standing water in rice field. The weed management information in organic rice production system is restricted to cultural practices, brown manuring and manual and mechanical weeding; while they have varied adaptation due to cost and energy involved and their varied effectiveness. The biological methods have restriction of selective weed control of one or few species while composite weed flora cannot be addressed by biological methods. Hence, manual weeding or suitable substitute for manual weeding through mechanical weeding (to reduce drudgery) is considered as most important and potential option for weed management in organic production system. The substitution of manual weeding with mechanical tools is considered as an important intervention in both upland rice and organic production system (Saravanane 2020, Mohanty and Bhuyan 2020). Therefore, their economic and practical suitability in upland rice with organic production system need to

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be evaluated in on-farm condition. Besides the organic production system, introduction of new crop varieties also needs to be evaluated due to their varied response to weed management practices. Therefore, the study was conducted with hypothesis that mechanical weeding will reduce the cost involved over manual weeding and combination of both manual and mechanical weeding will be more economics than manual weeding besides knowing the impact of combinations and frequency of mechanical and manual weeding on productivity of organic rice variety (*ArizeTej Gold*).

The field trail was conducted at farmer's field at Kyrdemkulai village (25^0 751' N, 91^0 832' E) in Ri-Bhoi district of Meghalaya in *Kharif* (rainy) season of 2021. The climate of selected area is subtropical with average seasonal (June to September) and annual rainfall of 1424.1 mm and 2119.3 mm, respectively. The seasonal rainfall (28 May to 30 September) of 1328.9 mm received in 73 rainy days and highest and lowest relative humidity of 92.5% (27^{th} meteorological week) and 74.6% (35^{th} meteorological week) were recorded during year of experiment. The highest temperature of 34.4 ^{0}C and 33.4 ^{0}C was recorded in 41^{st} and 31^{st} meteorological week.

The experiment was conducted under organic production system and planned in randomized block design involving seven treatments. The treatments consisting of combination of time and frequency of manual and mechanical weeding and two controls (weedy check and weed free check) and all treatments were replicated thrice **(Table 1)**. The field was prepared by giving two passes of power tiller followed by preparation of field for sowing of crop by stubble collection (plots size- 5×3 m). Rice variety (hybrid) *ArizeTej Gold* was grown as direct seeded in upland condition on 2^{nd} July, 2021 with seed rate of 60 kg/ha and spacing of 20 cm row spacing followed by gap filling at 7 days after sowing (DAS). The crop was manured with poultry manure 120 kg/ha out of which 80 kg/ha was applied before sowing and remaining 40 kg/ha was applied in two equal split (after first and second weeding). The crop was grown as rainfed crop. In weed free plots, hand weeding was done 4 times (12-15 DAS, 25-30 DAS, 45-50 DAS and 60 DAS) and for manual weeding treatments weeds were removed by hand and also using 'khurpi'(hand operated small spade) as per the treatment details. For mechanical weeding, manual operated star wheel weeder was used.

For measurement of plant height five plants were randomly selected from each plot and for tiller measurement, tillers from one meter row length at three places from each plot were measured. For measurement of above ground shoot dry matter air dried plant samples were further dried in a hot air oven at 60±5 ^{0}C temperature till constant weight was obtained and expressed in g/m^2. Yield attributes (filled and unfilled spikelets) were measured from a sample of 10 panicles drawn at random from each plot at harvesting. The net plot (4 × 3 = 12 m^2) was harvested and sun dried for seven days followed by weighing the biological yield. Threshing was done manually and weighing of grain was done at 14% moisture content. Straw yield was measured by subtracting grain yield from biological yield. The fertility index was calculated by dividing filled spikelets with total spikelets and multiplied with 100. For measurement of weed count and weed dry matter accumulation, 30 × 30 cm quadrant was used and samples at three spots were taken at all observation. Weed dry matter accumulation and weed density data is transformed using square root transformation. The statistical significance among applied treatments were studied using the F-test and least significant difference (LSD) values (p=0.05).

Effect on weed density and dry matter accumulation

The weed density was highest at 30 DAS (381 – 409 no./m^2), decreased by 9.5 – 60.6 % and 33.6 – 68. % at 60 DAS and at harvest, respectively over 30 DAS (**Table 1**). The decrease in weed population in weed free check were 52.0% and 48.3% over two time weeding and three weeding, respectively at 60 DAS. The significant variation in weed free check and three-time manual weeding indicates that, the weed flushes are observed even after third weeding (60 DAS) and this leads to extension of period crop weed competition in directed-seeded rice. This also indicates the abundance of weed seed bank. The longer duration of crop weed competition in upland direct-seeded rice than transplanted rice was reported by Chaudhary *et al.* (2022); while role of weed seed bank in affecting the weed population was reported by Sharma *et al.* (2020). The major weed species were *Heliotropium indicum* (L.), *Chromolaena odorata* (L. R.M. king & H. Rob.), *Elephantopus scaber, Mimosa pudica* (L.), *Galinsoga Parviflora, Panicum repens, Cyperus iria* (L.), *Cyperus rotundus* (L.), *Fimbristylis aestivalis, Dactyloctenium aegyptium* (L.) Willd, *Paspalum conjugatum, Marsilea quadrifolia* (L) Linn., *Oxalis corniculata* (L.) and *Commelina diffusa* (L.). The weed dry matter accumulation at 60 DAS showed significant response to applied treatment with superiority of manual weeding over mechanical weeding in

controlling weeds; while in case of combination, mechanical weeding followed by manual weeding was more promising than reverse trend. The major reason for variation in weed population was locations of field around the wild vegetation, no history of chemical measure control measure, variation in the relief as the field is not completely levelled and field was vacant during summer season occupied with wild vegetation. This resulted in higher weed population as well as variation in population density.

Effect on rice growth attributes

Both sequence and methods of weeding found to differ significantly for their effects on growth attributes of rice (**Table 1**). Manual weeding (three times) and weed free check remained at par with each other and had significantly higher tiller/m^2 than other treatments; while in case of sequence, mechanical weeding *fb* manual weeding was found significantly superior over manual *fb* mechanical weeding indicating higher weed population at 45–50 DAS (314.0 versus 351.3 no./m^2) and need of both inter and intra row weeding possible with manual weeding. The dry matter accumulation at 60 DAS was highest in manual weeding three times (209.0 g/m^2). The growth variations across weed management treatments arose due to higher weed dry matter accumulation and weed density (**Table 1**). The variation in plant growth due to mechanical weeding was also reported by Veeraputhiran *et al.* (2014).

Effect on yield attributes, yield and economics

All yield attributes were differed significantly among the treatments and two treatments, *viz.* three times manual weeding and weed free check had significantly higher values for all yield attributes studied (**Table 2**). The grain and straw yield in weedy check was lower than weed free check by 69.5 % and 61.9%, respectively indicating the volume of losses caused by weeds. Such variation in yield attributes and yield was also reported by Aske *et al.* (2018) in organic rice production system; while variation in rice yield due to different weed management practices in organic rice was reported by Gnanasoundari and Somasundaram (2014) and Rathod and Somasundaram (2019) in transplanted rice. The highest grain yield of 1.84 t/ha was recorded in weed free check which was at par with manual weeding three times (25-30, 45-50 and 60 DAS) (1.74 t/ha). The manual weeding two times (25-30 and 45-50 DAS) remaineded at par with combination of mechanical weeding (23-25 DAS) followed by manual weeding at 45-50 DAS, indicating the place of mechanization in upland rice. In term of economics, weed free check (90.28 × 10^3 ₹/ha and 27.65 × 10^3 ₹/ha) and manual weeding three times (85.46 × 10^3 ₹/ha and 27,72 × 10^3./ha) recorded highest gross and net returns; while mechanical weeding at 23-25 DAS *fb* manual weeding 45-50 DAS and manual weeding two times are other treatment found promising in economic

Table 1. Effect of mechanical and manual weeding on the weed and plant growth attributes in direct seeded upland rice

Treatment	Weed attribute					Plant attribute						
	Weed dry matter accumulation (g/m^2)		Weed density (no./m^2)			Plant height (cm)		Tiller/m^2			Dry matter accumulation (g/m^2)	
	30 DAS	60 DAS	30 DAS	60 DAS	At Harvest	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS
Manual weeding at 25-30 DAS and 45-50 DAS	17.09 (292.0)	14.72 (216.7)	19.48 (379.3)	18.29 (313.3)	12.31 (151.7)	76.0	89.6	336.3	378.7	348.0	94.00	193.0
Manual weeding at 25-30 DAS, 45-50 DAS and 60 DAS	17.12 (296.7)	13.95 (194.7)	19.55 (382.3)	17.05 (290.7)	11.59 (134.3)	80.0	95.7	343.3	395.0	364.7	95.33	209.0
Mechanical weeding at 23-25 DAS and 45-50 DAS	16.91 (283.3)	15.28 (233.3)	19.87 (394.7)	18.63 (347.3)	14.35 (206.0)	71.0	72.7	334.0	351.0	332.7	96.60	180.8
Manual weeding at 25-30 DAS *fb* Mechanical weeding at 45-50 DAS	16.79 (282.0)	15.13 (229.0)	19.87 (395.0)	18.74 (351.3)	14.18 (201.0)	71.0	74.7	334.0	356.0	334.3	98.27	181.6
Mechanical weeding at 23-25 DAS *fb* manual weeding 45-50 DAS	16.86 (284.3)	14.73 (217.0)	19.58 (383.3)	18.72 (314.0)	12.50 (156.3)	75.0	87.3	338.0	377.7	347.0	99.13	196.3
Weed free	16.87 (284.7)	13.11 (172.0)	19.53 (381.3)	12.26 (150.3)	10.98 (121.7)	81.0	96.7	339.0	398.7	368.3	94.00	206.0
Control	17.40 (302.7)	16.82 (283.0)	20.23 (409.7)	19.25 (370.7)	16.49 (272.0)	62.7	75.00	338.0	333.0	308.0	97.37	102.6
LSD (p=0.05)	0.33	0.53	NS	0.88	1.04	3.51	3.81	10.0	9.41	8.78	4.10	4.98

DAS: days after sowing; Square root transformation was used for weed dry matter accumulation and weed density; The original values were mention in parentheses; *fb*: followed by

Table 2. Effect of mechanical and manual weeding on the yield attributes, yield and economics of rice in direct seeded upland condition

Treatment	Length of panicle (cm)	Weight of panicle (g)	Filled spikelets (no./ panicle)	Unfilled spikelets (no./ panicle)	Total spikelets (no.)	1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index	Gross returns (× 10^3 `/ha)	Cost of cultivation (× 10^3 `/ha)	Net returns (× 10^3 `/ha)	B: C
Manual weeding at 25-30 DAS and 45-50 DAS	20.0	2.22	95.3	25.3	120.7	21.8	139	4.02	5.41	25.7	67.63	47.93	19.69	1.41
Manual weeding at 25-30 DAS, 45-50 DAS and 60 DAS	21.4	2.45	106.0	20.0	126.0	22.3	174	5.23	6.98	25.0	85.46	57.73	27.72	1.48
Mechanical weeding at 23-25 DAS and 45-50DAS	18.2	2.06	86.0	25.3	111.3	22.1	102	2.78	3.80	27.0	49.33	38.13	11.19	1.29
Manual weeding at 25-30 DAS *fb* mechanical weeding at 45-50 DAS	18.5	2.13	85.0	26.3	111.3	21.9	106	2.82	3.88	27.4	50.90	43.03	7.87	1.18
Mechanical weeding at 23-25 DAS fb manual weeding 45-50 DAS	19.9	2.15	97.7	23.3	121.0	22.1	133	3.77	5.10	26.1	64.42	43.03	21.39	1.50
Weed Free	21.3	2.45	107.7	17.7	125.3	22.3	184	5.57	7.41	24.8	90.28	62.63	27.65	1.44
Control	16.3	1.08	34.0	44.7	78.7	21.3	0.56	0.22	1.79	21.0	28.78	28.33	0.45	1.02
LSD (p=0.05)	1.31	0.10	7.44	5.16	5.16	0.73	0.18	0.67	0.78	0.78	9.26	-	9.26	0.24

(DAS: days after sowing)

terms (**Table 2**). The manual weeding was costly considering its cost of cultivation (62.63 × 10^3 /ha); while it was expected to have potential for marginal land holdings. Our on-farm evaluation of weed management in organic production system concluded that, combination of mechanical weeding (23-25 DAS) and manual weeding (45-50 DAS) is potential option to reduce cost involved in two- or three-time manual weeding.

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