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Effect of weed management on crop growth and yield of rice in organically grown transplanted aromatic rice-tomato cropping system

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Abstract
A field experiment was conducted at Instructional cum Research Farm, Indira Gandhi KrishiVishwavidyalaya, Raipur (C.G.) during *kharif* season 2022 and 2023. The soil of experimental field was neutral in reaction, medium in organic carbon and low in available nitrogen, low in available phosphorus and high in available potassium. Experiment was laid out in randomized block design with three replications, consisted of T_1- hand weeding (HW) twice at 20 and 40DAT, T_2- motorized weeder twice (single row type) at 20 and 40 DAT, T_3- motorized weedertwice (single row type) at 20 and 40 DAT+ one intra row HW at 20 DAT, T_4- mechanical weeding through Ambika paddy weeder at 20 and 40 DAT, T_5- mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT, T_6- green leaf manuring (incorporation at puddling) + one HW at 20 DAT, T_7-10 days delayed planting with incorporation of emerged weeds, T_8- dense planting (closer spacing of 15 × 10 cm) and T_9- Weedy check. The weeds ofthe experimental site were dominated with grasses like *Echinochloacolona*, *Cyanotis axillaris*, broad leaves like *Alternanthera sessilis*, *Celosia argentea*, sedge like *Cyperus sps.* and otherweeds. Results revealed that all growth parameters and yield was highest in Hand weeding (HW)twice at 20 and 40 DAT which was at par with Motorized weeder twice (single row type) at 20and 40 DAT+ one intra row HW at 20 DAT. Similarly, total weed density and biomass at 90 DAT was also significantly reduced in these treatments to others. However, higher WCE (Weed control efficiency) at 90 DAT was noticed in this treatment than weedy check. Highest net return recorded under hand weeding (HW) twice at 20 and 40 DAT and B:C ratio recorded in Motorized weeder twice (single rowtype) at 20 and 40 DAT+ one intra row HW at 20 DAT. However, lowest net return and B:Cratio was noticed in this treatment than weedy check.

Keywords: Rice, weed, organic

Introduction
The demand for organic rice is increasing due to the growing interest in residue-free food and organic production. Over half of the world's population depends on rice (*Oryza sativa* L.), which grows on 162.06 million hectares of land and produced 496.40 million tonnes in 2019-20 (FAOSTAT, 2021). The crop provides over 60% of daily energy needs, 3.5 billion man-days of employment, and 10% of agricultural GDP. Chhattisgarh, known as the “Rice Bowl of India,” is a major producer (Mooventhan *et al*., 2015) [6]. However, continuous herbicide use on the same land leads to weed shifts and ecological imbalances, raising environmental concerns (Rathod, 2017) [10]. Growth parameters are key indicators used to assess the vegetative development, physiological efficiency, and overall performance of the rice crop under different environmental and management conditions.

Growth parameters of rice include plant height, number of tillers per plant, leaf area index, dry matter accumulation, crop growth rate (CGR). These parameters reflect the crop’s ability to intercept light, utilize nutrients and water efficiently, and convert photosynthates into biomass. Monitoring these growth attributes at different growth stages helps in understanding the response of rice to agronomic practices such as nutrient management, irrigation, planting methods, and weed control.

Aromatic rice is grown organically by farmers, although they have difficulties, especially with weed management, which is a significant obstacle to organic farming. If weeds are not managed

within 45 days of transplanting, they can cut rice-tomato yields by 20-80%; losses of 35-55% have been documented with transplanted rice. Since organic farming forbids the use of chemical herbicides, non-chemical weed control techniques continue to be the most practical way to maintain output and ecological balance.

Materials and Methods

The study was carried out at Instructional cum Research Farm, Indira Gandhi KrishiVishwavidyalaya, Raipur (C.G.) during kharif crop 2022 and 2023. The soil of experimental field was Vertisols. Experiment was conducted in randomized block design with three replications, consisted of T_1- hand weeding (HW) twice at 20 and 40 DAT, T_2- motorizedweeder twice (single row type) at 20 and 40 DAT, T_3- motorized weeder twice (single row type)at 20 and 40 DAT+ one intra row HW at 20 DAT, T_4- mechanical weeding through Ambika paddy weeder at 20 and 40 DAT, T_5- mechanical weeding through Ambika paddy weeder + oneintra row HW at 20 DAT, T_6- green leaf manuring (incorporation at puddling) + one HW at 20DAT, T_7-10 days delayed planting with incorporation of emerged weeds, T_8- dense planting(closer spacing of 15 × 10 cm) and T_9- Weedy check. The rice variety "CG Devbhog" was transplanted on 2 nd august 2022 and 27 th July 2023. The cropping system was Rice-tomato and all nutrients were supplied through farm yard manure and vermicompost. All the recommended agronomic practices were adopted to raise the crop.

Plant height (cm): Height of the five randomly tagged plants were measured at 30, 60, 90 DAT and at harvest from ground surface to the tip of the top most leaf until the panicle emerged. Thereafter, the height of plant was recorded from ground level to the tip of the longest panicle. Afterward, the average height was worked out by taking mean.

Crop dry matter accumulation (g plant^{-1}): Dry matter of the five randomly tagged plants were taken at 30, 60, 90 DAT and at harvest. After removing the samples were washed thoroughly with flowing water, then sundried followed by drying in oven at 65^0 C for 24 to 48 hours till the constant weight was obtained. The samples were weighed on an electronic balance and then averaged to get plant dry matter accumulation plant^{-1}.

Number of tillers (m^{-2}): Tiller number of rice crop were counted from randomly selected one meter row length from fives randomly selected places of transplanted rice at 30, 60, 90 DAT and at harvest stages of crop. The mean values were converted to number of tillers m^{-2}.

Leaf area (cm^{2}hill^{-1}): The leaf area of rice plant was measured under the leaf area meter from samples taken for dry matter accumulation and the mean value converted to leaf area plant^{-1} and multiply to factor 0.75.

Grain and straw yield (t ha^{-1}): After proper sun-drying, the produce of the net plot was tied in bundles and weighed to determine the dry matter produce (grain + straw). The clean seeds obtained after threshing and winnowing from each net plot was weighed. The straw yield was obtained by subtracting weight of the seed yield from the total weight of the bundle and converted to t ha^{-1}.

Total Weed density (no. m^{-2}): Total and species wise weeds associated with crop in the experimental plots were recorded at 90 DAT. Weed count was made randomly from three spots by quadrate of 0.5 m x 0.5 m (0.25 m^2) in each plot. The number of weeds was counted and the data were converted and computed per m^{-2} for statistical analysis. Weed density was subjected to square root transformation *i.e.*,$\sqrt{x+0.5}$

Total Weed biomass (g m^{-2}): Species wise dry weight and dry weight of total weeds was recorded at 30, 60, 90 DAT and at harvest. Weeds present in quadrate of 0.5×0.5m (0.25m^2) were uprooted carefully along with roots. The root portion was cleaned thoroughly so that the attached soil would be detached. Then the weeds were oven dried at 60ºC for 36 to 48 hours. After complete oven drying, the weight was recorded on electronic balance and converted into g m^{-2}. Dry weight of weeds was subjected to square root of transformation i.e.$\sqrt{x+0.5}$

Crop growth rate (CGR) (g m^{-2} day^{-1}): It denotes the overall growth rate of the crop per unit time, irrespective of the previous growth rate. The value was calculated by using the following formula (Leopold and Kridemann, 1975) [4]. The crop growth rate was calculated at 0-30, 30-60, 60-90 DAT and 90 DAT - at harvest.

$$\text{Crop growth rate (CGR)}(\text{g m}^{-2}\text{day}^{-1}) = \frac{W_2 - W_1}{(t_2 - t_1)}$$

Where, W_2 - W_1 = difference in oven dry biomass at the time intervals of T_2-T_1.
T_2 - T_1 = time interval in days.

Weed control efficiency (%): Weed control efficiency (WCE) was calculated taking into consideration the reduction in weed dry weight in treated plot over the weed dry weight in untreated weedy check and expressed in percent.

$$\text{WCE (\%)} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

Where, WCE = Weed control efficiency (%)
DWC = Dry weight of weeds in untreated plot (g)
DWT = Dry weight of weeds in treated plot (g)

Benefit: cost ratio: This index provides an estimate of the benefit derived from the expenditure incurred in adopting a particular cultivation practice. It is calculated by the following formula.

$$\text{Benefit :Cost ratio} = \frac{\text{Net return } (₹\ \text{ha}^{-1})}{\text{Cost of cultivation } (₹\ \text{ha}^{-1})}$$

Results and Discussion

Plant height: Observations on plantheight were recorded at 30 days interval from 30 to 90 DAT and at harvest, althoughthe increase rate was increasing upto 90 DAT and thereafter it became increasing atdecreasing rate. The data presented in Table 1 shows that the plant height at 30 DAT was found statistically non-significant. But numerically maximum and minimumheight recorded under the hand weeding at 20 and 40 DAT and weedy check plotduring both the years and mean data.Among the weed management practices, hand weeding at 20 and 40 DAT,produced significantly taller plants at all the observations from 60 DAT to at harvest during both the years, however it was

statistically at par with motorized weeder twice (single row type) at 20and 40 DAT + one intra row hand weeding (HW) at 20 DAT at all the observational stage during both the years. The shortest plant height was observed in weedy check plot during both the year as well as mean data at all the observational stages. Similar results were reported by Kumar *et al*, (2017) [3].

Dry matter accumulation (g m^{-2})- Data on dry matter accumulation of rice was recorded at 30, 60, 90 DAT and at harvest are presented in Table 2. shows that the plant dry matter accumulation at 30DAT was found non-significant. Whereas at 60, 90 DAT and at harvest, the dry matter accumulation differed significantly due to weed management practices. Organically grown transplanted aromatic rice crop when imposed to hand weeding (HW) twice at 20 and 40 DAT, showed significantly higher dry matter accumulation over all the weed management practices but it was statistically at par with motorized weeder twice (single row type) at 20 and 40 DAT +one intra row HW at 20 DAT at all the observational stage during both the years as well as in mean data. However, the lowest dry matter accumulations were noticed with weedy check plot during both the years at all the observational stages. Similar findings of Kiran *et al*, (2010) [1], Rao *et al*, (2015) [9].

Number of tillers (no. m^{-2}): The data on number of tillers of rice was recorded at 30, 60 DAT and at 90DAT (maturity) in Table 3 shows that the number of tillers at 30 DAT was found non-significant. Whereas at 60 and 90 DAT, the number of tillers differed significantly due to weed management practices. Organically grown transplanted aromatic rice crop when imposed to hand weeding (HW) twice at 20 and 40 DAT, showed significantly maximum number of tillers no. m $^{-2}$, as compared to other weed management practices during both the years, however it was statistically at par with motorized weeder twice (single row type) at 20 and 40 DAT + one intra row hand weeding (HW) at 20 DAT at all the observational stages and both of them were significantly superior over all the weed management practices adopted for transplanted aromatic rice. The weedy check recorded the minimum value of numbers of tillers during both the year at all the observational stages.

Leaf area (cm^2 hill^{-1}): Leaf area at 30, 60, 90 DAT and harvest are presented in Table 4. At 30 DAT, leaf area was found to be non-significantly. At 60, 90 DAT and at harvest, in organically grown transplanted aromatic rice crop when imposed to hand weeding (HW) twice at 20 and 40 DAT, showed significantly maximum leaf area over all the weed management practices but it was statistically at par with motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HWat 20 DAT during both the years as well as in mean data. However, the minimum leaf area was noticed with weedy check during both the years as well as mean data at 60and 90 DAT.

Grain yield and straw (t ha $^{-1}$): Grain yield and straw yield are presented in Table 5. Among weed management practices the highest grain yield of rice was recorded under hand weeding(HW) twice at 20 and 40 DAT which was statistically at par with the motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT during both the years and also in mean data. The weedy check exhibited significantly lower grain yield of rice during both the years. The present findings are in accordance with (Rao *et al*, 2015) [9] who observed that increased yield in these treatments might be due to cumulative effect of lower weed density, weed biomass, higher weed control efficiency and increased number of panicle bearing tillers per unit area, filled grains per panicle.

Crop growth rate (g m^{-2} day $^{-1}$): Crop growth rate (CGR) was computed between at 0-30, 30-60, 60-90 DAT and at 90 DAT-at harvest in organically grown transplanted aromatic rice. In general, CGR was increased with the advancement of crop age upto 60 DAT and it was decreased thereafter. Among weed management treatments, hand weeding (HW) twice at 20 and 40 DAT was proved to be best in increasing crop growth rate at 0-30, 30-60, 60-90 DAT and 90 DAT-at harvest during both the years and on mean data basis followed by treatment comprised with motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT at all the observational stage during both the years as well as in mean data. However, the lowest crop growth rate was seen in weedy check plot during 2022, 2023 and mean data. This is in accordance with the findings of Meher *et al*, (2018) [5].

Total weed density (no. m $^{-2}$)

The data presented in Table 6. Revealed that the total weed density was significantly influenced by the different weed management practices during both the years at observation periods (i.e. 90 DAT). Among different weed management practices, At 90 DAT the total weed density significantly lower was recorded under hand weeding (HW) twice at 20 and 40 DAT which was statistically at par with motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT. With regards to weed management practices, at all the observational stages maximum density of other weed species was found under weedy check plot which was significantly higher over rest of the weed management practices during both the years. Itis further revealed that maximum reduction in total weed density m $^{-2}$ was recorded in mechanical hand hoeing over control (weedy check). Rao *et al*. (2013) [8] and Tiwari *et al*. (2018) [13], who emphasized that manual weeding ensures precise and complete weed removal, especially in transplanted rice, whereas mechanical and cultural measures are only partially effective.

Total weed biomass (g m^{-2}): The data presented in Table 7. Among weed management practices, at 30 DAT significantly lower total weed biomass was recorded underhand weeding (HW) twice at 20 and 40 DAT which was statistically at par with green leaf manuring (incorporation at puddling) + one HW at 20 DAT. At 90 DAT significantly lower biomass of total weed was recorded under hand weeding (HW) twice at 20 and 40 DAT which was statistically at par with motorized weeder twice (single row type) at 20 and 40 DAT+ one intra row HW at 20 DAT during both the years, whereas highest other weed biomass was observed under weedy check at all observation periods during both the years and in mean data. Similar conclusions were also drawn by Yaduraju.

Weed control efficiency (%): WCE gradually increased up to 90 DAT and started declining after that towards harvest in both the years in all treatments. Among weed management practices, at all the observation periods and in both the years, maximum weed control efficiency was recorded in hand weeding at 20 and 40 DAT emphasizing the superior performance of manual weeding in suppressing weed biomass due to direct and effective removal. On the other hand, the lowest WCE was recorded indense planting (15×10 cm) and 10 day delayed planting with weed incorporation, particularly at later stages due to ineffective

weed suppression and increased competition for resources. The declining trend in WCE from early to later stages among all treatments also indicates weed resurgence and the need for continuous weed management. These findings are in agreement with studies by Yaduraju *et al*., Tiwari *et al*. (2013) [12], and Kumar *et al*. (2018) [2], who reported that integrated weed management techniques involving early-stage interventions and timely follow-ups significantly enhance weed control efficiency and improve crop competitiveness.

B:C ratio: In terms of profitability, the benefit-cost (B:C) ratio was found to be highest in motorized weeder twice + one intra-row HW, while the lowest was noted in weedy check. This indicates that although hand weeding twice recorded the highest gross and net returns, the combination of motorized weeder with partial manual weeding proved to be more economically viable and sustainable, as it reduced labor costs and provided the highest profitability. These findings are supported by Singh *et al*. (2016) [11] and Ramesh *et al*.(2020) [7], who also reported that integrated and mechanized weed management practices result in higher B:C ratios compared to sole manual or unchecked weedy conditions.

Table 1: Plant height of rice during different growth periods as influenced by weed management practices in organically grown transplanted aromatic rice-tomato cropping system

Plant height (cm)								
Treatment	**30DAT**		**60DAT**		**90DAT**		**At harvest**	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
Hand weeding (HW) twice at 20 and 40 DAT	35.5	40.0	67.4	74.0	79.5	81.6	83.0	89.0
Motorized weeder twice (single row type) at 20 and 40 DAT	33.1	35.8	63.9	69.0	75.7	78.8	79.0	85.7
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	33.8	36.1	66.8	73.4	79.2	81.0	81.0	88.6
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	33.3	35.9	64.0	69.4	76.0	79.0	79.6	86.0
Mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT	33.5	36.0	63.3	68.0	72.8	75.7	78.0	82.8
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	35.0	37.5	63.5	68.7	74.0	76.0	78.7	83.0
10 days delayed planting with incorporation of emerged weeds	33.0	33.8	63.0	67.0	72.0	75.0	76.0	81.0
Dense planting (closer spacing of 15x10 cm)	32.8	33.4	62.0	66.9	70.0	73.0	74.0	80.7
Weedy check	32.0	30.8	57.0	51.0	64.0	59.0	67.0	61.0
SEm±	1.37	1.98	0.22	0.24	0.09	0.41	0.74	0.28
CD (P=0.05)	NS	NS	0.66	0.72	0.27	1.23	2.22	0.84

Table 2: Plant dry matter of rice during different growth periods as influenced by weed management practices in organically grown transplanted aromatic rice-tomato cropping system

Treatment	**Dry matter accumulation (g hill^{-1})**							
	30DAT		**60DAT**		**90DAT**		**At harvest**	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
Hand weeding (HW) twice at 20 and 40 DAT	1.04	1.05	7.35	7.43	20.12	21.29	23.62	23.98
Motorized weeder twice (single row type) at 20 and 40 DAT	0.94	0.96	6.82	6.87	18.64	19.67	21.94	22.02
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	1.00	0.98	7.04	7.18	19.62	20.95	23.02	23.49
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	0.96	0.94	6.94	7.09	19.07	20.23	22.35	22.68
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	0.98	0.97	5.95	6.29	16.91	18.11	20.01	20.34
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	1.01	1.01	6.49	6.71	17.93	19.01	21.13	21.25
10 days delayed planting with incorporation of emerged weeds	0.91	0.93	5.61	5.78	16.28	17.27	19.28	19.41
Dense planting (closer spacing of 15x10 cm)	0.88	0.90	5.32	5.55	15.64	16.82	18.54	18.85
Weedy check	0.85	0.87	5.01	5.12	14.81	15.97	17.61	17.93
SEm±	0.12	0.14	0.12	0.10	0.33	0.12	0.31	0.25
CD (P=0.05)	NS	NS	0.36	0.29	0.99	0.37	0.92	0.75

Table 3: Number of tillers of rice during different growth periods as influenced by weed management practices in organically transplanted grown aromatic rice-tomato cropping system

Treatment	**Number of tillers (m^{-2})**					
	30DAT		**60DAT**		**90DAT**	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**
Hand weeding (HW) twice at 20 and 40 DAT	234.33	237.62	347.83	348.62	328.50	329.01
Motorized weeder twice (single row type) at 20 and 40 DAT	210.83	207.65	318.65	322.48	308.00	311.21
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	227.50	224.52	338.17	340.19	324.00	326.19
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	220.33	217.85	323.50	327.65	310.00	315.79
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	225.50	221.48	302.88	306.36	277.50	282.53
Green leaf manuring(incorporation at puddling) + one HW at 20 DAT	231.17	233.49	310.75	314.62	302.00	306.25
10 days delayed planting with incorporation of emerged weeds	199.96	188.60	290.72	291.24	271.67	273.09
Dense planting (closer spacing of 15x10 cm)	194.33	173.73	285.39	289.57	262.17	263.14
Weedy check	152.74	131.09	183.84	185.30	160.17	162.13
SEm±	1.46	1.79	4.11	4.86	3.56	2.94
CD (P=0.05)	NS	NS	12.33	14.58	10.68	8.82

Table 4: Leaf area of rice during different growth periods as influenced by weed management practices in organically grown transplanted aromatic rice-tomato cropping system

Treatment	Leaf area (cm^2 $hill^{-1}$)							
	30DAT		60DAT		90DAT		At harvest	
	2022	2023	2022	2023	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	294.3	300.4	724.9	728.7	819.2	829.2	537.39	541.24
Motorized weeder twice (single row type) at 20 and 40 DAT	273.2	280.1	700.1	702.5	801.0	809.6	512.57	514.99
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	282.2	289.2	720.8	724.1	815.3	823.7	533.30	536.57
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	276.4	280.4	713.4	717.5	805.3	813.5	516.08	518.57
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	280.0	285.6	682.5	685.1	778.2	782.9	525.87	529.99
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	285.5	290.5	696.1	706.1	788.0	792.3	495.02	497.60
10 days delayed planting with incorporation of emerged weeds	268.1	273.3	667.1	669.5	763.2	772.0	479.63	481.99
Dense planting (closer spacing of 15x10 cm)	266.4	272.7	655.3	658.2	758.1	765.5	467.77	470.72
Weedy check	262.2	267.6	651.9	654.4	747.6	752.6	464.42	466.88
SEm±	11.2	12.1	3.3	3.5	3.0	2.6	8.85	9.26
CD (P=0.05)	NS	NS	9.9	10.5	9.0	7.8	26.54	27.76

Table 5: Grain yield and straw yield of rice at harvest as influenced by weed management practices in organically grown transplanted aromatic rice-tomato cropping system

Treatment	Grain yield (tha^{-1})		Straw yield (tha^{-1})	
	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	3.65	3.88	4.82	5.10
Motorized weeder twice (single row type) at 20 and 40 DAT	3.43	3.54	4.64	4.85
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	3.53	3.73	4.71	4.94
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	3.51	3.66	4.67	4.90
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	3.25	3.40	4.45	4.71
Green leaf manuring(incorporation at puddling) + one HW at 20 DAT	3.35	3.45	4.49	4.79
10 days delayed planting with incorporation of emerged weeds	3.21	3.10	4.43	4.47
Dense planting (closer spacing of 15x10 cm)	3.06	3.00	4.21	4.31
Weedy check	1.82	1.92	2.88	3.07
SEm±	0.06	0.05	0.03	0.05
CD (P=0.05)	0.19	0.15	0.09	0.16

Table 6: Total Weed Density at 90 DAT as influenced by weed management practices in organically grown transplanted aromatic rice during *Kharif* season

Treatments	*Echinochloacolona*		C iria		A sessilis		*Cyanotis axillaris*		*Celosia argentea*		Other weeds		Total weed density	
	90 DAT		90 DAT		90 DAT		90 DAT		90 DAT		90 DAT		90 DAT	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Hand weeding (HW) twice at 20 and 40 DAT row type) at 20 and 40 DAT	1.22	1.32	1.41	1.33	2.06	1.83	1.58	1.55	1.62	1.35	2.23	2.17	3.92	3.64
	(1.000	(1.23)	(1.50)	(1.26)	(3.75)	(2.84)	(2.00)	(1.90)	(2.14)	(1.31)	(4.49)	(4.22)	(14.88)	(12.76)
Motorized weeder twice (singlerow type) at 20 and 40 DAT	2.05	2.13	2.10	2.37	2.31	2.27	2.14	1.96	2.03	2.17	3.00	2.61	5.40	5.31
	(3.71)	(4.02)	(3.89)	(5.12)	(4.84)	(4.66)	(4.06)	(3.34)	(3.61)	(4.23)	(8.52)	(6.29)	(28.63)	(27.66
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	1.43	1.55	1.70	1.94	2.22	1.87	1.97	1.65	)					
	(1.55)	(1.91)	(2.40)	(3.27)	(4.45)	(3.00)	(3.40)	(2.21)	1.77	1.50	2.55	2.34	4.58	4.20
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	1.89	1.58	2.05	2.20	2.28	1.98	2.12	1.80	(2.64)	(1.75)	(6.00)	(4.96)	(20.44)	(17.10)
	(3.06)	(2.00)	(3.71)	(4.33)	(4.72)	(3.43)	(3.99)	(2.75)	2.00	1.75	2.76	2.55	5.16	4.65
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	2.17	2.25	2.22	2.60	2.39	2.50	2.24	2.20	(3.50)	(2.57)	(7.10)	(6.00)	(26.08)	(21.08)
	(4.20)	(4.57)	(4.42)	(6.28)	(5.21)	(5.75)	(4.51)	(4.32)	2.32	2.27	3.19	2.71	5.78	5.74
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	2.13	2.18	2.10	2.48	2.35	2.31	2.23	2.04	(4.88)	(4.65)	(9.690	(6.86)	(32.91)	(32.43)
	(4.02)	(4.24)	(3.90)	(5.66)	(5.00)	(4.85)	(4.49)	(3.65)	2.11	2.20	3.06	2.69	5.54	5.47
10 days delayed planting with incorporation of emerged weeds	2.24	2.28	2.45	2.64	2.61	2.54	2.35	2.32	(3.96)	(4.32)	(8.87)	(6.75)	(30.24)	(29.47)
	(4.50)	(4.69)	(5.48)	(6.48)	(6.31)	(5.97)	(5.04)	94.87)	2.39	2.50	3.21	2.91	6.07	6.02
Dense planting (closer spacing of 15 × 10 cm	2.31	2.35	2.52	2.74	2.68	2.61	2.77	3.02	(5.22)	(5.74)	(9.79)	(7.97)	(36.34)	(35.72)
	(4.85)	(5.00)	(5.86)	(7.02)	(6.70)	(6.33)	(7.19)	(8.65)	2.80	2.84	3.30	3.11	6.55	6.65
Weedy Check	2.32	2.59	2.62	2.97	3.13	2.74	3.08	3.62	(7.33)	(7.59)	(10.41)	(9.16)	42.34	43.75
	(4.87)	(6.20)	(6.35)	(8.32)	(9.28)	(6.99)	(8.97)	(12.58)	2.90	2.93	3.52	3.63	7.05	7.44
SEm±	0.22	0.09	0.21	0.29	0.07	0.06	0.18	0.08	0.13	0.14	0.17	0.13	0.42	0.37
CD(P=0.05)	0.67	0.27	0.64	0.87	0.22	0.17	0.54	0.25	0.38	0.42	0.52	0.38	1.25	1.11

Table 7: Total Weed biomass at 90 DAT as influenced by weed management practices in organically grown transplanted aromatic rice during *Kharif* season

Treatments	*Echinochloacolona*		C iria		A sessilis		*Cyanotis axillaris*		*Celosia argentea*		Other weeds		Total weed density	
	90 DAT		90 DAT		90 DAT		90 DAT		90 DAT		90 DAT		90 DAT	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Hand weeding (HW) twice at 20 and 40 DAT row type) at 20 and 40 DAT	1.37	1.35	1.36	1.34	1.97	1.89	1.98	1.89	1.72	1.65	1.56	1.54	3.80	3.66
	(1.37)	(1.32)	(1.34)	(1.31)	(3.39)	(3.06)	(3.42)	(3.09)	(2.47)	(2.23)	(1.94)	(1.87)	(13.94)	(12.87)
Motorized weeder twice (singlerow type)at 20 and 40 DAT	2.03	1.78	1.86	1.71	2.90	2.97	2.42	2.25	2.44	2.25	2.39	2.37	5.57	5.31
	(3.62)	(2.66)	(2.97)	(2.43)	(7.89)	(8.30)	(5.36)	(4.56)	(5.45)	(4.58)	(5.20)	(5.13)	(30.50)	(27.66)
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	1.53	1.43	1.63	1.52	2.09	1.90	2.14	2.08	1.94	1.68	1.71	1.66	4.26	3.92
	(1.84)	(1.55)	(2.17)	(1.81)	(3.86)	(3.10)	(4.10)	(3.83)	(3.28)	(2.33)	(2.41)	(2.26)	(17.65)	(14.88)
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	1.55	1.64	1.75	1.57	2.49	2.47	2.21	2.22	2.22	2.16	1.96	1.92	4.78	4.70
	(1.90)	(2.20)	(2.58)	(1.98)	(5.70)	(5.59)	(4.38)	(4.45)	(4.44)	(4.15)	(3.34)	(3.19)	(22.34)	(21.56)
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	2.30	2.26	2.17	2.10	3.23	3.15	2.81	2.69	2.99	2.91	2.52	2.51	6.41	6.24
	(4.79)	(4.63)	(4.23)	(3.89)	(9.91)	(9.39)	(7.42)	(6.75)	(8.45)	(7.98)	(5.83)	(5.80)	(40.63)	(38.45)
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	2.26	2.15	2.06	1.91	3.02	3.06	2.60	2.54	2.91	2.88	2.50	2.51	6.12	6.01
	(4.62)	(4.11)	(3.73)	(3.16)	(8.63)	(8.85)	(6.25)	(5.97)	(7.98)	(7.78)	(5.77)	(5.79)	(36.98)	(35.66)
10 days delayed planting with incorporation of emerged weeds	2.46	2.40	2.27	2.23	3.41	3.22	3.05	2.92	3.12	2.97	2.65	2.53	6.81	6.51
	(5.56)	(5.27)	(4.67)	(4.49)	(11.14)	(9.88)	(8.80)	(8.03)	(9.23)	(8.31)	(6.52)	(5.90)	(45.93)	(41.88)
Dense planting (closer spacing of 15 × 10 cm	2.55	2.50	2.41	2.31	3.75	3.62	3.39	3.29	3.27	3.19	3.35	3.26	7.57	7.34
	(5.99)	(5.76)	(5.33)	(4.81)	(13.55)	(12.64)	(10.99)	(10.33)	(10.22)	(9.65)	(10.72)	(10.15)	(56.80)	(53.34)
Weedy Check	3.08	3.19	3.18	2.90	3.94	4.66	3.80	3.91	3.71	3.72	3.61	3.50	8.59	8.89
	(8.96)	(9.68)	(9.63)	(7.89)	(15.04)	(21.18)	(13.94)	(14.78)	(13.25)	(13.31)	(12.54)	(11.72)	(73.36)	(78.56)
SEm±	0.06	0.10	0.14	0.08	0.24	0.22	0.08	0.11	0.20	0.18	0.13	0.16	0.33	0.35
CD(P=0.05)	0.18	0.29	0.41	0.23	0.72	0.66	0.23	0.33	0.61	0.54	0.40	0.48	0.98	1.04

Table 8: Weed control efficiency of rice during different growth periods as influenced by weed management practices in organically grown transplanted aromatic rice-tomato cropping system

Treatment	Weed control efficiency (%)	
	90DAT	
	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	81.00	83.62
Motorized weeder twice (single row type) at 20 and 40 DAT	58.43	64.80
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	75.94	81.06
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	69.55	72.56
Mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT	44.62	51.06
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	49.59	54.60
10 days delayed planting with incorporation of emerged weeds	37.40	46.69
Dense planting (closer spacing of 15x10 cm)	22.58	32.10
Weedy check	-	-

Table 9: Net return and cost of benefits (B:C) ratio of rice influenced by weed management in organically grown transplanted aromatic rice-tomato cropping system

	Net return (Rs. ha^{-1})		B:C ratio	
	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	77115	84955	2.42	2.55
Motorized weeder twice (single row type) at 20 and 40 DAT	71710	77855	2.46	2.57
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	76490	83335	2.51	2.64
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	75760	80775	2.50	2.58
Mechanical weeding through Ambikapaddy weeder + one intra row HW at 20 DAT	66400	71415	2.31	2.40
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	71340	74575	2.45	2.50
10 days delayed planting with incorporation of emerged weeds	64290	59935	2.25	2.16
Dense planting (closer spacing of 15x10 cm)	64250	61775	2.39	2.33
Weedy check	22960	26295	1.54	1.61

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