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IMPACT OF INTEGRATED WEED MANAGEMENT ON YIELD AND PROFITABILITY OF JUTE (*CORCHORUS OLITORUS* L.)

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ABSTRACT

A field experiment was conducted at the Central Demonstration Farm (CDF) located at Wanirambhapur, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the *Kharif* season of 2023-24 to develop an integrated weed management practice for effective weed control in jute cultivation. The experiment was set up in Randomized Block Design with eight treatments and replicated thrice. Yield attributes *viz.*, number of pods per plant, number of seeds per pod, seed weight per plant (g), pod weight per plant (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and Harvest Index (%) were significantly affected by the various IWM practices. The maximum yield characters were observed with farmer practice of two weedings at 15-20 DAS and two hoeings at 30-35 DAS, which was on par with Pendimethalin 38 EC (PE) @ 1.5 kg a.i. ha^{-1} followed by one hand weeding at 35-40 DAS. Hence, a combine practice of manual weeding and hoeing or application of Pendimethalin is suggested for effective and profitable jute cultivation to farmers.

***Keywords* :** Integrated Weed Management, Pendimethalin, Yield, Jute, Farmer practices

Introduction

Jute *(Corchorus spp.)* is a crucial fiber crop, widely cultivated in the eastern Indian states of West Bengal, Assam, Bihar, Odisha, and parts of Uttar Pradesh. Known as the "golden fiber" jute is an annual, short-day plant with primary fiber sourced from two species: *Corchorus capsularis* (white jute) and *Corchorus olitorius* (tossa jute). Jute is valued for its natural and biodegradable qualities, making it a sustainable alternative to synthetic fibers. Primarily grown by small and marginal farmers, jute supports a substantial part of rural economies, with India and Bangladesh being the world's largest producers. (Singh *et al.*, 2018)

Despite its economic significance, jute cultivation faces various production challenges, one of the most severe being weed infestation. Weeds, especially C_4 species, compete aggressively with jute (C_3 plant) for essential resources like light, nutrients and water, especially during the critical early growth stages. This competition can result in significant yield losses, with studies indicating a reduction of up to 70% in fiber yield if weeds are not effectively managed. Conventional manual weeding methods are labor-intensive contributing approximately about 40 % of the total cost of cultivation. (Ghorai, 2008) Although chemical herbicides offer a quick solution, they may lead to environmental degradation, herbicide resistance in weeds and unintended harm to beneficial organisms.

Provided these challenges, Integrated Weed Management (IWM) has emerged as an optimal solution for sustainable jute cultivation. IWM integrates mechanical, chemical and cultural practices to control weeds effectively while minimizing environmental impact and production costs. (Sarak *et al*., 2024) Although, IWM practices are well-studied in other crops, research focusing on jute remains limited.

This study aims to address this gap by evaluating the impact of various IWM practices on yield and profitability of jute. By assessing combinations of manual weeding, herbicide application and mechanical practices, present investigation seeks to identify efficient, weed control strategies that is potent to improve jute productivity and profitability from farmers point of view.

Materials and Methods

This research trial was conducted during the 2023-24 *kharif* season at the Central Demonstration Farm (CDF) Wanirambhapur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, under subtropical conditions. The farm is situated at 22°42' N latitude, 77°02' E longitude and an altitude of 307.4 m above mean sea level. The soil at the experimental site was clayey with slightly alkaline reaction, with low available nitrogen (216 kg/ha), moderate phosphorus (14.50 kg/ha) and very high potassium (338.35 kg/ha). The experiment was laid out in a randomized block design with eight treatments, each replicated three times. The treatments allocated were *viz.,* Pendimethalin 38 EC (PE) at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding (HW) at 35-40 DAS (T_1), Butachlor 50 EC (PE) at 1.0 kg a.i. ha^{-1} followed by 1 HW at 35-40 DAS (T_2), Pretilachlor 50 EC (PE) at 0.60 kg a.i. ha^{-1} followed by 1 HW at 35-40 DAS (T_3), Metolachlor 50 EC (PE) at 0.50 kg a.i. ha^{-1} followed by 1 HW at 35-40 DAS (T_4), Propaquizafop 10% EC (POE) at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 HW at 35-40 DAS (T_5), Quizalofop ethyl 5% (POE) at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 HW at 35-40 DAS (T_6), Farmer's practice of two weedings and two hoeings at 15-20 and 30-35 DAS (T_7) and a weedy check (T_8).

The experimental plot measured 5.40 × 5.40 m and the jute cultivar 'JRO-524' was sown with a spacing of 45×10 cm. Fertilizer was applied at a basal rate of 80:40:40 NPK kg ha^{-1}. Seeds were sown at a rate of 5 kg ha^{-1} on July 17, 2023, after adequate rainfall at field capacity. Herbicides were applied as per treatment specifications, using 300 liters of water per hectare with a flat fan nozzle through high-volume knapsack sprayer within 24 hours of sowing. The jute crop was harvested on November 6, 2023.

Predominant weed flora observed in the experimental field were *viz., Cyperus rotundus* L., *Cynodon dactylon, Commelina benghalensis, Parthenium hysterophorus, Alternanthera triandra* L., *Portulaca oleracea, Euphorbia geniculate, Phyllanthus niruri* L., *Xanthium strumarium* L., *Tridax procumbens etc.*

The number of pods per plant and seeds per pod were recorded from randomly selected ten plants from each per treatment and their averages were calculated. The seeds and pods collected from these plants were weighed using an analytical weighing balance to determine their mean weight. Test weight, was measured by randomly sampling 1000 seeds from the net plot produce of each treatment and weighed accordingly, expressed in grams. After harvesting, the produce was threshed, and the seeds from each net plot were weighed to calculate seed yield per plot (kg/ha) using a hectare factor. Straw yield per plot was determined by weighing the straw after separating the seeds and converting it to per-hectare values. Plants in the net plots were cut at ground level, sun-dried, weighed per plot and expressed on a per-hectare basis. Biological yield (kg/ha) was calculated as the sum of seed yield and stalk yield:

Biological yield (kg/ha) = Seed yield (kg/ha) + Stalk yield (kg/ha)

Harvest Index (HI), representing the efficiency of the crop to produce economic yield relative to total biological yield, was calculated using Donald's (1962) formula:

$$\text{Harvest Index (\%)} = (\text{Economic yield} / \text{Biological yield}) \times 100$$

The cost of cultivation included all expenses for growing the jute crop, incorporating main and treatment-specific costs. Gross return was calculated based on market prices, and net profit for each treatment was derived using the formula:

Net profit (Rs/ha) = Gross return (Rs/ha) – Cost of cultivation (Rs/ha)

The Benefit: Cost Ratio (BCR) was computed as:

BCR = Gross monetary return (Rs/ha) / Cost of cultivation (Rs/ha)

Data of yield parameters, including number of pods per plant, number of seeds per pod, seed weight per plant (g), pod weight per plant (g) and test weight (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and Harvest Index (%), were analyzed statistically using ANOVA.

Results and Discussion

Yield and yield attributing characters

The data depicted in Table 1. Shows significant variations among yield and yield attributing characters as discussed below.

Number of pods plant^{-1}

The number of pods per plant in the jute crop was significantly affected by various Integrated Weed Management Practices. The highest pod count per plant was observed in the T_7 treatment, which involved the farmers practice of weed control with two weedings and two hoeings at 15-20 DAS and 30-35 DAS, respectively. This result was statistically on par with treatments T_1 (Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS), T_6 (Quizalofop ethyl 5% at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 HW at 35-40 DAS), which all outperformed the remaining treatments. The lowest number of pods per plant was recorded in the weedy check (T_8).

The improvement in yield-contributing attributes can likely be attributed to the timely control of weeds. This resulted in a significant reduction in competition for nutrients and moisture from the soil, which in turn increased the photosynthetic efficiency of the jute crop. These findings align with Ferdous *et al.* (2021) and Bhattacharjee *et al.* (2000).

Number of seed pod^{-1}

The highest total number of seeds per pod (198.86) was recorded in the T7 treatment, involving farmer practices of two weedings and two hoeings at 15-20 DAS and 30-35 DAS (198.86), which was significantly superior to the weedy check (T8) with 150.56 seeds per pod. However, treatments T_1 (Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1}) followed by 1 hand weeding (193.16) at 35-40 DAS, T_6 (Quizalofop ethyl 5% at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 HW at 35-40 DAS were on par with T_7 in terms of the number of seeds per pod. The maximum number of seeds per pod was observed in the T_7 (farmer practices), T_1 (Pendimethalin) and PE treatments (T_6 and T_5).

This increase in seed count may be attributed to the higher weed control efficiency of these treatments, which allowed for better resource utilization by the plants in a weed-free environment, thereby enhancing seed development.

Weight of seed plant^{-1} (g)

The maximum seed weight per plant (8.99 g) was recorded in the T_7 treatment, which involved farmer practices of two weedings and two hoeings at 15-20 and 30-35 DAS, respectively. This was at par with the T_1 treatment, Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS (7.87 g). The lowest seed weight per plant was observed in the weedy check (T_8), with a value of 3.41 g, likely due to the competition between the crop and weeds in this treatment.

The manual weeding and herbicide application significantly reduced weed density and dry matter accumulation, creating a more favorable environment for the jute plants. This allowed for better utilization of available nutrients, moisture, and space, ultimately contributing to higher seed weight per plant. Similar findings were reported by Aalam *et al.* (2002).

Weight of pods plant^{-1} (g)

The average pod weight per plant was 17.59 g. This parameter was significantly influenced by the different integrated weed management practices. The highest pod weight per plant (24.0 g) was recorded in the T_7 treatment, which involved farmer practices of two weedings and two hoeings at 15-20 and 30-35 DAS, respectively. This was followed by T_1 (Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS), T_6 (Quizalofop ethyl 5% at 0.50 kg a.i. ha^{-1} at 15-20 DAS. Whereas, the lowest pod weight per plant (10.73 g) was recorded in the weedy check (T_8).

The higher pod weight per plant under Integrated Weed Management Practices can be attributed to the improved soil environment, better nutrient and moisture availability, and reduced competition between the crop and weeds for radiant energy. This enhanced the photosynthetic efficiency of the jute crop, resulting in increased pod weight.

Test weight (g)

The impact of different integrated weed management treatments on test weight (1000 seeds) was found to be non-significant, although there were numerical differences. The highest test weight (2.07 g) was observed in the T_7 treatment, involving farmer practices with two weedings and two hoeings at 15-20 and 30-35 DAS, followed by the pre-emergence herbicide treatment T_1 Pendimethalin 38 EC at 1.5 kg a.i. ha⁻¹. In contrast, the lowest test weight (1.82 g) was recorded in the weedy check treatment T_8 (weedy check).

Seed yield (kg ha^{-1})

Among all treatments, the highest seed yield (948 kg ha^{-1}) was recorded in T_7 (farmer practices of two weedings and two hoeings at 15-20 DAS and 30-35 DAS), which was statistically similar to T_1 (891 kg ha^{-1}), Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS, T_6 (850 kg ha^{-1}), Quizalofop ethyl 5% at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 hand weeding at 35-40 DAS and T_5 (836 kg ha^{-1}). These treatments performed better than rest of treatments. Except for T_7, treatments T_1 (Pendimethalin) and T_6 (Quizalofop ethyl) exhibited the best performance. The lowest seed yield (603 kg ha^{-1}) was observed in T_8, the weedy check.

These results tune with findings reported by Ferdous *et al*. (2021), Alam *et al*. (2002), Khanom *et al.* (2012), Bhattacharjee *et al.* (2000), and Mondal *et al*. (2007).

Straw yield (kg ha^{-1})

Among all treatments, the highest straw yield (3377 kg ha^{-1}) was recorded in T_7 (farmer practices of two weedings and two hoeings at 15-20 DAS and 30-35 DAS), which was statistically at par to T_1 (3207 kg ha^{-1}), Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS, T_6 (3191 kg ha^{-1}), These treatments differed significantly from rest of the treatments. Among the herbicidal treatments, T_1 (Pendimethalin) and T_6 (Quizalofop ethyl) exhibited the best performance. The lowest straw yield (2338 kg ha^{-1}) was observed in T_8, the weedy check.

The higher straw yields in the manually weeded plots can be attributed to the reduced competition between weeds and the main crop (Sarkar, 2006). Similar results were reported by Chakraborty *et al.* (2020), who noted that the highest straw yield (12.39 t ha^{-1}) was achieved with two hand weedings at 15 and 30 DAS, followed by Nail weeder at 7 DAS combined with Quizalofop ethyl 5% at 60 g ha^{-1} (11.70 t ha^{-1}), with both treatments showing statistically similar results.

Biological yield (kg ha^{-1})

The biological yield (kg ha^{-1}) was significantly affected by the various weed management treatments. The highest biological yield (4325 kg ha^{-1}) was recorded in T_7, which involved farmer practices of two weedings and two hoeings at 15-20 DAS and 30-35 DAS. This treatment was at par with T1 (Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS), T_6 (Quizalofop ethyl 5% at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 hand weeding at 35-40 DAS). Whereas, the lowest biological yield (2941 kg ha^{-1}) was recorded in T_8 i.e. weedy check treatment.

Harvest Index (%)

The treatments T_7 (farmer practices of two weedings and two hoeings at 15-20 DAS and two hoeings at 30-35 DAS), T_2 (Butachlor 50 EC at 1.0 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS), T_1 (Pendimethalin 38 EC at 1.5 kg a.i. ha^{-1} followed by 1 hand weeding at 35-40 DAS), and T_6 (Quizalofop ethyl 5% at 0.50 kg a.i. ha^{-1} at 15-20 DAS followed by 1 hand weeding at 35-40 DAS) recorded the highest harvest index (%) compared to the treatment T_8 (weedy check). The manual weeding, along with pre-emergence and post-emergence herbicide applications in jute crops at 15-20 DAS and 35-40 DAS, significantly reduced weed intensity in the experimental plot, leading to improved plant growth and higher yields compared to the weedy check.

Table 1 : Effect of integrated weed management practices (IWMP) on yield and yield attributing characters as influenced by different treatments

Treatment		Number of pods plant^{-1}	Number of seed pod^{-1}	Weight of seed plant-^{1} (g)	Weight of pod plant^{-1} (g)	Test Weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
T_1	Pendimethalin 38 EC (PE) @ 1.5 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	29.50	193.16	7.87	22.05	2.01	891	3207	4097	21.74
T_2	Butachlor 50 EC (PE) @ 1.0 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	22.13	158.11	6.60	14.80	1.86	751	2543	3294	21.79
T_3	Pretilachlor 50 EC (PE) @ 0.60 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	24.23	178.53	6.98	17.00	1.96	827	3155	3982	20.81
T_4	Metolachlor 50 EC (PE) @ 0.50 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	23.13	163.52	6.91	15.80	1.94	769	2884	3653	21.08

T_5	Propaquizafop 10% EC (POE) @ 0.50 kg a.i. ha^{-1} at 15-20 DAS *fb* 1 HW at 35-40 DAS	25.53	180.76	7.07	17.80	1.97	836	3093	3930	21.27
T_6	Quizalofop ethyl 5%(POE) @ 0.50 kg a.i. ha^{-1} at 15-20 DAS *fb* 1 HW at 35-40 DAS	27.13	181.95	7.43	18.52	1.99	850	3191	4040	21.05
T_7	Farmer practices 2 weeding and 2 hoeing 15-20 and 30-35 DAS	32.70	198.86	8.99	24.00	2.07	948	3377	4325	21.98
T_8	Weedy check	20.23	150.56	3.41	10.73	1.82	603	2338	2941	20.53
S.E (m)+		1.20	9.27	0.36	0.82	0.06	38.27	157.3	184.1	-
CD at 5%		3.68	28.46	1.09	2.52	NS	117.4	482.67	565.1	-
GM		**25.58**	**175.68**	**6.91**	**17.59**	**1.95**	**809**	**2973**	**37.83**	**-**

Profitability of jute cultivation

The data presented in Table 2. depicts profitability of jute cultivation as influenced by different treatments as discussed and justified below.

Gross monetary returns (GMR)

Higher gross monetary returns (Rs. 81,085 ha^{-1}) were recorded in hand weeding (T_7) compared to other treatments, attributed to better weed control. In contrast, the lowest gross monetary return (Rs. 51,811 ha^{-1}) was observed in the weedy check. Effective weed management, leading to improved seed yield, contributed to the higher returns in these treatments.

Net monetary returns (NMR)

Higher net monetary returns (Rs. 40,985 ha^{-1}) were recorded in hand weeding (T_7), surpassing all other treatments. The lowest net monetary return (Rs. 22,711 ha^{-1}) was observed in the weedy check. Effective weed management, which enhanced seed yield, contributed to the higher returns in the superior treatments. Similarly, Singh *et al.* (2015) reported that applying Quizalofop-p-ethyl along with one hand weeding yielded the highest net profit of Rs. 43,550 ha^{-1}.

Benefit: Cost Ratio (BCR)

Pendimethalin 38 EC (PE) @ 1.5 kg a.i. ha^{-1} followed by one hand weeding at 35–40 DAS (T_1) recorded the highest benefit-cost ratio (BCR) of 2.15. In contrast, the lowest BCR (1.78) was observed in the weedy check (T_8), attributed to reduced seed yield due to increased weed competition. In weed-free plots, where farmers practiced two weedings and two hoeings at 15–20 and 30–35 DAS, the cost of cultivation significantly increased due to the frequent manual weeding operations required for clean cultivation. This led to higher labour costs and elevated cultivation expenses. The lower BCR in the weedy check was caused by reduced productivity resulting from high weed competition. The variation in BCR across treatments was influenced by differences in herbicide costs and crop productivity. Similar findings were reported by Dutta and Kheroar (2020), who noted that increased labour engagement in weed-free treatments led to higher cultivation expenses.

Table 2 : Effect of integrated weed management practices (IWMP) on profitability of jute cultivation as influenced by different treatments

Treatment		Cost of Cultivation (Rs. ha^{-1})	Gross Monetary Returns (Rs. ha^{-1})	Net Monetary Returns (Rs. ha^{-1})	Benefit Cost Ratio
T_1	Pendimethalin 38 EC (PE) @ 1.5 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	35425	76245	40820	2.15
T_2	Butachlor 50 EC (PE) @ 1.0 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	34800	64151	29351	1.84
T_3	Pretilachlor 50 EC (PE) @ 0.60 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	35020	70962	35942	2.02
T_4	Metolachlor 50 EC (PE) @ 0.50 kg a.i. ha^{-1} *fb* 1 HW at 35-40 DAS	37900	65966	28066	1.74
T_5	Propaquizafop 10% EC (POE) @ 0.50 kg a.i. ha^{-1} at 15-20 DAS *fb* 1 HW at 35-40 DAS	34675	71676	37001	2.06
T_6	Quizalofop ethyl 5%(POE) @ 0.50 kg a.i. ha^{-1} at 15-20 DAS *fb* 1 HW at 35-40 DAS	35050	72861	37811	2.07
T_7	Farmer practices 2 weeding and 2 hoeing 15-20 and 30-35 DAS	40100	81085	40985	2.02
T_8	Weedy check	29100	51811	22711	1.78

Conclusion

The study demonstrated that Integrated Weed Management Practices significantly enhanced the, yield of jute. Among all the treatments, the farmer practice of two weedings and two hoeings at 15-20 and 30-35 DAS (T_7) resulted in the highest yield parameters, including number of pods per plant, seed yield and straw yield. This treatment was comparable to the application of Pendimethalin 38 EC (PE) at 1.5 kg a.i. ha⁻¹ followed by hand weeding (T_1) and Quizalofop ethyl 5% (POE) at 0.50 kg a.i. ha⁻¹ followed by hand weeding (T_6), with significant improvements in seed weight, pod weight. The highest Gross Margin Returns (GMR), Net Margin Returns (NMR) and Benefit: Cost Ratio (BCR) were recorded for (Pendimethalin 38 EC at 1.5 kg a.i. ha⁻¹ followed by hand weeding at 35-40 DAS), followed by (Quizalofop ethyl 5% at 0.50 kg a.i. ha⁻¹ at 15-20 DAS followed by hand weeding at 35-40 DAS), indicating the economic viability of these treatments. The weedy check showed the lowest yield and economic returns, underlining the importance of effective weed management in maximizing jute productivity. These findings are consistent with previous research, supporting the effectiveness of integrated weed management strategies for improving jute production in subtropical regions.

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Conflict of Interest

Authors declare no conflict of interest.

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