Original Research Article

Performance of Herbicide Regimes on Weed Control, Growth and Yield of Transplanted Rice (*Oryza sativa* L.)

Abstract

In transplanted rice, uncontrolled weed infestation poses a significant impact to productivity, causing substantial yield losses by competing for resources. This study evaluated the effect of various weed management practices on growth, yield attributes characters and yield. The treatments included, T_1 (Absolute Weedy check), T_2 (Two Hand weeding), T_3 (Pyrazosulfuron 150g *a.i.* ha^{-1} PE), T_4 (Ethoxysulfuron 25g *a.i.* ha^{-1} PE), T_5 (Azimsulfuron 30 *a.i.* ha^{-1} POE), T_6 (Penoxsulam 25g *a.i.* ha^{-1} POE), T_7 (Pyrazosulfuron 150 *a.i.* ha^{-1} + Azimsulfuron 30g *a.i.* ha^{-1}), T_8 (Pyrazosulfuron 150g *a.i.* ha^{-1} + Penoxsulam 25g *a.i.* ha^{-1}), T_9 (Ethoxysulfuron 25 *a.i.* ha^{-1}+ Azimsulfuron 30 *a.i.* ha^{-1}), T_{10} (Ethoxysulfuron 25g *a.i.* ha^{-1} + Penoxsulam 25 *a.i.* ha^{-1}). The highest of plant height, Panicle length (cm), Filled grains $panicle^{-1}$, test weight (g), grains yield (44.8 q ha^{-1}), straw yield, biological yield were found in T_2 (Two Hand weeding) closely followed by T_9 (Ethoxysulfuron 25g *a.i.* ha^{-1} PE + Azimsulfuron 30g *a.i.* ha^{-1} POE) which yielded (43.4 q ha^{-1}). Both T_2 and T_9 resulted in significantly superior grain, straw and biological yields compared to the absolute weedy check (T_1) demonstrating the critical importance of effective weed management for optimizing rice productivity.

Keywords: *Weed management, Transplanted rice, Hand weeding, Grain yield, Ethoxysulfuron and Azimsulfuron*

INTRODUCTION

The primary food source for around 60% of the world's population, rice (*Oryza sativa* L.) is the most significant staple grain crop in the world. In India, rice accounts for 46% of all cereal production and 43% of all food grain production. Rice was grown on 46.65 m ha^{-1}, yielding 135.75 m tonnes annually at a productivity of roughly 2910 kg ha^{-1} in 2023, DES, MoA and FW. It is well known that weeds cause more losses than any other type of agricultural pest. Weeds cause 45% of India's annual loss of agricultural produce due to pests, followed by insects (30%), diseases (20%), and other pests (5%), according to Rao (2015). The most common weed plants in rice fields that have been transplanted are *Echinochloa colona* (L.), *Digitaria sanguinalis* (L.) Scop., *Cyperus rotundus* (L.), *Cyperus difformis* (L.), *Cyperus iria* (L.), *Eclipta alba* (L.) Hassk. and *Ammania baccifera* (L.) (Deepthi *et al.*, 2010). Due to their rapid and vigorous growth, weeds take up the crop's environment and lower its potential production. Crop characteristics, such as cultivar, density, age and plant spacing, affect how much competition there is from rice weeds Moody (1989). According to Sharma *et al.* (2016), yield losses from weeds in significant field crops ranged from 28.2 to 83.5% over weedy

control and from 12.8% to 42.7% over farmers' practices. Manna (1991) observed that weeds reduced output by 25% in transplanted rice, 32% in puddle transplanted rice and 52% in direct-sown rice. Due to the simultaneous growing of the crops and weeds, puddle seeded rice has a more severe weed infestation than un puddled transplanted rice additional labor, which raises production costs and causes planting delays because of a labor shortage. Transplanting, a common technique for establishing rice crops, especially during *kharif*, requires extra labor, which raises production costs. Because of labor shortages, planting is frequently delayed. It would be beneficial if transplanting could be replaced by a low-cost crop establishment method (Jana *et al.*, 1981). However, because of high labor costs and field worker shortages during peak times, transplanting in a puddle field resulted in less nutrient loss from weeds than in an unbundled one, but in the latter case, many weeds were infested and there was less growth. Considering these facts, an effort has been undertaken to determine the most effective weed management technique for the various establishing techniques, including transplanting and direct seeding. Transplanted puddle rice has supplanted conventional transplanted unpuddled rice due to its increased yield and reduced weed population infestation. Aside from a few sedges and broad-leaved weeds, barnyard grass is the primary pest of transplanted rice. Furthermore, suggested herbicides only work against grasses when applied as pre-emergence treatments, which guarantee water availability for at least 48 hours following application. Furthermore, persistent application of the same herbicide may cause changes in the flora and intensity of weeds over time, as well as the evolution of resistance in some weed species.

Weed management is a critical determinant of productivity in transplanted rice, with numerous studies quantifying its direct impact on key agronomic and yield-attributing characters. Singh *et al.* (2005) demonstrated that effective pre- and post-emergence herbicide regimes significantly increased plant height and the number of productive tillers per hill compared to unweeded control plots, which directly translated to higher grain yield. Similarly, research by Rao and Nagamani (2010) found that integrated weed management (IWM) practices combining cultural and chemical methods resulted in superior crop growth parameters, including dry matter accumulation and leaf area index, by minimizing early-season weed competition for resources. Gopal *et al.* (2010) specifically highlighted that the use of herbicides like bispyribac-sodium not only provided excellent control of complex weed flora but also maximized the expression of yield components such as panicles per meter square and filled grains per panicle. Further supporting this, a study by Chauhan and Johnson (2011) concluded that the timing of weed removal was crucial; early intervention was paramount to preventing irreversible reductions in tiller initiation and ultimate crop biomass. Finally, Mani

et al. (2013) provided evidence that the highest grain and straw yields were consistently recorded in treatments where a two-step herbicide application (pre- followed by post-emergence) was employed, underscoring that sustained weed-free conditions throughout the critical growth periods are essential for the rice plant to achieve its full genetic potential for growth and yield.

MATERIAL AND METHODS

This study was conducted during the *Kharif* 2024 season at the CRC Farm of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh.The experimental site latitude of 29^0 40' North and longitude of 77^0 42' East and at an altitude of 237 metres above mean sea level. The experimental field was uniform and leveled, sandy loam in texture, low in available nitrogen (225.40 kg ha^{-1}), medium in available phosphorus (14.76 kg ha^{-1}) and potassium (170.82 kg ha^{-1}) with slightly alkaline reaction (pH 7.5). The experiment was carried out in Randomized Block Design with three replications and 10 treatments in variety of Pusa Basmati-1885. Fertilizer were applied at 120:60:60 of N:P:K kg ha^{-1}. Nitrogen was applied in 3 split doses i.e., half of N was applied in final ploughing, one fourth at active tillering stage and remaining one fourth at panicle initiation stage. All the phosphatic and potassic fertilizers were applied during final land preparation. The treatments comprised of T_1 Absolute Weedy check, T_2 Two Hand weeding, T_3 Pyrazosulfuron @ 150g a.i. ha^{-1} (PE), T_4 Ethoxysulfuron @ 25g a.i. ha^{-1} (PE), T_5 Azimsulfuron @ 30g a.i. ha^{-1} (POE), T_6 Penoxsulam @ 25g a.i. ha^{-1} (POE), T_7 Pyrazosulfuron @ 150g a.i. ha^{-1} + Azimsulfuron @ 30g a.i. ha^{-1}, T_8 Pyrazosulfuron @ 150g a.i. ha^{-1} + Penoxsulam @ 25g a.i. ha^{-1}, T_9 Ethoxysulfuron @ 25g a.i. ha^{-1}+ Azimsulfuron @ 30g a.i. ha^{-1}, T_{10} Ethoxysulfuron @ 25g a.i. ha^{-1} + Penoxsulam @ 25g a.i. ha^{-1}. Growth was measured by Sample plants were selected at random in net plot area and tagged for recording observations. Almost all the growth parameters were recorded at 30, 60, 90 DAT and at harvest. The height of randomly selected five tagged rice plants in net plot area was measured from the base of the plant to the tip of the upper most leaf at all the growth stages. Five panicles randomly selected from the tagged plants were harvested separately. The number of tillers per meter row were counted at 30, 60, 90 DAT and at harvest stage. The lengths of panicles were measured in cm from the neck node to its tip and finally the average length of panicle was worked out. The total number of panicles per meter were counted at the time of harvesting from the net plot area. Ten panicles were selected randomly from each plot and number of filled and unfilled grains per ten panicles was counted and average number of grains per panicles was worked out. Total number of Grains per panicle was calculated by

adding the numbers of filled and empty spikelets panicle^{-1}. Grain yield was determined from the net plot area and was weighed in kg and converted into q ha^{-1}. Grains were harvested, dried and weighed, and grain weight was taken at 14 % moisture content.

RESULT AND DISCUSSIONS

In this study the results pertaining to various observations on crop growth studies, yield attributes, yield, recorded during course of investigation entitled "Effect of weed management practices on growth, yield attributing characters and yield of transplanted rice" during *kharif* season of 2024. The effect of herbicides has been systematically tabulated for illustration with the help of table and diagrams for easy understanding of patterns.

Table 1. Effect of weed management practices on plant height (cm) at different stages

Treatments		Plant height (cm)			
		30 DAT	60 DAT	90 DAT	At harvest
T_1	Absolute Weedy check	**30.93**	**45.62**	77.49	**78.73**
T_2	Two Hand weeding	**38.20**	**60.87**	108.69	**109.93**
T_3	Pyrazosulfuron @ 150g *a.i.* ha^{-1}	**33.40**	**51.28**	94.00	**95.24**
T_4	Ethoxysulfuron @ 25g *a.i.* ha^{-1}	**33.53**	**54.86**	94.23	**95.47**
T_5	Azimsulfuron @ 30g *a.i.* ha^{-1}	**32.33**	**51.00**	93.90	**95.14**
T_6	Penoxsulam @ 25g *a.i.* ha^{-1}	**32.27**	**50.96**	93.82	**95.11**
T_7	Pyrazosulfuron @ 150g *a.i.* ha^{-1} + Azimsulfuron @ 30g *a.i.* ha^{-1}	**34.47**	**55.92**	99.86	**101.10**
T_8	Pyrazosulfuron @ 150g *a.i.* ha^{-1} + Penoxsulam @ 25g *a.i.* ha^{-1}	**33.87**	**55.02**	95.33	**96.57**
T_9	Ethoxysulfuron @ 25g *a.i.* ha^{-1} + Azimsulfuron @ 30g *a.i.* ha^{-1}	**35.47**	**56.14**	101.23	**102.47**
T_{10}	Ethoxysulfuron @ 25g a.i. per ha + Penoxsulam @ 25g a.i. ha^{-1}	**35.15**	**55.94**	99.90	**101.14**
	SEm(±)	**1.20**	1.90	3.47	3.56
	C.D.(P=0.05)	**3.47**	**5.51**	**10.02**	**10.31**

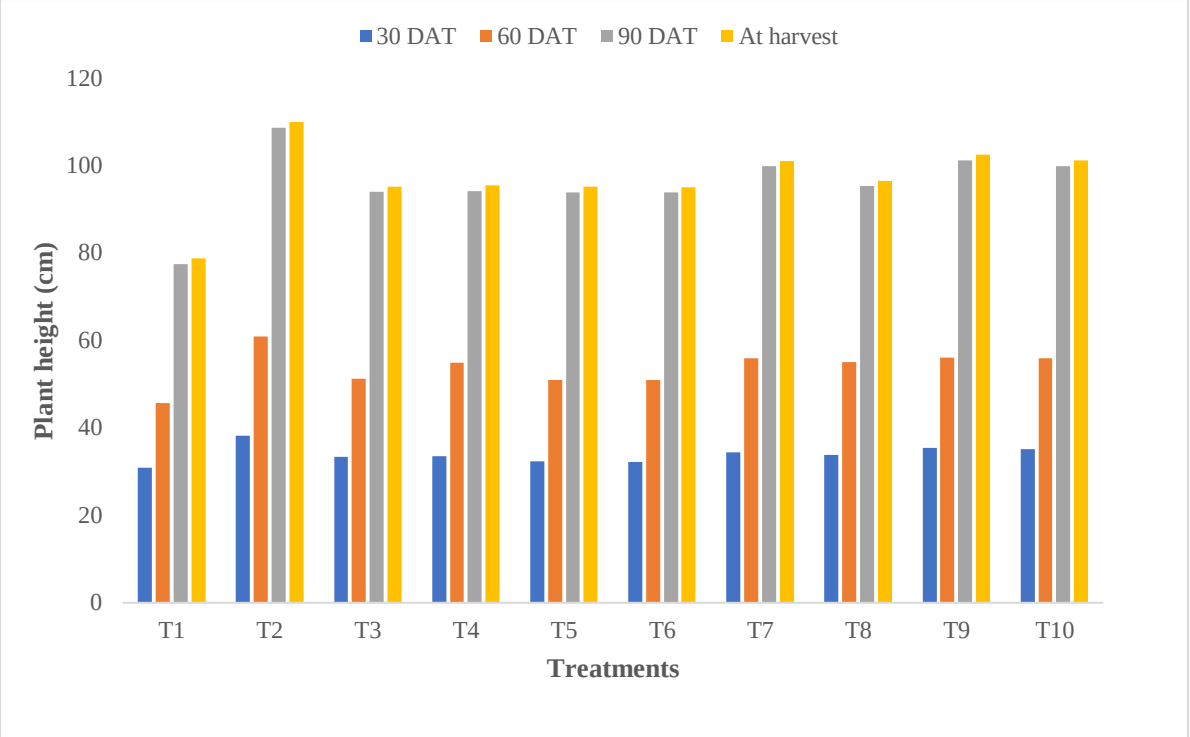

Fig. 1 Effect of weed management practices on plant height (cm) at different stages

The data revealed that weed management practices significantly influenced crop growth, with two hand weeding producing the maximum plant height. Among herbicidal treatments, the application of Ethoxysulfuron @ 25g a.i. per ha + Azimsulfuron @ 30g a.i. per ha resulted in the tallest plants. This superiority is attributed to the significantly lower weed dry weight in these plots, which minimized crop-weed competition for resources. This treatment was statistically on par with Ethoxysulfuron @ 25g a.i. per ha + Penoxsulam @ 25g a.i. per ha and Pyrazosulfuron @ 150g a.i. per ha + Azimsulfuron @ 30g a.i. per ha. The critical period for this competition was identified as 15-60 days after transplanting (DAT), where unchecked weed infestation negatively impacted early plant height and biomass by limiting nutrient uptake. The effective herbicides created a congenial, longer weed-free environment, allowing for better overall growth and development. This finding is consistent with earlier research by Sharma *et al.* (2003), who noted that the combination of Ethoxysulfuron and Azimsulfuron was as effective as hand weeding in promoting plant height, a result further supported by the work of Narwal *et al.* (2002) and Mukherjee *et al.* (2008).

Table 2. Effect of weed management practices on no. of tillers metre^{-1} row length at different stages

Treatments	Number of tillers metre^{-1} row length			
	30 DAT	60 DAT	90 DAT	At harvest

T_1	Absolute Weedy check	27.0	34.8	37.7	33.6
T_2	Two Hand weeding	41.1	58.1	63.8	52.3
T_3	Pyrazosulfuron @ 150g a.i. ha^{-1}	33.0	44.3	51.0	40.1
T_4	Ethoxysulfuron @ 25g a.i. ha^{-1}	33.3	45.7	51.6	41.1
T_5	Azimsulfuron @ 30g a.i. ha^{-1}	33.0	43.3	49.9	38.8
T_6	Penoxsulam @ 25g a.i. ha^{-1}	32.7	42.9	48.2	38.7
T_7	Pyrazosulfuron @ 150g a.i. ha^{-1} + Azimsulfuron @ 30g a.i. ha^{-1}	35.1	51.2	57.8	46.3
T_8	Pyrazosulfuron @ 150g a.i. ha^{-1} + Penoxsulam @ 25g a.i. per ha	33.5	46.1	52.8	42.3
T_9	Ethoxysulfuron @ 25g a.i. ha^{-1}+ Azimsulfuron @ 30g a.i. ha^{-1}	37.1	52.3	58.4	47.0
T_{10}	Ethoxysulfuron @ 25g a.i. ha^{-1}+ Penoxsulam @ 25g a.i. ha^{-1}	35.7	51.5	58.0	46.8
	SEm(±)	**1.2**	1.7	1.9	1.5
	C.D.(P=0.05)	**3.5**	**4.9**	**5.5**	**4.5**

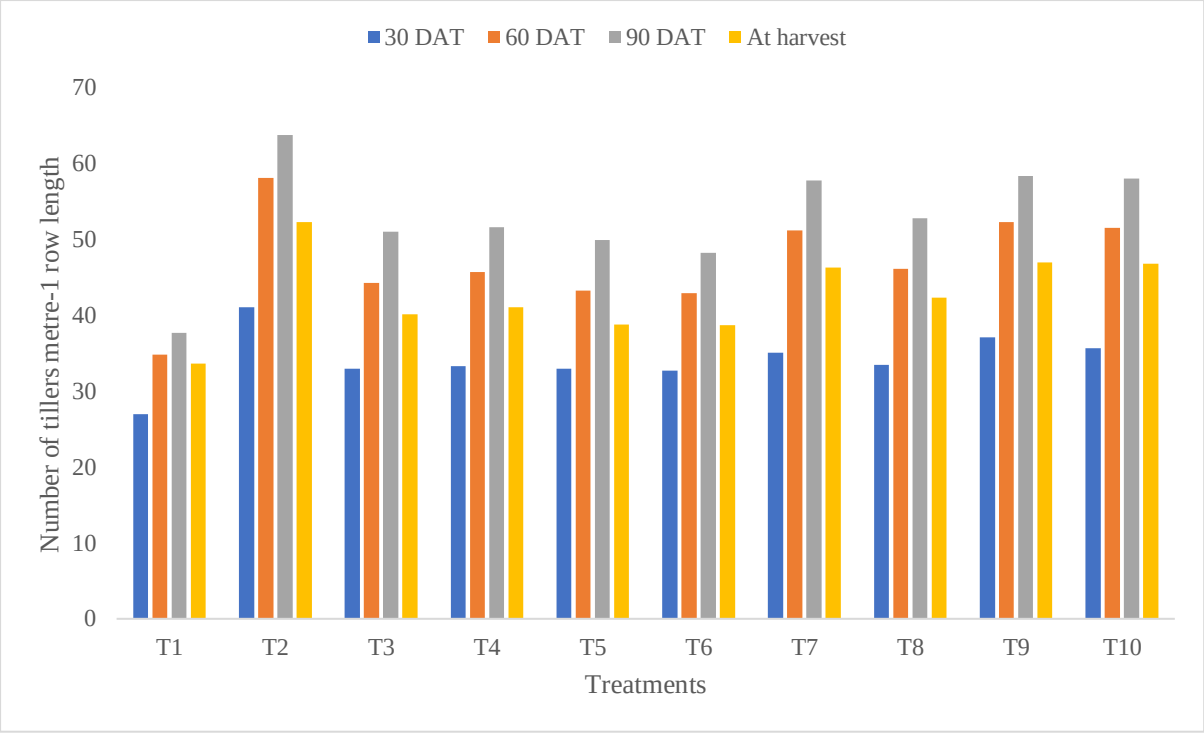

Fig. 2 Effect of weed management practices on no. of tillers metre^{-1} row length at different stages

The number of tillers per metre^{-1} row length and dry matter accumulation were also highest under the two hand weeding treatment. Generally, all plots where weeds were controlled through herbicides, cultural, or mechanical methods (alone or in combination) accumulated significantly higher dry matter in rice plants compared to the un-weeded control.

This increase is a direct result of effective weed suppression, which provided the rice plants with less competition for essential resources such as space, moisture, light, and nutrients. The higher dry matter accumulation was intrinsically linked to greater plant height and a higher number of tillers per metre. The increased foliage from more tillers enhanced the photosynthetic capacity of the crop, thereby driving greater biomass production. This physiological relationship confirms that effective weed control creates optimal conditions for tillering and photosynthetic efficiency. This conclusion aligns with the findings of Khaliq (2013), who also reported that reduced weed competition led to improved tillering and superior dry matter production in rice.

Table 3. Effect of weed management practices on yield attributes of rice

Treatments		Yield attributes			
		Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	1000 grains weight (g)
T_1	Absolute Weedy check	**18.32**	74	34	**17.10**
T_2	Two Hand weeding	**26.57**	106	16	**20.23**
T_3	Pyrazosulfuron @ 150g a.i. ha^{-1}	**22.32**	90	23	**19.80**
T_4	Ethoxysulfuron @ 25g a.i. ha^{-1}	**22.93**	92	22	**19.83**
T_5	Azimsulfuron @ 30g a.i. ha^{-1}	**21.65**	87	25	**19.93**
T_6	Penoxsulam @ 25g a.i. ha^{-1}	**21.12**	85	28	**19.90**
T_7	Pyrazosulfuron @ 150g a.i. ha^{-1} + Azimsulfuron @ 30g a.i. ha^{-1}	**24.07**	96	20	**20.05**
T_8	Pyrazosulfuron @ 150g a.i. ha^{-1} + Penoxsulam @ 25g a.i. ha^{-1}	**23.60**	94	21	**19.87**
T_9	Ethoxysulfuron @ 25g a.i. ha^{-1} + Azimsulfuron @ 30g a.i. ha^{-1}	**25.10**	102	18	**20.17**
T_{10}	Ethoxysulfuron @ 25g a.i. ha^{-1} + Penoxsulam @ 25g a.i. ha^{-1}	**24.33**	98	19	**20.10**
	SEm(±)	**0.84**	3.3	1.42	0.68
	C.D.(P=0.05)	**2.42**	**9.7**	**4.10**	**1.97**

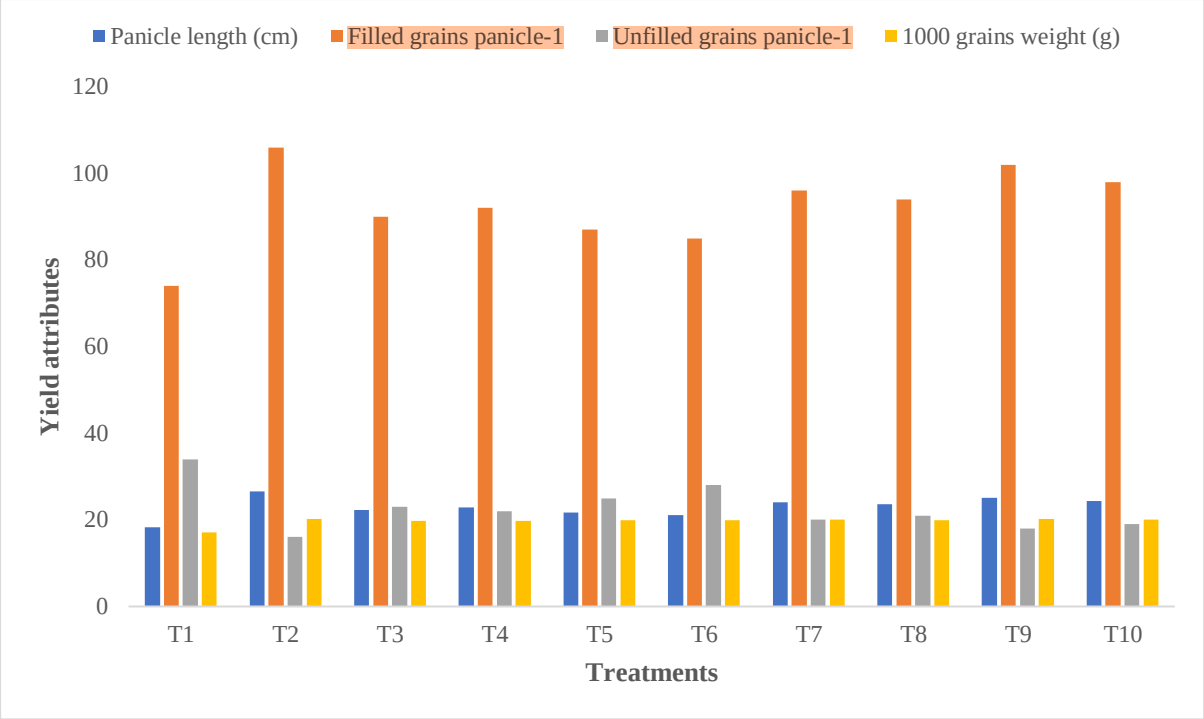

Fig. 3 Effect of weed management practices on yield attributing characters of rice

Panicle length, filled grains panicle^{-1} and test weight, was significantly influenced due to various weed management practices. Treatment Ethoxysulfuron @ 25g a.i. per ha + Azimsulfuron @ 30g a.i. per ha was found superior as compared to all other weed management plots except Pyrazosulfuron @ 150g a.i. per ha + Penoxsulam @ 25g a.i. per ha. Due to reduced crop-weed competition and better sink capacity performed a greater number of filled grains, panicle length and test weight. The yield attributes are decided by genetic makeup of the crop and variety, but the agronomic manipulation also mostly affects them. The reproductive growth depends on vegetative growth of plants. More vegetative growth increases the photosynthetic area and supply of photosynthetic toward sink which decides the yield attributes and ultimately the yield. The higher values of yield attributes were due to increased synthesis and translocation of metabolites for the panicle development and grain formation. Besides, thousand grain weights were also maintained because of high mobilization of photosynthesis from source to sink. However, this is quite possible because these combinations of herbicides might have been very effective to reduce the mixed weed density and their growth resulting in a better and congenial environment favored the rice plant to utilize nutrients, light, space luxuriantly and grew well to produce more fertile tillers. Rest of the treatments of weed management also proved to be significantly effective in producing higher number of effective tillers as compared

to un-weeded control under which the minimum tiller metre^{-1} row length was recorded. Similar results were noted by Sharma *et al.,* (2003) also confirmed the same.

Table 4. Effect of weed management practices on grains, straw, biological and harvest index (%) of rice

	Treatments	**Yield (q ha^{-1})**			Harvest index (%)
		Grains	Straw	Biological	
T_1	Absolute Weedy check	27.6	43.5	71.1	38.8
T_2	Two Hand weeding	44.8	60.2	105.0	42.7
T_3	Pyrazosulfuron @ 150g a.i. ha^{-1}	34.9	48.7	83.6	41.7
T_4	Ethoxysulfuron @ 25g a.i. ha^{-1}	35.1	49.0	84.1	41.7
T_5	Azimsulfuron @ 30g a.i. ha^{-1}	34.0	47.0	81.0	42.0
T_6	Penoxsulam @ 25g a.i. ha^{-1}	33.2	46.2	79.4	41.8
T_7	Pyrazosulfuron @ 150g a.i. ha^{-1} + Azimsulfuron @ 30g a.i. ha^{-1}	38.4	54.0	92.5	41.6
T_8	Pyrazosulfuron @ 150g a.i. ha^{-1} + Penoxsulam @ 25g a.i. ha^{-1}	36.2	48.6	84.8	42.7
T_9	Ethoxysulfuron @ 25g a.i. ha^{-1} + Azimsulfuron @ 30g a.i. ha^{-1}	43.4	58.0	101.4	42.8
T_{10}	Ethoxysulfuron @ 25g a.i. ha^{-1} + Penoxsulam @ 25g a.i. ha^{-1}	40.5	56.2	96.7	41.9
	SEm(±)	**1.3**	1.8	3.1	1.5
	C.D.(P=0.05)	**3.8**	**5.2**	**8.9**	**4.3**

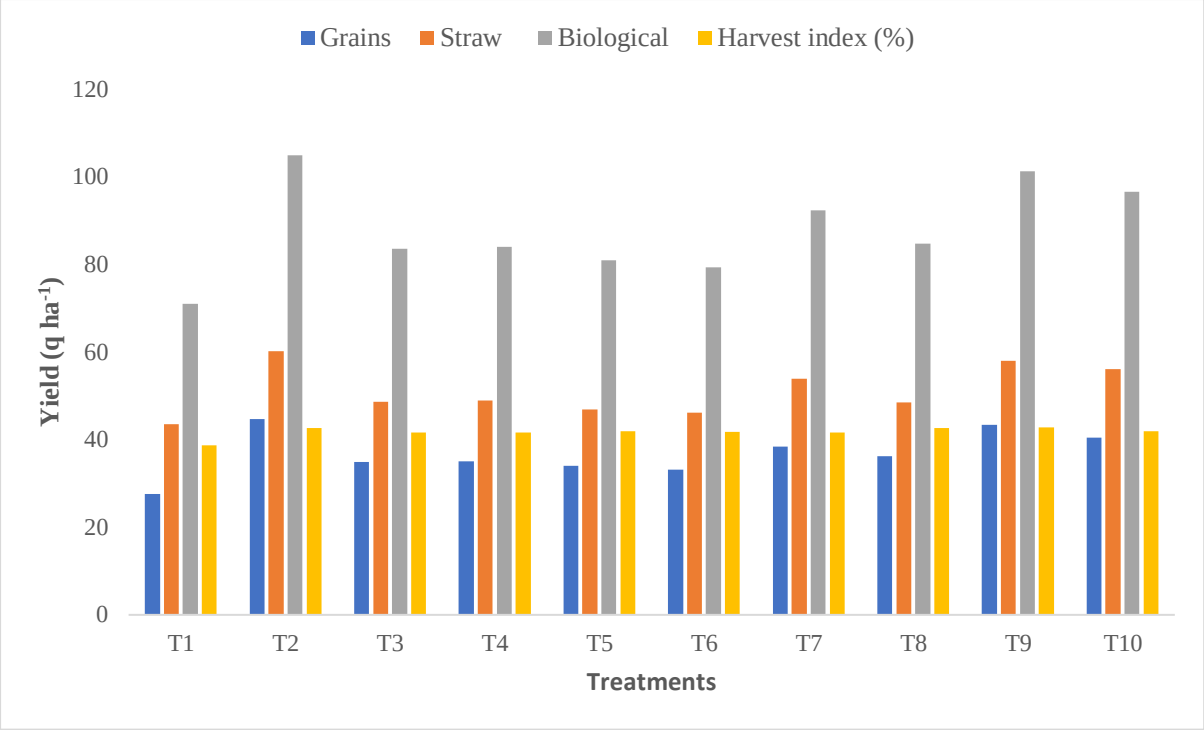

Fig. 4 Effect of weed management practices on grains, straw, biological and harvest index (%) of rice

The final yield of the crop was the cumulative effect of yield attributes and the factor which directly affected and/or indirectly influenced them. A crop can perform best only when the display of foliage on the ground surface was in such a manner that utilizes maximum natural resources. In our study, grain yield ha^{-1} was significantly influenced by the different herbicide management. Treatment two hand weeding was superior in relation to grain yield ha^{-1} followed by Ethoxysulfuron @ 25g a.i. per ha + Azimsulfuron @ 30g a.i. per ha plots. Among the herbicide Ethoxysulfuron @ 25g a.i. per ha + Azimsulfuron @ 30g a.i. per ha was superior in grain yield ha^{-1} and 57.2% higher grain yield over weedy check. This might be due to the higher crop growth of rice in terms of foliage, large amount of photosynthesis, which act as source and helped in developing yield attributes due to low crop weed competition and finally the higher grain yield Application of post emergence herbicide resulted in the highest grain yield (Bhowmick and Ghosh, 2006). The minimum grain yield was obtained from un-weeded control due to no control measure was adopted in this plot. Finding of present investigation agree with finding of Narwal (2002).

Higher straw yield was due to more accumulation of dry matter m^{-2} along with highest plant height, and number of tillers $plant^{-1}$. Treatment weed free produced 2.7% higher straw yield

over Ethoxysulfuron @ 25g a.i. per ha + Azimsulfuron @ 30g a.i. per ha due to better vegetative growth and more dry matter accumulation. The application of Ethoxysulfuron @ 25g a.i. per ha + Azimsulfuron @ 30g a.i. per ha was recorded straw yield (58.0 q ha^{-1}) which was (33.3%) higher as compared to weedy check plot. Similar patterns were observed in biological yield. This finding confirms the results of Singh (2013).

Conclusion

This study confirms that effective weed control is essential for maximizing the productivity of transplanted rice. Among the evaluated practices, the manual Two Hand weeding treatment (T_2) yielded the best results, achieving the highest plant height, tiller density, panicle length (26.57 cm), number of filled grains (106 $panicle^{-1}$), test weight (20.23 g), and a grain yield of 44.8 q ha^{-1}. However, the herbicide combination T_9, comprising a pre-emergence application of Ethoxysulfuron @ 25g a.i. ha^{-1} followed by a post-emergence application of Azimsulfuron @ 30g a.i. ha^{-1}, proved to be statistically on par with manual weeding for most key parameters. This chemical intervention resulted in excellent growth, superior yield attributes (25.10 cm panicle length, 102 filled grains $panicle^{-1}$, 20.17 g test weight), and a significantly high grain yield of 43.4 q ha^{-1}. This output was only marginally less than the manual method and a substantial 57.2% greater than the unweeded control. Consequently, this sequential herbicide application is recommended as a highly efficacious and sustainable integrated weed management strategy.

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