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ECONOMICAL WEED MANAGEMENT THROUGH EFFECTIVE HERBICIDES APPLICATION AND THEIR IMPACT ON SWEET SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH), SUCCEEDING GROUNDNUT CROP AND SOIL MICROORGANISMS

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ABSTRACT

Sweet sorghum, which is essential for producing energy and sugar, could help Egypt fulfill its growing sugar needs, but its low productivity is a result of poor agronomic techniques. Alongside sugarcane and sugar beet, improving these methods could increase its contribution. The aim of the research is to study Economical weed management through effective herbicide application and their phytotoxic impact on sweet sorghum [*Sorghum bicolor* (L.) Moench] succeeding groundnut crop and soil microorganisms. This experiment was conducted in the Department of Agronomy, College of Agriculture, Instructional Farm, Junagadh Agricultural University, Junagadh (Gujarat). The study used a randomized block design with three replications and ten treatments. The standard package of techniques was used to sow the sweet sorghum (SSV 84). Pre-emergence application (PE) of atrazine 50 WP 500 g/ha was one of the weed control treatments. Inter-cultivation and hand weeding (T₁) or post-emergence application (PoE) of 2,4-D (SS) 95 SP (T₂), halosulfuron-methyl 75 WG 60 g/ha (T₃), topramezone 33.6 SC 25 g/ha (T₄), clodinafop-propargyl 15 WP 60 g/ha (T₅), tembotrione 42 SC 100 g/ha (T₆), mesotrione + atrazine 44.97 SC (Premix) 875 g/ha (T₇), at 30 days after seeding (DAS), IC & HW at 15 and 30 DAS (T₈), Weed free check (T₉) and Unweeded control (T₁₀). Higher grain and fodder yield, reducing, non-reducing sugars and total sugar in juice were recorded under weed-free conditions (T₉), comparable to IC & HW at 15 and 30 DAS (T₈), PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS, (T₇) and PE application of atrazine 50 WP 500 g/ha + IC & HW (T₁). The maximum net realization, B:C ratio was achieved with PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS, (T₇), followed by atrazine 50 WP 500 g/ha as PE fb IC & HW at 30 DAS (T₁). Phytotoxicity observations at 3, 5, and 7 days after spraying revealed no visible injury in sweet sorghum with any pre- or post-emergence herbicide, except topramezone 33.6 SC at 25 g/ha and tembotrione 42 SC at 100 g/ha applied at 30 DAS. Both treatments showed a slight stunting or discolouration with a phytotoxicity rating of '1' on a 0–10 scale, likely due to temporary inhibition of the D1 protein in Photosystem II. The crop fully recovered within 25–30 days after spraying, and no stand loss was observed. According to field bioassay on groundnut crops, the aforementioned pre-emergence and post-emergence herbicides have no residual phytotoxicity.

Keywords : Sweet sorghum, Herbicide, Weed Management, Phytotoxicity.

Introduction

In India, sweet sorghum accounts only about 0.002 percent of all sorghum. Sorghum's high WUE and low N requirements also give growers significant advantages because it fits into a standard rotation system with corn and soybeans, has lower production costs, and uses similar equipment. Its ratooning ability enables many harvests every season, potentially expanding the sorghum agricultural region. Grain, bagasse, and stalk juice can be used to produce food, fodder, power, and ethanol. Because of these beneficial traits, Dar (2012) refers to it as a SMART crop. Due to its drought-resistant qualities, it is referred to as "the camel among crops" and the sugarcane of the desert (Sanderson *et al.*, 1992). These crucial features, in addition to its Sweet sorghum is a viable crop due to its compatibility for seed propagation, mechanized crop production, and equivalent ethanol production capacity to sugarcane and sugar beet is another method of producing ethanol.

Weeds are the most significant biotic factor limiting the output and productivity of sweet sorghum. According to Bitzer (1997), two of the primary parameters influencing the growth, sugar, and forage yields of sweet sorghum are plant density and weed control compared to 25% due to diseases, 20% due to insects, 15% owing to storage, and various pests, the presence of weeds in India generally lowers crop yields by 37–45% and in certain situations might result in total crop failure (Bahadur *et al.*, 2015). Weeds must be managed during crucial stages of the crop growth cycle to avoid yield losses (Knezevic *et al.*, 2002). According to Silva *et al.* (2014), weeds can typically cut sweet sorghum output by 50%. Chemical weed management is an essential component of contemporary crop production and a superior addition to traditional methods. Compared to other methods, it is faster, more efficient, and saves time and labour (Abbas *et al.*, 2018).

A number of variables, including crop stage, application time, and weed emergence pattern, affect how well chemical weed control techniques work (Tanveer *et al.*, 2019). One of the main risks to optimal crop production and global food security is crop yield loss caused by weed interference. Weed infestation is still one of the key issues limiting sorghum yield (Tuinstra *et al.*, 2009).

Therefore, the current study was conducted to evaluate the bioefficacy of various herbicides for cost-effective weed management in sweet sorghum [*Sorghum bicolor* (L.) Moench] and their residual effect on subsequent crops for more selective weed control in sweet sorghum.

Materials and Methods

Experimental Location

Thus, the current study was carried out to assess the bioefficacy of several herbicides for more specific weed control in sweet sorghum [*Sorghum bicolor* (L.) Moench] and their residual effect on succeeding crops for cost-effective weed management. Inter-cultivation and hand weeding (T1) or post-emergence application (PoE) of 2,4-D (SS) 95 SP (T2), halosulfuron-methyl 75 WG 60 g/ha (T3), topramezone 33.6 SC 25 g/ha (T4), clodinafop-propargyl 15 WP 60 g/ha (T5), tembotrione 42 SC 100 g/ha (T6), mesotrione + atrazine 44.97 SC (Premix) 875 g/ha (T7).

Herbicides were sprayed at 1 DAS for pre-emergence and at 30 DAS for inter-cultivation/post-emergence. A backpack sprayer with a flat fan nozzle and a 500 L/ha spray volume was used to apply all of the herbicides before and after emergence. The sweet sorghum was fertilized with 90-40-40 N-P₂O₅-K₂O kg/ha. The crop was supplied with urea (46% N), single super phosphate (16% P₂O₅, 12% S 21%, Ca), and potash muriate (K 60%), in that order. As a basal dressing, half of the total N, P, and K should be applied; the remaining N should be applied at 30 DAS. The JAU's suggestions were followed in the adoption of the remaining practice packages. Using a 0.25 m² quadrat, weed density and biomass were randomly recorded by category. To standardize the distribution of the weed density and biomass data, the square root transformation square root of (x+0.5) was applied. The efficacy of weed management was calculated using the approach recommended by Mani *et al.* (1973).

At harvest, every yield component was noted. After dividing gross returns by cultivation costs, the benefit-cost ratio was computed. As recommended by Panse and Sukhatme (1985), statistical analysis was performed on the crop and weed data.

Result and Discussion

Phytotoxicity scoring

Topramezone and tembotrione applied at 30 DAS showed slight stunting or discoloration in sweet sorghum with phytotoxicity rating of '1' (Table 1), which indicates slight stunting injury due to reduction in internodal length or discoloration in sweet sorghum. This may be due to inhibition of D₁ protein in photosystem-II in crop plants, which in turn stop the photosynthesis leading to slight stunted growth and discoloration but there was no stand loss and the crop fully recovered within 25-30 days. These results were in conformity with the finding of Galon *et al.* (2016) in sweet sorghum.

Effect on growth and yield

Among various weed management treatments, an experiment of data showed that the weed free check (T9) recorded significantly higher plant height at harvest in 2022–2023, 2023–2024, and in pooled results, respectively (Table 2). This was statistically comparable to the IC & HW at 15 and 30 DAS (T8). Weight of earhead (g), weight of green millable stalk (g), and extractability (kg/ha) of sweet sorghum (Table 3 and Table 4) were observed under the PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS (T7) and PE application of atrazine 50 WP 500 g/ha fb IC & HW at 15 and 24, as well as pooled results. Less weed density and weed dry weight under weed free check (T9) and all other treatments may be the result of periodic weed removal by hand weeding and interculturing, which may have maintained high soil fertility status and moisture content by reducing the removal of nutrients and water through weeds. The crop may have absorbed more nutrients and water as a result, increasing the rate of photosynthesis. The unweeded check (T10) had the lowest values of growth parameters and yield attributes due to intense weed competition for resources, which prevented the crop plant from absorbing enough moisture, nutrients, and light. As a result, growth was suppressed due to decreased photosynthesis and photosynthate partitioning. These results are consistent with those of Simarmata *et al.* (2017), Kumar *et al.* (2022), and Galon *et al.* (2016).

Effect on yield and quality parameters

Under weed-free check (T9), sweet sorghum yielded significantly more grain, fodder, and extractability (kg/ha), which stayed statistically comparable to the IC & HW at 15 and 30 DAS (T8), PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS (T7), and PE application of atrazine 50 WP 500 g/ha fb IC & HW at 30 DAS (T1) in 2022–23, 2023–24, and pooled results (Table 4 and Table 5). This could be due to increased nutrient availability as a result of weeds decreased competition, which led to increased grain and feed productivity.

In comparison to unweeded control and other herbicide treatments, the yield of sweet sorghum increased significantly when PE (atrazine) and PoE (mesotrione + atrazine 44.97 SC (Premix)) applied herbicides with broad spectrum activity on grasses and broad-leaved weeds, together with manual weeding and interculturing in the early and later stages. The unweeded control (T10) had the lowest yield and quality parameter values. The current results closely

resemble those that Lagoke (1986) reported using various weed management techniques by Mishra *et al.* (2012), Rao *et al.* (2013), Silva *et al.* (2014), Simarmata *et al.* (2017), Jantar *et al.* (2018), Saini *et al.* (2018), Mukherjee *et al.* (2019), Reis *et al.* (2019), Krishnamurthy *et al.* (2021), Kumar *et al.* (2022).

Effect on weed density and biomass

The unweeded control (T10) showed increased dry weight and weed density at harvest. The weed-free check (T9), which is statistically comparable to IC & HW at 15 and 30 DAS (T8), had the lowest weed density and dry weight of all the treatments. The PE application of atrazine 50 WP 500 g/ha + IC & HW (T1) comes next, and it is statistically equivalent to the PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS (T7) in 2022–2023 and 2023–24. This could be because the hydroxyphenylpyruvate dioxygenase (HPPD) enzyme inhibits carotenoid production, which in turn inhibits the synthesis of plastoquinone (PQ) in weeds by (Duke *et al.* (2000), Wichert *et al.* (1999), Takano *et al.* (2016), Simarmata *et al.* (2017).

Due to outstanding performance in controlling all weed categories, the weed free check (T9) had the best weed control effectiveness at harvest, followed by IC & HW at 15 and 30 DAS (T8). Following this, atrazine 50 WP 500 g/ha + IC & HW (T1) with higher WCE was applied PE-wise. Atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha was applied PE-wise at 30 DAS in 2022–23 and 2023–24, respectively (Table 7). This resulted in a higher yield because it controlled broad-spectrum weeds and decreased the total weed dry weight. The unweeded control (T10) had the lowest weed control efficacy and the highest weed index, indicating that the production of sweet sorghum grain and feed was decreased by unchecked weed development. Due to superior weed suppression and crop growth, the weed-free check (T9) had the highest weed management index (WMI), followed by T8. The WMI for treatments T7 and T1 (Table 7) was moderate, indicating good but marginally worse control. Ineffective weed control, which resulted in worse crop production, was probably the cause of T5 is lowest WMI.

Economics

The weed-free check (T9) yielded the highest gross returns, followed by IC & HW at 15 and 30 DAS (T8), according to the gross return statistics provided in Tables 8 and 9. The PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS was the next best treatment (T7). This may be because the average of the two years,

2022–2023 and 2023–2024, had higher seed and fodder yields, respectively.

Concerned results showed that the weed-free check (T₉) had the highest cultivation costs, followed by IC & HW at 15 and 30 DAS (T₈) because of the increased labor and bullock pair costs associated with manual weeding and interculturing. The next treatment with a higher cultivation cost was the PE application of atrazine 50 WP 500 g/ha fb IC & HW at 30 DAS (T₁), which incurred the cost of pre-emergence herbicides, manual labor costs for interculturing, and bullock charges for carrying out the necessary operations. This was followed by the PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS (T₇) because of the cost of pre-emergence and post-emergence herbicides.

The PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS, (T₇) in 2022-23, 2023-24, and average of both years, respectively, produced the highest net realization on average of both years (Table 9). This was followed by PE application of atrazine 50 WP 500 g/ha fb IC & HW at 30 DAS (T₁) in 2022-23, 2023-24, and average of both years, respectively. This may be the result of integrating pre- and post-emergence herbicides with hand weeding to effectively and efficiently control weeds.

The PE application of atrazine 50 WP 500 g/ha fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha at 30 DAS produced the highest B:C ratio among the various weed management treatments (T₇). This was followed by atrazine 50 WP 500 g/ha as PE fb IC & HW at 30 DAS (T₁), with B:C ratio in 2022–2023 and the average of both years, respectively. The unweeded control (T₁₀), on the other hand, had the lowest gross returns, net returns, cost of cultivation (sole common cost), and B:C ratio. This could be because of lower yields brought on by an overabundance of weeds. The findings are consistent with those of Krishnamurthy *et al.* (2021), Yadav *et al.* (2018), Verma *et al.* (2022), and Mitra *et al.* (2018).

Effect on microbial population

There is non-significant effect on the total microbial population (bacterial, fungi and actinomycetes) before sowing in 2022-23, 2023-24, and in the pooled results (Table 10).

Total microbial population at 20 days after application of PoE herbicides

As far as total bacterial, fungal and actinomycetes population in soil is concern, significantly highest total population in soil was observed in unweeded control

(T₁₀) which remained statistically at par with the treatments weed free check (T₉), IC & HW at 15 and 30 DAS (T₈). Minimum bacterial population was observed in all the herbicidal treated plots, which performed similarly to each other (Table 10).

Shortly after application of herbicides significant differences in population of soil microorganisms was noticed as compared to their population before herbicide application. Such inhibitory effect of herbicides used in the study persisted upto 30 days after spraying of herbicides in the crop with respect to either pre-emergence single herbicide or post-emergence herbicides. However, under sequential application of pre-emergence herbicide on 1 day after sowing followed by post-emergence spray on 30 days after sowing the effect of herbicides on soil microorganisms population extended beyond 30 days after spraying of herbicides in the crop.

Bioassay Studies

One important method for determining the persistent effect of herbicides both quantitatively and qualitatively is bioassay. This method uses indicator plants cultivated in a field to test a chemical's characteristic in terms of some biological responses, which are then compared to those of similar plants grown in untreated soil.

Residual effect on succeeding crop

The germination percentage (10 DAS) of the subsequent crop groundnut was found to be unaffected by the residual effects of various herbicides used in the sweet sorghum crop (Table 11). The findings unequivocally showed that various herbicides, such as atrazine 50 WP 500 g/ha pre-emergence and 2,4-D (SS) 95 SP 500 g/ha, halosulfuron-methyl 75 WG 60 g/ha as PoE at 30 DAS, topramezone 33.6 SC 25 g/ha, Clodinafop-propargyl 15 WP 60 g/ha, tembotrione 42 SC 100 g/ha, and fb mesotrione + atrazine 44.97 SC (Premix) 875 g/ha, did not leave any residual phytotoxic effects on the groundnut crop. Therefore, it is safe to plant groundnuts following the harvesting of sweet sorghum crops that have received pre-emergence and post-emergence treatments.

Riddle (2012), Sharma *et al.* (2013), Nazreen *et al.* (2018), Yadav *et al.* (2018), Singh *et al.* (2019), Siabusu *et al.* (2020), Rani *et al.* (2022), and Saimaheswari *et al.* (2022) findings are consistent with each other.

Conclusion

The two-year study finds that a PE application of atrazine 50 WP (500 g/ha) fb mesotrione + atrazine (875 g/ha) at 30 DAS can effectively control weeds

and produce profitable *rabi* sweet sorghum. As an alternative, when labor is available, atrazine 50 WP (500 g/ha) plus IC & HW at 30 DAS works well. It is safe for groundnut crops in the future because there is no residual phytotoxicity.

Table 1: Effect of different treatments on phytotoxicity symptoms of sweet sorghum after the spray of post-emergence Herbicides.

Treatments	2022-23					2023-24				
	1	3	5	7	10	1	3	5	7	10
T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	0	0	0	0	0	0	0	0	0	0
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	0	0	0	0	0	0	0	0	0	0
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	0	0	0	0	0	0	0	0	0	0
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	0	1	1	1	1	0	1	1	1	1
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	0	0	0	0	0	0	0	0	0	0
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	0	1	1	1	1	0	1	1	1	1
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	0	0	0	0	0	0	0	0	0	0
T ₈ : IC & HW at 15 and 30 DAS	0	0	0	0	0	0	0	0	0	0
T ₉ : Weed free check	0	0	0	0	0	0	0	0	0	0
T ₁₀ : Unweeded control	0	0	0	0	0	0	0	0	0	0

Table 2: Effect of different treatments on plant height and number of tillers per m² at harvest

Treatments	Plant height (cm) at harvest			No. of tillers per m ² at harvest		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	161.99	171.20	166.59	50.18	51.63	50.91
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	137.60	142.50	140.05	42.10	42.50	42.30
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	132.20	136.10	134.15	35.50	35.90	35.70
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	141.30	145.20	143.25	41.10	41.50	41.30
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	135.40	139.30	137.35	35.40	35.80	35.60
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	140.20	144.10	142.15	41.50	41.90	41.70
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	166.50	170.40	168.45	50.20	52.20	51.20
T ₈ : IC & HW at 15 and 30 DAS	190.00	193.90	191.95	54.50	54.90	54.70
T ₉ : Weed free check	198.00	201.90	199.95	54.70	55.10	54.90
T ₁₀ : Unweeded control	100.80	104.70	102.75	27.50	27.90	27.70
SEm ±	7.84	6.79	5.35	2.02	1.97	1.41
C.D. at 5%	23.29	20.17	15.34	5.99	5.85	4.04
C.V.%	8.76	8.76	8.58	8.08	7.76	7.92
Y x T						
SEm ±			7.56			1.99
C.D. at 5%			NS			NS

Table 3: Effect of different treatments on weight of earhead and weight of green millable stalk at harvest

Treatments	Weight of earhead (g)			Weight of green millable stalk (g)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	33.12	34.06	33.59	101.31	103.33	102.32
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	23.80	24.30	24.05	77.30	80.60	78.95
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	21.07	21.57	21.32	61.00	65.80	63.40
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	23.30	23.80	23.55	75.50	78.80	77.15
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	20.77	21.27	21.02	61.40	66.60	64.00
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	22.80	23.30	23.05	72.00	75.30	73.65
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	33.70	34.20	33.95	102.40	103.90	103.15

T ₈ : IC & HW at 15 and 30 DAS		34.70	35.20	34.95	104.50	107.80	106.15
T ₉ : Weed free check		35.50	36.00	35.75	106.00	110.50	108.25
T ₁₀ : Unweeded control		17.60	18.60	18.10	49.60	52.80	51.20
	SEm ±	1.28	1.22	0.88	3.57	3.74	2.59
	C.D. at 5%	3.81	3.62	2.54	10.60	11.12	7.41
	C.V.%	8.35	7.75	8.05	7.62	7.67	7.65
	Y x T						
	SEm ±				1.25		3.66
	C.D. at 5%				NS		NS

Table 4: Effect of different treatments on grain, dry fodder yield and harvest index at harvest

Treatments	Grain yield (kg/ha)			Dry fodder yield (kg/ha)			Harvest Index at harvest (%)			
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	
T ₁ : Atrazine 50 WP 500 g/ha as PE,fb IC & HW at 30 DAS	2253	2282	2267	8239	8322	8280	21.42	21.50	21.46	
T ₂ : Atrazine 50 WP 500 g/ha as PE,fb 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	1790	1969	1879	7247	7329	7288	19.88	21.16	20.52	
T ₃ : Atrazine 50 WP 500 g/ha as PE,fb Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	1568	1602	1585	6190	6272	6231	20.22	20.45	20.34	
T ₄ : Atrazine 50 WP 500 g/ha as PE,fb Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	1792	1974	1883	7174	7256	7215	20.05	21.35	20.70	
T ₅ : Atrazine 50 WP 500 g/ha as PE,fb Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	1561	1597	1579	6098	6180	6139	20.38	20.53	20.45	
T ₆ : Atrazine 50 WP 500 g/ha as PE,fb Tembotrione 42 SC 100 g/ha PoE at 30 DAS	1785	1967	1876	7145	7227	7186	19.94	21.38	20.66	
T ₇ : Atrazine 50 WP 500 g/ha as PE,fb Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	2272	2289	2281	8146	8261	8203	21.82	21.70	21.76	
T ₈ : IC & HW at 15 and 30 DAS	2321	2338	2330	8367	8129	8248	21.76	22.36	22.06	
T ₉ : Weed free check	2452	2469	2460	8443	8505	8474	22.48	22.42	22.45	
T ₁₀ : Unweeded control	1236	1296	1266	4707	4969	4838	20.84	20.71	20.82	
	SEm ±	96	101	69	290	305	211	0.82	0.52	0.67
	C.D. at 5%	285	299	199	862	907	604	NS	NS	NS
	C.V.%	8.73	8.81	8.77	7.01	7.30	7.16	6.84	4.01	5.57
	Y x T									
	SEm ±			98		298			0.66	
	C.D. at 5%			NS		NS			NS	

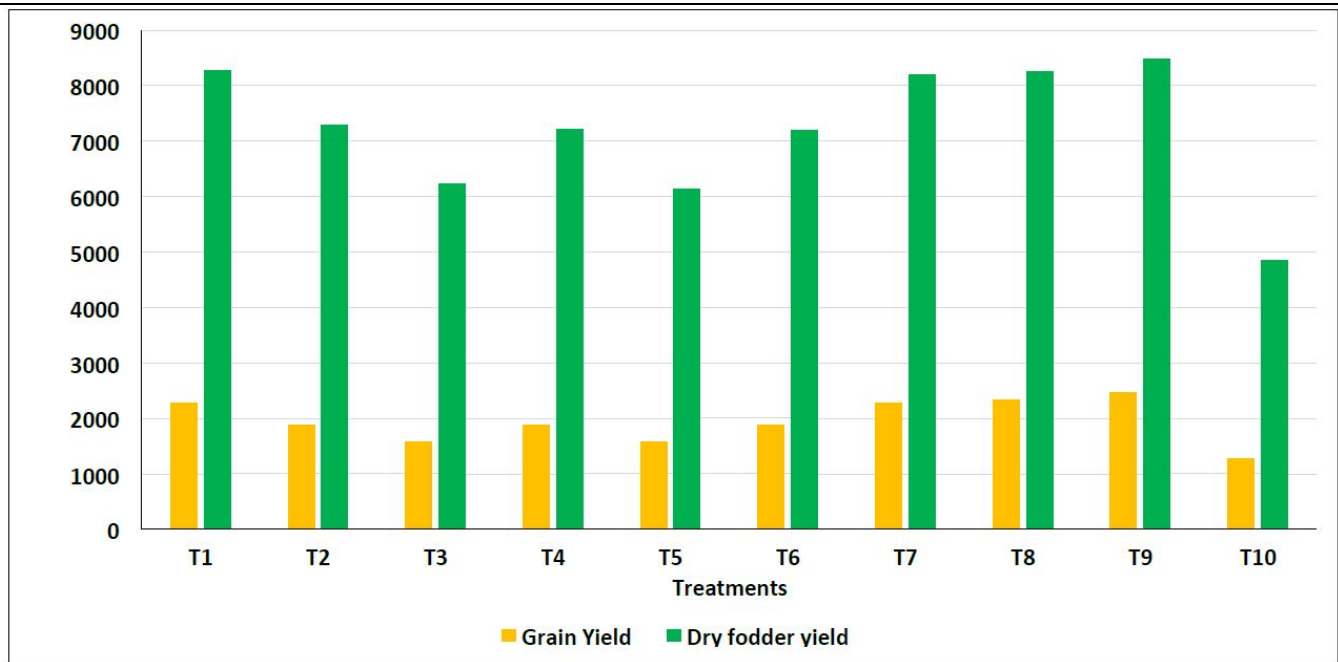


Fig. 1 : Effect of different treatments on grain yield and fodder yield at harvest (pooled)

Table 5: Effect of different treatments on extraction and extractability of sweet sorghum

Treatments	Extraction (%)			Extractability (kg/ha)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁ : Atrazine 50 WP 500 g/ha as PE fb IC & HW at 30 DAS	46.73	50.70	48.72	467.30	507.00	487.15
T ₂ : Atrazine 50 WP 500 g/ha as PE fb 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	38.50	41.40	39.95	385.00	414.00	399.50
T ₃ : Atrazine 50 WP 500 g/ha as PE fb Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	32.20	35.10	33.65	322.00	351.00	336.50
T ₄ : Atrazine 50 WP 500 g/ha as PE fb Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	37.40	40.30	38.85	374.00	403.00	388.50
T ₅ : Atrazine 50 WP 500 g/ha as PE fb Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	31.70	34.60	33.15	317.00	346.00	331.50
T ₆ : Atrazine 50 WP 500 g/ha as PE fb Tembotrione 42 SC 100 g/ha PoE at 30 DAS	36.40	39.30	37.85	364.00	393.00	378.50
T ₇ : Atrazine 50 WP 500 g/ha as PE fb Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	46.70	49.60	48.15	467.00	496.00	481.50
T ₈ : IC & HW at 15 and 30 DAS	46.70	49.40	48.05	467.00	494.00	480.50
T ₉ : Weed free check	48.50	51.20	49.85	485.00	512.00	498.50
T ₁₀ : Unweeded control	27.07	29.97	28.52	270.67	299.67	285.17
SEm ±	0.99	0.93	0.68	9.92	9.29	6.79
C.D. at 5%	2.95	2.76	1.95	29.47	27.59	19.49
C.V.%	4.38	3.82	4.09	4.38	3.82	4.09
Y x T						
SEm ±				0.96		9.61
C.D. at 5%				NS		NS

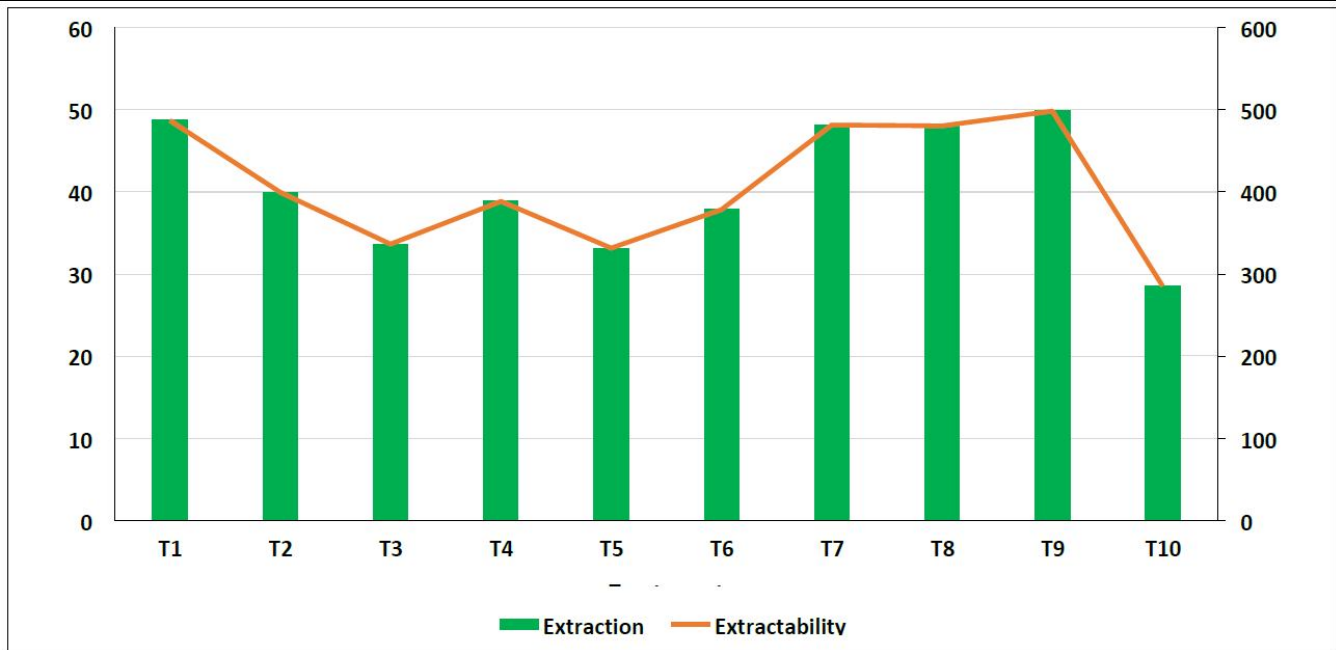


Fig. 2 : Effect of different treatments on extraction and extractability at harvest (pooled)

Table 6: Effect of different treatments on total weed density and dry weight at harvest

Treatments	At harvest			
	Weed density (No./m ²)		Weed dry weight (g/m ²)	
	2022-23	2023-24	2022-23	2023-24
T ₁ : Atrazine 50 WP 500 g/ha as PE fb IC & HW at 30 DAS	6.00 (39.17)	5.87 (34.78)	6.82 (46.22)	6.16 (40.69)
T ₂ : Atrazine 50 WP 500 g/ha as PE fb 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	8.63 (74.50)	8.32 (69.50)	9.17 (83.75)	8.83 (77.65)
T ₃ : Atrazine 50 WP 500 g/ha as PE fb Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	10.15 (102.90)	9.81 (96.20)	11.01 (121.54)	10.66 (113.58)
T ₄ : Atrazine 50 WP 500 g/ha as PE fb Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	8.76 (76.40)	8.43 (70.70)	9.28 (85.90)	8.91 (79.02)
T ₅ : Atrazine 50 WP 500 g/ha as PE fb Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	11.17 (124.30)	10.83 (116.80)	11.88 (140.76)	11.48 (132.08)

T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	8.61 (73.90)	8.33 (69.10)	9.10 (83.15)	8.81 (77.25)
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	6.54 (42.30)	6.09 (36.70)	7.05 (49.47)	6.56 (42.68)
T ₈ : IC & HW at 15 and 30 DAS	1.79 (2.70)	1.61 (2.10)	2.01 (3.53)	2.41 (5.31)
T ₉ : Weed free check	1.52 (1.80)	1.45 (1.60)	1.54 (1.88)	1.49 (1.72)
T ₁₀ : Unweeded control	14.30 (204.50)	14.05 (197.50)	15.31 (234.79)	15.09 (227.63)
SEm ±	0.48	0.40	0.43	0.52
C.D. at 5%	1.44	1.19	1.29	1.54
C.V.%	10.83	9.27	9.06	11.16

Table 7: Effect of different treatments on weed control efficiency (%) and weed index at harvest

Treatments	Weed Control Efficiency (WCE)		Weed Management Index (WMI)	
	2022-23	2023-24	2022-23	2023-24
T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	80.31	82.13	0.66	0.62
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	64.33	65.89	0.29	0.34
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	48.24	50.11	0.13	0.12
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	63.41	65.28	0.29	0.34
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	40.05	41.98	0.11	0.10
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	64.58	66.06	0.29	0.34
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	78.93	81.25	0.66	0.62
T ₈ : IC & HW at 15 and 30 DAS	98.50	97.67	0.86	0.79
T ₉ : Weed free check	99.20	99.25	0.98	0.90
T ₁₀ : Unweeded control	80.31	82.13	0.00	0.00

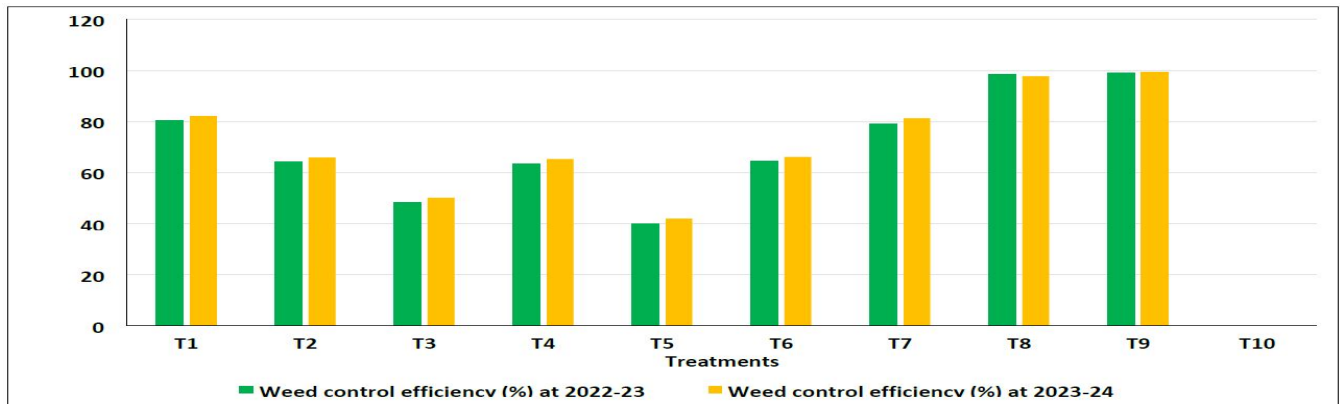


Fig. 3 : Effect of different treatments on weed control efficiency (2022-23) and (2023-24)

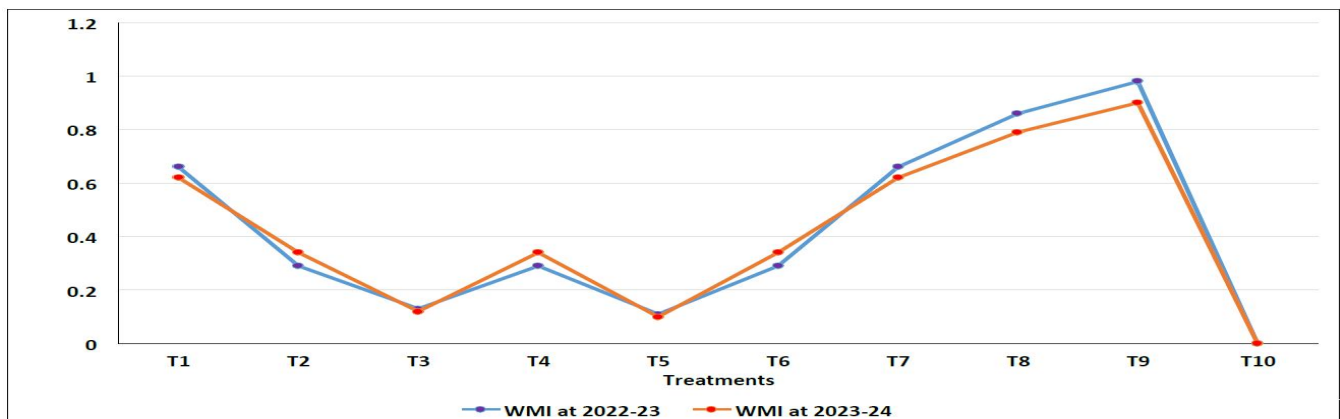


Fig. 4 : Effect of different treatments on weed management index at harvest (2022-23 and 2023-24)

Table 8: Economics of different treatment.

Treatments	Gross returns (Rs./ha)			Cost of cultivation (Rs./ha)		
	2022- 23	2023- 24	Average	2022- 23	2023- 24	Average
	T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	126102	127656	126879	44619	50898
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	102291	110592	106442	37977	43626	40802
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	89130	90906	90018	38108	43758	40933
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	102162	110598	106380	37935	43583	40759
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	88539	90405	89472	38836	44485	41661
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	101760	110196	105978	38259	43908	41084
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	126678	127788	127233	41419	47068	44244
T ₈ : IC & HW at 15 and 30 DAS	129546	129597	129572	58594	66202	62398
T ₉ : Weed free check	135669	136620	136145	62325	70283	66304
T ₁₀ : Unweeded control	69741	73227	71484	36207	41716	38962

Table 9: Economics of different treatment

Treatments	Net returns (Rs./ha)			B:C ratio		
	2022- 23	2023- 24	Average	2022- 23	2023- 24	Average
	T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	81483	76758	79121	2.83	2.51
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	64314	66966	65640	2.69	2.54	2.61
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	51022	47148	49085	2.34	2.08	2.21
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	64227	67015	65621	2.69	2.54	2.62
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	49703	45920	47812	2.28	2.03	2.16
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	63501	66288	64895	2.66	2.51	2.58
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	85259	80720	82990	3.06	2.71	2.89
T ₈ : IC & HW at 15 and 30 DAS	70952	63395	67174	2.21	1.96	2.08
T ₉ : Weed free check	73344	66337	69841	2.18	1.94	2.06
T ₁₀ : Unweeded control	33534	31511	32523	1.93	1.76	1.84

Table 10: Phytotoxicity of different herbicides on germination per cent of succeeding crops

Treatments	Groundnut			
	2022-23	2023-24	Pooled	
T ₁ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> IC & HW at 30 DAS	76.69	75.90	76.29	
T ₂ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	75.50	77.20	76.35	
T ₃ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	71.40	73.10	72.25	
T ₄ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	74.60	76.30	75.45	
T ₅ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	71.00	72.70	71.85	
T ₆ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Tembotrione 42 SC 100 g/ha PoE at 30 DAS	73.40	75.10	74.25	
T ₇ : Atrazine 50 WP 500 g/ha as PE <i>fb</i> Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	78.60	80.30	79.45	
T ₈ : IC & HW at 15 and 30 DAS	82.10	83.80	82.95	
T ₉ : Weed free check	83.40	85.10	84.25	
T ₁₀ : Unweeded control	70.80	72.50	71.65	
	SEm ±	3.13	2.97	2.01
	C.D. at 5%	NS	NS	NS
	C.V.%	7.15	7.70	7.44

Table 11: Effect of different treatments on pooled total microbial population before sowing, at 20 DAA and at harvest

Treatments	Before sowing			20 DAA		
	Bacteria ($\times 10^7$ CFU/g)	Fungi ($\times 10^3$ CFU/g)	Actinomy- cetes ($\times 10^3$ CFU/g)	Bacteria ($\times 10^7$ CFU/g)	Fungi ($\times 10^3$ CFU/g)	Actinomy- cetes ($\times 10^3$ CFU/g)
T ₁ : Atrazine 50 WP 500 g/ha as PE fb IC & HW at 30 DAS	24.11	21.81	28.05	21.45	19.95	25.15
T ₂ : Atrazine 50 WP 500 g/ha as PE fb 2,4-D (SS) 95 SP 500 g/ha as PoE 30 DAS	23.75	23.10	28.45	18.15	17.00	21.85
T ₃ : Atrazine 50 WP 500 g/ha as PE fb Halosulfuron- methyl 75 WG 60 g/ha as PoE at 30 DAS	23.95	22.40	27.95	18.35	16.30	22.25
T ₄ : Atrazine 50 WP 500 g/ha as PE fb Topramezone 33.6 SC 25 g/ha as PoE at 30 DAS	23.65	22.70	27.75	18.05	16.60	21.75
T ₅ : Atrazine 50 WP 500 g/ha as PE fb Clodinafop-propargyl 15 WP 60 g/ha as PoE at 30 DAS	24.95	23.20	28.35	18.68	17.10	21.55
T ₆ : Atrazine 50 WP 500 g/ha as PE fb Tembotrione 42 SC 100 g/ha PoE at 30 DAS	24.45	22.90	27.45	18.85	16.80	22.15
T ₇ : Atrazine 50 WP 500 g/ha as PE fb Mesotrione + Atrazine 44. 97 SC (Premix) 875 g/ha at 30 DAS	23.65	22.30	28.65	18.05	16.20	21.25
T ₈ : IC & HW at 15 and 30 DAS	24.65	23.50	27.85	24.38	23.17	29.25
T ₉ : Weed free check	24.15	23.30	28.15	25.45	23.90	30.15
T ₁₀ : Unweeded control	24.95	22.30	27.85	26.15	24.40	30.45
SEm \pm	0.44	0.42	0.46	0.41	0.31	0.43
C.D. at 5%	1.27	1.22	1.31	1.19	0.89	1.24
C.V.%	5.17	5.27	4.59	5.63	4.57	4.98

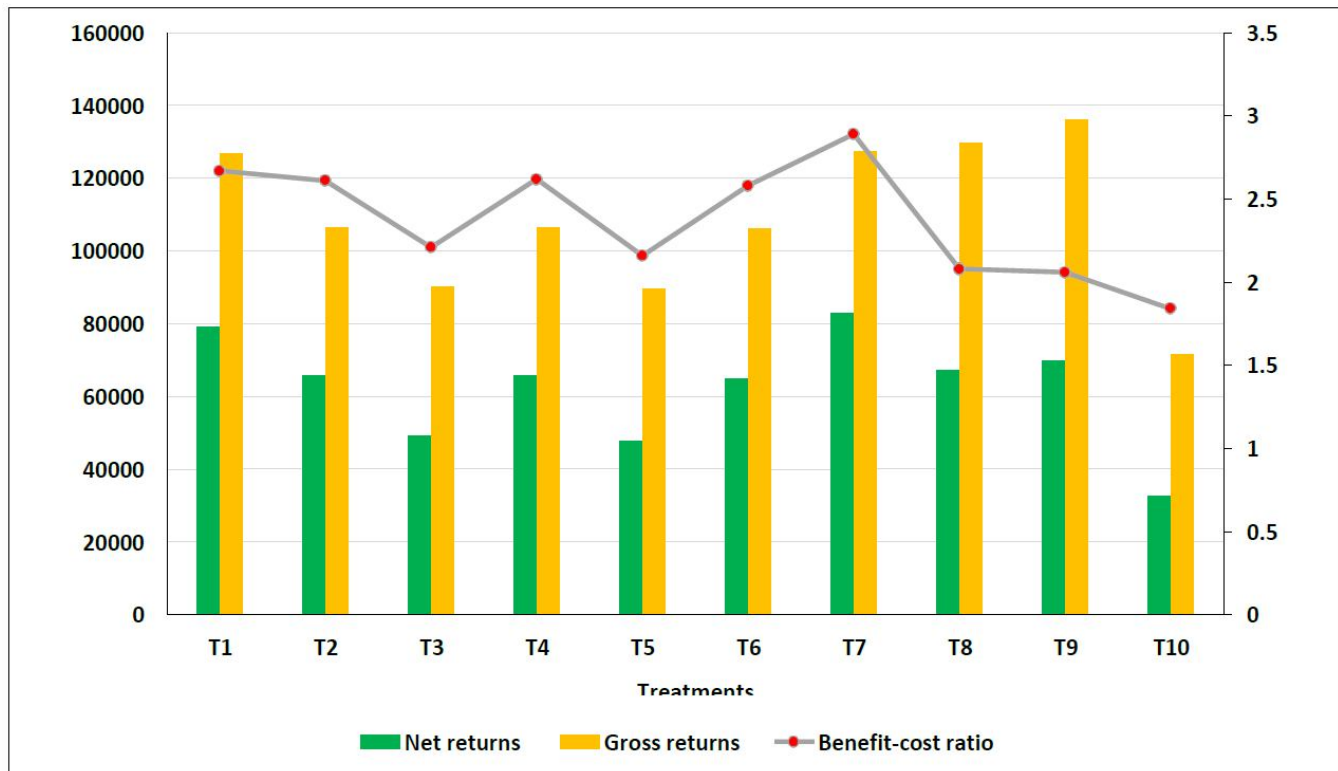


Fig. 5 : Effect of different treatments on gross returns (Rs./ha), net returns (Rs./ha) and B:C ratio at harvest (2022-23 and 2023-24)

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