



Effect of Integrated Weed Management Practices on Growth and Yield of Rabi Sorghum (*Sorghum bicolor*. L)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field study to "Evaluate the effect of new herbicide molecules in sorghum (*Sorghum bicolor* L.)" was conducted during Rabi season of 2023-24 at college farm, College of Agriculture, Professor Jayashankar Telangana Agriculture University, Rajendranagar, Hyderabad, Telangana. The experiment was laid out in randomized block design with twelve treatments each replicated thrice.

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The results revealed that weed free condition resulted to the highest growth parameters (plant height, dry matter production), yield attributing characters (number of ear heads per square meter, grains per ear head, ear head length, and 1000-grain weight), and maximum grain and stover yield (2830 & 6795 kg ha⁻¹) due to higher weed control efficiency of 93.21%, reduced weed density (2.67 No. m⁻²) and weed dry matter (3.00 g. m⁻²). Among the various weed management treatments, pre- emergence (PE) application of atrazine 0.5 kg a.i. ha⁻¹ followed by mechanical weeding (MW) at 30 DAS; post-emergence (PoE) ready mix (RM) application of halosulfuron methyl 5% + atrazine 48% WG @ 56.25+540 g a.i. ha⁻¹ followed by MW at 45 DAS and PoE application of halosulfuron methyl 5% + atrazine 48% WG@ 56.25+540 g a.i. ha⁻¹ recorded grain yields comparable to the weed free treatment. This implies that these treatments serve as effective alternatives for attaining comparable weed control and yield benefits to those of the weed-free treatment.

Keywords: Herbicides; pre-emergence; ready mix; sorghum; mechanical weeding; weed free.

1. INTRODUCTION

Sorghum (*Sorghum bicolor*), also called as king of millets, is a C4 plant that originated in Africa's semi-arid regions and is now grown in tropical and subtropical areas. It ranks as the fifth most important cereal crop globally, following rice, wheat, maize, and barley, due to its high nutritional value. In India, it is known as "Jowar" and is the fourth most important crop, especially in dryland farming. Sorghum is grown for food, animal feed, and biofuel production, making it a vital crop for both food and industry. It is better than maize and millets in tolerating salt, drought, and heat stress, making it crucial for food security in many developing countries, especially in Africa. It is also a key crop in arid regions, requiring less irrigation and thriving in hot summer conditions (Peerzada et al., 2017).

Sorghum grains are highly nutritious, containing 10.4% protein, 3.1% fat, 70.7% carbohydrates, and 2.0% crude fiber. The area under sorghum in India accounts 3.81 m ha, with a total production of 4.23 million metric tons and an average yield of 1110 kg ha⁻¹ (Directorate of Economics and Statistics, GOI 2022).

Weed pressure is high in sorghum due to its slow growth and low vigor during the first 20–25 days. However, as it matures, it forms a dense canopy, which helps it compete better with weeds in the later stages (Kaur et al., 2024). Uncontrolled weed growth in sorghum can cause yield losses ranging from 40 to 60% (Contreras et al., 2020).

Manual weeding and mechanical cultivation are the most common methods used for weed control in sorghum in tropical regions (Mishra et al., 2015). But these methods are expensive and labor-intensive. Integrating herbicides with

cultural practices or using a combination of pre-emergence and post-emergence herbicides along with mechanical methods can be more effective (Singh et al., 2019). However, chemical weed control is a better alternative to manual weeding as it is more cost-effective and saves labor.

Among herbicides, atrazine and 2,4-D are the most commonly used herbicides for grain sorghum cultivation. However, 2,4-D is selective for broad-leaved weeds, while atrazine is less effective against grasses and sedges, particularly under moisture stress conditions (Anju et al., 2023, Agricultural Statistics at a Glance 2022).

These days, new-generation and ready-mix herbicides are becoming popular. New-generation herbicides work well at low doses, target different types of weeds, have a shorter lifespan in the environment, and are less harmful to mammals. Ready-mix or pre-mix herbicides are pre-made products that combine two or more herbicides with different ways of working to control various weeds in a single application. So, the present study was taken up to evaluate the effectiveness of these novel herbicides and their integration with mechanical or manual weed management practices as a sustainable, long-term strategy for enhanced weed control, growth, and yield of sorghum, with minimal environmental impact.

2. MATERIALS AND METHODS

This experiment was conducted at college farm, College of Agriculture, Professor Jayashankar Telangana Agriculture University, Rajendranagar, Hyderabad, Telangana during Rabi season, 2023-24. The experimental site was situated at an altitude of 542.3 m above mean sea level, at 17° 19' 21" N latitude and 78°

24' 36" E longitude, within the Southern Telangana Agro-Climatic Zone, classified as part of the Semi-Arid Tropical (SAT) region. The soil texture was sandy loam with pH of 7.2, low in organic carbon of (0.54%), low available nitrogen of (191 kg ha⁻¹), high in available phosphorus of (48 kg ha⁻¹) and high available potash of (333 kg ha⁻¹). The experiment included twelve treatment combinations, laid out in a randomized block design with three replications each. Treatments include T1- atrazine 50% WP 0.50 kg a.i. ha⁻¹ as PE, T2- pyroxasulfone 85% WG @ 95.625 g a.i. ha⁻¹ as PE, T3- pyroxasulfone 85% WG @ 95.625 g a.i. ha⁻¹ as PE fb topramezone 336 g l⁻¹ as PoE, T4- pyroxasulfone 85% WG @ 95.625 g a.i. ha⁻¹ as PE fb halosulfuron methyl @ 50.625 g a.i. ha⁻¹ as PoE, T5- atrazine 50% WP @ 0.50 kg a.i. ha⁻¹ as PE fb MW at 30 DAS, T6- pyroxasulfone 85% WG @ 95.625 g a.i. ha⁻¹ as PE fb MW at 30 DAS, T7- topramezone 10 g l⁻¹ + atrazine 300 g l⁻¹ SC (RM) @ 581 g a.i. ha⁻¹ as PoE, T8- topramezone 10 g l⁻¹ + atrazine 300 g l⁻¹ SC (RM) @ 581 g a.i. ha⁻¹ as PoE fb MW at 45 DAS, T9- halosulfuron methyl 5% + atrazine 48% WG (RM) @ 56.25+540 g a.i. ha⁻¹ as PoE, T10- halosulfuron methyl 5% + atrazine 48% WG (RM) @ 56.25+540 g a.i. ha⁻¹ as PoE fb MW at 45 DAS, T11- weed free (MW at 20 & 40 DAS + intra row HW), T12- weedy check. The crop was sown on 16th Oct, 2023, with a spacing of 45 cm x 15 cm. A total of 100 kg ha⁻¹ N, 60 kg ha⁻¹ of P₂O₅ and 40 kg ha⁻¹ K₂O was applied as the recommended fertilizer dose (RDF) following PJTAU guidelines, using urea, single superphosphate, and muriate of potash as source. Nitrogen was supplied in three splits at the time of sowing (basal), knee high stage and during flowering stage using the pocketing method, while the entire quantities of phosphorus and potassium were applied at the time of sowing. The weekly mean maximum temperature ranged between 27.7 and 34.3 °C, with an average of 31°C, throughout the crop growth period, while the weekly mean minimum temperature ranged from 15.3 to 21.1°C, with an average of 18.2°C. In terms of relative humidity, the weekly mean RH-I (morning) ranged from 81 to 90 % with an average of 85.5 %, while the RH-II (afternoon) ranged from 21 to 62 %, with an average of 41.5 %. The weekly mean bright sunshine hours per day ranged from 3.5 to 9.3 hours per day with an average of 6.4 hours.

There was a total of 13.4 mm of rainfall over one rainy day received during the crop growth period. Weekly mean evaporation ranged from 2.9 to 5.6 mm per day, with an average of 4.25 mm per

day. The effect of various weed management practices on growth parameters (plant height, dry matter production, days to ear head initiation and maturity) and yield attributes (number of earheads per square meter, grains per earhead, earhead length, and 1000-grain weight) were recorded following standard procedures and results from the studied parameters were statistically analyzed and interpreted according to the methodology outlined by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1 Phytotoxicity

Among various herbicidal treatments, pyroxasulfone as pre-emergence (PE) and combination of topramezone + atrazine as post-emergence (PoE) treatments have shown phytotoxic effects on sorghum. Pyroxasulfone 85% WG @ 95.625 g a.i. ha⁻¹ as PE significantly impacted germination, resulting in subsequent stand loss with phytotoxicity rating of 7 (Bhutada et al. 2022). Affected plants exhibited chlorosis (yellowing), necrosis (tissue death), and stunting. Symptoms of chlorosis and necrosis resolved by 21 days after application (DAA), while stunting persisted until harvest. Similarly, topramezone 10 g l⁻¹ + atrazine 300 g l⁻¹ SC (RM) @ 581 g a.i. ha⁻¹ as PoE treatment also led to chlorosis and stunting with phytotoxicity rating of 2-3 (Krishnamurthy et al. 2021). Although plants recovered fully from chlorosis 14 DAA, stunting remained until harvest.

3.2 Growth Parameters

3.2.1 Plant height (cm)

Among various treatments, significantly taller plants (216 cm), were observed under weed free (T11) and it was on par with T5- atrazine 50% WP 0.50 kg a.i. ha⁻¹ as PE fb MW at 30 DAS, T10- halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE fb MW at 45 DAS, T1- atrazine 50% WP 0.50 kg a.i. ha⁻¹ as PE, T9- halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE and T8- topramezone 10 g l⁻¹ + atrazine 300 g l⁻¹ SC (RM) 581 g a.i. ha⁻¹ as PoE fb MW at 45 DAS (Fig. 1). Except for the phytotoxicity-affected treatments, such as pyroxasulfone PE (T2, T3, T4 and T6) and topramezone + atrazine

(RM) PoE (T8), the lowest plant height (178 cm) was observed in the unweeded control (T12). This was due to intense competition for resources between the crop and weeds, resulting in reduced internodal length and less translocation of photosynthates compared to other treatments. Similar results were reported by Patel et al. (2014) and Prasanna et al. (2020).

3.2.2 Dry matter production (kg ha⁻¹)

Weed free treatment recorded higher dry matter accumulation compared to all other treatments and it was on par with T5- atrazine 50% WP 0.50 kg a.i. ha⁻¹ as PE fb MW at 30 DAS, T10- halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE fb MW at 45 DAS and T9- halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE (Fig. 2). This was due to effective weed control during the critical period of crop-weed competition through herbicides or mechanical weeding. These methods improve soil aeration, enhance nutrient uptake, and reduce weed competition, allowing sorghum to grow more vigorously and utilize resources efficiently. In

contrast, the application of atrazine + topramezone at PoE (ready mix), resulted in lower crop growth despite achieving higher weed control efficiency. This reduction in growth can be attributed to the occurrence of phyto-toxicity, which negatively impacted the growth and yield of sorghum. These results are consistent with the findings of Krishnamurthy et al. (2021) in sorghum. Weedy-check treatment (T12) recorded lowest dry matter production due to higher crop- weed competition.

3.3 Yield Attributes

Yield attributes, such as the number of earheads per square meter, grains per earhead, earhead length, and 1000-grain weight, were registered higher with weed free which was found on par with atrazine 0.5 kg a.i. ha⁻¹ as PE fb MW at 30 DAS, halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE fb MW at 45 DAS and halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE (Table 1). This may be due to increased dry matter accumulation and improved translocation of photosynthates from the source to the sink.

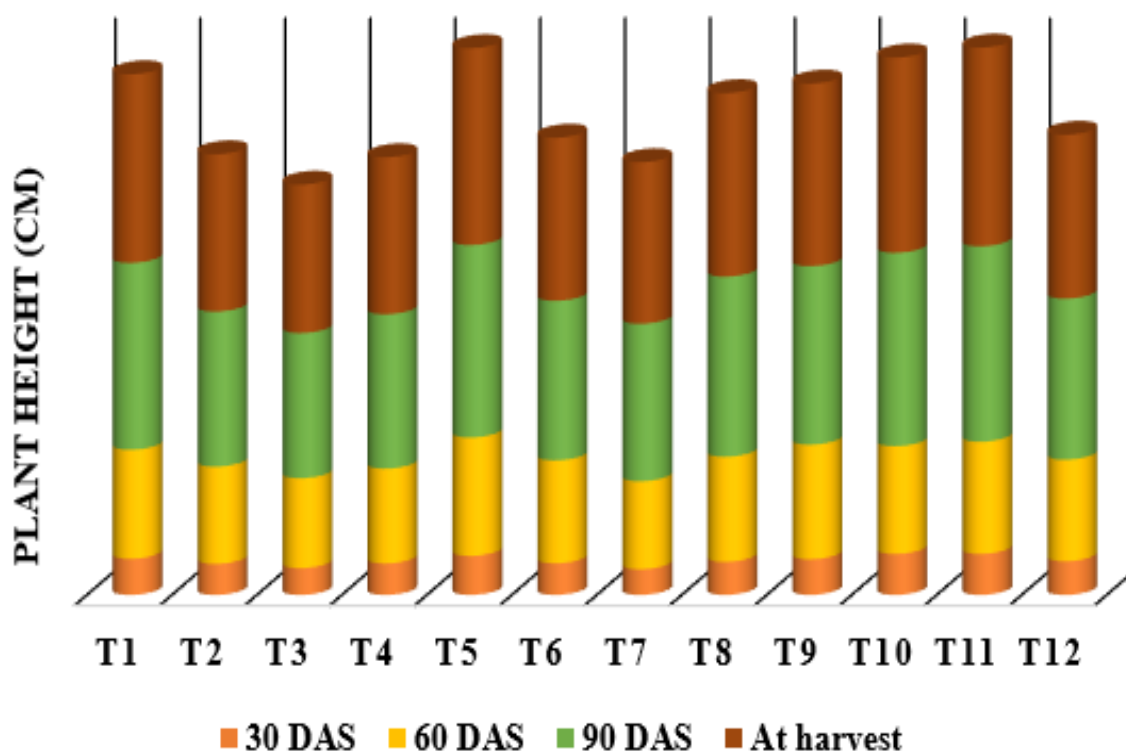


Fig. 1. Bar graph showing plant height measurement

Table 1. Yield attributes and yield of sorghum as influenced by various weed management practices

Treatments		No of earheads m ⁻²	Earhead length (cm)	No. of grains earhead ⁻¹	Test weight(g)	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index
T1	Atrazine 50% WP 0.50 kg a.i. ha ⁻¹ as PE	12	14.4	755	24.5	2125	5177	29.10
T2	Pyroxasulfone 85% WG 95.625 g a.i. ha ⁻¹ as PE	6	14.0	289	23.94	430	1105	28.01
T3	Pyroxasulfone 85% WG 95.625 g a.i. ha ⁻¹ as PE <i>fb</i> topramezone 336 g/lit PoE	5	14.0	198	23.55	380	948	28.61
T4	Pyroxasulfone 85% WG 95.625 g a.i. ha ⁻¹ as PE <i>fb</i> halosulfuron methyl 50.625 g a.i./ha as PoE	6	14.7	222	24.00	453	990	31.39
T5	Atrazine 50% WP 0.50 kg a.i. ha ⁻¹ as PE <i>fb</i> MW at 30DAS	17	16.9	907	25.36	2792	6596	29.74
T6	Pyroxasulfone 85% WG 95.625 g a.i. ha ⁻¹ as PE <i>fb</i> MW at 30 DAS	6	13.3	316	24.05	485	1078	31.03
T7	Topramezone 10 g l ⁻¹ + atrazine 300 g l ⁻¹ SC (RM)581 g a.i. ha ⁻¹ as PoE	13	16.2	795	24.15	2216	5217	30.00
T8	Topramezone 10 g l ⁻¹ + atrazine 300 g l ⁻¹ SC (RM)581 g a.i. ha ⁻¹ as PoE <i>fb</i> MW at 45 DAS	14	16.3	817	24.87	2480	5759	30.10
T9	Halosulfuron methyl 5% + atrazine 48% WG (RM)56.25+540 g a.i. ha ⁻¹ as PoE	16	15.8	856	24.45	2593	6188	29.53
T10	Halosulfuron methyl 5% + atrazine 48% WG (RM)56.25+540 g a.i. ha ⁻¹ as PoE <i>fb</i> MW at 45 DAS	17	16.8	861	24.98	2656	6347	29.50
T11	Weed free (MW at 20 & 40 DAS + intra row HW)	18	17.9	942	25.62	2830	6795	29.40
T12	Weedy check	8	13.1	352	23.39	680	1600	29.82
	S.Em ±	0.6	0.7	32.3	0.92	93.3	242.5	1.47
	CD	2.0	2.1	94.8	NS	273.7	711.2	NS

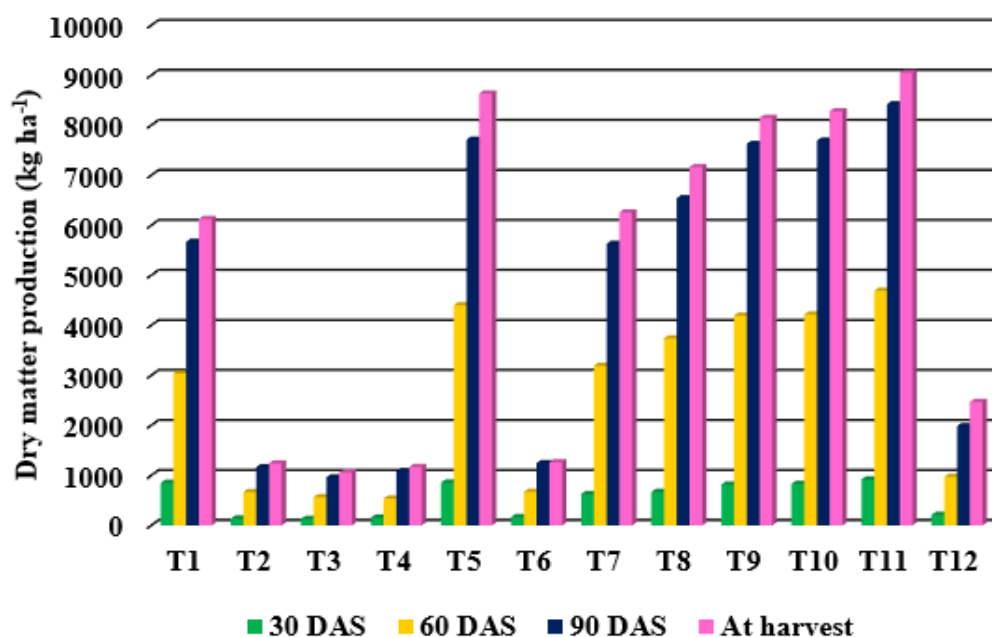


Fig. 2. Bar graph showing dry matter production

3.4 Grain and Stover Yield (kg ha⁻¹)

The experimental findings revealed that, maximum grain and stover yield was registered with weed free *i.e.*, (2830 & 6795 kg ha⁻¹, respectively (Table 1)). Among the herbicides, atrazine 0.5 kg a.i. ha⁻¹ as PE *fb* MW at 30 DAS, halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE *fb* MW at 45 DAS and halosulfuron methyl 5% + atrazine 48% WG (RM) 56.25+540 g a.i. ha⁻¹ as PoE had recorded higher grain and stover yield and on par with weed free treatment. The higher yields achieved with the combination of halosulfuron methyl 5% + atrazine 48% WG (RM) as post-emergence (PoE) treatments result from their effective weed control during the critical period of crop-weed competition, which enhances growth and yield attributes.

When atrazine PE is combined with mechanical weeding (MW), there is a significant improvement in plant height, dry matter accumulation, and grain yield compared to using atrazine PE alone. These findings align with those of Kaushik et al. (2005). Mechanical weeding at 30 days after sowing (DAS) and 45 DAS helps keep the crop free from weeds for a longer time, which improves soil aeration and ultimately boosts growth and yield. This practice also enhances the effectiveness of both atrazine

and the halosulfuron methyl 5% + atrazine 48% WG (RM) combination.

Lower grain and stover yield were recorded in pyroxsulfone treatments (T2, T3, T4 & T6) due to their phytotoxicity effect on sorghum germination and same was reported by Bhutada et al. (2022) in sorghum. This led to a decreased plant stand, subsequently impairing growth and development, which ultimately resulted in overall lower yields.

4. CONCLUSION

Among all the weed management treatments, PE application of atrazine @ 0.5 kg a.i. ha⁻¹ followed by mechanical weeding (MW) at 30 DAS or halosulfuron methyl 5% + atrazine 48% WG (RM) @ 56.25 + 540 g a.i. ha⁻¹ as PoE with or without MW at 45 DAS controlled the weeds effectively in yellow sorghum and were at par with weed free treatment. These practices can be recommended to farmers for effective weed control and higher yields.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-

image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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