Advanced Natural Sciences: Life and Health Sciences,
ISSN: 3107-636X, Vol-2, Issue-1, June-2025, PP-26-32
https://indjournals.com/index.php

Original Research

Comparative Analysis of glyphosate as an ideal weed controller in sugarcane crop

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Article Info

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[Received 10-04-2025,
Modified 11-05-2025,
Accepted 25-06-2025,
Published 30-06-2025]

Abstract

Effective weed management is essential for ensuring the profitability of sugarcane cultivation, as weeds compete with the crop for vital resources such as moisture, nutrients, and sunlight throughout the growing season. Taller sugarcane plants have demonstrated a greater tolerance to glyphosate-based herbicides. A significant aspect of the present study was the strategic application of herbicides four months after planting, a stage at which sugarcane appears to exhibit increased resistance to herbicidal stress.

As presented in Table 2, the post-emergence application of herbicides resulted in varying degrees of weed suppression, measured in terms of dry weight. The treatment yielding the most effective control showed a reduction in weed biomass to 38.8 g/m², in contrast to the untreated control, which recorded a significantly higher weed biomass of 105 g/m². Specific herbicidal treatments, such as 2,4-D sodium salt and Metribuzin, resulted in weed dry weights of 65.9 g/m² and 61.2 g/m², respectively, while Paraquat was less effective, yielding 83.3 g/m².

Previous research indicates that early application of herbicides such as glyphosate—particularly within the first 90 days after planting—can negatively affect sugarcane yield. However, findings from the current study suggest that when applied at an appropriate growth stage, glyphosate demonstrates superior efficacy in controlling weed populations compared to other herbicidal treatments.

Conclusion:

The study concludes that glyphosate is a highly effective post-emergence herbicide for weed control in sugarcane cultivation. Its application, particularly after the initial growth phase, may provide efficient and selective weed management without adversely affecting crop performance.

Keywords: Weed, sugarcane, glyphosate, herbicides, Paraquat, Metribuzin, 2,4-D sodium salt.

Cite this article: Rajiv Chalwad and VV Gaikwad, 2025 Comparative Analysis of glyphosate as an ideal weed controller in sugarcane crop, Advanced Natural Sciences: Life and Health Sciences, ISSN: 3107-636X,Vol-2, Issue-1, 2025, PP-26-32, https://indjournals.com/index.php

Introduction

Sugarcane (*Saccharum officinarum* L.) ranks among the world's most vital cash crops, cultivated extensively across approximately 58 countries, covering an estimated 26.9 million hectares globally. While its primary economic value lies in sugar production, sugarcane serves as a highly versatile raw material, supporting a wide array of industrial and commercial applications. These include the production of fiber, biofuels, chemicals, and numerous industrial commodities such as alcohol, furfural, dextran, chipboard, paper, beverages, confectioneries, plastics, paints, synthetic materials, pharmaceuticals, enzymes, pesticides, and detergents.

Effective weed management remains a cornerstone of profitable sugarcane cultivation, as weeds compete vigorously for vital resources—moisture, nutrients, and sunlight—throughout the crop's growth cycle, thereby hampering yield potential. Research consistently highlights the pivotal role of herbicides in optimizing productivity. For instance, Sharma and Tomar [10] reported that pre-emergence application of Atrazine at 1 kg/ha, supplemented by post-emergence treatments, boosted cane yields from 52.84 t/ha to 74.63 t/ha. Complementary findings by Sharma [11] indicated that integrating pre-emergence herbicide application with a single intercultural operation at 75–80 days post-planting enhanced yields by 106% to 124% compared to untreated plots—levels comparable to those achieved with two manual hoeings (116.5%).

Likewise, Syed and Shahid [12] emphasized that pre-emergence herbicide use is less phytotoxic, more effective, economical, and labor-saving. Notably, Gesapax Combi demonstrated substantial efficacy when applied before crop emergence. Similarly, Raskar [13] observed that combining a pre-emergence application of Metribuzin (1.5 kg/ha) with a post-emergence application of 2,4-D sodium salt (1 kg/ha) significantly suppressed weed infestation.

Globally, herbicide adoption has become indispensable to sugarcane weed control strategies due to multiple factors:

1. The dwindling availability and rising costs of manual labor,
2. The limited effectiveness of traditional weed management practices,
3. The inability of conventional methods to control early-season weed growth without additional mechanical operations, and
4. The increasing complexity, time demands, and costs associated with manual and mechanical weeding techniques.

Characteristics of the herbicide glyphosate

Sugarcane cultivation poses significant weed management challenges due to the crop's lengthy growth duration and wide spacing between rows, which favor weed proliferation. To address these challenges effectively, an integrated strategy that combines cultural, mechanical, and chemical control measures is typically employed. Among chemical options, glyphosate remains one of the most extensively used systemic herbicides. It is primarily absorbed through the leaf surface and then translocated throughout the plant, reaching the foliage, growing tips, and underground organs [14].

As noted by [15], the efficiency of glyphosate uptake is influenced by various factors, including the plant's growth stage, environmental conditions, the addition of surfactants, and the herbicide's soil concentration. Glyphosate is widely regarded as one of the least hazardous agrochemicals in modern agriculture [16]. When applied in accordance with recommended protocols, glyphosate-based products pose minimal risk to human health and demonstrate low toxicity [17].

Nonetheless, despite its relatively low toxicity profile, glyphosate remains a powerful chemical, and its excessive or improper use can result in ecological harm by negatively impacting non-target species through direct contact or indirect environmental pathways [18]. Presently, glyphosate is approved for agricultural use in over 130 countries, employed to manage more than 300 weed species across more than 100 cropping systems [19], solidifying its status as the most extensively used herbicide worldwide [20]. Moreover, over 150 commercially available glyphosate-based formulations are registered globally [21].

A key factor in maximizing glyphosate's effectiveness is the developmental stage of the target plant. Studies indicate that the ideal application window is when plants reach a height of 40 to 80 centimeters, ensuring sufficient leaf area for optimal herbicide interception [22]. Taller plants often exhibit greater inherent tolerance to glyphosate [23], and once culm (stem) development begins, plants tend to become more resistant to its herbicidal effects [24].

Objective: This study assessed the efficacy of various post-emergence herbicides in managing weed populations in sugarcane fields, with the aim of identifying the most effective treatment strategies. The results were systematically documented to support a comparative analysis. Selective herbicide application has shown considerable promise in reducing competition between crops and weeds over extended periods, ultimately contributing to increased cane yield.

However, the exclusive use of a single herbicide may not provide sufficient weed control in sugarcane cultivation. This is primarily due to the diverse weed flora present and the prolonged weed emergence pattern, which involves multiple flushes throughout the crop cycle. Hence, an integrated approach combining pre-emergence and post-emergence herbicides is recommended.

Specifically, pre-emergence applications of Sencor at 2 L/ha, Atrazine at 2.0 L/ha, and Diuron at 3.0 kg/ha, followed by a post-emergence application of Roundup (Glyphosate 480 g/L) at 2 L/ha, have proven effective in controlling grassy weeds. Additionally, Velpar 75 DF, applied at 700 g or 1 kg per hectare depending on soil type (sandy or sandy clay loam), has demonstrated efficacy in achieving broad-spectrum weed suppression in sugarcane fields [25].

Field Experiment

Impact of Glyphosate Application on Commercial Sugarcane Cultivar

The effectiveness of glyphosate application was evaluated on the commercial sugarcane cultivar *MS10001*, which is noted for its exceptional tillering ability and yields—producing 38.69% more cane and achieving a 35.69% higher commercial cane sugar (CCS) yield compared to the early-maturing standard check variety *VSI 434*, which typically matures within 10–12 months. This field study was conducted on a privately owned farm in Ashta, Taluka Chakur, Maharashtra, India.

The experiment comprised five treatments: four herbicidal applications—glyphosate, paraquat, 2,4-D sodium salt, and metribuzin—plus an untreated control. The site's soil was classified as clay loam with relatively low organic matter (0.57%) and nutrient levels of 198.8 kg/ha nitrogen (N), 19.5 kg/ha phosphorus (P), and 221.4 kg/ha potassium (K). The soil pH was slightly alkaline at 7.9. Each treatment plot covered one hectare, with 1.5-meter spacing between plots to prevent cross-contamination.

Nutrient management practices included the application of 350 kg/ha of urea and a basal dose of 300 kg/ha of single superphosphate (P_2O_5) at planting. Irrigation was provided at 15-day intervals until mid-October to ensure consistent soil moisture.

A key methodological feature was the timing of herbicide application: all herbicides were applied post-emergence, four months after planting, when the sugarcane had reached heights of 50–80 cm—an optimal stage for minimizing phytotoxic effects. Previous research indicates that applying glyphosate within the first 90 days of planting can be detrimental to sugarcane yields due to the plant's heightened sensitivity during early

development. Therefore, the selected timing and herbicides reflected local agronomic recommendations and proven regional efficacy.
The herbicidal treatments consisted of glyphosate at 3.50 kg/ha, paraquat at 1.50 kg/ha, 2,4-D sodium salt at 4.50 kg/ha, and metribuzin at 1.50 kg/ha, all directed at controlling emerging weeds 240 days after planting. A clear understanding of cultivar-specific tolerance levels allows growers to fine-tune herbicide timing and dosage—sometimes employing higher-than-standard rates when justified by local conditions.
The crop was planted with a row spacing of 1.5 meters, a configuration that significantly influences weed dynamics. Narrower row spacing typically reduces weed proliferation by restricting the availability of light, water, and nutrients. Conversely, wider spacing (typically 80–120 cm) can lower intra-crop competition but may permit increased weed growth due to greater light penetration. In this study, wider spacing during early growth stages allowed the sugarcane to establish robustly, with the developing canopy subsequently suppressing weeds through shading—a finding consistent with Khan et al. [26], who documented similar interactions between crop geometry and weed suppression.
Mechanical weeding was employed effectively during the initial growth phase, when the plants were approximately 35 cm tall, using tractor-mounted equipment that could easily maneuver between rows. However, by the time the crop reached 50–80 cm in height—240 days post-planting—mechanical methods were no longer feasible, necessitating a shift to chemical weed control for the remainder of the cropping period.

Table1: Major weed species in experimental field

Scientific Name	Local Name	Weed type	Weed density no./m^2
Echinochloa colonum	**jharua**	Grass	11
Convolvulus arvensiss	hirankhuri	Broadleaved	15
Sesbania aegyptica	**Shewarie**	Broadleaved	8
Sonchus oleraceus	*Mhatara*	Broadleaved	14
Parthenium hysterophorus	Gajar Gavat	Broadleaved	37
Brachiaria reptans	Shipratt	Grass	6
Cynodon dactylon	Durva grass	Broadleaved	9

According to the table1, there are major weed in our field area were Echinochloa colonum(11%), Convolvulus arvensiss(15%), Sesbania aegyptica(8%), Sonchus oleraceus(14%), Parthenium hysterophorus(37%), *Brachiaria reptans(6%) and* Cynodon dactylon(9%). In which the grass weeds Echinochloa colonum and *Brachiaria reptanscomprises 17% and other broad leaved weeds comprised 83%.*

Figure 1: Emergence of weed in sugarcane crop.

Figure2: Application of glyphosate and other herbicides on weeds in sugarcane crop after 240 days of plantation.

Figure3: Effect of glyphosate on weeds in sugarcane crop after 240 days of plantation.

Variable	Convolvulu sarvensiss	Sesbania aegyptica	Sonchus oleraceus	Parthenium hysterophorus	*Brachiaria reptans*	Cynodon dactylon	Echinochloa colonum	Total g/m^2
Glyphosate	7.5	2.9	3.0	15.2	2.4	3.0	5.2	38.8
Paraquat	11.2	4.2	22.0	25.0	3.9	7.9	9.1	83.3
2,4-D sodium salt	12.6	5.8	14.2	11.5	4.2	7.6	10.0	65.9
Metribuzin	10.2	4.9	10	17.5	3.0	7.0	8.6	61.2
Control	18	8	7	39	8	16	9	105

Table 2. Effect of post emergence herbicides on dry weight of weeds / m^2(g) species in sugarcane.

According to Table 2, the effect of post-emergence herbicides on dry weight of weeds showed that 38.8g/m2 had a greater effect on the weeds than the control 105m2. The application of 2,4-D sodium salt resulted in an effect of 65.9 g/m2, Metribuzin 61.2g/m2, and Paraquat 83.3g/m2. Taking into consideration cane losses on-farm over the top sections estimated at 1 t/ha, this corresponds to sugar losses of 0.13 t/ha for variety SP71-1406 when treated. It appears therefore crucial, during manual harvest, to clip the highest feasible top sections of the stems in order to prevent sugar losses on such kinds [27].

Conclusion

Glyphosate herbicide applications were shown to be substantially more effective in decreasing weed dry weight than the control. The decrease in dry weight of green weeds with glyphosate treatment might be due to control of most types of weeds due to its application in the late phases of crop development. Using glyphosate in sugarcane dramatically decreased green weed dry weight to 38.8 g/m^2, compared to 105 g/m^2 in the control group. Glyphosate is an effective pesticide for controlling a variety of weeds.

Funding: None

Acknowledgements: None Stated

Conflict of Interests:
The authors have not declared any conflict of interests.

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