Iranian Journal of Weed Science (2025) 21(2): 98-126

Iranian Research Institute of Plant Protection

Iranian Journal of Weed Science

https://ijws.areeo.ac.ir/

Review Article

Sugarcane Weed Management in Iran: Evolution and Current Status

Sasan Abdolahi Lorestani*[1], Abbas Ebrahimi[2], Seyed Reza Ahmadpour[3]

[1] Weed Science Department, Iranian Institute of Sugarcane Research and Training, Khuzestan, Iran.
[2] Ph.D Student of Tehran University, Weed Science Department, Iranian Institute of Sugarcane Research and Training, Khuzestan, Iran.
[3] Salman Farsi Agro-Industry Co., Khuzestan, Iran.

Article Info

Received:
October 22, 2025

Accepted:
December 17, 2025

First published online:
December 29, 2025

Corresponding Author:
Sasan Abdolahi Lorestani

Email:
sasanabd@yahoo.com

Keywords:
Herbicide,
Integrated weed management (IWM),
Mechanical control,
Resistance,
Perennial weeds.

Abstract

Sugarcane is a key industrial crop in Khuzestan province, Iran. However, sugarcane production is constrained by a remarkably diverse weed flora encompassing over 140 species. This flora includes some of the most dangerous annual and perennial species such as *Leptochloa fusca*, *Echinochloa colona*, *Cynanchum acutum*, *Imperata cylindrical* and *Cynodon dactylon* can reduce cane yield by as much as 80%. For decades, chemical control relying on some Photosystem II inhibitors (Atrazine, Metribuzin) and synthetic auxin (2,4-D + MCPA) herbicides was the dominant strategy. This strategy resulted in several major challenges, including the emergence of herbicide-resistant weed populations (*Echinochloa colona*), a shift in the weed flora favoring invasive species (*Cynanchum acutum*), increased weed management costs, and environmental concerns. In response to these challenges, the weed management paradigm has shifted towards an Integrated Weed Management (IWM) approach based on the optimization and integration of chemical, mechanical and physical control methods tailored to the specific conditions of sugarcane production. Some of the most important measures include introducing new herbicides with different sites of action (e.g., indaziflam, pendimethalin), applying a herbicide rotation program, optimizing application timing and method (e.g., delayed pre-emergence), and significantly increasing the role of physical-mechanical control. As a result, the average herbicide input has declined from approximately 20 kg/L ha^{-1} to less than 6 kg/L ha^{-1}. Effective management of perennial weeds in sugarcane requires a thorough understanding of their biological and ecological characteristics, together with the integration of chemical, mechanical, and cultural control methods into species-specific management programs. The future outlook emphasizes strengthening this trend through training, developing precision application technologies, optimizing water and fertilizer management, and implementing crop rotation to achieve sustainable sugarcane production. This journey from a chemically dependent system to a multifaceted IWM framework highlights the critical importance of adaptive, research-based strategies for the long-term sustainability of sugarcane agroecosystems in Iran.

Cite this article: Abdolahi Lorestani, S., Ebrahimi, A., Ahmadpour, S.R. (2025). Sugarcane weed management in Iran: Evolution and current status. *Iran. J. Weed Sci.*, 21(2): 98-126. DOI:10.22034/ijws.2026.371377.1512

مجله دانش علف‌های هرز ایران (١٤٠٤) دورهٔ ٢١، شمارهٔ ٢: صفحات ٩٨-١٢٦

مجله دانش علف‌های‌هرز ایران

https://ijws.areeo.ac.ir/

مقاله مروری

مدیریت علف‌های هرز نیشکر در ایران: سیر تحول وضعیت کنونی

ساسان عبدالهی لرستانی[*1]، عباس ابراهیمی[2]، سیدرضا احمدپور[3]

[1] موسسه تحقیقات و آموزش توسعه نیشکر و صنایع جانبی، خوزستان، ایران.

[2] موسسه تحقیقات و آموزش توسعه نیشکر و صنایع جانبی، خوزستان، ایران.

[3] شرکت کشت و صنعت سلمان فارسی، خوزستان، ایران.

اطلاعات مقاله

تاریخ دریافت:
۱۴۰۴/۰۷/۳۰

تاریخ پذیرش:
۱۴۰۴/۰۹/۲۶

تاریخ انتشار برخط:
۱۴۰۴/۱۰/۰۸

نویسنده مسئول:
ساسان عبدالهی لرستانی

ایمیل:
sasanabd@yahoo.com

واژه‌های کلیدی:
علف‌هرز چندساله،
مبارزه مکانیکی،
مدیریت تلفیقی علف‌های‌هرز،
مقاومت به علف‌کش،
نیشکر.

چکیده

نیشکر یکی از محصولات صنعتی کلیدی استان خوزستان در ایران است. بااین‌حال، تولید نیشکر با یک محدودیت عمده از جمله فلور بسیار متنوع علف‌های‌هرز روبرو است که بیش از ۱۴۰ گونه را در بر می‌گیرد. برخی از گونه‌های یکساله و چندساله خطرناک از جمله *Leptochloa fusca*، *Echinochloa colona*، *Cynanchum acutum*، *Imperata cylindrica* و *Cynodon dactylon* در این فلور حضور دارند که می‌توانند تا ۸۰ درصد موجب کاهش عملکرد شوند. برای دهه‌ها، مبارزه شیمیایی با تکیه بر علف‌کش‌های بازدارنده سامانه نوری ۲ (آترازین، متریبوزین) و اکسین‌های مصنوعی (تو، فور–دی + ام‌ث‌پ‌آ)، استراتژی غالب بود. این رویکرد منجر به بروز چالش‌های جدی از جمله ظهور علف‌هرز مقاوم (*Echinochloa colona*)، تغییر در ترکیب فلور علف‌های‌هرز به سود گونه‌های مهاجم (*Cynanchum acutum*)، افزایش هزینه‌های مبارزه و نگرانی‌های زیست محیطی شد. در پاسخ به این چالش‌ها، الگوی مدیریت به سمت مدیریت تلفیقی علف‌های‌هرز از طریق اصلاح و بهینه‌سازی روش‌های مبارزه شیمیایی، فیزیکی- مکانیکی و ترکیبی از تمام روش‌های مناسب با شرایط کشت نیشکر تغییر جهت داد. برخی از اقدامات مهم انجام شده عبارت بودند از معرفی علف‌کش‌های جدید با محل‌های اثر متفاوت (مانند ایندازیفلام، پندیمتالین)، اجرای برنامه تناوب علف‌کش‌ها، بهینه‌سازی زمان و روش کاربرد (مانند روش پیش‌رویشی تأخیری) و افزایش قابل توجه نقش مبارزه فیزیکی- مکانیکی. درنتیجه، میانگین میزان کاربرد علف‌کش از حدود ۲۰ پیمانه (کیلوگرم یا لیتر) در هکتار به کمتر از ۶ پیمانه از گذشته تا به اکنون کم شده است. در مورد گونه‌های چندساله در نیشکر، افزون بر مطالعه و درک ویژگی‌های زیستی و بوم‌شناختی آنها، نیاز به تلفیق روش‌های شیمیایی، مکانیکی و زراعی در چارچوب برنامه‌های مدیریتی ویژه‌ی هرگونه است. چشم‌انداز آینده بر تقویت این روند از طریق آموزش، توسعه فن‌آوری‌های کاربرد دقیق، بهینه‌سازی مدیریت آب و کود، و اجرای تناوب زراعی برای دستیابی به یک سامانه تولید پایدار نیشکر تأکید دارد. این روند از یک سامانه وابسته به سموم شیمیایی به یک چهارچوب چندسویه مدیریت تلفیقی، جایگاه سرنوشت‌ساز راهبردهای سازش‌پذیر و پژوهش‌بنیان را برای ماندگاری درازمدت زیست‌بوم‌های کشاورزی نیشکر در ایران برجسته می‌کند.

عبدالهی لرستانی، ساسان؛ ابراهیمی، عباس؛ احمدپور، سیدرضا (۱۴۰۴). مدیریت علف‌های‌هرز نیشکر در ایران: سیر تحول وضعیت کنونی. *مجله دانش علف‌های‌هرز ایران*، ۲۱(۲): ۹۸-۱۲۶.

DOI: 10.22034/ijws.2026.371377.1512

Introduction

Sugarcane (*Saccharum officinarum* L.) is a significant economic crop, supplying over 60% of the global sugar demand (Sulaiman et al., 2023). It is widely cultivated in several countries located in tropical and subtropical regions of the world. The main sugar-producing countries globally are Brazil, India, China, and Thailand (Voora et al., 2023). Sugarcane is cultivated on approximately 27.3 million hectares in over 90 countries worldwide (FAOSTAT, 2023). This plant is an important global crop, recognized not only for sugar production but also as a notable option for bioenergy production (Surendran et al., 2016; Gunarathna et al., 2018). Brazil, India, the European Union, and China, with shares of 24, 15, 9, and 6% (equivalent to 43.7, 28, 16.5, and 11 million tons), respectively, are the largest sugarcane producers in the world (USDA, 2024). In Iran, the growing environment for sugarcane requires high temperatures, frequent irrigation, wide row spacing (150-183 cm), and the application of chemical fertilizers. In the 2022-2023 crop year, the cultivated area of sugarcane in Khuzestan province reached 102 thousand hectares. With a production of 7.59 million tons of sugarcane and a yield of 74 tons per hectare, it ranked third (10.05% of the total) after silage corn and wheat in terms of production of irrigated field crops. Khuzestan province, with a 99.99% share, was the largest producer of sugarcane in the country that year (Anonymous, 2024a).

Weed Damage in Sugarcane and the Importance of Control

Sugarcane is an important crop for bioenergy and sugar production. It annually is damaged by various biotic and abiotic factors, among which weeds are one of the most important limiting factors (Hussain et al., 2018).

Weeds exhibit very high diversity in the sugarcane fields of Khuzestan. Results from conducted studies have shown that so far, over 140 plant species have been recorded in sugarcane fields, of which about 60 species are competitive with this crop and have been reported as weeds in sugarcane fields. Among these weeds, 18 annual and 13 perennial species have greater importance and distribution compared to other species (Zand et al., 2009; Abdolahi Lorestani et al., 2019a). The studies conducted show that the share of weeds in reducing sugarcane yield can be between 50 to 80 percent, and in other studies including in countries like India, Indonesia, the Philippines, Sudan, and Ethiopia, it is significant and ranges from a minimum of 16 to a maximum of 96 percent (Yirefu et al., 2012; Elahifard et al., 2017). Results from various studies have shown that the critical period for weed control in sugarcane, in order to reduce competition and limit maximum yield loss to 5%, is within 3 to 4 months after planting (Maurya et al., 2021). Sugarcane being a long duration crop and due to its initial slow growth it takes longer time for ground coverage and so crop faces tough competition with weeds upto 120 days after planting (DAP) which causes significant yield reduction. The critical period of crop weed competition in sugarcane ranged between 100 to 105 days (Rathika et al., 2023). In Iran, effective weed management particularly before the sugarcane canopy is fully developed within the initial 100 days after planting, is also extremely critical (Abdolahi Lorestani et al., 2008).

Diversity and Importance of Weeds in Iranian Sugarcane Fields

Since the beginning of sugarcane cultivation in Iran and the conversion of uncultivated and virgin lands into sugarcane fields located in the north and south of Khuzestan, predominant annual and biennial broadleaf and grass weeds included *Beta maritima* L., *Malva neglecta* Wallr., *Spergula fallax* (Lowe) E.H.L.Krause., *Scorpiurus muricatus* L., *Sonchus spp.*, *Schanginia aegyptiaca* L., *Carthamus oxyacantha* M.Bieb., *Medicago spp.*, *Melilotus indicus* (L.) All., *Sonchus asper* (L.) Hill, *Sonchus oleraceus* L., *Cressa cretica* L., *Trifolium spp.*, *Eruca sativa* Mill., *Erucaria hispanica* (L.) Druce., *Aeluropus littoralis* (Gouan) Parl., *Alhagi pseudalhagi* (M.B.) Desv., *Alopecurus myosuroides* Huds., *Dichanthium annulatum* (Forssk.) Stapf, *Setaria glauca* (L.) P. Beauv., *Panicum capillare* L., *Polypogon monspeliensis* (L.) Desf., *Diplachne fusca* (L.) P. Beauv. ex Roem. & Schult., *Digitaria sanguinalis* (L.) Scop., *Echinochloa colona* (L.) Link, *Echinochloa crus-galli* (L.) P. Beauv., *and Phalaris minor* Retz. (Bani Abbasi et al., 1971; Khajavi, 1978; Kazemi, 1990b; Dezfoli, 1997; Mousavi, 2001; Pour Azar et al., 2011b). Some weeds with lesser importance in distribution and density have also been consistently present in sugarcane fields, among which *Capsella bursa-pastoris* (L.) Medik., *Anagallis arvensis* L., *Dinebra retroflexa* (Vahl) Panz., *Heliotropium europaeum* L., *Urtica urens* L., *Spergularia marina* (L.) Besser., *and Spergula fallax* (Lowe) E.H.L. Krause. can be mentioned. In some leached fields, some hydrophilic weeds such as *Phragmites australis* (Cav.) Trin. ex Steud., *Typha angustifolia* L., *Juncus spp.*, *Scirpus spp.*, *and Cyperus rotundus* L. are also observed in patches and dense stands (Pour Azar et al., 2011b; Abdolahi Lorestani et al., 2019a).

In some sugarcane fields with inadequate drainage and high water table, perennial weeds including *Imperata cylindrica (L.)* P. Beauv, *Sorghum halepense* (L.) Pers., *Paspalum dilatatum* Poir., *Cynodon dactylon* (L.) Pers., *Cynanchum acutum* L., *Convolvulus arvensis* L., *Cyperus rotundus* L., *and Trachomitum venetum* L. are among the important and problematic types (Taherkhani, 1999; Ahmadpour & Alizadeh, 2008a; Ahmadpour & Alizadeh, 2008b; Abdolahi Lorestani et al., 2023b). These species are often able to complete their life cycle in the fields during the crop growth stage and spread not only by seed but also through reproductive organs such as tubers, rhizomes, stolons, and roots (Taherkhani et al., 2003; Abedinzadeh, 2006; Abdolahi Lorestani et al., 2021b; Eskandari et al., 2022). Given the importance and role of understanding the biological and ecological characteristics of weeds, especially the perennial and problematic species in sugarcane fields, in their management, numerous studies have been conducted in this area, the results of which are summarized in Table 1.

Table 1. Summary of the results of research conducted to determine the biological characteristics of perennial sugarcane weeds and the effect of environmental stresses on them.

Weed Species	Key Findings and Management Implications	References
Cogongrass (*Imperata cylindrica*)	High Stress Tolerance: Seed germination tolerates salinity up to 160 mM NaCl and drought up to -0.8 MPa osmotic potential. Rhizomes can germinate even under saline (6.42 dS/m) and drought (-0.96 MPa) stress, confirming its high resilience. Management Implications: Requires strategies targeting both seeds and resilient rhizomes.	Abin et al. (2014); Hamidavi et al. (2015)
Bearded Sprangletop (*Leptochloa fusca*)	Cardinal Temperatures: Base temperature: 1.4°C; Optimal range: 9.2-40.8°C; Ceiling temperature: 54.7°C. Management Implications: Use thermal thresholds to predict emergence and plan pre-emergence control.	Ebrahimi et al. (2017); Ghanbarpour et al. (2015)
Swallow-wort (*Cynanchum acutum* L.)	Germination Dynamics: Peak germination rate occurs 56 days after fruiting at ~30°C (97% germination). Seedlings from seeds and root buds require 349.09 and 428.58 GDD, respectively, to reach 50% emergence. Spatial Distribution: Exhibits a strong patchy distribution (patch diameter 14-23 meters before earthing up). Management Implications: Critical control window is within 2 weeks after fruiting. Use GDD models and target patches.	Abdolahi Lorestani et al. (2020) Abdolahi Lorestani et al. (2021a,b)

From the late 1990s and during the 2000s and 2010s, the weed population in sugarcane underwent relative changes, resulting in increased density and distribution of some weeds including *Malva neglecta, Rottboellia cochinchinensis* (Lour.) Clayton., *Galium aparine* L., *Alternanthera philoxeroides* (Mart.) Griseb., *Polygonum aviculare* L., *Eclipta prostrata* (L.) L., *Leptochloa fusca ssp. fascicularis (Lam.) N. Snow, Cynanchum acutum, Physalis divaricata* D.Don, *Corchorus trilocularis L., Crepis sancta* (L.) Bornm., and *Cleome viscosa* L. (Pour Azar et al., 2011b; Rafatjoo & Saedi Nasab 2013c; Abdolahi Lorestani et al., 2019a; Abdolahi Lorestani et al., 2021c). So far, in total, over 140 weed species from 118 genera and 37 families have been observed in sugarcane fields, among which the highest number of weed species belong to the families Poaceae with 36 species, Asteraceae with 26 species, Fabaceae with 12 species, Brassicaceae with 10 species, and Chenopodiaceae with 6 species (Dezfoli, 1997; Saradar Zadeh, 2006; Ahmadpour & Alizadeh, 2008a, b; Abdolahi Lorestani et al., 2019a).

Considering the various aspects of damage caused by these weeds, determining their relative importance in the sugarcane agro-industries has been an estimate and depends on various factors including the weed's life cycle, seed production capacity, vegetative reproductive organs (rhizomes, stolons, tubers), the quality of land preparation operations, etc. (Pour Azar et al., 2011b; Abdolahi Lorestani et al., 2019a). Accordingly, among the weeds in Khuzestan's sugarcane fields, 15 annual broadleaf species (Table 2), 11 annual grassy weeds (Table 3), and 17 perennial species (Table 4) have relatively greater importance and distribution.

Table 2. Importance and distribution of annual broadleaf weeds in Sugarcane fields of Khuzestan province, Iran (Bani Abbasi et al., 1971; Khajavi, 1978; Kazemi, 1990b; Dezfoli, 1997; Mousavi, 2001; Pour Azar et al., 2011b).

Scientific Name	Location of Weed Presence (Agro-industries Co.)	
	In the North of Khuzestan	In the South of Khuzestan
Carthamus oxycantha M.Bieb.	* 2	** 2
Chenopodium murale	* 3	* 1
Cleome viscosa	** 1	** 1
Corchorus trilocularis	** 1	** 1
Cucumis melo L.	* 2	* 2
Erigeron canadensis L.	* 2	* 2
Lactuca serriola L.	* 3	** 2
Malva neglecta	* 2	** 3
Medicago spp.	** 2	** 3
Melilotus indicus	** 4	** 4
Physalis divaricata	** 2	** 2
Polygonum patulum L.	* 2	** 2
Silybum marianum (L.) Gaertn.	** 1	* 1
Sonchus asper	*** 3	** 3
Xanthium strumarium L.	* 2	** 1

Importance guide: (*) Unimportant, (**) Moderately important, (***) Important. Distribution guide: (1) Low spread, (2) Moderate spread, (3) High spread, (4) Very high spread. (-) indicates absence or no data.

Table 3. Importance and distribution of annual grassy weeds in Sugarcane fields of Khuzestan province, Iran (Bani Abbasi et al., 1971; Khajavi, 1978; Kazemi, 1990b; Dezfoli, 1997; Mousavi, 2001; Pour Azar et al., 2011b).

Scientific Name	Location of Weed Presence (Agro-industries Co.)	
	In the North of Khuzestan	In the South of Khuzestan
Alopecurus myosuroides	** 2	** 1
Avena ludoviciana L.	** 2	** 1
Brachiaria sp.	*** 1	-
Dichanthium annulatum	***3	** 2
Digitaria sanguinalis	** 1	* 1
Echinochloa colona	*** 4	*** 4
Leptochloa fusca ssp. *fascicularis*	** 2	*** 4
Phalaris minor	** 3	** 3
Polypogon monspeliensis	*** 3	** 1
Rottboellia cochinchinensis	*** 1	-
Setaria glauca	** 3	** 2

Importance guide: (*) Unimportant, (**) Moderately important, (***) Important. Distribution guide: (1) Low spread, (2) Moderate spread, (3) High spread, (4) Very high spread. (-) indicates absence or no data.

Key Challenges in Sugarcane Weed Management

Effective weed management in sugarcane is hindered by several interconnected challenges, which can be summarized as follows:

Neglect of Prevention and Field Sanitation

The fundamental principle of prevention is often overlooked, leading to the introduction and spread of weed seeds via irrigation water, wind, and contaminated machinery. Essential practices such as field monitoring, using certified seeds, and cleaning equipment are frequently neglected (Anonymous, 2007b; Abdolahi Lorestani et al., 2019a).

Inefficient Spraying Equipment and Technology

Key issues include the use of outdated sprayers and nozzles, inadequate operator knowledge, poor calibration, and improper storage of herbicides. These factors reduce application efficacy, increase resistance risks, and pose contamination hazards. Environmental conditions and poor field preparation further diminish herbicide performance (Ahmadpour and Abdolahi Lorestani, 2013b; Abdolahi Lorestani et al., 2019a).

Table 4. Importance and distribution of perennial weeds in Sugarcane fields of Khuzestan province, Iran (Taherkhani, 1999; Saradar Zadeh, 2006; Ahmadpour & Abdolahi Lorestani, 2008a; Ahmadpour & Alizadeh, 2008a; Abdolahi Lorestani et al., 2019a).

Scientific Name	Location of Weed Presence (Agro-industries Co.)	
	In the North of Khuzestan	In the South of Khuzestan
Grassy Weeds		
Aeluropus littoralis (Gouan) Parl.	** 3	** 2
Cynodon dactylon	*** 3	*** 3
Diplachne fusca	*** 4	*** 4
Eleusine indica (L.) Gaertn.	* 2	* 1
Imperata cylindrica (L.) P. Beauv.	*** 4	*** 4
Panicum capillare	** 2	* 1
Paspalum distichum L.	** 2	* 1
Phragmites australis	** 4	** 4
Sorghum halepense	*** 3	*** 2
Broadleaved Weeds		
Convolvulus arvensis	*** 3	*** 2
Conyzanthus squamatus (L.) Gaertn	** 2	** 2
Cynanchum acutum	*** 2	*** 4
Cyperus rotundus	*** 3	** 2
Glycyrrhiza glabra L.	** 1	** 1
Ipomoea cairica (L.) Sweet	* 2	* 2
Trachomitum venetum	** 2	** 2

Importance guide: (*) Unimportant, (**) Moderately important, (***) Important. Distribution guide: (1) Low spread, (2) Moderate spread, (3) High spread, (4) Very high spread. (-) indicates absence or no data.

Herbicide Resistance and Limited Herbicide Portfolio

Overreliance on chemical control has led to resistance in major weeds like *Echinochloa colona* to Photosystem II inhibitors (e.g., metribuzin, atrazine) (Elahifard et al., 2013, 2017; Ahmadpour et al., 2017). The limited availability of selective herbicides with diverse modes of action restricts the implementation of effective resistance management strategies such as herbicide rotation (Sayyad Mansour, 2007a; Ahmadpour et al., 2017).

Impact of Inefficient Water and Input Management

Low water-use efficiency and imbalanced fertilizer application promote weed growth and competition. Weeds exploit these resources, leading to increased crop damage. Additionally, aquatic weeds in irrigation canals reduce water efficiency and damage infrastructure (Ahmadpour & Alizadeh, 2008b; Abbasi & Sheini Dashtgol, 2016; Pour Azar et al., 2011b; Abdolahi Lorestani et al., 2023b).

Shifts in Weed Flora and Invasion of Aggressive Species

Rapid changes in weed communities and the invasion of highly competitive perennial species, such as *Cynanchum acutum* and *Leptochloa fusca ssp. fascicularis*, have complicated control efforts (Ebrahimi et al., 2017; Abdolahi Lorestani et al., 2021c). Managing these species requires a deep understanding of their biology and ecology.

Methodology

To compile the review article entitled "Sugarcane Weed Management in Iran: Evolution and Current Status," a systematic methodology was employed. First, a comprehensive search was conducted across relevant domestic and international scientific databases, conference proceedings, and the archives of research reports of the Iranian Sugarcane Research and Training Institute. The inclusion criteria encompassed the direct relevance of the content to sugarcane weed management under Iranian conditions and the availability of the full-text. Following the collection, documents were screened based on their titles and abstracts. Pertinent data were then extracted from the selected sources and systematically classified according to a methodological framework comprising five principal categories: "Basic Studies," "Applied Field Studies," "Management & Strategic Studies," "Review & Meta-Studies," and "Technological & Innovative Studies" (Table 5). This framework was adopted to move beyond a purely thematic analysis and to critically examine the nature and scope of the research conducted. A qualitative and quantitative content analysis was performed, taking into account the historical sequence and prevailing methodological trends. Subsequently, by synthesizing these findings, a comprehensive overview of the evolution of research approaches, current knowledge status, and future directions within this domain is presented.

Table 5. Distribution of literature by primary weed management category.

No.	Methodological Category	Definition	Number of References	Percentage (%)
1	Basic Studies	Foundational research on weed biology, ecology, physiology, and identification.	33	20.6
2	Applied Field Studies	Field trials evaluating the efficacy of a specific method, tool, or input.	103	64.4
3	Management & Strategic Studies	Research focused on developing, comparing, or evaluating management strategies and systems.	15	9.4
4	Review & Meta-Studies	Review articles, guidebooks, policy reports, and meta-analyses.	7	4.4
5	Technological & Innovative Studies	Research centered on developing, modifying, or assessing novel technologies and inputs.	2	1.2
	Total References		160	100

Guidelines for Weed Control in Iranian Sugarcane Fields

In Iran, chemical control using herbicides has always been the most important strategy for controlling weeds, to the extent that overreliance resulted in an average consumption of up to 20 kg or L per hectare during one growing season of sugarcane field. This approach led to a dramatic increase in herbicide consumption, the emergence of herbicide resistance (*Echinochloa colona*), the establishment of some new weed species (*Physalis divaricata*, *Cleome viscosa*, *Cynanchum acutum*), created environmental problems, and higher control costs (Pour Azar et al., 2011b). Currently, the main methods of weed control in Khuzestan's sugarcane include chemical control using herbicides and mechanical control. Most of the research conducted on sugarcane weed control has belonged to chemical herbicides, their application methods, and thereafter mechanical and physical control. A summary of the results of research conducted over the past three decades (1990–2025) for each control method is presented in Tables 6, 7, and 8.

Table 6: Comprehensive review of herbicide efficacy and resistance groups in Iranian Sugarcane fields.

Herbicide Group (HRAC) & Herbicide	Herbicide Combination and Formulation	Application Rate & Key Findings	References
Triazines (5)	Atrazine (WP 80%)	1-4 kg ha^{-1} (Pre): 50-80% control; Better on broadleaves.	Taherkhani (1999); Makvandi et al. (2011); Rafatjoo et al. (2013a); Anonymous (2007a).
	Atrazine (WP 80%) + Metribuzin (WP 70%)	2+2 and 3+2 kg ha^{-1} (Pre): Best density reduction; increased yield.	Taherkhani et al. (2003); Makvandi et al.(2011); Abdolahi Lorestani et al.(2021d).
	Metribuzin (WP 70%)	2.5 kg ha^{-1} (Pre and Early Post): Best density reduction; increased yield.	Abdolahi Lorastani et al.(2019c); Makvandi et al.(2011).
	Ametryn (WG 80%)	2-2.5 kg ha-1 (Pre):): Control of annual broadleaf and grass weeds.	Abedinzadeh & Ahmadi (2006).
	Ametryn (WG 80%) + Atrazine (WP 80%)	6+6 kg ha-1 (Pre): Effective control without crop damage.	Kazemi (1990a).
	Atrazine (DF 90%)	1-2 kg ha^{-1} (Pre): control of annual broadleaf and grass weeds.	Anonymous (2007a).
Triazines (5) + Synthetic Auxins (4)	Terbuthylazine + MCPA (SC 27.5+16%)	1-1.5 L ha^{-1} (Pre): control of annual broadleaf and grass weeds.	Anonymous (2007a).
Triazines (5)	Metribuzin (EC 48%)	3-3.5 L ha^{-1} (Pre): control of annual broadleaf and grass weeds.	Anonymous (2023).
Sulfonylureas (2) + Triazines (5)	Trifloxysulfuron-sodium + Ametryn (WG 75%)	2-2.5 kg ha^{-1} (Pre): Superior control of *Cyperus rotundus* and *Echinochloa colona*: Mild phytotoxicity.	Pour Azar et al. (2006a); Pour Azar et al. (2008); Boromand Far et al. (2008); Ahmadpour et al. (2009); Abdolahi Lorestani et al. (2019c); Sayyad Mansour (2007b); Ahmadpour & Abdolahi Lorestani (2006).
Sulfonylureas (2)	Mesosulfuron + Iodosulfuron + Mefenpyr-diethyl (WG 6%)	250-400 g ha^{-1} (Post, 2-3 leaf): Effective control of annual weeds.	Farahbakhsh et al. (2005); Al-Kathir & Borumandfar, (2003); Soraghi et al. (2003).
Sulfonylureas (2)	Sulfosulfuron (WG75%)	6-7 g ha^{-1} (with surfactant): control of annual grass weeds.	Al-Kathir et al. (2003).
Sulfonylureas (2)	Rimsulfuron (25%)	40-60 g ha^{-1} (Post): Control of annual weeds. Causes phytotoxicity.	Al-Kathir et al. (2003).
Sulfonylureas (2)	Nicosulfuron (OD 4%)	2 L ha^{-1} (Post): Control of perennial grasses. Causes crop injury.	Rafatjoo et al. (2013a); Abdolahi Lorestani et al. (2024).
Triazines (5) + Ureas (5)	Tebuthiuron (SC 50%) + (Atrazine (WP 80%))	2+2 kg ha^{-1} (Pre): Highest efficacy on annual weeds; superior combination.	Taherkhani et al. (2003); Shimi et al. (2004); Mohemati Shirazi et al. (2003); Abedinzadeh (2005); Daman Afshan & Maknali (2005b).
Dinitroanilines (3)	Pendimethalin (CS 45.5%)	3 L ha^{-1} (Early post): Best density reduction; increased yield.	Abdolahi Lorestani et al. (2020).
	Pendimethalin (EC 33%)	2-3.5 L ha^{-1} (Pre): Effective in late-harvest; 91-92% efficacy on *E. colona*; controls triazine-resistant weeds.	Kheyr Andish et al. (2013); Abdolahi Lorestani et al. (2023a); Abin et al. (2017); Abdolahi Lorestani et al. (2019c, 2020); Ahmadpour et al. (2013);

Herbicide Group (HRAC) & Herbicide	Herbicide Combination and Formulation	Application Rate & Key Findings	References
			Ehsanipour et al. (2024); Anonymous (2024b).
	Trifluralin (EC 48%)	2-2.5 L ha^{-1} (Soil Inc.): Control of annual weeds.	Rezaei et al. (2017); Haji Sharafi (2005, 2006).
Chloroacetamides (15)	Alachlor (EC 50%)	3-5 L ha^{-1} (Pre): control of annual weeds.	Kazemi (1990b, 1995); Rokouei et al. (2008); Abdolahi Lorestani et al. (2019a).
Chloroacetamides (15) + Triketone (27) + Triazines (5)	S-Metolachlor + Mesotrione + Terbuthylazine (SE 53.75%)	4 L ha^{-1} (Pre): Suitable efficacy; safe for sugarcane.	Sasanfar et al. (2021); Abdolahi Lorestani et al. (2019b).
Chloroacetamides (15)	Acetochlor (EC 50%)	3 L ha^{-1} (Pre): control of annual weeds.	Abdolahi Lorestani et al. (2019c).
Diphenyl Ethers (14)	Oxyfluorfen (EC 24%)	1.5-2 L ha-1 (Pre to Early Post): Highest population reduction; controls annual weeds. Phytotoxic.	Bigdeli Shamloo et al. (2003); Al-Kathir et al. (2003); Ebrahimi et al. (2023).
Isoxazoles (27)	Isoxaflutole (WG 75%)	100-200 g ha^{-1} (Pre): control of annual weeds.	Taherkhani et al. (2003); Al-Kathir et al. (2003); Daman Afshan & Maknally (2005a); Farahbakhsh & Taherkhani (2005).
Isoxazoles (27) + Triazines (5)	Isoxaflutole (WG 75%) + Atrazine (WP 80%)	200 g + 2.5 kg ha^{-1} (Pre): Effective weed control; better combination.	Daman Afshan et al. (2003a).
Imidazolinones (2)	Imazamethabenz-methyl (EC 25%)	2.5 L ha^{-1} (Post): control of annual weeds.	Daman Afshan et al. (2003a); Bigdeli Shamloo et al. (2003).
Triazolinones (5)	Amicarbazone (WG 70%)	2 kg ha^{-1} (Pre): control of annual weeds.	Pour Azar (2011c); Ahmadpour et al. (2011); Abdolahi Lorestani & Pour Azar (2012b); Pour Azar (2011a); Abdolahi Lorestani et al. (2019c).
Triazinones (5)	Hexazinone + Diuron (DF 60%)	4 kg ha^{-1} (Pre): Control of annual weeds.	Sayyad Mansour (2007b); Pour Azar et al. (2006b, 2008); Ahmadpour et al.(2013).
Alkylazines (29)	Indaziflam (SC 50%)	100-125 mL ha^{-1} (Pre): >85% control; density reduction up to 90%. Superior control of *C. rotundus* (150 mL ha^{-1})	Zand et al. (2016); Abin et al. (2017, 2019); Abdolahi Lorestani et al. (2019c); Ahmadi et al. (2017); Kheyr Andish et al. (2024).
Alkylazines (29) + Triazines (5)	Indaziflam (SC 50%) + Metribuzin (WP 70%)	150 mL + 2 kg ha^{-1} (Pre): 90% control; potential for consumption reduction.	Kheyr Andish et al. (2024).
Carbamates (8)	EPTC (EC 82%)	3.12-8 L ha^{-1} (Pre): Better efficacy on *D. annulatum*; grass weed control.	Kazemi (1990a); Kazemi (1998); Rokouei et al. (2008).
Glycin (9)	Glyphosate (SL 41%)	2-3% (Post): Highest control of *R.cochinchinensis*; significant density /dry weight reduction.	Rafatjoo & Saedi Nasab (2013c).
Synthetic Auxins (4) + Triazines (5)	(2,4-D + MCPA) + Ametryn (SL 67.5% + WP 80%)	(Post): Highest weed control and sugarcane yield; Optimal combination.	Ahmadpour et al. (2009).

Herbicide Group (HRAC) & Herbicide	Herbicide Combination and Formulation	Application Rate & Key Findings	References
Synthetic Auxins (4) + Chloroacetamides (15)	Quinmerac + Metazachlor (SC 33.3+8.3%)	2.5 L ha^{-1} (Pre): control of annual weeds.	Abdolahi Lorestani et al. (2019c).
Nitrile (6) Synthetic Auxins (4)	Ioxynil + 2, 4-D (EC70%)	2 L ha^{-1} (Post): control of annual weeds.	Ahmadpour & Abdolahi Lorestani (2006, 2013a); Anonymous (2007a).
Synthetic Auxins (4)	Clopyralid (SL30%)	600-800 ml ha^{-1} (Post): control of annual weeds. Limited spectrum.	Daman Afshan et al. (2003b).
Synthetic Auxins (4)	Triclopyr (EC 48%)	2-2.5 L ha^{-1} (Post): Control of annual /perennial broadleaves, emphasis on *C. acutum*.	Anonymous (2025).

Table 7. **Mechanical and physical weed control methods in Sugarcane - A research review.**

Method/Tool Studied	Research Implications	Key Findings	Reference
Hilling up (earthing up)	Simple mechanical method for annual weed	Weed density reduction (up to 75%) vs. control	Ahmadpour et al. (2011) Abdolahi Lorestani (2012a)
Sweep cultivator	Optimal tool for mechanical control	Effective when used properly	Hossein Zadeh et al. (2012)
Seasonal mechanical control (autumn/winter)	Cost-effective integrated management	80% cost reduction when combined with chemicals	Rafatjoo et al. (2013b)
Deep moldboard plowing (30-40 cm)	Suitable for control of perennial weeds in fallow	Effective control of *Imperata cylindrica* rhizomes	Hamidavi et al. (2014)
Optimizing sweep cultivator operation	Critical operational parameters	Best at 10 km/h with 14-16% soil moisture	Abdolahi Lorestani et al. (2014)
Disk cultivator + broadcast fertilization	Supplementary effect on weed control	Enhanced canopy closure and highest cane yield	Abedinzadeh et al. (2015)
Black polyethylene plastic mulch	Sustainable reduction in herbicide dependency	Effective control of *Imperata cylindrica* patches	Sharafizadeh et al. (2018)
Comparative study: Rotovator vs sweep cultivator	choice of best tools for annual weed	96.4% and 94.7% weed reduction respectively	Abdolahi Lorestani et al. (2017)

Table 8. Research synthesis and practical recommendations for integrated weed management in Sugarcane.

Methods/Tools Studied	Key Findings	Practical Recommendations	References
Band application + hilling-up + tillage	Significantly reduced weed density and control costs	Combine band spraying with mechanical methods	Ahmadpour et al. (2009)
Moldboard plow + glyphosate vs. disk + glyphosate	Moldboard plow (2 passes) + glyphosate, showed 62.5% efficacy against *Cynanchum acutum*	Use deep tillage combined with systemic herbicides during fallow.	Abdolahi Lorestani et al. (2016).
Herbicide combinations + mechanical control	Excellent broadleaf weed control with integrated approach	Implement herbicide mixtures with mechanical weeding	Ahmadpour et al. (2011).
Tillage + indaziflam pre-emergence ± post-emergence herbicides	Tillage + indaziflam most effective (6.33-9.33 plants/m²) against *C.acutum*	Apply pre-emergence herbicides after tillage	Parian et al. (2019)
Mechanical weeding + herbicides	Rotovator + indaziflam showed 52.47% weed reduction and yield increase	Prefer rotovator and combine with residual herbicides	Rezaei et al. (2021).
Sequential herbicides + mechanical weeding	96% weed reduction and 102-104 ton/ha yield	Use sequential pre/post-emergence herbicides with mechanical control	Abdolahi Lorestani et al. (2022).
Deep tillage + herbicide combinations	95.9-96.4% control of *C.arvensis* in spring-summer.	Apply deep tillage followed by herbicide mixtures in warm seasons during fallow.	Abdolahi Lorestani et al. (2023c).
Dredging + glyphosate in drainage canals	Higher glyphosate rate (6 L/ha) more effective in warm seasons.	Use elevated herbicide rates with dredging for aquatic weed managemen	Abdolahi Lorestani et al. (2023b).

Chemical Control

Pre-emergence Application

Pre-emergence herbicides are applied in plant cane and ratoon fields using tractor-mounted sprayers specific to sugarcane fields. Application of herbicides by the delayed pre-emergence method and/or early post-emergence is done before the second irrigation of the fields, which increases the efficiency and effectiveness of herbicides in controlling weeds. If at the time of spraying before the second irrigation, germination and emergence of annual grass and broadleaf species at early growth stages are observed in the field, herbicides metribuzin and/or 2,4-D + MCPA can be used in mixture with other recommended herbicides to achieve maximum weed control (Anonymous, 2025) (Table 8).

Post-emergence Application

After performing pre-emergence spraying in new plantings and ratoon fields, usually for various reasons including clod formation in the furrow after ratoon subsoiling operations, soil bed disturbance due to hilling-up operations and displacement of weed seeds to the soil surface and provision of conditions for their germination, inadequate pre-emergence spraying due to nozzle clogging, problems with pesticide quality, leaching of the applied pesticide due to heavy irrigation, the reduction in residual activity of the herbicide due to chemical, photolytic, or microbial degradation, we will face weed emergence in sugarcane fields. Therefore, post-emergence control of weeds under such conditions will be essential. In the early stages of sugarcane growth where plant height is low, tractor-mounted (mechanized) spraying is used; otherwise, manual spraying is performed. For this purpose, selective herbicides such as metribuzin and 2,4-D + MCPA are used. Typically, a mixture of selective herbicides is used for optimal control of various broadleaf and grass species. Non-selective herbicides are used for controlling annual and perennial species in a directed manner or on field margins (Anonymous, 2025) (Table 8).

Mechanical and Physical Control

Mechanical or Physical control is among the strategies to reduce chemical pesticide use, which for example uses non-living mulch and mechanical tools such as sweep cultivator and rotovator. Cultivation between crop rows before weed establishment is very effective (Liebman & Zimdahl 2018; Abdolahi Lorestani 2015). Table 8 presents the latest guidelines for the application of mechanical and physical methods for controlling sugarcane weeds under crop growth and fallow conditions.

Hand Weeding

In cases where chemical control of seasonal weeds is not possible for any reason, or delay in control has led to their excessive growth for using mechanized control methods (chemical/mechanical), hand weeding or hoeing operations can be used. In this method, laborers equipped with tools such as hand hoes, picks, trowels, rakes, and sickles are used. The average efficiency per worker for weeding grass weeds, broadleaf weeds, and a mixture of the two is 0.13, 0.18, and 0.16 hectares per day, respectively (Anonymous, 2025) (Table 8).

Mechanized Weeding

The use of mechanical machine tools is done when weeds are in their early stages of growth and development. Under sugarcane growth conditions, this time period starts from late winter and can continue until mid-spring depending on the harvest time of sugarcane fields. Various implements including cultivators and rotovator (after hilling-up between rows), and combined cultivator (before hilling-up on the row) are used (Table 8). These equipment cultivate the soil to a depth of 5 (Up to 10) centimeters and cause cutting, uprooting, and burying of the weed's aerial organs. Uniform tillage of the soil bed and complete coverage of the tilled surface are advantages of this equipments. (Anonymous, 2025) (Table 8).

Integrated Management

For fields where the infestation of perennial weeds has reached high density, the only effective control method is to take advantage of the fallow period for integrated weed management. In such fields - often severely infested with Cogongrass (Imperata cylindrica), common reed, or Swallow-wort (Cynanchum acutum) - the initial step should be the use of consecutive moldboard plowing + disc plowing (at least twice) with intervals of one to three weeks. During this process, light irrigation prior to tillage, spaced one-month apart, will help control rhizomes that may have escaped mechanical management. To complete mechanical operations, chemical control can be applied using non-selective herbicides like glyphosate. In standing crop fields, thick, durable black plastic mulch can be used as a non-living mulch and physical barriers to cover patches of perennial weeds such as Cogongrass up to a maximum coverage of 200 square meters. Under such conditions, it is necessary that the aerial organs of the weeds have been destroyed beforehand, either using a contact herbicide (e.g., Glufosinate ammonium) or by mowing. Then the patch surface should be thoroughly covered, and the edges of the cover should be sealed to prevent any opening or outlets that could allow weed growth. The retention period required for effective destruction of underground organs should be considered 4 to 6 months (Anonymous, 2025) (Table 9).

Table 9. Weed management framework in Iranian sugarcane fields.

Management Strategy	Category	Key Herbicide Combinations / Techniques	Key Technical Notes & Terminology
Chemical Control	Pre-Emergence	Metribuzin (±Atrazine); Pendimethalin; Indaziflam; Diuron; EPTC; Acetochlor, Tebuthiuron.	Applied before weed emergence; foundational for resistance management. Terms: Pre-emergence, Residual activity, Resistance management.
	Post-Emergence	2,4-D + MCPA; Triclopyr; Glyphosate (directed); Glufosinate-ammonium; Metribuzin + (2,4-D + MCPA); S-metolachlor + Terbuthylazine + Mesotrione	*4-6 weed leaf stage; phenoxy mixes control broadleaves. Terms: Systemic, Contact, Directed spraying
Mechanical & Physical Control	Tillage (Mechanize)	Inter-row cultivation (Sweep cultivator, Rotovator, other cultivators), Fallow (moldboard plow and Disc.	*Effective at 6-8 weed leaf stage; soil moisture dependent. Terms: Inter-row cultivation, Soil moisture dependency
	Manual Control	Hand weeding	High precision but labor-intensive. Terms: Labor-intensive, Precision.
Integrated Weed Management (IWM)	Combined Methods	Chemical-Mechanical: Glyphosate + tillage Chemical-Physical: Herbicide + Plastic mulch Cultural: Crop rotation (wheat, canola)	Sustainable approach reducing herbicide reliance. Terms: Burndown, Crop rotation, Sustainable.

*Note: This framework emphasizes strategic principles over specific application rates, which may vary based on regional regulations, soil conditions, and herbicide formulations. Always consult local agricultural extension services for region-specific recommendations

Strategies for Improving Sugarcane Weed Management

Diversifying the Herbicide Portfolio

In recent years, continuous efforts to introduce new herbicides from different chemical families and groups along with applying lower doses and changing methods of herbicide application, optimizing sprayer technology and using non-chemical weed control strategies, have contributed to a declining trend in herbicide use (Ahmadpour et al., 2013; Abdolahi Lorestani et al., 2019a). A look at the trend of herbicide application over a five-year period shows that the general orientation has been towards optimal use and improved management of herbicides in sugarcane. Average consumption decreased from 20 kg/liter per hectare (Pour Azar et al., 2011b) until the late 2000s to nearly 12 kg/liter per hectare by the mid-2010s (Abdolahi Lorestani et al., 2019a), and reached six units or less by the end of the 2010s (Figure 1) (Anonymous, 2024b).

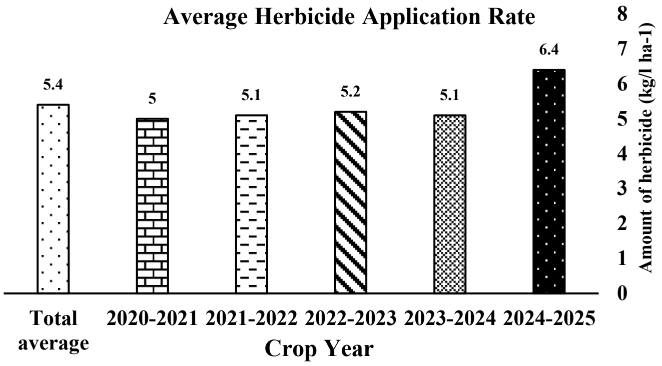

Figure 1. Average herbicide rate in sugarcane fields (plant and ratoon cane) during the crop years 2020-2021 to 2024-2025 (Anonymous, 2024b).

Considering the planting, cultivation, and harvesting conditions of sugarcane and the presence of weeds, a herbicide will be successful and effective when it has suitable persistence in controlling weeds during sugarcane growing season. As mentioned earlier, atrazine, metribuzin, ametryn and 2,4-D + MCPA, tebuthiuron, and EPTC (pre-emergence application by herbigation method) as selective herbicides and the two non-selective herbicides glyphosate and paraquat constituted all the herbicides used in sugarcane (Abdolahi Lorestani et al., 2019a). So far, the largest share of consumption among selective and non-selective herbicides has belonged to metribuzin and glyphosate, respectively (Anonymous, 2024b). One of the strategies to prevent resistance and reduced herbicide efficacy is introducing a greater number and diversity of herbicides and their rotational use in sugarcane. For example, using multi-purpose herbicides and mixing compatible herbicides for simultaneous control of various types of weeds are among these advantages. Table 8 shows the characteristics and qualitative evaluation summary of herbicides tested over the past two decades to introduce new sugarcane herbicides (Pour Azar et al., 2011b; Abdolahi Lorestani et al., 2019a). Following the conducted investigations, a number of new herbicides with different modes of action were introduced for application in sugarcane fields (Abdolahi Lorestani et al., 2019a; Abdolahi Lorestani et al., 2021d; Anonymous, 2024b). The specifications of conventional and promising herbicides are presented in Table 10. Field evaluations for promising herbicides have been conducted in sugarcane agro-industries and are included in the spraying area development program based on the herbicide rotation model.

Table 10. Conventional and promising herbicides in Iranian sugarcane fields.

Weed Species	Key Findings and Management Implications	References
Metribuzin (WP 70%)	Pre & Post-emergence	Photosynthesis inhibitor at PS II (C1)
Atrazine (WP 80%)	Pre & Post-emergence	Photosynthesis inhibitor at PS II (C1)
Ametryn (WP 80%)	Pre & Post-emergence	Photosynthesis inhibitor at PS II (C1)
Tebuthiuron (SC 50%)	Pre & Post-emergence	Photosynthesis inhibitor at PS II (C1)
2,4-D + MCPA (SL 67.5%)	Post-emergence	Synthetic auxins (O)
EPTC (EC 80%)	Pre-emergence	Lipid synthesis inhibitor (N)
Glyphosate (SL 41%)	Post-emergence	EPSPS synthase inhibitor (G)
Paraquat* (SL 20%)	Post-emergence	Photosynthesis inhibitor at PS I (D)
Diuron (DF 90%)	Pre & Post-emergence	Photosynthesis inhibitor at PS II (C2)
Pendimethalin (CS 45.5%)	Pre emergence & Early Post-emergence	Cell division inhibitor (K1)
Indaziflam (SC 50%)	Pre emergence & Early Post-emergence	Cellulose synthesis inhibitor (Z)
Quinmerac + Metazachlor (SC 33.3+8.3%)	Pre emergence & Early Post-emergence	Synthetic auxins (O) + Cell division inhibitor (K3)
Acetochlor (EC 50%)	Pre emergence & Early Post-emergence	Cell division inhibitor (K3)
Trifloxysulfuron-sodium + Ametryn** (WDG 75%)	Pre emergence & Early Post-emergence	ALS inhibitor (B) + Photosynthesis inhibitor at PS II (C1)
Amicarbazone (WDG 70%)**	Pre emergence & Early Post-emergence	Photosynthesis inhibitor at PS II (C1)
Mesotrione + S-metolachlor + Terbuthylazine (SE 53.75%)	Post-emergence	Pigment inhibitor (F2) + Cell division inhibitor (K3) + Photosynthesis inhibitor at PS II (C1)
Metribuzin (SC 48%)	Pre emergence & Post-emergence	Photosynthesis inhibitor at PS II (C1)
Triclopyr (EC 48%)	Post-emergence	Synthetic auxins (O)
Pendimethalin (EC 33%)	Pre-emergence	Cell division inhibitor (K1)

* Its use is prohibited or **unavailable

Attention to Non-Chemical Control Methods

The employment of various tillage implements, especially in the past decade, for weed control in sugarcane fields (various types of sweep cultivator and rotovator) and during fallow (moldboard plow, disc, and sub-soiler) has increased the area of mechanical control. Statistical review of weed management in sugarcane agro-industries in recent years shows that overall reliance on herbicides has decreased, and in contrast, with emphasis on using non-chemical control methods, the share of mechanical and manual weeding has increased (Anonymous, 2024b). Although the area of weeding operations has fluctuated in some years due to unfavorable weather conditions and patchy infestations of perennial weeds over relatively wide areas, it has nevertheless increased significantly, such that over a 5-year period from 2020-2021 to 2024-2025, it accounted for more than 30% of the weed control area in sugarcane fields (Figure 2).

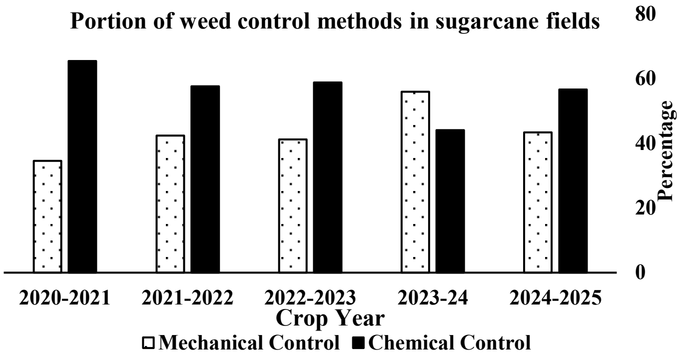

Figure 2. Portion of chemical and Mechanical method (mechanized and manual) on weeds control in sugarcane fields during the crop years 2020-2021 to 2024-2025 (Anonymous, 2024b).

Management of Perennial and Noxious Weeds of Sugarcane

Research into controlling perennial weeds should leverage modern technologies such as GPS, satellite guidance, and video imaging to monitor and target weed populations (Abdolahi Lorestani et al., 2021c). Key activities include improving expert training, establishing diagnostic and reporting systems for invasive species, creating distribution maps, and studying the biology and integrated management of these weeds (Abdolahi Lorestani et al., 2019a). Effective control requires species-specific strategies. For example, deep plowing to bury Cogongrass (Imperata cylindrica) rhizomes at a depth of 30-40 cm can suppress its growth (Hamidavi et al., 2014). Covering infested patches with black plastic or timely spraying with glyphosate application using Controlled Droplet Application (CDA) sprayers are also effective approaches (Parian et al., 2019; Sharafizadeh et al., 2018). Preventive measures are essential and include preventing the introduction of invasive species into new areas, rapid eradication of new patches, adhering to quarantine principles during the transfer of seed cuttings, and controlling weeds in fallow fields using non-selective herbicides and tillage before they set seed (Pour Azar et al., 2011b).

Optimizing Methods and Tools for Weed Control

Effective and efficient weed control is not possible without using methods and technologies that are novel and compatible with sugarcane cultivation. Some suggested strategies for optimizing sugarcane weed control include: using the delayed pre-emergence or early post-emergence spraying method (before the second irrigation in new plantings); limiting the use of the herbigation method for pre-emergence control in new planting fields as much as possible (except for controlling some weeds like *Dichanthium annulatum* and *Leptochloa fusca* ssp. *fascicularis* (Lam.) N. Snow to prevent herbicide loss through leaching and poor control); timely control and in the early growth stages of annual or perennial weeds considering their applied biology and ecology; designing and supplying sprayers specific to sugarcane fields, using microner sprayers, standard spraying equipment, and efficient mechanized weeding tools (Pour Azar et al., 2011b); using reduced doses of pre-emergence herbicides especially from the second half of September in the planting season (Ahmadpour et al., 2013); using additives including surfactants, pH modifiers, and water hardness reducers (ammonium sulfate) to increase pesticide efficiency (Mirzaei et al., 2023); observing the timing and dose of herbicides, especially in post-emergence applications, as two important factors for achieving the highest level of weed control (Harker et al., 2004), using high-quality water for post-emergence spraying (Daramola et al., 2022; Buhler and Melinda, 1999).

Optimal Management of Water and Inputs to Reduce Weed Competition with Sugarcane

The substantial water requirements of sugarcane, along with the use of nitrogen-based fertilizers during its cultivation, establish proper conditions for weed proliferation. In the absence of timely and effective control, weeds efficiently utilize these nutrient resources, rapidly colonize the field and through competition for light and other essential resources, they can lead to significant reductions in sugarcane yield (Kazemi, 1995; Tomar & Singh, 2024). The nitrogen (N) requirement of sugarcane is very high due to the extensive growth of biomass. N fertilisers are applied excessively to ensure the optimum growth of the sugarcane crop. Improper N management causes a decrease in nitrogen utilisation and leading to unintended negative consequences (Abhiram et al., 2025). In sugarcane fields of Iran, excessive irrigation (1400-1700 m^3/ha) raises the water table, which hinders crop growth and promotes hydrophilic weeds (Sheini Dashtgol, 2015). Optimizing water use through practices like irrigation scheduling, alternate furrow irrigation, and using gated pipes can reduce water application to the recommended 1000-1200 m^3/ha, thereby suppressing these weeds (Abbasi and Sheini Dashtgol, 2016; Sheini Dashtgol, 2015). Proper fertilizer use improves crop health and competitiveness against weeds (Shafiei Bafti and Behravan, 2012). Fertigation is a key strategy, as it allows for precise, split fertilizer applications. This increases efficiency, reduces nutrient leaching, and limits the nutrient availability for nitrophilous weeds, suppressing their growth (Salamati et al., 2015b). Sub surface drip fertigation is a highly effective method of water application, which is also ideally suited for controlling the placement and supply rate of water-soluble fertilizers in sugarcane cropping system (Christy Nirmala Mary and Jeyachandran, 2019). Sheini Dashtegol et al. (2020) demonstrated that subsurface drip irrigation could reduce irrigation water consumption in sugarcane fields by up to 31% compared to conventional furrow irrigation. Salamati et al. (2015a), in an evaluation of water distribution uniformity and nitrogen application in furrow fertigation of sugarcane, demonstrated that optimal fertigation management enhances the coefficients of uniformity for both water and fertilizer distribution. Using the model proposed in their study, it was shown that by considering different field conditions including defining infiltration coefficients for the model, adjusting slope, increasing or decreasing flow rate, and modifying furrow length, optimal conditions can be established to improve water use efficiency and fertilizer distribution uniformity. Consequently, optimizing irrigation and adopting precise fertigation techniques, such as subsurface drip irrigation, are essential for suppressing weeds and enhancing water and nitrogen use efficiency in sugarcane cultivation.

Managing Herbicide Resistance: Do's and Don'ts

***The do's of managing herbicide resistance in sugarcane*:**

pursuing populations suspected of resistance and regular field monitoring, rotating herbicide applications, using pre-tillage irrigation to remove weeds suspected of resistance with plowing or using contact herbicides, performing tillage in fallow, collecting and removing aerial organs containing seeds and vegetative reproductive parts of perennial weeds, using pesticides proportionally and optimally, using low-persistence pesticides, observing the recommended dose to increase the frequency of susceptible phenotypes in the population, applying herbicide at a sensitive stage of the weed's life, using additives such as surfactants to increase herbicide efficacy, using crop rotation in sugarcane.

***The don'ts of managing herbicide resistance*:**

not using herbicides more or less than the recommended amount, not using crop seeds contaminated with weed seeds in crop rotation with sugarcane, not using herbicides with the same family or chemical group in consecutive years in one field, and not providing arbitrary and non-expert recommendations in weed control (Abdolahi Lorestani et al., 2019a).

Future Horizons in Weed Management of Sugarcane Cultivation in Iran

Employing New and Alternative Methods in Sugarcane Weed Control

Some suggested alternative and practical methods regarding sugarcane weed management include the use of natural products and materials, intercropping, mixed and companion cover crops, various types of mulch (Mansuy et al., 2016; Di Bella et al., 2021; Viaud et al., 2023), crop rotation (Jos et al., 2013), and allelopathic plants (Webber et al., 2018; Shukla et al., 2022). Also, determining the optimal planting date, consuming sufficient number of setts per hectare to achieve optimal density and row spacing are among other methods that should be considered in sugarcane weed management (El-Shafai et al., 2010; Takim and Suleiman, 2017). Various types of organic mulch (cover crops, straw or sugarcane bagasse) and non-organic mulch (filter cake, polyethylene plastic cover of hydroflume pipes) can also effectively prevent weed growth, especially annuals. Organic mulches also reduce weed growth through allelopathy. Non-organic mulches control them by burying weeds and also preventing light penetration (Tabatabaei, 2015).

Attention to Biological and Ecological Approaches

Effective weed management policies in sugarcane require a deep understanding of weed biology, ecology, and their interaction with the crop (Zafar et al., 2010). Shifts in cropping patterns and agronomic management have been reported to cause significant changes in the composition and distribution of weed populations (Rathika et al., 2023). Climate change will have direct and indirect effects on weed biology, their competitive ability, as well as the efficacy of herbicides (Ramesh et al., 2017; Kaur et al., 2024). Consequently, a proper understanding of the biological characteristics of weeds and monitoring the population dynamics in response to evolving agronomic practices and climatic shifts is essential (MacLaren et al., 2020; Leguizamón, 2024). Hence, the primary challenge for weed scientists today is to develop innovative and effective management strategies based on a deep understanding of weed biology under climate change conditions. Insufficient knowledge can also lead to failed control operations, both chemical and non-chemical. The adoption of modern practices (e.g., minimum tillage, herbicide-tolerant cultivars) can shift weed flora, selecting for highly adaptive species. Therefore, predicting the impact of new technologies on weed dynamics is crucial before implementation.

Key research priorities for developing predictive models include:

Weed Emergence Patterns**;** Understanding the germination of key weeds like Swallow-wort.

Seed Bank Dynamics**;** Assessing the non-uniform seed bank in response to management.

Competition Mechanisms**;** Elucidating the physiological and ecological basis of crop-weed competition.

Competitive Ability**;** Determining how biotic and abiotic stresses affect the competitive balance between the crop and weeds.

Reducing Environmental Risks

Mitigating the risks posed by chemical herbicides to human health and the environment necessitates the investigation and development of strategies to reduce their application rates, enhance efficacy, and minimize spray drift (Mohd Ghazi et al., 2023; Siddique, 2023). Practical approaches in this regard include: implementing precise spot spraying to reduce treated area and herbicide consumption (Pokharel et al., 2024; Azghadi et al., 2025); decreasing volatilization through optimal timing, such as delayed pre-emergence or early post-emergence applications in sugarcane fields (Araldi de Castro, 2024; Moges et al., 2024); improving and optimizing tractor-mounted and manual spraying equipment (Araldi de Castro, 2024; Odero, 2024). Furthermore, applying herbicides under suitable climatic and growth conditions to maximize absorption and translocation within the weed tissue is another key factor in enhancing effectiveness and reducing the required dose (De la Cruz et al., 2020; Mendes et al., 2022). In the realm of research, future priorities may include establishing safer herbicide application systems, employing remote sensing technology to facilitate targeted spraying, and utilizing optimized delivery methods such as centrifugal nozzles, Controlled Droplet Application (CDA), and anti-drift nozzles, all of which ultimately contribute to improved herbicide performance and reduced drift (Jalu et al., 2023; Huang et al., 2025).

Forward-Looking Research

From a weed science perspective, key research priorities for sustainable sugarcane systems include:

Optimizing Herbicide Use: Investigating reduced rates, split applications, improved timing, and the use of adjuvants to enhance efficacy while minimizing environmental impact (Queiroz et al., 2022; Moges et al., 2024).

Integrated Weed Management (IWM): Developing and combining mechanical, physical, and cultural control methods with chemical tools to create robust, multi-tactic strategies (Rezaei et al., 2021; Patel et al., 2024).

Proactive Invasive Species Management: Using germination models and distribution mapping to monitor, predict, and manage the spread of invasive weed species (Abdolahi Lorestani et al., 2021a, b, c; Oveisi et al., 2024).

Conclusion

The progression of weed management in Iranian sugarcane cultivation illustrates a critical shift toward agricultural sustainability, moving from a narrow reliance on herbicides to a dynamic Integrated Weed Management (IWM) system. Excessive past dependence on a limited range of modes of action, particularly Photosystem II inhibitors, triggered serious consequences: evolved herbicide resistance in weeds such as Echinochloa colona, a shift in weed spectra toward resilient perennials like Imperata cylindrica and Cynanchum acutum, and increased environmental and economic problems. Strategic adaptation has since materialized through diversifying herbicide chemistry with new sites of action (e.g., indaziflam, pendimethalin), refining application timing via delayed pre-emergence sprays, and enhancing mechanical and physical control measures. This integrated strategy has successfully cut average herbicide use from approximately 20 to below 6 units per hectare. Advances in species-specific management, informed by an improved understanding of weed biology and ecology, further underscore a transition to more precise, knowledge-based control. However, persistent and emerging challenges including weed population shifts under climate change, emerging resistant biotypes, and the necessity of optimizing agronomic practices to enhance crop competitiveness highlight that IWM is an ongoing, adaptive process rather than a fixed solution. Ensuring long-term sustainability depends on reinforcing this multidimensional framework through dedicated research into precision technologies and non-chemical tools, continuous education and support for end users, and the systemic integration of weed management with optimized crop, water, and nutrient management. The Iranian experience confirms that enduring productivity and ecological integrity are best achieved through proactive, science-informed, and holistic management practices.

References

Abbasi, F. & Sheini Dashtgol, A. (2016). Evaluation and improvement of furrow irrigation management in Khuzestan's sugarcane fields. *Water and Soil Science*, 26(2). (In Persian).

Abdolahi Lorestani, S. (2012a). Investigating the possibility of using hilling-up operation in sugarcane weed management. Paper presented at the 12th Iranian Congress of Agronomy and Plant Breeding, Karaj, Iran. (In Persian).

Abdolahi Lorestani, S. (2015). Evaluation of the effectiveness of the rotovator tillage tool in controlling annual weeds in sugarcane fields. Paper presented at the 8th National Conference of Iranian Sugarcane Technologists, Iranian Society of Sugarcane Technologist. (In Persian).

Abdolahi Lorestani, S., & Pour Azar, R. (2012b). Investigation of the efficacy of the new pre-emergence herbicide Dynamic® in sugarcane fields. Paper presented at the 5th Congress of Iranian Sugarcane Technologists, Ahvaz, Iran. (In Persian).

Abdolahi Lorestani, S., Abdolahi, A. R., Bi-Mesl Shaerbafi, M., Barabadi, A. (2023a). Investigation of the effectiveness of post-emergence application of several herbicides in suppressing weeds in sugarcane (*Saccharum officinarum* L.) fields. Paper presented at the 10th Iranian Weed Science Congress, Bu-Ali Sina University, Hamadan, Iran. (In Persian).

Abdolahi Lorestani, S., Abin, A., Jamshidi, P., Ebrahimi, A. (2023b). Integrated management of common reed (*Phragmites australis* (Cav.) Trin. ex Steud.) in open drains of sugarcane (*Saccharum officinarum* L.) fields. Paper presented at the 10th Iranian Weed Science Congress, Bu-Ali Sina University, Hamadan, Iran. (In Persian).

Abdolahi Lorestani, S., Ahmadpour, S.R., Paknazar, A., Shahrooz, M., Parian, H. (2019a). Sugarcane weed management: Emerging challenges and opportunities. Paper presented at the 8th Iranian Weed Science Congress, Ferdowsi University of Mashhad, Mashhad, Iran. (In Persian).

Abdolahi Lorestani, S., Bazaz, M., Bab Gapian, N., Karimian, T. (2023c). Evaluation of the efficacy of control methods of field bindweed (*Convolvulus arvensis* L.) under fallow of sugarcane (*Saccharum officinarum* L.) fields. Paper presented at the 10th Iranian Weed Science Congress, Bu-Ali Sina University, Hamadan, Iran. (In Persian).

Abdolahi Lorestani, S., Ebrahimi, A., Paknazar, A. (2019b). Evaluation of the efficacy of several herbicides for post-emergence control of broadleaf weeds in sugarcane (*Saccharum officinarum* L.) fields. Paper presented at the 8th Iranian Weed Science Congress, Ferdowsi University of Mashhad, Mashhad, Iran. (In Persian).

Abdolahi Lorestani, S., Jafari, S., Aghamohamadi, H. (2017). Evaluation and comparison of efficacy of the rotovator and the sweep cultivator on annual weed control in sugarcane fields. Paper presented at the 7th Iranian Weed Science Congress, Gorgan, Iran. (In Persian).

Abdolahi Lorestani, S., Jafari, S., Ahmadpour, S. R., Aghamohammadi, H. (2014). An evaluation of two sweep cultivator types on annual weeds control in sugarcane fields. Paper presented at the 10th EWRS Workshop on Physical and Cultural Weed Control, Alnarp, Sweden. (In Persian).

Abdolahi Lorestani, S., Karimi, B., Bazaz, M. (2016). Evaluation of the efficiency of integrated control (mechanical-chemical) method in suppressing swallow-wort in sugarcane fallow fields (Final Report of Research Project). Sugarcane Research and Training Institute, Plant Protection Research Management, Weed Science Section. (In Persian).

Abdolahi Lorestani, S., Lorzadeh, S., Fathi, G. (2008). Integrated management of sugarcane weeds using chemical and mechanical (hilling-up) methods [Master's thesis, Islamic Azad University, Shushtar Branch]. (In Persian).

Abdolahi Lorestani, S., Malek Mohammadi, A., Eidizadeh, A. (2024). Investigation of the efficacy of various post-emergence herbicides in suppressing bermudagrass (*Cynodon dactylon* Pers. (L.)) in sugarcane (*Saccharum officinarum* L.) fields (Final Report of Research Project). Sugarcane Research and Training Institute. (In Persian).

Abdolahi Lorestani, S., Oveisi, M., Alizade, H., Rahimian Mashhadi, H. (2022). Integrated methods of swallow-wort (*Cynanchum acutum* L.) control in sugarcane. *Iranian Journal of Field Crop* Science, 53(3): 1–16. https://doi.org/10.22059/ijfcs.2021.316186.654782 (In Persian).

Abdolahi Lorestani, S., Oveisi, M., Alizadeh, H., Rahimian Mashhadi, H. (2021b). Predicting the emergence pattern of seedlings from seeds and root buds of Swallow-wort (*Cynanchum acutum* L.) in sugarcane. Paper presented at the 9th Iranian Weed Science Congress, Tehran, Iran. (In Persian).

Abdolahi Lorestani, S., Oveisi, M., Alizadeh, H., Rahimian Mashhadi, H. (2021a). Critical time of cutting after fruit development to prevent germination of Swallow-wort (*Cynanchum acutum* L.) seeds. *Iranian Journal of Weed Science*, 17(2): 111–126. https://doi.org/10.22092/ijws.2020.127596.1347 (In Persian).

Abdolahi Lorestani, S., Oveisi, M., Alizadeh, H., & Rahimian Mashhadi, H. (2021c). Effect of earthing up on spatial variation of swallow-wort (*Cynanchum acutum* L.) in sugarcane fields. Paper presented at the 9th Iranian Weed Science Congress, Tehran, Iran. (In Persian).

Abdolahi Lorestani, S., Sasanfar, H., Zand, E., Borumandfar, M., Shahrouz, M., & Eidizadeh, A. (2021d). Effect of pre-emergence application of different doses of diuron herbicide on suppressing weeds in sugarcane fields. Paper presented at the 9th Iranian Weed Science Congress, Agricultural Education and Extension Institute, Tehran, Iran. (In Persian).

Abdolahi Lorestani, S., Shahrouz, M., Borumand Far, M., Eidizadeh, A. (2020). Investigating the possibility of using the new microencapsulated pendimethalin (Prowl®, CS 45.5%) herbicide for controlling weeds in sugarcane (*Saccharum officinarum* L.) fields. Paper presented at the International Conference on Nanoscience and Nanotechnology, University of Tehran, Tehran, Iran. (In Persian).

Abdolahi Lorestani, S., Shahrouz, M., Borumandfar, M., Eidizadeh, A. (2019c). Investigation of the efficacy of promising herbicides in sugarcane (*Saccharum officinarum* L.) for suppressing resistant jungle rice (*Echinochloa colona* L. Link). Paper presented at the 8th Iranian Weed Science Congress, Ferdowsi University of Mashhad, Mashhad, Iran. (In Persian).

Abedinzadeh, M. (2005). Tebuthiuron (tebusan) application in comparison to common atrazine herbicide and mechanical control in ratoon sugarcane fields [Master's thesis, Islamic Azad University of Shushtar]. (In Persian).

Abedinzadeh, M. (2006). Study of perennial weeds biology in sugarcane fields of Khuzestan. Proceedings of the 2nd Iranian Weed Science Congress. (In Persian).

Abedinzadeh, M., & Ahmadi, M. (2006). Investigation of the efficacy of a new formulation to replace ametryn herbicide in sugarcane. Paper presented at the 17th Iranian Plant Protection Congress, Karaj, Iran. (In Persian).

Abedin Zadeh, M., Makvandi, M. A., Bahadori, F. (2015). Effect of mechanical control of weeds and nitrogen fertilizer use on the growth and yield of sugarcane. *Journal of Plant Production Science*, 5(2): 30–34. (In Persian).

Abhiram, G., Gopalasingam, T., Inthujan, J. (2025). Enhancing sustainability in sugarcane production through effective nitrogen management: A comprehensive review. *Nitrogen*, 6(3): 69. https://doi.org/10.3390/nitrogen6030069

Abin, A. A., Saoudi, J., Zalikakahkash, P., Jamshidi, P. (2017). Evaluation of promising herbicides for pre-emergence weed control in new sugarcane fields of Dehkhoda Sugarcane Agro-Industry. Paper presented at the 7th Iranian Weed Science Congress, Gorgan, Iran. (In Persian).

Abin, A. A., Saoudi, J., Zalikakaksh, P., Norouzi, H. (2019). Evaluation of the efficacy of Alion herbicide in pre-emergence control of weeds in new sugarcane fields with different cultivars in Dehkhoda Sugarcane Agro-Industry. Paper presented at the 8th Iranian Weed Science Congress, Ferdowsi University of Mashhad, Mashhad, Iran. (In Persian).

Abin, A., Rah Khodaee, A., Zand, E. (2014). Investigation of germination response of cogongrass (*Imperata cylindrica* (L.) P. Beauv) seeds to salinity and drought stresses. Paper presented at the 7th National Congress of Iranian Sugarcane Technologists, Ahvaz, Iran. (In Persian).

Ahmadi, A., Elahifard, A., Siahpoosh, A. R., Farkhari, M. (2017). Chemical management of purple nutsedge (*Cyperus rotundus* L.) in sugarcane cultivation. *Iranian Crop Science*, 48(4): 1139–1147. (In Persian).

Ahmadpour, S. R., & Abdolahi Lorestani, S. (2006). Comparison of the efficacy of new post-emergence herbicides in sugarcane. Annual Research Report of Weed Projects (2005-2006) (pp. 1–8). Sugarcane Research Center Publications. (In Persian).

Ahmadpour, S. R., & Abdolahi Lorestani, S. (2013a). Investigating the possibility of using reduced herbicide doses for early post-emergence weed control in new sugarcane fields. Paper presented at the 5th Iranian Weed Science Congress, Karaj, Iran. (In Persian).

Ahmadpour, S. R., & Abdolahi Lorestani, S. (2013b). Investigation on factors reducing the efficacy of herbicide application in sugarcane fields (Final Report of Research Project). Sugarcane Research and Training Institute. (In Persian).

Ahmadpour, S. R., & Alizadeh, H. (2008b). Study of methods for controlling aquatic weeds in irrigation and drainage networks of Khuzestan province [Master's thesis, University of Tehran]. (In Persian).

Ahmadpour, S. R., Alizadeh, H., Majnoon Hosseini, N. (2009). Investigation of the efficiency of strip spraying method in weed control and reducing herbicide consumption in sugarcane fields. Paper presented at the 3rd Iranian Weed Science Congress, Tehran, Iran. (In Persian).

Ahmadpour, S. R., Alizadeh, H., Majnoon Hoseini, N. (2011). Integrating of hilling up and cultivation with banded spraying in weed management in sugarcane fields. *Iranian Journal of Field Crop Science*, 41(4): 719–729. (In Persian).

Ahmadpour, S. R., Nabipour, M., Mesgarbashi, M., Farzaneh, M. (2017). Investigation of metribuzin resistance in barnyardgrass (*Echinochloa colona* (L.) Link.) populations from sugarcane fields. *Journal of Plant Protection*, 31(4): 512–525. (In Persian).

Ahmadpour, S., Abdolahi Lorestani, S., Zand, E. (2013). Evaluation of the efficacy of several new herbicides in early post-emergence control of junglerice (*Echinochloa colona* (L.) Link.) in sugarcane fields. Paper presented at the 5th Iranian Weed Science Congress, Karaj, Iran. (In Persian).

Ahmadpour, S.R., & Alizadeh, H. (2008a). Floristic study of weeds in sugarcane fields of Khuzestan. *Iranian Journal of Field Crops Research*, 6(1): 115–126. (In Persian).

Al-Kathir, J., & Borumandfar, M. (2003). Comparison of the effect of two herbicides, tebuthiuron and merlin, in new sugarcane fields. Annual Research Report of Weed Projects (2002-2003) (pp. 27–35). Sugarcane Research Center Publications. (In Persian).

Al-Kathir, J., Borumandfar, M., Farahbakhsh, A. N. (2003). Investigation of the efficacy of four dual-purpose herbicides in sugarcane. Annual Research Report of Weed Projects (2002-2003) (pp. 36–41). Sugarcane Research Center Publications. (In Persian).

Anonymous. (2007a). Internal reports of Sugarcane Development and By-products Company. (In Persian).

Anonymous. (2007b). Internal Report on Weed Seed Dispersion via Irrigation Water. Safiabad Agricultural Research Center. (In Persian).

Anonymous. (2023). Internal reports of Sugarcane Research and Training Institute. Weed Science Section, Plant Protection Management. (In Persian).

Anonymous. (2024a). Agricultural Statistics Yearbook 2022-2023, Field Crops, Vol. 1. Ministry of Jihad-e-Agriculture, Deputy of Economic Planning, Center for Statistics, Information and Communication Technology. (In Persian).

Anonymous. (2024b). Internal reports of Sugarcane Research and Training Institute. Weed Science Section, Plant Protection Management. (In Persian).

Anonymous. (2025). Sugarcane production technology in Iran: Agronomic Guidelines for sugarcane production (2nd ed.). Khuzestan's sugarcane & By-Products Research & Training Institute. (In Persian).

Araldi de Castro, R., de Castro, S. G. Q., Quassi de Castro, S. A., Piassa, A., Soares, G. O. D. N., Tropaldi, L., Christofoletti, P. J. (2024). Optimizing herbicide selection for pre-emergence control of itchgrass and cypress vine morningglory in sugarcane. *Journal of Environmental Science and Health*, Part B, 59(6): 350–360. https://doi.org/10.1080/03601234.2024.2352321

Bani Abbasi, N. A., Azizi, H., Gowing, D. P., Sund, K. A. (1971). Weeds and their control methods in Haft Tappeh Sugarcane Project. Agricultural Research Department of Haft Tappeh Sugarcane Project, Khuzestan Water and Power Authority, Ministry of Energy. (In Persian).

Bigdeli Shamloo, M. T., Narimaniyan, M., Farahbakhsh, A. N. (2003). Comparison of the efficacy of dual-purpose herbicides imazamethabenz and oxyfluorfen in sugarcane. Annual Research Report of Weed Projects (2002-2003) (pp. 53–61). Sugarcane Research Center Publications. (In Persian).

Boromand Far, M., Lorzadeh, S., Ariannejad, N. (2008). Investigation of the efficacy of trifloxysulfuron sodium + ametryn (Crysta) herbicide in controlling purple nutsedge (*Cyperus rotundus* L.) in Khuzestan's sugarcane fields. Paper presented at the 18th Iranian Plant Protection Congress, Bu-Ali Sina University, Hamadan, Iran. (In Persian).

Buhler, D. D., & Melinda, L. H. (1999). Expanding the context of weed management. *Journal of Crop Production*, 2: 1–7.

Christy Nirmala Mary P., & Jeyachandran, M. (2019). Effect of irrigation regime and fertilizers on sugarcane productivity and soil health enhancement under subsurface fertigation system of planting. *Journal of Pharmacognosy and Phytochemistry*, 8(6): 264–268.

Daman Afshan, A., & Maknali, A. (2005a). Investigation of the efficacy of isoxaflutole herbicide in sugarcane. Annual Research Report of Weed Projects (2003-2004) (pp. 47–55). Sugarcane Research Center Publications. (In Persian).

Daman Afshan, A., & Maknali, A. (2005b). Investigation of the efficacy of tebuthiuron herbicide in sugarcane. Annual Research Report of Weed Projects (2003-2004) (pp. 56–63). Sugarcane Research Center Publications. (In Persian).

Daman Afshan, A., Najafabadi, R. T., Jokar, L. (2003a). Comparison of the efficacy of dual-purpose herbicides imazamethabenz and oxyfluorfen in sugarcane. Annual Research Report of Weed Projects (2002-2003) (pp. 87–92). Sugarcane Research Center Publications. (In Persian).

Daman Afshan, A., Najafabadi, R. T., Jokar, L. (2003b). Comparison of the efficacy of lontrel and derby herbicides in sugarcane. Annual Research Report of Weed Projects (2002-2003) (pp. 93–98). Sugarcane Research Center Publications. (In Persian).

Daramola, O. S., Johnson, W. G., Jordan, D. L., Chahal, G. S., Devkota, P. (2022). Spray water quality and herbicide performance: a review. *Weed Technology*, 36(6): 758–767. https://doi.org/10.1017/wet.2022.97

De la Cruz, R. A., da Silva Amaral, G., Mendes, K. F., Rojano-Delgado, A. M., De Prado, R. (2020). Absorption, translocation, and metabolism studies of herbicides in weeds and crops. *In Radioisotopes in Weed Research* (pp. 127–154). CRC Press. https://doi.org/10.1201/9781003005070-5

Dezfoli, A. (1997). Study of weed flora in sugarcane fields of Khuzestan [Master's thesis, University of Tehran]. (In Persian).

Di Bella, L., Zahmel, M., van Zwieten, L., Rose, T. J. (2021). Weed suppression, biomass and nitrogen accumulation in mixed-species and single-species cover crops in a tropical sugarcane fallow. *Agriculture*, 11(7): 640. https://doi.org/10.3390/agriculture11070640

Ebrahimi, A., Eidizadeh, A., Alimehr, P. (2023). Evaluation of the efficacy of imazatapyr and oxyfluorfen herbicides in controlling sugarcane weeds (Final Report of Research Project). Khuzestan's sugarcane and By-products Industries Research and Development Institute Publications. (In Persian).

Ebrahimi, A., Rahimi Mashhadi, H., Oveisi, M., Zand, E., Ahmadpour, S. R. (2017). Determining cardinal temperatures for germination of rhizome buds of the invasive weed *Leptochloa fusca* L. Paper presented at the 7th Iranian Weed Science Congress, Gorgan, Iran. (In Persian).

Ehsanipour, A., Naseri, H., Zali Kakesh, P., Neisi, D. (2024). Comparison of pendimethalin EC 33% herbicide (Titan) with metribuzin and atrazine in the control of weeds in sugarcane fields. *Weed Research Journal*, 15(2): 27–35. (In Persian).

Elahifard, E., Ghanbari, A., Rashed Mohassel, M. H., Zand, E., Mirshamsi Kakhki, A., Mohkami, A. (2013). Characterization of triazine resistant biotypes of junglerice (*Echinochloa colona* (L.) Link.) found in Iran. *Australian Journal of Crop Science*, 7(9): 1302–1308.

Elahifard, E., Shamshirgarzadeh, N., Abdali Mashhadi, A., Moradi Telavat, M. R. (2017). Negative cross resistance in atrazine resistant junglerice (*Echinochloa colona* (L.) Link) populations in sugarcane (*Saccharum officinarum* L.) fields. *Journal of Iranian Plant Protection Research*, 31(3): 456–465. https://doi.org/10.22067/jpp.v0i0.58329 (In Persian).

El-Shafai, A., Fakkar, A., Bekheet, M. (2010). Impact of row spacing and some weed control treatments on growth, quality and yield of sugarcane. *Egyptian Journal of Agricultural Sciences*, 61(2): 124–136. https://doi.org/10.21608/ejarc.2010.215373

Eskandari, F., Keramat, B., Filizadeh, Y., Aynehband, A. (2022). Cogongrass *(Imperata cylindrica* (L.) P. Beauv) management in sugarcane fields of subtropical *Iran. Plant Production*, 45(1): 123–132. https://doi.org/10.22055/ppd.2020.33905.1919 (In Persian).

FAOSTAT. (2023). Crops and livestock products. Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#data/QCL

Farahbakhsh, A. N., Taherkhani, K. (2005). Investigation of the efficacy of isoxaflutole herbicide in combination with atrazine or diuron in sugarcane. Annual Research Report of Weed Projects (2003-2004) (pp. 30–34). Sugarcane Research Center Publications. (In Persian).

Farahbakhsh, A. N., Narhaee, A., Saraghi, A., Al-Kathir, J. (2005). Investigation of the efficacy of the dual-purpose herbicide chevalier in sugarcane. Annual Research Report of Weed Projects (2003-2004) (pp. 21–29). Sugarcane Research Center Publications. (In Persian).

Ghanbarpour, N., Zand, E., Sajedi, N. (2015). Efficacy of post-emergence herbicide for managing *Diplachne fusca* in sugarcane field. *Australian Journal of Basic and Applied Sciences*, 3: 108–117.

Gunarathna, M. H. J. P., Sakai, K., Nakandakari, T., Kazuro, M., Onodera, T., Kaneshiro, H., Uehara, H., Wakasugi, K. (2018). Optimized subsurface irrigation system: The future of sugarcane irrigation. *Water*, 10(3): 314. https://doi.org/10.3390/w10030314

Haji Sharafi, G. H., & Mousavinia, H. (2006). Investigation of the possibility of replacing sugarcane herbicides in order to reduce the use of chemical pesticides and optimal use of agricultural inputs in Amir kabir industry Co. of Khuzestan Province. Paper presented at the Sixth Biennial Conference of the Society of Environmental Experts, Tehran. (In Persian).

Haji Sharafi, G. H. (2005). Investigation of the effect of trifluralin herbicide on yield and weed control in sugarcane fields of southern Khuzestan province [Master's thesis, Islamic Azad University, Shushtar Branch]. (In Persian).

Hamidavi, H., Eslami, S. V., Jami Al-Ahmadi, M. (2015). Effect of salinity and drought stresses on germination ability of rhizomes of the stubborn weed cogongrass (*Imperata cylindrica* (L.) P. Beauv). *Journal of Environmental Stresses in Crop Sciences*, 8(2): 335–338. (In Persian).

Hamidavi, H., Eslami, S.V., Jami Al-Ahmadi, M. (2014). Investigation of the effect of different burial depths on the growth characteristics of the rhizome of cogongrass (*Imperata cylindrica* (L.) P. Beauv). Paper presented at the 13th Iranian Conference on Agricultural Sciences and Plant Breeding and 3rd Iranian Conference on Seed Science and Technology, Karaj. (In Persian).

Harker, K. N., Clayton, G. W., O'Donovan, J. T., Blackshaw, R. E., Stevenson, F. C. (2004). Herbicide timing and rate effects on weed management in three herbicide-resistant canola systems. *Weed Technology*, 18(4): 1006–1012. https://doi.org/10.1614/WT-03-275R

Hossein Zadeh, A., Aynehband, A., Hamdi, H. (2012). The effect of combined weed control methods on quantitative and qualitative yield of sugarcane in Khuzestan. *Plant Production*, 35(3): 55–68. (In Persian).

Huang, Y., Sun, X., Rai, N., Yao, H., Reddy, K. N., Jenkins, J. (2025). Remote sensing for precision weed management. *Pest Management Science,* 81(8): 4190–4199. https://doi.org/10.1002/ps.8833

Hussain, S., Khaliq, A., Mehmood, U., Qadir, T., Saqib, M., Iqbal, M. A., Hussain, S. (2018). Sugarcane production under changing climate: Effects of environmental vulnerabilities on sugarcane diseases, insects and weeds. *In Climate Change and Agriculture*. IntechOpen. http://dx.doi.org/10.5772/intechopen.81131

Jalu, M. V., Yadav, R., Ambaliya, P. S. (2023). A comprehensive review of various types of sprayers used in modern agriculture. *Pharma Innovation Journal*, 12: 143–149.

Jos, E., Cantarella, H., Bovi Ambrosano, G. M., Aparecida, E., Ferreira Dias, F. L., Rossi, F., Salom Teramoto, J. R. (2013). Crop rotation biomass and effects on sugarcane yield in Brazil. In Crop rotation. *InTech*. https://doi.org/10.5772/53825

Kaur, R., Kumar, S., Ali, S. A., Kumar, S., Ezing, U. M., Bana, R. S., Meena, S. L., Dass, A., Singh, T. (2024). Impacts of climate change on crop–weed dynamics: Challenges and strategies for weed management in a changing climate. *Open Journal of Environmental Biology,* 9(1): 15–21. https://doi.org/10.17352/ojeb.000042

Kazemi, K. (1990a). Control of *Dichanthium annulatum* L. weed in Haft Tappeh sugarcane fields. Haft Tappeh Agro-Industry Publications. (In Persian).

Kazemi, K. (1990b). Weeds of sugarcane fields in Khuzestan. Haft Tappeh Sugarcane Agro-Industry Publications. (In Persian).

Kazemi, K. (1995). Effect of EPTC herbicide on bermudagrass control and sugarcane yield. Haft Tappeh Agro-Industry Publications. (In Persian).

Kazemi, K. (1998). Control of *Dichanthium annulatum* L. in sugarcane fields in Iran with applied herbigation. Paper presented at the 72nd Annual SASTA Congress (South African Sugar Technologists' Association). (In Persian).

Khajavi, M. (1978). Weed identification key for sugarcane fields. Ministry of Agriculture Publications. (In Persian).

Kheyr Andish, S., Elahifard, E., Sayyad Mansour, A. R. (2013). Evaluation of some broadleaf herbicides in controlling weeds in sugarcane (*Saccharum officinarum* L.) fields of Khuzestan province. Paper presented at the 5th Iranian Weed Science Congress, Karaj, Iran. (In Persian).

Kheyr Andish, S., Rezaei, G., Elahifard, E. (2024). Evaluation of the efficacy of metribuzin + indaziflam in controlling sugarcane weeds. Paper presented at the 25th Iranian Plant Protection Congress, Tehran, Iran. (In Persian).

Leguizamón, E. S. (2024). The unsung champions of evolution: Weeds and their management in agricultural systems. Agriculture, 14(12): 2368. https://doi.org/10.3390/agriculture14122368

Liebman, M., & Zimdahl, R. L. (2018). Cultural techniques to manage weeds. In Integrated Weed Management for Sustainable Agriculture (pp. 203–226). Burleigh Dodds Science Publishing.

MacLaren, C., Storkey, J., Menegat, A., Metcalfe, H., Dehnen-Schmutz, K. (2020). An ecological future for weed science to sustain crop production and the environment. A review. *Agronomy for Sustainable Development, 40*(4): 24. https://doi.org/10.1007/s13593-020-00631-6

Makvandi, M. A., Abedinzadeh, M., Zand, E. (2011). Investigating the effect of application time of atrazine and metribuzin herbicides on weed control and sugarcane yield. Paper presented at the 4th Iranian Weed Science Congress, Ahvaz, Iran. (In Persian).

Mansuy, A., Marion, D., Labrunie, T. (2016). Cover crops associated with sugarcane to control weeds. In Proceedings of the International Society of Sugar Cane Technologists (Vol. 29, pp. 748–753).

Maurya, S. K., Singh, R. K., Kumar, B., Sarvajeet, Ranvir. (2021). A review on weed management in sugarcane: Critical periods of *Paspalum paniculatum* and Paspalum urvillei. *Pharma Innovation Journal*, 10(3): 521–525.

Mendes, K. F., Mielke, K. C., D'Antonino, L., Alberto da Silva, A. (2022). Retention, absorption, translocation, and metabolism of herbicides in plants. *In Applied Weed and Herbicide Science* (pp. 157–186). Springer International Publishing. https://doi.org/10.1007/978-3-031-01938-8_5

Mirzaei, M., Zand, E., Rastgoo, M., Hasanfard, A., Kudsk, P. (2023). Effects and mitigation of poor water quality on herbicide performance: a review. *Weed Research*, 63(3): 139–152. https://doi.org/10.1111/wre.12573

Moges, G., Delele, M. A., McDonnell, K., Mengistu, L. (2024). Optimization of herbicide dose for post-emergence weed control in sugarcane plantation using magnetic spraying. *International Journal of Pest Management*, 70(4): 766–777. https://doi.org/10.1080/09670874.2022.2038399

Mohd Ghazi, R., Nik Yusoff, N. R., Abdul Halim, N. S., Wahab, I. R. A., Ab Latif, N., Hasmoni, S. H., Zakaria, Z. A. (2023). Health effects of herbicides and its current removal strategies. *Bioengineered*, 14(1): 2259526. https://doi.org/10.1080/21655979.2023.2259526.

Mohemati Shirazi, H., Alimohammadi, M., Ostad Karampour, K. (2003). Comparison of two new herbicides, Tebusan® and Merlin®, in sugarcane. Annual Research Report of Weed Projects (2002-2003) (pp. 57–61). Sugarcane Research Center Publications. (In Persian).

Mousavi, S. K. (2001). Ecological study of weeds in sugarcane fields of Khuzestan [Ph.D. thesis, University of Shiraz]. (In Persian).

macllOdero, D. C. (2024). Early postemergence control of ragweed parthenium in sugarcane. *Journal of the American Society of Sugar Cane Technologists,* 44: 34–37.

Oveisi, M., Alizadeh, H., Abdolai Lorestani, S. A., Esmaili, A., Sadeghnejad, N., Piri, R., Müller-Schärer, H. (2024). Triangle area model (TAM) for predicting germination: An approach to enhance hydrothermal time model applications. *Current Plant Biology*, 39: 100356. https://doi.org/10.1016/j.cpb.2024.100356

Parian, H., Abdolahi Lorestani, S., Ghasemi, M. R., Pour Mahmoud, M. (2019). Management of swallow-wort (*Cynanchum acutum* L.) weed in sugarcane fallow fields. Paper presented at the 8th Iranian Weed Science Congress, Ferdowsi University of Mashhad, Mashhad, Iran. (In Persian).

Patel, T., Dudhat, M. S., Patel, D., Thanki, J. D. (2024). Comparative evaluation of agronomical, mechanical and chemical management of weeds and their impact on sugarcane productivity. *Indian Journal of Weed Science.* 56(2): 167–175. https://doi.org/10.5958/0974-8164.2024.00027.X

Pokharel, P., Sharda, A., Flippo, D., Ladino, K. (2024). Design and systematic evaluation of an under-canopy robotic spray system for row crops. *Smart Agricultural Technology*, 8, 100510. https://doi.org/10.1016/j.atech.2024.100510.

Pour Azar, R. (2011a). Investigation of the efficacy of the new herbicide Dinamic® (Amicarbazone) in sugarcane (Final Report). Khuzestan Agricultural and Natural Resources Research Center. (In Persian).

Pour Azar, R. (2011c). Study of the effectiveness of the new herbicide Dinamic® (Amicarbazone) in sugarcane (Final report). Khuzestan Agricultural and Forest Resources Research Center. (In Persian).

Pour Azar, R., Sayyad Mansour, A. A., Sharififar, S., Zand, E. (2006a). Evaluation of the efficacy of the new herbicide Krismat WG 75 (ametryn + trifloxysulfuron sodium) in sugarcane. Paper presented at the 17th Iranian Plant Protection Congress, Karaj, Iran. (In Persian).

Pour Azar, R., Sayyad Mansour, A. R., Ahmadpour, S. R., Taherkhani, K., Zand, E. (2011b). Trend of research conducted on weeds and herbicides over the past 20 years in sugarcane cultivation in Khuzestan province, problems and solutions. Paper presented at the 4th Iranian Weed Science Congress, Khuzestan Agricultural and Natural Resources Research Center, Ahvaz, Iran. (In Persian).

Pour Azar, R., Sayyad Mansour, A. R., Sharifi Far, S., Zand, E. (2008). Investigation of the efficacy of three new herbicides in sugarcane. Paper presented at the 18th Iranian Plant Protection Congress, Bu-Ali Sina University, Hamadan, Iran. (In Persian).

Pour Azar, R., Sayyad Mansour, A. R., Sharififar, S., Zand, E. (2006b). Investigation of the efficacy of Stamina (Stamina DF) and Diuron (Diuron DF) herbicides compared to common sugarcane herbicide. Paper presented at the 9th Iranian Congress of Agronomy and Plant Breeding, Karaj, Iran. (In Persian).

Queiroz, A. F., Luís, A., Fernandes, T., Ferdinando, M., Lima, S. (2022). Efficacy of adjuvants photoprotectors for herbicides in sugarcane. *American Academy Scientific Research Journal for Engineering, Technology, and Sciences*, 88(1): 279–291. https://asrjetsjournal.org/American_Scientific_Journal/article/view/7695

Rafatjoo, A., & Saedi Nasab, K. (2013c). Report on the presence and establishment of the invasive weed itchgrass (*Rottboellia cochinchinensis*) and investigation of the possibility of its post-emergence control in Haft Tappeh sugarcane fields. Paper presented at the 7th National Congress of Iranian Sugarcane Technologists, Ahvaz, Iran. (In Persian).

Rafatjoo, A., Ghasemipour, A., Heidari, M. (2013a). Investigation of the effect of selective pre-emergence herbicides of sugarcane fields on some agronomic traits of Chamran wheat in northern Khuzestan. Paper presented at the 7th National Congress of Iranian Sugarcane Technologists, Ahvaz, Iran. (In Persian).

Rafatjoo, A., Ghasemipour, A., Heidari, M., Aghabi, H., Rafiei, R. (2013b). Economic evaluation of the development and replacement of non-chemical (mechanical) methods with autumn and winter chemical control of sugarcane weeds. Paper presented at the 7th National Congress of Iranian Sugarcane Technologists, Ahvaz, Iran. (In Persian).

Rahimi Azghadi, M., Olsen, A., Wood, J., Saleh, A., Calvert, B., Granshaw, T., Fillols, E., Philippa, B. (2025). Precision robotic spot-spraying: Reducing herbicide use and enhancing environmental outcomes in sugarcane. *Computers and Electronics in Agriculture,* 235: 110365. https://doi.org/10.1016/j.compag.2025.110365

Ramesh, K., Matloob, A., Aslam, F., Florentine, S. K., Chauhan, B. S. (2017). Weeds in a changing climate: Vulnerabilities, consequences, and implications for future weed management. *Frontiers in Plant Science*, 8, 95. https://doi.org/10.3389/fpls.2017.00095

Rathika, S., Ramesh, T., & Jagadeesan, R. (2023). Weed management in sugarcane: A review. *The Pharma Innovation Journal*, 12(6): 3883–3887.

Rezaei, G., Kheyrandish, S., Saradar Zadeh, N. (2017). Investigation of the effect of several herbicides applied through herbigation in sugarcane cultivation. Paper presented at the 7th Iranian Weed Science Congress, Gorgan, Iran. (In Persian).

Rezaei, Y., Elahifard, E., Siadat, S. A., Abdolahi Lorestani, S. (2021). Integration of mechanical weeding and herbicide application in weed management of sugarcane (*Saccharum officinarum* L.). *Journal of Plant Production*, 44(2): 171–182. (In Persian).

Rokouei, A., Lorzadeh, S., Ariannia, N., Rajabi, R. (2008). Investigation of the effect of chemical control of barnyardgrass on yield of sugarcane cultivar Cp82-1592. Paper presented at the 18th Iranian Plant Protection Congress, Bu-Ali Sina University, Hamadan, Iran. (In Persian).

Salamati, N., Abbasi, F., Delbari, M., Sheini Dashtgol, A., Afrasiab, P. (2015a). Distribution uniformity of water and nitrogen in sugarcane furrow fertigation. *Food Engineering Research*, 16(2): 41–60. https://doi.org/10.22092/jaer.2015.101965 .(In Persian).

Salamati, N., Delbari, M., Abbasi, F., Sheini Dashtgol, A., Afrasiyab, P., Karandish, F. (2015b). Effects of split application and different amounts of furrow fertigation on yield and some quantitative and qualitative traits of sugarcane cultivar CP69-1062. *Iranian Journal of Soil and Water Research*, 46(2): 195–205. (In Persian).

Saradar Zadeh, N. (2006). Sugarcane weeds. Agricultural Education Publication (Commissioned by Karun Agro-Industry Company). (In Persian).

Sasanfar, H., Abdolahi Lorestani, S., Abin, A. A., Rezaei, G., Zand, E., Parian, H., Kheyrandish, S., Saoudi, J., Ghasemi, M. H. (2021). Investigation of the efficacy of Lumax herbicide (mesotrione + S-metolachlor + terbuthylazine, 53.75% SE) as post-emergence application in controlling weeds in sugarcane fields (Final Report of National Coordinated Research Project). Iranian Research Institute of Plant Protection. (In Persian).

Sayyad Mansour, A. (2007a). Investigating weed resistance to conventional herbicides in sugarcane fields. Proceedings of the 2nd Conference of Sugar Cane Technologists, Imam Khomeini Sugarcane Agro-Industry, Ahvaz, Iran (pp. 78–87). (In Persian).

Sayyad Mansour, A. (2007b). History of herbicide use in sugarcane fields of Iran. Proceedings of the 1st National Conference on Sugarcane Science (Vol. 8, pp. 15–18). (In Persian).

Shafiei Bafti, M., & Behravan, R. (2012). The role of organic and chemical fertilizers in soil health and sugarcane yield. Journal of Soil and Water Resources Conservation, 1(2): 45–58. (In Persian).

Sharafizadeh, P., Nik Pei, A., Kord, H., Banader, M. (2018). Effect of hydroflum time on control of cogongrass (*Imperata cylindrica* (L.) P. Beauv) in sugarcane fields. Paper presented at the 23rd Iranian Plant Protection Congress, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran. (In Persian).

Sheini Dashtegol, A., Naseri, A., Boroomand Nasab, S. (2020). Effects of subsurface drip irrigation and furrow irrigation management on growth variables and root distribution in sugarcane cultivation. *Iranian Journal of Irrigation & Drainage*, 14(2): 535–547. (In Persian).

Sheini Dashtgol, A. (2015). Principles of applied water management in sugarcane. Kerdegar Publications. (In Persian).

Shimi, P., Atri, A., Sharifi, S., Mohemati Shirazi, H. (2004). Investigation of the efficacy of tebuthiuron (Tebusan® 50% SC) herbicide in sugarcane cultivation. Paper presented at the 16th Iranian Plant Protection Congress, Tabriz, Iran. (In Persian).

Shukla, S. K., Sharma, L., Jaiswal, V. P., Dwivedi, A. P., Yadav, S. K., Pathak, A. D. (2022). Diversification options in sugarcane-based cropping systems for doubling farmers' income in subtropical India. *Sugar Tech*, 24(4): 1212–1229. https://doi.org/10.1007/s12355-022-01127-1

Siddique, I. (2023). Herbicides and safeners: enhancing agricultural productivity and environmental safety. European *Journal of Advances in Engineering and Technology*, 10(11), 40–46. https://doi.org/10.5281/zenodo.12804511

Soraghi, A., Mohebi, A., Jokar, L., Farahbakhsh, A. N. (2003). Investigation of post-emergence control of weeds in sugarcane. Annual Research Report of Weed Projects (2002-2003) (pp. 42–45). Sugarcane Research Center Publications. (In Persian).

Sulaiman, A.A., Arsyad, M., Amiruddin, A., Teshome, T.T., Nishanta, B. (2023). New trends of sugarcane cultivation systems toward sugar production on the free market: A review. *AGRIVITA Journal of Agricultural Science*, 45(2): 395–406. https://doi.org/10.17503/agrivita.v45i2.4066

Surendran, U., Ramesh, V., Jayakumar, M., Marimuthu, S., Sridevi, G. (2016). Improved sugarcane productivity with tillage and trash management practices in semi-arid tropical agro ecosystem in India. *Soil and Tillage Research*, 158: 10–21. https://doi.org/10.1016/j.still.2015.10.009

Tabatabaei, S. A. (2015). The use of mulches in sustainable agriculture. Takta Publications. (In Persian).

Taherkhani, K. (1999). Effect of different herbicides on weed control in sugarcane fields of Imam Khomeini Unit. Imam Khomeini Sugarcane Agro-Industry Publications. (In Persian).

Taherkhani, K., Narhaee, A., & Askarian Zadeh, A. (2003). Investigation of the efficacy of pre-emergence herbicide Tebusan® S.C. in sugarcane fields. Annual Research Report of Weed Projects (2002-2003) (pp. 10–17). Sugarcane Research Center Publications. (In Persian).

Takim, F. O., & Suleiman, M. A. (2017). Impact of plant population and weed control methods on the growth, yield and economic potential of sugarcane (*Saccharum officinarum* L.) cultivation. *Planta Daninha*, 35. https://doi.org/10.1590/s0100-83582017350100081

Tomar, V., & Singh, J. (2024). Effective weed management strategies for sustainable cultivation of sugarcane (Saccharum officinarum L.): a comprehensive review. *Journal of Experimental Agriculture International*, 46(7): 120–133. https://doi.org/10.9734/jeai/2024/v46i72564

USDA. (2024). World Agricultural Production (Circular Series WAP 04-25). U.S. Department of Agriculture, National Agricultural Statistics Service. https://www.nass.usda.gov/Publications/AgCensus/2022/index.php/

Viaud, P., Heuclin, B., Letourmy, P., Christina, M., Versini, A., Mansuy, A., Chetty, J., Naudin, K. (2023). Sugarcane yield response to legume intercropped: A meta-analysis. *Field Crops Research,* 295: 108882. https://doi.org/10.1016/j.fcr.2023.108882

Voora, V., Bermúdez, S., Le, H., Larrea, C., Luna, E. (2023). *Global Market Report: Sugarcane Prices and Sustainability*. Sustainable Commodities Marketplace Series. International Institute for Sustainable Development (IISD). https://www.iisd.org/publications/report/2023-global-market-report-sugar-cane

Webber, C.L., III, White, P.M., Jr., Landrum, D.S., Spaunhorst, D.J., Wayment, D.G., Dorvil, E. (2018). Sugarcane field residue and root allelopathic impact on weed seed germination. *Journal of Agricultural Science*, 10(1): 66–72. https://doi.org/10.5539/jas.v10n1p66

Yirefu, F., Tana, T., Tafesse, A., Zekarias, Y. (2012). Competitive ability of sugarcane (*Saccharum officinarum* L.) cultivars to weed interference in sugarcane plantations of Ethiopia. *Crop Protection*, 32: 138–143. https://doi.org/10.1016/j.cropro.2011.10.016

Zafar, M., Tanveer, A., Cheema, Z. A., Ashraf, M. (2010). Weed-crop competition effects on growth and yield of sugarcane planted using two methods. *Pakistan Journal of Botany*, 42(2): 815–823.

Zand, E., Baghestani, M. A., Nezamabadi, N., Minbashi Moeini, M., Hadizadeh, M. H. (2009). A review on the last list of herbicides and the most important weeds of Iran. *Weed Research Journal*, 1(2): 83–100. (In Persian).

Zand, E., Sharafizadeh, P., Abdolahi Lorestani, S., Rezaei, G. (2016). Investigation of the efficacy of indaziflam (Alion®) herbicide in controlling weeds in sugarcane fields (Final Report of Research Project, Registration No. 51042). Iranian Research Institute of Plant Protection. (In Persian).