山西農業大學
Shanxi Agricultural University

Weed Control Strategies in Foxtail Millet (*Setaria italica* (L.) P. Beauv.) Fields

Xiangyang Yuan
原向阳

College of Agriculture,
Shanxi Agricultural University

March 2026

Report Outline

- 1. Importance of Foxtail Millet
- 2. Foxtail Millet Planting: A Global and Domestic Overview
- 3. Weed Species in Foxtail Millet Fields and Their Identification
- 4. Current Status of Weed Control in Foxtail Millet Fields
- 5. Future Strategies for Weed Management in Foxtail Millet Fields

1. Importance of Foxtail Millet

- *Setaria italica* (L.) P. Beauv., commonly known as foxtail millet, is an annual grass species valued for its drought tolerance, adaptability to barren soils, high water-use efficiency, and strong resilience. Nutritionally rich in protein, fat, and vitamins, it serves as a distinctive and competitive export crop in China. As a strategic reserve crop to combat the increasingly serious shortage of water resources, it plays an important role in ensuring national food security and supporting the implementation of "the Healthy China" strategy.
- Foxtail millet serves as a milk substitute for infants, a staple food for adults, and a nutritional supplement for the elderly.


Porridge


Fried millet


Biscuits


Millet pancakes


Millet crackers
小米锅巴
Millet Crisp


Millet noodles
100%
纯小米面条
华小米
100%纯
小米面条


Millet wine
小米酒
真养人
亏本
冲销量
（下单立减20）
小米养生酒
折合
价为
49元


Millet vinegar
沁州黄小米醋
3.5°
2500ml
如有勾兑 全额退款


Millet coke
Micola
小米可乐
50%


Millet drinks
酒店特供
瓢城
小米露
饮料
不含防腐剂


Millet oil
小米油
孕婴专用油


Millet nutritional powder
PRO-LOVE
谷之爱
婴幼儿
营养小米米粉
钙铁锌
70%


不用熬的
小米粥
尽享欢乐时光

2. Foxtail Millet Planting: A Global and Domestic Overview

- Foxtail millet originated in the Yellow River Basin of China, with a cultivation history spanning over 8,000 years. It is revered as the foundational crop that nurtured the Chinese civilization.
- **China accounts for over 80% of the world's foxtail millet cultivation area, while India constitutes about 10%.**
- In the early years of the People's Republic of China, the annual planting area of foxtail millet remained as high as 9.87 million hectares, with extensive cultivation across 23 provinces and autonomous regions.
- Currently, the total foxtail millet planting area in China stands at approximately 1 million hectares. This cultivation is concentrated in 10 provinces within the northern arid and semi-arid regions, which account for 97% of the national total. Notably, three provinces in North China—Inner Mongolia, Shanxi, and Hebei—alone contribute about 67.1% of the total area.

Foxtail Millet Production Status in Shanxi, Inner Mongolia, and Hebei (2022-2023)

Unit: 10,000 mu, 10,000 metric tons

省份		山 西	内 蒙	河 北
2022年	面积	328.65	380.4	215
	全国排名	第二	第一	第三
	总产	52.8	92.3	54.18
	全国排名	第二	第一	第三
2023年	面积	312.5	344.8	210
	全国排名	第二	第一	第三
	总产	49.6	77	54
	全国排名	第二	第一	第三

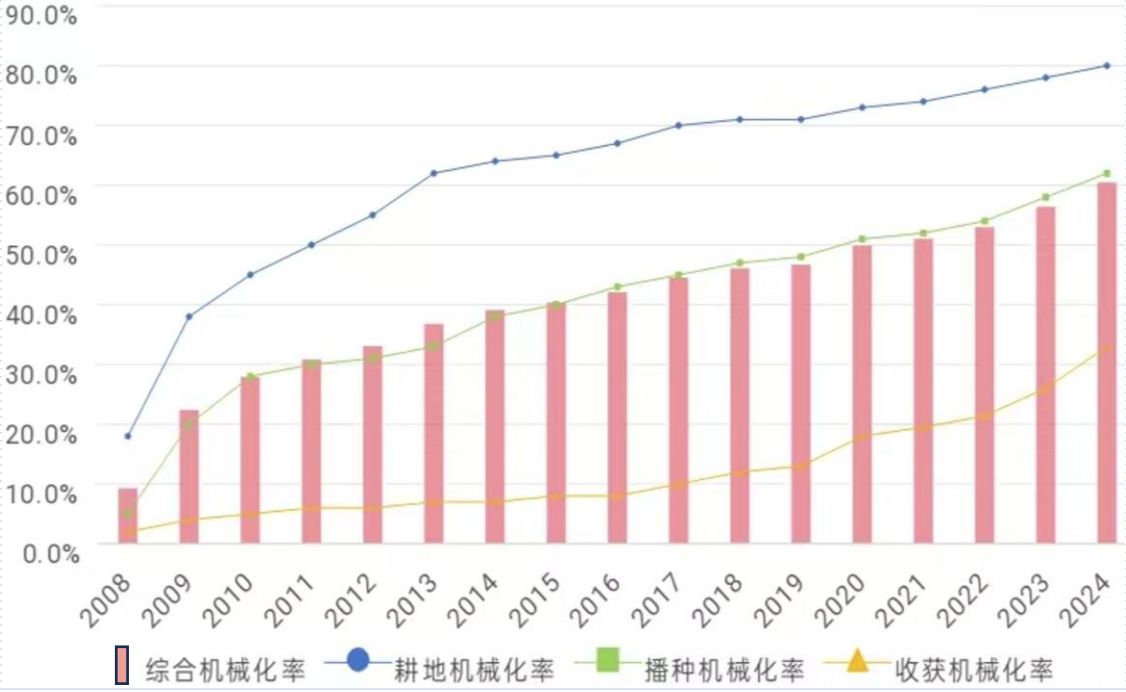


Figure 1. National Integrated Mechanization Rate for Foxtail Millet Farming, Planting, and Harvesting (2008-2024)

- The integrated mechanization rate for foxtail millet production has increased annually, reaching approximately 60.5% in 2024. This overall rate comprises a 80% mechanization rate for land preparation, 62% for planting, and 32% for harvesting.

2017.6、2020.5、2022.1、2023.5习近平7年4次视察山西

2017年6月，习近平总书记视察山西时指出“山西的现代农业发展，要打好特色优势牌。山西是著名的‘小杂粮王国’，孕育出众多的特色农产品，谷子、杂豆、莜麦等产量在全国名列前茅，要立足优势，扬长避短，突出‘特’字，发展现代特色农业。”

“大力发展有机旱作农业”、“要打好特色优势牌”

Foxtail millet is the golden calling card of Shanxi Province's kingdom of coarse grains.

谷子是山西省杂粮王国的黄金名片。

山西省人民政府办公厅文件

晋政办发〔2017〕104号

山西省人民政府办公厅
关于印发“山西小米”品牌建设实施方案的通知

各市、县人民政府，省人民政府各委、办、厅、局：

经省人民政府同意，现将《“山西小米”品牌建设实施方案》印发给你们，请认真组织实施。

打造区域性公共品牌，实现好米变名米，名米卖好价

山西省人民政府办公厅
2017年8月31日

山西省人民政府办公厅文件

晋政办发〔2018〕100号

山西省人民政府办公厅
关于印发“山西小米”品牌建设三年发展规划的通知

各市、县人民政府，省人民政府各委、办、厅、局：

《“山西小米”品牌建设三年发展规划》已经省人民政府同意，现印发给你们，请结合实际，认真组织实施。

20个企业，30万亩基地，产量突破1亿斤，增收20亿元

山西省人民政府办公厅
2018年9月30日

山西省人民政府办公厅文件

晋政办发〔2019〕29号

山西省人民政府办公厅
关于加快杂粮全产业链开发的实施意见

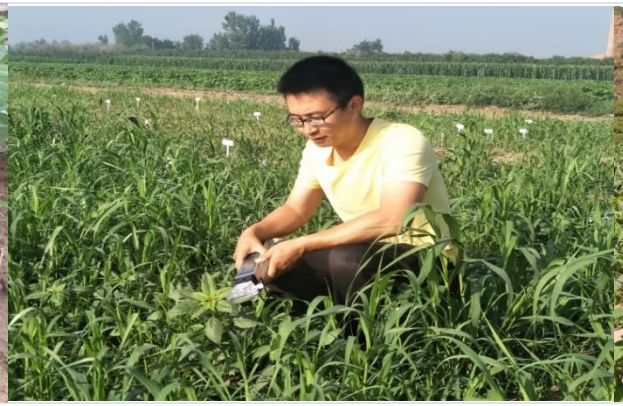
各市、县人民政府，省人民政府各委、办、厅、局：

为深入贯彻习近平总书记视察山西重要讲话精神，抓好省委省政府《关于坚持农业农村优先发展做好“三农”工作的实施意见》（晋[illegible]构性改革，打好特色优势牌，着力推进杂粮全产业链开发，经省政府同意，提出如下实施意见。

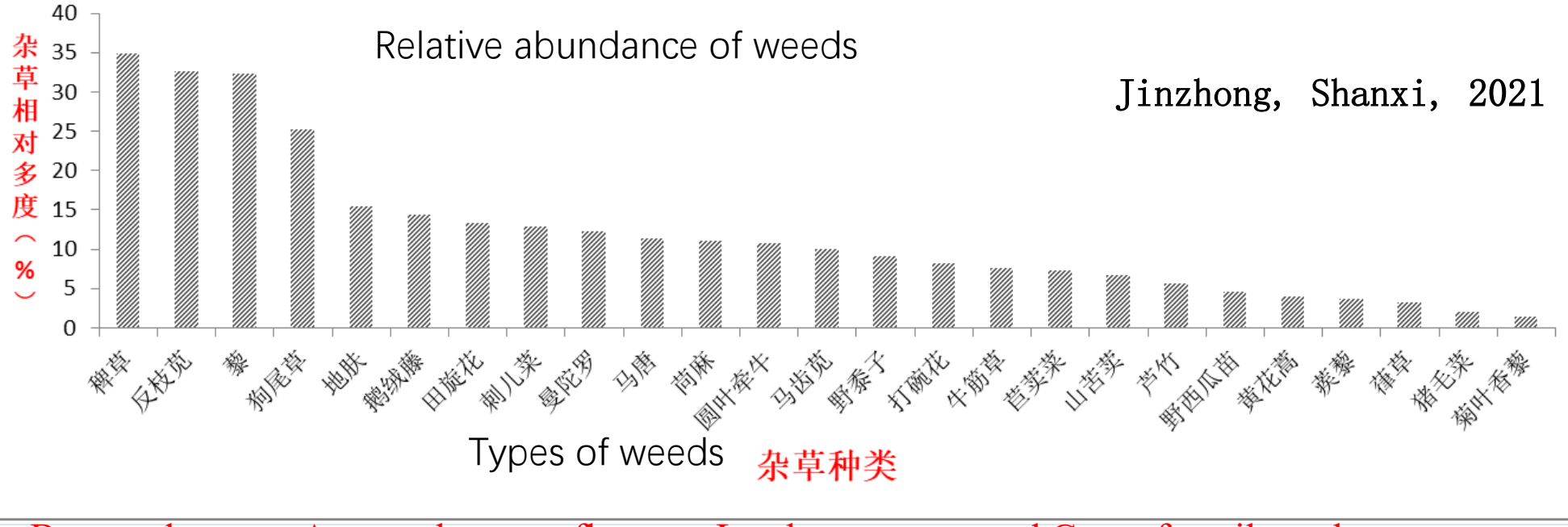
良种繁育、有机旱作生产等六大重点工程

3. Weed Species in Foxtail Millet Fields and Their Identification

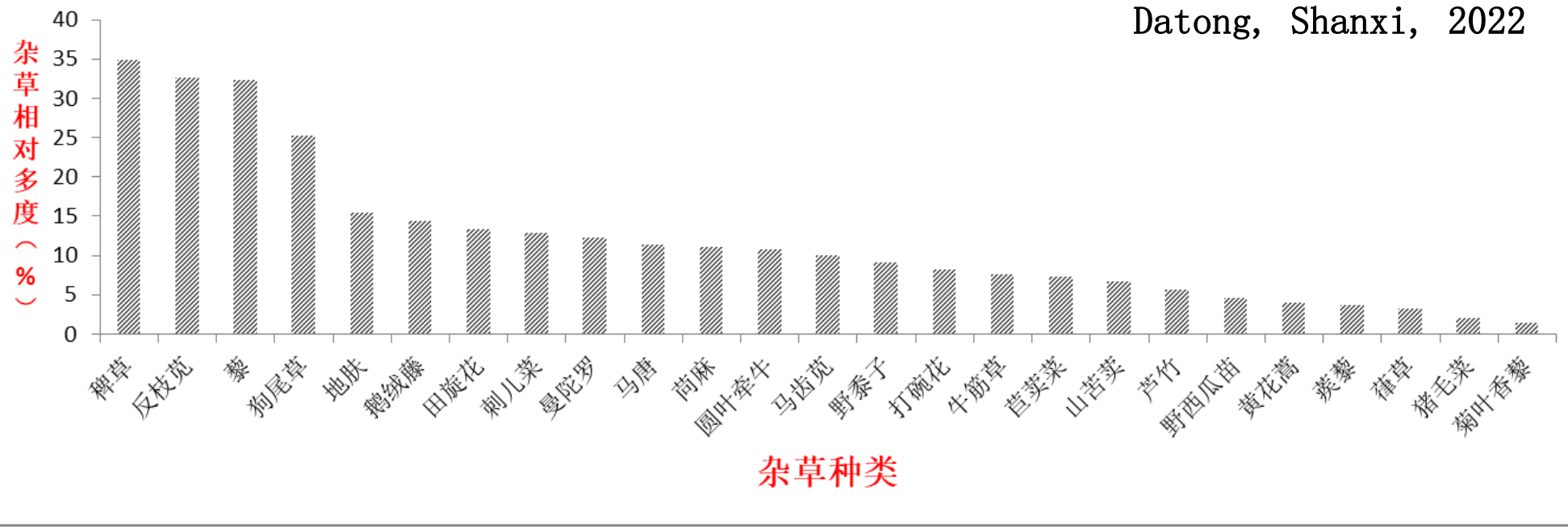
Weeds "Consume" 1 Billion Tons of Rations (Science and Technology Daily, 2017). Global crop yield losses caused by weeds amount to as high as 95 billion US (FAO). In China, weeds infest 85% of farmland, causing an annual grain output reduction of 37 million metric tons (Ministry of Agriculture and Rural Affairs).


- Weeds in foxtail millet fields pose significant threats to crop growth by competing with millet for water, nutrients, and sunlight, while also spreading diseases and insect pests. These factors severely hinder millet development, reducing both grain quality and yield. Furthermore, weed infestation impedes the efficiency and effectiveness of mechanized farming operations.
- Weeds in foxtail millet fields encompass 30 species across 16 families. Common dominant species include grass weeds such as Barnyardgrass（稗草）, Green foxtail（狗尾草）, and Goosegrass（牛筋草）, as well as broadleaf weeds like Lambsquarters（藜）, Amaranthus retroflexus（反枝苋）, Cephalanoplos segetum（刺儿菜）, Purslane（马齿苋）, and velvetleaf（苘麻）.



Barnyardgrass, Amaranthus retroflexus, Lambsquarters, and Green foxtail are the most type.



4. Current Status of Weed Control in Foxtail Millet Fields

4.1 Manual weeding

Manual weeding is the most primitive method for field weed control, characterized by low efficiency, labor-intensiveness, and time consumption. However, it offers excellent weed control results and is safe with no residue. This method is still widely adopted in many practical scenarios, such as: small-scale fields (less than 667m^2 per household), hilly or mountainous fields, herbicide-sensitive variety field (such as Jingu 21), and organic millet production bases.

4.2 Mulching for Weed Control

It primarily includes white plastic film, black plastic film, and biodegradable mulch. Plastic film can increase soil temperature, retain soil moisture, and maintain soil structure. However, plastic film is difficult to recycle and contaminates the soil. Biodegradable mulch is a future trend but currently faces challenges of high cost and immature technology.

Sowing in rows beside plastic film

Semi-mulching

Rotary tillage-plastic film mulching and hole sowing technology

Hole sowing in furrows with full plastic film mulching

Full-mulching

Hole sowing with full plastic film mulching

谷锄三遍 八米二糠

锄头有水，锄头有火

锄头有粪，越锄越嫩

4.3 Mechanized Inter-row Hilling

- Two-Row Inter-row Weeding and Hilling Machine, with adjustable row spacing of 40-60 cm, working depth of 5-10 cm, and operating speed of 6-8 mu/h.
- Inter-row cultivation promotes deeper root penetration, providing benefits such as drought resistance, lodging prevention, and weed control. However, it is difficult to remove weeds between seedlings within the row.

4.4 Chemical Weed Control

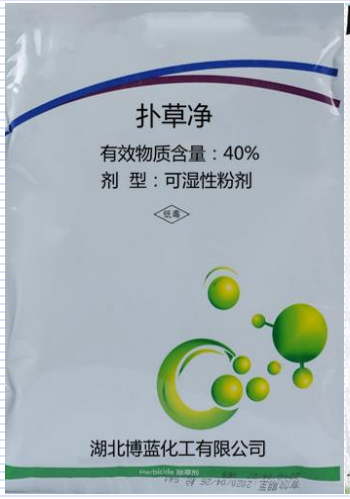
- Chemical weed control is one of the key hallmarks of modern agriculture.
- Foxtail millet is extremely sensitive to herbicides, so herbicides must be used with great caution. They should be tested first before application to ensure the safety of crops, humans, livestock, and the environment.

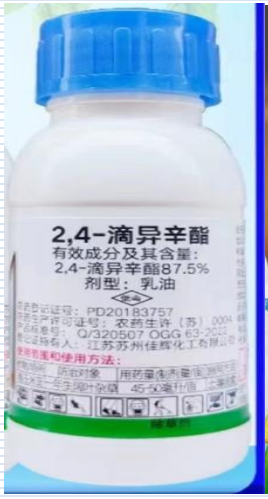
Injured foxtail millet seedlings

Herbicide trial in field

（1）Currently, there are only eight active ingredients of herbicides registered for foxtail millet fields on China Pesticide Information Network.

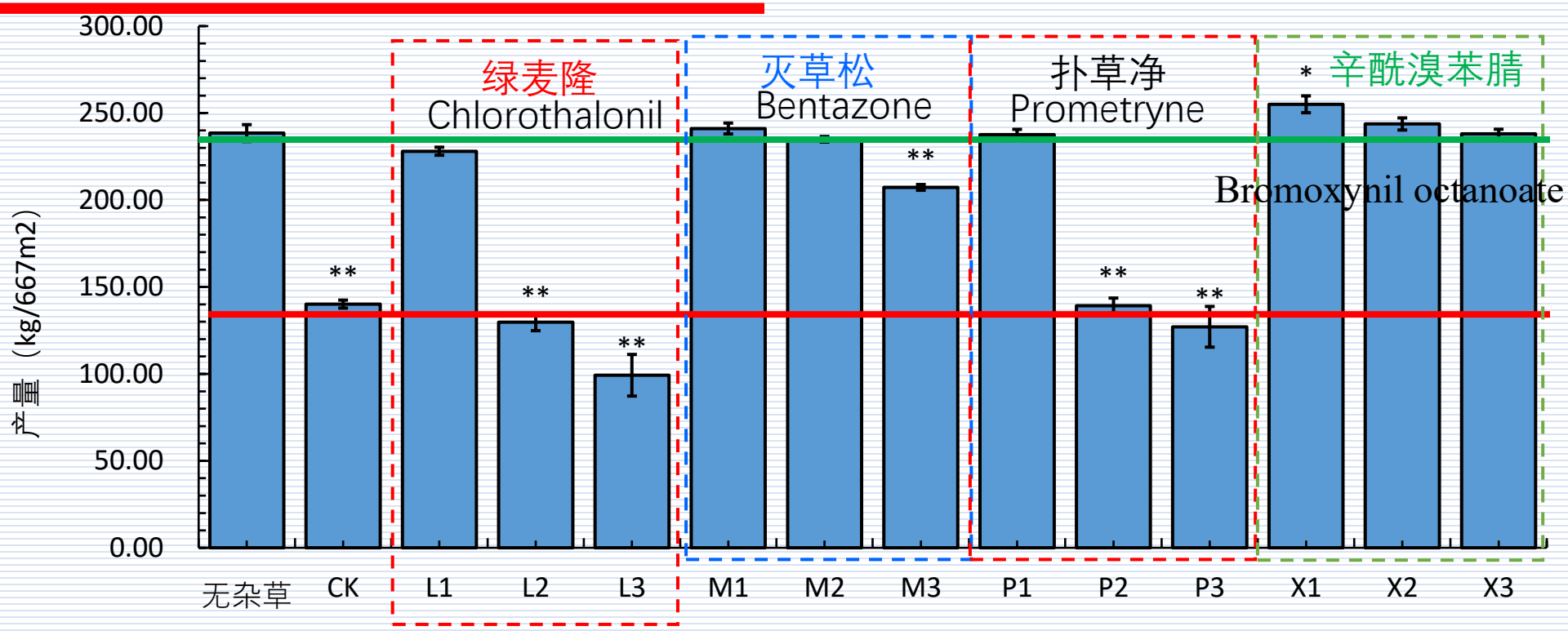
Prometryn wettable powder (8 products), Monosulfuron wettable powder (1 product), MCPA-isooctyl ester emulsifiable concentrate (2 products), MCPA·fluroxypyr mixture (2 products), 2,4-D isooctyl ester emulsifiable concentrate (1 product), Bromoxynil octanoate emulsifiable concentrate (1 product), 2,4-D butyl emulsifiable concentrate (1 product: banned effective January 29, 2023), and Sethoxydim emulsifiable concentrate (1 product). However, various safety issues continue to occur in practical applications





扑草净可湿性粉剂（8种）、单嘧磺隆可湿性粉剂（1种）、2甲4氯异辛酯乳油（2种）、2甲·氯氟吡（2种）、2，4－滴异辛酯乳油（1种）、辛酰溴苯腈乳油（1种）、2,4-滴丁酯乳油（1种：2023.01.29被禁止使用）、烯禾啶乳油（1种）。但生产中还出现各种安全问题。

(2) Safety Effects of Different Foliar-applied Herbicides on Foxtail Millet



Compared to manual weeding, applications of chlortoluron at the recommended dose, bentazone at 1x and 2x the recommended dose, prometryn at the recommended dose, and bromoxynil octanoate at 1x, 2x, and 3x the recommended dose showed no significant effect on the yield of the Jingu 21 variety. However, the weed control efficacy of bentazone was relatively poor, while the other treatments provided satisfactory control.

(2) Safety Effects of Different Foliar-Applied Herbicides on Foxtail Millet

- The experiment was conducted using both pot and field trials to investigate the safety of different application rates of tribenuron-methyl (0, 7.5, 15, 30, 60 g/mu), fenoxaprop-p-ethyl (0, 30, 60, 120, 240 ml/mu), and quizalofop-p-ethyl (0, 15, 30, 60, 120 ml/mu) on foxtail millet seedlings. The recommended dosage for tribenuron-methyl is 15 g/mu, 60 ml/mu for fenoxaprop-p-ethyl, and 30 ml/mu for quizalofop-p-ethyl. A completely randomized design with three replications was adopted. Herbicides were applied via foliar spray at the 4-5 leaf stage of the millet, and plant height and yield were measured at maturity.

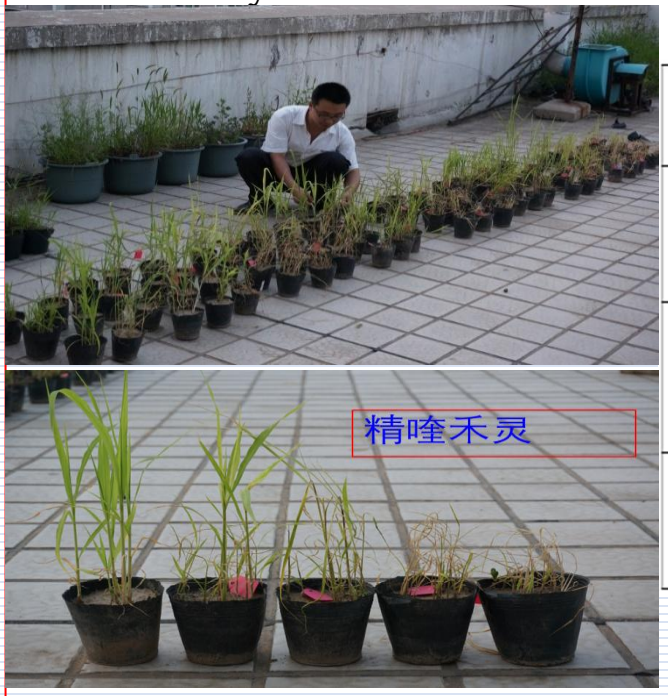
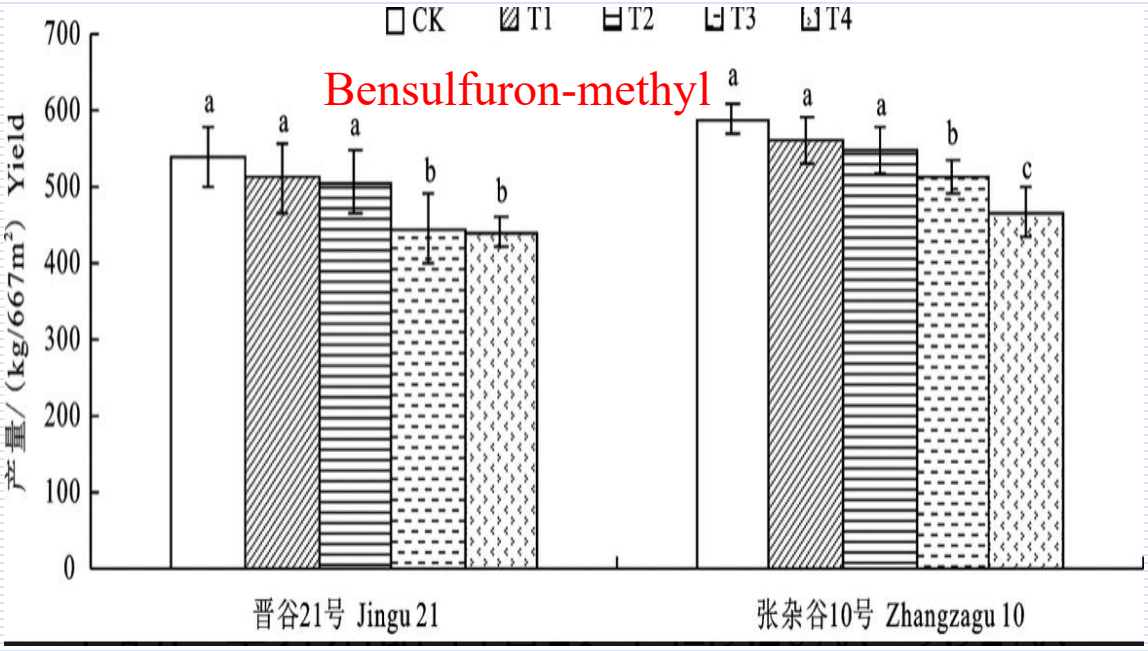


表 1 叶面喷施苯磺隆、骠马、精喹禾灵对谷子产量的影响

除草剂	品种	CK	1/2	1	2	4
苯磺隆 (kg/667m²)	张杂 10	333.5	407.5	353.5	168.4	188.4
	晋谷 21	251.8	286.8	182.5	96.7	0
骠马 (kg/667m²)	张杂 10	333.5	395.2	375.2	210.1	223.4
	晋谷 21	251.8	0	0	0	0
精喹禾灵 (kg/667m²)	张杂 10	333.5	496.9	260.1	211.4	0
	晋谷 21	251.8	0	0	0	0

Na Ning, et al., Grain Yield and Quality of Foxtail Millet (Setaria italica L.) in Response to Tribenuron-Methyl. PLOS ONE, 2015.

Bensulfuron-methyl is relatively safe to foxtail millet in one year field trial.
Byrazosulfuron-methyl is not recommended for application in foxtail millet fields.



Varieties	Treatments (g ai ha^{-1})	Yield (kg 667m^{-2})
	Pyrazosulfuron-methyl	
Jingu 21	CK	533.50 ± 14.58 a
	T1	488.12 ± 12.12 b
30 g ai ha^{-1}	T2	449.63 ± 14.72 c
	T3	348.88 ± 5.81 d
	T4	261.08 ± 8.83 e
Zhangzagu 10	CK	583.11 ± 7.10 a
	T1	563.08 ± 7.50 a
30 g ai ha^{-1}	T2	419.08 ± 9.16 b
	T3	348.60 ± 9.96 c
	T4	285.23 ± 10.39 d

Effect of Bensulfuron-methyl and Pyrazosulfuron-methyl on Foxtail Millet Yield

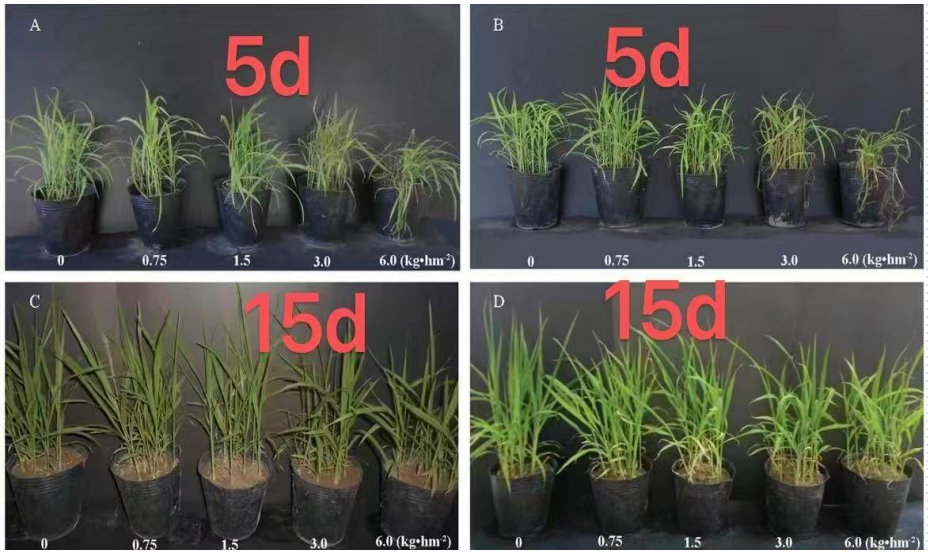
- Under the treatment of 300 g/ha bensulfuron-methyl, the yield of both varieties showed no significant difference compared to the control treatment.
- 30 g ai ha^{-1} Pyrazosulfuron-methyl inhibited the growth of foxtail millet and reduced the photosynthetic pigment contents, photosynthetic rate, and photosynthetic system II activity.

张丽光,等. 苄嘧磺隆对谷子的安全性及叶片生理特性的影响[J].西北农业学报,2019

MaK, et al., Effect of Pyrazosulfuron-Methyl on the Photosynthetic Characteristics and Antioxidant Systems of Foxtail Millet. Front. Plant Sci. 2021, 12:696169.

MCPA application can maintain higher chlorophyll content, photosynthetic rate, and Photosystem II (PSII) activity in foxtail millet seedlings (Pot Experiment).

品种 Cultivars	有效剂量 Effective dosage (kg·hm^{-2})	株高 Plant height (cm)		叶面积 Leaf area (cm^2)	
		5 DAT	15 DAT	5 DAT	15 DAT
晋谷 21 号 Jingu 21	0	29.25±0.84a	30.95±0.14a	8.56±0.21a	12.39±0.10a
	0.75	26.65±0.26b	28.55±0.09b	7.51±0.12b	8.27±0.20b
	1.50	24.45±0.32c	26.30±0.06c	7.25±0.06b	8.19±0.06b
	3.00	24.25±0.09c	25.70±0.58c	6.44±0.03c	7.72±0.18c
	6.00	22.15±0.49d	25.25±0.66c	4.44±0.05d	6.90±0.41d
张杂 10 号 Zhangza 10	0	31.00±0.58a	32.87±0.37a	14.91±0.51a	15.41±1.30a
	0.75	30.43±0.34a	31.97±0.73a	12.86±0.38b	14.24±0.21a
	1.50	25.93±0.86b	28.50±1.04b	11.05±0.43c	11.50±0.33b
	3.00	25.73±0.37b	27.20±0.20b	9.41±0.34d	10.07±0.07b
	6.00	23.00±0.29c	24.33±0.17c	8.39±0.09d	9.43±0.62b



Effect of MCPA Treatment on Antioxidant Enzyme Activities and MDA Content in Foxtail Millet Leaves

- MCPA treatment enables foxtail millet seedlings to maintain higher chlorophyll content, photosynthetic rate, and Photosystem II (PSII) activity.
- At the recommended dosage (1.50 kg·ha⁻1), MCPA is relatively safe to foxtail millet, with the effects being most pronounced within 15 days after application.

郭美俊,二甲四氯胁迫对谷子幼苗叶片衰老特性和内源激素含量的影响[J].中国农业科学,2020.

（3）Safety Effects of Different Soil-Applied Herbicides on Foxtail Millet

Atrazine 阿特拉津

Prometryn 扑草净

Metoclopramide 异丙甲草胺

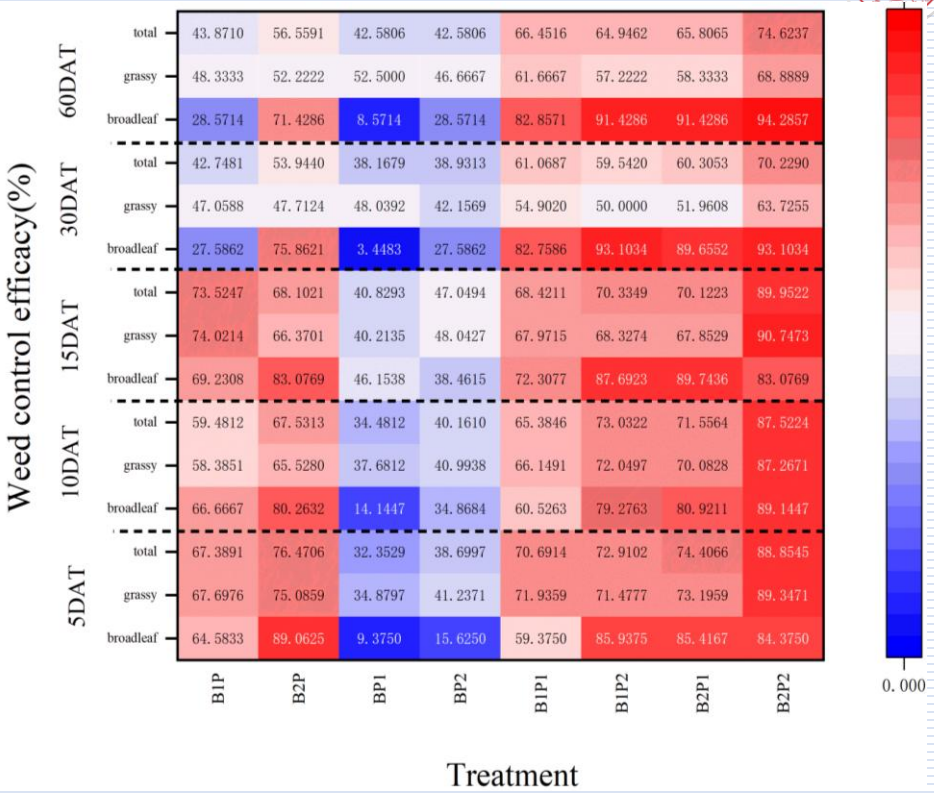
Acetochlor 乙草胺

Meijun Guo, et al., Precision orientation herbicide spraying against weeds in plastic-mulched fields of spring hybrid millet. Emirates Journal of Food and Agriculture, 2019.
刘韶光, 等. 膜间喷施芽前除草剂对谷子安全性及对杂草防效的影响. 作物杂志, 2019.
赵夏童, 等. 膜间喷施乙草胺对张杂谷10号生理特性及产量的影响. 山西农业大学学报(自然科学版), 2019.
赵夏童, 等. 膜间喷施2种二硝基苯胺类除草剂对谷田杂草药效及安全性评价. 山西农业科学, 2019.
刘韶光, 等. 膜间喷施二甲戊灵对谷子幼苗叶片光合特性的影响. 山西农业科学, 2019.

Mixture of bromoxynil octanoate (辛酰溴苯腈) and pendimethalin (二甲戊灵) enhanced weed control efficacy

CK

B2P2



- Weed control efficacy in the foxtail millet field increased with higher herbicide concentrations. The spectrum and level of weed control achieved by the bromoxynil octanoate and pendimethalin mixture were markedly superior to those of any single herbicide treatment.
- Among the combinations, the B2P2 treatment was the most effective. The B2P2 treatment enhanced weed control efficacy by 16.19%-32.08% and 75.25%-117.93%, compared to bromoxynil octanoate and pendimethalin applied alone, respectively.

Meijun Guo, et al., Comprehensive evaluation of fluroxypyr herbicide on physiological parameters of spring hybrid millet. Peer J, 2019.

（4）Application of Mechanized Chemical Weeding Technology

Effect of 1:1 Fluroxypyr + Sethoxydim Treatment:

Application of 20% fluroxypyr emulsifiable concentrate at 50-70 mL/mu effectively controls broadleaf weeds.

For hybrid foxtail millet, 12.5% sethoxydim emulsifiable concentrate at 75-100 mL/mu can be used to control gramineous weeds.

张杂谷10号

Mei jun Guo, et al., Responses of the antioxidant system to fluroxypyr in foxtail millet (Setaria italica L.) at the seedling stage. Journal of Integrative Agriculture, 2018.

DOI: 10.1007/s11099-017-0734-z PHOTOSYNTHETICA 56 (3): 820-831, 2018

Photochemical changes and oxidative damage in four foxtail millet varieties following exposure to sethoxydim

M.J. GUO, Y.G. WANG+, S.Q. DONG, Y.Y. WEN, X.E. SONG, and P.Y. GUO+

Key Laboratory of Crop Chemical Regulation and Chemical Weed Control, Agronomy College, Shanxi Agricultural University, Taigu 030801, China


2018/8/6 10:45


可调 喷雾器防风喷头
防风高压喷头
接口M14内螺纹


机械化定向喷药效果

（5）Alleviation of Herbicide Injury in Foxtail Millet

项目批准号	31301269
申请代码	C130301
归口管理部门	
依托单位代码	03080108A0777-1457

3130126910193 23

国家自然科学基金委员会

资助项目计划书

资助类别：青年科学基金项目

亚类说明：

附注说明：

项目名称：油菜素内酯缓解谷子阔世玛药害的光合生理机制研究

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负 责 人：原向阳

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Spraying Brassinolide improves Sigma Broad tolerance in foxtail millet (*Setaria italica* L.) through modulation of antioxidant activity and photosynthetic capacity

Xiang-Yang Yuan[1], Li-Guang Zhang[2], Lei Huang[1,3], Hui-Jie Yang[1], Yan-Ting Zhong[1,4], Na Ning[1], Yin-Yuan Wen[1], Shu-Qi Dong[1], Xi-E Song[1], Hong-Fu Wang[1] & Ping-Yi Guo[1]

Effect of Foliar Application of Brassinolide on Leaf Photosynthetic Physiology in Foxtail Millet Seedlings Under Mesosulfuron-methyl Stress (Pot Experiment)

表 2 阔世玛对谷子叶片光合色素含量的影响

Table 2 Effects of Sigma Broad on photosynthetic pigment content in leaves of foxtail millet

品种 Varieties	处理 Treatment	叶绿素 a Chla /(mg·g⁻¹FW)	叶绿素 b Chlb /(mg·g⁻¹FW)	类胡萝卜素 Car /(mg·g⁻¹FW)	总叶绿素 Chl(a+b) /(mg·g⁻¹FW)
张杂 5 号	CK	7.66±1.25 a	2.27±0.39 a	2.41±0.26 a	9.93±1.63 a
	S1	7.11±0.11 a	2.30±0.11 a	2.24±0.01 a	9.41±0.22 a
	S2	7.01±0.52 a	2.37±0.12 a	2.23±0.25 a	9.38±0.63 a
	S3	6.14±0.77 a	1.99±0.39 a	2.14±0.03 a	8.13±1.16 a
	S4	5.74±1.17 a	1.81±0.42 a	2.15±0.18 a	7.55±1.59 a
晋谷 21 号	CK	8.35±0.22 a	2.71±0.26 a	2.66±0.19 a	11.07±0.05 a
	S1	7.58±0.11 ab	2.35±0.14 ab	2.39±0.12 ab	9.93±0.25 ab
	S2	6.70±0.32 bc	1.98±0.03 bc	2.41±0.05 ab	8.67±0.35 bc
	S3	5.83±0.35 cd	1.86±0.26 c	2.17±0.04 b	7.69±0.61 cd
	S4	5.19±0.96 d	1.75±0.09 c	2.02±0.30 b	6.95±1.05 d

Effects of Mesosulfuron-methyl on Foxtail Millet

Table 5 Effects of BR on photosynthetic pigment content in leaves of foxtail millet under Sigma Broad stress

品种 Varieties	处理 Treatment	叶绿素 a Chla /(mg·g⁻¹FW)	叶绿素 b Chlb /(mg·g⁻¹FW)	类胡萝卜素 Car /(mg·g⁻¹FW)	总叶绿素 Chl(a+b) /(mg·g⁻¹FW)
张杂 5 号	S	11.40±0.69 b	2.31±0.08 b	2.20±0.16 cd	13.71±0.76 bc
	S+0.05	12.02±0.00 b	4.34±0.00 a	2.79±0.00 b	16.37±0.00 b
	S+0.1	15.79±1.95 a	4.00±0.49 a	3.47±0.25 a	19.79±1.46 a
	S+0.2	10.25±0.26 b	2.12±0.03 b	2.61±0.02 bc	12.46±0.29 c
	S+0.4	6.94±2.01 c	1.28±0.44 c	2.07±0.28 d	8.22±2.45 d
晋谷 21 号	S	7.01±0.37 bc	0.70±0.01 c	1.83±0.04 bc	7.71±0.36 b
	S+0.05	6.34±0.14 d	1.58±0.03 b	1.41±0.03 c	7.65±0.16 b
	S+0.1	8.36±0.6 ab	2.05±0.28 a	2.39±0.38 a	10.41±0.34 a
	S+0.2	9.33±1.05 a	2.03±0.13 a	2.13±0.08 ab	11.36±1.18 a
	S+0.4	5.57±0.43 cd	1.31±0.02 b	1.89±0.01 b	7.14±0.44 b

Effect of Mesosulfuron-methyl Stress on Photosynthetic Pigment Content in Foxtail Millet Leaves

- Mesosulfuron-methyl can inhibit leaf photosynthesis to a certain extent. A concentration of 7.5 mg·L^{-1} causes minor damage to foxtail millet seedlings, whereas the recommended dosage (30 mg·L^{-1}) causes severe damage and should not be used for chemical weed control in foxtail millet fields.
- Foliar application of brassinolide (BR) can effectively alleviate mesosulfuron-methyl injury in foxtail millet. The optimal BR concentration range for mitigating this injury is 0.05-0.2 mg·L^{-1}.

杨慧杰.叶面喷施油菜素内酯对阔世玛胁迫下谷子幼苗叶片光合特性的影响[D].山西农业大学,2017.

Residues of Fluroxypyr in grains are typically below the limit of detection or present in trace amounts.

药后取样时间	1.05 L/hm²		1.58 L/hm²	
	叶片	茎秆	叶片	茎秆
2 h	70.942 ± 2.632a	4.768 ± 0.559b	116.700 ± 3.147a	9.015 ± 0.632b
8 h	39.048 ± 3.166a	3.634 ± 0.324b	60.572 ± 3.004a	5.895 ± 0.214b
12 h	28.419 ± 2.335a	2.874 ± 0.158b	40.629 ± 2.415a	4.312 ± 0.245b
1 d	24.093 ± 2.124a	2.695 ± 0.187b	38.195 ± 2.168a	4.015 ± 0.189b
3 d	4.635 ± 0.224a	2.084 ± 0.214b	7.958 ± 0.387a	2.565 ± 0.115b
7 d	0.013 ± 0.001a	0.012 ± 0.001a	0.020 ± 0.001a	0.018 ± 0.001a
14 d	0.005a	0.005a	0.015 ± 0.001a	0.008a
28 d	0.002a	0.001a	0.003a	0.002a

Residue Levels of Fluroxypyr in Foxtail Millet Leaves and Stems at Different Time Intervals

- When the recommended dosage (1.05 L/ha) of Fluroxypyr emulsifiable concentrate is applied through foliar spray during the foxtail millet seedling stage, the residue levels in both plant leaves and stems exhibit a declining trend over time.
- Residues of Fluroxypyr in grains are typically below the limit of detection or present in trace amounts. Low residues can be detected in stems, while the residue level in soil depends on the time after application and environmental conditions.

刘亚楠,高效液相色谱-串联质谱法（HPLC-MS/MS）定量分析谷子叶片和茎秆中使它隆的残留差异[J].山西农业科学,2020.

The final residues of mesosulfuron-methyl in foxtail millet plants, grains, and soil were all below the limit of quantification (LOQ).

施药后天数 /d	植株		土壤			
			27 g/hm²		54 g/hm²	
	残留量 /(mg/kg)	消解率 /%	残留量 /(mg/kg)	消解率 /%	残留量 /(mg/kg)	消解率 /%
1 h	0.64		0.067		0.130	
1	0.46	28.1	0.053	20.3	0.100	18.9
3	0.22	65.5	0.042	37.5	0.077	40.4
5	0.18	71.9	0.027	59.7	0.050	60.9
7	0.11	82.6	0.023	65.4	0.047	63.3
14	0.082	87.3	0.020	70.8	0.040	69.0
21	0.054	91.6	0.016	76.5	0.035	72.4
28	<0.020	>95.0	0.014	78.7	0.032	75.1
35			0.013	80.3	0.029	77.2
消解方程	$C=0.394\ 8e^{-0.108\ 2T}$ $r=-0.917\ 4$ $T_{1/2}=6.4$ d		$C=0.044\ 1e^{-0.041\ 6T}$ $r=-0.890\ 5$ $T_{1/2}=16.6$ d		$C=0.083\ 3e^{-0.036T}$ $r=-0.841\ 0$ $T_{1/2}=18.7$ d	

有效剂量 /(g/hm²)	残留量 /(mg/kg)		
	秸秆	籽粒	土壤
6.75	<0.02	<0.02	<0.008
13.50	<0.02	<0.02	<0.008

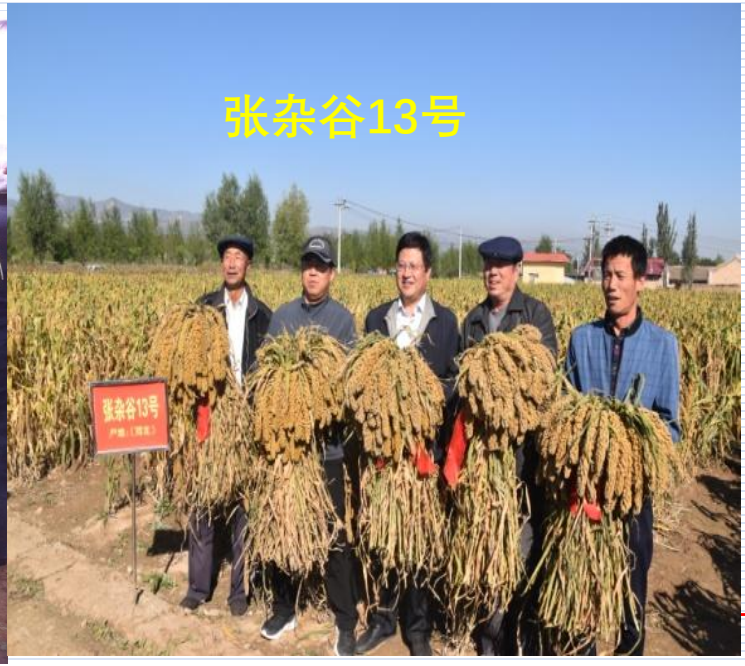
Final Residues of Mesosulfuron-methyl in Foxtail Millet and Soil

- Mesosulfuron-methyl is a readily degradable herbicide. Using this detection method, the final residues of mesosulfuron-methyl in foxtail millet plants, grains, and soil were all below the limit of quantification (LOQ).
- A single application of Sencor 3% mesosulfuron-methyl emulsifiable concentrate at the 5-6 leaf stage of foxtail millet, with an application rate of 6.75-13.5 g a.i./hm², poses no harm to humans and livestock and is safe for the soil environment.

刘丹，高效液相色谱法测定甲基二磺隆在谷子和土壤中的残留及消解动态[J].山西农业科学,2018.

4.5 Herbicide-Resistant Varieties

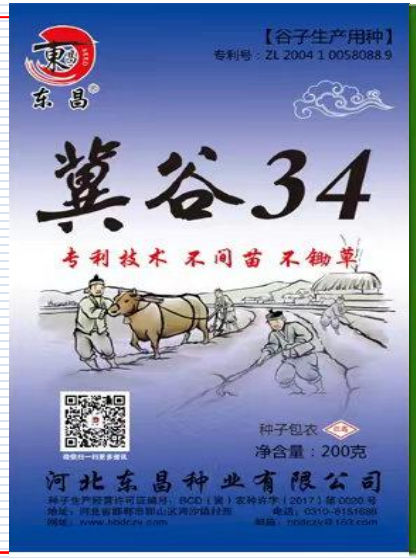
- **Zhangzagu 3:** A drought-resistant and high-yield foxtail millet hybrid developed by the Zhangjiakou Academy of Agricultural Sciences. It exhibits resistance to the herbicide sethoxydim and is certified as a National Grade 2 high-quality millet.
- **Zhangzagu 10:** This variety is resistant to the herbicide sethoxydim and is certified as a National Grade 1 high-quality millet.
- **Zhangzagu 13:** This variety is resistant to the herbicide sethoxydim and is certified as a National Grade 1 high-quality millet.



Jigu 34: A foxtail millet variety developed by the Millet Research Institute of the Hebei Academy of Agricultural and Forestry Sciences through the hybridization of Jigu 24 (atrazine-resistant阿特拉津) and Jigu 31 (sethoxydim-resistant). It is a new millet variety characterized by high starch and low fat content, making it suitable for staple food processing.

Jigu 35: A foxtail millet variety developed through distant hybridization, using the sethoxydim-resistant material K359 as the female parent and the imazethapyr-resistant breeding material M4-1 as the male parent. This variety exhibits dual resistance to both imazethapyr (咪唑乙烟酸) and sethoxydim (烯禾啶) herbicides.

Jigu 39: A high-quality foxtail millet variety developed by the Millet Research Institute of the Hebei Academy of Agricultural and Forestry Sciences using hybridization. It is resistant to both imidazolinone (咪唑啉酮) and nicosulfuron (烟嘧磺隆) herbicides.



- **Yu Gu 35:** A sethoxydim-resistant foxtail millet variety developed by the Anyang Academy of Agricultural Sciences in Henan Province.
- **Jin Gu 56 and Changnong 47:** Sethoxydim-resistant foxtail millet varieties developed by the Millet Research Institute of Shanxi Agricultural University (Shanxi Academy of Agricultural Sciences).
- **Jin Miao K1:** A sethoxydim-resistant foxtail millet variety developed by the Millet Research Institute of the Chifeng Academy of Agriculture and Animal Husbandry in Inner Mongolia.
- **Zhong Gu 19:** A sethoxydim-resistant foxtail millet variety developed by the Institute of Crop Sciences of the Chinese Academy of Agricultural Sciences.

PBJ | 碱基编辑新突破！山西农大团队利用ABE，成功创制抗除草剂谷子新种质，产量不变！

原创 舟可 可研Plus 2025年12月30日 01:33 1人

谷子(Setaria italica) 作为一种抗旱耐贫瘠的作物，其产量往往受到田间杂草的严重限制。**草害控制已成为制约谷子生产和产业发展的主要瓶颈。**

虽然草铵膦是一种广泛使用的广谱除草剂，但通过传统手段获得非转基因的抗除草剂种质仍具挑战。

2025年12月24日，**Plant Biotechnology Journal** 在线发表了**山西农业大学谷子产业化技术创新团队王家刚教授、王宏智老师和原向阳教授**的最新合作进展：***"CRISPR/Cas9-Mediated Base Editing of SiGS1 Confers Glufosinate Resistance in Foxtail Millet (Setaria italica)"***。该研究利用ABE技术，**对谷子中的谷氨酰胺合成酶基因 *SiGS1* 进行了精准编辑，成功创制了对草铵膦具有高抗性且无产量惩罚的谷子新种质。**

5. Future Strategies for Weed Management in Foxtail Millet Fields

- 5.1 Manual weeding will become increasingly scarce.
- 5.2 The breeding of high-quality herbicide-resistant varieties is a trend (including conventional hybrid varieties, transgenic varieties, gene-edited varieties, etc., such as varieties with dual resistance, multiple resistances, or resistance to broad-spectrum herbicides).
- 5.3 The screening and formulation of foliar herbicides with broad spectrum, high efficiency, safety, low toxicity, and low residue are better choices; it would be even better if pre-emergence soil-applied herbicides safe for foxtail millet can be developed.
- 5.4 Comprehensive, mechanized, low-cost, easy-to-operate, and intelligent weed control (prevention + management) technologies will be the trend in the future.


Thank you
山西农业大学“谷子生产全程机械化技术”示范基地
（繁峙县 · 金山铺）