Open Access Library Journal
2021, Volume 8, e7462
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Screening and Safety Evaluation of Herbicides in Oat Field

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How to cite this paper: Song, W.M., Guo, L.Z., Weng, H., Cheng, L. and Wei, Y.H. (2021) Screening and Safety Evaluation of Herbicides in Oat Field. *Open Access Library Journal*, **8**: e7462.
https://doi.org/10.4236/oalib.1107462

Received: April 27, 2021
Accepted: May 25, 2021
Published: May 28, 2021

Abstract

In order to screen safe and efficient herbicide varieties and combinations suitable for oat field use, field plot experiment method was used to spray stems and leaves from 3 to 5 leaf stages of oat. The results showed that the control effects of single-dose treatment of 45.9% difluoro-dioctyl SC 450 mL/hm^2 and 20% tribenuron-chlorofluoropyroxyacetic acid WP 900 g/hm^2 on weeds in oat fields were all above 80%, herbicides 10% tribenuron-methyl WP 150 g/hm^2, 42% 2-methyl·fluroxypyr EC 1125 mL/hm^2, 48% bentazone AS 3000 mL/hm^2 and 72% 2,4-D butylate EC 150 mL/hm^2 mixed use, and 10% pyrazone WP 300 g/hm^2 + 56% 2-methyl 4-sodium chloride WP 1200 g/hm^2 + 50 g/L difluorsulphonamide SC 90 mL/hm^2 mixed use of broad-leaved weeds in oat field control effect were more than 80%, significantly higher than the conventional herbicide used in production, 48% bentazone AS 3000 mL/hm^2 + 72% 2,4-D butylate EC 150 mL/hm^2 and 2-methyl·fluroxypyr EC 1125 mL/hm^2 + 72%. The test results enriched the available herbicide varieties for chemical weeding in oat fields and could be applied in oat fields.

Subject Areas

Agricultural Science

Keywords

Oats, Herbicides, Mixed, Control Effect, Safety

1. Introduction

Oat (*Avena sativa*) is a one-year-old dual-purpose crop with the sixth largest planting area in the world. It has wide adaptability, high yield and health care function [1] [2]. Oat is the only forage crop that adapts to alpine pastoral areas [2]. Oat planting area in Qinghai accounts for more than 70% of the artificial grass planting area in Qinghai Province [1], which plays a vital role in animal husbandry and social and economic development in alpine regions of Qinghai Province [3] [4] [5]. In production, the commonly used 2,4-D butylate EC and tribenuron-methyl herbicides are used to control weeds, and the problem of resistance to drug-resistant weeds such as *Galium spurium L.* and *Lepyrodiclis holosteoides* is becoming increasingly prominent. In order to pursue the control effect of weeds, the use of wheat herbicides also leads to the coexistence of efficacy and drug damage [6]. When the weed density in the field reaches above 50 plants/m^2, the wheat yield can be reduced by 25% - 40% [7]. The use of chemical herbicides can greatly affect the growth and reproduction of weeds in the field, and the mixed use of herbicides has the characteristics of enhancing the control effect, expanding the weed control spectrum and reducing the dosage [8] [9] [10]. In recent years, although there are reports on the use of herbicides in oat fields, there are few reports on reducing the use of chemical herbicides, reducing pollution to the ecological environment and ensuring oat yield under special natural conditions in Qinghai alpine and arid areas. Therefore, this study aims to enrich the herbicide varieties that can be used for weed control in oat fields, develop weed solutions for oat fields, delay the succession rate of weed communities in oat fields, and reduce the damage of herbicides to crops through experimental screening and crop safety evaluation of herbicides in oat fields.

2. Materials and Methods

2.1. Test Materials

(1) 10% Bensulfuron WP, Shandong Qiaochang Chemical Co., Ltd. (2) 72% 2,4-D butyl ester EC, Dalian Songliao Chemical Co., Ltd. (3) 20% chlorofluoropyroxyacetic acid EC (Tao, China) Co., Ltd. (4) 56% sodium 2-methyl-4-chloro WP, Shandong Qiaochang Modern Agriculture Co., Ltd. (5) 10% azone WP, Suruibang Pharmaceutical Factory Co., Ltd. (6) 48% AS, BASF Plant Protection (Jiangsu) Co., Ltd. (7) 20% Bensulfuron·chlorofluoropyroxyacetic acid WP (Mianyang Lier Chemical Co., Ltd.). (8) 42% 2-methyl-chlorofluoropyridine EC (Hansheng Biotechnology Co., Ltd., Qingdao, Shandong Province). (9) 45.9% difluorooctyl ester SC, Dow Yinong (China) Co., Ltd. (10) 30% aminochlor·dichloropyridine acid AS (Chongqing Shuangfeng Chemical Co., Ltd.).

The tested crops are: Oat, variety Liner.

2.2. Test Design and Method

The test set 20% tribenuron-methyl·fluroxyacetic acid WP 900 g/hm^2, 42% 2-methyl·fluroxypyr EC 1125 mL/hm^2, 45.9% difluorooctyl SC 450 mL/hm^2, 48% bentazone AS 3000 mL/hm^2, 10% oxazolidinone WP 360 g/hm^2, 30% chloramphenic acid AS 450 mL/hm^2 alone, 30% chloramphenic acid AS 450 mL/hm^2, 10% tribenuron-methyl WP 150 g/hm^2, 42% 2-methyl·fluroxypyr EC 1125 mL/hm^2, 48% bentazone AS 3000 mL/hm^2, 10% oxazolidinone WP 360 g/hm^2 and 72% 2,4-D butyl EC 150 mL/hm^2 mixed use and 10% azone WP 300 g/hm^2 + 56% sodium 2-methyl 4-chloro WP 1200 g/hm^2 + 50 g/L difluorsulphonamide SC 90 mL/hm^2 mixed use of 13 treatments as screening agent treatment, The commonly used 10% tribenuron-methyl WP 150 g/hm^2, 72% 2,4-D butylate EC 750 mL/hm^2, and 20% fluroxypyr EC 750 mL/hm^2 were used as control agents, and the water control (CK) without spraying and weeding was set up. A total of 17 treatments were repeated for 3 times, and 51 plots were arranged in random groups with an area of 5 m × 4 m = 20 m^2.

The test was applied on 29 May, sunny day, northwest wind direction, temperature 12.5˚C, maximum temperature 19.1˚C, minimum temperature 6.3˚C, relative humidity 58%. Over 85% of oats have 3 leaves and 1 heart to 5 leaves. The dominant weeds in the field are 4 - 5 leaves of Brassica napus, 1 - 3 pairs of Elsholtzia densa, 2 - 4 pairs of Lepyrodiclis holosteoides, 1 - 3 rounds of Galium spurium, 2 - 8 pairs of Thlaspi arvense and 1 - 4 pairs of Chenopodium album.

The HD400 back-loaded manual sprayer (conical nozzle) produced by Linong Company of Singapore was used to spray stems and leaves from three to five leaves of oats, and the water amount was calculated at 300 L/hm^2.

2.3. General Situation of Test Site

The experiment was conducted in Zhujiazhuang Village, Lushaer Town, Huangzhong County, Qinghai Province, with an elevation of 2850 m and an annual precipitation of 550 mm. It belongs to rain-fed agricultural area. The weed species in the field are mainly self-grown rape, Elsholtzia dense flower, thin capsule grass, calamus, quinoa and so on. The occurrence density is large and the distribution is uniform. The soil in the test site was chestnut soil. The soil organic matter content was 22.15 g·kg^{-1}, pH 8.23, total nitrogen content was 3.51 g·kg^{-1}, total phosphorus content was 1.95 g·kg^{-1}, total potassium content was 31.99 g·kg^{-1} and the terrain was flat.

The previous crop was rape (Qingyou 305).

2.4. Experimental Investigation and Data Statistics

2.4.1. Investigation on Weed Control Efficacy

The responses of weeds and crops to pesticides were observed at 7 d and 15 d after treatment. Three points were randomly sampled in each plot 30 days after application, with an area of 0.25 m^2. The number of residual weeds in the treatment area was investigated, and the aboveground fresh weight was weighed to calculate the plant control effect and fresh weight control effect.

The efficacy calculation formula is:

Plant control % = [(number of plants in control area—number of plants in application area)/number of plants in control area] × 100

Fresh weight control effect % = [(control area fresh weight—application area fresh weight)/control area fresh weight] × 100

2.4.2. Crop Safety Assessment

After treatment, the reaction of oats to each pesticide treatment was observed, and the leaf color growth of oats in the control area was compared with that in the blank area. After maturity, 3 points of diagonal sampling were taken in each plot, and the sample area was 1 m^2.

Yield increase rate % = [(treatment area yield-control area yield)/control area yield] × 100

2.4.3. Data Processing

Excel 2007 was used for data processing, and Duncan's new complex range method was used to determine the difference of control effect between the treatments.

3. Results and Analysis

3.1. Effect of Different Experimental Treatments on Weed Control in Field

Seven days after application, the growth and chlorosis of *Blassikakapestris*, *Elsholtzia densa* and *Galium spurium* in the tribenuron-methyl treatment area were inhibited, while the growth and chlorosis of *Galium spurium*, *Lepyrodiclis holosteoides* and *Blassikakapestris*. In the tribenuron-methyl treatment area were significantly inhibited. In 30 % AS treatment, the growth of rapeseed was normal, while *Elsholtzia densa*, *Lepyrodiclis holosteoides* and *Galium spurium* were inhibited. After 15 days, *Elsholtzia densa*, *Lepyrodiclis holosteoides*, *Galium spurium* and other weeds in 30 % AS and 30 % AS + 72 % 2,4-D butyl ester EC treatments recovered to varying degrees. The weed damage in other treatment areas was aggravated, and dead plants were observed in some treatment areas. The experimental investigation was carried out 30 days after the application, and the control effect of each treatment area on weeds was counted. The results are shown in Table 1. The control effect of 45.9% difluorooctyl SC 450 mL/hm^2 on weeds was 93.90%, and the control effect of fresh weight was 82.30%. The control effect of 20% bensulfuron-methyl·chlorofluoropyroxyacetic acid WP 900 g/hm^2 on weeds was 87.59%, and the control effect of fresh weight was 86.56%. The control effect of 10% bensulfuron-methyl WP 150 g/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2 on weeds was 89.00%, and the control effect of fresh weight was 89.83%. The control effect of 42% methyl·chlorofluoropyroxyacetic acid EC 1125 mL/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2 on weeds was 97.3%, and the control effect of fresh weight was 93.99%, The control effect of 10% acetochlor WP 300 g/hm^2 + 56% sodium 2-methyl 4-chloro WP 1200 g/hm^2 + 50 g/L difluorfen SC 90 mL/hm^2 on weeds was 89.90%, and the control effect of fresh weight was 88.58%, which was better than that of 10% tribenuron-methyl WP 150 g/hm^2, 72% 2,4-D butyl EC 750 mL/hm^2 and 20% fluroxypyr EC 750 mL/hm^2 (about 75%). 10% acetochlor WP 360 g/hm^2, 48% bentazone AS 3000 mL/hm^2, 30% aminochlor·dichloropy-ridinic acid AS 450 mL/hm^2 and 72% 2,4-D butyl ester EC 150 mL/hm^2 mixed treatment of weed control effect and fresh weight control

Table 1. Control effect of different herbicide weeds in oat field.

Experimental treatment	Dosage	Plant defence	Fresh weight control effect	Oat yield	
	g·mL/hm^2	%	%	kg/hm^2	Yield increasing rate ± %
Blank (sytrain, g/m^2)	0	426.03a A	615.81a A	4125.37o O	0
45.9% Difluorooctyl SC	450	93.9de B	82.3bcd C	4569.27e E	10.76
20% Bensulfuron·chlorofluoropyroxyacetic acid WP	900	87.59cde B	86.56bcd C	4562.86f F	10.60
10% Bensulfuron WP + 72% 2,4-D Butyl EC	150 + 150	89.00cde B	89.83bcd C	4587.66d D	11.21
42% 2 methyl·chlorofluoropyridine EC + 72% 2,4-D butyl EC	1125 + 150	97.30e B	93.99cd C	4695.31a A	13.82
48% Patrol AS + 72% 2,4-D butyl ester EC	3000 + 150	93.08e B	94.64d C	4643.93b B	12.57
10% azone WP + 56% sodium 2-methyl-4-chloro WP + 50 g/L sulfenachlor SC	300 + 1200 + 90	89.90cde B	88.58bcd C	4590.63c C	11.28
42% 2-methyl·chlorofluoropyridine EC	1125	85.22cde B	76.85bcd C	4452.52g G	7.93
48% Patrol AS	3000	19.94ab A	61.56a ABC	4241.74m M	2.82
10% Azone WP	360	69.96bcde AB	72.54b ABC	4372.12k K	5.98
10% Azone WP + 72% 2,4-D Butyl EC	360 + 150	75.59bcde AB	75.48bcd BC	4421.87j J	7.19
30% Aminochlor·dichloropyridine acid AS	450	53.76abcd AB	65.31b ABC	4348.23l L	5.40
30% Aminochlor·dichloropyridine acid AS +72% 2,4-D Butyl EC	450 + 150	48.35abc AB	12.15a A	4210.04n N	2.05
10% Bensulfuron WP	150	83.57cde AB	69.87bc BC	4373.64k K	6.02
72% 2,4-D Butyl EC	750	78.41cde AB	78.57bcd C	4432.19h H	7.44
20% Chlorofluoropyroxyacetic acid EC	750	73.25bcde AB	72.72bcd BC	4428.94i I	7.36

Note: After the same data in the table, different capital letters and capital letters showed significant difference ($P < 0.01$) and significant difference ($P < 0.05$).

effect is about 70% or lower.

The control effects of different herbicide varieties or herbicide combinations on dominant weeds in oat fields were statistically analyzed (Table 2 and Table 3). The results showed that the control effects of single treatment of 45.9% difluorooctyl SC 450 mL/hm^2 and 20% tribenuron-chlorofluoropyroxyacetic acid WP 900 g/hm^2 on dominant weeds in oat fields were all above 80%. The control effects of 10% tribenuron WP 150 g/hm^2, 42% dimethyl·chlorofluoropyr EC 1125 mL/hm^2, 48% papyran AS 3000 mL/hm^2 and 72% 2,4-D butyl EC 150 mL/hm^2, and 10% azone WP 300 g/hm^2 + 56% methyl 4 sodium chloride WP 1200 g/hm^2 + 50 g/L difluorosulfonamide SC 90 mL/hm^2 and 72% tribenuron-ethyl EC 750 mL/hm^2 on dominant weeds in oat fields. 30% Chloramphenic acid AS is mainly used for weed control in rape field.

Table 2. Effects of different herbicides on dominant weeds in oat field.

Experimental treatment	Dosage g·mL/hm^2	Plant defence %			
		Blassikakapestris	*Elsholtzia densa*	*Galium spurium*	*Lepyrodiclis holosteoides*
Blank (sytrain, g/m^2)	0	20.67	14.22	23.89	22.78
45.9% Difluorooctyl SC	450	96.71	87.38	93.31	87.54
20% Bensulfuron·chlorofluoropyroxyacetic acid WP	900	94.63	85.94	91.26	92.28
10% Bensulfuron WP + 72% 2,4-D Butyl EC	150 + 150	92.25	90.39	94.68	92.53
42% 2 methyl·chlorofluoropyridine EC + 72% 2,4-D butyl EC	1125 + 150	96.03	94.23	97.81	96.41
48% Patrol AS + 72% 2,4-D butyl ester EC	3000 + 150	97.63	95.62	91.73	97.56
10% azone WP + 56% sodium 2-methyl-4-chloro WP + 50 g/L sulfenachlor SC	300 + 1200 + 90	98.52	91.40	94.53	96.73
42% 2-methyl·chlorofluoropyridine EC	1125	93.55	85.36	89.57	90.67
48% Patrol AS	3000	90.32	78.82	68.59	96.11
10% Azone WP	360	86.02	68.75	65.72	67.99
10% Azone WP + 72% 2,4-D Butyl EC	360 + 150	89.79	78.13	74.29	72.06
30% Aminochlor·dichloropyridine acid AS	450	0	41.27	54.33	53.03
30% Aminochlor·dichloropyridine acid AS +72% 2,4-D Butyl EC	450 + 150	80.65	71.87	31.45	28.06
10% Bensulfuron WP	150	89.10	69.53	68.55	72.06
72% 2,4-D Butyl EC	750	92.01	68.75	62.81	68.11
20% Chlorofluoropyroxyacetic acid EC	750	91.38	78.90	93.07	91.83

Table 3. Effects of different herbicides on fresh weight of dominant weeds in oat field.

Experimental treatment	Dosage g·mL/hm^2	Fresh weight control effect %			
		Blassikakapestris	*Elsholtzia densa*	*Galium spurium*	*Lepyrodiclis holosteoides*
Blank (sytrain, g/m^2)	0	20.39	20.45	18.85	19.52
45.9% Difluorooctyl SC	450	97.27	82.16	87.63	85.37
20% Bensulfuron·chlorofluoropyroxyacetic acid WP	900	92.56	83.72	89.34	84.88
10% Bensulfuron WP + 72% 2,4-D Butyl EC	150 + 150	95.18	91.94	92.27	94.55
42% 2 methyl·chlorofluoropyridine EC + 72% 2,4-D butyl EC	1125 + 150	98.38	95.11	96.71	97.65
48% Patrol AS + 72% 2,4-D butyl ester EC	3000 + 150	98.62	96.52	94.33	95.31
10% azone WP + 56% sodium 2-methyl-4-chloro WP + 50 g/L sulfenachlor SC	300 + 1200 + 90	98.47	92.13	92.87	96.84
42% 2-methyl·chlorofluoropyridine EC	1125	83.24	84.39	82.45	92.61
48% Patrol AS	3000	60.77	62.54	69.51	83.94
10% Azone WP	360	80.38	75.55	73.45	77.82
10% Azone WP + 72% 2,4-D Butyl EC	360 + 150	88.56	70.66	73.63	77.82
30% Aminochlor·dichloropyridine acid AS	450	20.67	58.37	33.26	53.89
30% Aminochlor·dichloropyridine acid AS +72% 2,4-D Butyl EC	450 + 150	15.01	20.15	13.52	16.34
10% Bensulfuron WP	150	81.22	74.47	69.12	67.57
72% 2,4-D Butyl EC	750	84.61	72.27	75..33	74.39
20% Chlorofluoropyroxyacetic acid EC	750	86.43	73.94	92.19	88.12

3.2. Safety Evaluation of Oats under Different Experimental Treatments

After spraying, the leaves of oats in the treatment area were chlorotic and yellowed at 7 d, and disappeared at 15 d. There was no significant difference in leaf color between the other treatments and the blank control, and the growth of oat was normal in the middle and late growth stages. After maturity, the yield was measured. The results are shown in Table 1. The yield of clean water control area was 4125.37 kg/hm^2, 10% tribenuron WP 150 g/hm^2, 72% 2,4-D butyl EC 750 mL/hm^2, 20% fluroxypyr EC 750 mL/hm^2, 20% tribenuron·fluroxypyr WP 900 g/hm^2, 42% dimethyl·fluroxypyr EC 1125 mL/hm^2, 45.9% difluorooctyl ester SC 450 mL/hm^2, 10% oxadiazolone WP 360 g/hm^2, 30% ammonia chloride·dichloropyridine acid AS 450 mL/hm^2, which were all above 5% higher than those of the blank control, and the yield of 48% bentazone AS 3000 mL/hm^2 was 2.82%. The mixed herbicide 10% tribenuron-methyl WP 150 g/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2, 42% 2-methyl·fluroxypyr EC 1125 mL/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2, 48% bentazone AS 3000 mL/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2, 10% azone WP 300 g/hm^2 + 56% 2-methyl sodium chloride WP 1200 g/hm^2 + 50 g/L difluorosulphonamide SC 90 mL/hm^2 increased yield more than 11% compared with the blank control, 30% aminochlor·dichloropyridine acid AS 450 mL/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2 and 10% azone WP 360 g/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2 increased yield by 2.05% and 7.19%, respectively.

4. Summary

The results of this experiment showed that the control effects of herbicides 45.9% difluorooctyl SC 450 mL/hm^2 and 20%
bensulfuron-methyl·chlorofluoropyroxyacetic acid WP 900 g/hm^2 on broadleaf weeds in oat fields were all above 80%, and the control effects of 10% bensulfuron-methyl WP 150 g/hm^2, 42% dimethyl·chlorofluoropyroxyacetic acid WP 1125 mL/hm^2, 48% Patrol AS 3000 mL/hm^2 and 72% 2,4-D butyl EC 150 mL/hm^2 on broadleaf weeds in oat fields were all significantly higher than those of conventional herbicides 85% on broadleaf weeds in oat fields, and the control effects of 10% azone WP 300 g/hm^2 + 56% methyl 4 sodium chloride WP 1200 g/hm^2 + 50 g/L bensulfuron-methyl SC 90 mL/hm^2, Among them, 48% Paicaodan AS 3000 mL/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2 and 2 methyl·chlorofluoropyr EC 1125 mL/hm^2 + 72% 2,4-D butyl EC 150 mL/hm^2 were sprayed on the stems and leaves of oats from 3-leaf stage to 5-leaf stage, and the overall control effect on weeds was more than 90%. It had good control effect on the dominant weeds such as *Blassikakapestris*, *Elsholtzia densa*, *Galium spurium* and *Chenopodium album* in oat field. It was safe for the tested oat varieties Liner, and the yield increased significantly after weeding.. Due to the long-term and single use of herbicides, the selective pressure of herbicides is increased, which further leads to the resistance of weeds to herbicides. Therefore, it is suggested that the above

herbicide varieties or mixed combinations should be used alternately in oat fields to prevent the resistance of weeds and delay the succession rate of weed communities.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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