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Effect of Florasulam and 2,4-D on Fineleaf Fumitory (*Fumaria parviflora* Lam.) Infestation in Wheat Crop

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Authors' contributions

This work was carried out in collaboration among all authors. Author BH designed the study. Author BH performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AEO, HT and MC managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: High infestations of *Fumaria parviflora* (*Fineleaf fumitory*) may led to cereal crops yield reduction. The aim of this study is to investigate the effect of mixture of Florasulam and 2,4-D on *F. parviflora* infestation in a soft wheat crop.
Study Design: The experimental design was Randomized Complete Block Design (RCBD) with three replications. Each block contained 4 elementary plots, 3 plots of which were treated with three rates of application of mixture of Florasulam and 2.4-D and one untreated control plot.
Place and Duration of Study: Trials were conducted in Ouazzane region of Morocco in January 2017. Calculation of dry *F. parviflora biomass* was carried out at weed research laboratory of INRA-CRRA Tangier in March 2017.
Methodology: Treatments were carried out with a knapsack sprayer with the nozzle delivering a 3 bar jet. A quadrant of 1 m x 1 m was used to calculate percentage of *F. parviflora* density reduction, height reduction and biomass reduction. *F. parviflora* dry biomass were determined using an oven at 75ºC for 48 hours. Then, weighed with a precision balance.

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Results: Treatment with mixture of Florasulam and 2,4-D respectively at 5.63 and 270 g/ha gave the best control of *F. parviflora* infestations. In fact, "Florasulam+2,4-D" at (5.63+270) g/ha recorded 85±3.1%, 81±2.5% and 92±3.1% respectively on *F. parviflora* density reduction, *F. parviflora* height reduction and *F. parviflora* dry biomass reduction. "Florasulam+2,4-D" at (3.75 +180) g/ha recorded 66±5.3%, 63±4.7% and 74±2.6% respectively on *F. parviflora* density reduction, *F. parviflora* height reduction and *F. parviflora* dry biomass reduction. Florasulam + 2,4-D at (1.88+90) g/ha recorded the lowest efficacies 45±10.4%, 22±9.5% and 45±11.4% respectively on *F. parviflora* density reduction, *F. parviflora* height reduction and *F. parviflora* dry biomass reduction.

Conclusion: «Florasulam+2,4-D» at (5.63+270) g/ha could be recommended to farmers in Ouazzane region when *F. parviflora* infestation is dominant on wheat. A further assessment of «Florasulam+2,4-D» residues in soils and their phytotoxicities should be evaluated on other crops grown in rotations.

Keywords: Fumaria parviflora; soft wheat; herbicide; florasulam; 2,4-D; Morocco.

1. INTRODUCTION

Cereals play an important role in human food and contributes to employment in rural areas of Morocco [1]. Cereals cover about 59% of the agricultural area [2]. Cereals are mainly represented by soft wheat, barley, durum and corn crops. Sorghum and rice are also practiced but with marginal importance [3]. Weeds are a serious problem in Morocco. They reduce crop yield and quality and compete with crops using water, nutrients and lights [4,5,6,7,8,9]. *Fumaria parviflora* Lam. (Fineleaf fumitory) is a common weed in Morocco. It is a dicotyledonous plant that belong to *Fumariaceae* family. It is an annual, hairless blue-green plant [10]. Stem branched 5 to 30 cm. Leaves divided into linear segments. Raceme inflorescence. Irregular flowers. Two triangular sepals. Corolla with 4 white or pink petals. Spherical seeds 1.5 to 2.5 cm in diameter [10]. Florasulam is a post-emergence broadleaf herbicide registered for use on cereals. It belongs to triazolopyrimidines chemical family that causes inhibition of acetolactate synthase ALS [11]. Inhibition of the activity of ALS leads to inhibition of synthesis of essential branched-chain amino acids, which causes inhibition of cell division [12]. Only a small amount of active ingredient is needed to kill weeds [11]. It is a systemic herbicide absorbed by the foliage or roots of plants resulting in plant death 2 to 8 weeks following application. 2,4 D is a systemic post-emergence herbicide acting through the foliage for the control of broadleaf weeds on wheat. It belongs to Phenoxy-carboxylic-acid Family. It kills weeds by mimicking the plant growth hormone auxin, and when applied at effective doses, causes uncontrolled and disorganized plant growth and the tissues of the plant are damaged, which leads to plant death [13]. In Morocco, Massive infestations of *F. parviflora* can severely affect cereal yields. No studies have been conducted on chemical control of *F. parviflora* in the Ouazzane region. This study aims to evaluate different mixtures of Florasulam and 2,4-D on *F. parviflora* infestation in a soft wheat crop.

2. MATERIALS AND METHODS

A weeding trial was conducted in Ouazzane region of Morocco during 2016-2017 growing season. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The distance between the blocks was 2 meters and the distance between plots was 1 meter. Each block contained 4 elementary plots, 3 plots of which were treated with the post-emergence herbicides tested (Table 1) and one untreated control plot. The size of the elementary plots was 2 m x 5 m (10 m²). Treatments was carried out on January 13, 2017 with a Knapsack herbicide sprayer with nozzle delivering a 3 bar jet. The spray volume per hectare is 200L. Treatments consist on three rates of application of mixture of Florasulam and 2.4-D (Table 1). In Morocco, commercial mixture of and 2,4-D and Florasulam is available with active ingredient contents of (6.25 +300) g/l of Florasulam and 2,4-D respectively. Observations were at 60 days after application of herbicides. Observations concerned Percentage of *F. parviflora* density reduction, height reduction and biomass reduction. *F. parviflora* density reduction percentage= [*F. parviflora* density in control plots – *F. parviflora* density in treated plots] x 100 / [*F. parviflora* density in control plots], Calculation of the density at the experimental level of the plot was made by a quadrant of 1 m x 1 m. *F. parviflora* height reduction percentage= [*F. parviflora* height in control plots – *F. parviflora* height in treated plots] x 100 / [*F. parviflora*

Table 1. Applied herbicides in experimental site

Herbicide treatments	Herbicide active ingredient	Rate of application
Treatment 1	Florasulam + 2,4-D	(1.88+90) g/hectare
Treatment 2	Florasulam + 2,4-D	(3.75 +180) g/hectare
Treatment 3	Florasulam + 2,4-D	(5.63+270) g/hectare

height in control plots]. *F. parviflora* dry biomass reduction percentage= [*F. parviflora* dry biomass weight in control plots – *F. parviflora* dry biomass weight in treated plots] x 100 / [*F. parviflora* dry biomass weight in control plots]. Calculation of dry *F. parviflora* biomass were made by collecting *F. parviflora* in each plot using a quadrant of 1 m x 1 m. Samples were dried in a drying oven at 75ºC for 48 hours. Then, dry plant material in each plot were weighed with a precision balance. Statistical analyzes were performed with IBM SPSS [14] Statistics, version 21.0 using the analysis of variance (ANOVA).The differences among treatment means was compared by Tukey's test at p= .05.

3. RESULTS AND DISCUSSION

3.1 Effect on *F. parviflora* Density Reduction

Statistical analysis revealed significant differences between treatments (Table 2). Results in Table 2 showed that the best *F. parviflora* density reduction was obtained by «Florasulam+2,4-D» at (5.63+270) recording 85±3.1% of *F. parviflora* density reduction. «Florasulam+2,4-D» at (1.88+90) and (3.75 +180) g/ha, showed lower to medium efficacies that did not exceed 66±5.3% of *F. parviflora* density reduction.

Table 2. Effect of treatments on *F. parviflora* density reduction

Treatments	*F. parviflora* density reduction (%)
Florasulam + 2,4-D at (1.88+90) g/ha	45±10.4 [a]
Florasulam + 2,4-D at (3.75 +180) g/ha	66±5.3 [b]
Florasulam + 2,4-D at (5.63+270) g/ha	85±3.1 [c]
Pα = 0.05	.001

Data represented are mean ± standard deviation for (n=3).Significant differences within the same column and means followed by the same letter do not differ at p= .05 according to Tukey's test

3.2 Effect on *F. parviflora* Height Reduction

Statistical analysis revealed significant differences between treatments (Table 3). Results in Table 3 showed that the best *F. parviflora* height reduction was obtained by «Florasulam+2,4-D» at (5.63+270) g/ha recording 81±2.5% of *F. parviflora* height reduction (Table 3). Concerning the effect of «Florasulam+2,4-D» at (3.75 +180) g/ha, data in Table 3 showed medium efficacies that did not exceed 63±4.7% of *F. parviflora* height reduction. Furthermore, «Florasulam+2,4-D» at (1.88+90) g/ha showed very weak efficacy recording only 22±9.5% of *F. parviflora* height reduction.

Table 3. Effect of treatments on *F. parviflora* height reduction

Treatments	*F. parviflora* height reduction
Florasulam + 2,4-D at (1.88+90) g/ha	22±9.5 [a]
Florasulam + 2,4-D at (3.75 +180) g/ha	63±4.7 [b]
Florasulam + 2,4-D at (5.63+270) g/ha	81±2.5 [c]
Pα = 0.05	< .001

Data represented are mean ± standard deviation for (n=3).Significant differences within the same column and means followed by the same letter do not differ at p= .05 according to Tukey's test

Table 4. Effect of treatments on *F. parviflora* dry biomass reduction

Treatments	*F. parviflora* dry biomass reduction
Florasulam + 2,4-D at (1.88+90) g/ha	45±11.4 [a]
Florasulam + 2,4-D at (3.75 +180) g/ha	74±2.6 [b]
Florasulam + 2,4-D at (5.63+270) g/ha	92±3.1 [c]
Pα = 0.05	< .001

Data represented are mean ± standard deviation for (n=3).Significant differences within the same column and means followed by the same letter do not differ at p= .05 according to Tukey's test

Table 5. Correlation between treatments and observed efficacies on *F. parviflora*

		***F. parviflora* density reduction**	***F. parviflora* height reduction**	***F. parviflora* dry biomass reduction**	**Treatments**
F. parviflora density reduction	Pearson correlation	1	.955**	.825**	.946**
	Sig. (bilateral)		.000	.006	.000
	N	9	9	9	9
F. parviflora height reduction	Pearson correlation	.955**	1	.892**	.957**
	Sig. (bilateral)	.000		.001	.000
	N	9	9	9	9
F. parviflora dry biomass reduction	Pearson correlation	.825**	.892**	1	.950**
	Sig. (bilateral)	.006	.001		.000
	N	9	9	9	9
Treatments	Pearson correlation	.946**	.957**	.950**	1
	Sig. (bilateral)	.000	.000	.000	
	N	9	9	9	9

***. The correlation is significant at the 0.01 level (bilateral)*

3.3 Effect on *F. parviflora* Dry Biomass Reduction

Statistical analysis revealed significant differences between treatments (Table 4). Data in Table 4 indicate that the best *F. parviflora* dry biomass reduction was achieved by «Florasulam+2,4-D» at (5.63+270) g/ha recording 92±3.1% of *F. parviflora* dry biomass reduction. Concerning the effect of «Florasulam+2,4-D» at (3.75 +180) g/ha, results showed medium efficacies that did not exceed 74±2.6% of *F. parviflora* dry biomass reduction. «Florasulam+2,4-D» at (1.88+90) g/ha showed weak efficacy that did not exceed 45±11.4%. Ezzahiri, et al. [11] reported that the recommended rate of application of «Florasulam+2,4-D» is (3.75 +180) g/ha in order to control broadleaf weeds in wheat crop. In this study, we found that the best control of *F. parviflora is* achieved with «Florasulam+2,4-D» at (5.63+270) g/ha which is 50% higher. In fact, herbicide efficacy depends on the nature of weed species. Several factors influence the activity of the herbicides and the access of the product to its target site, in particular the attachment of the spray droplets on the plant and herbicide penetration through the cuticle which differs from weed species [15].

3.4 Correlation between Treatments and Observed Efficacies

The correlation coefficients show a significant positive correlation between all observed parameters (Table 5). Data in Table 5 revealed a high significant positive correlation between «Florasulam+2,4-D» rates of application and different observed efficacies. This means that efficacies on *F. parviflora* are higher as the rates of application of «Florasulam+2,4-D» increase.

4. CONCLUSION

This study has shown that the herbicide «Florasulam+2,4-D» at (5.63+270) g/ha gave the best control of *F. parviflora*. «Florasulam+2,4-D» at (1.88+90) g/ha and Florasulam + 2,4-D at (3.75 +180) g/ha showed weak to medium control of *F. parviflora*. Thus, «Florasulam+2,4-D» at (5.63+270) g/ha can be recommended to farmers in Ouazzane region when *F. parviflora* infestation is dominant. This study should be completed with the assessment of «Florasulam+2,4-D» residues in soils and its phytotoxicity to crops grown in rotations.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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