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Paraquat and glyphosate action on purple nutsedge (*Cyperus rotundus* L.) in Olive Orchards

Hajjaj B*, El Oualkadi A*

*Regional Agricultural Research Center of Tangier, Morocco
Corresponding author. E-mail: h_badr15@yahoo.fr

Abstract**—** *A weed control trial was conducted in order to investigate the effect of two herbicides, paraquat and glyphosate, on Cyperus rotundus infestation in olive orchards. Treatments consist on two glyphosate rates of application and two paraquat rates of application. The experimental design was Randomized Complete Block Design (RCBD) with three replications. Each block contained five elementary plots, four plots of which were treated with the herbicides and the untreated plots serving as control. Observations were carried out at 30 and 90 days after application of herbicides. Results showed that treatment with glyphosate at 1080 g/ha and Paraquat at 400 g/ha recorded 100% of visual efficacy rating on C. rotundus at 30 days after treatment. At 90 days after treatment, glyphosate at 1080 g/ha showed the best efficacy recording 80% of visual efficacy rating on C. rotundus. However, paraquat at 800 g/ha showed weak control of C. rotundus recording only 50%. Glyphosate at 1080 g/ha recorded 78.6% of C. rotundus dry biomass reduction at 90 days after treatments. Paraquat at 400 g/ha, paraquat at 800 g/ha and glyphosate at 540 g/ha recorded weak efficacy varying from 34.7% to 53.5 % of C. rotundus dry biomass reduction at 90 days after treatments. Glyphosate at 1080 g/ha could be recommended to olive farmers when C. rotundus infestation is dominant.*

Keywords**— *Paraquat, glyphosate, purple nutsedge, Cyperus rotundus, Olive Orchards, Morocco.***

I. INTRODUCTION

Weeds compete with olive trees for water, nutrients, and sunlight. Orchard productivity is affected and young orchards may take longer to come into production (G. Steven Sibbett & Louise Ferguson). Weeds can also enhance the activities of other insects and diseases, and cause a fire hazard in the summer. Perennials are common weeds in olive orchards in Morocco. Their mode of multiplication is mainly vegetative by rhizomes, stolons, bulbs, suckers or tubers (Baudry, 2001). These methods of multiplication make their control difficult and limit the effectiveness of control methods. Purple nutsedge (*Cyperus rotundus* L.) is among the most harmful weed on tree plantations in Morocco (Hilali, 1995; Bensellam & *al*., 1997; Tahiri, 1997). It is a geophyte plant with ovoid tubers, blackish 10 to 15 mm long and 5 to 13 mm wide, with small stoloniferous rhizomes. Stems with triangular section, hairless, smooth, 15 to 60 cm high. Alternate leaves, arranged in rosette. Flattened spikelets, linear 1 to 2 cm long, composed of 10 to 20 fertile flowers. Trigon, brown, smooth seeds, 1 to 1.5 mm long and 0.8 to 1 mm wide (Tanji, 2005). Herbicides can control weed species in olive orchards provided are properly used. Paraquat and glyphosate are common herbicides used in olive tree in Morocco. Glyphosate is a non-selective broad-spectrum systemic herbicide. It belong to Amino-acids chemical family (Ezzahiri, 2017). It targets the enzyme 5-enolpyruvyl-3-shikimate phosphate synthase (EPSPS). It is effective for perennial weed control because it moves in phloem and kills all plants meristems. Paraquat is a non-selective broad-spectrum herbicide. It belong to Bipyridylium chemical family (Ezzahiri, 2017). It affects photosynthesis, by diversion of electrons from the iron-sulfur centres in chloroplast Phytosystem "I" and destructive reactive oxygen species are produced (Ezzahiri, 2017). Paraquat is not systemic and only desiccates the green foliage that it touches; it kills annual weeds but woody crops and the roots of perennial plants remain unaffected. This causes the characteristic browning of the leaves, which can occur within as little as 30 minutes of treatment under strong light conditions, and complete desiccation within a few days (Brown & *al*., 2004). In Marrakech region of Morocco, *C. rotundus* infestations in olive orchards become a serious constraint for many olive farmers. This study aims to evaluate different doses of glyphosate and paraquat herbicides on *C. rotundus* infestation in olive plantation.

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II. MATERIAL AND METHODS

A trial of chemical control of *C. rotundus* was conducted in SAADA INRA research station in Marrakech region of Morocco during 2013-2014 growing season. The experimental design was Randomized Complete Block Design (RCBD) with three replications. Each block contained five elementary plots, four plots of which were treated with the herbicides and the untreated plots serving as control. Treatments were carried out on January 03 April 2014 with Knapsack herbicide sprayer with nozzle delivering a 3 bar jet equipped with a nozzle cover to protect the trees from spray drift. The spray volume per hectare is 200L. Treatments consist on two *glyphosate* rates of application and two *paraquat* rates of application (Table 1).

Table.1: Applied herbicides in experimental site

Herbicide treatments	Herbicide active ingredient	rate of application (g/hectare)
Treatment 1	glyphosate	540 g/ha
Treatment 2	glyphosate	1080 l/ha
Treatment 3	paraquat	400 g/ha
Treatment 4	paraquat	800 g/ha

Observations were made at 30 and 90 days after application of herbicides. Observations concerned Visual rating of efficacy on *C. rotundus* following a scale ranging from 0 to 100% (where 0% is ineffective while 100% is a total destruction of weeds) and biomass reduction. *C. rotundus* dry biomass reduction percentage= [*C. rotundus* dry biomass weight in control plots – *C. rotundus* dry biomass weight in treated plots] x 100 / [*C. rotundus* dry biomass weight in control plots]. Calculation of dry *C. rotundus* biomass were made by collecting *C. rotundus* in each plot using a quadrant of 1m x 1m. Samples were dried in an oven at 75 ° C for 48 hours. Then, dry plant material in each plot was weighed with a precision balance. Statistical analyzes were performed with IBM SPSS Statistics, version 21.0 using the analysis of variance (ANOVA).The difference among treatment means was compared by Tukey's test at $P = 0.05$.

III. RESULTS AND DISCUSSION

1. Effect on visual efficacy rating

Statistical analysis revealed significant differences in the efficacy between treatments. Data in table 2 show that glyphosate at 1080 g/ha and paraquat at 400 g/ha recorded 100% of *C. rotundus* control at 30 days after treatments. Glyphosate at 540 g/ha and paraquat at 400 g/ha recorded 85% and 80% respectively at 30 days after treatment. At 90 days after treatment, glyphosate at 1080 g/ha showed the best efficacy recording 80% of *C. rotundus.* Conversely, paraquat at 400 g/ha, paraquat at 800 g/ha and glyphosate at 540 g/ha recorded weak efficacy varying from 20% to 50% of *C. rotundus* control at 90 days after treatment.

Table.2: Effect of herbicides on visual efficacy rating of C. rotundus

Treatments	Visual efficacy rating (%) (30 DAT*)	Visual efficacy rating (%) (90 DAT*)
Glyphosate at 540 g/ha	85^b	40^b
Glyphosate at 1080 g/ha	100^a	80^a
Paraquat at 400 g/ha	80^b	20^c
Paraquat at 800 g/ha	100^a	50^b
Pα = 0.05	*< 0.001*	*< 0.001*

**DAT: Days After Treatment. Significant differences within the same column and means followed by the same letter do not differ at p= .05 according to Tukey's test.*

2. Effect on weed dry biomass reduction

Statistical analysis revealed significant differences in the efficacy between treatments. Result in table 3 show that glyphosate at 1080 g/ha showed the best control of *C. rotundus* recording 78.6% of *C. rotundus* dry biomass reduction 90 days after treatments. Paraquat at 400 g/ha, paraquat at 800 g/ha and Glyphosate at 540 g/ha recorded weak efficacy varying from 34.7% to 53.5 % of *C. rotundus* dry biomass reduction at 90 days after treatment. Some authors reported that glyphosate applied at 1080 g/hectare in Gharb region in Morocco showed only 48.23% on monocotyledonous weed dry biomass reduction including *C. rotundus* (Bensellam & Bouhache, 2007). In our trial, glyphosate at 1080 g/ha recorded 78.6% of *C. rotundus* dry biomass reduction. This difference registered between regions could be explained by climatic conditions that differ from one region to another.

Table 3: Effect of herbicides on weed dry biomass reduction of C. rotundus

Treatments	C. rotundus dry biomass reduction (%) (90 DAT*)
Glyphosate at 540 g/ha	45.4^b
Glyphosate at 1080 g/ha	78.6^a
Paraquat at 400 g/ha	34.7^c
Paraquat at 800 g/ha	53.5^b
Pα = 0.05	*< 0.001*

**DAT: Days After Treatment. Significant differences within the same column and means followed by the same letter do not differ at p= .05 according to Tukey's test.*

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IV. CONCLUSION

This study has shown that glyphosate at 1080 g/ha gave the best control of *C. rotundus*. Paraquat achieved excellent efficacy on *C. rotundus* at 30 days after treatment but not at 90 days after treatment. Glyphosate at 1080 g/ha could be recommended to olive farmers in Marrakech region of Morocco when *C. rotundus* infestation is dominant. This study should be repeated on other perennial weed species to evaluate their response to herbicides application.

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