Evaluation of glyphosate-alternative weed control practices in Southern Europe

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Introduction

Globally, glyphosate applications remain by far the most common and effective practice to control weeds in perennial orchards. However, the agricultural sector seems to be over reliant on this specific herbicide resulting in the rapid spread of glyphosate-resistant populations [1]. Moreover, policy and environmental issues have created concerns regarding glyphosate future in Europe [2]. Thus, to maintain efficacy over time and partially counterbalance the economic consequences of the worst–case scenario (glyphosate phase-out), alternative weed management strategies should be investigated in the perennial orchards of Europe. The major objective of the current study was to perform an initial screening of several glyphosate-alternative weed control options in a citrus orchard in Southern Greece. Moreover, the effects of weed competition on citrus yield performance were also evaluated.

Materials and methods

The experimental field was located 5 km outside Pyrgos, Elis, Greece. was the studied crop. This two-year (2018-2020) field trial was conducted in a citrus (*Citrus clementina* Hort. ex Tan) orchard. A randomized complete block design was implemented with nine treatments assigned in four blocks. Plot size was 7.5 m long by 7.5 m wide to include four trees in each plot. Treatments included: glyphosate at 720 g ae ha^{-1} when weeds were between the 4- and 6- leaf growth stages, a double application of pelargonic acid in a fifteen–day interval, mowing, three soil-applied pre-emergence herbicides i. e. flazasulfuron (50 g ai ha^{-1}), oxyfluorfen (144 g ai ha^{-1}) and flumioxazin at (150 g ai ha^{-1}), while barley (*Hordeum vulgare* L.) and white mustard (*Sinapis alba* L.) cover crop residues were left on soil surface to suppress weeds. An untreated control was also included. Herbicides were applied with a pressurized backpack Gloria ® 405 T sprayer calibrated to deliver 300 L ha^{-1} of spray solution at 200 kPa constant pressure through five flat spray nozzles (direct spraying). Barnyardgrass [*Echinochloa crus-galli* (L.) P.Beauv.] was the dominant species, highly persistent during both years. Weeds were counted four weeks after glyphosate application in two 1 m^2 quadrats, permanently placed between tree rows in areas away from plot margins. Fruit yield per tree was measured at fruit maturity. Data were subjected to Analysis of Variance (α = 0.05) and means were separated according to Fischer's LSD test. A linear regression was also performed between barnyardgrass density and fruit yield.

Results and discussion

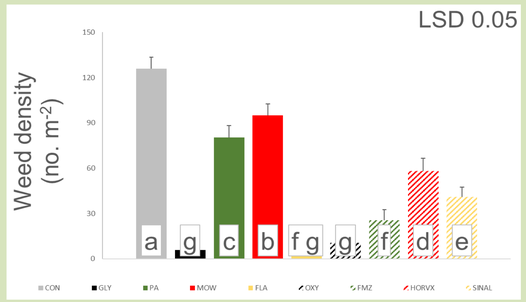

Figure 1. Weed density (no. m^{-2}) in the citrus orchard.

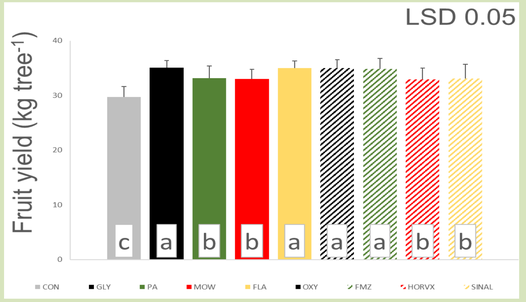

Figure 2. Fruit yield data (kg tree^{-1}) at fruit maturity.

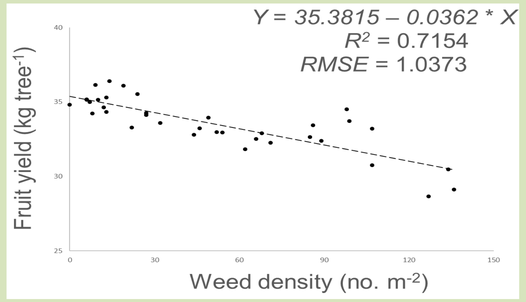

Figure 3. Regression between weed density (no. m^{-2}) and fruit yield (kg tree^{-1}).

No significant treatment by year interactions were detected in barnyardgrass density and fruit yield per tree ($p \geq 0.05$); therefore data were pooled across growing seasons. Significant were the effects of treatment on weed density and crop yield ($p < 0.001$). In particular, it was revealed that pre-emergence applications of alternative herbicides with soil residual activity can provide solutions to the management of *Echinochloa* spp. in perennial cropping systems. Glyphosate provided the highest levels of weed control. Flazasulfuron, flumioxazin and oxyfluorfen caused 87–91% reductions in weed density compared to the untreated. Pre-emergence herbicides with soil residual activity are considered as effective alternative weed control options to glyphosate [2]. Barnyardgrass was less affected from pelargonic acid applications and mowing operations. However, cover crop residues were more effective. Combined across the two experimental years, barley and, especially, white mustard residues suppressed barnyardgrass emergence at a significant point, in comparison to the control treatment. The management of cover crop residues is a well-recommended agronomic practice to suppress weeds in perennial orchards and can be combined with supplementary weed control operations [3]. Glyphosate as well as the alternative herbicides tested, provided the highest fruit yield per tree values. In addition, a negative and strong linear regression was observed between barnyardgrass density and crop yield (R^2 = 0.7154). Such findings are in accordance with recommendations indicating that weed competition is recognized as an important obstacle limiting the yield performance of perennial crops in the Mediterranean region [4].

Conclusions

The present study screened glyphosate-alternative weed control strategies in a citrus orchard. Pre-emergence herbicides with soil residual activity offer an alternative option for the control of noxious grass species such as barnyardgrass. The presence of cover crop residues provide also some levels of weed suppression. Effective weed control practices enhance the productivity of perennial crops. Research is required to evaluate more glyphosate-alternative weed control practices in perennial orchards.

References & Acknowledgements

1. Travlos I, Kanatas P, Tsekoura A, Gazoulis I, Papastylianou P, Kakabouki I, Antonopoulos N (2020) Efficacy of different herbicides on Echinochloa colona (L.) Link control and the first case of its glyphosate resistance in Greece. Agronomy 10:1056.
2. Fogliatto S, Ferrero A, Vidotto F, Sparks D (2020) Current and future scenarios of glyphosate use in Europe: Are there alternatives. Pages 219–278 in Sparks DL, ed. Advances in Agronomy. Volume 163. Cambridge: Academic Press
3. Alcántara C, Pujadas A, Saavedra M (2011) Management of Sinapis alba subsp. mairei winter cover crop residues for summer weed control in southern Spain. Crop Prot 30:1239–1244
4. Travlos IS, Bilalis DJ, Katsenios N, De Prado R (2018) Sustainable weed control in vineyards. Pages 526–542 in Korres NE, Burgos NR, Duke SO, eds. Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide. Boca Raton, Florida: CRC Press

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