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SHORT COMMUNICATION

Factors influencing the efficiency of foliar sprays of monopotassium phosphate in the olive

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Abstract

Olive trees have been traditionally cultivated in dry conditions as it is a crop very well adapted to Mediterranean dry lands. Foliar fertilization is a widespread application method used by olive growers to correct frequent deficient levels of potassium in olive trees under rainfed conditions. Monopotassium Phosphate (MKP) is an economic and easily available fertilizer and a fast source of P and K when it is applied as a foliar spray. The influence of environmental and formulation factors on the efficiency of MKP foliar application has never been evaluated. In this study the different responses of five MKP foliar treatments (control-untreated, MKP3% at dayligh, MKP3% overnight, MKP3% plus urea and MKP3% plus surfactant) on olive trees under field conditions were evaluated during three different application times (April, July, and November). In all cases, MKP3% plus urea and MKP3% plus surfactant increased P contents with July being the most effective treatment month. All treatments, except MKP3% at dayligh, improved the K nutritional state of olive in July, but not in November or April. In general, the addition of urea and surfactant to the MKP3% solution and its application in July improved its efficiency on olive trees, most likely due to the higher proportion of young leaves present during this period.

Keywords: *Olea europaea* L; Leaf absorption; Foliar fertilization; MKP.

Introduction

Olive (*Olea europaea* L.) is one of the oldest agricultural tree crops of remarkable cultural and economic importance in the Mediterranean Basin and it also represents a widely distributed fruit tree in the world (FAO, 2008). Current olive groves are estimated at approximately 960 million olive trees, of which some 945 million (98% of the total), are found in the Mediterranean Basin countries where they cover approximately 9.3 million hectares (Civantos, 2008). Approximately 50 million olive trees are under irrigation, but most groves are rainfed. Olive trees have been traditionally cultivated in dry conditions as it is a crop very well adapted to Mediterranean dry lands.

Foliar fertilization is a widespread application method used in these rainfed orchards as it provides good nutritional results and increases olive yields (Pastor, 2005). Generally, these orchards are characterized by low levels of nitrogen (N), potassium (K), phosphorus (P), and boron (B). Foliar application of urea is an effective method of replacing nitrogen fertilization of the soil (Klein and Weinbaum, 1984; Sánchez-Zamora and Fernández-Escobar, 2001). Although Restrepo et al. (2008a) did not find differences between foliar and soil applications of K salt (KCl and K_2SO_4), these researchers recommend foliar K fertilization in olive orchards growing in the drylands due to its lower application cost compared to injecting K fertilizers into the soil. Moreover, the lack of moisture in the soil during the growing period could limit K uptake by the roots. Recent studies have shown that K plays an important role on growth and water-use-efficiency in olive (Arquero et al., 2006; Restrepo et al., 2008b) as and could be useful in ameliorating abiotic stresses effects in olive plants (Abdolzadeh et al., 2009) as have been reported in other species (Cakmak, 2005; Fanei et al., 2009). Deficiencies of P are unusual in olive orchards, except in soils that are deficient in this element (Fernández-Escobar, 2008). Nevertheless, the foliar application of P may have a positive effect by increasing fruit set (Pastor et al., 2005).

Monopotassium Phosphate (MKP) is a cost effective and readily available fertilizer. Among the potassium and phosphate fertilizers used in foliar applications, MKP is the formulation with the lowest salt index and thus the foliar fertilizer of choice for many crops (Ankorion, 1998). It is an excellent and fast source of P and K when applied as a foliar fertilizer. Additionally, it controls powdery mildew in fruit trees and grapevines (Reuveni and Reuveni, 1998; Reuveni and Reuveni, 2001). MKP also reduces fruit retention force during olive ripening, which facilitates easier mechanical harvesting (Barranco et al., 2004).

Numerous factors that influence foliar absorption of nutrients on fruit tree crops have been studied. Urea and the addition of surfactants have a positive influence on increasing the effectiveness of the application (Klein and Weinbaum, 1984; Swietlik and Faust, 1984; Fernández-Escobar, 2008). Also, the higher relative humidity and lower temperatures during overnight applications could improve the absorption of foliar treatments. However, there is no specific information about how MKP absorption in olive is affected by these factors.

The aim of this experiment was to investigate the effects of some environmental and formulation factors on the efficiency of MKP fertilizer in olive these during three different application times. The influence of these factors on the absorption of foliar applications of MKP has not been previously evaluated. For this purpose, measurements of K and P contents of olives growing under rainfed conditions were performed at three application times: April, July, and November (when Spanish farmers usually apply phytosanitary products), after four different MKP treatments.

Results of this study could be very useful to improve the MKP foliar application in olive trees growing under dryland conditions. Knowledge of how and when the performance of MKP fertilizer is enhanced may reduce the cost of the applications and decrease the environmental impact of their use.

Materials and Methods

Experiments were carried out on thirty rainfed 20-year-old olive trees (cv. Picual) at distances of 7 m between rows and 7 m within trees (204 trees/ha) with bare soil management, growing in the “Alameda del Obispo”- IFAPA farm in Cordoba, Spain.

Five foliar spray treatments were performed: 1) control-untreated; 2) standard treatment, 3% MKP at daylight (*MKP3%*); 3) 3% MKP overnight (*MKP3%+night*); 4) 3% MKP plus 1% urea (*MKP3%+urea*); 5) 3% MKP plus a surfactant agent (polyethoxylated nonylphenol, Agral®; Syngenta Agro, Madrid, Spain) at a concentration of 0.1% (*MKP3%+srf*). Concentration of 3% MKP (Monopotassium Phosphate, Multi-MKP®; 52% P2O5, 34% K2O; Haifa Chemicals, Haifa, Israel) was used for all treatments but the control. Previous studies have shown that this concentration was the most effective for the assessment of high levels of P in leaves and did not cause phytotoxicity (De Toro, 1999). Foliar applications of four MKP treatments were performed at three different times: July 2006, November 2006, and April 2007, when the new leaves were 3-4, 7-8, and 12-13 months old, respectively. A randomized block design with five treatments and six replications was used considering each tree as an elementary plot. Before treatments, all the trees included an untreated control presented appropriate P and K contents according to the levels established by Beutel et al. (1983) for olive tree in July. Spray applications were done using a 100 l tank equipped with a pressurized handgun until runoff. Maximum and minimum temperatures of the day of application were 22-36, 11-23, 9.5-23 ºC, in July 2006, November 2006, and April 2007, respectively.

Foliar analyses were carried out in July 2006 to establish the P and K contents of the trees before MKP applications. Before treatments, all the trees included an untreated control presented appropriate P and K contents according to the levels established by Beutel et al. (1983) for olive tree in July. Also, P and K contents of the leaves of different ages were in agreement with those established by Fernández-Escobar et al. (1999). Phosphorus and potassium concentrations of olive leaves were measured 7 days after each application according to the method used by De Toro (1999) in order to determine the MKP absorption efficiency. About 50 fully-expanded leaves per tree were collected from the middle portion of nonbearing current season shoot growth and stored in paper bags in a portable cooler at 10 ºC. Once in the laboratory, leaves were washed with 0.03% Triton X-100 (Merck, Darmstadt, Germany), rinsed in deionized water, and dried at 80 ^{o}C for 48 h. Afterwards, leaves were ground to determine levels of P and K. Total phosphorous content was determined by colorimetry using the method described by Murphy and Riley (1962). Potassium determination was measured using an atomic absorption spectrophotometer (Perkin-Elmer 1100B, Waltham, Massachusetts, USA). A randomized block design with five treatments and six replications was used considering each tree as an elementary plot. Data of P and K contents were subjected to analyses of variance (ANOVA) and means were compared using the Fisher´s protected high significant difference (HSD) test. Data were analyzed using Statistix v.8.0 (Analytical Software, Tallahassee, Florida, USA).

Results and Discussion

In general, MPK applications had a positive effect in increasing the P content of olive leaves at the three application times (Table 1). In April and November, the four MKP treatments increased P contents significantly ($P<0.05$) compared to the control, and there were no differences among treatments. In July, the highest significant increment of P content with respect to the control was obtained by the *MKP3%+urea*, and *MKP3%+srf* treatments. There were also significant differences with the *MKP3%* treatment. The

MKP3%+night treatment showed significant differences with the control, except in November. This application time had the lowest effect of enhancing the P contents in the four treatments.

By contrast, MPK applications had a positive effect of increasing the K level of the olive leaves only when it was carried out in July (Table 2). In this month, *MKP3%+night*, *MKP3%+urea*, and *MKP3%+srf* treatments showed significant differences with the control.

Table 1. P content (% dry mater) in olive leaves under different foliar treatments with Monopotassium Phosphate (MKP) at three different application times.

Application Time	Age of the leaves (months)	Treatments				
		Control	MKP3%	MKP3%+urea	MKP3%+night	MKP3%+srf
April	12-13	0.110[a]	0.152[c]	0.144[bc]	0.143[bc]	0.140[b]
July	3-4	0.091[a]	0.112[b]	0.142[c]	0.129[bc]	0.144[c]
November	7-8	0.156[a]	0.197[b]	0.195[b]	0.171[ab]	0.191[b]

Values are the mean of 6 olive trees. For each application time, mean values with the same letter are not different according to Fisher´s protected high significant differences test at $P<0.05$.

Table 2. K content (% dry mater) in olive leaves under different foliar treatments with Monopotassium Phosphate (MKP) at three different application times.

Application Time	Age of the leaves (months)	Treatments				
		Control	MKP3%	MKP3%+urea	MKP3%+night	MKP3%+srf
April	12-13	0.411[a]	0.412[a]	0.431[a]	0.425[a]	0.399[a]
July	3-4	0.943[a]	1.073[ab]	1.158[b]	1.161[b]	1.232[b]
November	7-8	0.611[a]	0.604[a]	0.656[a]	0.642[a]	0.661[a]

Values are the mean of 6 olive trees. For each application time, mean values with the same letter are not different according to Fisher´s protected high significant differences test at $P<0.05$.

The overall better performance of the July application in increasing P and K contents, in comparison with April or November, could be due to the higher proportion of young leaves that developed during this period. Olive young leaves have higher nutrient requirements and absorption capacity (Fernandez-Escobar, 2008). The increased ability of young leaves to absorb P after the fertilization treatment in July was reported earlier by Fisher and Walker (1955) in apple. Also, the influence of the age of the leaves in the K uptake has been observed in different fruit trees species (Swietlik and Faust, 1984) and specifically in olive (Restrepo, 2006), with absorption being higher in young leaves.

The greater mobility of K with respect to P, due to a reduction of the K content in leaves from November to April (Fernández-Escobar, 1999), may explain the differences of absorption between both elements. In fact, in November and April the treatments showed no significant differences in K content with the control. The irregular response of olive trees to foliar K application, particularly when they are growing under rainfed conditions, has been reported by Restrepo et al. (2008a; 2008b). Neither treated nor control trees were below the deficiency level of 0.4% during the experiment, which could explain the lack of differences among treatments with the control (Restrepo et al., 2008a). Even in olives growing under rainfed conditions and with a K status near deficiency levels, external applications of K have shown an irregular response because absorption of foliar applied K by leaves is restricted by water stress or K deficiency (Restrepo et al., 2008a; Restrepo et al., 2008b).

MKP3%+urea, and *MKP3%+srf* treatments showed a good performance in increasing P and K contents. Urea enhances the permeability of the cuticle of the leaves (Yamada et al., 1965a), and it is generally agreed that surfactants increase spray deposition on foliage, which improve the efficacy of foliage-applied products, especially if these are to be used at reduced dosage rates (Leece, 1976; De Ruiter et al., 1990; Holloway, 1994; Holloway, 2000). Although the *MKP3%+night* treatment had similar effects as the *MKP3%+urea* and *MKP3%+srf* treatments, these latter two treatments are easier, more economical, and more convenient alternatives.

Potassium deficiency is common in many olive orchards in Andalusia. For this reason the foliar application of this element together with other phytosanitary treatments, is routinely used in olive orchards management. However, these treatments do lack of technical criteria and knowledge related with the moment and the method of application. According to our results, the efficiency of foliar MKP application in olive may be increased by simple practices, such as the addition of urea or surfactants, with July being the most efficient application time. Foliar MKP fertilization in early summer, when olive leaves are young and completely developed, has provided good results of increasing P and K levels. Besides, the dosage rates of MKP foliar application indicated here, in olive trees grown under dry land conditions, may contribute into reducing costs and environmental impacts.

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