Italian Journal of Agronomy
Rivista di Agronomia

An International Journal of Agroecosystem Management

July-September 2008
Vol. 3, No. 3 supplement

10th Congress of the European Society for Agronomy
15-19 September 2008, Bologna, Italy

Multi-functional Agriculture
Agriculture as a Resource for Energy and Environmental Preservation

edited by
Paola Rossi Pisa

The Official Journal of the
Italian Society of Agronomy

Soil Phosphorus Dynamic in an Olive Orchard Grown Under Different Weed-Control Systems

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Most of the olive orchards in Northeastern Portugal are on steep slopes. Tillage is the usual soil management system for these orchards. The combination of both these factors increases greatly the risk of soil erosion. To protect the soil, alternative weed-control systems, such as the use of post-emergence herbicides, must be implemented. As collateral effects, the weed-control systems may influence several aspects of soil fertility and crop nutrition, including P availability. The bioavailability of P in these soils is frequently low, mainly if they are acid, due to phenomena insolubility. Consequently, regular application of P fertilizers is needed to promote the growth of crops (Arrobas and Coutinho, 2002). The aim of this work is to study how the different soil surface management systems can affect the soil P dynamic in a rainfed olive orchard.

Methodology

The field trial is located in Mirandela (NE Portugal). The climate is Mediterranean type, hot and dry during the summer growing season. The soil is Leptosol, sandy-loamy textured, with an organic matter content in the first 20 cm of 6.1g kg^{-1} and $pH_{(H2O)}$ (1:2.5) of 4.9.The field trial was established in 2001 with the following weed-control systems: i) glyphosate based herbicide (Gly), applied in April; ii): herbicide with a residual component (glyphosate + diuron + terbutilazine) (Res), applied in February; and iii) conventional tillage (CT). Annually, each individual tree received 0.5 kg of a compound fertilizer (10-10-10) that was spread beneath the tree canopy at the end of winter. Soil cores were taken in October 2007, beneath the trees and between rows, in the 0-5, 5-10 and 10-20 cm depth. Samples from the 20-30 cm layer were only collected beneath the trees. Soil P fractionation was performed according the Hedley et al (1982) procedure. Total P and Total Organic P were determined by the Saunders and Williams (1955) procedure. In the ANOVA, the weed-control systems were included as treatments and the sampling site, beneath the trees and between rows, as blocks. The means with significant differences ($p<0.05$) were separated by t-Student and Tukey HSD tests.

Results

The results of soil P dynamic under the different weed-control systems and beneath the trees and between rows are presented in Table 1. The mean values of the more available P fraction (Resin-Pi + $NaHCO_3$-Pi) were significantly higher beneath the canopy than between rows in the 0-5, 5-10 and 10-20 cm layers. The results identify a pool of labile inorganic P fraction beneath the trees. The presence of a pool of fertility under the trees was previously reported by Rodrigues et al (2005) as a result of fertiliser placement and nutrient recycling by leaves. Comparing the labile P fractions among the three weed-control systems, the values were lower in Gly treatment. The differences were statistically significant in the 5-10 and 10-20 cm layers. From the beginning of this experiment the olive yield and trunk perimeter were significantly higher in Gly treatment (Rodrigues *et al.*, 2006). The higher performance of trees on Gly treatment should imply a higher uptake of P and may justify the lower values found as inorganic P fraction. No significant differences were found among treatments or between sampling sites in NaOH-Pi fraction. However, the mean values tended to be lower in the Gly treatment. This soil is acid and this fraction represents P bounded to iron and aluminum. Quantitatively this is an important P fraction which could be relevant for the crop nutrition. This fraction is sensitive to changes in soil pH. In fact, the influence of the weed-control systems in soil pH was low at this time (data not shown). Phosphorus extracted with HCl represents P bounded to calcium. The influence of sampling site and weed-control systems was not statistically significant for this P fraction. The upper soil layer (0-5 cm) presented the higher values, as a probable result of calcium application in the compound fertilisers. The organic P pool showed significant differences among the weed-control systems. In the 5-10 and 10-20 cm soil layers the organic P fraction was higher in Gly and lower in the CT treatment. Regarding total organic P, the values were higher in Gly and Res treatments. In the layer 5-10 cm, the values were significantly high in Gly treatment, and in the layer 10 to 20 cm both the herbicide treatments showed values significantly higher than that of CT treatment. Total P reflects the differences found in the other fractions, in particular the labile and organic ones.

Table 1- Soil P fractions in different sampling sites and under different weed-control systems

P fraction	depth (cm)	Sampling site		weed-control systems		
		Beneath trees	Between rows	Gly	Res	CT
Resin P + $NaHCO_3$ Pi ($mg\ kg^{-1}$)	0 to 5	84.6 a	55.2 b	56.7 b	88.7 a	64.2 b
	5 to 10	46.9 a	36.1 b	25.8 b	52.3 a	46.4 a
	10 to 20	39.1 a	31.6 b	24.8 b	43.2 a	38.0 a
	20 to 30	20.5	-	16.4 a	24.1 a	21.0 a
NaOH Pi ($mg\ kg^{-1}$)	0 to 5	153.9 a	137.8 a	110.5 a	171.9 a	155.1 a
	5 to 10	142.1 a	132.2 a	101.1 a	162.0 a	148.4 a
	10 to 20	129.2 a	121.9 a	88.5 a	157.3 a	130.8 a
	20 to 30	82.3	-	73.3 a	90.4 a	83.1 a
HCl P ($mg\ kg^{-1}$)	0 to 5	192.8 a	106.3 a	128.4 a	213.7 a	106.6 a
	5 to 10	47.3 a	44.0 a	35.2 a	50.2 a	51.5 a
	10 to 20	43.9 a	38.3 a	37.8 a	42.0 a	43.5 a
	20 to 30	24.9	-	23.7 a	29.6 a	21.5 a
Organic total P ($mg\ kg^{-1}$)	0 to 5	56.5 a	77.3 a	49.0 a	61.9 a	83.6 a
	5 to 10	126.1 a	105.0 a	182.7 a	103.6 b	60.3 c
	10 to 20	117.1 a	136.7 a	152.4 a	140.1 a	84.3 b
	20 to 30	87.3	-	47.9 a	114.3 a	99.8 a
Total P ($mg\ kg^{-1}$)	0 to 5	507.9 a	441.1 b	409.4 b	582.3 a	431.9 b
	5 to 10	432.4 a	381.1 b	375.9 b	449.2 a	395.1 ab
	10 to 20	394.4 a	409.4 a	357.0 c	456.4 a	398.6 b
	20 to 30	305.4	-	167.8 b	481.4 a	267.2 b

For sampling site and weed-control systems separately, means followed by the same letter in row are not statistically different ($p<0.05$).

Conclusions

The results showed a slight reduction in the more labile P fraction in Gly treatment, justified with the higher performance of trees and a probably higher P uptake on this plot. In Gly plot it seems not sustainable to maintain the higher olive yields if the P fertilization was not increased. A pool of P fertility was recorded beneath the trees as a result of fertiliser placement and P recycling in leaves.

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