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# WASTES

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## USE OF OLIVE MILL WASTE COMPOST AND ARBUSCULAR MYCORRHIZAL FUNGI IN THE FERTILIZATION OF RYEGRASS

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### ABSTRACT

Organic matter has an unquestionable important role in agriculture productivity due to its capacity to store water and nutrients, increase of the soil biodiversity and immobilize pollutants. Although fresh olive mill waste has phytotoxic properties, its compost can be used as a fertilizer. Mycorrhizal fungi can, potentially, increase crop productivity due to its relation with higher water and nutrients absorption by the roots. This work intended to evaluate the application of mycorrhizal fungi and composted olive mill waste on biomass production of ryegrass. The results showed that the olive mill waste compost could be used as an alternative source of fertiliser for ryegrass, but there must be a simultaneous application of inorganic nitrogen and phosphorus fertilizer. In that case, the application of mycorrhizal fungi demonstrated to be able to improve ryegrass forage yield.

**Keywords:** *Lolium multiflorum* L, organic matter, sustainable fertilization

### INTRODUCTION

Agricultural sector plays a strategic role in the process of economic development of a country. The *importance of organic matter (OM)* in maintaining the sustainability of cropping systems and an indispensable agricultural activity, is unquestionable. However, the official Communication 'Towards a Thematic Strategy for Soil Protection', considered declining soil OM as one of the most serious processes of soil degradation, especially in southern Europe [1]. Presently, beyond social and economic services, soil functions on ecosystem services has assumed particular relevance [2]. Some examples of the ecological functions of soils, beyond biomass production, are storage and filtration of water, storage and recycling of nutrients, habitat for biological activity and carbon storage [3]. Increasing soil C content improves chemical and physical soil properties, resulting in an increment of crops productivity [4]. Nowadays, a set of organic residues are produced by society, whose characteristics allow that agricultural use be the best destination to them. Olive mill waste is a common by-product of olive oil production which, when fresh, has a high plant and microbial toxicity. However, after being composted, this organic residue can be safely used as a soil fertilizer [5]. In addition to OM, the incorporation into the soil of organic residues allows a reuse of essential nutrients for the plants. For economic and environmental reasons, the nutrients applied to the soils should be used as efficiently as possible by plants. Soil microorganisms such as arbuscular mycorrhizal fungi (AMF) represent a key link between plants and soil mineral nutrients [6]. According to these authors AMF constitute a group of root obligate biotrophs that exchange mutual benefits with about 80% of plants. Among other things, they provide the host plant with mineral nutrients from soil volumes that are inaccessible to roots, in exchange for photosynthetic products. The impact of arbuscular mycorrhizal symbioses varies in different environmental conditions and depends on the specific combination of plant and fungus involved [7]. This study aims to evaluate the effectiveness of a

fertilization system with soil application of olive mill waste compost and/or mineral fertilizers, with the use of mycorrhizal fungi, on the *production of ryegrass forage*.

## MATERIAL AND METHODS

This work was conducted at the School of Agriculture of Polytechnic Institute of Castelo Branco, Portugal. The soil used was taken from the layer 0-0.20 m of a dystric Regosol derived from granitic rock. The soil was acidic ( $\text{pH}_{\text{H}_2\text{O}} = 5.2$ ), of sandy loam texture, with medium level of organic matter ( $27 \text{ g kg}^{-1}$ ), low level of Olsen P ( $8 \text{ mg kg}^{-1}$ ) and high level of available K ( $127 \text{ mg kg}^{-1}$ ). The soil was air dried and sieved in a  $<5 \text{ mm}$ -mesh sieve. The experiment was conducted in a completely randomized design and the fourteen treatments tested, with four replications, consisted of: the application of two levels of N ( $1 - 85 \text{ kg ha}^{-1}$  and  $2 - 170 \text{ kg ha}^{-1}$ ) applied through olive mill waste compost (Norg) and/or mineral forms (N), three levels of mineral phosphorus ( $0\text{P} - 0 \text{ kg ha}^{-1}$ ,  $1\text{P} - 40 \text{ kg ha}^{-1}$  and  $2\text{P} - 80 \text{ kg ha}^{-1}$ ) and application, or not, of mycorrhizal fungi. It was also considered the non-application of any fertilizer or mycorrhizal fungi (Control) and the practice of a conventional mineral fertilization ( $170\text{N} + 80\text{P}$ ). The pots with 6 kg of capacity were filled with the sieved soil, the fertilisers were added to soil according to the treatments and the tetraploid annual ryegrass (*Lolium multiflorum* L.; cv. Winter Star II) was sown in December 2018, using a seed density equivalent to  $40 \text{ kg ha}^{-1}$ . The olive mill waste compost was applied at a rate corresponding to the application of  $170 \text{ N kg ha}^{-1}$  only at sowing (2Norg) and at a rate of  $85 \text{ kg N ha}^{-1}$  (1Norg) at sowing with  $42.5 \text{ kg N ha}^{-1}$  through the application of a mineral fertiliser at the first cut and the same amount at the second cut (total  $85 \text{ N}$ ). In the N1 treatments half of mineral nitrogen was applied at the first cut and the same amount at the second cut and in the N2 treatments half of mineral nitrogen was applied at sowing and the other half divided by the second and third cuts. Mineral phosphorus fertilizer was applied at sowing. The mycorrhizal fungi (*Glomus intraradices* and *Glomus mosseae*) were applied to the soil ( $1 \text{ kg ha}^{-1}$ ;  $500 \text{ spores g}^{-1}$  of each species) at the first watering, after sowing. At February 15th. the first cut of the ryegrass was done, the second cut occurs in March after 5 weeks and the third cut at May 7. The plants were dry at  $65^\circ\text{C}$  during 48h and weighted for dry matter production. The soil during the experiment was maintained at 70% of field capacity.

## RESULTS AND DISCUSSION

Concerning the chemical composition of the olive mill waste compost (Table 1) we can observe that this product presents a dry matter value  $>75\%$  and more than 50% of OM, important requirements for a residue which we intend to use as an organic fertilizer. The C:N ratio (22) suggests a reasonable stabilization of the compost. It is an alkaline product with a pH value of 8.0. The content of heavy metals in the olive mill waste compost are in low concentration.

Table 1. Parameters evaluated in the olive mill waste compost used in the experiment

Properties <sup>1</sup>	Dry Matter (DM)	Organic Matter (OM)	pH	Electrical Conductivity (EC)	N <sub>k</sub>	P	K	Ca	C:N	N:P
	[g kg <sup>-1</sup> ]			[dS m <sup>-1</sup> ]		[g kg <sup>-1</sup> ]				
	757	570	8.0	1.41	15.0	0.635	22.1	11.2	22	24
Properties <sup>1</sup>	Mg	Na	Fe	Mn	Zn	Cu	Pb	Cd	Ni	Cr
	[g kg <sup>-1</sup> ]					[mg kg <sup>-1</sup> ]				
	2.4	2.3	6.8	143	68	16	<0.28	<0.04	7	12

<sup>1</sup> All data referred to dry matter, except dry matter, pH and EC

In the first cut of the ryegrass it was observed that, in general, the application of mycorrhizal fungi resulted in an increase of forage production (Fig. 1), more evident in the Control (more 22% of DM) and in the treatment with application of  $170 \text{ kg N ha}^{-1}$  through compost plus  $80 \text{ kg P ha}^{-1}$  in the mineral form (2Norg 2P; more 26% of DM). On the contrary, in the second cut, no positive effect was observed on forage production as a result of the application of mycorrhizal fungi, and the higher value of yield was obtained with the application of all nitrogen in mineral form (2N 2P treatment). In the third cut, the incorporation to the soil of mycorrhizal fungi resulted again in an increase of forage

production (between 7% and 35%), except in 2N 2P and in 2Norg 0P. Attending to the cumulative forage production obtained in the different treatments, we can observe that the use of olive mill waste compost as the only fertilizer in ryegrass, may imply a decrease in forage production of around 60%. Besides, the results showed that the use of mycorrhizal fungi might be interesting when an organic waste is used simultaneously with N and P mineral fertilizers, but its soil incorporation could be harmful if mineral fertilizers only were applied to the soil.

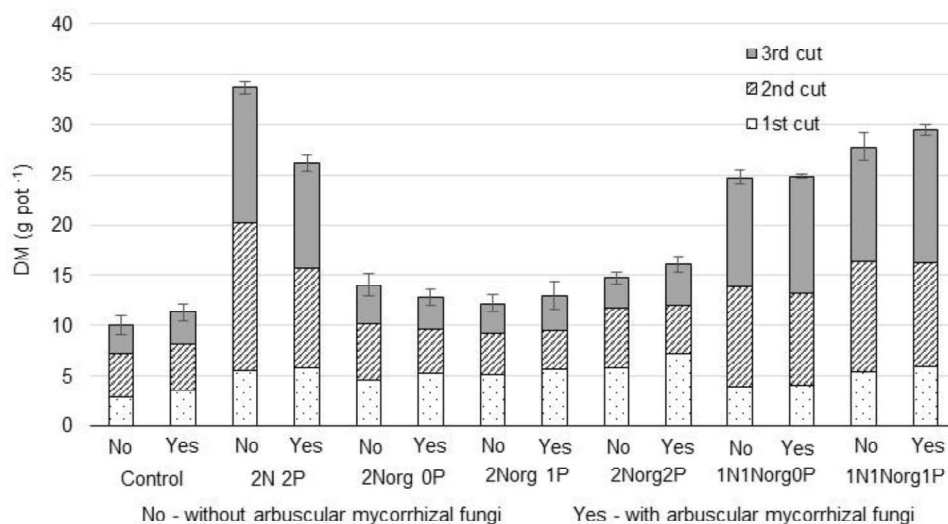


Figure 1 – Cumulative ryegrass (*Lolium multiflorum* L.; cv. Winter Star II) forage dry matter production (g pot<sup>-1</sup>) obtained in the different treatments (bars represent  $\pm$ SEM, n=4).

## CONCLUSIONS

The olive mill waste compost could be used as an alternative source of fertilizer, but with simultaneous application of mineral N and P (at least in soils with low P level). Besides, the use of mycorrhizal fungi showed to be able to improve ryegrass forage yield if olive mill waste compost and N and P mineral fertilizers are used simultaneously.

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