Effects of arbuscular mycorrhizal symbiosis on the nitrogen uptake of three durum wheat genotypes from two different organic sources

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1. Background & Objectives

Arbuscular mycorrhizal (AM) fungi are obligate symbionts of the majority of terrestrial plants. By enhancing nutrient and water uptake, AM symbiosis improves the host plant's growth, nutrient status, and response to biotic and abiotic stress. The role of AM fungi in nitrogen (N) acquisition remains unclear. Although several studies have shown that AM symbiosis enhances N uptake from inorganic sources (Cliquet et al., 1997), its effects on N uptake from organic sources remains unclear, particularly when both AM hyphae and plant roots can utilize the same source (Hodge, 2003; Hodge et al., 2000). These disparate results may result from the different plant species and genotypes used in the experiments, as well as the type and complexity of the added organic material (e.g., the carbon:nitrogen ratio), the different AM fungus species and strains, and the amount and quality of the bacterial populations. The present study tested the hypothesis that AM symbiosis enhances the N uptake of durum wheat (*Triticum durum*) from organic sources and examined whether N uptake varies with the type of organic material and the wheat genotype.

2. Materials & Methods

A pot experiment was conducted in a climate-controlled glasshouse (25/19°C day/night temperature; 16 h photoperiod). A complete randomized factorial design with four replicates was adopted. Treatments were: i) AM symbiosis, inoculation with *Glomus mosseae* (+Myc) and uninoculated control (–Myc); ii) organic matter (OM), the addition of 4.6 g ^{15}N-enriched maize biomass per kg of soil in the form of maize leaves (+ML: 1.90% N content, 4.78 ^{15}N atom%) or maize roots (+MR: 1.56% N content, 3.94 ^{15}N atom%); and iii) wheat genotype, Cappelli (an old Italian cultivar), Scorsonera (a Sicilian landrace), and Simeto (the most widely grown cultivar in Italy). Each pot was filled with 600 g of a quartz sand:soil mixture (2:1). Soil properties were: clay 20% and sand 37%; pH 8.1 (soil:water 1:2); 1.04% organic C; 1.05‰ total N. The soil mixture was steam-sterilised. Before starting the experiment, a soil filtrate was inoculated to normalise the microbial community. Three wheat plants per pot were grown. During the experiment, each pot received 5 ml of a modified Hoagland's solution (with no phosphorus and 10% N) once every 5 days. The dry weights of wheat shoots and roots were recorded 9 weeks after the emergence of the crop and both fractions were analyzed for total N and ^{15}N enrichment using an elemental analyzer–isotope ratio mass spectrometer. Wheat roots were stained with 0.05% trypan blue in lactic acid and AM infection was measured using the grid intersect method (Giovannetti and Mosse, 1980). The recovery of the applied ^{15}N in wheat was calculated according to Allen et al. (2004). An analysis of variance was performed according to the experimental design.

3. Results & Discussion

No AM root infection was observed in the –Myc treatment. In the +Myc treatment, AM root infection varied weakly but significantly with the genotype (Simeto > Scorsonera = Cappelli) and with the type of organic matter (+ML > +MR) added (Table 1). Inoculation with AM fungi (+Myc treatment) significantly increased both plant growth and total N uptake compared to –Myc treatments (+15% and +22%, respectively). However, AM inoculation significantly decreased the fraction of ^{15}N recovered from the added OM (–34% on average compared to –Myc) with differences among the genotypes but not between +ML and +MR. This decrease was lower in Cappelli and Scorsonera than in Simeto. Moreover, the latter genotype showed the highest ^{15}N recovery fraction when grown without AM symbiosis and the lowest benefit of AM symbiosis in terms of total N uptake. The lower fraction of ^{15}N recovered from the added OM (independently from the type of OM) observed in +Myc treatments is difficult to explain but may depend on the capacity of the fungus to take up N from decomposing OM in the form of amino acids and other products. Thus, fungal uptake of dissolved organic N is greater than host plant uptake (Rains and Bledsoe, 2007); the fungus could utilize this element primarily for its own growth and metabolism.

Table 1. Effects of AM symbiosis (AMS) on total biomass, total N uptake, ^{15}N recovery fraction from added OM, and AM root infection according to wheat genotype and the type of organic matter added.

Organic matter (OM)	Genotype (G)	Total biomass [g per pot]		Total N uptake [mg per pot]		^{15}N recovery fraction [%]		AM root infection [a] [%]
		–Myc	+Myc	–Myc	+Myc	–Myc	+Myc	+Myc
+Maize leaves	Cappelli	0.90	1.06	6.86	9.44	5.45	3.88	28.40
	Scorsonera	0.87	1.04	7.67	10.24	5.45	4.32	31.00
	Simeto	0.79	1.01	7.68	9.03	6.36	3.93	35.10
+Maize roots	Cappelli	0.81	0.77	5.88	6.75	5.22	3.68	27.80
	Scorsonera	0.72	0.98	5.04	6.74	4.42	2.88	28.10
	Simeto	0.76	0.71	7.05	6.91	6.37	3.26	34.50
F test [b]	AMS	***		***		***		–
	OM	***		***		***		***
	G	***		ns		*		***
	AMS × OM	***		***		ns		–
	AMS × G	***		*		*		–
	OM × G	ns		***		ns		*
	AMS × OM × G	***		ns		ns		–

[a] not applicable to –Myc treatments; [b] ns = not significant; * and *** significant for $P < 0.05$ and 0.001, respectively.

4. Conclusion

Our results show that AM symbiosis benefits the host plant in terms of both growth and total N uptake. Further analyses of the N content and the relative ^{15}N concentration of the AM extra-radical mycelium are needed to elucidate the complex symbiotic relationships between plants and fungi and their influence on the acquisition of N from different sources.

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