ONION (*Allium cepa* 'Talon')
Host response; Mycorrhizal colonization

Jenny A. Knerr[1], Timothy C. Paulitz[2], and Lindsey J. du Toit[1];
[1]Washington State University Mount Vernon NWREC, Mount Vernon, WA 98273; [2]USDA ARS, Pullman, WA 99164.

Effects of commercial arbuscular mycorrhizal fungi (AMF) products on onion in a growth chamber study, 2015.

Symbiotic arbuscular mycorrhizal fungi (AMF) colonize the roots of many plant species, helping mine soil for immobile nutrients, particularly phosphorus, enhance plant growth, and limit the severity of some soilborne plant diseases. Onions depend on AMF to compensate for the relatively sparse, unbranched root system. However, natural populations of AMF in soils can be reduced by common practices used by onion farmers, such as high phosphorus fertilization rates, relatively extensive cultivation, and soil fumigation. To assess the potential for commercial AMF products to boost or restore AMF populations in the soil and enhance onion production in the sandy soils of the Columbia Basin of central Washington and northcentral Oregon, a preliminary study was completed in a growth chamber set at 15 ± 1°C with a 12 h photoperiod/day to evaluate four commercial AMF products for onion root colonization by AMF and plant growth (shoot height and dry weight): BioTerra Plus (Plant Health LLC, Corvallis, OR), MycoApply Ultrafine Endo (Mycorrhizal Applications, Inc., Grants Pass, OR), Mykos Gold Granular (Reforestation Technologies Inc., Gilroy, CA) and MykePro Granular (PremierTech Horticulture, Quebec, Canada). Soil was collected from a certified organic field in the Columbia Basin that had relatively low phosphorus levels (average Olsen P of 18 mg/kg), and steam-pasteurized twice, each time for 1 h at 60°C, with a 24 h interval between pasteurizations. The soil was then air dried and sieved to a particle size ≤2 mm. Previous research with BioTerra Plus revealed variation in fertility levels among bags of the product. Therefore, three BioTerra Plus treatments were evaluated: a sample from a bag of product that had relatively high fertility levels, a sample from a bag relatively low in nutrients, and a sample of the first bag that was pasteurized for 45 min at 60°C using a table top pasteurizer (Powers Regulator Co., Skokie, IL) to kill any AMF that might be present in the product in order to distinguish the potential effects of the AMF in the product from the fertilizer in the product. The sample was pasteurized again after 24 h. Each AMF product was mixed thoroughly with pasteurized soil to a 1% concentration by weight. Soil (500 g) mixed with the appropriate AMF product was added to each of five replicate D40 deepots (each 25 cm deep x 7 cm diameter, Stuewe & Sons, Inc., Tangent, OR) after sealing the drain holes at the lower end of each deepot with paper towel. Water (150 ml) was added to the soil in each depot in 50 ml increments. After saturation, 10 onion seeds of the cv. Talon were placed on the soil surface and covered with 17 g (1 tablespoon) of dry soil that was not amended with an AMF product. Treatments were each replicated five times and arranged in a randomized complete block design in the growth chamber. The top end of each deepot was covered for 7 days with a plastic bag held in place with a rubber band to reduce evaporation during emergence. Water was added to the soil in each depot at 3-day intervals as needed. Four after planting, and again five weeks after planting, 25 ml of a suspension of 2/5th- strength nitrate type Long Ashton fertilizer without micronutrients or phosphorus was added to the soil in each deepot. Six and seven weeks after planting, the fertilizer suspension was added to each deepot twice/week. Onion seedling height and total dry weight of the shoots of all plants/depot were measured 60 days after seeding. Roots were washed carefully with running tap water, and then stained by boiling in 10% KOH followed by a 5% Sheaffer black ink and vinegar solution (Verheilig et al., 1998) to assess the presence or absence of AMF colonization microscopically (10x to 20x magnification) for each of 50 root sections per replicate plot using a modified gridline intersection method (Giovannetti and Mosse, 1980). Foliar nutrient analysis was completed on the dried leaves for each plot by Soiltest Farm Consultants (Moses Lake, WA). Analysis of variance and mean comparisons were computed with JMP Version 11 Pro (SAS Institute Inc., Cary, NC). The growth chamber trial was repeated.

In Trial 1, onions growing in soil amended with Mykos Gold Granular were significantly taller, had greater shoot dry weight, were colonized extensively by AMF (82.2%), and had significantly greater foliar levels of K, total N, Mg, S, Fe, and B compared to plants growing in control soil without an AMF treatment. The only other AMF treatments that improved onion growth were the three BioTerra Plus treatments: all three increased shoot height (with no significant difference among the three treatments), the high nutrient and low nutrient BioTerra Plus treatments increased shoot dry weight and total foliar N but decreased foliar K levels, the high nutrient product increased foliar Na and resulted in a very limited amount of root colonization (0.0008%), and pasteurized BioTerra Plus increased foliar S levels. MycoApply UltraFine Endo and MykePro Granular did not affect onion plant growth or foliar nutrient status significantly compared to the control soil, and AMF colonization was not observed on the roots of onion plants growing in soil amended with either of these products. The tallest plants (21.93 cm), in soil amended with Mykos Gold Granular, were 16.7% taller than plants of the next most effective treatment, the low nutrient BioTerra Plus (18.80 cm), which did not differ in height from plants in soil amended with high nutrient or pasteurized BioTerra Plus. Pasteurization of BioTerra Plus did not modify the effect of this product on shoot height, but negated the positive effects of BioTerra Plus on shoot dry weight, AMF root colonization, and foliar N. In this trial, onion plants grown in soil amended with BioTerra Plus or Mykos Gold Granular were darker green than plants in the other plots, which may have reflected the higher levels of foliar nutrients of plants growing in soil with these two products. In Trial 2, none of the AMF treatments resulted in a significant increase or decrease in onion shoot height or dry weight. However, AMF root colonization of plants growing in soil amended with Mykos Gold Granular was again very extensive (81.6%). Only two other products resulted in AMF root colonization, the high nutrient BioTerra Plus (but only on 0.284% of root sections examined) and MycoApply Ultrafine Endo (only at 0.084%). AMF root colonization in the Mykos Gold plots ranged from 64.7 to 93.6%. Similar to Trial 1, the Mykos Gold Granular treatment resulted in a significant increase in foliar levels of all nutrients measured except Fe, Mn, and B; whereas the BioTerra Plus treatments had almost no effect on plant foliar nutrient status except for a decrease in foliar P and increase in foliar Na in the low nutrient BioTerra Plus plots. As in Trial 1, plants in the Mykos Gold Granular plots were darker green than plants in other plots, but the difference was less pronounced than in Trial 2. Mykos Gold Granular consistently improved onion growth and AMF root colonization in both trials in this study, warranting evaluation under field conditions in the Columbia Basin.

Trial	Variable (unit of measurement)	AMF treatment[z]							
		BioTerra Plus (high nutrient)	BioTerra Plus (low nutrient)	BioTerra Plus (pasteurized)	Myco-Apply Ultrafine Endo	MykePro Granular	Mykos Gold Granular	Soil control	*P* value[y]
1	Shoot height (cm)	17.93 bc[y]	18.80 b	16.65 bcd	15.16 de	15.54 cde	21.93 a	14.00 e	<0.0001
	Shoot dry weight (g)	0.48 a	0.47 a	0.31 b	0.30 b	0.30 b	0.51 a	0.28 b	0.0003
	AMF root colonization (%)	0.0008 b	0 c	0 c	0 c	0 c	82.2 a	0 c	Rank[x]
	Foliar P (%)	0.182	0.244	0.372	0.338	0.368	0.35	0.348	0.1084
	Foliar K (%)	4.2 c	4.5 bc	5.3 ab	5.2 ab	5.2 ab	5.7 a	4.8 abc	0.0449
	Total foliar N (%)	2.8 ab	2.4 bc	2.3 cd	2.2 cd	2.0 cd	3.0 a	1.8 d	0.0003
	Foliar Ca (%)	0.958	0.930	0.974	0.950	0.956	1.152	0.926	0.0635
	Foliar Mg (%)	0.29 b	0.272 b	0.300 b	0.296 b	0.288 b	0.372 a	0.284 b	0.0031
	Foliar S (%)	0.394 bc	0.412 bc	0.452 ab	0.418 bc	0.400 bc	0.532 a	0.334 c	0.0080
	Foliar Zn (mg/kg)	18.0	16.4	17.2	18.8	17.4	19.8	18.4	0.5056
	Foliar Fe (mg/kg)	233.8 b	207.8 b	262.2 b	247.0 b	259.8 b	367.0 a	257.0 b	0.0245
	Foliar Mn (mg/kg)	202.8	183.8	213.6	242.4	249.6	284.6	244.0	0.1133
	Foliar Cu (mg/kg)	6.8	5.8	6.2	6.4	6.8	7.6	6.6	0.0783
	Foliar B (mg/kg)	17.0	18.8	20.2	20.2	19.4	20.2	23.4	0.5734
	Foliar Na (%)	0.534 a	0.412 b	0.384 b	0.388 b	0.344 b	0.56 a	0.334 b	0.0003
2	Shoot height (cm)	20.90	22.05	21.67	22.05	19.71	21.56	21.77	0.6886
	Shoot dry weight (g)	0.85	0.84	0.81	0.85	0.70	0.71	0.80	0.2053
	AMF root colonization (%)	0.284 b	0 c	0 c	0.084 b	0 c	81.6 a	0 c	Rank
	Foliar P (%)	0.24 cd	0.224 d	0.274 bcd	0.328 ab	0.294 bc	0.376 a	0.294 bc	0.0003
	Foliar K (%)	4.1 c	4.9 b	4.6 bc	4.6 bc	5.0 b	5.8 a	5.0 b	0.0004
	Total foliar N (%)	2.0 c	2.6 ab	2.3 bc	2.2 bc	2.4 bc	3.0 a	2.2 bc	0.0034
	Foliar Ca (%)	0.838 b	0.882 b	0.844 b	0.842 b	0.914 ab	0.992 a	0.850 b	0.0420
	Foliar Mg (%)	0.230 b	0.248 b	0.242 b	0.248 b	0.244 b	0.312 a	0.250 b	0.0008
	Foliar S (%)	0.410 c	0.436 bc	0.420 bc	0.486 ab	0.434 bc	0.530 a	0.446 bc	0.0397
	Foliar Zn (mg/kg)	13.0 b	14.4 b	13.4 b	14.4 b	14.0 b	17.8 a	14.4 b	0.0232
	Foliar Fe (mg/kg)	187.4	163.4	182	214.8	168.2	234.2	223	0.4843
	Foliar Mn (mg/kg)	193.2	209.6	218.8	166.2	227.6	245.0	247.2	0.1992
	Foliar Cu (mg/kg)	6.0 b	5.8 b	5.4 b	6.4 ab	5.4 b	7.4 a	6.0 b	0.0281
	Foliar B (mg/kg)	18.4	18.8	19.0	19.4	20.2	18.6	19.8	0.4594
	Foliar Na (%)	0.350 b	0.450 a	0.386 ab	0.352 b	0.356 b	0.456 a	0.320 b	0.0287

[z] Each product was added to the pasteurized soil at 1% by weight (30 g product + 2,970 g soil). This equated to 1.67 spores/g soil for the BioTerra Plus products, 2.8 spores/g soil for MycoApply Ultrafine Endo, 1.42 spores/g soil for MykePro Granular, and 0.8 spores/g soil for Mykos Gold Granular.

[y] Within each row, numbers followed by the same letter are not significantly different based on Fisher's protected least significant difference ($P < 0.05$).

[x] RANK = means separation based on rank transformed data because of heterogeneous variances among treatments, although the original treatment means are shown in the table.