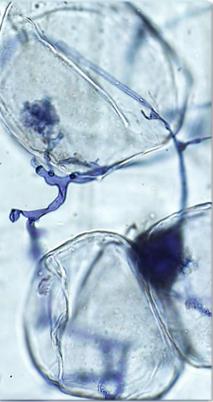


# Evaluation of Arbuscular Mycorrhizal Fungi (AMF) in Conventional and Organic Onion Production in the Columbia Basin, and the Potential Use of AMF to Reduce the Impact of Soilborne Pathogens of Onion

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## ABSTRACT

Symbiotic arbuscular mycorrhizal fungi (AMF) colonize roots of many plants. Onions are dependent on AMF for improved acquisition of immobile nutrients in soil, particularly phosphorus (P). AMF also help defend plants against some soilborne pathogens. However, soil fumigation and high P fertilization rates negatively impact AMF associations with plants. AMF were detected in plants and soil sampled from both organic and conventional onion crops in the Columbia Basin of Washington, and AMF species composition is being determined in certified organic and conventional soils using molecular methods. A commercial AMF product, BioTerra Plus, was evaluated for reducing onion stunting caused by *Rhizoctonia solani* in a greenhouse study using pasteurized soil with four soil treatments: 1) inoculation with AMF, 2) inoculation with *R. solani*, 3) inoculation with AMF + *R. solani*, and 4) non-inoculated soil. *R. solani* reduced onion plant height by 56%, and onion shoot, root, and total dry weights by 73, 70, and 72%, respectively, compared to plants in non-inoculated soil. Plants in soil with AMF were taller (average 20.0 cm) than plants in non-inoculated soil (15.8 cm). Plant height and dry weight of onion plants in soil with AMF + *R. solani* were 160 and 427% greater, respectively, than that of plants in soil with *R. solani* alone, i.e., AMF significantly reduced onion stunting. AMF products are being evaluated in growers' fields for enhancing onion growth and suppressing soilborne diseases such as stunting and pink root (latter caused by *Phoma terrestris*).

## INTRODUCTION

- Onion growers in the Columbia Basin produce ~27% of US storage onions, at an estimated farmgate value of \$4,000-\$7,000/acre<sup>1</sup>.
- Arbuscular mycorrhizal fungi (AMF) are beneficial to most plants, aiding nutrient uptake<sup>2</sup> and defense against some pathogens<sup>3</sup>.
- The prevalence of AMF in crops may be reduced by soil fumigation and high P levels.
- Other practices may also affect AMF prevalence and colonization of plants, e.g., conventional versus organic farming systems.

## RESEARCH OBJECTIVES

- Compare levels of AMF colonization of onion plants in organic and conventional onion crops in the Columbia Basin.
- Assess the ability of AMF to protect onion plants against soilborne onion pathogens, e.g., *Rhizoctonia solani*.

## MATERIALS AND METHODS

### 1. Comparison of AMF in organic vs. conventional onion fields:

- Soil and plants were collected from 5 sites in each of 9 fields in the Columbia Basin, 4 conventional and 5 certified organic crops.
- Soil nutrient analysis was performed by Soiltest Farm Consultants, Inc.
- In a greenhouse (15 ± 1°C and 12 h photoperiod/day), onion seeds of the cv. Talon (Bejo Seeds, Inc.) were grown in soil from each site in cone-tainers for 60 days.
- Shoot height, root length, wet root weight, and shoot dry weight were measured.
- Roots were homogenized. Half were boiled in 10% KOH and stained to observe AMF microscopically. The remaining roots will be used for 454 pyrosequencing to determine genera and species of AMF.
- The presence or absence of AMF was recorded to calculate the % AMF colonization of roots.
- The effects of organic vs. conventional and comparisons among fields were calculated using standard least squares.

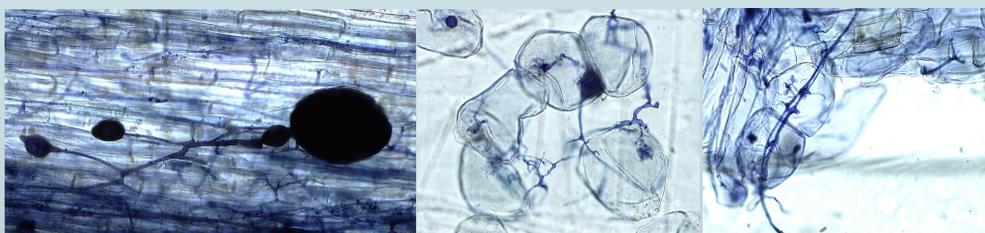


Fig. 1. Micrographs of onion roots stained with Schaeffer's blue ink and vinegar to reveal the presence of AMF.

### 2. Ability of AMF to protect onion roots against by *Rhizoctonia solani*:

- 16 g of BioTerra Plus (commercial AMF product) was placed above 110 g of pasteurized soil with 29 ppm phosphorus (P) in each replicate cone-tainer for the AMF treatment.
- Ground sterilized oats colonized by *R. solani* AG 8 were mixed with pasteurized soil (1% w/w) for *R. solani* AG 8 treatments.
- For co-inoculation of AMF and *R. solani* AG 8, BioTerra Plus was top-dressed above 110 g soil inoculated with *R. solani* AG 8.
- Non-inoculated control soil consisted of 130 g pasteurized soil/cone-tainer.
- Four seeds of Talon were planted/cone-tainer, and covered with 0.5 cm of soil.
- Treatments were replicated five times in a randomized complete block design.
- Onion seedling height, root length, and root and shoot dry weights were measured 60 days after seeding.

## CONCLUSIONS

- Conventional onion fields typically had higher P levels than organic fields but did not differ in prevalence of AMF.
- Onion root colonization by AMF was highly prevalent in organic and conventional fields.
- Co-inoculation with AMF and *R. solani* significantly increased plant height and dry weight compared to plants inoculated with *R. solani* alone.

## FUTURE WORK

- Assess how AMF can contribute to improved soil quality by facilitating reduced dependence on soil fumigation and soil applications of fungicides, as well as reduced P fertilization rates.
- Evaluate the use of AMF for disease suppression in onion and other crop species that form AMF.

## RESULTS

### 1. Comparison of organic and conventional onion fields (Table 1 and Fig. 2):

- Only soil pH and Olsen P levels differed significantly ( $p < 0.001$ ) in organic vs. conventional onion fields.
  - pH was 1.1 fold higher in organic vs. conventional fields (7.83 vs. 7.07, respectively).
  - Olsen P was 1.6 fold less in organic vs. conventional fields (30.19 vs. 49.35, respectively).



Fig. 2. Onion plants grown in soil sampled from organic (A) vs. conventional (B) fields in the Columbia Basin.

- Among the 9 fields sampled:
  - Soil pH ranged from 6.3 to 8.1.
  - Olsen P was relatively low overall: 22.7 to 67.6 mg/kg.
  - AMF were prevalent in all fields: 45-90% of onion roots had AMF, with >75% colonization of the roots of onion plants grown in soil from >50% of the fields surveyed.

Table 1. Comparison of AMF colonization, shoot dry weight and soil properties between organic and conventional onion fields in the Columbia Basin.

| Field  | Management   | pH      | Olsen P (mg/kg) | AMF Colonization (%) | Shoot dry wt (g) | Shoot height (cm) |
|--------|--------------|---------|-----------------|----------------------|------------------|-------------------|
| J38-1  | Organic      | 8.1 a   | 27.2 d          | 69.4 bc              | 0.80 ab          | 22.2 a            |
| J38-2  | Organic      | 7.5 bcd | 13.8 e          | 64.4 c               | 0.61 bcd         | 21.5 a            |
| BF-1   | Organic      | 8.1 a   | 33.5 cd         | 75.0 abc             | 0.70 bc          | 18.5 a            |
| B87U43 | Organic      | 7.9 ab  | 44.2 bc         | 85.5 ab              | 0.41 de          | 20.0 a            |
| B81U36 | Organic      | 7.6 bc  | 31.6 d          | 90.2 a               | 0.46 cde         | 19.4 a            |
| C102   | Conventional | 6.3 e   | 51.6 b          | 42.3 d               | 1.01 a           | 22.9 a            |
| C8     | Conventional | 7.3 cd  | 29.8 d          | 80.9 abc             | 0.19 e           | 19.3 a            |
| ANW522 | Conventional | 7.0 d   | 67.6 a          | 88.2 a               | 0.43 cde         | 21.6 a            |
| ANW718 | Conventional | 7.6 bc  | 48.4 b          | 89.3 a               | 0.29 e           | 17.8 a            |

Numbers in a column with the same letter are not significantly different (Fisher's protected least significant difference, LSD, at  $P < 0.05$ ).

### 2. Ability of AMF to protect onions from *Rhizoctonia solani* (Table 2 and Fig. 3):

- Rhizoctonia solani* reduced onion plant height by 56%, and onion shoot and shoot dry weights by 73 and 70%, respectively.
- Inoculation of soil with AMF increased plant height (average 20.0 cm vs. 15.8 cm in non-inoculated soil).
- Onion plant height and dry weight in soil with AMF + *R. solani* were 160 and 427% greater, respectively, than that of plants in soil with *R. solani* alone.

Table 2. Evaluation of AMF for control of *Rhizoctonia solani*.

| Soil treatment                        | Plant height (cm) | Root length (cm) | Dry weight (g) |           |          |
|---------------------------------------|-------------------|------------------|----------------|-----------|----------|
|                                       |                   |                  | Shoot          | Root      | Total    |
| BioTerra Plus                         | 20.0 a*           | 21.6 a           | 0.086 a        | 0.0172 bc | 0.1029 a |
| BioTerra Plus + <i>R. solani</i> AG 8 | 18.2 a            | 15.4 ab          | 0.105 a        | 0.0313 a  | 0.1361 a |
| <i>R. solani</i> AG 8                 | 7.0 c             | 9.8 b            | 0.017 b        | 0.0086 c  | 0.0258 b |
| Non-inoculated                        | 15.8 b            | 14.8 ab          | 0.065 a        | 0.0283 ab | 0.0930 a |
| LSD ( $P = 0.05$ )                    | 2.0               | 7.1              | 0.043          | 0.0138    | 0.0555   |

Numbers in a column with the same letter are not significantly different (Fisher's protected LSD at  $P = 0.05$ ).



Fig. 3. Onions grown in control soil (A), soil inoculated with *Rhizoctonia solani* AG 8 (B), soil inoculated with *R. solani* AG 8 + mycorrhizae (C), and soil inoculated with mycorrhizae alone (D).

## ACKNOWLEDGEMENTS

- WSU CSANR BIOAg Program
- Pacific Northwest Vegetable Association (PNVA)
- Dr. Bob Linderman, Plant Health LLC
- Columbia Basin onion growers

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