Research Paper

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Use of Mycorrhizal Fungi to Improve Soil Conditions for Agricultural Use

Introduction

The purpose of the study was to analyze the potential capabilities of fungal mycelia to convert non- arable soil into fertile soil. Intact mycelial networks increase soil fertility by increasing water and nutrient absorption capacity of plants, if the land is left untilled. With the use of a soil inoculant, such as mycelium, there could be a global expansion of farmland, to help in feeding the world's growing population. Fungi are very successful inhabitants of soil, due to their high plasticity and their capacity to adopt various forms in response to adverse or unfavorable conditions (Frac, 2018). Fungicides that kill harmful fungi are also toxic to "beneficial" mycorrhizal fungi. Therefore, in addition to tillage, fungicides are inhibiting mycelial growth (Taskeen-Un-Nisa, 2011). When tillage isn't used higher fungal populations as well as higher concentrations of acid-hydrolysable carbohydrates and increased contribution of microbial (Beare 1997). Tilling soil can disrupt the colonization of mycelium, which in turn can dictate the inoculum potential as well as decrease the nutrient absorption capacity independent of the degree of colonization (Evans 1989).It has been studied that when tillage isn't used higher fungal populations as well as higher concentrations of acid-hydrolysable carbohydrates and increased contribution of microbial (Beare 1997). Therefore, when soil isn't tilled mycelium can more easily colonize and aid plants in nutrient absorption and concentration.

It was hypothesized that by using fungal mycelia it is possible to convert depleted soils into fertile soils, in order to more successfully cultivate world food crops and other plants, as well as benefit the soil's inhabitant's health.

Methodology

The mycelial groups that were used are soil inoculants commercially sold MycoGrow® purchased from Fungi Perfecti. Since, these soil inoculants are commercially available it is exempt from SRC review.

There were three experimental groups and one control group used consistently in each experiment. Group A consisted of 11 species of endo and ectomycorrhizal fungi (**Endomycorrhizal fungi:** *Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum.* **Ectomycorrhizal fungi:** *Rhizopogon villosullus, Rhizopogon luteolus, Rhizopogon amylopogon, Rhizopogon fulvigleba, Pisolithus tinctorius, Scleroderma cepa, Scleroderma citrinum.*) Experimental Group B consisted of 19 species of endo and ectomycorrhizal fungi, beneficial bacteria, soluble kelp, humic acids and vitamin B1 (**Endomycorrhizal fungi**: *Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum, Glomus deserticola, Glomus monosporum, Glomus clarum, Paraglomus brasilianum, Gigaspora margarita.* **Ectomycorrhizal fungi:** *Rhizopogon villosulus, Rhizopogon luteolus, Rhizopogon amylopogon, Rhizopogon fulvigleba, Pisolithus tinctorius, Suillus granulatus, Laccaria bicolor, Laccaria laccata, Scleroderma cepa, Scleroderma citrinum.* **Disease Suppression Organisms:** *Trichoderma koningii, Trichoderma harzianum.* **Beneficial Bacteria :** *Bacillus licheniformis, Bacillus azotoformans, Bacillus megaterium, Bacillus coagulans, Bacillus pumilus, Bacillus thuringiensis, Paenibacillus polymyxa, Paenibacillus durum, Azobacter chroococcum,* *Pseudomonas aureofaciens, Pseudomonas fluorescens, Saccharomyces cerevisiae.*) Experimental Group C consisted of a mixture of *Glomus* mycelia (**Endomycorrhizal fungi:** *Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum.*) Group D will be the control group using no inoculants.

Eisenia fetida (Compost Worms) Experiment:

In this part of the study, mixtures of 50 mL autoclave sterilized compost, 50 mL of sterilized sand were mixed (autoclave sterilization was conducted by instructor) with 1.0 cc mycelial mixtures A, B, and C, and the control (D) of sterile water individually. The soil mixtures of each group were then put into separate divisions in a behavioral chamber. 20 mL of H_2O were sprayed into each quadrant in order to keep the worms and soil moist. *Eisenia fetida* was then placed into the middle of the behavioral chamber. After 24 hours the number of worms per group were counted in each quadrant of behavioral chamber.

Triticum aestivum (Wheat):

This experiment was comprised of mixtures of 20 mL sterilized sand and 10 mL sterilized compost, mixed with 0.6 cc mycelial mixture for each of the groups A, B, C, and D (the control was sterile water) individually. Four quadrants each with 30 mL soil mixtures were made per group, and 8 mL of sterile water was added to each of the quadrants. The *T. aestivum* seeds were then planted 4 days later to allow mycelial networks to form. Growth was measured every few days and plants were watered for 1 week then left unwatered for 2 weeks to test drought resistance.

Brassica rapa (Wisconsin Fast Plant®):

In this experiment, of 10 mL sterilized sand, 20 mL sterilized compost, were mixed with 0.6 cc each mycelial inoculant, A, B, and C, individually, and just sterile water for the control (D). Four quadrants each with 30 mL soil mixtures were made per group, and 8 mL of sterile water was added to each of the quadrants. The *B. rapa* seeds were then planted 4 days later to allow mycelial networks to form. Growth was measured every few days and plants were consistently watered.

Results

Eisenia fetida (Compost Worms) Experiment:

The *E. fetida* frequency counts were 31 worms in Group A, 97 worms in Group B, 2 worms in Group C, and 8 worms in Group D (control).

Triticum aestivum (Wheat):

On days 8 and 20 the number of sprouts were counted and the heights of the plants were measured. After 8 days of planting, Group A had 7 sprouts, Group B had 5 sprouts, Group C had 2 sprouts, and Group D had 1 sprout. Additionally, on day 8, Group A had an average height of 3.33 cm, Group B had an average height of 6.22 cm, Group C had an average height of 4.45 cm, and Group D had an average height of 0.7 cm.

After 20 days of planting, Group A had 8 sprouts, Group B had 7 sprouts, Group C had 8 sprouts, and Group D had 7 sprouts. Also, on day 20, Group A had an average height of 6.42 cm, Group B had an average height of 18.21 cm, Group C had an average height of 7.64 cm, and Group D had an average height of 5.63 cm

The *Triticum aestivum* plants in Group B were significantly taller and less wilted than those of the other groups.

Brassica rapa (Wisconsin Fast Plant®):

On days 7 and 14 the heights of the plants were measured. On day 7, Group A had an average height of 2.18 cm, Group B had an average height of 3.02 cm, Group C had an average height of 1.67 cm, and Group D had an average height of 1.97 cm. On day 14, Group A had an average height of 3.0 cm, Group B had an average height of 3.0 cm, Group C had an average height of 4.0 cm, and Group D had an average height of 4.5 cm.

Group D was significantly more wilted than Groups A, B, C, D, even though Group D was taller.

Discussion

Eisenia fetida experiment's results coincide with what was hypothesized that mycelium is beneficial to the land's inhabitants because there were drastically more worms in Groups A and B. It can be assumed, the worms were drawn to the beneficial properties of inoculants A and B.

Triticum aestivum experiment's results help prove what was hypothesized, that with the addition of a mycelial incolulant in soil and seeds, there is increased plant growth and health. After not being watered for a week, all the other wheat plants were wilted, but Group B seeds were thriving under the unfavorable conditions they were placed under. It can be inferred that mycelial mixture B aids in water retention and drought resistance since when the plants weren't watered for a week and they didn't dry out like the other groups did. This experiment demonstrated that mycelium aids in soil adhesion because the sand and compost mixture fall out of the container in Groups A, B, and C, as it did D.

The *Brassica rapa* experiment's results showed that the addition of a mycelial inoculant is beneficial toward plant health. Although the experimental groups didn't grow as tall as the control, they were greener, less wilted, and had firmer stems than the control (D).

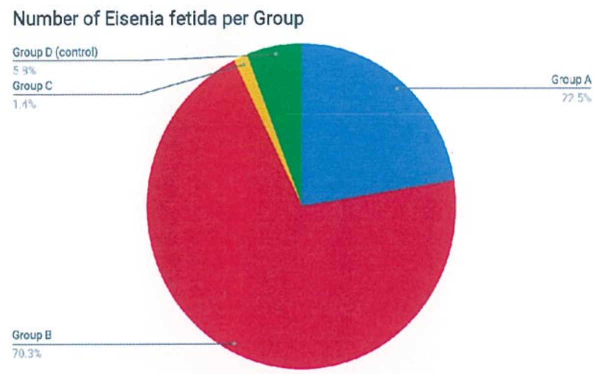

Figure 1: Eisenia fetida Counts

Group A- 31

Group B- 97

Group C- 2

Group D- 8

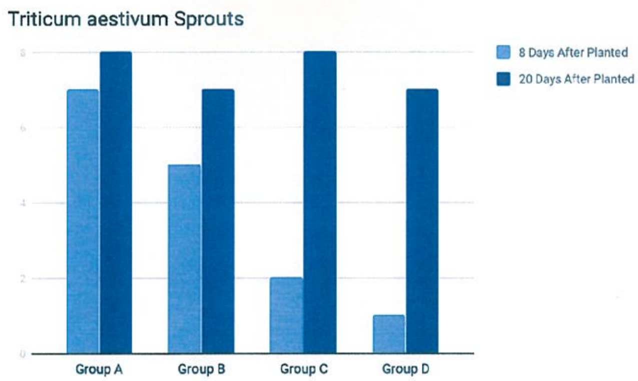

Figure 2: Growth of *T. aestivum* when exposed to pre-inoculated seeds and soil.

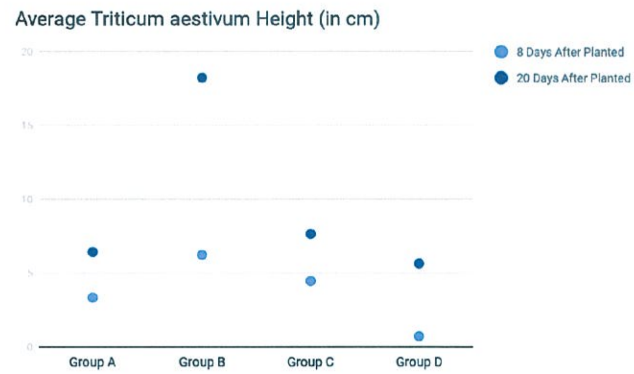

Figure 3: Triticum aestivum plants in B were significantly taller than the other groups after 20 days.

Figures 4: *Triticum aestivum* plants in Group B were significantly taller and less wilted than those of the other groups. (from left to right: A, B, C, D)

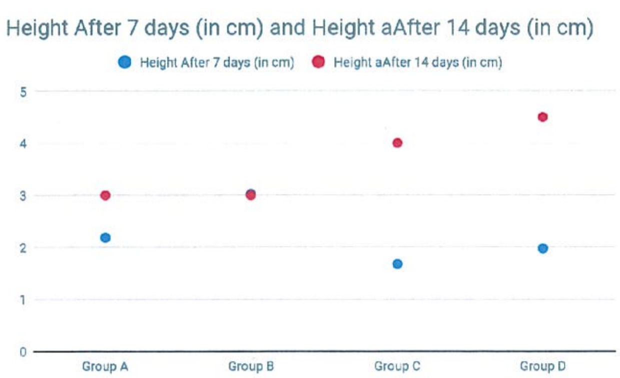

Figure 5: Growth of *B. rapa* when exposed to pre-inoculated seeds and soil.

Figure 6: *B. rapa* growth, 1 week after seeds were planted. Group D was significantly more wilted than Groups A, B, C, D, even though Group D was taller.
(from left to right: A, C, B, D)

Future Work

Seed germination using *Triticum aestivum* seeds to measure root hair growth and development as well as overall health of plants will be conducted on Yeast Malt Agar plates. Additionally, mycelial effects on *Solanum tuberosum* will be conducted in experiments similar to that of the methodology of *Triticum aestivum* . Other major world crops will be tested with mycelial inoculation to see if there are beneficial effects in an effort to increase the amount of fertile farmland farmland available, in order to help feed the world's growing population.

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