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To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

Effects of Mycorrhizal Fungi, Biostimulants and Water Absorbing Polymers on the Growth and Survival of Four Landscape Plant Species[1]

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Abstract

The addition of commercial mycorrhizal, transplant gel and/or biostimulant products to the root balls or backfill soil of Japanese holly, (*Ilex crenata* Thunb. 'Green Luster'); arborvitae, (*Thuja occidentalis* L. 'Emerald Green'); Japanese spirea, (*Spiraea japonica* L.f. 'Shibori'); Bradford Callery pear, (*Pyrus calleryana* Decne. 'Cleveland Select' and 'Redspire') at the time of planting did not lead to significant improvement of plant growth or transplant survival compared to untreated plants receiving routine mulching with pine bark mulch alone.

Index words: hydrogel, landscaping industry, mycorrhizae, transplant.

Species used in this study: Japanese holly (*Ilex crenata* Thunb. 'Green Luster'); arborvitae (*Thuja occidentalis* L. 'Emerald Green'); Japanese spirea (*Spiraea japonica* L.f. 'Shibori'); Bradford Callery pear (*Pyrus calleryana* Decne. 'Cleveland Select' and 'Redspire').

Significance to the Nursery Industry

Based upon this study, mycorrhizal fungi, transplant gel, biostimulants or combination products can provide newly transplanted trees and shrubs with some survival benefit, but do not increase plant survival and growth when compared to proper mulching. Landscaping professionals can use the results from this experiment to help decide whether to use additional root treatments. However, the value of routine mulch application has been re-affirmed in that untreated plants grown with pine bark mulch alone performed as well or better than the plants with the additional root treatments.

Introduction

Production and maintenance of landscape plants throughout New England have significant economic value and impact, estimated at approximately $4 billion annually (21). Ornamental plants are used primarily to improve the aesthetic appearance of commercial or residential landscapes. Unfortunately, new landscape plantings are often installed in settings with poor soil (e.g., heavy clay, low organic matter, and poor nutrition), and receive little or no supplemental irrigation, which may decrease their chance of survival. Plants treated with commercially available products containing mycorrhizae, hydrogel and/or biostimulants may be more tolerant of such stressful conditions, require less supplemental nutrients, and irrigation and have increased disease resistance (20).

Mycorrhizal fungi colonize plant roots and enhance plant health by improving nutrient and water uptake from the soil. There are two classifications of mycorrhizal fungi: ectomycorrhizae (associated with beech, birch, fir, hemlock, larch, oak, pine, spruce) that grow between root cells and out into the surrounding soil and endomycorrhizae (associated with apple, ash, bayberry, cherry, dogwood, holly, juniper, turfgrass and many herbaceous plants) that grow into root cells and the surrounding soil. Endomycorrhizae can be categorized as either arbuscular mycorrhizae (AM) or vesicular-arbuscular mycorrhizae (VAM). Together, they have a large host range of both herbaceous and woody plants. Mycorrhizal fungi can also protect the plant from root pathogens (1, 7). Inoculation of landscape plants with mycorrhizae has

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the most benefit in poor growing areas (such as unvegetated sites that contain no natural mycorrhizal fungi, recently graded, eroded topsoil, etc.) (3).

Past research has produced mixed results on the effect of mycorrhizae on ornamental plants. Black walnut (*Juglans nigra*) seedlings inoculated with mycorrhizae experienced slightly enhanced root and top growth (18). Container-grown Douglas-fir (*Pseudotsuga menziesii*) showed that ectomycorrhizae inoculated plants were taller than non-inoculated seedlings (4). Of four container-grown ornamental plant species (*Loropetalum chinense, Nandina domestica, Photinia fraseri, Salvia gregii*) treated with mycorrhizae, only one (*N. domestica*) exhibited increased growth due to mycorrhizae (8). Pin oak (*Quercus palustris*), willow oak (*Q. phellos*) and red maple (*Acer rubrum*) inoculated with the mycorrhizal fungus *Pisolithus tinctorium* showed no measurable growth benefit 6 and 12 months after treatment unless the treatment was combined with fertilizer (2). Pin and scarlet oak (*Q. coccinea*) showed no significant height or trunk diameter increase from the use of mycorrhizae (17). Four tree and nine shrub species were inoculated with the mycorrhizal fungus *Glomus intraradices* or *G. fasiculatum*, but only one species, *Syringa*, had any growth enhancement after 2 years (19). A trial that used container-grown woody and herbaceous plants showed no difference between inoculated and non-inoculated plants at the end of the second growing season (5). Finally, a study using nursery growing conditions (i.e., greenhouse-grown containerized plants, soilless potting media) showed no enhanced plant growth (6).

Biostimulants typically consist of a small percentage of nitrogen, micronutrients such as iron and magnesium, humic and amino acids and other organic products such as enzymes, kelp extract, and vitamins. Previous work on biostimulants showed no increase in root length or dry weight when applied to field-grown red maple trees (14). A similar study conducted on red maple and hawthorn (*Crataegus* sp.) showed no improvement to root growth after application of biostimulants, but a slight increase in hawthorn top dry mass due to biostimulants (13). Biostimulants applied to trees prior to digging provided some benefit to the trees after re-planting (16).

Transplant gels, such as hydrogel crystals used in this experiment, consist of synthetic acrylic polyacrylamide with a potassium base. Hydrogels make water available to plant roots when soil moisture is lacking. Transplant gels are reported to reduce the amount of watering needed, reduce soil compaction, and increase transplant survival (11). However, some studies have shown that hydrogels, used at labeled rates, did not have significant impacts on plant growth and survival (10, 12, 24, 25).

The objective of this experiment was to assess whether commercially available mycorrhizae, hydrogels, and biostimulant products enhance growth of four newly transplanted ornamental plant species when evaluated 2 years after planting.

Materials and Methods

Research plots were located at the Connecticut Agricultural Experiment Station Valley Laboratory, Windsor, in loamy-sand soil that is prone to drought. The experimental design was a randomized complete block with four replications (32 plants/species). A treatment block consisted of one each of the four plant species planted at 1 m (3 ft) intervals. Test plants were *Ilex crenata* 'Green Luster', *Thuja occidentalis* 'Emerald Green', *Spiraea japonica* 'Shibori', and *Pyrus calleryana* 'Cleveland Select' and 'Redspire'. (Unfortunately, a shortage of the same size *Pyrus* forced us to use two cultivars.) Plants were container-grown — #2 for *Ilex*, *Thuja*, *Spiraea* and #5 for *Pyrus*. The four plant species were selected because they are common and represent deciduous (*Spiraea* and *Pyrus*) and evergreen (*Ilex* and *Thuja*) plants.

Treatments were applied at the time of planting (June 5–6, 2001) to the rootball directly or incorporated into the backfill soil. Eight treatments were selected that represent the various options that can be utilized at the time of planting: a hydrogel; a biostimulant; 4 mycorrhizal fungi products; pine bark mulch; and an untreated control. All commercial treatments were applied at label rate and included:

- SoilMoist gel [JRM Chemical Inc., Cleveland, OH; 42.5 g (1.5 oz) for trees, 14.2 g (0.5 oz) for shrubs];
- Bio/Organics mycorrhizae [endomycorrhizal (VAM) spores of *Glomus brasilianum*, *G. clarum*, *G. deserticola*, *G. intraradices*, *G. monosporus*, *G. mosseae* and *Gigaspora margarita*; Bio/Organics La Pine, OR; 9.2 g (0.3 oz), for trees, 4.6 g (0.2 oz), for shrubs];
- Mycor Plant Saver [blend of endo- and ectomycorrhizal fungi, beneficial root/soil bacteria, chelated micronutrients and biocatalysts including humic acid, complex carbohydrates, yucca plant extract, sea kelp and organic nitrogen and phosphorus; Plant Health Care Inc., Pittsburgh, PA; (340 g, 12 oz) for trees, 113.4 g (4 oz) for shrubs];
- Greenburst biostimulant [6.5% nitrogen, chelated copper, iron, manganese, magnesium and zinc, natural surfactants, humic acids, amino acids and selected plant extracts, fermentation substances such as enzymes, amino acids, vitamin-B complex and microbial metabolites; BioBurst 'n Grow, Vernal, UT; as a preplant rootball dip 5 ml/3.78 liters (0.17 fl oz/gallon)];
- Mycor Tree Saver [blend of endo- and ectomycorrhizal fungi, gel (potassium acrylamide copolymer), natural humates, yucca plant and seaweed extracts; Plant Health Care Inc., Pittsburgh, PA; combination of fungi-gel-biostimulant 1 packet (85 g, 3 oz) for trees, 2/3 packet (56 g, 2 oz) for shrubs];
- M-Roots [blend of 17 species of endo- and ectomycorrhizal fungi, nitrogen, phosphorous, potassium, calcium, magnesium and iron; Roots Inc., Independence, MO; 675 g (23.8 oz) for trees, 225 g (8 oz) for shrubs];
- pine bark mulch alone 7.6 cm (3 in) depth; and
- a non-treated, no mulch control.

All treatments receiving a commercial product also received 7.6 cm (3 in) depth pine bark mulch at the time of planting and again the following year (April 19, 2002). All treatments received light irrigation [2 cm (0.75 in)] immediately after planting (June 6, 2001). In order to provide an environmentally stressful growing environment (i.e., simulation of low-maintenance conditions), no supplement irrigation was made throughout the rest of the experiment. Plots were hand-weeded when necessary except for those with the non-treated, no mulch treatment, which were occasionally mowed. Plant height and canopy width measurements were taken on August 2, 2001, May 16, 2002, August 13, 2002 and May 15, 2003. All plants were destructively sampled on September 15–16, 2003, and the final plant height, canopy width and root spread were measured. Soil was shaken from

Table 1. Effect of mycorrhizal fungi, biostimulants and water absorbing polymers on growth of 4 landscape species.

	Height (cm)	Canopy width (cm)	Root width (cm)	Root weight (g)
Ilex crenata				
SoilMoist gel	33.8abc[z]	57.9abc	89.7abc	45.6ab
Greenburst biostimulant	47.8a	76.2a	132.1a	46.7ab
M-Roots	38.9ab	57.9abc	68.1c	29.4abc
Bio-Organics mycorrhizae	39.4ab	64.8ab	119.4ab	48.5a
Mycor Plant Saver	26.7bc	39.4bc	56.6c	18.9bcd
Mycor Tree Saver	22.9c	35.1cd	66.8c	8.7cd
Non-treated with mulch	33.0abc	55.9abc	80.0bc	36.9abc
Control, no mulch	5.1d	9.7d	11.4d	0.88d
Pyrus calleryana				
SoilMoist gel	266.7a	96.5bc	274.3a	271.3a
Greenburst biostimulant	276.9a	118.9ab	270.5a	240.4a
M-Roots	254.8a	99.8bc	224.3a	142.8ab
Bio-Organics mycorrhizae	298.0a	106.2bc	299.2a	231.0a
Mycor Plant Saver	271.8a	108.7bc	227.3a	155.2ab
Mycor Tree Saver	266.7a	124.0ab	327.2a	226.0a
Non-treated with mulch	262.9a	160.8a	275.6a	280.5a
Control, no mulch	295.9a	70.6c	64.8b	12.7b
Spiraea japonica				
SoilMoist gel	84.6a	85.9a	128.3ab	147.3a
Greenburst biostimulant	80.8a	83.8a	130.8ab	137.4a
M-Roots	83.8a	92.2a	113.0abc	75.2bc
Bio-Organics mycorrhizae	85.1a	92.2a	123.2abc	133.2ab
Mycor Plant Saver	85.1a	94.7a	110.5bc	158.1a
Mycor Tree Saver	77.5a	80.0ab	137.9a	110.8abc
Non-treated with mulch	79.5a	84.6a	129.0ab	149.3a
Control, no mulch	61.7b	61.0b	98.6c	54.3c
Thuja occidentalis				
SoilMoist gel	135.4ab	50.8a	134.1b	139.9ab
Greenburst biostimulant	133.4ab	50.8a	170.9a	104.6c
M-Roots	146.8a	53.3a	144.8ab	115.0bc
Bio-Organics mycorrhizae	135.9ab	54.6a	131.6bc	101.5c
Mycor Plant Saver	146.1ab	54.6a	130.3bc	120.2abc
Mycor Tree Saver	136.7ab	50.3a	157.5ab	118.5abc
Non-treated with mulch	130.3b	50.8a	137.2ab	140.9a
Control, no mulch	97.8c	39.4b	97.3c	48.1d

[z]Means in the same column within the same plant species followed by the same letter are not significantly different (P = 0.05, Fishers's LSD).

the root ball. Plant height was measured from the top of the plant to the soil line. Root width was taken after digging by spreading the roots out laterally for measurement. To determine the amount of new root growth, roots were pruned from outside of the original, container-shaped rootball, which was still obvious. Roots were visually examined for evidence of mycorrhizal colonization (visible white mycelium) before drying. Roots were air-dried and then oven-dried at 70C (158F) before weighing. Though measurements were taken four times during the course of the experiment, only the final measurements were used for analyses.

Because of the inherent size differences, each plant species was analyzed separately and not compared to the other three species. Statistical analyses were performed using Number Cruncher Statistical Systems (NCSS) 2000 program (J.L. Hintze, Kaysville, UT). Data from the study were subjected to ANOVA and treatment means were separated using Fisher's LSD P = 0.05.

Results and Discussion

All four plant species had the poorest performance in the non-treated, no mulch control (Table 1). Growth was significantly (p = 0.05) lower in this treatment compared to all others. It is possible that this poor growth was due to the loss of soil moisture and competition with weed species (9, 15, 22, 23). Even though the non-treated, no mulch treatments with *Spiraea* and *Thuja* had significantly lower measurements from most of the other root treatments, the plants did not appear as visually stressed as the non-treated, no mulch *Ilex* and *Pyrus*. Three of the four *Ilex* died in the non-treated, no mulch treatment. One *Ilex* died in the Plant Saver and Tree Saver treatments also. These *Ilex* plants may have died from lack of soil moisture, particularly the non-treated, no mulch plants, and from winter desiccation. One *Pyrus* in the M-Roots and the Plant Saver treatments were broken during a storm in 2002. Thus, the analysis of data for this plant in the respective treatments was based on three instead of four trees.

Growth measurements of plant species in the non-treated, mulched treatment were not significantly different from most of the commercial root amendment treatments (Table 1). If any of the treatments should have lead to long term benefits, it would have been the ones containing mychorrizal fungi. Because they are living organisms, the mycorrhizae population could have increased and further colonized the roots. There are a number of potential reasons why a mycorrhizal inoculation fails: nonviable inocula, competition with native fungal species, improper host plant/fungus specificity, com-

pacted soil or heavy irrigation (3). There was no visual sign of mycorrhizal mycelium on the plant roots when they were dug. However, since there was no microscopic examination of the roots for the presence of mycorrhizae, there is still the possibility that some colonization took place. Expanded hydrogel crystals were not visible at the time of the final plant sampling. The gel pieces are typically present in the soil months after application. In this experiment, it is possible that the hydrogel may have broken down during the 2-year period. The biostimulant treatment may have provided short-term benefits, but there were no long-term growth effects.

The results suggest that the addition of mychorrizae, hydrogels or biostimulants to the roots or backfill soil at the time of planting did not lead to increased transplant survival or growth that could not be achieved with application of pine bark mulch alone and minimal care (e.g., light weeding). Mulch reduces the loss of soil moisture and decreases weed encroachment both of which benefit the ornamental plant's growth. However, it is still possible that these commercial products may improve plant growth if plants are transplanted into a poor growing environment, such as a non-vegetated location or an area where topsoil has recently been removed (which would contain minimal or no native mycorrhizae and low levels of nutrients and micronutrients) and with no follow-up care (e.g., irrigation and fertilizer).

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