AN ABSTRACT OF THE THESIS OF

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Title: ROOTING OF PEAR HARDWOOD CUTTINGS USING VESICULAR-ARBUSCULAR MYCORRHIZAE, AGROBACTERIUM RHIZOGENES AND ROOTING HORMONES.

Abstract approved: _____
Dr. Porter Lombard

Rooting experiments were conducted with hardwood cuttings of Old Home x Farmingdale (OHXF) pear rootstock selections 217 and 282 to determine the effects of rooting hormones, VA mycorrhizal (VAM) fungi and the bacteria Agrobacterium rhizogenes applied to the cuttings or added to the rooting medium.

Mycorrhizal fungus inoculum was generated in pot cultures of pear roots collected from pear trees at two locations. Pot cultures contained spores of Glomus fasciculatum, G. microaggregatum, G. intraradices, G. caledonium, G. mosseae, G. occultum, Acaulospora trappei, and a Glomus species similar to G. pallidum; the first three species were most prevalent.

Inoculation with VA mycorrhizal (VAM) fungus inoculum from pear roots did not increase, and sometimes reduced rooting of pear cuttings. This negative influence appeared to be the effects of other

microbial components of the pot culture contents, since few mycorrhizae formed on cutting roots.

Of three strains of Agrobacterium rhizogenes tested, strain TR105 improved rooting most, compared to untreated cuttings. Rooting enhancement, however, was only sometimes as good as but never better than that achieved with rooting hormones.

OHXF selection 282 always rooted better than selection 217, but both rooted best with the addition of rooting hormones, regardless of the rate or source. Rooting response was quantified by nine parameters including root number, root length, percent of root branching, survival, a rating of rooting based on a scale of 1 to 4, root dry weight, root area, shoot number, and shoot dry weight. Hormone treatments alone gave 71-96 % survival of cuttings compared to 8-21 % without hormones.

Some effects were detected between hormone treatments with A. rhizogenes and/or VAM fungus inoculum, such as increased rooting of cuttings with A. rhizogenes when no hormone was applied, and a decrease when VAM were used in combination with the powder.

These studies demonstrate that OHXF pear cuttings can be successfully rooted with hormone treatments, but the microbes A. rhizogenes and VAM fungi need further experimentation to demonstrate any possible value. Adding inoculum after rooting from hormone treatments could maybe enhance subsequent growth of roots and shoots.

ROOTING OF PEAR HARDWOOD CUTTINGS USING VA MYCORRHIZAL FUNGI, AGROBACTERIUM RHIZOGENES AND ROOTING HORMONES

by

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ROOTING OF PEAR HARDWOOD CUTTINGS USING VESICULAR-ARBUSCULAR MYCORRHIZAE, AGROBACTERIUM RHIZOGENES AND ROOTING HORMONES

I. INTRODUCTION

The use of clonal rootstocks, in contrast to seedlings, is of great value in tree fruit production. Those recommended for each species and cultivar have been selected for their characteristics such as disease resistance, performance under unfavorable soil and climatic conditions, scion compatibility and tree size-regulating capacity. Vegetative propagation of these clonal materials leads to orchard uniformity, which greatly contributes to cost-effective production. In cultivars where layering is not economical, rooting of stem cuttings is the next best alternative. Use of hardwood cuttings should be an efficient, relatively simple and inexpensive method of clonal propagation, requiring minimal investment and substantially less specialized labor compared to other promising alternatives such as tissue culture, especially when dealing with limited quantities which are frequently required with perennial tree crops. Orchards can be economically productive for over 15 years.

Plant materials, even within the Rosaceae family (deciduous fruits), differ widely in their propensity to root from stem cuttings. Frequently, rootability is markedly influenced by the mother plant and weather conditions (Hansen,1987), harvest date, dilution and nature of applied hormone and rooting bed conditions (Howard, 1968; Hartmann and Kester,

1985). Hardwood cuttings of pear are difficult to root because of such factors.

Commercial rooting of pear rootstock cuttings has involved the use of 1H-indole-3-butanoic acid (IBA) dips on hardwood (Westwood and Brooks, 1963). Two methods used in their propagation trials of Old Home X Farmingdale (OHXF) hardwood cuttings were: a) cuttings harvested in the fall after chilling commenced, prior to full chilling using 100 to 200 ppm IBA in a 24 h soak; and, b) dormant cuttings pruned in late January, after chilling requirements were met, treated with 1000 to 2000 ppm IBA in 5 sec dips. Rooting success in their trials ranged from 10 to 78 %, varying with the size and condition of the plant material. To be acceptable in commercial rooting of cuttings, they suggest a minimum of 50 % success. The OHXF rootstock series has been pointed out as displaying a wide spectre of propensity to root from stem cuttings, from 0 to 80 % (Westwood, pers. comm.). There is need to develop treatments which could improve the adventitious rooting of these difficult-to-root materials, and in the process, possibly improve the understanding of physiological events involved. With these purposes in mind, vesicular-arbuscular mycorrhizae (VAM) and the bacterium Agrobacterium rhizogenes were selected for study.

Mycorrhizal fungi have been found to produce growth-regulating substances and other organic compounds in the rhizosphere (Cooper,1985; Ek,1983; Rouillon,1985; Madej,1985) and thus were studied as potential rooting aids for many types of cuttings (Linderman and Call,1977; Barrows and Roncadori,1977; Branzanti et al,1985; Cooper,1985; Powell and Santanakrishnan,1986; Verkade,1986).

A. rhizogenes, formerly regarded as a pathogen, displays extraordinary ability to transfer certain parts of its DNA to the host genome. This transfer (T) DNA has been shown to confer auxin responsiveness to the transformed plant tissues enabling root differentiation in the presence of auxin, an event that did not occurr in untransformed material (Cardarelli et al., 1987).

Vesicular-arbuscular mycorrhizal (VAM) fungi, so-called because of the structures formed within root cortical tissues (arbuscules and vesicles) are fungal symbionts in the roots of many plants. Vesicles are storage organs formed on internal hyphae while arbuscules are complex haustoria-like structures involved in nutrient exchange within the plant cell. VA mycorrhizae differ from ectomycorrhizae in that the fungal symbionts are obligate, penetrate plant cells, and do not significantly alter root morphology. They achieve long term survival in soil by producing thick-walled chlamydospores.

Agrobacterium rhizogenes, first studied as the causal agent of 'hairy root' disease (Suit, 1933) in dicots (DeCleene,1981), is a bacterium which causes great proliferation of roots in wound sites, by means of a plasmid-mediated genetic transformation (Moore, 1979). Aside from the impressive potential that the Ri plasmid and its peculiarities represent for molecular biology (Birot, 1987; Klee, 1987; Zambryski, 1989), the capability of eliciting prolific rooting in host plants could prove to be a useful tool in plant propagation. This has been attempted with success (Diana,1986; Strobel,1985,1987; Bassil and Proebsting, pers. communic.), thus harnessing the very quality (Ark, 1961) that caused it to be considered pathogenic. Tepfer's (1984) finding that A. rhizogenes-transformed plants displayed

shortened internodes (dwarfing) merits verification for fruit trees; rootstocks displaying such traits are rare and desirable.

A number of works confirm the dynamic interactions occurring between rhizosphere microorganisms and mycorrhizae (Linderman, 1988; and Linderman and Paulitz, a review in press). In many cases, rhizobacteria and mycorrhizae were shown to exert a mutually positive influence on each other, either directly by increasing availability of certain nutrients or growth substances (Barea,1975; Raj,1981; Leyval,1988) or indirectly by suppressing potentially deleterious organisms (Cook and Baker,1983). Whenever such situations arise, it is valid to assume that the host plant would also benefit, whether from the absence or decreased populations of certain pathogens and/or the added effect/s that mycorrhizae and associated bacteria may exert, either directly or through mutual complementation.

In the case of a stem cutting, the potential for adding beneficial microorganisms is even more significant, since in the absence of roots it is severely stressed. Cutting survival depends on rapid morphological changes in response to small variations in many factors, the most important being phytohormones (Hartmann and Kester, 1985). Rhizospheric microorganisms which could consistently stabilize host response (and interact mutualistically) leading to enhancement of adventitious rooting processes could be extremely valuable, not only for improving the percentage and quality of rooting but also for safeguarding against potential stress problems, many of which cannot be detected until too late (e.g. pathogenic infection of plant tissue, drought, nutrient stress, etc.). Caesar and Burr (1987) showed that various bacterial strains promoted growth of clonal rootstocks of apple. Many species of higher plants have been shown to form

metabolites called phytoalexins when exposed to fungi or mechanical wounding (Keen,1981). Certain phytoalexins present in concentrations below their antibiotic activity have been shown to act synergistically with 1H-indole-3-acetic acid (IAA) to promote adventitious rooting (rooting cofactor activity) in mung bean bioassays, (Yoshikawa et al.,1986). This fact might partially account for the positive effects of certain bacteria and fungi on plant rooting processes.

The purpose of this study was to answer the following questions:

a. Is rooting of Old Home x Farmingdale pear hardwood cuttings influenced by VAM?

b. Does Agrobacterium rhizogenes affect rooting?

c. How do different concentrations and formulations of plant growth regulators compare to the above treatments?

d. Do any of the above factors interact in any way in adventitious rooting?

II. MATERIALS AND METHODS

An experiment to study the rooting of hardwood cuttings of the pear rootstock series Old Home x Farmingdale (Westwood, 1982), developed in Oregon and unique for its resistance to the diseases pear decline and fire blight, was begun in the greenhouse in November 1988. The treatments included VAM fungi collected from pear orchards, three strains of Agrobacterium rhizogenes and three phytohormone treatments.

Preparation of the VAM inoculum:

Pear roots were removed from trees in several orchards during fall and winter 1987/1988, washed in water, cleared and stained for detection of VAM colonization (Phillips and Hayman, 1970). Colonized roots were surface-sterilized using 0.5 % sodium hypochlorite and cut into 1 cm pieces to be used as inoculum to multiply the symbionts in plant pot cultures. The latter were started in the following way: half-gallon pots filled with pasteurized (air-steamed 1 h at 60 C) sand in which three cavities, 2.5 cm wide x 10 cm deep, were made. These cavities were 75 % filled with VAM root inoculum, topped with sand. One seed of subterranean clover (Trifolium repens L.), previously surface-sterilized 10 min. with .5 % sodium hypochlorite solution, was placed on each inoculum core. Cultures were maintained under greenhouse conditions for 3.5 months and watered and fertilized weekly with Long Ashton Plant Nutrient Solution (P content modified to 11 ppm). The pots were allowed to dry and were then harvested. Aerial plant parts were discarded, the roots were cleared and stained to determine the degree of VAM colonization. The entire volume of sand and roots divided into 1 cm pieces was thoroughly mixed and stored under dry,

cold conditions (4 C) for later use. VAM - free medium for controls was made by washing sand from pot cultures with water, sieving the resulting slurry through a 38 micron metal sieve and blending the sieved liquid with pasteurized sand.

Identification of VA mycorrhizae from pear roots:

The pot cultures of VAM that served as inoculum for the experiment were made from surface-sterilized pear roots gathered from orchards in Medford and in different locations at the National Germplasm Repository [USDA-ARS], Corvallis, OR. Dr. James Trappe, from the Department of Forest Science, Oregon State University, kindly indentified the VAM in those cultures based on examination of spores contained therein. The findings were as follows:

Sample(Location)	VAM species
1. (Medford)	Glomus fasciculatum (Thaxter) Gerd. & Trappe emend. Walker & Koske.
2. (")	a.G. microaggregatum Koske, Gemma & Alexis. b.G. caledonium (Nicol. & Gerd.) Trappe & Gerd.
3. (")	G. fasciculatum.
4. (")	G. fasiculatum ? (if so, spores very young).
5. (")	G. fasciculatum.
6. (")	None.
7. (")	G. intraradices Smith & Schenck.
8. (")	G. fasciculatum.

Sample(Location)	VAM species
9. (")	G. microaggregatum.
10. (")	Too few spores to identify.
11. (Corvallis)	Spores found mainly in roots, probably G. intraradices.
12. (")	Acaulospora trappei Ames & Linderman.
13. (")	a.A. trappei. b.Glomus sp. (too few spores to identify).
14. (")	G. cf pallidum Hall or poss. undescribed.
15. (")	" " " " " " .
16. (")	" " " " " " .
17. (")	G. mosseae, plus possibly one or two other immature or otherwise unidentifiable spp.
18. (")	a.G. fasciculatum. b.G. mosseae.
19. (")	G. occultum Walker.
20. (")	" " .
21. (")	G. fasciculatum.
22. (")	G. intraradices.
23. (")	G. fasciculatum.
24. (")	" " .

Source and method of application of A. rhizogenes:

Strains A 4, A 4783 and TR 105 were provided by Dr. Larry Moore, Department of Botany and Plant Pathology, Oregon State University. Strain A 4 was originally isolated by Dr. P. Ark (Univ. of California, Berkeley) from

roses, A 4783 was discovered by M. Canfield (Oregon State Univ.) from carrot, and TR 105 was of unknown origin. Petri dishes with mannitol glutamate medium (Keane et al., 1970) were inoculated with the bacteria and incubated for 72 h at 25 C. A cell suspension of each strain was made by pouring sterile water on these dishes and rubbing with a glass rod. The resulting cell suspension was poured into tubes and vortexed until homogenized. Sterile water was added to obtain the desired reading of 70 on a Klett colorimeter (approx. 3 x 10 colony forming units/mL). Approximately 30 plates were used to prepare 2.25 L of bacterial suspension for each strain. The suspensions for inoculation were prepared on the daythey were used; 5 mL of each was pipetted into the center of each pot shortly before cuttings were 'stuck'.

Hormone formulations and concentrations:

Indole butyric acid (IBA), dissolved in 50% ethanol, was used at 5000 and 2500 ppm (Westwood and Brooks, 1963) as was a dry hormone preparation, referred to as Hormodust, containing 1000 ppm each of IBA and NAA in talc.

Cuttings were dipped to a depth of 0.5 cm for 5 sec in the solutions or powder, (Howard and Nahlawi, 1970), excess liquid or powder was flicked off immediately, and the cutting was then stuck.

Plant material:

Cuttings of the pear rootstock series Old Home x Farmingdale (OHXF), genotype selections 217 and 282, provided by Patchwork Nursery, Forest Grove, Oregon, were harvested on October 22, 1988 and hand defoliated as necessary (Westwood and Brooks, 1963). The topmost and lowest 10 cms from each cutting were removed. Stems with calipers less than 0.7 cm and those greater than 1.0 cm were discarded (Marini, 1983). The bottom cut was made

perpendicular to the stem, 0.5 cm below the first leaf node, resulting in a final length of 15 cm. All cuts were made just before sticking.

Rooting media, containers and greenhouse conditions:

The rooting medium consisted of 4 parts perlite, 3 parts Douglas fir sawdust and 1 part steam sterilized Hypnum peat (Biermann and Linderman,1983) blended in a twin-shell blender and adjusted to pH 7 with CaCO3 (Davis et al.,1983). Black plastic 'band' pots measuring 6 x 6 x 13 cm were placed in plastic flats on a greenhouse bench equipped with bottom heat cables (24 C) and intermittent mist. The bench was covered entirely with a plastic tent rising 120 cm above the cuttings. Air temperature during the first three months was maintained at 10 C, but thereafter the temperature was allowed to rise during daylight hours.

Bands were filled with rooting media, leaving a central cavity of 7 cm deep x 2 cm wide, where 18 mL of VAM inoculum from the pear root sources or non-mycorrhizal medium were added. Cuttings were stuck so that their lower ends were in the inoculum.

Statistical design, treatments:

The design was a factorial in a randomized block for each pear genotype with 32 treatments of 24 cuttings per treatment, totalling 1536 units. All cuttings were placed on the same greenhouse bench, randomly arranged in 4 replicates of six cuttings each. The treatments were applied to each rootstock cultivar, as follows:

Treatment	VAM	- HORMONE	- A. rhizogenes
1.	-	-	-
2.	-	-	A 4
3.	-	-	A 4783
4.	-	-	TR 105
5.	-	IBA 2500	-
6.	-	IBA 2500	A 4
7.	-	IBA 2500	A 4783
8.	-	IBA 2500	TR 105
9.	-	IBA 5000	-
10	-	IBA 5000	A 4
11.	-	IBA 5000	A 4783
12.	-	IBA 5000	TR 105
13.	-	'HORMDST'	-
14.	-	'HORMDST'	A 4
15.	-	'HORMDST'	A 4783
16.	-	'HORMDST'	TR 105
17.	+	-	-
18.	+	-	A 4
19.	+	-	A 4783
20.	+	-	TR 105
21.	+	IBA 2500	-
22.	+	IBA 2500	A 4
23.	+	IBA 2500	A 4783
24.	+	IBA 2500	TR 105
25.	+	IBA 5000	-
26.	+	IBA 5000	A 4
27.	+	IBA 5000	A 4783
28.	+	IBA 5000	TR 105
29.	+	'HORMDST'	-
30.	+	'HORMDST'	A4
31.	+	'HORMDST'	A 4783
32.	+	'HORMDST'	TR 105

Evaluation:

The following observations were made:

a. Root production - Root number, average root length, root area, rooting rating and presence of lateral roots were quantified. Each cutting was extracted individually from the rooting medium and carefully washed in cold water. The roots were severed from the cutting and placed on a sheet of clear celulloid under a white background and photocopied (Collins et al., 1987). All separate roots were placed in the same direction. This provided

a permanent record of the configuration, number, average length and lateral branching of roots. The root images, as photocopies, were later analyzed with a Delta-T brand area meter (Harris and Campbell, 1989) and the measurement obtained is hence referred to as root area. The area meter was calibrated to read with precision to 0.1 cm on a cm2 scale.

An artificial scale to rate rooting response, ranging from 1 to 4 was used as follows:

1= base of cutting unchanged, no rooting.

2= presence of callus only, no rooting.

3= rooted, root lengths less than 5 cm

4= rooted, root lengths over 5 cm

Lateral branching of roots was estimated as a means of detecting 'hairy root'-like proliferation, a feasible occurrence in roots treated with A. rhizogenes. It involved a subjective evaluation of the profusion, ramification and size of lateral roots emerging from roots originating at the cutting base, expressed in percentage (100 % corresponding to the maximum and 0% to the minimum). In order to standarize readings the root photocopies were used instead of the actual roots, thereby confining the observations to one physical plane.

Total fresh weight of roots from each cutting was then measured. However, representative samples for clearing and staining for VAM colonization were removed after that step, and the remainder oven dried at 70 C for 72 hours. Sample fresh/dry weight ratios were used to calculate total dry weight. This conversion was used to add back the weight of the roots removed for VAM colonization analyses.

b. VAM colonization - VAM colonization was evaluated microscopically after clearing and staining with Trypan blue in lactoglycerin (Phillips and Hayman,1970). The percent root length with VAM was determined by the method of Biermann and Linderman (1981).

c. Retrieval of A. rhizogenes - Various techniques were used to retrieve A. rhizogenes from roots and/or rooting medium rhizosphere samplings. Another approach used was with water-washed root macerates, surface-sterilized (using 0.5 % sodium hypochlorite solution) or not, prepared either with mortar and pestle or by applying the hand-held 'tissue disrupter' (Agdia Corp.; Elkhart, Indiana 46154) over roots placed for that purpose in plastic self-locking bags into which 10 cc of sterile water was initially placed. The supernatants of each of the resulting samples, both rooting media or root macerations, were made into acqueous supensions diluted to 10-1, 10-2 and 10-3, and plated on Petri dishes containing two different agar selective media (Brisbane and Kerr, 1983), one containing malachite green (selective for Biovar II), the other gentian violet (Biovar I specific).

d. Leaf and shoot growth:

Numbers of shoots per cutting were recorded, and the total lengths recorded for each cutting. Freshly severed leaves and shoots laid flat under a clear glass sheet were measured with the Delta-T area meter, calibrated to read with precision of 0.1 cm on a cm2 scale. Shoot and leaf fresh weight was recorded, then dried for 72 h at 70 C for dry weight determination.

e. Survival:

Survival was determined by counting, within each replicate, those cuttings that have achieved sufficient root development to ensure survival.

This rating was subjective in that it did not consider cuttings which had only callused or had very sparse rooting; it aimed to evaluate survival capacity if transplanted to a larger container or into a field situation

III. RESULTS AND DISCUSSION

All the above parameters were evaluated, but shoot length was disregarded because variation was too great for it to be considered a reliable indicator of treatment effects. The values for shoot area indicated a positive trend in treatments which included rooting compounds, but the variability within treatments precluded them being statistically significant.

A parameter resulting from the artifact of multiplying average root length x root number for each cutting was tested as an additional estimation of root development, but was later disregarded because it showed the same patterns as root length measurement.

Effect of rootstock cultivar

Cuttings of OHXF 282 had higher survival and rooting ratings than OHXF 217, after 3.5 months in the rooting chamber (Figures 7, 8; and 9, 10 respectively, and Appendix Tables 3 and 4). The parameter "survival" refers to the 'take' of each cutting, while rooting rating, though related, is more descriptive of morphological changes which occurred (or not) at the base, (e.g. callusing; formation of short, stubby roots; or the long, healthy ones essential for good quality nursery stock). The survival index means for OHXF 217 and 282 were .62 and .71, respectively, giving a clear indication that the 'take' of OHXF 282 is inherently the better of the two. The rooting rating means also reflect that tendency, at 2.99 and 3.27 for 217 and 282, respectively.

Root number averages for each rootstock were 3.86 and 5.82; root length, 5.66 and 6.27; root branching, 13.06 and 18.79, the higher of each pair of

values invariably corresponding to OHXF 282. These data confirm what the nurseryman who provided the cutting material communicated, regarding the better rooting qualities of OHXF 282 over 217. Westwood and Brookes (pers. communic.) also indicated a wide range of adventitious rooting ability within this line of rootstocks.

Detection of VAM in rooted cuttings:

Roots of OHXF 217 cuttings yielded no detectable VAM colonizations, while those of OHXF 282 showed root length colonizations ranging between 5 and 10 per cent in four root samples, corresponding to treatments 19, 20, 21 and 28. It is assumed that the levels of colonization would have been higher should the cuttings have been evaluated at a later date, but such practices are not economically feasible for commercial nurseries. The low rates of colonization found made it impossible to identify the species of VAM involved.

In this study, inoculation with VAM fungi had no effect in most cases. Since the inoculum was generated in pot culture from colonized pear roots, we assume the fungi would be compatible with roots of pear cuttings. However, since practically no mycorrhizae were detected in cutting roots, other factors could have precluded their formation. Possible explantions for lack of colonization could be factors affecting inoculum potential including medium pH, spore dormancy, physical placement in relation to roots, delayed formation of roots, etc.

Effect of VAM on rooting:

Controls without VAM fungus inoculation actually rooted better than those containing VAM inoculum for the parameters survival and rooting rating (Figures 7, 8, and 9, 10, respectively; Appendix Tables 3 and 4). Values

for root number followed the same trend, with overall means for VAM treatments being 4.45 compared to 5.26 for controls.

VAM fungus treatments which included the powdered hormone formulation showed lower responses for rooting rating, shoot dry weight, root length, root number and root branching at the P=0.001 level of significance. For instance, means for root number were 6.33 for no VAM plus powder formulation versus 3.75 for VAM with powder (Figures 1 and 2). In contrast, results for IBA at 5000 ppm were 7.26 and 6.66, respectively, without and with VAM inoculum.

Rooting rating results reflect the same tendency, as shown by the means: 3.41 (no VAM inoculum plus powder) versus 2.88 (VAM inoculum plus powder). There was little difference between the rooting rating for the other hormones with or without VAM fungus inoculum. An explanation could be that the VAM inoculum exerted some negative effect on the hormone contained in the powder formulation, either through a degrading or immobilizing action. The fact that this is the only formulation studied which contains NAA invites speculation as to the possible effect on the rhizosphere flora or the microbes contained in the VAM pot culture inoculum.

A second relationship was found between VAM inoculum and Agrobacterium which indicated that rooting rating was decreased with VAM added to the rooting medium in the absence of bacteria or with strain TR 105 (Figures 9 and 10; Appendix Tables 3 and 4). It could be speculated that, since no other root parameters are affected, the factor being influenced is the formation of callus, which is only evaluated by rooting rating.

Retrieval of A. rhizogenes:

All attempts to recover and identify Agrobacterium strains failed due to the extensive proliferation of great numbers of bacterial colonies after 72 h incubation at 26 C, most of which did not have Agrobacterium characteristics. Controls responded in the same way as did treatments. A strain marked for antibiotic resistance might be considered for future studies.

Effect of A. rhizogenes on rooting:

The inclusion of any strain of A. rhizogenes in the rooting medium increased survival, rooting rating and root dry weight, (Figures 7, 8, 9, 10, 11 and 12; Appendix Tables 3 and 4). The most effective strains were A 4783 and TR 105. The survival rate of cuttings with any bacterial inoculum ranged from 65 to 77 per cent; average survival on cuttings without bacterial inoculum was 58 %. The positive effect of the bacterial suspension could be due to enhanced initiation of adventitious roots due to transformation of cells within the cutting. Confirmation of transformation by opine analysis was not done, however.

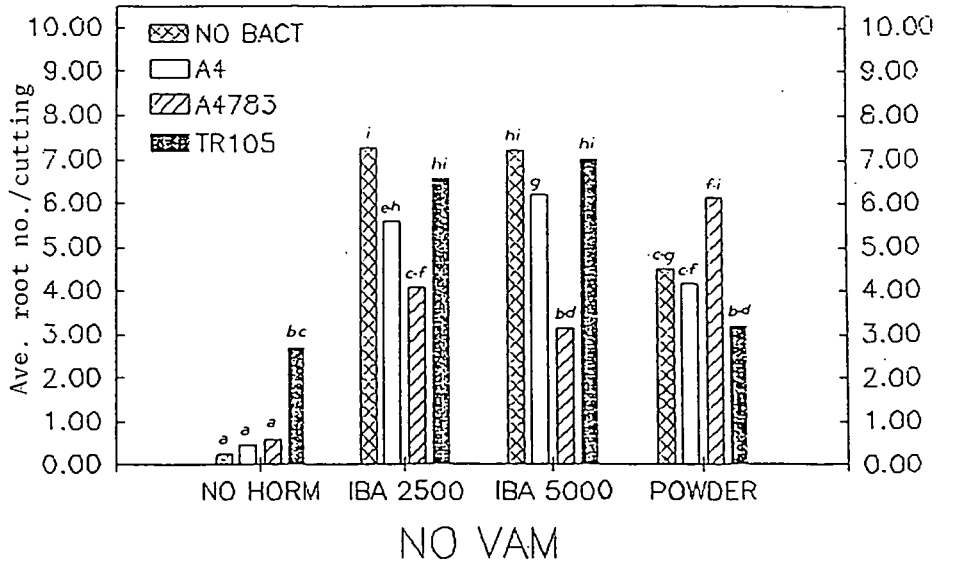
An relationship between Agrobacterium and rooting compounds was found for the parameters root number, root length, root branching, rooting rating, shoot number and shoot dry weight. When Agrobacterium was applied to the rooting medium without hormones, there was a slight increase in root initiation and development.

Effect of hormones on rooting:

Use of IBA at 2500 or 5000 ppm or the dry hormone formulation increased the rooting of both cultivars of pear cuttings regardless of the parameters measured ($P=0.001$). In contrast, none of the biological agents were as effective.

OLD HOME X FARMINGDALE 217: ROOT NUMBER

A)



B)

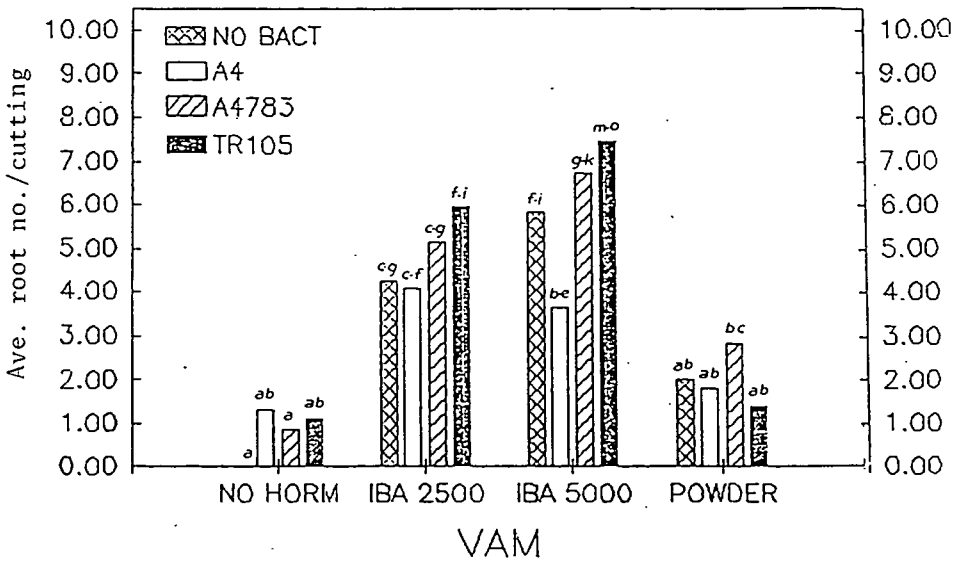


Fig. 1. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on the root number of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: ROOT NUMBER

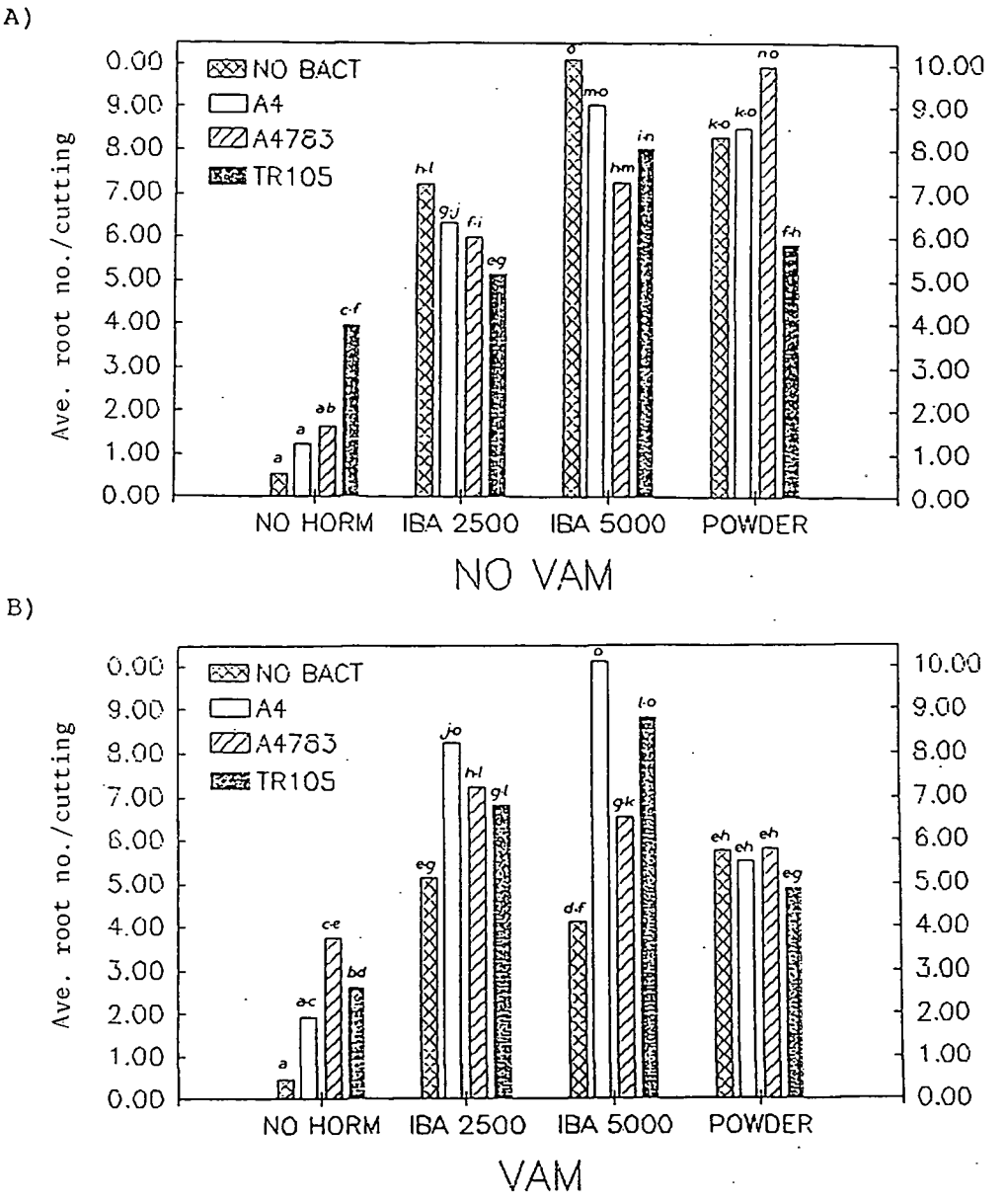


Fig. 2. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on the root number of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: ROOT LENGTH

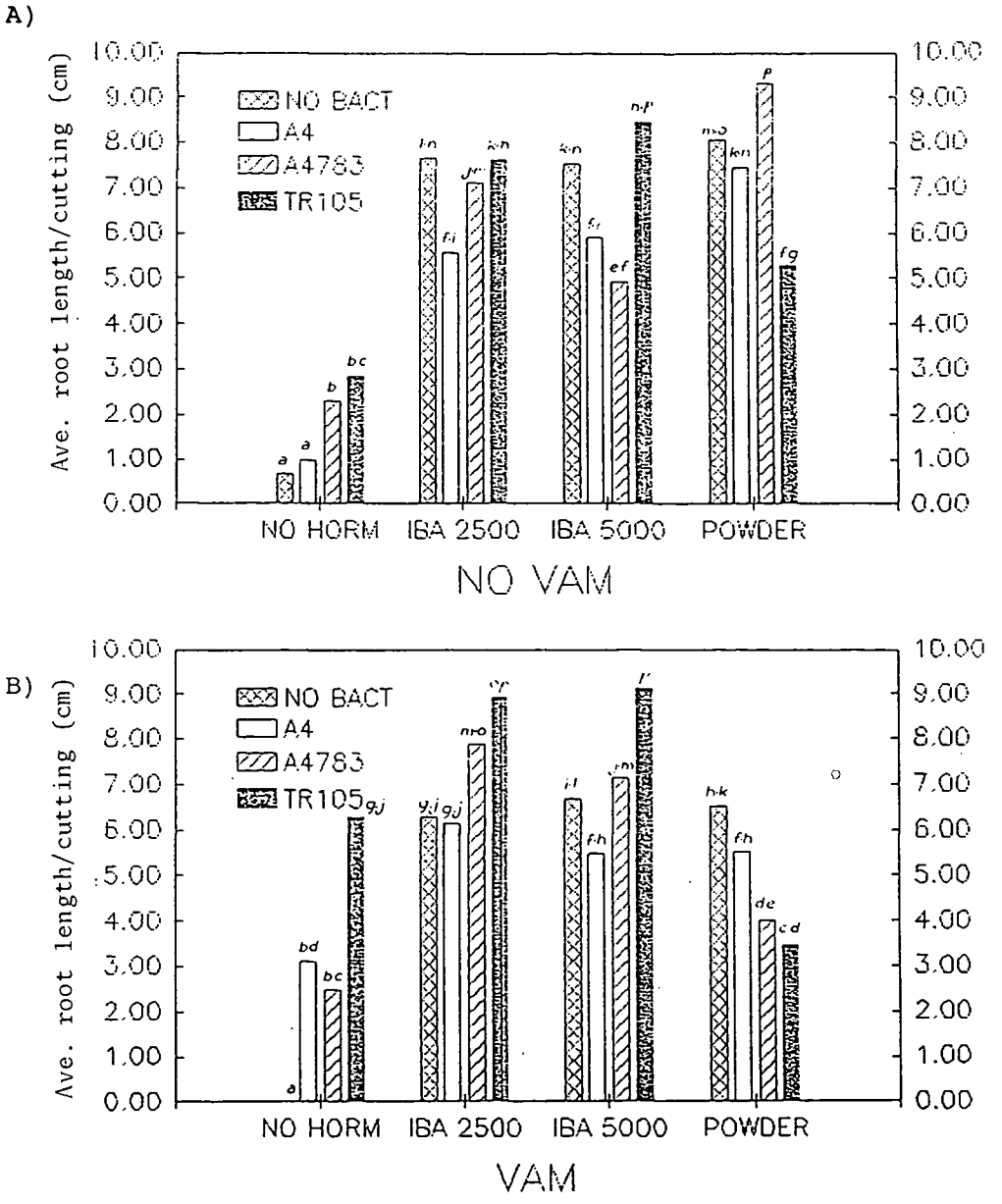


Fig. 3. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on the root length of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: ROOT LENGTH

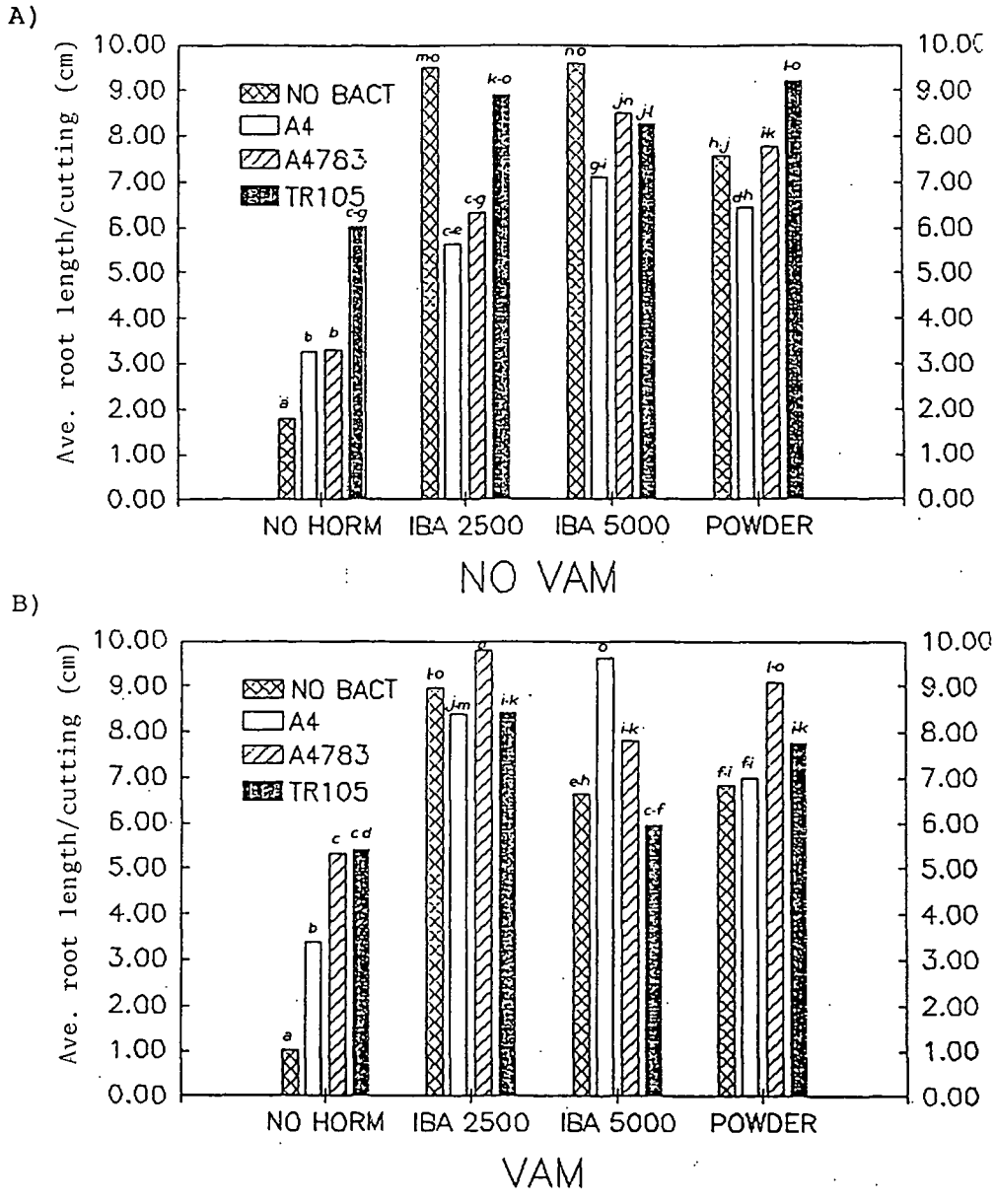


Fig. 4. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on the root length of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: ROOT BRANCHING

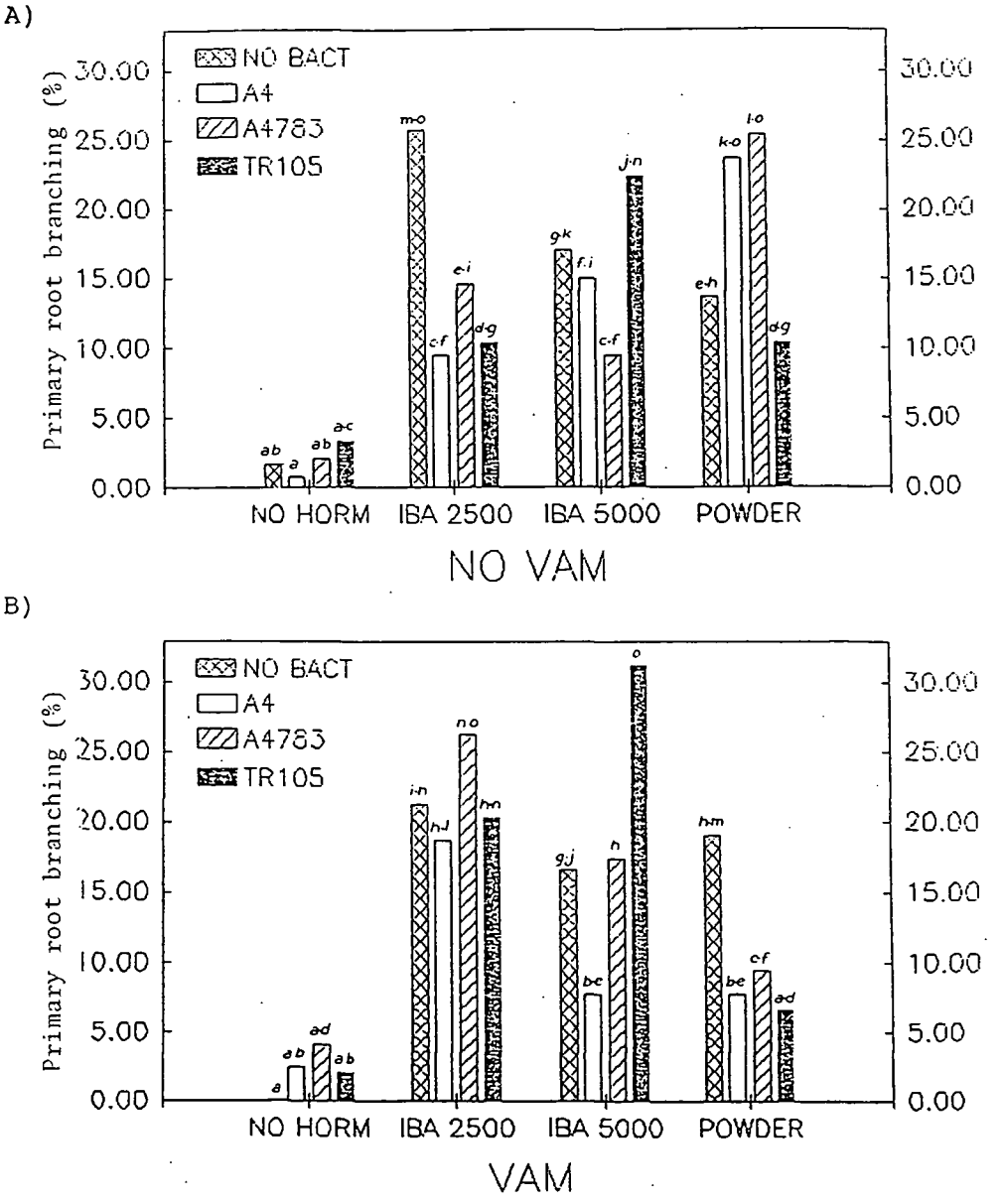


Fig. 5. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on % root branching of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

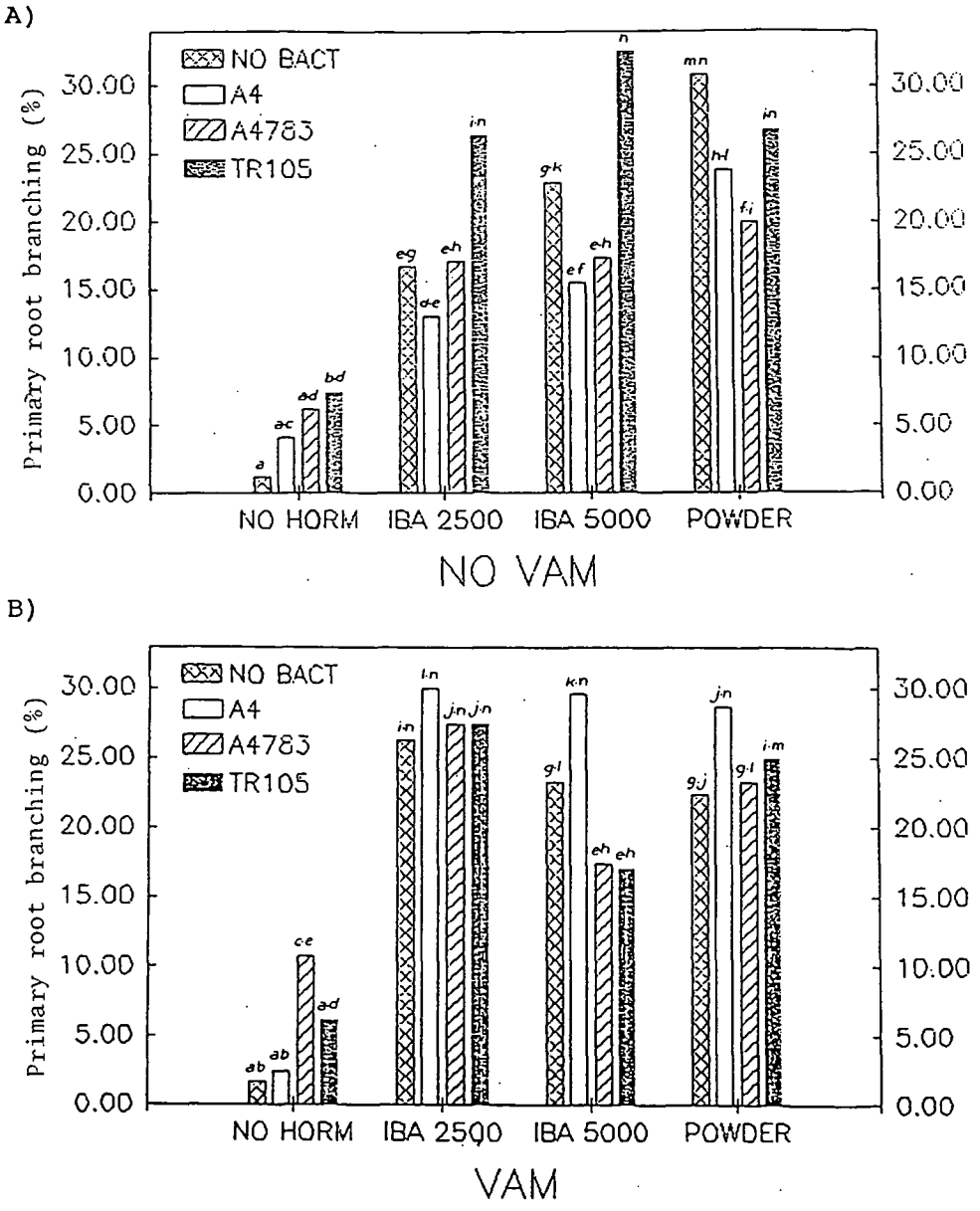


Fig. 6. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on % root branching of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: SURVIVAL

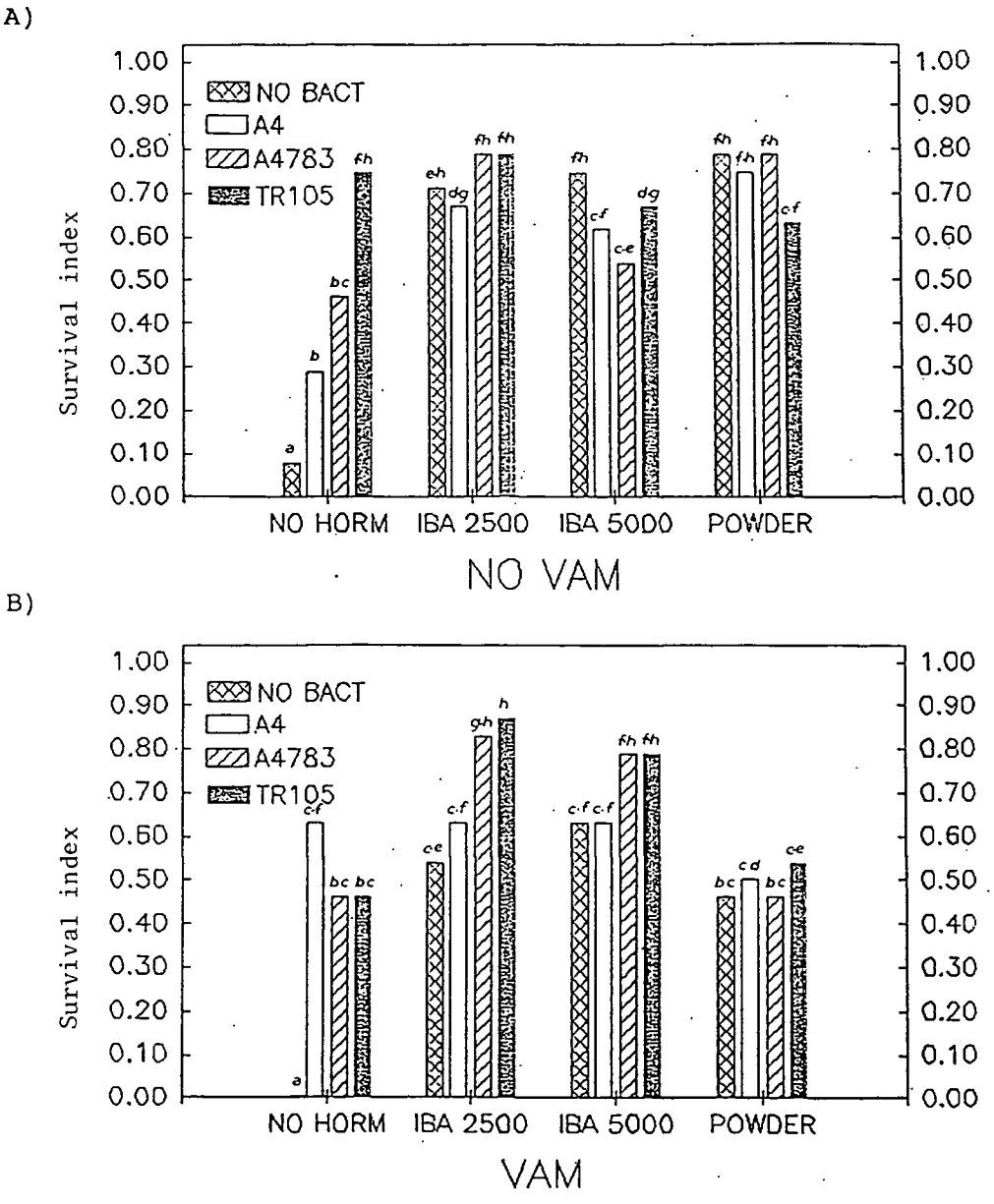


Fig. 7. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on survival index of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: SURVIVAL

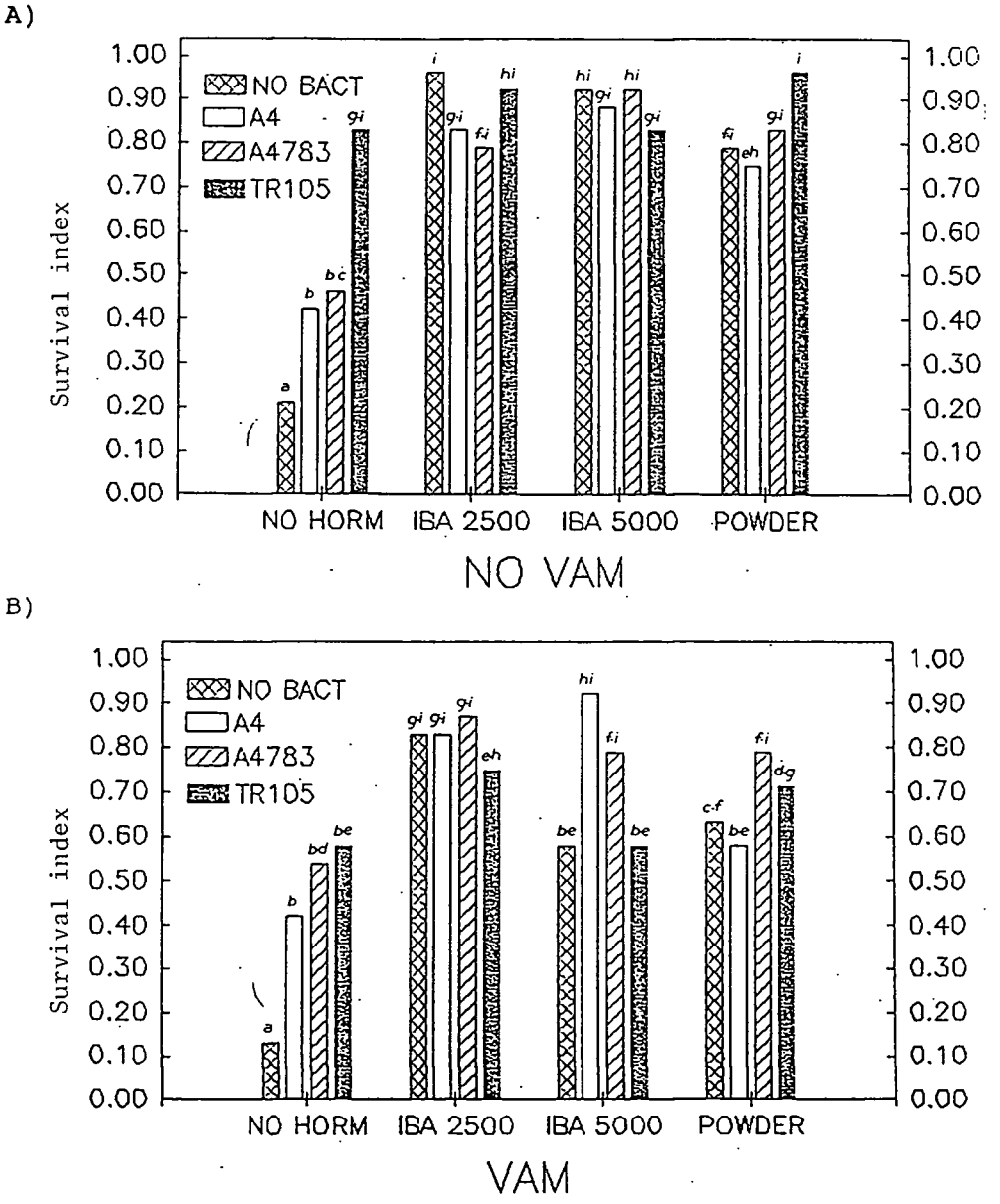


Fig. 8. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on survival index of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: ROOTING RATING

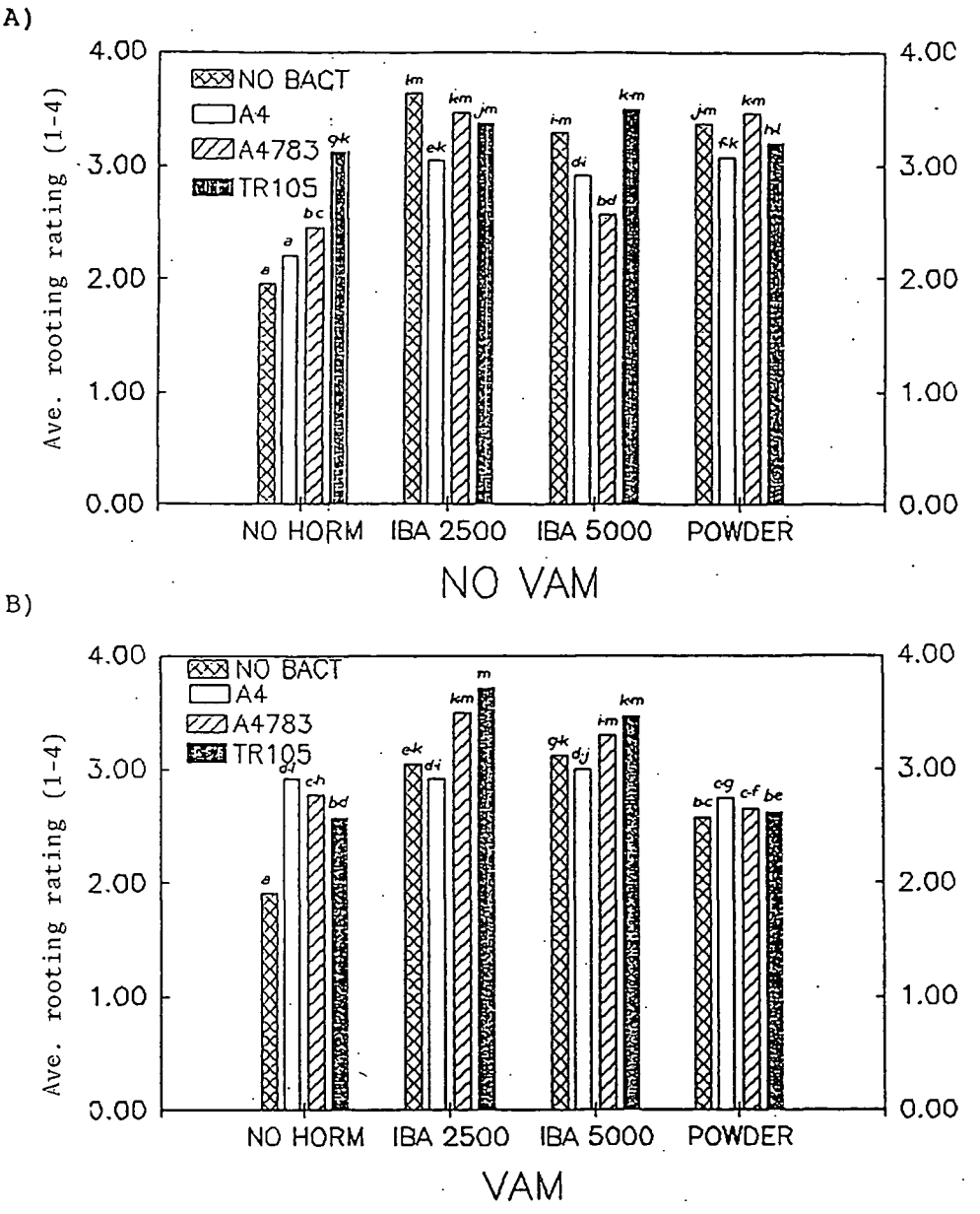


Fig. 9. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on rooting rating of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: ROOTING RATING

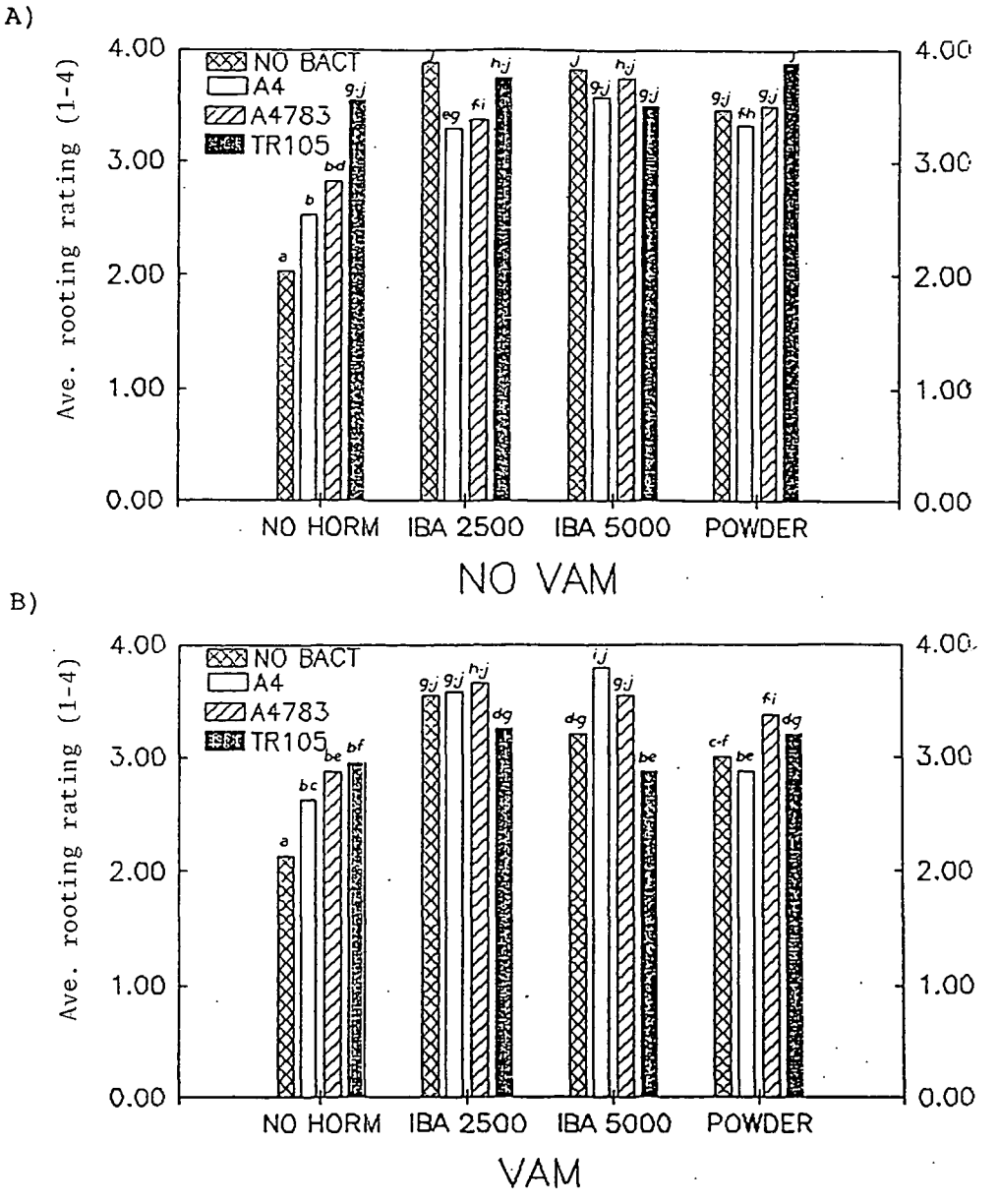


Fig. 10. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on rooting rating of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: ROOT DRY WEIGHT

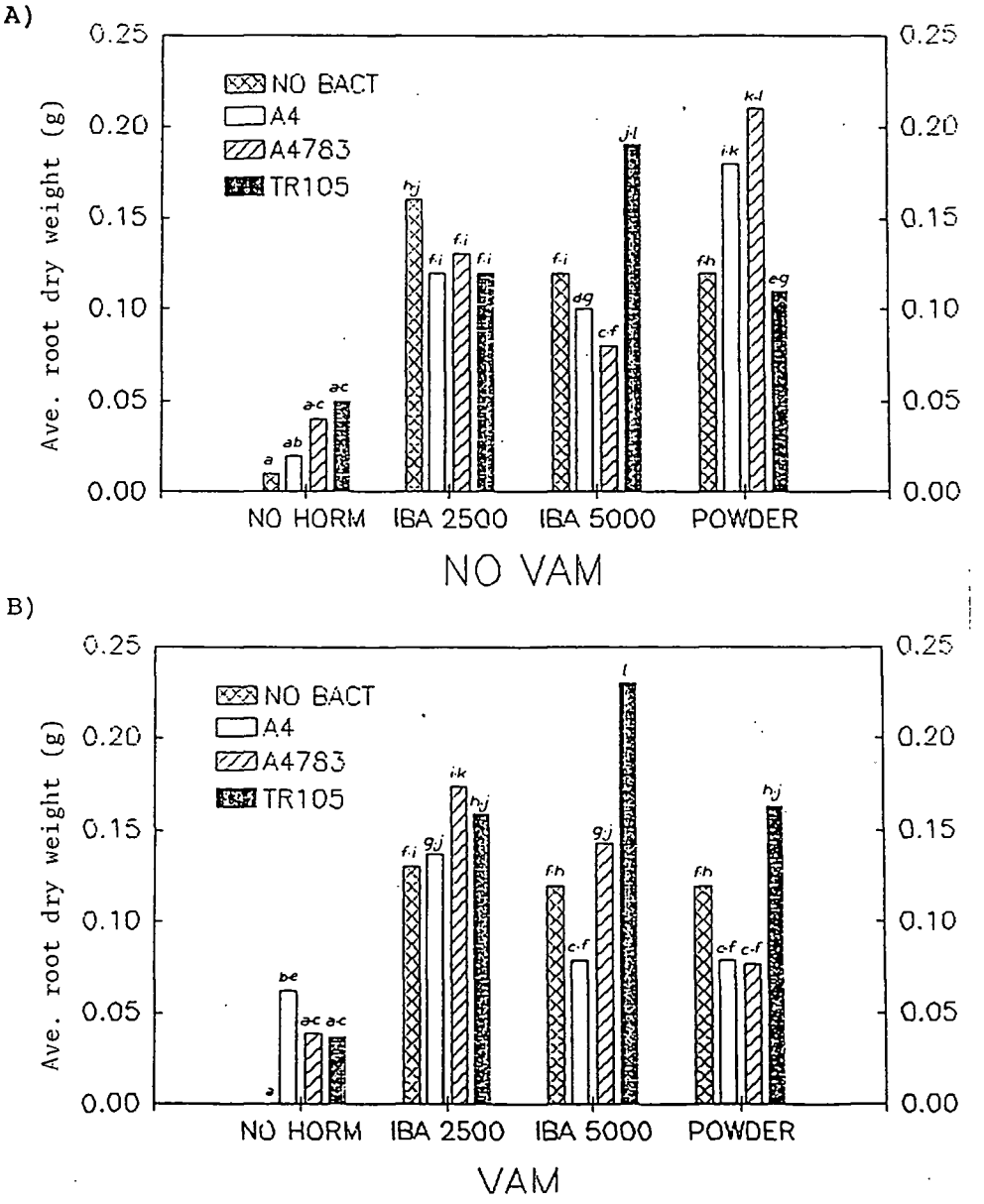


Fig. 11. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on root dry weight of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: ROOT DRY WEIGHT

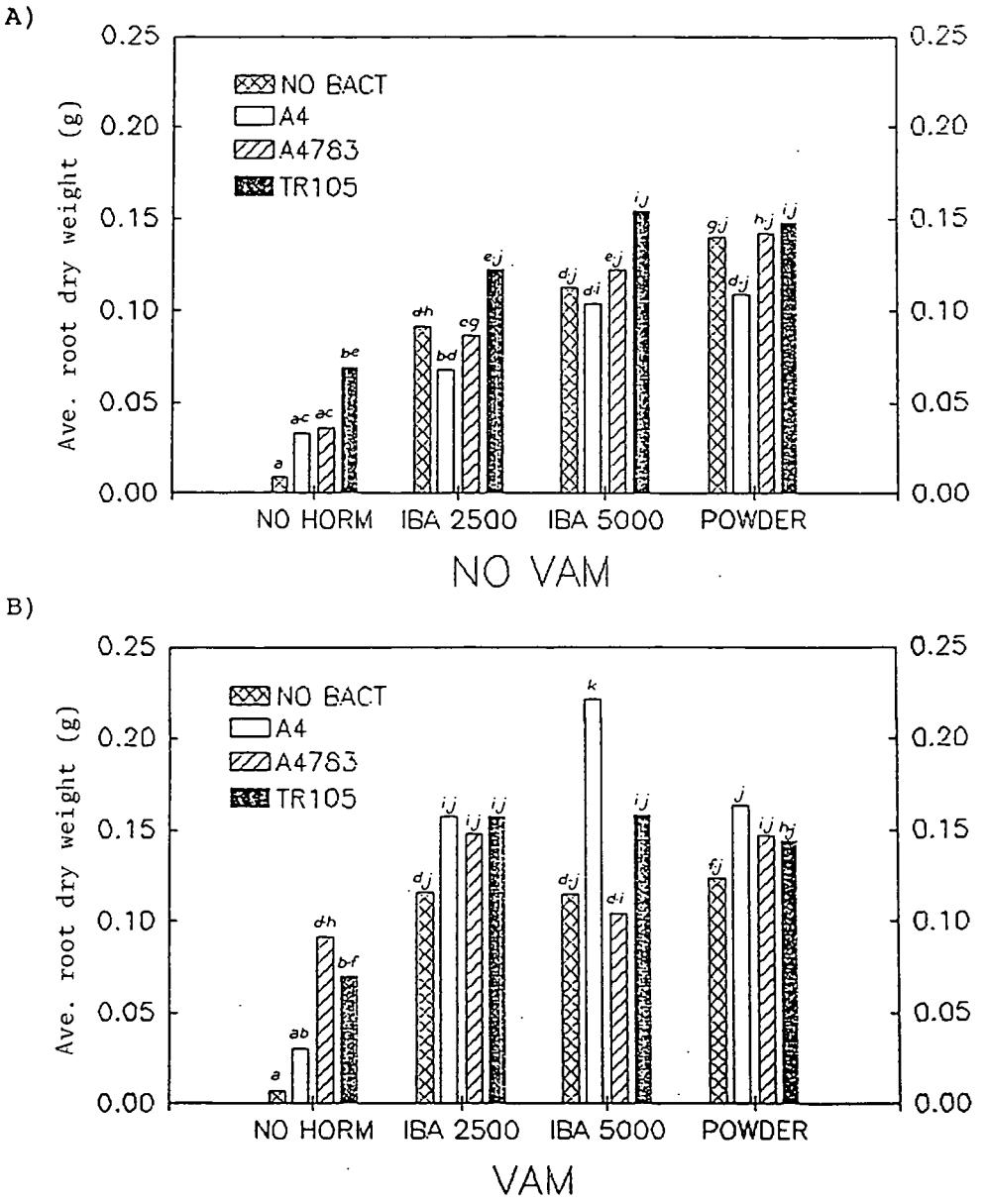


Fig. 12. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on root dry weight of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: ROOT AREA

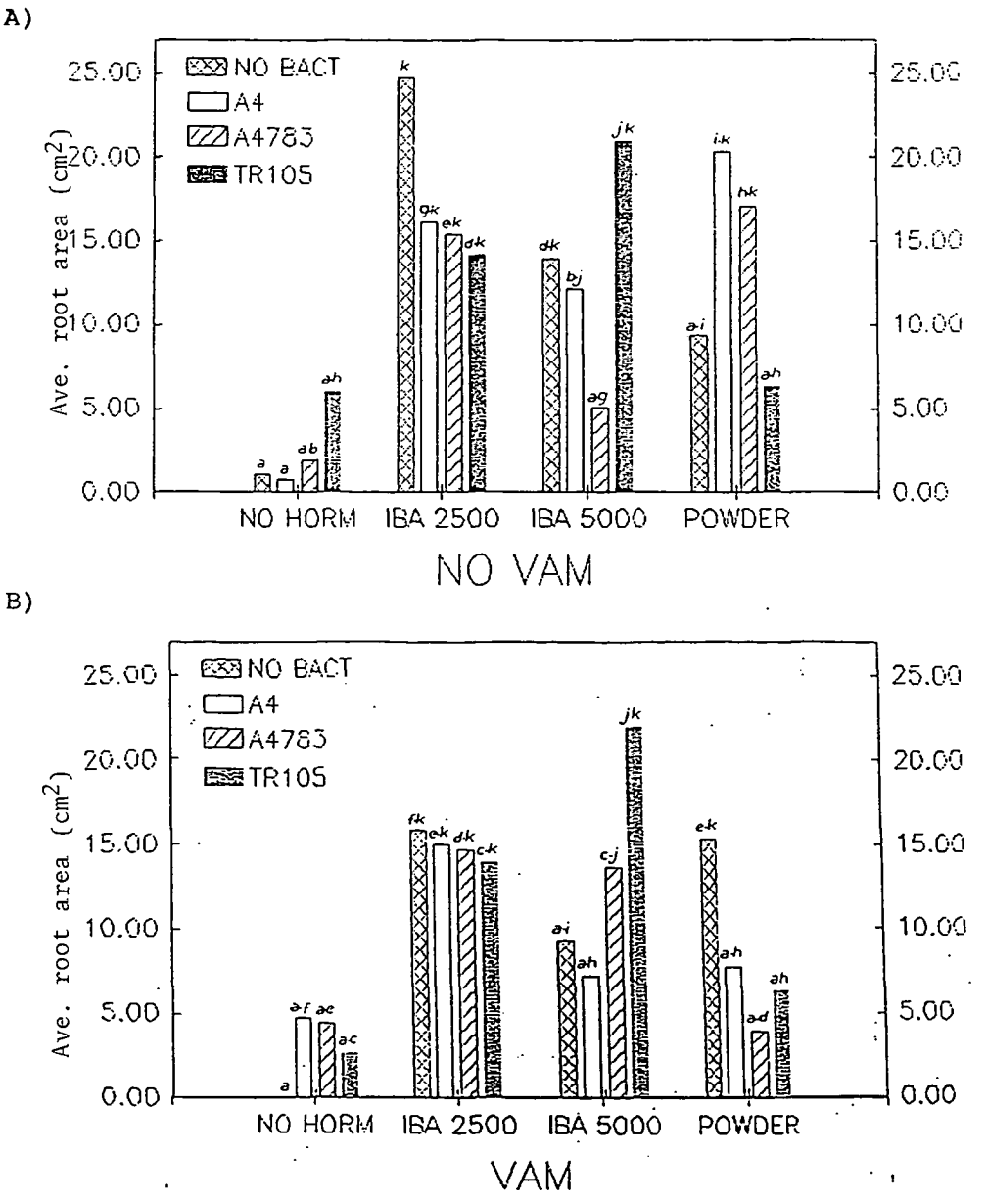


Fig. 13. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on root area of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: ROOT AREA

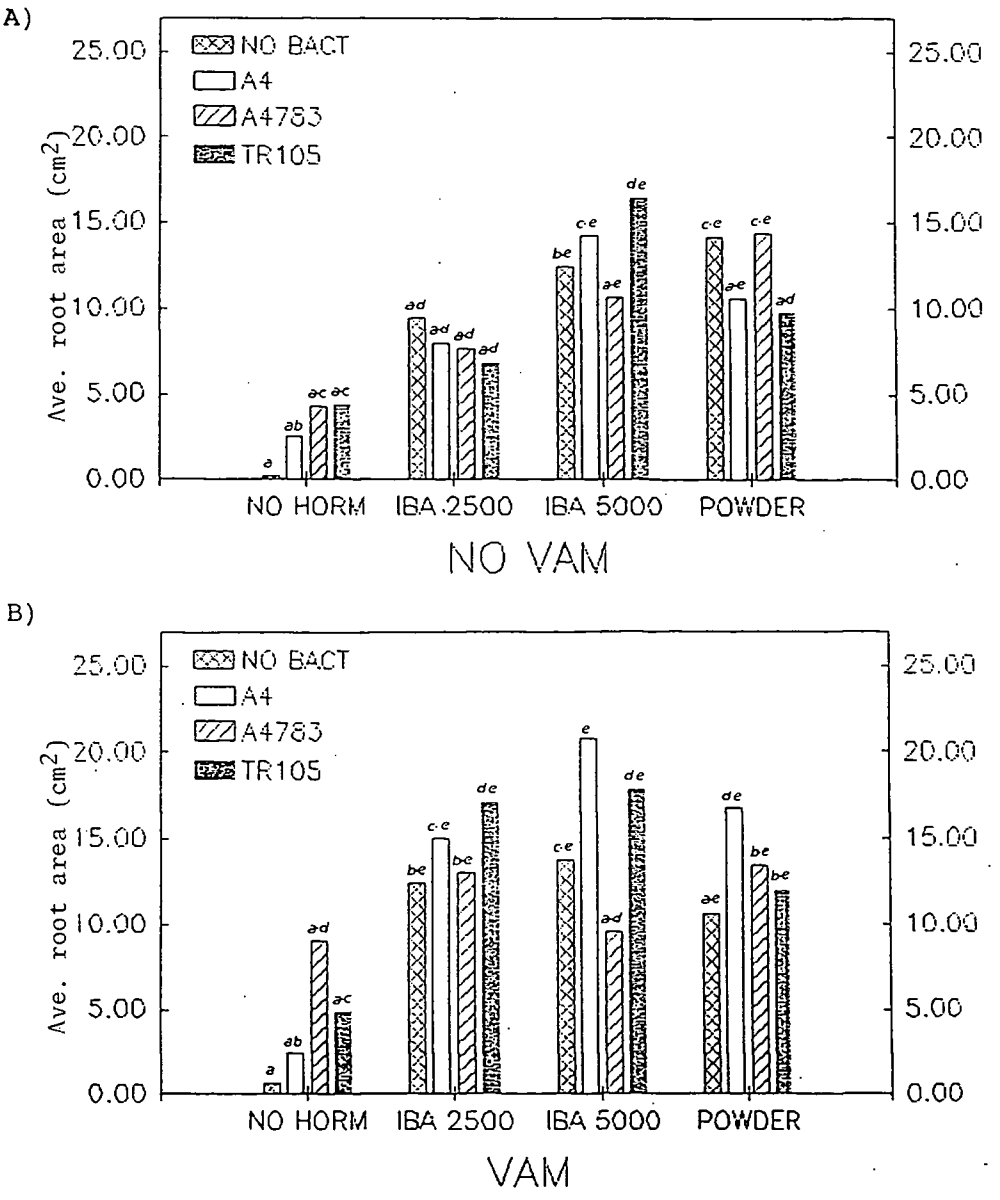


Fig. 14. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on root area of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: SHOOT NUMBER

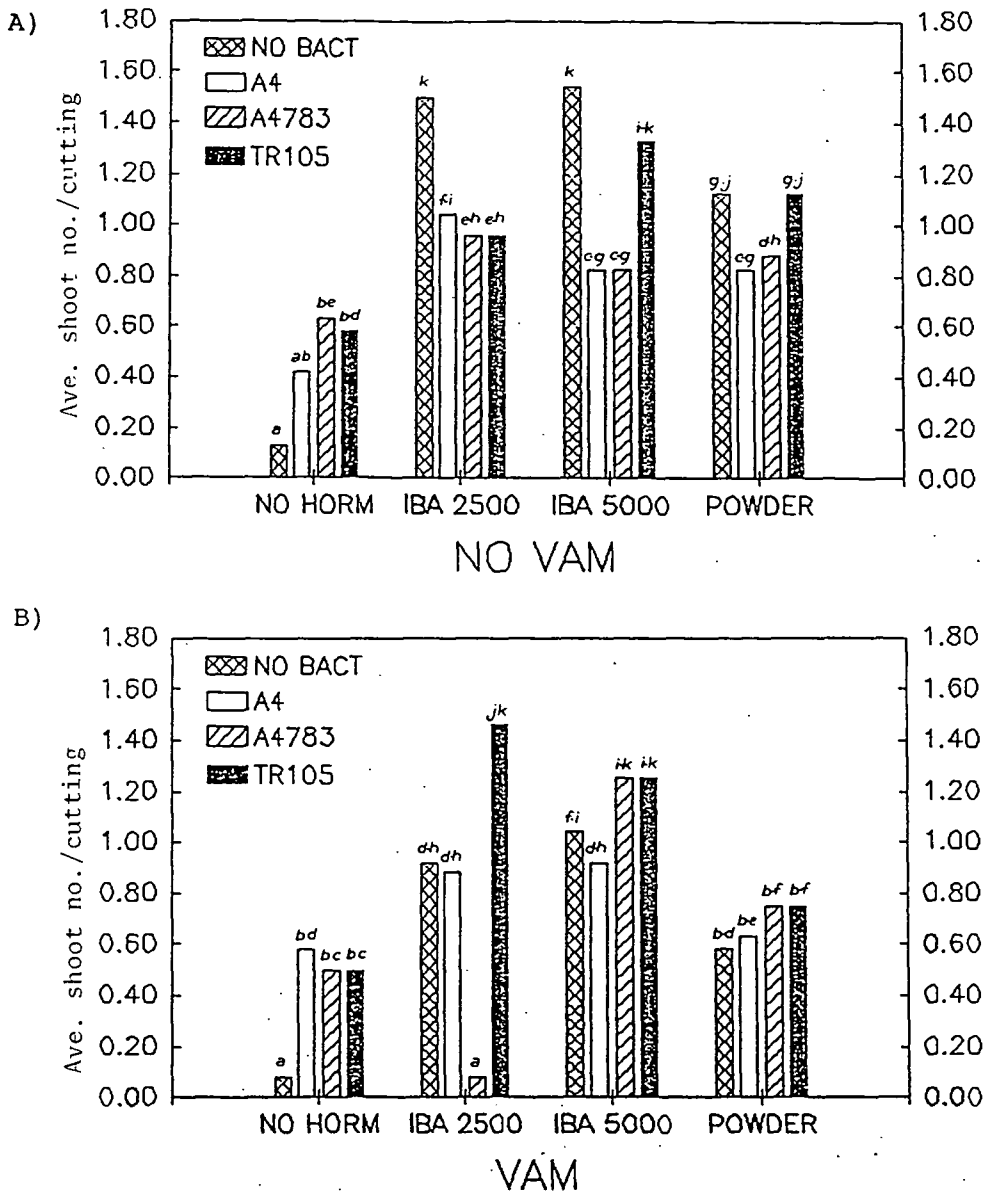


Fig. 15. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on shoot number of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: SHOOT NUMBER

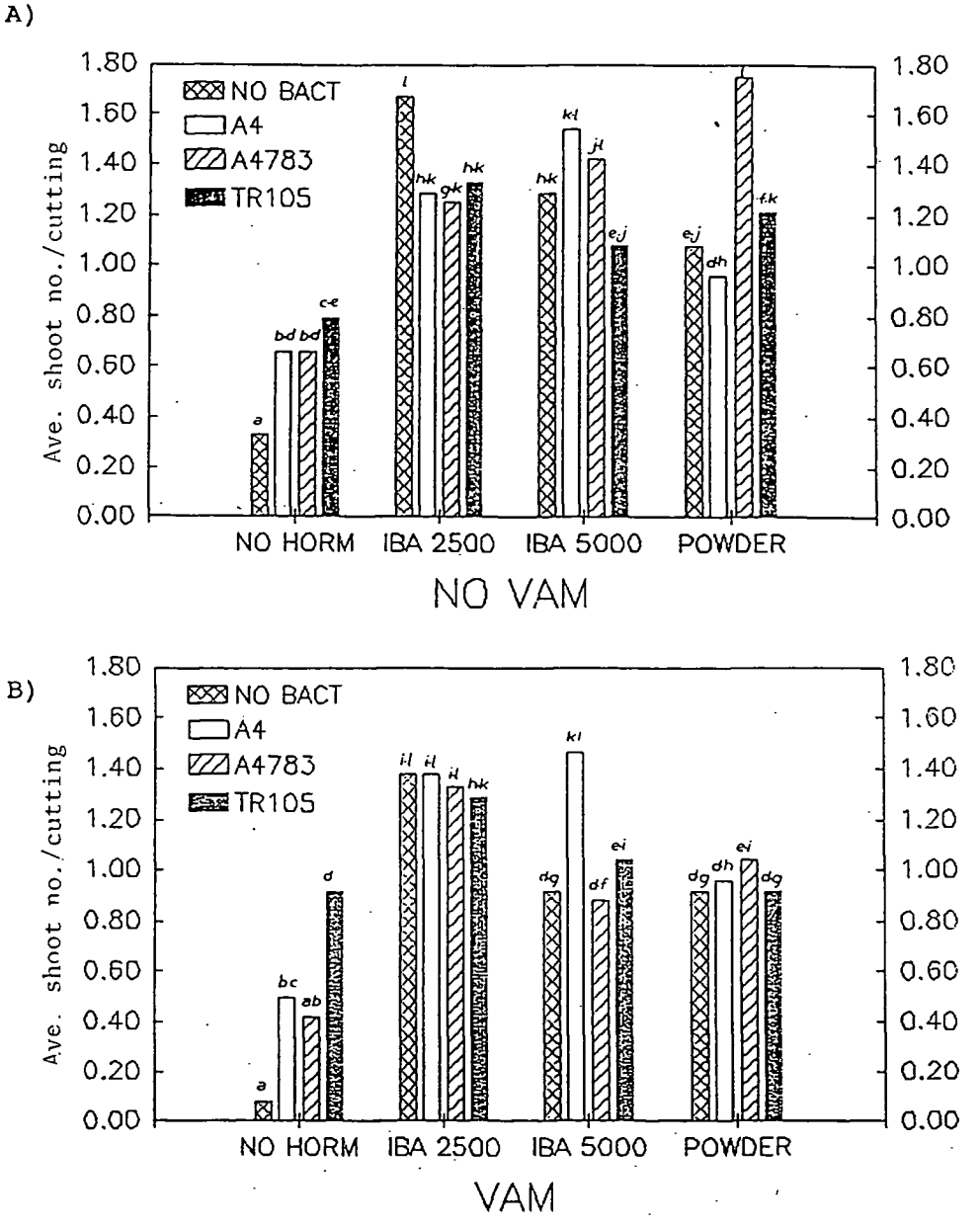


Fig. 16. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on shoot number of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 217: SHOOT DRY WEIGHT

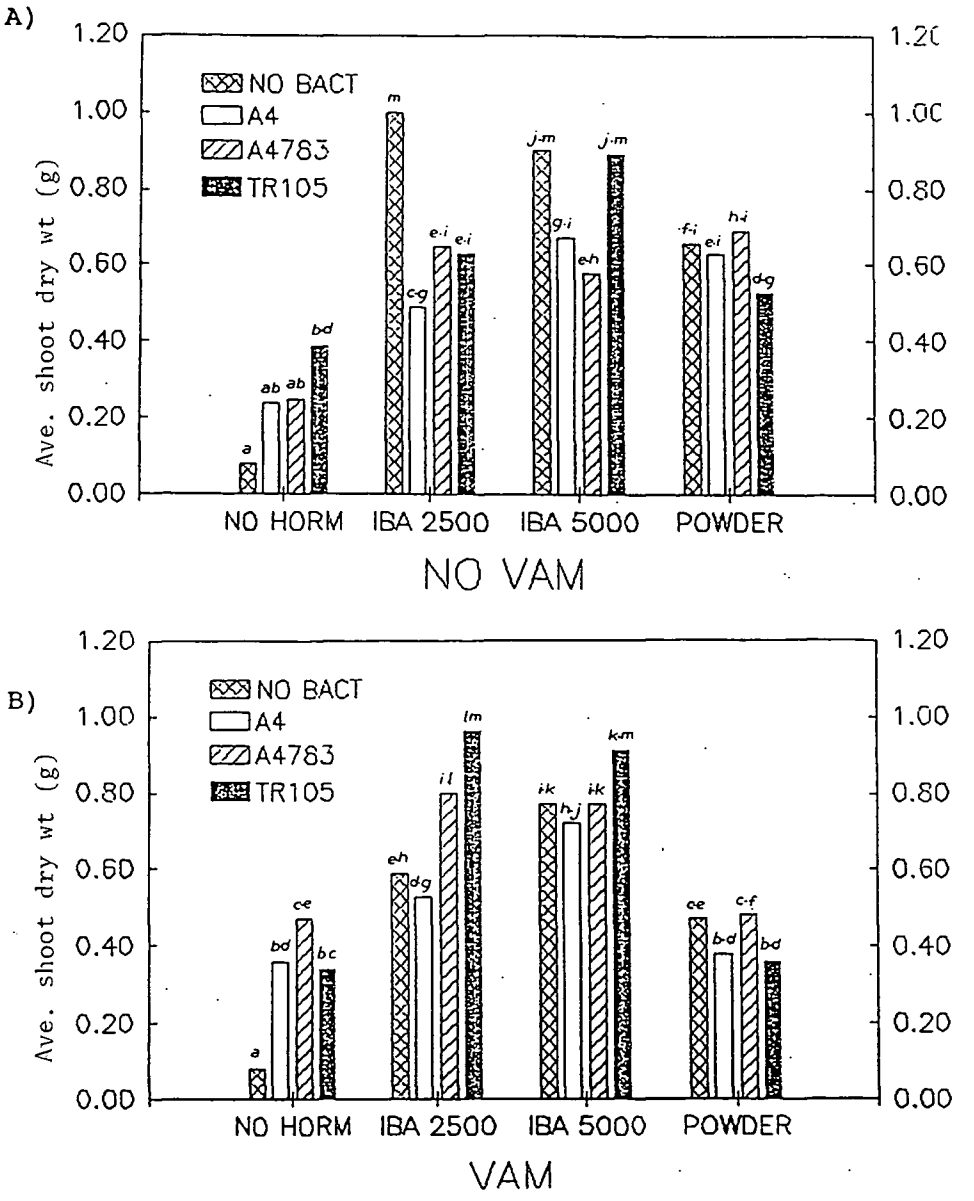


Fig. 17. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on shoot dry weight of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

OLD HOME X FARMINGDALE 282: SHOOT DRY WEIGHT

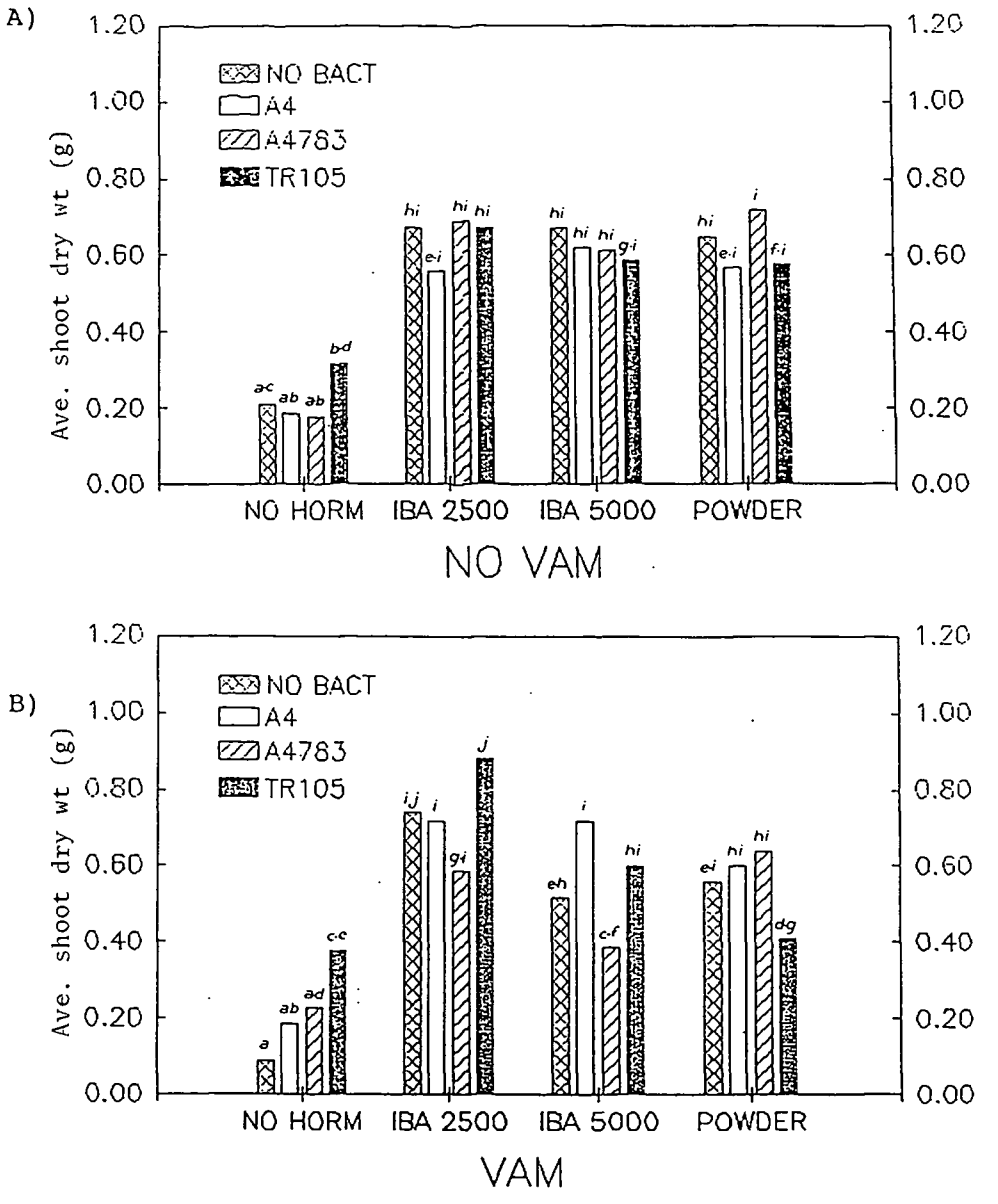


Fig. 18. Effect of VA mycorrhizae, Agrobacterium rhizogenes and rooting compounds on shoot dry weight of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each bar represents the mean of 24. Columns with the same letter/s are not significantly different at P=0.05 using mean standard error.

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V. APPENDIX

A)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT NUMBER		ROOT LENGTH		ROOT BRANCH.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.25	0.85	8.00	0.00	20.00	0.00
"	A4	0.46	1.29	8.00	1.00	6.67	5.77
"	A4783	0.58	1.38	11.00	4.36	10.00	7.07
"	TR105	2.78	4.94	6.18	1.60	7.27	6.47
IBA 2500	CONTROL	0.25	0.85	9.68	2.45	32.63	32.12
" "	A4	0.46	1.29	8.38	2.09	14.38	8.92
" "	A4783	0.58	1.38	9.50	3.26	19.44	27.33
" "	TR105	2.71	4.94	10.77	2.84	14.71	12.31
IBA 5000	CONTROL	7.21	7.25	10.06	2.69	22.78	19.65
" "	A4	6.21	6.89	9.47	1.69	24.00	21.31
" "	A4783	3.17	4.48	9.92	1.83	19.17	15.05
" "	TR105	7.04	6.06	10.68	3.42	28.42	28.53
POWDER	CONTROL	4.50	3.71	10.21	2.32	17.37	21.30
" "	A4	4.17	5.08	12.79	4.95	40.71	25.26
" "	A4783	6.13	4.42	11.79	2.28	32.11	20.97
" "	TR105	3.21	2.20	16.67	17.18	16.67	17.18

B)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT NUMBER		ROOT LENGTH		ROOT BRANCH.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.00	0.00	0.00	0.00	0.00	0.00
"	A4	1.33	2.32	7.50	1.90	6.00	5.16
"	A4783	0.88	1.48	7.50	2.00	12.50	17.53
"	TR105	1.13	2.23	8.14	0.69	7.14	4.88
IBA 2500	CONTROL	4.25	4.48	10.79	3.89	36.43	28.72
" "	A4	4.08	4.95	9.87	3.02	30.00	21.71
" "	A4783	5.17	4.67	10.50	3.50	35.00	25.73
" "	TR105	5.96	4.85	10.19	2.66	23.33	20.09
IBA 5000	CONTROL	5.83	6.79	10.67	1.99	26.67	23.81
" "	A4	3.67	4.25	9.43	2.98	13.57	23.41
" "	A4783	6.75	6.69	10.12	1.41	24.71	15.46
" "	TR105	7.46	5.80	11.53	2.65	39.47	29.34
POWDER	CONTROL	2.00	2.59	14.27	3.32	41.82	37.37
" "	A4	1.79	2.30	11.08	3.55	15.83	15.64
" "	A4783	2.83	3.98	9.60	2.46	23.00	24.52
" "	TR105	1.42	2.17	9.22	1.92	17.78	10.93

Table 1. Effect of VA mycorrhizae, Agrobacterium rhizogenes, and rooting compounds on root numbers, root length, and % of root branching of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each mean represents the mean of 24 cuttings.

A)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT NUMBER		ROOT LENGTH		ROOT BRANCH.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.54	1.41	10.75	2.63	7.50	9.57
"	A4	1.25	2.11	7.90	1.91	10.00	21.60
"	A4T83	1.67	2.37	8.00	2.45	15.00	17.80
"	TR105	3.96	3.81	7.63	2.91	9.47	13.53
IBA 2500	CONTROL	7.21	5.82	9.91	4.43	17.39	18.15
" "	A4	6.33	6.55	7.94	2.35	18.24	9.51
" "	A4T83	6.00	5.75	8.44	2.60	22.78	18.09
" "	TR105	5.13	3.58	9.68	1.99	28.64	28.17
IBA 5000	CONTROL	10.13	7.87	9.77	2.83	25.00	16.26
" "	A4	9.04	10.74	8.55	1.99	18.50	18.43
" "	A4T83	7.25	6.87	9.27	3.71	17.39	18.15
" "	TR105	8.04	6.08	10.47	2.34	41.05	24.24
POWDER	CONTROL	8.33	6.96	9.58	1.77	38.95	28.65
" "	A4	8.54	9.27	8.61	2.64	31.67	20.65
" "	A4T83	9.96	8.93	9.35	1.76	24.00	16.36
" "	TR105	5.83	2.76	9.61	2.68	27.83	25.04

B)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT NUMBER		ROOT LENGTH		ROOT BRANCH.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.46	1.38	9.33	1.53	13.33	5.77
"	A4	1.92	2.95	9.00	2.87	6.67	7.07
"	A4T83	3.75	5.94	9.85	4.24	20.00	24.83
"	TR105	2.63	3.35	9.29	3.05	10.71	12.07
IBA 2500	CONTROL	5.13	3.48	10.75	1.97	31.50	27.00
" "	A4	8.25	7.33	10.59	3.89	37.90	24.63
" "	A4T83	7.21	7.38	11.19	5.47	31.43	22.65
" "	TR105	6.83	6.41	11.22	2.86	36.67	22.49
IBA 5000	CONTROL	4.13	5.07	11.36	2.47	40.00	23.21
" "	A4	10.13	9.29	10.50	3.14	32.27	20.46
" "	A4T83	6.54	6.42	9.90	2.75	22.11	15.12
" "	TR105	8.83	9.35	10.21	1.25	29.29	18.59
POWDER	CONTROL	5.75	5.61	10.93	2.52	33.75	25.00
" "	A4	5.50	6.28	12.00	2.99	49.29	29.21
" "	A4T83	5.79	3.82	11.47	2.17	29.47	20.94
" "	TR105	4.92	4.76	11.00	2.65	35.29	27.89

Table 2. Effect of VA mycorrhizae, Agrobacterium rhizogenes, and rooting compounds on root numbers, root length, and % of root branching of mist propagated hardwood cutting of OHXF 282, A) no VAM, B) VAM. Each mean represents the mean of 24 cuttings.

A)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	SURVIVAL %		ROOTING RATE.		ROOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.08	0.17	1.96	0.75	0.01	0.02
"	A4	0.29	0.48	2.21	1.06	0.02	0.03
"	A4783	0.46	0.09	2.46	1.10	0.04	0.08
"	TR105	0.75	0.21	3.13	0.99	0.05	0.08
IBA 2500	CONTROL	0.71	0.37	3.63	0.82	0.16	0.18
" "	A4	0.67	0.27	3.04	1.40	0.12	0.11
" "	A4783	0.79	0.25	3.46	1.02	0.13	0.16
" "	TR105	0.79	0.08	3.38	1.10	0.12	0.13
IBA 5000	CONTROL	0.75	0.09	3.29	1.27	0.13	0.12
" "	A4	0.62	0.35	2.92	1.44	0.10	0.11
" "	A4783	0.54	0.37	2.58	1.50	0.08	0.10
" "	TR105	0.67	0.36	3.50	1.06	0.19	0.19
POWDER	CONTROL	0.79	0.16	3.38	1.25	0.12	0.18
" "	A4	0.75	0.21	3.08	1.25	0.18	0.20
" "	A4783	0.79	0.08	3.46	1.10	0.21	0.18
" "	TR105	0.83	0.25	3.21	1.14	0.11	0.15

B)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	SURVIVAL %		ROOTING RATE.		ROOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.00	0.00	1.91	0.28	0.00	0.00
"	A4	0.63	0.21	2.92	1.10	0.62	0.11
"	A4783	0.46	0.16	2.79	1.10	0.04	0.06
"	TR105	0.46	0.16	2.58	1.14	0.04	0.05
IBA 2500	CONTROL	0.54	0.28	3.04	1.23	0.13	0.19
" "	A4	0.63	0.44	2.92	1.44	0.14	0.16
" "	A4783	0.83	0.34	3.50	0.98	0.17	0.17
" "	TR105	0.87	0.09	3.71	0.86	0.16	0.14
IBA 5000	CONTROL	0.63	0.37	3.13	1.19	0.12	0.14
" "	A4	0.63	0.29	3.00	1.29	0.08	0.10
" "	A4783	0.79	0.16	3.29	1.23	0.14	0.11
" "	TR105	0.79	0.16	3.46	1.10	0.23	0.20
POWDER	CONTROL	0.46	0.28	2.58	1.38	0.12	0.29
" "	A4	0.50	0.20	2.75	1.33	0.08	0.15
" "	A4783	0.46	0.25	2.67	1.24	0.08	0.13
" "	TR105	0.54	0.25	2.63	1.28	0.16	0.49

Table 3. Effect of VA mycorrhizae, Agrobacterium rhizogenes, and rooting compounds on survival index, rooting rating, and root dry weight of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each mean represents the mean of 24 cuttings.

A)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	SURVIVAL %		ROOTING RATG.		ROOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.21	0.21	2.04	1.04	0.01	0.02
"	A4	0.42	0.17	2.54	1.32	0.03	0.06
"	A4783	0.46	0.34	2.83	1.09	0.04	0.05
"	TR105	0.83	0.14	3.54	0.98	0.07	0.08
IBA 2500	CONTROL	0.96	0.09	3.88	0.61	0.09	0.05
" "	A4	0.83	0.14	3.29	1.20	0.07	0.07
" "	A4783	0.79	0.25	3.76	1.17	0.09	0.07
" "	TR105	0.92	0.17	3.75	0.85	0.12	0.11
IBA 5000	CONTROL	0.92	0.17	3.83	0.57	0.11	0.08
" "	A4	0.88	0.16	3.58	1.02	0.11	0.12
" "	A4783	0.92	0.17	3.75	0.85	0.12	0.14
" "	TR105	0.87	0.24	3.50	1.06	0.16	0.11
POWDER	CONTROL	0.79	0.32	3.46	1.14	0.14	0.12
" "	A4	0.75	0.21	3.33	1.20	0.11	0.11
" "	A4783	0.83	0.14	3.50	1.14	0.14	0.14
" "	TR105	0.96	0.09	3.88	0.61	0.15	0.12

B)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	SURVIVAL %		ROOTING RATG.		ROOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.17	0.15	2.13	0.80	0.01	0.02
"	A4	0.42	0.35	2.63	1.17	0.03	0.05
"	A4783	0.54	0.34	2.88	1.30	0.09	0.13
"	TR105	0.58	0.32	2.96	1.30	0.07	0.11
IBA 2500	CONTROL	0.83	0.14	3.54	1.06	0.12	0.10
" "	A4	0.83	0.14	3.58	0.88	0.16	0.13
" "	A4783	0.87	0.09	3.67	0.92	0.15	0.13
" "	TR105	0.75	0.29	3.25	1.33	0.16	0.13
IBA 5000	CONTROL	0.58	0.40	3.21	0.98	0.12	0.14
" "	A4	0.92	0.10	3.79	0.72	0.22	0.16
" "	A4783	0.79	0.16	3.54	0.98	0.10	0.10
" "	TR105	0.58	0.40	2.88	1.42	0.16	0.17
POWDER	CONTROL	0.63	0.16	3.00	1.35	0.12	0.14
" "	A4	0.58	0.29	2.88	1.39	0.16	0.19
" "	A4783	0.80	0.16	3.38	1.14	0.15	0.13
" "	TR105	0.71	0.08	3.21	1.29	0.14	0.13

Table 4. Effect of VA mycorrhizae, Agrobacterium rhizogenes, and rooting compounds on survival index, rooting rating, and root dry weight of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each mean represents the mean of 24 cuttings.

A)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT AREA		SHOOT NUMBER		SHOOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	2.17	5.13	0.13	0.45	0.08	0.27
"	A4	1.48	3.02	0.42	0.58	0.24	0.32
"	A4T83	3.91	6.97	0.63	0.77	0.25	0.34
"	TR105	11.73	12.30	0.58	0.83	0.38	0.30
IBA 2500	CONTROL	49.00	24.50	0.96	0.69	6.17	6.55
" "	A4	32.17	21.74	1.04	1.12	5.33	7.09
" "	A4T83	30.34	23.25	0.96	0.69	0.65	0.51
" "	TR105	28.02	23.48	0.96	1.00	0.63	0.44
IBA 5000	CONTROL	27.67	22.40	1.54	1.22	9.67	7.64
" "	A4	24.25	24.48	0.83	0.76	0.66	0.70
" "	A4T83	10.00	15.36	0.83	0.92	0.58	0.55
" "	TR105	41.50	28.27	1.33	1.09	0.89	0.59
POWDER	CONTROL	18.58	16.27	1.13	0.95	0.66	0.44
" "	A4	40.37	24.13	0.83	0.87	0.63	0.59
" "	A4T83	33.98	26.41	0.88	0.74	0.69	0.52
" "	TR105	12.57	15.20	1.13	0.95	0.53	0.43

B)

TREATMENT		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT AREA		SHOOT NUMBER		SHOOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.00	0.00	0.08	0.41	0.84	0.41
"	A4	9.20	9.02	0.58	0.88	0.36	0.39
"	A4T83	8.73	10.37	0.50	0.59	0.47	0.49
"	TR105	5.23	7.67	0.50	0.83	0.34	0.40
IBA 2500	CONTROL	31.25	27.71	0.92	0.93	0.59	0.54
" "	A4	29.67	24.69	0.88	0.74	0.53	0.52
" "	A4T83	29.10	28.24	1.08	0.88	0.80	0.53
" "	TR105	27.58	16.18	1.46	1.06	0.96	0.57
IBA 5000	CONTROL	18.42	28.04	1.04	1.08	0.77	0.68
" "	A4	13.92	18.57	0.92	0.93	0.72	0.72
" "	A4T83	27.17	24.00	1.25	1.07	0.77	0.48
" "	TR105	43.59	29.72	1.25	0.99	0.91	0.66
POWDER	CONTROL	30.33	33.18	0.58	0.77	0.47	0.55
" "	A4	16.42	23.49	0.63	0.88	0.38	0.42
" "	A4T83	7.75	17.67	0.75	0.99	0.48	0.63
" "	TR105	12.62	19.95	0.75	1.03	0.36	0.47

Table 5. Effect of VA mycorrhizae, Agrobacterium rhizogenes, and rooting compounds on root area, shoot number, and shoot dry weight of mist propagated hardwood cuttings of OHXF 217, A) no VAM, B) VAM. Each mean represents the mean of 24 cuttings.

A)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT AREA		SHOOT NUMBER		SHOOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	0.58	2.02	0.33	0.70	0.21	0.36
"	A4	4.98	7.61	0.67	0.92	0.19	0.28
"	A4T83	8.38	9.86	0.67	0.96	0.18	0.27
"	TR105	8.83	8.96	0.79	0.78	0.32	0.28
IBA 2500	CONTROL	17.45	9.42	1.67	0.87	0.67	0.29
" "	A4	15.58	12.87	1.29	1.04	0.56	0.50
" "	A4T83	15.06	12.54	1.25	0.85	0.69	0.50
" "	TR105	15.57	10.40	1.33	0.82	0.65	0.41
IBA 5000	CONTROL	24.58	14.13	1.29	0.86	0.67	0.33
" "	A4	24.16	21.18	1.54	1.02	0.62	0.44
" "	A4T83	21.18	18.77	1.42	0.83	0.61	0.38
" "	TR105	32.58	12.18	1.08	0.93	0.59	0.47
POWDER	CONTROL	27.83	23.16	1.08	0.88	0.65	0.46
" "	A4	20.90	15.83	0.96	0.86	0.57	0.44
" "	A4T83	28.42	24.72	1.75	1.11	0.72	0.41
" "	TR105	19.16	15.24	1.21	0.83	0.58	0.32

B)

TREATMENTS		PARAMETER					
ROOTING COMPOUND	AGROB. RHIZ.	ROOT AREA		SHOOT NUMBER		SHOOT DRY WT.	
		MEAN	ST D	MEAN	ST D	MEAN	ST D
CONTROL	CONTROL	1.42	4.91	0.08	0.28	0.09	0.31
"	A4	4.66	6.87	0.50	0.72	0.20	0.27
"	A4T83	17.92	18.03	0.42	0.72	0.23	0.27
"	TR105	9.68	14.70	0.92	1.14	0.38	0.40
IBA 2500	CONTROL	24.46	14.05	1.38	0.97	0.74	0.49
" "	A4	29.67	21.93	1.38	0.97	0.72	0.46
" "	A4T83	25.83	15.45	1.33	1.01	0.59	0.39
" "	TR105	33.75	19.86	1.29	1.12	0.88	0.58
IBA 5000	CONTROL	27.36	23.54	0.92	0.97	0.51	0.49
" "	A4	40.92	19.32	1.46	1.06	0.72	0.44
" "	A4T83	18.72	18.28	0.88	0.74	0.50	0.45
" "	TR105	38.73	28.24	1.04	1.04	0.60	0.52
POWDER	CONTROL	21.08	22.93	0.92	1.02	0.56	0.62
" "	A4	33.23	23.76	0.96	1.12	0.60	0.61
" "	A4T83	26.58	21.53	1.04	0.91	0.64	0.41
" "	TR105	22.00	18.45	0.92	0.93	0.41	0.34

Table 6. Effect of VA mycorrhizae, Agrobacterium rhizogenes, and rooting compounds on root area, shoot number, and shoot dry weight of mist propagated hardwood cuttings of OHXF 282, A) no VAM, B) VAM. Each mean represents the mean of 24 cuttings.