Journal of Coastal Research	5	4	747-754	Fort Lauderdale, Florida	Fall 1989

Nursery Inoculation of Sea Oats with Vesicular-Arbuscular Mycorrhizal Fungi and Outplanting Performance on Florida Beaches

David M. Sylvia

Soil Science Department
University of Florida
Gainesville, FL 32611, USA

ABSTRACT

SYLVIA, D.M., 1989. Nursery inoculation of sea oats with vesicular-arbuscular mycorrhizal fungi and outplanting performance on Florida beaches. *Journal of Coastal Research*, 5(4), 747–754. Fort Lauderdale (Florida). ISSN 0749–0208.

Seedlings of *Uniola paniculata* L. were inoculated with a mixture of *Glomus deserticola* Trappe, Bloss & Menge and *G. macrocarpum* Tul. & Tul. or were not inoculated with the vesicular-arbuscular mycorrhizal (VAM) fungi in a commercial nursery using standard nursery practice. Moderate levels of colonization were achieved, even when inoculum was mixed with the growth medium at a dilution rate of 1:64. At Anastasia State Recreation Area (ASRA), sea oats inoculated with VAM fungi at the time of planting had greater root growth than noninoculated seedings after 2 mo; however, losses during winter storms precluded further evaluation of this study. At Miami Beach, VAM fungus-colonized sea oats obtained from a nursery study had 219, 81, 64, and 53% greater shoot dry mass, root length, plant height, and number of tillers, respectively, compared to sea oats that came from the same nursery without VAM fungi. In a greenhouse study conducted to examine mycorrhizal growth responses of sea oats in sand from ASRA and Miami Beach, sea oats without added P were found to be more dependent on VAM fungi in Miami Beach sand. The conclusion is that sea oats colonized with VAM fungi are better adapted for growth in beach sand than noncolonized plants, but additional studies are needed to optimize utilization of VAM fungus inoculum in the nursery.

ADDITIONAL INDEX WORDS: *Inoculum, fungi, greenhouse study, mycorrhizal growth response, dune plants, coastal vegetation.*

INTRODUCTION

Coastal sand dunes of the southeastern U.S. are stabilized naturally by perennial grasses such as sea oats (WOODHOUSE, 1982). Roots of these pioneer grasses are colonized by vesicular-arbuscular mycorrhizal (VAM) fungi (SYLVIA, 1986; KOSKE, 1987). The VAM fungi increase the effective absorptive surface of the plant (HARLEY and SMITH, 1983), thereby improving its ability to take up nutrients—a property especially valuable for plant growth in nutrient-poor sand dune soils (KOSKE and POLSON, 1984).

Beach erosion is of major economic concern in Florida, and extensive projects have been implemented to replenish lost sand (DEAN, 1983). Sand used for beach replenishment is often obtained from offshore. Following sand replenishment, beach grasses are typically planted along the back of the beach to reduce erosional losses and to initiate the dune-building process. However, SYLVIA and WILL (1988) reported that this sand lacked VAM fungi, and beach grasses transplanted into it were colonized only slowly by these beneficial fungi.

Greenhouse studies have demonstrated that growth of sea oats is improved by selected VAM fungi (SYLVIA and BURKS, 1988); however, data are lacking on growth of VAM fungus-inoculated sea oats planted on beaches. Inoculation of sea oats with VAM fungi for the purpose of enhancing their establishment on replenishment sand appears to be a reasonable goal. Unfortunately, production of large quantities of inoculum for field inoculation is still problematic (MENGE, 1984).

88058 received 26 September 1988; accepted in revision 5 January 1989.

Florida Agricultural Experimental Station Journal Series No 9327. This research was funded partially by the Florida Sea Grant College Program with support from the National Oceanic and Atmospheric Administration, Office of Sea Grant, U.S. Department of Commerce (grant NA86AA-D-SG068).

In Florida, sea oats are produced in container nurseries. Since plant materials and media are concentrated in a relatively small space during propagation, the nursery should afford an opportunity to inoculate a large number of plants with a limited amount of inoculum (JOHNSON, 1987). The objectives of this project were to: (i) determine if VAM fungus colonization of sea oats could be achieved under commercial nursery conditions and (ii) quantify the growth of VAM fungus-colonized sea oats transplanted to the beach.

MATERIALS AND METHODS

Plant and Fungal Material. Sea oats (*Uniola paniculata* L.) were used in all experiments. Seed was collected from plants on pioneer sand dunes at Anastasia State Recreation Area (ASRA) and St. George Island State Park, Florida. The VAM fungus inoculum was a mixture of *Glomus deserticola* Trappe, Bloss & Menge (isolate S305) and *Glomus macrocarpum* Tul. & Tul. (isolate S328). These fungi were isolated originally from the rhizosphere of sea oats growing on pioneer dunes along the north Atlantic coast of Florida, and were maintained in pot cultures of pasteurized beach sand and sea oats. Isolate S305 has been reported to be an effective growth promoter of sea oats in low-nutrient beach sand (SYLVIA and BURKS, 1988).

Nursery Studies

Two studies were conducted at the nursery of Horticultural Systems, Inc. located in Parrish, Florida. Standard nursery practice used in both experiments included: (i) Vergo transplant mix A (Verlite, Co., Tampa, Florida) as the growth medium; (ii) TODD planter flats (model 150, 25 mL/cell, Speedling Inc., Sun City, Florida) as the growth container; (iii) Peters 20N-20P-20K soluble fertilizer (W.R. Grace & Co., Allentown, Pennsylvania) applied through overhead irrigation; and (iv) Banrot (dimethyl 4,4'-o-phenylene bis(3-thioallophanate) and Daconil (tetrachloroisophthalonitrile) fungicides applied as needed to control fungal pathogens.

The first study, established in July, 1986, was a three-inoculation by two-fertility treatment factorial experiment. The inoculation treatments included no inoculation (none), inoculation with sand and chopped sea oat roots (4 mL/cell) from a nonmycorrhizal pot culture (control), and inoculation with sand and roots from a pot culture containing the VAM fungus mixture described above. Inoculum, placed directly in the planting hole, contained approximately eight chlamydospores and 1.3 cm of colonized root length mL^{-1}. The fertilizer treatments were applied either three (standard nursery practice) or one time per week. Uniformly-sized seedlings, approximately three weeks old, were transplanted into the planter flats and placed on a nursery bench following inoculation. Three blocks of each treatment were established, with each block containing 32 plants. Plants were harvested after eight wk, and their heights and shoot dry masses (dried at 60 C for 48 h) were determined. Percentage root length colonized by VAM fungi was estimated by the gridline-intersect method after roots were cleared in KOH and stained with trypan blue (GIOVANNETTI and MOSSE, 1980).

The second study, established in August, 1987, was conducted to quantify the relation between inoculum density and VAM fungus colonization in the nursery. The VAM fungus inoculum was mixed with the growth medium to provide five 4-fold dilutions from 1:4 to 1:1064. The inoculum density of nondiluted VAM fungus inoculum, as determined by a most-probable-number assay (DANIELS and SKIPPER, 1982), was 1.4 propagules mL^{-1}. Uniformly-sized seedlings were transplanted into the mixes as described above and placed on a nursery bench. Three blocks of each inoculum density were established, with each block containing ten plants. Plants were harvested after seven wk, and percentage root length colonized by VAM fungi was estimated.

Field Studies

A field study was initiated among the pioneer dunes at ASRA in July, 1986. The soil at ASRA was a fine sand (95% of the mass had particles < 0.1 mm in diam) and had a pH of 8.7 (1:2, soil to water), 75 μg total soluble salts g^{-1}, 0.37 μg soluble inorganic N g^{-1}, and 0.07 μm P mL^{-1} of soil solution. To estimate equilibrium soil-solution P, 50 g of soil were shaken with 100 mL of deionized water for approximately 12 h. The study was a two-inoculation by three-fertilizer-rate factorial experiment. The inoculation treatments were the control and the mixed VAM fungus inoculum as described above. The inoculum was placed in the bottom of the 10-cm-deep planting hole just prior to transplanting. The VAM fungus inoculum contained approximately eight chlamydospores and 1.1 cm of colonized root mL^{-1}. Fertility treatments were 0, 150, and 450 kg ha^{-1} of Osmocote 18N-6P-12K slow-release fertilizer (Sierra Chemical Co., Milpitas, California), incorporated into the sand with a rake prior to planting and also immediately after the first sampling in September, 1986. Plants (20- to 25-cm in height), obtained from the nursery of Horticultural Systems, Inc., were planted on 46-cm centers. The plants were free of VAM fungus colonization at planting. The experiment consisted of three blocks, each containing the six treatments, with 21 plants per treatment. A 2-m space separated treatment plots, and blocks were separated by approximately 100 m. The plants were watered only at planting. Five plants from each treatment were sampled for shoot and root growth 2- and 10-mo after planting.

A second field study was initiated on a replenishment beach at Miami Beach, Florida, in October, 1986. The soil was a coarse sand (80% of the mass had particles > 2.5 mm in diam) and had a pH of 9.5, 154 μg total soluble salts g^{-1}, 0.41 μg soluble inorganic N g^{-1}, and 0.01 μg P mL^{-1} of soil solution. The treatments included mycorrhizal and nonmycorrhizal plants obtained from the standard fertility treatment of the first nursery experiment described above. Sea oats placed in the experimental area were planted according to specifications required by a contract for an extensive planting project on Miami Beach, with the exception of added fertilizer. Planting protocol included excavating planting holes to 7.5-cm diam and 25-cm depth, and backfilling the holes approximately half way with a mixture of 70% peat, 30% pine bark, and 1.5 g Agrosoke (coarse granular, Grosoke International, Ft. Worth, Texas). Osmocote fertilizer was incorporated into the sand at a rate of 184 kg ha^{-1} immediately before planting, and at a rate of 300 kg ha^{-1} after 5 and 10 mo. Sea oats were planted on 46-cm centers and watered by overhead irrigation as needed. The experiment consisted for three blocks, each containing two treatments, with 21 plants per treatment. Data were collected on shoot and root growth of five plants from each treatment 5-, 10-, and 19-mo after planting. Shoot nutrient contents were determined on five plants from each treatment after 10 mo; shoots were digested by the sealed-chamber method of ANDERSON and HENDERSON (1986), and the digest was analyzed on a Jarrel-Ash model 9000 inductively-coupled argon plasma spectrophotometer.

Greenhouse Studies

To compare the growth of sea oats in ASRA versus Miami Beach sand over a range of phosphorus nutrition levels, a two-sand-source by two-inoculation by three-phosphorus-level factorial experiment was established in August, 1987. The inoculation treatments included filtered washings of the inoculum (control) or 10 g of VAM fungus inoculum placed approximately 5 cm below the soil surface. The inoculum density of nondiluted VAM fungus inoculum, as determined by a most-probable-number assay, was 2.0 propagules g^{-1}. Inoculum washings were prepared by suspending 100 g of VAM fungus inoculum in 1 L of water, filtering twice through a sieve with 45-μm openings, and once through a Gelman metricel membrane with 5-μm pores.

Sea oats were germinated in vermiculite, after which two 3-wk-old seedlings were transplanted into 620-mL Deepot inserts (6.4 cm top diam by 25.4 cm long, J.M. McConkey & Co., Sumner, Washington) containing 725 g of pasteurized beach sand. After pasteurization, the sand from ASRA had a pH of 9.5, 14 μg total soluble salts g^{-1}, 0.10 μg soluble inorganic N g^{-1}, and 0.04 μg P mL^{-1} of soil solution, while the sand from Miami Beach had a pH of 9.6, 42 μg total soluble salts g^{-1}, 0.10 μg soluble inorganic N g^{-1}, and 0.01 μg P mL^{-1} of soil solution. The plants were arranged on the bench of a nonshaded greenhouse in a randomized complete-block design with 12 replicates per treatment. The mean maximum and minimum temperatures were 28 and 19 C, respectively, and the mean maximum photosynthetic photon flux density was 1335 μmol m^{-2} s^{-1}. Seedlings received weekly 50 mL of a modified Hoagland's solution containing 20 mg N L^{-1} and 0.0, 0.02, or 0.20 mg P L^{-1}.

Plants were harvested after 16 wk and shoot height, dry mass, and P content, as well as total root length and root length colonized by VAM fungi were determined. Percentage data were subjected to an arcsine transformation and all data were analyzed by an ANOVA procedure.

RESULTS AND DISCUSSION

Nursery Studies

The high nutrient and organic content of nursery mixes may suppress VAM fungus root colonization (BIERMANN and LINDERMAN, 1983a). However, the VAM fungus inoculum in our experiments established successfully on roots of sea oats under commercial nursery conditions (Table 1). While the level of colonization realized at the nursery was less than that obtained in sand (see greenhouse study), adequate colonization did occur (see field study). Without inoculation, sea oats did not become colonized by VAM fungi; the nursery growth medium was free of VAM fungi, and contamination did not occur during the course of the experiment. The use of the commercial fungicides Banrot and Daconil did not eliminate the inoculated fungus. TRAPPE *et al.* (1984) reported that these fungicides are not likely to reduce mycorrhizal colonization when used at recommended rates.

Inoculation with VAM fungi did not affect plant growth (Table 1), an expected result under the high fertility levels found in the nursery. The fertilizer regime was found to affect plant growth, but not VAM fungus colonization in the nursery. The primary purpose of nursery inoculation is not to promote plant growth at this stage of production—that can be accomplished with soluble fertilizers—but instead to establish VAM fungi on plant roots so that mycorrhizae will be efficiently transferred to the field (JOHNSON, 1987).

A near-linear decrease in root colonization in the nursery occurred with dilution of the inoculum, down to a dilution rate of 1:256 (Figure 1). The minimum level of colonization necessary for successful transfer of mycorrhizal plants to the field is not known; however, BIERMANN and LINDERMAN (1983b) reported that a very low level of colonization (< 10%) spread rapidly to new roots after transplanting. Furthermore, sea oats are often held in the nursery beyond the seven weeks used in this study, providing time for colonization levels to increase still further. Since problems encountered in the production of VAM fungus inoculum severely limits inoculum application (JEFFRIES, 1987), additional research should be conducted to determine the minimum inoculum density required for nursery inoculation and successful establishment of mycorrhizal plants after outplanting.

Field Studies

Two months after planting at ASRA, sea oats inoculated with VAM fungus inoculum had mean root colonization of 27%, compared to <

Table 1. *Effect of VAM fungus inoculation and fertilization on root colonization and growth of sea oats in a commercial nursery after 8 weeks.*

Inoculation[a] treatment	Fertilizer[b] rate	Root colon.	Plant height	Shoot dry mass
		(%)	(cm)	(mg)
Control	Standard	0[c]	51	570
	Reduced	0	41	360
None	Standard	0	54	600
	Reduced	0	44	470
VAMFI	Standard	27	54	630
	Reduced	29	45	360
Inoculation		**	NS	NS
Fertilizer		NS	**	**
Interaction		NS	NS	NS

[a]Control refers to sand and chopped roots from a nonmycorrhizal pot culture, None refers to no inoculation, and VAMFI refers to mycorrhizal inoculum containing a mix of *Glomus deserticola* and *G. macrocarpum*.

[b]Plants were fertilized with Peter's soluble fertilizer (20-20-20), three (standard) or one (reduced) time per week.

[c]Values represent the mean of 15 replictes. **,$P \leq 0.01$; *,$P \leq 0.05$; NS, not significant.

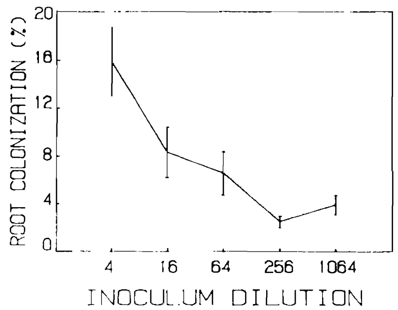

Figure 1. The effect of inoculum dilution of VAM fungi in the growth medium on root colonization of sea oats in a commercial nursery after 7 wk. Data points are means of 30 plants ± S.E.M.

1% for control plants (Table 2). Fungal inoculation increased root growth (mean = 57%) but not plant height, whereas both these parameters were increased by fertilizer. During winter storms the plots were inundated by sea water, resulting in poor plant survival. Plants sampled 10 mo after planting had variable levels of root colonization. Plant response to VAM fungus inoculation was not observed; however, fertilizer effects were still apparent.

Six months after planting at Miami Beach, sea oats inoculated with VAM fungus inoculum had a mean root colonization of 52%, compared to 9% for control plants; establishment of a low-level of colonization at the nursery resulted in well-colonized plants in the field (Figure 2a). Fourteen months after planting a difference in colonization was not evident between treatments. Plant-growth responses due to initial colonization by the VAM fungus inoculum were observed at all sampling dates (Figures 2b-c & 3), even though plants were the same size when outplanted (Table 1). Twenty months after planting, sea oats that were colonized with VAM fungi in the nursery had a 219, 81, 64, and 53% greater shoot dry mass, root length, plant height, and tillers per plant, respectively, compared to sea oats that came from the nursery without VAM fungi. Nutrient contents of shoots were not affected by treatment; mean values for Ca, Mg, K, P, Zn, Cu, Mn, and Fe were, respectively, 5003, 2146, 2989, 849, 12, 7, 4, and 59 $\mu g\ g^{-1}$.

Greenhouse Study

This study was conducted to examine the mycorrhizal growth response of sea oats in sand from ASRA and Miami Beach. Plants inoculated with VAM fungi had mean increases of 67, 63, and 57% in shoot dry mass, height, and root length, respectively, compared to noninoculated plants (Table 3). Inoculation with VAM fungi also increased shoot P and Zn concentrations, but P application did not. Soluble P was apparently leached rapidly from these sands.

Table 2. *Effect of VAM fungus inoculation and fertilization on root colonization and growth of sea oats planted at Anastasia State Recreation Area in July, 1986.*[+]

Inoculation[a] treatment	Fertilizer[b] rate	September, 1986			May, 1987		
		Root colon.	Root length	Plant height	Root colon.	Plant height	Tillers per plant
	(kg/ha)	(%)	(mm/g)	(cm)	(%)	(cm)	
Control	0	0[c]	140	62	3	65	2.0
	150	0	120	67	3	89	3.9
	450	2	230	70	14	78	6.7
VAM fungus	0	24	200	56	30	59	1.1
	150	26	300	67	3	82	3.4
	450	36	350	76	20	88	8.2
Inoculation		**	**	NS	*	NS	NS
Fertilizer		NS	*	**	*	**	**
Interaction		NS	NS	NS	*	*	NS

[+]Site was inundated by sea water during the winter of 1987.
[a]The control was sand and chopped roots from a nonmycorrhizal pot culture and the VAM fungus inoculum was sand and chopped roots from mixed pot cultures of *Glomus deserticola* and *G. macrocarpum*.
[b]Osmocote (18-06-12) slow-release fertilizer.
[c]Values represent the mean of 15 replicates. **, $P \leq 0.01$; *, $P \leq 0.05$; NS, not significant.

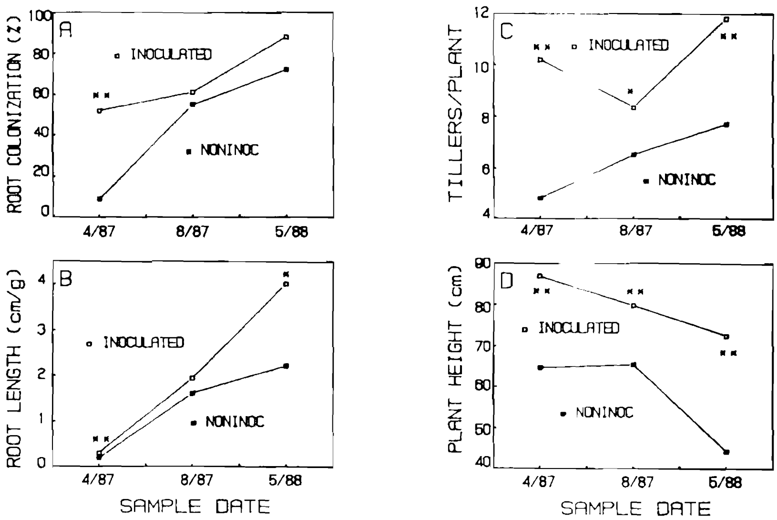

Figure 2. Percent VAM fungus root colonization (A), total root length (B), tiller production (C), and plant height (D) of sea oats inoculated or not with VAM fungi in the nursery and outplanted on replenishment sand at Miami Beach. Symbols represent the means of 5 plants. Date of planting, Oct 1986. Asterisks indicate significant differences between inoculated and noninoculated plants at P ≤ 0.05 (*) or P ≤ 0.01 (**).

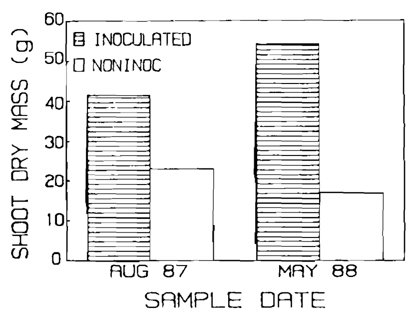

Figure 3. Shoot dry mass of sea oats inoculated or not with VAM fungi in the nursery and outplanted on replenishment sand at Miami Beach. Bars represent the means of 5 plants. Treatments were significantly different (P ≤ 0.01) for each sampling.

Without added P, the mycorrhizal growth response was greater in Miami Beach sand then in ASRA sand. This was due to the fact that noninoculated plants grown in Miami Beach sand were more nutrient-deficient than those grown in ASRA sand. Regardless of inoculation treatment, sea oats grown in sand from ASRA had greater shoot dry mass, height, and root length than those grown in sand from Miami Beach (Table 3).

CONCLUSIONS

Sea oats colonized with VAM fungi are better adapted for growth in beach sand than are noncolonized plants. In the studies reported here, sea oats responded to VAM fungus root colonization in greenhouse and field environments, with and without fertilizer. As would be expected, growth responses were greatest in the most nutrient-deficient sand. However, even under intensive culture on Miami Beach—plants which received slow-release fertilizer and irrigation—a highly significant growth response was observed up to 19 mo after outplanting. Since fertilizers applied to the sand leach rapidly from the rooting zone, the alternative strategy of providing adequate nutrition to dune-stabilizing plants with VAM fungi should be pursued.

Passive and active mechanisms may spread inoculum of VAM fungi from native dunes to transplanted sea oats (HETRICK, 1984). However, the source of inoculum and the rate of colonization must be carefully considered. In Florida, much of the native dune system has been destroyed by construction. Even where native dunes are in close proximity to transplants, colonization of roots by indigenous VAM fungi

Table 3. *VAM fungus colonization and growth of sea oats in sand collected from Miami Beach and Anastasia State Recreation area after 16 weeks in the greenhouse.*

Sand source	Inoculation[a] treatment	Phosphorus[b] level	Root colon.	Root length	Shoot dry mass	Plant height	*Shoot* P	*tissue* Zn
		(μg/mL)	(%)	(cm)	(mg)	(cm)	(mg/g)	(μg/g)
Anastasia	Control	0.00[c]	0	696	38	52	0.4	75
		0.02	3	500	31	47	0.5	42
		0.20	0	503	26	45	0.4	47
	VAM fungus	0.00	68	950	56	66	0.9	82
		0.02	69	901	58	67	0.9	75
		0.20	71	859	44	66	0.9	118
Miami Beach	Control	0.00	0	316	18	31	0.3	73
		0.02	9	615	32	41	0.4	56
		0.20	0	272	18	32	0.4	71
	VAM fungus	0.00	76	526	36	67	1.1	143
		0.02	62	599	37	65	0.9	125
		0.20	61	486	30	54	0.7	92
Sand			NS	**	**	**	NS	*
Inoculation			**	**	**	**	**	**
Phosphorus			NS	NS	*	*	NS	NS

[a]The control was sand and chopped roots from a nonmycorrhizal pot culture and the VAM fungus inoculum was sand and chopped roots from mixed pot cultures of *Glomus deserticola* and *G. macrocarpum*.
[b]Weekly application of 50 mL of a modified Hoagland's solution.
[c]Values represent the mean of 12 replicates. **, $P < 0.01$; *, $P < 0.05$; NS, not significant. There were no interactions among main effects.

may be slow (SYLVIA and WILL, 1988). Furthermore, VAM fungi that colonize most rapidly under natural conditions may not be the most effective in producing a plant growth response (SYLVIA and BURKS, 1988).

An efficient approach for introducing VAM fungi into replenishment sand is to inoculate seedlings in the nursery. In this study, the moderate amount of colonization achieved in the nursery was sufficient for successful transfer of VAM fungus colonized plants to the beach. Further studies should be conducted to optimize use of VAM fungal inoculum in the nursery.

ACKNOWLEDGMENTS

I wish to express sincere appreciation to Jacob Burks and M. Elizabeth Will for technical assistance, and to Otto Bundy and Emilio Fontana for cooperation with the nursery and field plantings.

LITERATURE CITED

ANDERSON, D.L. and HENDERSON, L.J., 1986. Sealed chamber digestion for plant nutrient analyses. *Agronomy Journal*, 78, 937-939.

BIERMANN, B.J. and LINDERMAN, R.G., 1983a. Effect of container plant growth medium and fertilizer phosphorus on establishment and host growth response to vesicular-arbuscular mycorrhizae. *Journal of the American Society for Horticultural Science*, 108(6), 962-971.

BIERMANN, B.J. and LINDERMAN, R.G., 1983b. Increased Geranium growth using pretransplant inoculation with a mycorrhizal fungus. *Journal of the American Society for Horticultural Science*, 108(6), 972-976.

DANIELS, B.A. and SKIPPER, H.D., 1982. Methods for the recovery and quantitative estimation of propagules from soil. *In*: N.C. Schenck (Ed.), *Methods and Principles of Mycorrhizal Research*. St. Paul: Am. Phytopathol. Soc., pp. 29-35.

DEAN, R.G., 1983. Principles of beach nourishment. *In*: P.D. Kormar and J.R. Moore (Eds.), *CRC Handbook of Coastal Processes and Erosion*. Boca Raton: CRC Press, pp. 217-231.

GIOVANNETTI, M. and MOSSE, B., 1980. An evaluation of techniques for measuring VA mycorrhizal infections in roots. *New Phytologist*, 84, 489-500.

HARLEY, J.L. and SMITH, S.E., 1983. *Mycorrhizal Symbiosis*. Academic Press, New York, 483p.

HETRICK, B.A.D., 1984. Ecology of VA mycorrhizae. *In*: C.L. Powell and D.J. Bagyaraj (Eds.), *VA Mycorrhizae*. Boca Raton: CRC Press, pp. 35-55.

JEFFRIES, P., 1987. Use of mycorrhizae in agriculture. *CRC Critical Reviews in Biotechnology*, 5(4), 319-357.

JOHNSON, C.R., 1987. Utilization of VAM in greenhouse production of transplanted crops. *In*: D.M.

Sylvia, L.L. Hung, and J.H. Graham (Eds.), *Mycorrhizae in the Next Decade: Practical Applications and Research Priorities. Proceedings of the 7th North American Conference on Mycorrhizae.* Gainesville: University of Florida, pp. 275-277.

KOSKE, R.E. 1987. Distribution of VA mycorrhizal fungi along a latitudinal temperature gradient. *Mycologia*, 79(1), 55-68.

KOSKE, R.E. and POLSON, W.R., 1984. Are VA mycorrhizae required for sand dune stabilization? *Bioscience*, 34, 420-424.

MENGE, J.A. 1984. Inoculum production. *In*: *VA Mycorrhiza*. C.L. Powell and D.J. Bagyaraj (Eds.), *VA Mycorrhiza*. Boca Raton: CRC Press, pp. 187-203.

SYLVIA, D.M., 1986. Spatial and temporal distribution of vesicular-arbuscular mycorrhizal fungi associated with *Uniola paniculata* in Florida foredunes. *Mycologia*, 78(5), 728-734.

SYLVIA, D.M. and BURKS, J.N., 1988. Selection of vesicular-arbuscular mycorrhizal fungi for inoculation of *Uniola paniculata* L. *Mycologia* 80(4), 565-568.

SYLVIA, D.M. and WILL, M.E., 1988. Establishment of vesicular-arbuscular mycorrhizal fungi and other microorganisms on a beach replenishment site in Florida. *Applied and Environmental Microbiology*, 54(2), 348-352.

TRAPPE, J.M.; MOLINA, R. and CASTELLANO, M.A., 1984. Reactions of mycorrhizal fungi and mycorrhizal formation to pesticides. *Annual Review of Phytopathology*, 22, 331-359.

WOODHOUSE, W.W., 1982. Coastal sand dunes of the U.S. *In*: R.R. Lewis (Ed.), *Creation and Restoration of Coastal Plant Communities*. Boca Raton: CRC Press, pp. 1-44.

□ RÉSUMÉ □

Des plants de *Uniola paniculata* 1. ont été inoculés avec un mélange de *glomus deserticola* Trappe, Bloss et Menge et de *G. macrocarpum* Tul. et Tul., et n'ont pas été inoculés ave les champignons à micorrhize vésiculaire et arbusculaire (VAM) dans une pépinière commerciale utilisant les pratiques courantes. Des niveaux moyens de colonisation sont atteints, même dans le cas de mélange avec un médium de croissance dilué à 1/64. A l'Anastasia State Recreation Area (ARSA), les "avoines maritimes" traitées au VAM en pépinière, comparées à celles non traitées de la même pépinière ont en plus: 219% de masse sèche en pousses, 81% de longueur de racines, 64% de hauteur, et 53% de talle. Dans une étude menée à l'ASRA et à Miami Beach sur les réponses de la croissance des micorrhizes sur les "avoines maritimes" dans le sable, on remarque que les avoines sans adjonction de P semblent plus dépendants du VAM à Miami Beach. En conclusion, les "avoines maritimes" colonisés par le VAM sont mieux adaptés à la croissance dans le sable que les plants non colonisés, mais ds études seraient nécessaires pour optimiser l'utilisation d'inoculation de VAM dans les pépinières.—*Catherine Bressolier (EPHE, Montrouge, France).*

□ ZUSAMMENFASSUNG □

Setzlinge bestimmter Pflanzen wurden gemeinsam mit speziellen Pilzarten (VAM) angezüchtet. Besondere Erfolge wurden dabei mit Strandhafer erzielt, der mit den Pilzen behandelt bessere Anwachsraten erreicht. Im Bereich von Miami Beach angepflanzte pilzbehandelte Strandhaferkulturen erreichten eine größere Trockenmasse, Wurzellänge, Größe und Anzahl der Ableger als vergleichbare unbehandelte Kulturen. Gewächshausstudien zeigen, daß die Anzucht von Strandhafer in phosphatarmen Substraten wesentlich abhängig ist vom Einsatz der VAM-Pilze. Ergänzende Studien für die Optimierung der VAM-Pilze in Anzuchtstationen sind jedoch erforderlich.—*Reinhard Dieckmann, WSA Bremerhaven, West Germany (FRG).*

□ RESUMEN □

Semillas de *Uniola paniculata* inoculadas con una mezcla de hongos micorrizicos vesiculares-arbusculares (VAM), *Glomus deserticola* Trappe, Bloss & Menge y *G. macrocarpum* Tul. & Tul. fueron comparadas con semillas no inoculadas de dicha especie en un criadero comercial usando las prácticas standar de siembra. Se consiguieron niveles moderados de colonización, aún cuando el inóculo se mezclaba con medio de crecimiento diluido a 1:64. En Anastasia State Recreation Area (ASRA), la avena marina inoculada con el hongo VAM en el momento de plantarlo, tenia mayor desarrollo rizoidal que la semilla no inoculada después de 2 meses; sin embargo, la pérdida durante las tormentas invernales impidió la posterior evaluación de este estudio. En Miami Beach, la avena marina colonizada por el hongo VAM y obtenida de un criadero estudio tenia 219, 81, 64 y 53% mayor peso seco de tallos, longitud rizoidal, altura de la planta y número de vástagos respectivamente, comparado con la avena marina que viene del mismo criadero sin hongo VAM.

En un estudio invernadero dirigido a examinar las respuesta del crecimiento de las micorrizas de la avena marina en arena desde ASRA y Miami Beach, la avena marina sin añadir P es más dependiente del hongo VAM en la arena de Miami Beach.

La conclusión es que la avena marina colonizada con el hongo VAM se adapta mejor al crecimiento en la arena de la playa que las plantas no colonizadas, pero se necesita estudios adicionales para las plantas no colonizadas, pero se necesita estudios adicionales para optimizar la utilización de inóculos de hongos VAM en los criaderos.—*Department of Water Sciences,* University of Cantabria, Santander, Spain.