Organic Matter: Short-Term Benefits and Long-Term Opportunities[1]

John G. Mexal and James T. Fisher[2]

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Abstract: Crop benefits derived from organic amendments to southern nurseries appear minor and limited by the rapid rates of OM decomposition common to,the region. This paper reviews a case study and related studies to examine the actual and potential benefits of amendments as determined by the kinds, amounts and frequencies of applications. It is possible to increase the stable fraction of OM in nursery soils and, potentially, to improve seedling growth and yield. However, it will be necessary to apply amendments more frequently than conventionally done.

INTRODUCTION

Nursery managers believe organic amendments are essential to efficient nursery production in southern regions. This belief is at least partially derived from the manner in which seedlings are harvested. In contrast to most agricultural crops, nursery seedlings are harvested as whole plants, and only negligible amounts of post-harvest crop residues remain in the soil.

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[2] Authors are, respectively, Assoc. Professor and Professor, Dept. of Agronomy and Horticulture, New Mexico State University, Las Cruces, N.M. 88003

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Clearly, organic matter (OM) is essential for efficient crop production. It acts as a reservoir of nutrients that become available slowly as decomposition proceeds. In addition, OM improves soil cation exchange capacity (CEC). Consequently, more nutrients are retained against leaching in soils high in OM. OM also buffers the soil against abrupt changes in soil acidity that can occur when fertilizers such as ammonium sulfate are applied.

OM improves water infiltration and augments net soil moisture retention. These benefits are important for soils that tend to crust or that have high salt content, esp., sodium (DeBano, 1981). OM adsorbs the cations and prevents flocculation of clay particles. Certain types of OM can suppress soil-borne plant pathogens such a _Pythium_ and _Phytopthora_ through the release of fungicides. OM also can alleviate the symptoms of certain abiotic diseases caused by herbicides or excess salts.

Nurseries apply a variety of organic amendments to maintain soil OM (Davey, 1984). In the South, conifer sawdust and bark are commonly applied because of the abundance of wood mill residue. Other OM amendments include hardwood sawdust and bark, municipal waste and animal waste. Use of these materials is usually limited by local availability. For example, fish waste or horse manure is applied if the nursery is near a hatchery or racetrack, respectively. Transportation costs generally preclude nurseries from using northern peat moss.

Green manures or cover crops do not add to the stable organic fraction of the soil. In fact, when a cover crop is turned under, soil OM may actually decrease after a brief period (Pieters and McKee, 1938). Essentially, the stimulation of microbial activity created by the addition of a readily decomposable food supply can cause a net reduction in the steady state level of soil OM. However, cover crops are not without merit; they can be used effectively to reduce wind erosion and to eliminate plow pans.

Nursery soil OM depends on location and soil type. Nurseries in the Northwest tend to have OM levels greater than 3 % (Davey, 1984). However, nurseries in the South average less than 3 % soil OM (South and Davey, 1982) and those on sandy or sandy loam soils have less than 1.5 % OM. Nurseries in the Southwest (New Mexico and Oklahoma) average about 1 % (Myatt, 1980; Windle, 1980).

The objective of this paper is to discuss the short-term response of nursery soil to organic matter additions using the USFS Albuquerque Tree Nursery as a case study, and to discuss the long-term opportunities to improve crop production through better OM management in nurseries.

ORGANIC AMENDMENTS APPLIED TO A SOUTHWESTERN NURSERY: A CASE STUDY

Treatments

Before fumigation for the 1984 crop, approximately 12 mm of OM was incorporated into the surface 15 cm. The OM treatments included gamma-irradiated sewage sludge, pine bark, pine sawdust, horticulture grade peat moss and no OM. Treatments were added at the rate of 67 t/ha, except sawdust that was added at 43 t/ha. Soil and seedling nutrient status were followed over the course of the production cycle (1.5 growing seasons), and seedling yield and morphology were determined November 1985.

Results

The OM additions caused immediate but short-term changes in soil OM and nutrient availability. Soil OM (particles < 2 mm) was affected most by sawdust (Fig. 1). The sawdust plots had an OM content of nearly 4 % about 2 months after application. Sludge increased OM less than 1.0 %. Particles 2 mm were still visible in the soil, but these are not measured in standard OM determinations. In all likelihood, particles this large neither stimulate soil microbial activity nor directly influence seedling nutrition.

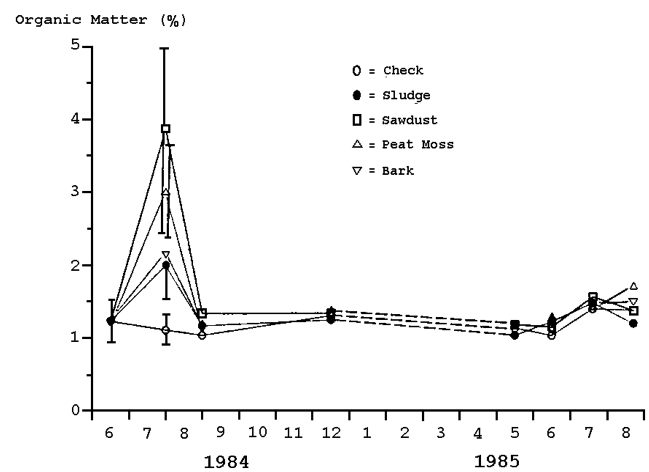

Figure 1.--Effect of organic amendments on soil test OM at the Albuquerque Tree Nursery. Only the peat moss treatment is significantly different from the control ($\alpha = .05$) for the July 1984 sample only. Vertical bars represent $\pm$ 1 S.E. of the mean.

The response of soil nutrients to OM was also short-lived. Only sludge increased soil NO_3 (Fig. 2A). Bark and peat moss had no detectable effect, but sawdust caused rapid immobilization of NO_3. By August, NO_3 in the sawdust plots was 1 ppm compared to 28 ppm for the control. By December, all plots had only 1 ppm N03. Five applications of urea (53 kg/ha) failed to increase soil NO_3 to more than 20 ppm, and by August 1985, soil NO_3 returned to 1 ppm, the pre-application level.

Other nutrients (P,K and Fe) behaved similarly (Fig. 2B-D). Generally, soil nutrient levels increased shortly after OM application, and decreased over the remainder of the rotation. For example, K decreased from 145 ppm before sowing to about 60 ppm 14 months later. Again, sludge increased soil K slightly early in the season, while sawdust decreased soil K slightly. Bark and peat moss did not alter nutrient levels. All treatment differences disappeared by December 1984.

OM amendments had no effect on seedling yield, height, caliper or fresh weight. However, seedling R/S was significantly reduced by bark, sludge and peat moss (Table 1). Seedling shoot fresh weight was positively correlated with increased soil nutrient levels brought about by the OM additions. However, R/S and shoot fresh weight were only slightly affected by OM addition. Nevertheless, the responses detected do indicate that OM amendments can alter seedling morphological development. However, additional work is needed to adequately explain this relationship.

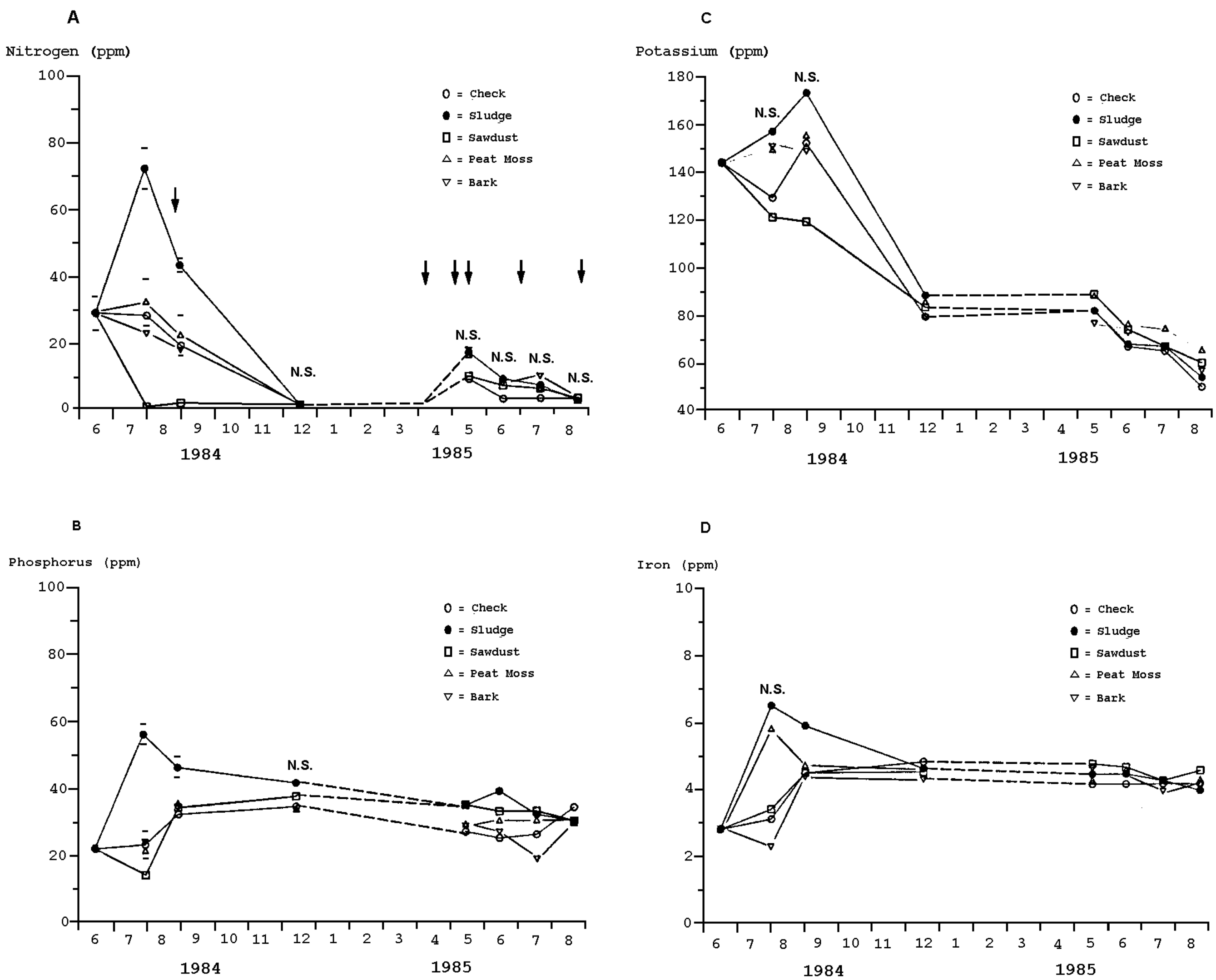

Figure 2.--Effect of organic amendments on soil test nutrient contents at the Albuquerque Tree Nursery, where A = nitrogen, B = phosphorus, C = potassium and D = iron. Arrows in Fig. 2A indicate applications of 53 kg/ha of urea. Vertical bars represent ± 1 S.E. of the mean; N.S. = not significant.

Table 1.--Effect of different organic amendments on 1.5 + 0 ponderosa pine seedling morphology.

	Height	Caliper	Fresh	Weight (g)	
Treatment	(cm)	(mm)	Shoot	Root	R/S
CONTROL	10.5	3.4	3.84	1.94	.36
SAWDUST	9.7	3.4	3.59	1.74	.54
BARK	11.4	3.4	3.98	1.86	.51 [1]
PEAT MOSS	10.4	3.2	3.66	1.72	.31 [1]
SLUDGE	11.2	3.5	4.16	1.89	.50 [1]
	N.S.	N.S.	N.S.*	N.S.	

[1] Significantly different from Control (d-.0 5)

* Correlated with Now. 1985 Soil CP7 and CN)

DISCUSSION

Although not encouraging, our results generally agree with studies conducted in the southern United States. Saloman (1953) treated soil with various levels of sawdust and found no change in soil OM and no improvement in plant growth. Similarly, the addition of sewage sludge to a nursery soil in the Northwest resulted in few improvements among the conifer species tested, and results from the outplanting trials were generally negative (Coleman, et al., 1986). However, Berry (1980) found that pine responded positively to the addition of sludge in a Florida nursery. Seedlings responded best to sludge applied at rates of 60-136 t/ha. The 67 t/ha treatments employed in our study failed to promote a similar response in ponderosa pine seedling growth.

Long-Term Opportunities

Many studies, including this one, examine the short-term response of soils, and generally report the response of one seedling crop to a single OM addition. Such studies point to the rather abrupt changes occurring in amended soils. Within 1 year, more than 60 Y of the OM added will decompose, and about 90 I will be decomposed in 2 years or less (Davey, 1984). Davey and Krause (1980) believed the stable fraction of soil OM could be increased about 0.1 % by adding 20 t/ha. However, Munson (1983) found peat moss decomposed more readily as application rates were increased. Munson found OM levels in the soil would return to ambient levels in 28 months after the addition of 22 t/ha, and 34 months after the application of 90 t/ha (Fig. 3).

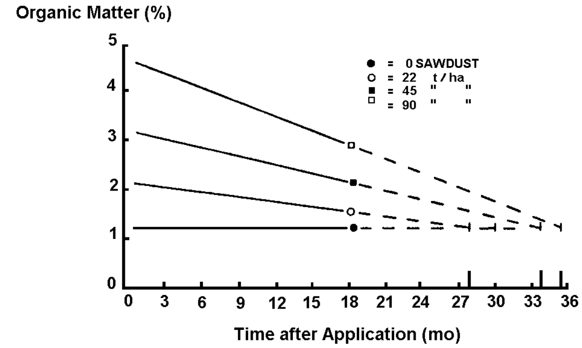

Figure 3.--Effect of rate of application on the decomposition of sawdust in a Florida nursery (after Munson, 1983). Return to ambient level is extrapolated to be 28 mo for 22 t/ha, 34 mo for 45 t/ha and 35 mo for 90 t/ha.

Apparently, amendments would have to be applied more frequently than once every 3-4 years to cause a net increase in stable soil OM.

A similar conclusion can be drawn from May and Gilmore (1984) who applied OM repeatedly in a loblolly pine nursery during a 6-year period. Sawdust was applied at 33 or 66 t/ha rates repeated two, three or six times over the course of the study. The maximum rate (66 t/ha applied every year) added a total of 396 t/ha of organic matter and effectively increased soil OM from 1.9 % to 3.2 % (Fig. 4). The OM level of the control plots was not altered over the 6-year period, despite the harvest of six seedling crops. Soil OM responded in a linear manner to the amount applied and to the frequency of application. The positive effects reported by May and Gilmore contrast sharply with studies employing single applications of comparatively large amounts of organic matter, and consequently reporting no practical benefits (e.g., Munson, 1982).

A relationship often ignored in the United States is the efficacy of inorganic fertilization as a substitute for organic amendments. Most information on this subject comes from the United Kingdom where the climate is much less severe than in the South or Southwest. Nevertheless, trials conducted in the United Kingdom have shown that inorganic fertilization can serve as a suitable replacement for OM.

However, in certain tests, the best treatment was a combination of inorganic fertilization and OM addition.

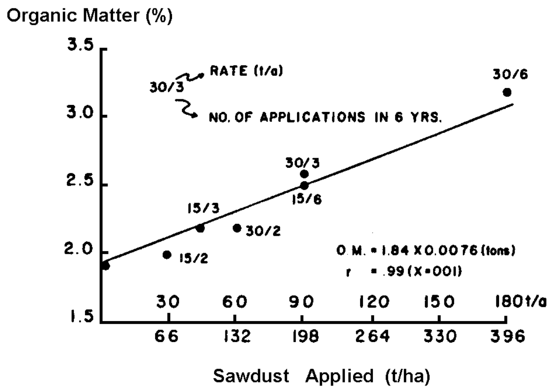

Figure 4.--Effect of amount and frequency of application of sawdust on OM content in a Alabama nursery soil (after May and Gilmore, 1984). The application rate was 16 and 33 t/ha applied either 2, 3, or 6 times in 6 years.

Future Prospects

Few studies have actually demonstrated that OM additions applied at conventional frequencies significantly improve nursery soils, seedling crops or profit margins. Present day practices will not significantly increase soil OM levels, and crop benefits will be of minor importance (see Fig. 4). More specifically, many nurseries apply 22 t/ha every 3 or 4 years before sowing 2+1 or 2+2 crops, respectively. Clearly, such practices will not significantly improve crop yield (Fig. 5). Within 4 years, the additional OM will decompose and will not cause a net gain in steady-state soil OM. Therefore, to significantly increase the stable OM fraction, at least 22 t/ha should be applied years 1 and 2 before sowing a cover crop.

Frequent applications of organic amendments will benefit some nurseries more than others. Among the problem soils potentially benefiting greatly

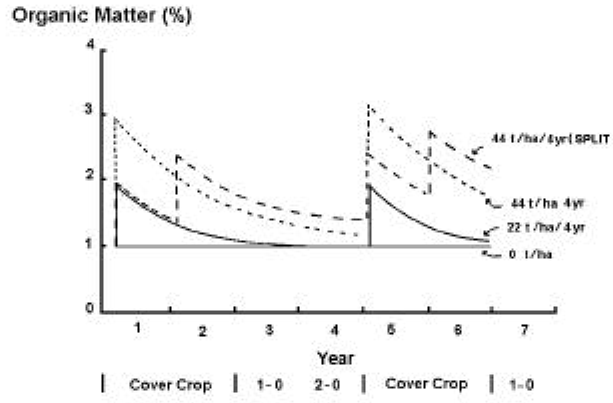

Figure 5.--Hypothetical trends in soil OM following different schemes of addition (adapted from Davey and Krause, 1980)

from frequent applications are those with comparatively low water infiltration rates. As seen in Fig. 6, OM level significantly affects water permeability. In the Southwest, the occurrence of torrential rains and the need to control evaporative losses are related concerns. OM should also increase soil nutrient retention and reduce the occurrence of crop maladies associated with salts and pesticides, as numerous studies of low-OM soils have shown.

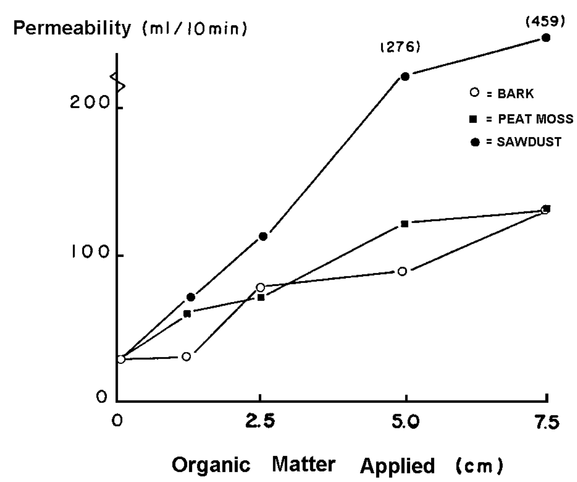

Figure 6.--Effect of type and amount of OM on water permeability (after Pokorny, 1982).

CONCLUSIONS

Extrapolations from our work and the study of May and Gilmore (1984) suggest that nursery soil OM can be raised to higher stable levels, even in regions where high temperatures and irrigation are conducive to rapid OM decomposition (Munson, 1982). Also evident is that present day amendment practices would have to be revised to provide the benefits desired.

Although OM amendments theoretically can improve nursery yield, field data for this region are inadequate to confidently predict economic benefits. For the present, we recommend nurserymen in the South and Southwest either apply no OM, or at least 2 applications of 22 t/ha over a 4-year rotation. Additionally, nursery managers should not overlook the opportunity to add OM before sowing the seedling crop, or the benefits derived from mulching with organic materials such as bark.

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