VOL. I 1942 No. 19

BLACK ROCK FOREST PAPERS

HENRY H. TRYON, DIRECTOR

MYCORRHIZAL INOCULATION OF SOIL OF LOW FERTILITY

By
R. F. FINN

CORNWALL-ON-THE-HUDSON, NEW YORK

MYCORRHIZAL INOCULATION OF SOIL OF LOW FERTILITY

MANY nurseries raise their coniferous seedlings in soil of low fertility. This medium is frequently so low in required nutrients that fertilizers must be added. The best seedling growth is made, provided other factors are not limiting, when the nutrients in the soil solution are at an optimum concentration. (Mitchel et. al. 1937).[1] Under natural field conditions the optimum nutrient concentrations in the soil are seldom reached. Under such conditions mycorrhizae are important for the satisfactory growth of coniferous seedlings (Hatch, 1937).[2] Much of the recent work on Mycorrhizae show that these structures, provided the seedlings are not in a weakened condition, are distinctly beneficial to seedlings. Hence, it appears desirable to have mycorrhizae form on coniferous seedlings. In this experiment a simple method of inoculating the seed bed with known mycorrhizae-forming fungi was used, and the effect of this inoculation on white pine seedlings was measured in terms of total dry weight, root/shoot ratio, nitrogen, phosphorus and potassium intake.

Seed Beds and Inoculation

On September 22, 1939 a box 36″ x 36″ and 12″ deep was filled with an infertile clay-sand soil taken from a road cut. The upper surface of the box was gridded (6″ x 6″) and into each small square "granulated" fungi (known mycorrhizae formers) were mixed with the upper two inches of soil. Enough fungi were used to insure thorough inoculation. The soil-fungus mixture was then covered with about two inches of soil. A ¼″ mesh screen was nailed over the box to exclude animals. A "control box" similar in all respects to the experimental box but lacking the fungi was set up. Both boxes were placed outdoors in the open for the winter, on a platform about ten inches from the ground.

Seed used in this experiment was collected in fall of 1939 from a single tree on the Pack Forest, Warrensburg, N. Y. It was stratified on February 27, 1940 in Erlenmeyer flasks using moist filter paper and pure quartz sand. The average fresh weight as determined by the average of 150 individually weighed seeds, was 17.5 mgms. On May 4, 1940 both the experimental and control boxes were treated with 8% glacial acetic acid at the rate of 1.5 pints per square foot to control damping off. The seeds were planted broadcast immediately after the acetic acid treatment. Germination was completed in about 16 days. A good, dense stand was produced and no damping off was noted then or thereafter. The boxes were screened with a ¼″ mesh for a week after germination and thereafter received full sunlight.

During the growing season (May 4-October 9, 1940) the only treatment the seedlings received was weeding and daily watering using city tap water, until July 10 when the stands were thinned to an approximate 2″ x 2″ spacing.

About July 3, 1940 it was noticed that the needles on the seedlings in the experimental box were a normal green while those in the control box were a decided yellowish green. In the inactive season the difference decreased although it was still noticeable. With the coming of the warm spring weather of 1941 this color difference again became pronounced.

About half the seedlings in each of the two boxes, excluding those along the edge of the boxes, were pulled on October 9, 1940. The remainder of the seedlings were left in the seedbeds. The seedlings were washed and blotted dry. Fifty seedlings from each box were separated into root and top and stored in numbered glassine envelopes. The balance of the seedlings was put in similar envelopes in lots of 10. 120 seedlings in all were taken from each box. These were immediately washed and counts were taken, using a microscope, to determine the number of short roots infected with mycorrhizae. These were expressed as a percentage of the total number of short roots. The counts showed that seedlings from the inoculated seedbed had an average of 87% of their short roots infected with mycorrhizae while seedlings from the uninoculated seedbed had only 10% infected. These results are shown in Tables 1 and 2. In this experiment no attempt was made to prevent spores from getting into the boxes hence the uninfected box was inoculated to a small extent, probably by wind-borne spores. Fifty individual seedlings from each box were used to determine the root/shoot ratio and the average dry weight of the whole seedling. The seedlings were dried in a constant temperature oven at 70° C. The root/shoot ratio of the inoculated seedlings was 1.15 and of the uninoculated seedlings 1.49. The total dry weight of the inoculated seedlings was 223.4 mgm. which is 32% heavier than the weight, 155.4 mgm., of the uninoculated seedlings. (Plate I). Fisher's "t" test shows this difference to be highly significant.

The heaviest roots are produced at about 300 p.p.m. external nitrogen concentration but the proportion of roots to shoots decreases with an increase of external nitrogen concentration above 50 p.p.m. (Mitchell).[1] Internal nitrogen concentration is positively correlated with external nitrogen concentration. The internal nitrogen concentration of the inoculated seedlings is significantly higher than in the non-mycorrhizae seedlings. The root/shoot ratio of the mycorrhizal seedlings is lower than root/shoot ratio of non-mycorrhizal seedlings. This relationship holds whether total nitrogen or N% is used as a standard.

The tops and roots were analyzed for nitrogen, phosphorus and potassium, using the micro-Kjeldahl ammonium-molybdate cobalt nitrite methods respectively. Data is summarized in Table 2, from which it is seen that

[1] Mitchell, H. L. et al. (1937), The Relation between Mycorrhizae and the Growth and Nutrient Absorption of Coniferous Seedlings in Nursery Beds. (Black Rock Forest Paper, Vol. I, No. 10).

[2] Hatch, A. B. (1937), The Physical Basis of Mycotrophy in Pinus. (Black Rock Forest Bulletin No. 6).

[1] Mitchell, Harold L., Pot Culture Tests of Forest Soil Fertility. Black Rock Forest Bulletin No. 5, 1934.

nitrogen and potassium were taken up in larger quantities by the inoculated seedlings than by the uninoculated ones. Phosphorus was absorbed in a slightly larger quantity by the inoculated seedlings than by the seedlings which were not inoculated. Rosendahl [1] found that mycorrhizae on seedlings was correlated with greater intakes of nitrogen and potassium on soils where phosphorus was not deficient. It is difficult to explain why the mycorrhizal seedlings did not take up a larger quantity of phosphorus. The difference in the quantity of phosphorus absorbed by the mycorrhizal and non-mycorrhizal is not significant and yet the soil in which both grew was infertile, having a high percentage of clay. It may be that the phosphorus was tied up by colloidal action and that the mycorrhizae were unable to absorb this bound phosphorus. Nitrogen and potassium on the other hand are usually present as easily exchangeable ions and hence can be readily assimilated. It was observed that frost killed fewer inoculated seedlings than uninoculated seedlings. The higher K intake may account for this. The decomposition of the fungi used to inoculate the experimental box probably contributed some nutrients but the amount must necessarily be very small when it is remembered that fungi are composed of from 90-95% water. The color difference previously noted is in agreement with the total weights and internal nitrogen concentrations of the control and experimental seedlings.

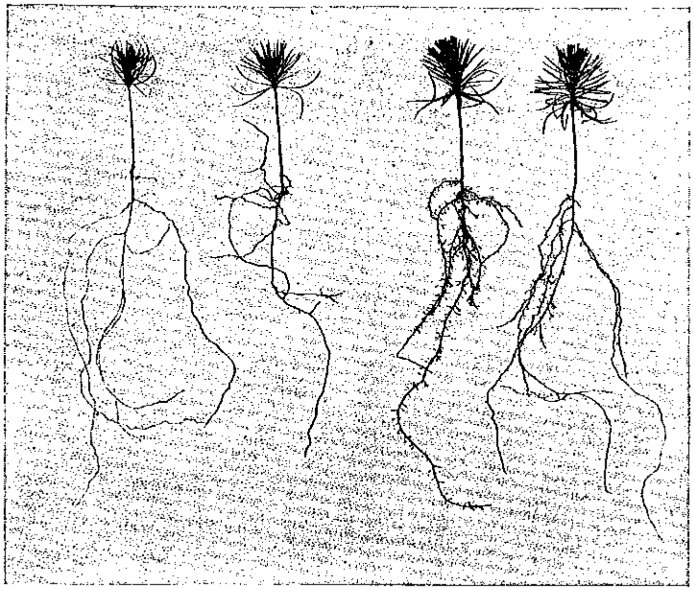

PLATE 1. Uninoculated, left; inoculated, right.

[1] Rosendahl, R. O., Survey of Mycorrhizae in Forest Nurseries or the Lake States, Technical Note 21, Coll. of Agric., University of Wisconsin, 1941.

Conclusions

(1) If a soil of low fertility is inoculated with known mycorrizhae-forming fungi and mycorrizhae form in sufficient numbers on the seedlings, the growth of the seedlings will be significantly increased.

(2) Nitrogen and potassium were absorbed in significantly larger amounts by mycorrizhal seedlings than by non-mycorrizhal seedlings.

(3) Nitrogen deficiency in the uninoculated seedlings produced a characteristic yellow-green color in the needles.

TABLE No. 1

Treatment	*Weight in mgm. of*			*Root/Shoot Ratio*	*% of Short Roots Infected With Mycorrhizae*
	Tops	*Roots*	*Whole Seedling*		
Inoculated Seedbed	104.0	119.4	223.4	1.15	87
Uninoculated Seedbed ..	62.5	92.9	155.4	1.49	10

TABLE No. 2

Treatment	*% Short Roots Infected with Mycorrhizae*	*Nitrogen %*			*Mgm. N in Whole Seedling*	*Phosphorus %*			*Mgm. P in Whole Seedling*	*Potassium %*			*Mgm. K in Whole Seedling*
		Tops	*Roots*	*Whole Seedling*		*Tops*	*Roots*	*Whole Seedling*		*Tops*	*Roots*	*Whole Seedling*	
Inoculated Seedbed	87	.98	.78	.88	2.05	.13	.14	.135	.30	.64	.71	.68	1.52
Uninoculated Seedbed	10	.79	.71	.75	1.17	.16	.15	.155	.24	.58	.68	.63	0.98