Effects of Recently Incorporated Organic Amendments on Damping-Off of Conifer Seedlings

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ABSTRACT

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In greenhouse tests, forest nursery soil containing the damping-off fungi *Fusarium oxysporum, Rhizoctonia solani,* and *Pythium* spp. was planted to oats (*Avena sativa*), rye (*Secale cereale*), buckwheat (*Fagopyrum esculentum*), and red clover (*Trifolium pratense*). After 15 and 20 wk, these green manure crops were incorporated into the soil, which was then amended with two levels each of sphagnum peat or fresh conifer sawdust. Black spruce and jack pine planted on these soils were not significantly affected by the peat or sawdust amendments but the oat, rye, and red clover green manure crops caused an increase in postemergence damping-off. Jack pine was most affected by 15-wk-old oats and rye. Black spruce had the most postemergence damping-off in soil containing 15-wk-old red clover. Based on these results and earlier studies, it is suggested that any green manure crop is potentially damaging if incorporated into soil immediately before planting.

Undecomposed plant residues incorporated into soils before planting can have various effects on the ensuing crop. Beneficial effects include improved soil tilth, aeration, moisture-holding capacity, improved root penetration, and suppression of pathogenic microorganisms (1,5,7,9,15,16). Deleterious effects include release of phytotoxic decomposition products (2,11–13), competition for nutrients (4,18), and enhancement of pathogenic microorganisms (3,14,19). In spite of extensive research and reviews on various aspects of this subject (2,4,10,12), information is general and many studies are only applicable to specific crops grown in limited geographic areas.

Effects of plant residues on seedling growth and disease incidence depend on maturity of the tissues, their carbon: nitrogen (C/N) ratios, and time elapsed between incorporation and planting. Immediately after incorporation, there is usually an explosion of microbial activity including germination of propagules of pathogenic fungi (1,10,16). If susceptible seedlings are present at this time, they might be invaded by these pathogens. In the absence of susceptible hosts, however, many of these newly germinated fungal hyphae may be lysed by soil bacteria or starved by competition for nutrients (1,5,7,16). Disease incidence may sometimes be decreased by delaying planting for several weeks after incorporation of green manure crops (9). Phytotoxic effects from decomposing plant residues have been found to increase for 10–25 days after incorporation and then decrease (13). Decomposed sawdust is considered superior to fresh sawdust as an organic amendment in forest nurseries (8,18).

Certain fresh plant residues appear especially damaging to emerging conifer seedlings (3,14,19). The nature of these effects has not been determined in most instances, but Redfern (14) demonstrated an increase in fungal damping-off after incorporating buckwheat stems. Iyer and Benson (6) noted suppression in seedling growth after incorporating coniferous bark but this was offset by adding nitrogen fertilizer plus inoculum of a wood-rotting fungus. Thus, effects on seedlings may be direct through competition for nutrients or through injury by phytotoxins or indirect through stimulation of pathogenic fungi.

In forest nurseries, agronomic crops are often planted between rotations of conifer crops, not only to augment organic matter levels but to prevent erosion. In addition, peat, sawdust, or bark amendments may be applied before seeding of conifers. The fallow period before seeding is short and is usually during the cooler spring or fall months when decomposition is slow. Some green manure crops and amendments might be superior to others for this practice but there has been little systematic investigation of this possibility. Therefore, this study was designed to determine if there is significant variation in effects of various green manure crops, combined with other organic amendments, on seedling performance.

MATERIALS AND METHODS

The soils used were fine sandy loams, pH 5.0–5.5, collected from local forest nurseries and had been used previously to grow seedlings in the greenhouse for pathogenicity studies with damping-off and root rot fungi. Populations of *Fusarium oxysporum* Schlect., *Rhizoctonia solani* Kühn, *Pythium* spp., and *Cylindrocarpon* spp. were therefore present.

Soils were mixed thoroughly, screened through a sieve with 0.5-cm openings, and placed in wooden flats 30 × 50 × 6 cm, which were placed in the greenhouse and watered daily. After 1 wk, half of the flats were planted to green manure crops, and 5 wk later, the remainder were planted (with the exception of the controls, which were left unplanted). The green manure crops, oats (*Avena sativa* L. 'Stormont'), rye (*Secale cereale* L. 'Kustro'), buckwheat (*Fagopyrum esculentum* 'Redstraw'), and red clover (*Trifolium pratense* L.), were grown during the summer in a glass greenhouse and weeded regularly. Flats of rye were placed in a coldroom at 5 C from the ninth through the 13th week after planting to simulate vernalization.

Twenty weeks after the first planting, all green manure crops were chopped into 2-cm or smaller segments and incorporated into the soils on which they had been grown. At the time of incorporation, the first planting of oats was nearly ripe and the second planting was in the dough stage. The first planting of rye was about 30 cm tall and had not begun to flower; the second was about 10 cm tall. The first planting of buckwheat had been ripe for about 3 wk; the second still had green leaves and some ripened seed. The first planting of red clover was about 20 cm tall and had a few flower buds; the second was 15 cm tall and had not begun to flower.

The soils were reworked and watered every 2–3 days for 2 wk. Each was then divided into five equal parts; one served as a control and four were amended with 1) 10% (v/v) fresh spruce-fir sawdust from a local sawmill, 2) 2% sawdust, 3) 10% (v/v) comminuted Fafard sphagnum peat, and 4) 2% peat. Each of the 45 soil mixtures was placed in a clay pot with a 12.5-cm top diameter and watered for the next 2 days. Triplicate pots of each type were planted to either jack pine (*Pinus banksiana* Lamb.) or black spruce (*Picea mariana* (Mill.) B.S.P.), 30 seeds per pot. Seeds were covered with 0.5 cm of coarse silica sand and pots were placed in a glass greenhouse at 20 C night temperature and

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day lengths were extended to 16 hr with 300W incandescent lights.

Seedlings were counted twice each week until mortality ceased. Dying seedlings were surface-sterilized in 1% sodium hypochlorite for 2 min, then diseased portions were excised and placed on 2% malt-extract agar to isolate damping-off fungi. Differences among treatments in emergence, postemergence mortality, and survival were evaluated using two-way analyses of variance and means were compared using Newman-Keuls multiple range test (20).

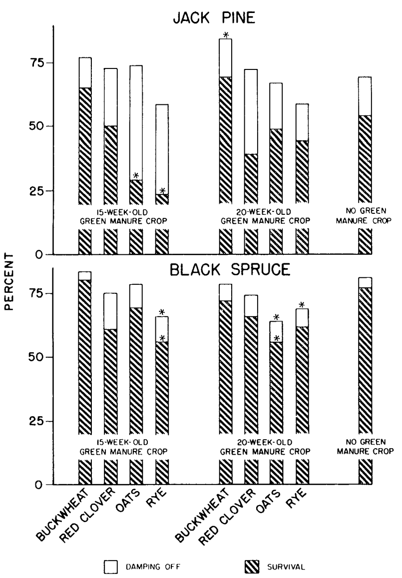

Fig. 1. Emergence, postemergence damping-off, and survival of seedlings grown in soils with freshly incorporated green manure crops. Percentages were based on the number of seeds planted. Starred columns are significantly different ($P = 0.05$) from the unamended control.

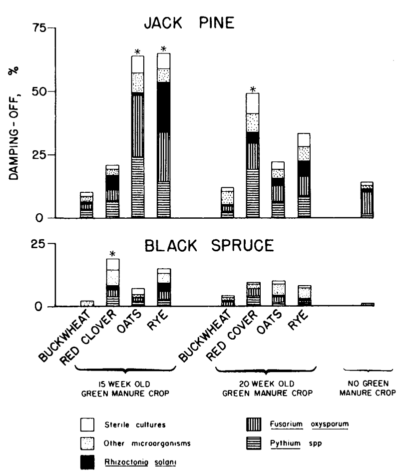

Fig. 2. Percent postemergence damping-off and fungi cultured from damped-off seedlings in soils with freshly incorporated green manure crops. Percentages were calculated from arc sine $\sqrt{\%}$ transformed values and based on the number of emerged seedlings. Starred columns are significantly different ($P = 0.05$) from the unamended control.

RESULTS

Nearly all variation in seedling performance could be attributed to the green manure crops. Sawdust and peat amendments did not significantly affect emergence, mortality, or the final number of seedlings per pot, and there were no significant interactions between green manure crops and sawdust and peat amendments.

Emergence of jack pine was enhanced (ie, preemergence damping-off was suppressed) by mature buckwheat but was not affected by the other treatments. Black spruce emergence was suppressed by ripened oats and by both 15- and 20-wk-old rye (Fig. 1).

Postemergence damping-off in jack pine was increased by the younger oat and rye crops and by the older red clover, and increased damping-off of black spruce was observed in soil amended with 15-wk-old red clover (Fig. 2). Pythium damping-off was the disease most frequently stimulated by the green manure crops, although designation of causal agents is difficult because of frequent co-occurrence of damping-off fungi (17). Rhizoctonia damping-off was stimulated by the rye crops.

Generally, all cover crops except buckwheat enhanced postemergence mortality and reduced survival (Figs. 1 and 2). Age of crop was almost as important as species. Fifteen-week-old oats and rye reduced survival of jack pine, whereas 20-wk-old oats and 15-wk-old rye lowered survival of black spruce.

DISCUSSION

Effects of organic amendments vary with soils, climate, and crop species as well as with the type of amendment. Based on results of this study, claims cannot be made for one green manure crop over another with respect to their effects on conifer seedlings. Although buckwheat appeared to be the least damaging of the green manure crops, earlier work (14) has demonstrated that this crop also can stimulate damping-off fungi. In general, planting immediately after plowing under green manure crops must be discouraged. Peat and sawdust appeared to be less detrimental than green manure crops as preplanting amendments, but planting immediately after their incorporation also may be unwise.

Green manure crops either stimulated populations of damping-off fungi, particularly *Pythium* spp., or caused seedlings to be more susceptible to damping-off. The same fungi that cause damping-off can be involved in decomposition of green plant material, especially succulent immature tissues with low C/N ratios. In these experiments, the green oat, rye, and red clover crops caused more damping-off than the more mature buckwheat, and C/N ratios, though not specifically studied, provide a possible explanation for these differences.

A fallow period of several weeks or months between the time of incorporation of organic amendments and the planting of conifers may allow a drop in pathogen populations and a reduction of other deleterious side-effects of decomposing organic matters. The fallow period may not be entirely compatible with other requirements, eg, a cover crop to prevent erosion, but may pay dividends in seedling survival and quality.

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