Topsoil storage effects on primary production and rates of vesicular-arbuscular mycorrhizal development in *Agropyron trachycaulum*

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Summary  A greenhouse study was conducted to determine the effects of stockpiling prairie grassland topsoil for 3 years on mycorrhizal development and root and shoot production of slender wheatgrass. The vesicular-arbuscular mycorrhizal (VAM) fungi involved in the symbiosis were also assessed as was the decomposition potential of the soil. During the first week of growth, VAM development in grasses grown in the stockpiled soil lagged behind that observed for grasses in the undisturbed soil. However, by 3 weeks, the mycorrhizal infection in plants in the stockpiled soil had reached levels similar to that in plants in the undisturbed soil. The dominant species of VAM fungi involved in the symbiosis at 8 weeks after planting shifted from *Glomus fasciculatum* in the undisturbed soil to *G. mosseae* in the stockpiled soil. The delay in initial VAM infection and shift in VAM fungal species did not significantly affect plant productivity which was greatest in the stockpiled soil. The greater shoot production exhibited by grasses in the stockpiled soil was attributed to higher levels of NO₃-N in the stockpiled than undisturbed soil. The potential of the soil to decay dead slender wheatgrass roots was not altered by stockpiling.

Introduction

It has become widely recognized that VAM fungi benefit their hosts by improving their ability to absorb P^{12}. There is also some evidence that the VAM relationship may play an important role in the water relations of the plant and in doing so improve its survival^{3,19}. Plants grown in minespools, particularly those located in the semi-arid regions of western North America, are subjected to both nutrient and moisture stress; therefore, it is reasonable to assume that mycorrhizal fungi are necessary to ensure their establishment, survival and growth in these relatively extreme environments.

Various studies have demonstrated that stockpiling topsoil not only reduces the microbial biomass^{18,22}, but also causes a significant decrease in the VAM infection potential^{7,17}. These observations could partially explain the lower VAM infection measured in plants grown in minespools amended with stored topsoil compared with infection in plants grown in undisturbed prairie soil^{2,9}. The rate at which annual plants become mycorrhizal may be crucial in semi-arid climates where
moisture is often limiting and plants must respond rapidly to rainfall events. It has also been suggested that plants may be more dependent on the mycorrhizal symbiont during the early phases of growth that at later stages\textsuperscript{12}. Therefore, when determining the effectiveness of VAM fungi, the rate of mycorrhizal development, particularly in plants grown in short season climates, should be considered\textsuperscript{1}.

In view of this, it was decided that the rate at which grass seedlings become mycorrhizal, rather than inoculum levels or percent VAM infection at isolated sampling times, would provide a better indication of how stockpiling could have potentially detrimental effects on plant establishment and growth. Consequently, a study was conducted in the greenhouse to determine the effect of stockpiling prairie soil for 3 years on root and shoot production by *Agropyron trachycaulum* (Link) Malte (slender wheatgrass), the rate of mycorrhizal development, and the VA fungi involved in the symbiosis.

**Materials and methods**

The study site was located at Bow City, Alberta within the mixed grass prairie of the eastern Alberta plains. A full description of the site and details of stockpile construction and plot design have already been reported\textsuperscript{21,22}. Thirty six months after stockpiling, 6 replicate samples were randomly removed from the undisturbed grassland plot and from the 0–15 cm, 100–150 cm and 150–200 cm depths of the stockpile\textsuperscript{22}. Soil samples were passed through a 2 mm screen. Separated roots were cut into 1–2 cm segments and returned to their respective samples since it has been demonstrated that roots are an important source of VAM inoculum\textsuperscript{17}. After thoroughly mixing each of the stockpile samples, subsamples of equal size were removed from each of the 3 depths sampled from each stockpile subunit and combined. The combined stockpile samples were considered equivalent to the soil mixture which would result if the stockpiled soil was spread on a minespoil.

The levels of PO$_4$ ions in the grassland and stockpiled soil samples were 2.5 and 1.8 $\mu$g g$^{-1}$ respectively, while NH$_4$-ions were 2.6 and 8.7 $\mu$g g$^{-1}$ respectively. The quantity of NO$_3$-N was significantly ($p < 0.05$) greater in the stockpiled soil (13.2 $\mu$g g$^{-1}$) than in the undisturbed grassland soil (0.4 $\mu$g g$^{-1}$).

**Time required to achieve VAM infection**

Soil from each of the 6 undisturbed and 6 stockpile samples was packed into 65 cc Leach Cone-tainers (Ray Leach, Canby, Oregon) using 3 replicates. Each container was planted with a slender wheatgrass seedling germinated 2–3 days previously. Seedlings were watered with distilled water and raised in the greenhouse (photoperiod of 20 h and minimum light intensity of 3.5 klux; air temperature 16–25°C). At 1, 3 and 5 days after planting, 1 seedling from each replicate soil sample was assessed for shoot and root weights. The total root length per seedling was determined using a map-measuring device and the entire root system was then cleared, stained\textsuperscript{13} and mounted. The root system was scanned under 200 X magnification, and the number of VAM 'infection units' counted. The 'infection unit' was defined as 'the internal mycelium relating to a single entry point'\textsuperscript{5}.

**Rate of VAM development**

Leach tube Cone-tainers (150 cc) were filled with remoistened soil from (1) undisturbed grassland, and (2) stockpiled topsoil with all 3 depths combined. Tubes in each treatment