ABSTRACT

Oil sand companies are evaluating techniques to solidify wet slurries and produce a non-segregating tailings stream known as consolidated or composite tailings (CT). Successful establishment of vegetation directly on CT can contribute to dewatering and assist in meeting reclamation objectives. The goal of this research was to develop a list of plant species which may be suitable for dewatering and reclamation of consolidated tailings. A growth chamber study was conducted in 1999 and a greenhouse study in 2001. In total, 44 native grasses, 50 native forbs, 8 introduced grasses and 4 introduced forbs were tested. The density of seedlings was recorded for 6 to 10 weeks depending on the experiment. Maximum emergence and establishment were calculated, and species vigour evaluated. Height and leaf number were measured in 1999. Grasses had higher average emergence and establishment (19.6% and 29.8%) than forbs (16.1% and 7.9%) in both studies. Introduced species had higher emergence and establishment (56.4% for grasses and 37.4% for forbs) compared to native species in CT treatments. All species except introduced grasses had higher emergence in control treatments compared to CT treatments. Field research needs to be conducted to further test the 14 grasses and 6 forbs identified in these studies as having potential for biological dewatering and reclamation of consolidated tailings.

INTRODUCTION

Oil sand companies are evaluating techniques to solidify wet slurries and produce a non-segregating tailings stream known as consolidated tailings (CT). Successful establishment of vegetation directly on CT can contribute to dewatering through evapotranspiration, increasing the solids content (by as much as 50 to 60%) and surface stability allowing the substrate to be traversed. Vegetation establishment on CT also reduces erosion, increases aesthetics, encourages wildlife use and promotes long-term plant community development. Limitations to plant growth on CT, however, include water logging and associated low bearing capacity, high salt content, crusting, low organic matter and low fertility. Research was conducted in a greenhouse where performance of different plant species could be compared directly under controlled growing conditions.
The goal of this research was to develop a list of plant species which may be suitable for dewatering and reclamation of consolidated tailings. Two studies were conducted. The specific objective of each was to determine plant species emergence, establishment and vigour when grown in CT.

**MATERIALS AND METHODS**

Treatments consisted of CT and a control of commercial potting soil. In 1999, CT was replicated by mixing material from Syncrude Canada Ltd. including tailings sand, mature fine tailings, recycled water and phosphogypsum. CT was poured into trays containing 18 cells within 1 cm from the top. The trays were arranged in a growth chamber on a sheet of plastic that folded over the top of the trays to slow the rate of evapotranspiration. The CT trays did not contain drainage holes (to approximate worst case scenario), while the control trays did. For each species, 25 seeds were sprinkled on top of control and CT mixtures. Each species was replicated 4 times for a total of 100 seeds. The control treatments were watered with tap water and the CT treatments with recycled water from Syncrude. A film of 2 to 5 mm water on the surface of CT was maintained. Growth chambers provided an average of 16 hours of light per day. The temperature was maintained at 15 °C for 16 hours then lowered to 10 °C during 8 hours of darkness.

In 2001, CT was shipped from Suncor Energy to the university greenhouse. The CT had been exposed to freeze-thaw conditions for at least one year and therefore had a higher solids content than that used in the 1999 research. Pots were filled with CT, the surface lightly raked with a fork and 20 seeds sprinkled on top. This was replicated 5 times for each species. The greenhouse was maintained at a 16 hour photoperiod and a temperature of 21 °C. Heat lamps were not turned on for the first 10 days following seeding to reduce desiccation and allow for maximum germination. Pots were watered with distilled water and CT remained moist. Drainage water was collected by placing each pot in a plastic bag and periodically poured back into the pot.

Plant species were selected based on past oil sands research, their suitable attributes for reclamation of disturbed lands such as ability to bind soil and provide quick vegetation cover and/or presence in the Boreal Forest ecoregion.

In 1999, 6 week and 10 week sessions were conducted; in 2001, an 8 week session was conducted. Monitoring was conducted every 3 to 4 days depending. The number of seeds that germinated and emerged were initially counted. Following germination and emergence, establishment was determined by counting live seedlings. Seedling vigour (colour, wilting, size) was observed. In 1999, height and number of leaves were recorded. Tufts of stems were counted for bunch species such as *Poa alpina* (alpine...
bluegrass) and Deschampsia caespitosa (tufted hairgrass). For rhizomatous species such as Agropyron dasystachyum (northern wheatgrass) each tiller was counted. Paired t-tests were conducted to determine differences in plant performance in control and CT treatments.

RESULTS

Emergence was greater for most species, grasses and forbs, in control treatments compared to CT. Grasses had higher emergence than forbs. In the 2001 study, Phleum commutatum (alpine timothy), Trisetum spicatum (spike trisetum) and Elymus innovatus (hairy wildrye) had greater emergence in CT treatments than in controls though results were not significant. In the 1999 study, introduced grasses had slightly higher emergence in CT treatments than controls. Introduced species had higher emergence than native species in CT treatments. Native grasses had higher emergence in the 2001 study with a mean for grasses of 48% compared to 23.5% in 1999. Native forbs, however, had higher emergence in the 1999 study (19.4% versus 1.7% in 2001). Native forbs did not establish in abundance even in controls.

Survival was greater in the control treatments than in CT treatments. Mean seedling height and leaf number were reduced in CT treatments compared to the controls. Most seedlings showed signs of reduced vigour including drying tips, wilting and discolouration by the end of the studies. In 1999, seedling survival following 10 weeks was lower for all species groups compared to the 6 week study. Percent survival was much lower even for species that had high emergence. Only 10% of the native forbs that germinated and 11% of the introduced forbs survived in 1999. The percent survival for grasses was 27.5% for native grasses and 49.4% for introduced grasses. In 2001, only 25.5% of the native grasses survived and 1.4% of the native forbs.

CONCLUSIONS

The fourteen grass species that performed best on consolidated tailings were: Phleum commutatum (alpine timothy), Trisetum spicatum (spike trisetum), Festuca saximontana (rocky mountain fescue), Festuca ovina (sheep fescue), Agropyron dasystachyum (northern wheatgrass), Agropyron trachycaulum (slender wheatgrass), Elymus innovatus (hairy wildrye), Deschampsia caespitosa (tufted hairgrass), Agropyron riparian (streambank wheatgrass), Agrostis scabra (ticklegrass), Koeleria macrantha (junegrass), Poa alpina (alpine bluegrass), Poa pratensis (Kentucky bluegrass) and Bromus ciliatus (fringed brome).

Native forbs did not establish in abundance in any treatment including controls. Methods to break seed dormancy and enhance establishment, particularly of legumes, need to be investigated. Six forbs were
identified for further research: *Glycyrrhiza lepidota* (wild licorice), *Helianthus annuus* (annual sunflower), *Vicia americana* (wild or American vetch), *Helianthus maximilianii* (sunflower), *Hedysarum boreale* (northern hedysarum) and *Oxytropis splendens* (showy locoweed).

Field research needs to be conducted to further test the potential of these species for biological dewatering and reclamation of consolidated tailings.

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