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Research Note

Artificial rope-wick roots improve the germination and establishment of tree species

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Summary

Direct seeding is an alternative method to conventional planting for woodland establishment that has several potential advantages. However, a major drawback of this approach is that there is often desiccation of the seeds. To overcome this problem a novel seed sowing technology was developed and tested, that involved artificial roots made of rope-wicks. Each wick root test included a mixed sample of seeds of Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), silver birch (*Betula pendula*) and grey alder (*Alnus incana*). Rucola (*Eruca sativa*) seeds were added to monitor germination conditions. It was shown that the seeds ability to germinate in relatively dry soil can be enhanced using the artificial roots by improving the capillary rise of water from deeper soil levels.

Experimental and discussion

Although direct seeding is a potentially cheaper method of woodland establishment than conventional planting, it is often considered to be less reliable. The main factor limiting seed germination is thought to be drying of the top layers of the soil (Castro *et al.,* 2004; Bolibok and Andrzeczyk, 2008). Both water and nutrient deficiencies often characterise the sites used for reforestation. Forest tree seeds are sown usually on the ground or up to 1 cm deep depending on the tree species and sowing method. The soil's top layer desiccates during warm and windy periods easily and puts germinating seeds and seedlings at risk, depriving them of the water necessary for vital functions (Oleskog *et al.*, 2000; Oleskog and Sahlén, 2000; Chantal, 2003; Hille and Ouden, 2004; Pamuk, 2004).

While conditions during the first vegetation season substantially influence subsequent growth (Winsa and Sahlén, 2001), it is important to create favourable conditions for emerging plants in order to achieve a higher level of bio-production and rate of survival in the tree community. Current techniques for enhancing water availability for small plants and seedlings are based on adding a super-absorbent into the soil near the roots of the plants. Pamuk (2004) published results for *Pinus sylvestris* L. seeds germinated using

short wick-roots (up to 6 cm) made of powdery superabsorbent material. In Pamuk's study the powder also worked as a water holding medium.

The aim of the work presented here was to verify the hypothesis that the seeds ability to germinate in relatively dry soil can be enhanced by improving local capillary rise of water and nutrients from deeper soil levels with artificial roots. Seeds were supplied with rope-wicks (artificial roots) and growth substrate granules. This approach was expected to support the seeds germination and the subsequent development of plants due to the larger water supply present in deeper soil layers.

An acorn of English oak (*Quercus robur* L.) was used as the model for our seed granule due to its sufficient nutrient supply and remarkably deep root (radicle). Seed granules were assembled from rope-wicks, support rods, growth substrate packets, fertilizer and seeds (figure 1). Capillary rise of soil water was secured by using special hollow cotton wicks. The artificial wick was attached to the support rod. The seed granule was shaped like a hollow cylinder, 5 cm long with a 1 cm inner diameter and a 2.5 cm outer diameter. The granules were prepared from a substrate made from coir covered by soft paper and shade cloth (as a supporting net). The substrate was to provide seeds with moisture and nutrients. The shade cloth located in the lower part of the granule enabled the roots to penetrate through its openings. The sprouts were mostly able to penetrate the soft paper covering the upper part of the granule. The 40 cm long support rod was made from wood with and had a diameter of 4.5 mm.

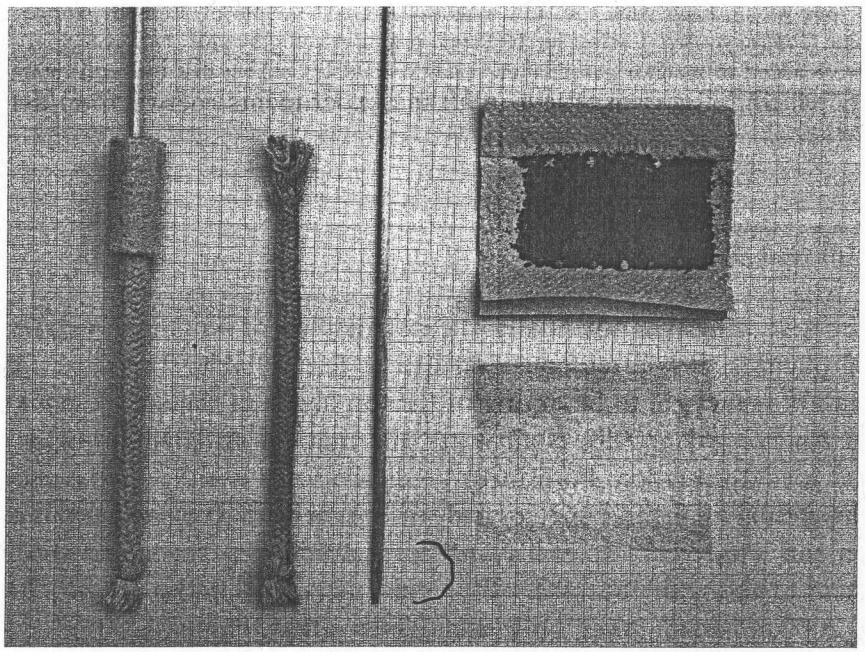

Figure 1. Assembled test granule (left) and its components: rope-wick, support rod, binding wire, paper with coir, seeds and fertilizer and support net. Background is graph paper with one line per mm and cm index lines.

Seeds of Norway spruce (*Picea abies* L.), Scots pine (*Pinus sylvestris* L.), silver birch (*Betula pendula* Roth) and grey alder (*Alnus incana* L.) were inserted into the granules. Rucola (*Eruca sativa* Mill.) were also added to evaluate the conditions under which

germination could take place; under favourable conditions rucola seeds germinate in just two days. The number of seeds inserted into one granule was no less than five for the forest tree species and no less than three for rucola. The test granules were planted up to their upper brims into holes poked into the soil. The holes were made using a simple tool designed to create a suitable hollow compartment for the wicks and the granules. Reference tests were conducted with the same sets of seeds, but without inserting them into granules; these seeds were sown simultaneously on the ground and approximately 5 mm deep nearby each granule. Four test sites were selected according to soil type as follows: (1) moist loamy sand (newly clear-cut forest); (2) peat (depleted peat field); (3) clay soil (on agricultural land); and (4) sand (in depleted sand and gravel mine). The total number of granules was 400, and the total number of sets of seeds used for reference tests was accordingly 800. The germination of seeds was assessed three weeks after sowing.

Germination of all the tree seeds inserted into granules sown into loamy sand was excellent (70-95%; table 1). The comparable experiments (seed sets sown 0.5 cm deep) resulted in lower germination (23-41%). These results clearly show that better water availability was secured through wicks. Surprisingly, on the peat soil the germination of seeds inserted into granules was approximately half that of seeds sown not in granules at a depth of 0.5 cm. The reason might be that the evaporation of water from the upper part of the granules was higher than its replacement through wicks and/or there was better aeration of seeds 0.5 cm deep in the soil compared with wick granules. The seed sets sown on the peat surface showed very low ability for germination due to the lack of humidity of the surface layers of this soil type. In the case of clay and sand, the germination of all the tree seeds used in the experiments was negligible. At the same time, the germination of rucola seeds in granules was excellent in all the experiments (between 80 and 95%; data not shown). The germination of rucola seeds not in the granules was negligible except when seeds were sown 0.5 cm deep in loamy sand when there was 44% germination.

The proposed solution of using wicks made of ropes in order to conduct water from deeper layers to the seeds rather than to store water near seeds is a completely novel and more efficient approach, compared with existing technologies.

Table 1. Germination of tree seeds determined three weeks after planting.

	Germination on loamy sand, %			Germination on peat soil, %		
Species	Granules	Seed sets sown 0.5 cm deep	Seed sets sown on the surface	Granules	Seed sets sown 0.5 cm deep	Seed sets sown on the surface
Norway spruce and Scots pine together	95	53	23	34	67	6
Silver birch	70	23	10	4	7	6
Grey alder	79	41	13	10	21	10

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