Destiny of Tree Seeds During Germination Under Stress

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INTRODUCTION

When testing germination capacity of seeds in soil or growth substrates the emergence of the shoot is normally recorded. Germination events in the soil are not observed. It would, however, be very beneficial to know more about what happens to the seed in the soil. When studying vigour in tree seeds, it is well known that high- and low-vigour seed lots display different emergence capacity. But what happens to the fraction of the seeds that do not emerge? These may die, stay alive without germination, or may develop a small root or shoot without being able to penetrate to the surface of the soil and, therefore, not establish themselves as seedlings. The fraction of seeds that will not be able to penetrate the surface is larger when environmental stresses increase, but it is not well known how different stress factors affect the destiny of seeds during germination. Increasing our knowledge of the different germination events in a population will enable us to better understand seed vigour and develop more reliable laboratory tests for testing field germination capacity.

METHODS

Seeds of *Abies nordmanniana* (nordmann fir) were prechilled under moist conditions at 4°C for 6 weeks to release dormancy, and sown in boxes with sand. These boxes were developed specifically to test the effect of different temperatures, soil moisture, and sowing depths. A specific type of washed sand was used as growth substrate. The sand was moistened before being placed into the boxes and moistened again in the boxes to water saturation. Afterwards, water was drained off to different levels of standing water in the boxes establishing distances of 4 (V8), 8 (V4), and 12 (V0) cm from the seed position to the water level. These three moisture regimes represent very high, semi-high, and close to optimal moisture contents of the sand. The oxygen concentration is expected to be inversely related to the sand moisture content. Surplus drained sand from each box was used to cover the seeds after sowing. No irrigation was done during the test period.

Exact sowing depths were obtained by using sand-scraping devices to establish a precise sowing surface and surface of the covering sand. The distance from sowing surface to cover surface was 1 (S1), 2 (S2) or 3 (S3) cm, providing increased mechanical stress to the seeds. Controlled temperatures of 5 (T5), 15 (T15) or 25°C (T25) were obtained by placing the sand boxes in growth rooms at 12 h artificial light.

One hundred seeds were sown in each box with three replicate boxes per treatment. Emergence was recorded after a 30-day test period and all non-emerged seeds were retrieved from the sand and classified into empty seeds, dead ungerminated seeds, viable ungerminated seeds, and seeds that germinated in the sand but did not emerge. The final average germination percentage (radicle protrusion of 3 mm) of 4 replicates of 100 seeds on top of moist filter paper at constant 5°C (T5) in the dark was used as control.

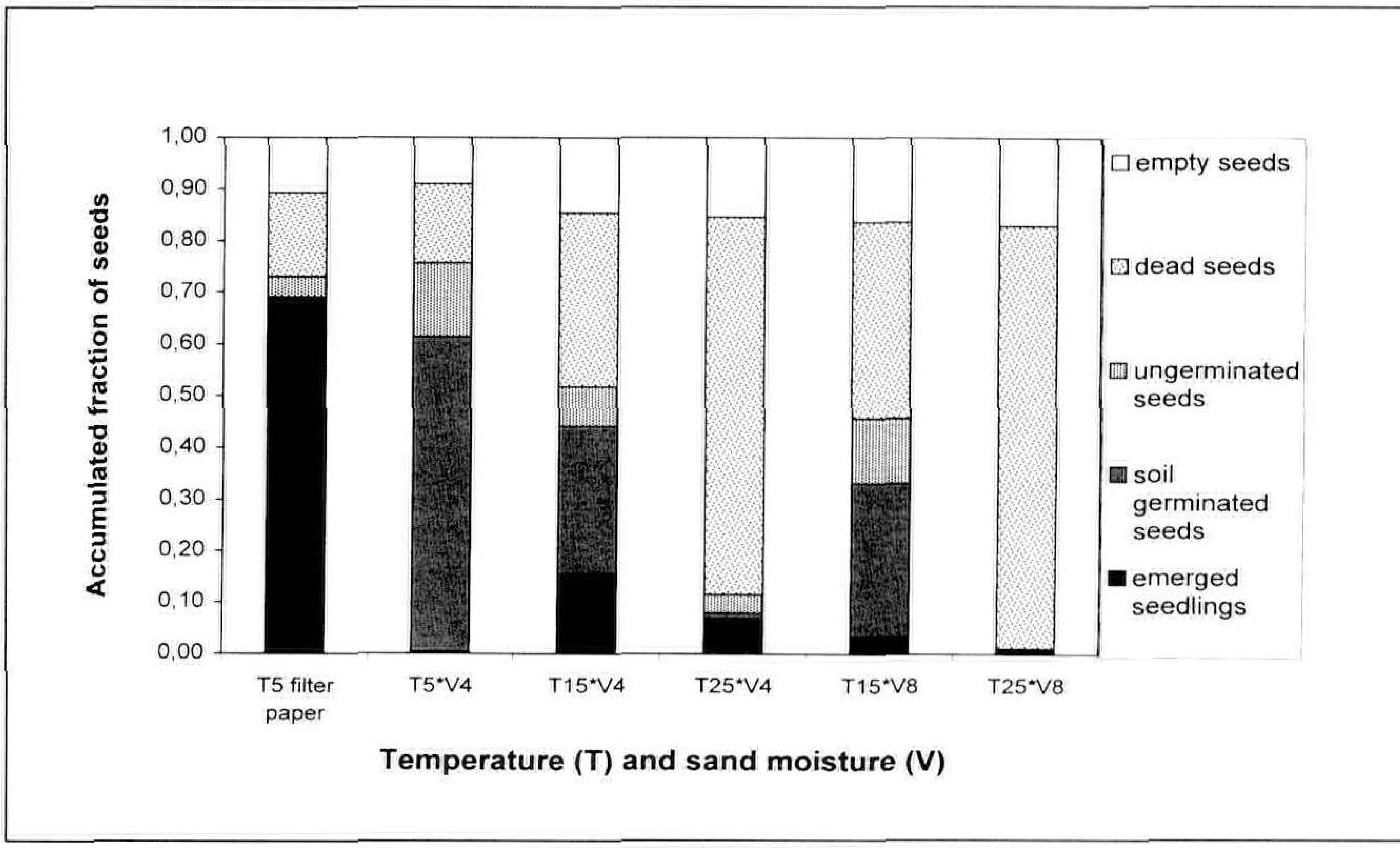

Figure 1. Destiny distribution of *Abies nordmanniana* seeds after a 30-day germination test in sand at different temperatures (T) and sand moisture contents (V). Sowing depth was 1 cm.

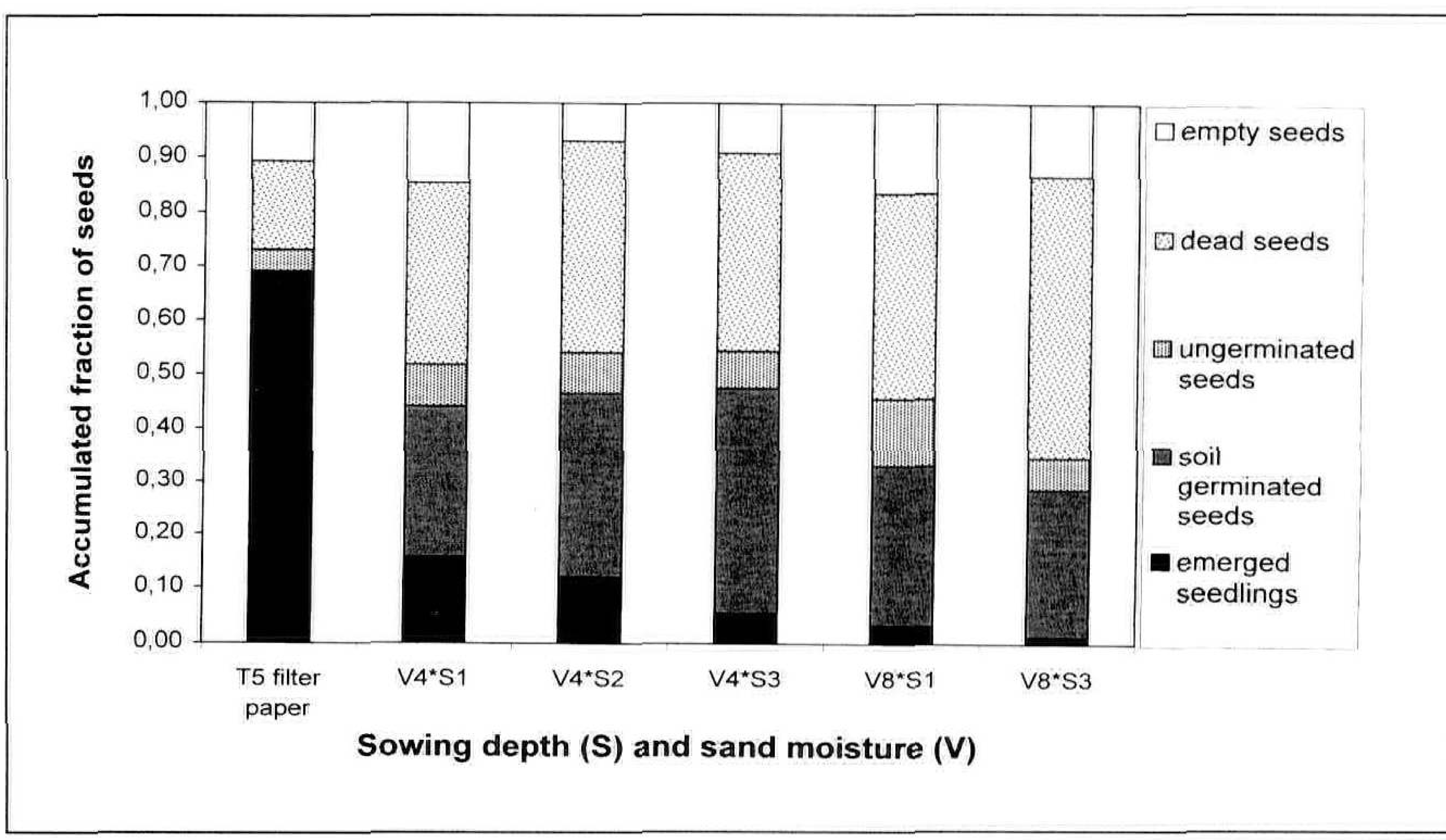

Figure 2. Destiny distribution of seeds after a 30-day germination test in sand with different moisture contents (V) and sowing depths (S). Temperature was 5°C in the filter-paper test or 15°C in sand.

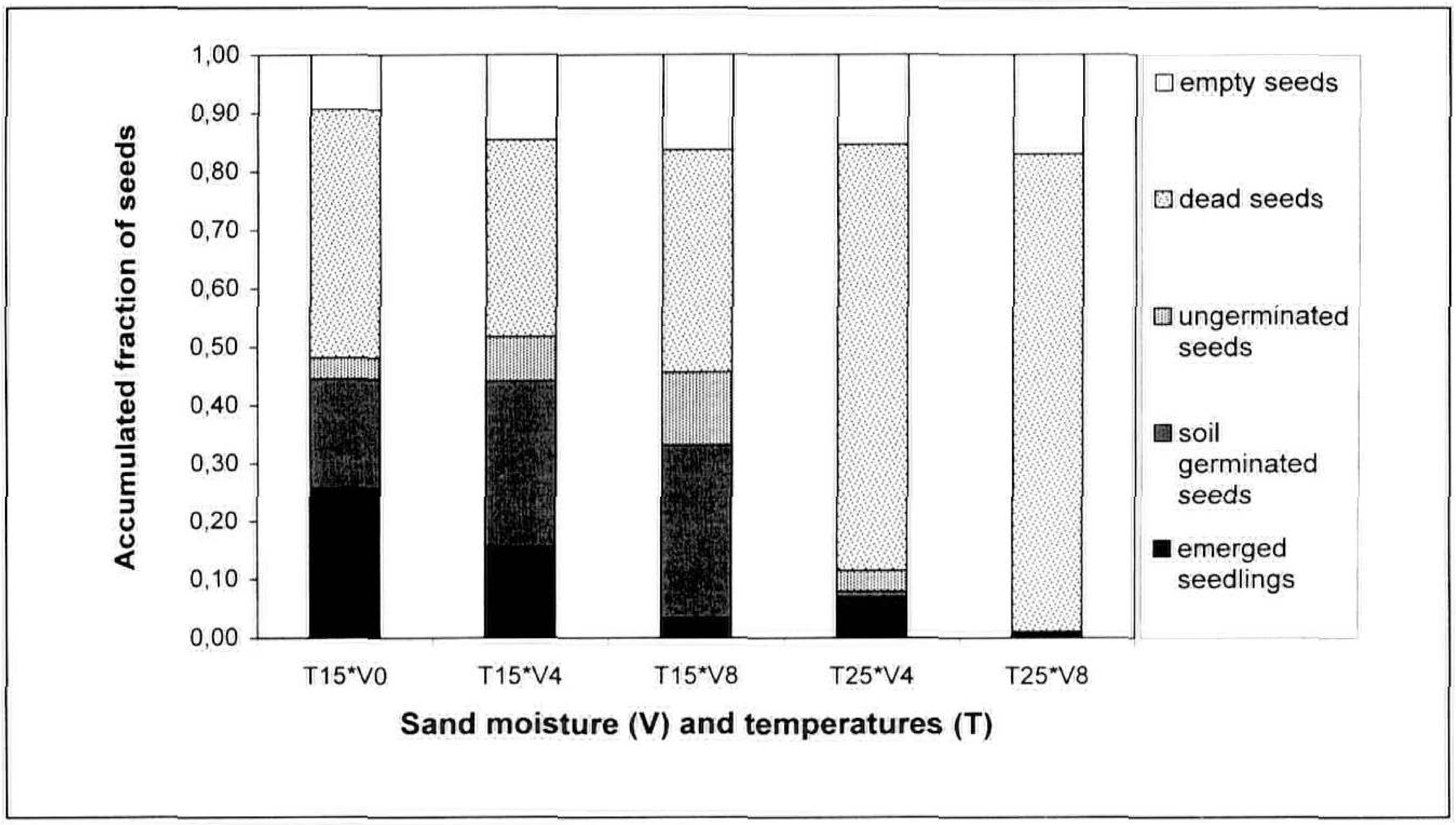

Figure 3. Destiny distribution of seeds after a 30-day germination test in sand at different temperatures (T) and sand moisture contents (V). Sowing depths was 1 cm.

RESULTS

Effect of Temperature. At 5°C and semi-high moisture content (T5V4) seeds germinated almost as well in sand as on filter paper (Fig. 1). However, none of the seeds emerged from the sand. At 15°C some seeds emerged but the fraction of dead seeds at the same time increased significantly. At 25°C a very large proportion of the seeds died before they could initiate germination. In sand with very high moisture content (V8) this was even worse, almost all seeds were killed at 25°C. The combination of high temperature and sand with very high moisture content is found to be detrimental to germination in this seed lot. This tendency is believed to be general to seeds of *A. nordmanniana*.

Effect of Sowing Depth. At 15°C even 1 cm of sand cover reduced the summed fraction of emerged and soil-germinated seeds compared to the germination capacity on filter paper at 5°C (T5, Fig. 2). At increased sowing depths the percentage of emerged seedlings decreased whereas the percentage of sand-germinated seeds increased correspondingly. Thus, the seeds were able to germinate but could not overcome the increasing mechanical resistance of the covering substrate to emerge. The combination of deep sowing and high moisture content of the sand seems to affect emergence capacity negatively.

Effect of Substrate Moisture Content. At 15°C the percentage of emerged seedlings decreased significantly at increasing moisture content from V0 to V8 while the total percentage of emerged, germinated, and viable seeds only changed little (Fig. 3). At 25°C emergence and soil germination was almost completely eliminated when substrate moisture was raised from V4 to V8.

DISCUSSION

This study clearly shows that not all seeds that will germinate under optimal conditions on moist filter paper at 5°C are able to germinate and emerge when sown in a substrate. This partly implies that the seed lot was of medium or low vigour and partly that germination in a substrate impose increased environmental stress on the seeds. Increased stress generally leads to reduced emergence. Seed germination in *A. nordmanniana* seems to be particularly sensitive to high temperatures, high moisture contents, and deep sowing — combinations of these factors giving detrimental results.

The results suggest that oxygen availability is critical. It is shown that it is possible to establish reproducible germination tests with defined stress. Such a test can be used as a vigour test for separating low- and high-vigour seed lots but may also be used to test and predict field emergence, when test conditions are chosen to simulate field stress. An applied vigour test for predicting field emergence based on the sand box system is currently being developed in our laboratory.

ADDITIONAL READING

Jensen, M. and **L. Westergaard.** 1999. Test af frøspiring under stress. Gartnertidende 115 (19)18-19.

Native and Naturalized Plants of North America Worthy of Garden Merit

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INTRODUCTION

The North American portion of the United States is vast with 9,375,000 km^2, 10 climatic zones, over 8000 native species of plants, and 1600 naturalized plant species (Flora of North America, 1993). The climates range from near tropical with rain forest, swamps to deserts, to high plains steppes, and high altitude mountains with arctic conditions at the summits.

Over all summers are hot, usually 25°C or higher, at times near 38°C, highly humid on the East Coast and much drier and less humid west of the Mississippi River. Winters are often cold in the northern portions with wide temperature ranges and snow.

More southernly reaches don't experience severe cold but this is relative with respect to plant populations. These vast climatic differences account for the great potential for natural plant development since many species occur over several climatic and geographic ranges. Plants of the same species found in New York will often be different from those in South Georgia or Texas.

Another factor influencing native plant development is the occurrence of glaciers during the several ice ages. The latest about 13,000 years ago pushed many cold-hardy species into the more southernly reaches of the continent where they have