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PROPAGATION AND ESTABLISHMENT OF *SPINIFEX SERICEUS* - A REVIEW

INVESTIGATION NO : S591
KEY OUTPUT NO: 4.19

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Forest Research Institute Contract Report: FWE 91/27

PREPARED FOR:
Director, Science and Research
Conservation Sciences Centre
Department of Conservation

DATE: June 1991

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CONTENTS

EXECUTIVE SUMMARY (FINAL):

KEY OUTPUT: 4.19
INVESTIGATION NO: S591

INVESTIGATION TITLE:	Propagation and establishment of *Spinifex sericeus* - a review
STUDY VENUE:	National
INVESTIGATION LEADERS:	D.O. Bergin and W.B. Shaw
INVESTIGATION STATUS:	Completed
CLIENT:	DOC, Science and Research Division

INVESTIGATION OVERVIEW:

Spinifex (*Spinifex sericeus*) is an important native sand-binding plant that occurs in many coastal areas of New Zealand. Many areas of coastline have been disturbed, resulting in major changes to foredunes, sometimes leading to erosion problems. A survey of relevant literature on the propagation and establishment of spinifex was undertaken by the Northern Wildlands section, Forest Research Institute, Rotorua, for the Department of Conservation in early 1991.

OBJECTIVE:

- To review relevant literature and other existing information on establishment techniques for the use of *Spinifex sericeus* for stabilisation of sand.

METHODS:

A computer search accessed references on sand-dune stabilisation using spinifex. Relevant information on ecology, propagation, and establishment of spinifex was summarised from these sources. Much of the information was sought directly from the Beach Protection Authority of Queensland, Brisbane, Australia. Information was also sought from individuals and nurseries in New Zealand known to have had some involvement with spinifex propagation or planting.

RESULTS:

Spinifex thrives in raw sand and is tolerant of salt spray, drought, extreme temperatures, and strong wind. It is superior to marram grass as a dune stabiliser because it has a greater tolerance of sea water, provides an even cover that forms a low dune, and spreads quickly downslope to invade fresh sand deposits.

Most research on spinifex and large-scale establishment programmes using spinifex have been done in Australia. Trials indicate that germination of spinifex seed is inhibited by light. Germination of seed in spikelets is consistently less than germination of seed that has been removed from surrounding layers of chaff. However, on a large scale, removing seed from spikelets is impractical.

The most commonly used method of establishing spinifex in Australia is by direct seeding. Large quantities of spikelets are broadcast onto the surface and harrowed into the sand. Spikelets need to be buried to a depth of at least 2.5 cm. Newly-sown areas are then covered with a mulch of brush, hay, or straw as a temporary sand stabiliser.

Small numbers of spinifex seedlings have been successfully raised from seed and cuttings in New Zealand nurseries. Cuttings are taken from terminal or lateral shoots of long rhizomes and rooted in a light potting mix within a mist unit.

An alternative to nursery-raised seedlings is transplanting layers or tip cuttings directly to new sites. Tip cuttings 40-60 cm long are planted to a depth of 20-30 cm at approximately 1-m intervals in spring.

Australian work, particularly with topdressing of direct-seeded sand dunes, indicates that spinifex responds to applications of nitrogenous fertiliser and to a lesser extent to phosphatic fertiliser.

CONCLUSIONS:

Revegetation of dunelands using spinifex is likely to be feasible in many disturbed areas of New Zealand's coast. Past work, particularly in Australia, shows that spinifex can be established successfully using a range of techniques. However, a comprehensive trial that compares planted nursery-raised seedlings with direct seeding and transplanted cuttings, and tests the need for fertilisers and sand stabilisers, is needed to determine the most appropriate techniques for establishing spinifex in New Zealand conditions.

6. MAIN FINDINGS

6.1 Ecology

6.1.1 Plant description

Spinifex is a stout perennial grass with strong creeping runners (Fig. 1). Leaves are usually 5-10 mm wide and up to 38 cm long (Craig 1984). The runners or stolons can be up to 20 m long, with internodes up to 20 cm long. Each node produces erect leafy shoots and adventitious roots. Leaves are upright, silvery green, and hairy on both surfaces (McDonald 1983). Spinifex is palatable to grazing stock (van Kraayenoord 1986).

Spinifex is dioecious, i.e., male and female inflorescences (or flowers) are borne on separate plants. Male and female plants form colonies of equal size (Connor 1984, Maze & Whalley 1990). The male plant produces pale brown, compact inflorescences about 5 cm long on short branches (Fig. 1D) (Harty & MacDonald 1972). The female plant produces large, spiny, spherical inflorescences about 20-30 cm in diameter (Fig. 1B). The female inflorescence is commonly a terminal head but a second or third head can develop below this. The head consists of many spine-like branches 10-15 cm long. Each spine has a single spikelet just above its base, which contains the seed. The head becomes detached from the plant and the spines help its wind-dispersal along the shoreline.

Both male and female inflorescences can become infected by a floral smut, *Ustiago spinificis*. High infection rates have been found in spinifex populations in Australia and New Zealand. In almost all of the infected inflorescences examined, all ovaries and anthers were destroyed by the smut (Kirby 1988). The diseased female inflorescence is strikingly different from the normal as spikelets are borne 1.5-4 cm above the base of each spine (Fig. 2). Kirby estimated that in infected populations, the reproductive cost of the smut is nearly 20%. However, because the relative importance of seedling establishment and clonal spread are not known for spinifex, the ecological significance of a reduction in seed set cannot be fully evaluated. Osborn (1922) describes in detail the effects of *Cintractia spinificis* on spinifex inflorescences (presumably an early name for the same species of smut). As seed of infected inflorescences are likely not to be viable, they should be avoided for revegetation purposes.

6.1.2 Distribution

Spinifex sericeus is common along the coast of Australia, New Zealand, and New Caledonia (Beach Protection Authority of Queensland 1981). In New Zealand it occurs throughout the country where there are sand dunes but is not found in the south of the South Island (van Kraayenord 1986). In Australia three taxa are recognized, each located in different areas (Craig 1984). *S. sericeus* occurs in the eastern states including Tasmania, and *S. hirsutus* is restricted to the south-west of Western Australia. *S. alterniflorus* occurs where the distributions of *S. hirsutus* and *S. longifolius* overlap in the south-west of Western Australia.

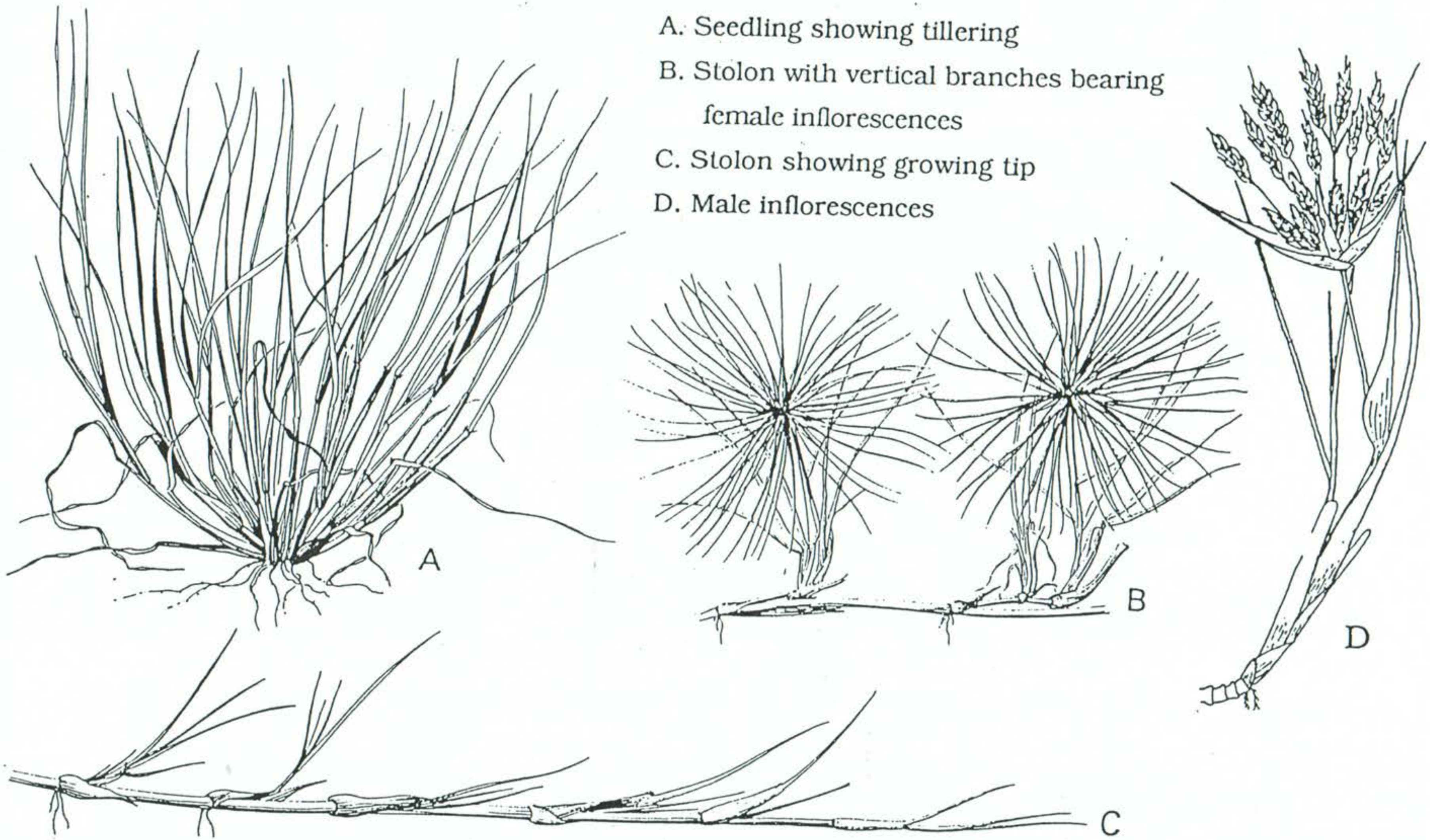

Figure 1: Growth characteristics of spinifex (*Spinifex sericeus*). (Illustrations A, B & C reproduced from McDonald 1983; illustration D by Dale Williams)

seems to have begun with spinifex establishing on an incipient foredune (Esler 1974). The stabilisation of the dune has, however, been retarded by cattle grazing the spinifex.

6.2 Germination trials

Harty & McDonald (1972) carried out a detailed study of the germination behaviour of spinifex seed. The Australian study indicated that because of the grain softness of spinifex seed, extraction methods that producted spikelets (seed enclosed with the outer chaffy scales and the spine still largely attached) were preferable to mechanical extraction of individual seeds (Harty & McDonald 1972). Of three machines tested, a barley de-awner produced spikelets in which the spines were uniformly clipped short so that they were free-flowing and suitable for mechanical sowing.

Preliminary tests showed that seed and spikelets were susceptible to the growth of saprophytic fungi during germination. Mould growth was controlled by applications of a fungicidal dust made up of 12.5% thiram as the active ingredient.

Laboratory experiments showed that germination of seed was significantly inhibited by light, with only 14% germination in light compared to 56% in the dark (Harty & McDonald 1972). This suggests that spinifex seed must be buried in the sand before appreciable germination will occur. Germination in the dark of separated seed (seed removed from surrounding layers of chaff and the spike) (56%) also significantly exceeded germination of seed in spikelets (21%). Germination in the spikelet may be inhibited by a slow rate of gaseous exchange between the embryo and the atmosphere.

Alternating periods of temperature were generally superior to constant temperature in inducing germination (Harty & McDonald 1972). Delayed sowing of seed for 2 months after collection indicated that there were no pronounced after-ripening requirements. There was no beneficial effect on germination of soaking spikelets in sea water or fresh water for various periods of time. There was also no evidence of water-soluble chemical inhibitors in the spikelets of spinifex.

Pot trials showed that in waterlogged sand germination was poor at depths below 3.75 cm. In sand held at field capacity germination occurred down to 8.75 cm, but maximum rates of 50 and 53% occurred at depths of 2.5 and 2.75 cm, respectively. Surface-sown spikelets did not germinate (Harty & McDonald 1972).

6.3 Propagation in New Zealand

There appear to have been few successful attempts to propagate spinifex. However, several nurseries have raised spinifex seedlings on a small scale. These include the New Plymouth District Council Nursery, and the Whakatane District Council and Butler's Nurseries in the eastern Bay of Plenty.

The New Plymouth District Council Nursery has successfully raised spinifex from seed and cuttings (K. Davey, New Plymouth District Council, pers. comm.). Fully open seedheads were harvested just as they were being released by the plants. The number of seeds per head varied considerably. Seed was difficult to extract because the awns were large. Viability appeared to be about 80% when seed was sown soon after collection. Germination was complete in 2-3 weeks, and the seedlings transplanted well. Small seedlings could, however, be over fertilised, resulting in high mortality.

The New Plymouth District Council also looked at two methods of propagation using cuttings. The first method involved collecting terminal and lateral shoot clusters in early December from long rhizomes of a healthy colony. These were divided into single shoot cuttings, the foliage was reduced by one-third and the cuttings were put into small pots with a pumice medium and placed in a mist unit. Rooting took 10 days, and the plants were potted into large pots in a light, low-fertility potting mix. Up to 70% of the cuttings rooted. Plant vigour was affected by waterlogging of the hairy leaves, which could have been the result of the wetting agent in the fungicide applied to the cuttings.

The second method involved selection of long rhizomes for stem-section propagation. The rhizomes were cut into 2-3 node sections and all dead material was removed. Shoot initiation occurred in only 10-15% of conventionally treated cuttings placed into small pots in a mist unit, but in 40% of stem sections laid on the surface of trays filled with pumice in the mist unit. Roots develop from the base of each shoot initial, which were easily cut from the original stem section when 6-8 leaves had developed. These were then potted on and treated as normal rooted cuttings or seedlings.

The Whakatane District Council Nursery in collaboration with the Department of Conservation collected seedheads in late February and early March (J. Perkinson, Whakatane District Council, pers. comm.). Separating the spikelets from seedheads was difficult. After being soaked in sea water overnight, spikelets doubled in size and viable spikelets sank, enabling easy recovery.

Spikelets sown into Tinus rootrainers or seed trays to a depth of 3-4 cm and placed in a shadehouse did not germinate. Spikelets sown in trays placed in a mist unit with bottom heat did begin to germinate slowly 6 weeks after sowing, and this continued sporadically for several months. Four months after sowing, seedlings were pricked out into rootrainers, taking care to include the spike so that damage to fragile roots was avoided. Only 7% of the spikelets sown survived 9 months after sowing, with seedlings 15-30 cm high.

The Whakatane District Council Nursery is also attempting to propagate seedlings from cuttings. Rhizomes collected from a local beach in early March were 2-3 m long and were hardened current season's growth. Soft ends of rhizomes were discarded. The rhizomes were cut into two and three-node lengths, with a straight basal cut below a node and a slanted cut above a node. Loose leaf and stem material was removed and the cuttings were inserted into rootrainers. Rooting occurred within 3 weeks where cuttings had been placed in a shadehouse and plants were liquid-fed with fertiliser (Phostrogen and Nitrophoska). Downy mildew became a problem during winter and was controlled by a fungicide (Bravo). Only 30% of the two-node cuttings have survived, but over 60% of the three-node cuttings. Growth of cuttings was vigorous, and a prostrate growth habit formed on many seedlings within 9 months of sowing. Propagation of cuttings resulted in

High sowing rates are necessary with these methods, and germination is commonly uneven or patchy (Barr *et al.* 1987b). Failure in germination is caused by one or more of the following factors:

- Unfavourable moisture and temperature conditions.
- Spikelets are sown too deeply or too shallowly or not buried at all.
- A large proportion of non-viable seed.

Incorporating spinifex seed within a plug of growing medium and sowing pre-germinated seed were tested at South Stradbroke Island. However, neither gave better results than the standard practice of sowing spikelets directly into the sand. The best method for establishing spinifex was using transplanted nursery-raised seedlings with fertiliser (Barr *et al.* 1987b).

Spinifex was successfully re-established on the Manawatu coast by hand sowing about 1930, and it now forms extensive stands (Esler 1970). However, details on how seed was sown are not known.

For New Zealand van Kraayenoord (1986) suggested seedheads be collected in January-February either as complete seedheads or as individual seeds. Contrary to the findings of Harty & McDonald (1972), van Kraayenoord suggested that soaking seed for 24 hours in sea water will improve germination. Seed should then be buried 2.5-4 cm deep.

6.4.3 Transplanting cuttings

In Australia, layers or tip cuttings 40-60 cm long planted to depth of 20-30 cm at 90-cm centres are usually successful. Planting depth varies according to moisture conditions (Beach Protection Authority of Queensland 1981).

For New Zealand conditions, van Kraayenoord (1986) recommended taking tip cuttings 50-60 cm long from vigorous growing stolons and planting in early spring, 20-30 cm deep at a spacing of 1 x 1 m. Spinifex can also be established by transplanting volunteer seedlings, carefully dug up without disturbing the root system.

The New Plymouth District Council Nursery have successfully transplanted spinifex after treating stolons before removal (K. Davey, pers. comm.). The method involves stimulating vigorous root development by cutting the rhizome on either side of each lateral or tip shoot cluster in March-April. In June-July the plants are then lifted for transplanting.

6.4.4 Fertilisers

Many studies in Australia have investigated the response of spinifex to applications of fertilisers. For most trials and management plantings of spinifex, topdressings of fertiliser were applied when seed was sown directly onto sand dunes. The objectives are to increase seedling vigour during the establishment phase and to speed up colonisation of the sand so that surface stabilisation is achieved in a relatively short period.

Early pot trials indicated that 56 kg of nitrogen/ha and 120 kg of phosphorus/ha increased yields of dry matter of spinifex by approximately 10 times over a 4-month period. In the field, stolon elongations of 50 cm/week were obtained by using 450 kg/ha of a mixed fertiliser, at 3-4 monthly intervals (Barr 1974). Further fertiliser trials carried out by the Beach Protection Authority of Queensland on South Stradbroke Island indicate that the best growth response was achieved by split applications of nitrogenous fertilisers and to a lesser extent by split applications of phosphatic fertilisers (Barr 1980, Barr & McDonald 1980, Barr & McKenzie 1980).

Up to 934 kg N/ha in five split applications every 3 months over a 15-month period increased growth rates and ground cover of spinifex and produced a significantly higher number of inflorescences (Barr & McKenzie 1980). A greater number of split-fertiliser dressings of nitrogen during the period of active growth (August to April in Australia) may be even more successful. Fertiliser was best applied after rain or when rain was expected. Although not tested, it was suggested that fewer applications of a slow-release fertiliser may be a worthwhile alternative to applying fast-release fertilisers regularly.

Field trials generally supported pot trials, indicating that superphosphate alone (9.2% P) had no effect on growth of spinifex (Barr 1980, Barr & McDonald 1980) but when applied with nitrogen did increase ground cover in the short term and ground biomass in the long term (Barr *et al.* 1983a).

6.4.5 Mycorrhizas

A pilot trial established on South Stradbroke Island, Queensland, to determine whether the growth and phosphorus-uptake of spinifex could be improved by inoculating it with spores of a suitable mycorrhiza showed no significant response to inoculation (Barr *et al.* 1983b).

6.4.6 Temporary sand stabilisers

The usual method of establishing spinifex on frontal dunes in eastern Australia is to cover newly sown exposed sand surfaces with a temporary sand stabiliser or mulch until vegetation cover is established. A layer of brush, hay or straw is normally used to protect newly germinated seedlings from drying winds and the sun (Barr & McKenzie 1976). Brush matting was superior to all other treatments under very exposed and windy conditions. Materials need to be readily available in the local area to be cost-effective.

Trials using spray-on emulsions such as bitumen or synthetic latex that can be applied by machines indicate that these are a cost-effective alternative on some sites. However, depending on formulation, some emulsions do not allow ready establishment of vegetation. These stabilisers also require protection from vehicle and pedestrian traffic because of the fragile seal produced.

6.4.7 Fencing and accessways

Fencing and defined walkways over dunes have successfully protected vulnerable natural and planted dune vegetation in Australia and in parts of New Zealand by eliminating trampling and the initiation of erosion and blow-outs (NSW Public Works Department and Soil Conservation Service 1987). They are put in place after the beach dynamics and public usage patterns have been determined.

new plant species or techniques, controlling weeds, and applying fertilisers. Fences and accessways need regular inspection, and repairing or lifting to new levels where buried by sand.

7. RECOMMENDATIONS FOR ESTABLISHING SPINIFEX

Revegetation programmes are expensive and should only be considered where natural regeneration of desirable species is too slow or is non-existent. Where large areas of sand dune have been disturbed and major stands of spinifex have been removed or fragmented, revegetation with spinifex may be justified if the objective is to achieve a cover of vegetation as quickly as possible to build up dune systems and reduce erosion. Revegetation with spinifex may also be justified in small areas of foredune that are repeatedly blown out by wind or high seas.

Although experimental work is needed on both propagation and establishment of spinifex in local conditions, some conclusions relevant to New Zealand conditions can be drawn from this review of past work.

7.1 Selection of sites

Although spinifex is a vigorous native sand binder, correct choice of planting site is essential to ensure effective development of vegetation cover. Spinifex is best planted on the foredune where some sand movement occurs. Establishing plants at or near the top of dunes or mounds will allow stolons to spread rapidly down slopes and revegetate open sites. Shifting sand will encourage plants to grow new stolons, extend existing ones, and trap more sand, resulting in the building-up of further mounds.

7.2 Propagation

7.2.1 Cuttings

Terminal or lateral shoot cuttings from long rhizomes of a healthy colony have proved successful. The single-shoot cuttings are set into a light potting mix where rooting takes about 10 days under mist. Other alternatives are to place stem sections on the surface of trays filled with a light potting mix or to place semi-hardened rhizomes cut into 3-node lengths into rootrainers.

Rooted cuttings are potted on and treated as normal rooted cuttings. Seedlings are ready for planting within 15 months of collecting cuttings.

7.2.2 Seed

On a small scale reasonable germination can be achieved from seed that has been removed from surrounding layers of chaff, sown at a depth of 2.5 cm in sand, and placed in the dark. Some germination can be expected from spikelets, which are more practical to obtain than separated seed. Applications of fungicidal dust may be necessary to control mould growth. Soaking in sea water or fresh water is unlikely to have a beneficial effect on germination of spikelets. Small seedlings transplant well but care should be taken not to over-fertilise.

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