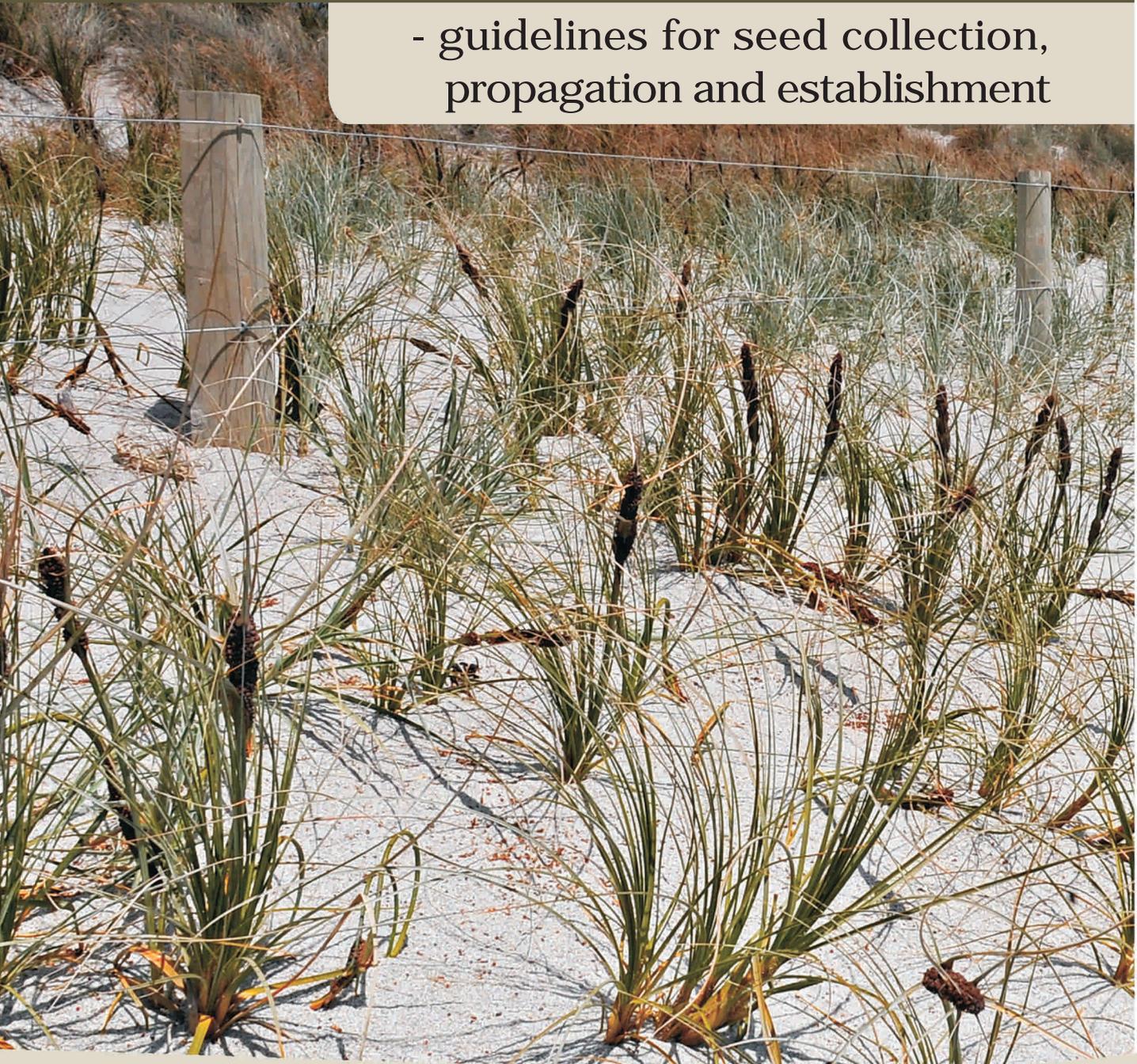


Pingao

Golden Sand Sedge

- guidelines for seed collection,
propagation and establishment





Pingao is often in association with spinifex on foredunes in northern beaches where they co-exist to effectively trap and bind wind-blown sand (left). However, foredunes in many regions are degraded due to human activities such as this dune scoured out by a drainage outlet with loss of the native sand binding vegetation (below).



INTRODUCTION

The natural form and function of coastal foredunes in New Zealand is largely dependent on less than a handful of key native species including pingao (*Ficinia spiralis*). Pingao along with spinifex (*Spinifex sericeus*) in northern coastal regions, and to a lesser extent other foredune species such as sand fescue (*Austrofestuca littoralis*) and sand convolvulus (*Calystegia soldanella*), is essential in maintaining stability of foredunes. However, dune vegetation cover is highly susceptible to disturbance from both natural and human-induced factors and it is often the latter influences that have resulted in degraded coastal dunes and increased instability.

As indicated in Dunes Restoration Trust of New Zealand Technical Handbook Article No.7.3 on the ecology and current status of pingao, most populations have been substantially reduced in distribution and vigour. Trials were established over two decades ago aimed at developing practical establishment and management techniques for the restoration of our degraded dunes with pingao (Bergin and Herbert, 1997; 1998). This has led to the successful large-scale planting and management of pingao for restoration of foredunes by local communities and managing authorities throughout the country, both for dune protection and stability.

Plantings of cuttings of pingao has been investigated for revegetation of dunes (Bicknell and Butcher, 1986) but success has been variable and this method

is considered to be less reliable than use of plants raised from seed.

Research to date and operational experience in the revegetation of coastal dunes using pingao (known as pikao in southern regions) has been drawn on to provide guidelines for seed collection, raising of seedlings and establishment of the species on dunes. These guidelines are aimed at both large-scale restoration programmes as well as small planting projects undertaken by coastal dune managing authorities, community-based Beach Care and Coast Care groups, iwi, landowners and the public.

As spinifex is the dominant native sand binding plant on sand dunes on most beaches from the north of the South Island and throughout the North Island, pingao is likely to be established as a smaller component in restoration programmes in these regions. However, pingao is the dominant sand binder from Canterbury southwards and will be the key species in any rehabilitation programmes on these southern foredunes.



Seedhead of pingao showing spiral pattern where seed is located.

SEED COLLECTION AND PREPARATION

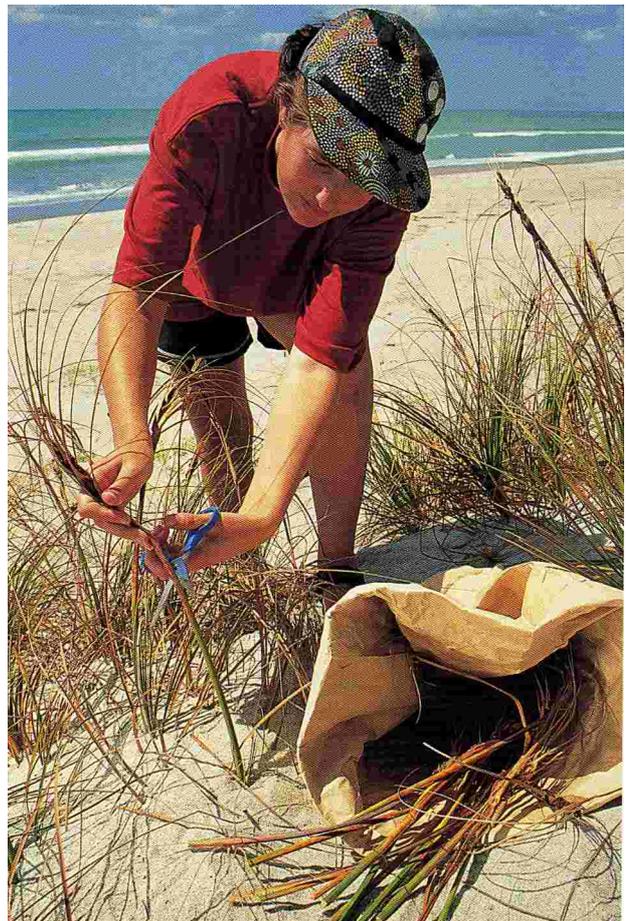
Pingao seed can be collected in large quantities from established stands during December to early January in northern districts and through to February in cooler southern districts. The ripening period varies from year to year and is probably influenced by local climate. Where mean summer temperatures are high, pingao seed is shed earlier. The seeding period (2-4 weeks) is longest in larger colonies where vigorous plants have numerous large flower heads. Collection is best carried out when seed begins to fall and appears in sand hollows in the vicinity of flowering plants. At this stage the seeds are easily dislodged from dry seedheads by rubbing with fingers. Seed in immature seedheads is greenish in colour and difficult to dislodge; collection should be delayed until the nuts have turned shiny brown-black.

Alternatively, for large collections, seedheads can be harvested by severing the stalk with scissors or a sharp knife. If possible, seedheads should be collected over an extensive area and from relatively

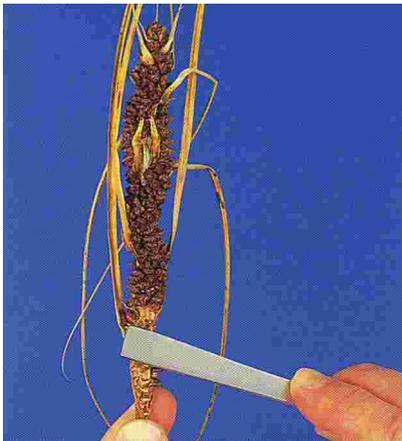


After ripening in early summer, seed and seed husks collect in hollows in the vicinity of flowering plants.

large colonies to ensure that only a small proportion of the total seed is collected and that it is derived from a range of different plants within one locality. They can be temporarily stored in hessian or paper bags. Plastic bags are not advised as these will cause fresh seedheads to sweat, making the seed difficult to extract and prone to fungal infection.



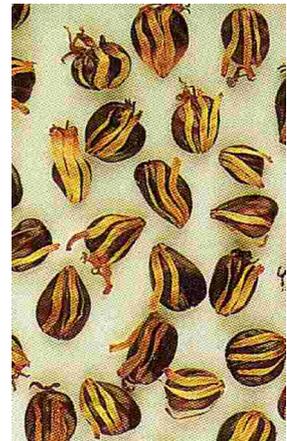
Collection of pingao seedheads. Scissors are used to cut the stems, and the seedheads are placed in a paper bag.



Seed being extracted from pingao seedhead.



Seed of pingao that has been removed from seedhead with the considerable quantity of seed chaff.



The shiny black ovoid pingao seed that has been sorted from seed chaff.

Preparing seed for sowing

Ripe seed is easily separated from dry seedheads by rubbing them between the fingers or with a blunt object. Separating the seed from chaff (mainly husks) is difficult. Some chaff can be removed by gently blowing, but intensive cleaning of seed is not necessary for propagation.

Soundness of seed can be assessed by cutting individuals in a sample with a sharp blade. Viable seed contains creamy-coloured endosperm. Non-viable seed is hollow or shrivelled, with discoloured, dry contents. Seed can be stored dry for several months in plastic bags in a refrigerator with no significant loss of viability (Bergin and Kimberley, 1999). Schedules used for sowing seed, raising seedlings and planting pingao are dependent on local climate and available propagation facilities.

SEED SOWING AND GERMINATION

Pingao seed is easily germinated and does not need any pre-treatment. Nurseries growing pingao often have their own slightly different practices, but the basic procedure is the same. The seed, mixed with remaining husks, is scattered onto a firm bed of seed raising mix (1:1 peat:pumice) in seed trays. It is then covered with sieved potting mix to a depth of 3-5 mm. An empty seed tray is inverted over the germination tray and a plastic sheet is secured over the top to maintain high humidity. Trays are placed in a glasshouse, although heating is only necessary

during colder months. Regular light watering is provided. Once germination begins, the covers are removed, taking care to protect the young seedlings from rodents and birds.

A mixture of seed and seed husks is scattered onto firmed seed-raising mix in a seed tray.



Trials over several years indicate that seed sown in late summer germinates in 11 to 20 days. In the winter, germination takes from 26 to 31 days. Seed collected from five different sites in one year had germination rates varying from 36% to 93% (Bergin and Kimberley, 1999). Depending on growing conditions, seedlings will take from four to eight weeks to grow large enough for transplanting.



Seed germinates within one month, and in another four or more weeks seedlings are 7-10 cm high ready for pricking out into containers.



RAISING SEEDLINGS

“Pricking out”

Within four to six weeks of germination, pingao seedlings are about 7-10 cm tall and can be transferred from the seed trays into containers. They are carefully removed from the tray and separated. Long roots are trimmed before transplanting. It is important to ensure that the main tap root is not distorted when the seedling is being replanted. In nurseries a dibbler is used to make a hole to accommodate the roots. Containers may be root trainers (e.g., Hillson, Tinus), PB polythene bags (e.g., ¾ or PB2) or, for home growers, any suitably sized container that is available (e.g., cardboard milk cartons). For good survival, free drainage is essential, and if cartons are used they should have a hole in the bottom. Humidity should be kept to a minimum. A light potting mix such as 3:1 peat:pumice (or sand), plus a slow-release fertiliser is recommended.

Size of planting stock

The best size of container for raising plants varies with the planting programme; factors to consider are the area to be planted, the nature of the site, and the resources available. In a planting trial, 12-month-old seedlings grown in large containers (PB ¾ polythene planter bags) initially grew faster on the dunes than seedlings from smaller containers (Hillson root trainers). Against this, larger containers require more potting mix and nursery space, and are heavier and more difficult to handle.

The initial early growth advantage of seedlings raised in large containers may be out-weighted by the disadvantages of increasing nursery costs and transportation difficulties (especially on site).

The smaller Hillson root trainers have been widely used to grow plants for rehabilitation programmes. They have the advantage that the



Pricking out seedlings into Hillson root trainers.

seedlings are cheaper, yet still large enough to establish well on dunes. Regardless of container type, it is important that the seedling root system binds the potting mix adequately so that it remains intact during transfer from the container to the planting hole. This means that seedlings in larger containers must be grown for a longer period (and will normally be larger) than those in smaller containers.



Suitable containers for raising pingao seedlings. Left to right: Tinus root trainers, Hillson root trainers, cardboard milk container, PB3/4 and PB2 polythene planter bags. Planting programmes in recent years indicate that using pingao raised in the smaller containers is giving good results on the dunes.



Stop Press! “Small root trainers are a Win-Win!”

Thousands of pingao are now being raised in the small Hillsons root trainers and planted successfully on foredunes on several Coromandel beaches (Jim Dahm, Eco Nomos, pers.comm.). This has reduced establishment costs compared to using nursery-raised pingao raised in larger containers. Using the small containers means reduced transport costs as more seedlings are accommodated per square metre. Plants in small containers are also easier to transport to the planting site by Coast Care volunteers. Planting seedlings deep and incorporating slow-release fertiliser in the sand during planting still remain key factors in ensuring good growth.

Maintenance and “hardening off”

Seedlings in containers are initially kept under cover but can be placed outside in spring once frosts have gone. It is essential that soil and seedlings do not become too wet. Nursery watering regimes must be carefully controlled to avoid this. Special precautions will be needed if seedlings are grown in areas with high rainfall or humidity.

Placing containers on a gravel bed is beneficial as this will allow free drainage. If older seedlings develop yellow foliage (a sign of stress) they may require supplementary feeding with a liquid fertiliser.

Before being transferred to the dunes, seedlings are given a three-month hardening-off period, during which they are exposed to increasingly harsh conditions approaching those of the planting site.

Good drainage and low humidity are features of the dune environment and are still important. At the time of planting, seedlings should be 40-50 cm tall, with a root collar diameter of 5-10 mm. They can reach this size between nine and 15 months after germination, depending on local climate.

High survival rates in excess of 90% can usually be expected in nurseries most years (Bergin and Herbert 1998). Mortality sometimes observed in nurseries with considerable experience in growing pingao may be related to unfavourable weather conditions when seedlings are placed outdoors.

Seedling costs

Seedling costs make up a significant proportion of expenditure on dune restoration, especially if voluntary labour is used. Currently, 12-month-old seedlings raised in Hillson root trainers or similar-sized containers are available from North Island nurseries at \$1.20 each. Two-year-old or older seedlings in larger containers cost at least \$2.50. Seedlings in smaller containers incur lower freight costs and are also easier to handle both during transport and at the planting site.



Thousands of pingao seedlings are raised in large commercial nurseries each year for sand dune rehabilitation programmes throughout the country.



TIMELINES FOR RAISING SEEDLINGS

In most trials to date and in many operational revegetation programmes over several years, the preferred seedling size of 50 cm high and root collar diameters of at least 5 mm have been raised in a wide range of nurseries in 12 months from time of sowing. With seed collected in early to mid summer, two frequently used timelines for sowing seed, raising seedlings and planting seedlings of pingao, which are dependent on local climate and available propagation facilities, are:

- Cold climate and no heated raising facilities but with protection from frosting - sow autumn - prick-out early spring - plant following autumn or spring (12-15 month old seedlings);
- Warm climate or heated facilities - sow winter in heated facilities - prick-out spring - plant following autumn or spring (9-12 month old seedlings).

ESTABLISHING PINGAO ON DUNES

Site requirements

Trials and management-scale planting programmes have demonstrated that rehabilitation of degraded foredunes with a mixture of pingao, spinifex and sand tussock is possible on many dune sites throughout New Zealand (Bergin and Kimberley, 1999). Of the indigenous sand-binding species, pingao has been the most amenable to nursery culture and planting on active dunes.

Trials have shown that seedlings planted on exposed unstable foredunes with zero to moderate vegetation cover, consistently out-perform those planted on well-vegetated stable dunes (Table 1). As the plants grow they trap sand, and this may assist further growth; sand accumulation to a depth of 10-20 cm over the first year is suitable for young pingao.

Planting time

Anecdotal evidence from agencies, interest groups and individuals in many regions indicate that performance varies considerably from one year to the next and from one season to the next and is

Table 1: Performance of pingao at Nuhiti Beach, East Coast, North Island, 20 months after planting.

Site factors	Survival (%)	Seedlings with multiple shoots (%)	Seedling health score (1-5)*
SHELTER			
Exposed	75 a	70 a	2.6 a
Sheltered	60 b	47 b	2.0 b
STABILITY			
Unstable	72 a	70 a	2.8 a
Stable	62 b	48 b	2.0 b
VEGETATION			
None	76 a	76 a	3.6 a
Sparse cover	73 a	67 ab	2.4 b
Moderate cover	69 a	58 a	2.0 bc
Dense cover	52 b	36 c	1.2 c

*Seedling health score assessed as 1 - poor, 2 - unthrifty, 3 - average, 4 - good, 5 - excellent. Within groups, values followed by the same letter are not significantly different (5% probability level).

largely dependent on climatic conditions and incidence of storms damaging planting sites within the first two to three months after planting. The only firm recommendation that can be given is to avoid summer, when dune sand is likely to be too hot and dry.

Some people favour autumn planting and others plant in winter or spring. Autumn-planted seedlings may be exposed to fewer storms, but unless root systems have developed sufficiently they will be vulnerable to early summer drought. In one trial established at Whiritoa Beach, Coromandel



Peninsula, spring-planted pingao had a significantly higher survival rate (78% after one year) than autumn-planted pingao (41%). Planting season had no effect on growth. There is no guarantee, however, that similar results would be obtained in another year or in another location.

Fertiliser application

Application of a slow-release NPK fertiliser (e.g., Magamp, 30 g per plant, incorporated with the sand around each seedling) does not always increase survival (Figure 1) but at most sites it will significantly boost early growth and health (Figure 2). Occasionally, if there are high rates of sand accumulation at a planting site, or the sand is enriched, there may be no immediate benefit from fertiliser (e.g., the South Brighton Beach site, Figure 2). As a general rule, however it is advisable to apply slow-release fertiliser to all plantings.

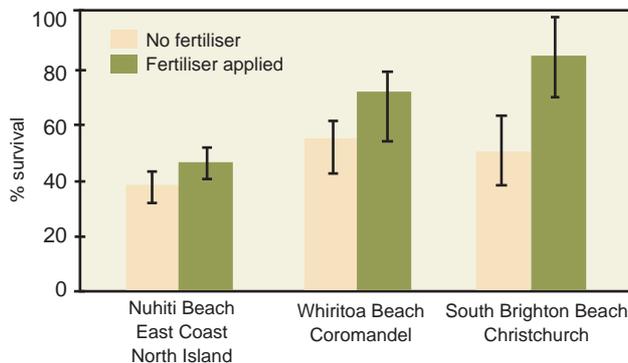


Figure 1: Survival of pingao seedlings after one year in three planting trials. Bars show standard errors of means. Overlapping bars indicate no statistically significant difference between treatments.

Application of slow-release fertiliser at planting of the natives sand binders pingao and spinifex has become standard practice for all operational dune restoration programmes throughout New Zealand. It appears that any slow-release fertiliser, whether in tablet or granulated form, with at least some nitrogen content, will give a substantial boost to growth of planted pingao.



Incorporating slow-release fertiliser granules into the hole as the pingao seedling is being planted.

The accidental use of fast-release fertiliser such as urea at planting, placed within the planting pit around the root systems, has killed sand binders. Fast-release fertiliser should only be applied by broadcasting light dressings over established plants.



A group of pingao plants growing vigorously on a foredune site. Fertiliser was applied at planting eight months earlier.

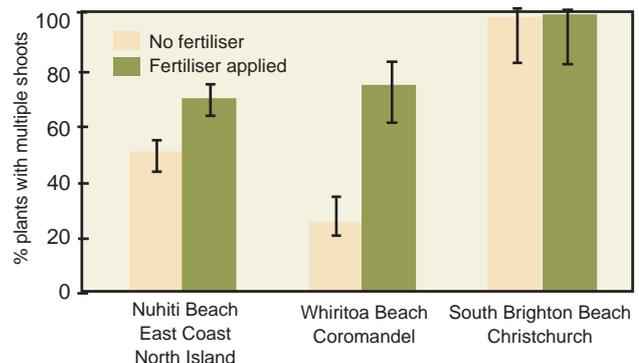


Figure 2: Percentage of one-year-old pingao seedlings with multiple shoots (a measure of growth and vigour) in three planting trials. Bars show standard error of means. Overlapping bars indicate no statistically significant difference between treatments.



As for the other major sand binder spinifex, broadcast applications of fast-release high-nitrogen fertiliser on planted and natural stands boost growth of pingao.

Results at Papamoa Beach, Bay of Plenty, indicate major growth responses to nitrogen applied at rates of 200 kg/ha or more (unpublished data). There have also been reports that where urea has been incidentally applied to pingao during marram grass treatment, pingao vigour has improved.

Use of Hydrogel ("Crystal Rain") was tested at two sites by incorporating wetted material in the planting hole. It did not improve growth or survival of planted pingao seedlings during the following season.

Planting technique and pattern

Planting groups of 10-20 pingao seedlings, with approximately 50 cm spacing between plants, has been effective in starting the dune building process within six months. Close spacing provides mutual shelter on exposed sites and application of fertiliser promotes growth, and thus the trapping of sand (Figure 3). On North Island dunes, planting of small groups has resulted in populations that resemble natural communities. Here, pingao is often found on the foredune in discrete patches, within a matrix of spinifex and other plants. In the South Island, where pingao once assumed greater dominance, it may be more appropriate to plant larger blocks.

Large numbers of container-grown seedlings can be quickly planted on foredunes using spades. Seedlings planted deeply, so that the root collar (the level of potting mix) is at least 10 cm below the sand



Deep planting pingao will increase survival especially on highly dynamic beaches where there is substantial sand movement. Planting pits need to be sufficiently deep to allow root collars of seedlings to be planted at least 10 cm below the sand surface.

Although these pingao seedlings had been planted deeply four weeks ago, strong winds since planting on this exposed North Island west coast beach has reduced the level of sand. Uncovered roots of planted pingao will reduce survival.



surface, are more likely to survive sand scouring by wind and will have greater root contact with moist sand layers.



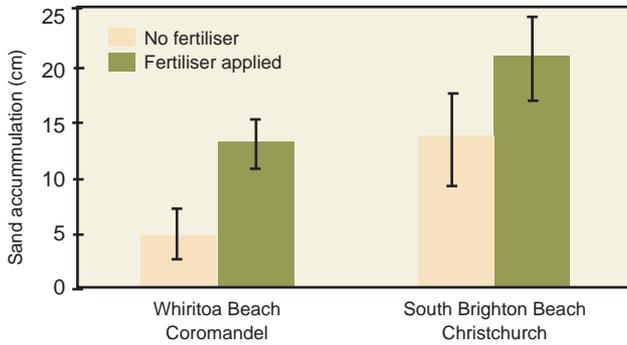


Figure 3: Sand accumulation around one-year-old pingao seedlings planted in groups. Bars show standard errors of means. Overlapping bars indicate no significant differences between treatments.



Use of formal accessways, fencing and signs to encourage beach users to avoid trampling over existing and recently planted pingao on foredunes has become necessary on most popular beaches throughout New Zealand. Regular maintenance of these structures is required to ensure fences and accessways are not buried or undermined by wind and wave action along the foredune.



Pingao raised in root trainers planted by Coast Care group members to fill in bare sand areas along a foredune.

Maintenance and care

Successful restoration of degraded dunes on an operational scale will require continued vigilance. Planting sites should also be protected from disturbance by beach users. This involves working with communities long before any planting is started to control access by providing formal accessways, erect fencing around planted sand binders and to erect signs informing beach users of the importance of keeping to accessways. Information on accessways and fencing on dunes is given in the Dunes Restoration Trust of New Zealand Technical Handbook Articles No.s 9.1 and 9.2. Regular inspection and follow-up maintenance of fences, signs and accessways will be required.

Browsing by rabbits and other animals is a major cause of pingao failure. Control of rabbits and hares, together with fencing of planting sites to exclude domestic animals, is essential. Control of rabbits is difficult especially on popular beaches but well planned poisoning by skilled operators in consultation with local communities has proved highly successful. Ongoing control is required to maintain low levels of animal pests.



Pingao is highly palatable to rabbits and is therefore a good indicator species for the presence of these pests on beaches.

Invasion of exotic weed species including the vigorously competitive exotic sand binder marram grass (*Ammophila arenaria*) particularly in southern regions will require monitoring and control.

Plant survival can vary considerably from one year to the next. The replanting of damaged areas and occasional fertiliser application may be required to enhance growth of surviving plants.



TRY GROWING SEEDLINGS AT HOME

Although the techniques described in this article focus mainly on large-scale raising and planting of seedlings, pingao is amenable to raising in small numbers using facilities and equipment in “backyard” gardens. Individuals, community-based Beach Care and Coast Care groups, iwi and other interest groups have raised pingao seedlings in small numbers using resources available in most homes.

- Discover where existing stands of pingao are growing best on your local sand dune and collect mature seed from December.
- Scrape the seed off dry seedheads. Sow the seed and chaff as a layer a few millimetres thick using the methods used for other plant species in the garden.
- Use a standard potting mix which includes a slow-release fertiliser. Add pumice or sand to the mix to improve drainage. *Don't use pure sand.*
- Pingao seedlings can be raised in a wide variety of containers including yoghurt pots, milk cartons and recycled nursery containers. Ensure containers have drainage holes.
- Heated facilities are not necessary even in colder areas - seed will just take longer to germinate and seedlings will grow more slowly. Protection of seedlings from frosts is essential. If possible, germinate seedlings in a glasshouse or plastic house and place containerised seedlings initially under shelter such as shade cloth.
- Good drainage is essential so place containers on gravel or raised beds of timber. Do not overwater.
- Pingao is also relatively tolerant to delays in pricking out from seed boxes and can be held in containers for several months if planting is delayed.
- About three months before planting, acclimatise seedlings to harsh dune conditions by progressively placing seedlings in more exposed conditions.

PLANT YOUR SEEDLINGS ON THE DUNES

The planting techniques used for large scale revegetation described in this bulletin can be equally applied to small-scale revegetation projects. Work with others in your community and consult with local managing agencies to determine appropriate methods and sites for revegetation.

- Plant pingao where some sand movement, particularly accumulation, is expected. This is usually along the front of the foredune.
- Plant seedlings with their bases (root collars) at least 10 cm below sand level.
- Plant seedlings in groups of 5-20 with 50-70 cm between seedlings to encourage rapid build up of new sand.
- Incorporate a small handful of slow-release fertiliser (such as Magamp or other slow-release granulated or pelletised fertiliser).
- Protect plants from browsing rabbits and domestic stock and disturbance from beach users.

People and pingao can co-exist! Sand binders dominated by pingao are protected with bollards and rope and are fulfilling the important role of trapping sand even on this highly popular Bay of Plenty beach.



Pingao planted with the other major sand binder spinifex as well as sand tussock successfully establishing on this foredune.



A STRATEGY FOR REHABILITATING FOREDUNES

Pingao (along with spinifex on northern dunes) grows best under conditions of moderate sand movement. Due to the continually changing nature of the coastal environment, it is not always easy to identify areas where greatest success can be expected. Foredunes are exposed to adverse weather and sea conditions which include unusually high tides, storms, strong winds from different directions, salt spray, extremes of temperature and drought, and the destructive effects of introduced animals and human activities. Failures must be expected from time to time. Often the degree of damage due to storm or human impact varies considerably over short distances and from one year to the next.

A rehabilitation strategy that spreads risk of failure over time and across a defined area will be most likely to succeed. Where planting is considered, the aims should be to produce large numbers of seedlings at low cost; to plant the most sheltered areas first; and to accept setbacks.

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The mission of the Dunes Trust is:

'To see the majority of New Zealand dunes restored and sustainably managed using indigenous species by 2050'.