EXPERIMENTAL REHABILITATION OF DUNELANDS WITH PINGAO

INVESTIGATION NO : S4070/557
CORPORATE OBJECTIVE NO: 6.44

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Forest Research Institute Contract Report: FWE 91/23

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

DATE: June 1991

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EXECUTIVE SUMMARY (FINAL)

INVESTIGATION NO: S4070/557
CORPORATE OBJECTIVE: 6.44

INVESTIGATION TITLE: Experimental rehabilitation of dunelands with pingao

STUDY VENUE: East Coast, Waikato

INVESTIGATION LEADER: J.W. Herbert and D.O. Bergin

INVESTIGATION STATUS: Final

CLIENT: Department of Conservation

INVESTIGATION SUMMARY:

Techniques for raising large numbers of pingao seedlings (*Desmoschoenus spiralis*) and establishing pingao on dunelands were investigated by the Northern Wildlands section, Forest Research Institute, Rotorua, for the Department of Conservation between 1988 and 1991.

OBJECTIVES:

- To collect seed of pingao, undertake germination trials, and raise approximately 4500 seedlings for planting.
- To design and implement out-planting trials on two sites in the North Island to test a range of duneland habitats, different planting stock, and different planting treatments.
- To interpret results and make recommendations to managers for rehabilitation of dunelands.
- To promote pingao as a wildland plant in its natural habitat and as a traditional fibre.

METHODS:

- Seed was collected during the 1988-89 summer from Whanganui, Waikawau Bay (Coromandel Peninsula), and Whatipu (Auckland). Smaller collections were made from several other sites.
- Seed was sent to two DOC nurseries (Taupo and Matawhero) and the Tairawhiti Polytechnic Rural Studies Unit Nursery for raising seedlings for planting trials. Small quantities of seed were kept for testing germination at the FRI Nursery in Rotorua.
- Out-planting trials were established at Nuhiti Beach and Waikawau Bay in August 1990.
- Trials designed to test for performance differences between planting stock and two dune habitats were assessed 4 and 8 months after planting. Fertiliser (30 g of slow-release NPK) and hydrogel treatments were superimposed. Plot factors included shelter, sand stability, and vegetation cover.

RESULTS:

- Germination ranged from 25% to 93% for the five provenances tested. Germination started 11-20 days after sowing, and most seedlings appeared 2-4 weeks after sowing.
- At Nuhiti Beach, all but one of five seedlings types tested had high survival. Only about half the small Whanganui planting stock, which were severely hardened off before planting, survived. Pingao seedlings raised in larger containers, particularly polythene planter bags, grew better after planting than seedlings raised in smaller containers.
- Survival and growth of pingao on the unstable dune habitat were significantly better than on the stable habitat. Fertiliser had no effect on survival but significantly boosted early growth and health. Hydrogel did not improve survival or growth.
- Severe browsing by rabbits at Waikawau Bay masked any growth differences between planting treatments.

CONCLUSIONS:

- Pingao seedlings of five North Island provenances were successfully raised from seed collected in December and sown in February.
- Sturdy, pingao seedlings with well-balanced root/shoot ratio grown in polythene bag containers gave very high survivals and growth rates when first planted on suitable duneland sites.
- Exposed foredunes with a small to moderate amount of shifting sand are the preferred habitat for pingao.
- Fertiliser boosted seedling growth and vigour.
- The lack of response to hydrogel may have reflected the lack of moisture-stress during the 1990/91 summer.
- Browsing animals must be excluded from sites on which pingao is to be established.

2. INTRODUCTION

Techniques for raising large numbers of pingao seedlings (*Desmoschoenus spiralis*) and establishing pingao on dunelands were investigated by the Northern Wildlands section, Forest Research Institute, Rotorua, for the Department of Conservation between 1988 and 1991.

The project was initiated in 1988 and involved seed collection and raising of pingao seedlings at three nurseries for out-planting trials. Information on the techniques used and success of previous plantings of pingao was gathered to assist the design of comprehensive planting trials. Planting trials were established on two sites in the North Island in August 1990 and the performance of seedlings was monitored for the first 8 months after planting.

3. BACKGROUND

Pingao (*Desmoschoenus spiralis*) is an endemic sand-binding plant found growing on or near the coastal foredune. It is one of the three major natural fibres used for weaving by Maori people.

Before European colonisation pingao formed extensive pure stands on foredunes in the North and South Islands. In the past 100 years the dunelands have been extensively altered by afforestation, mining, grazing, recreation, and accelerated erosion. Introduced marram grass, tree lupin, buffalo grass, and other exotic species have been planted to combat erosion and have displaced the native sand binders, especially pingao. Most areas of pingao have been reduced to small discontinuous patches, and this decline is continuing.

The decline in pingao coincides with a resurgence of interest in traditional weaving skills. Unfortunately, in most districts the residual populations of pingao are too small to sustain the demand for pingao fibre. Pingao can be readily propagated by layering or cuttings, and from seed (Bicknell & Butcher 1986). Thousands of plants have been raised from seed in many nurseries, and there have been several major plantings of pingao over the past 5 years in various parts of the country (S. Courtney 1985, unpubl. report; G. Walls 1990, unpubl. DSIR report). However, many out-plantings have suffered severe mortality, often in the first year. Desiccation, browsing animals, flooding by high tides, unsuitable sites, and massive sand movements have contributed to these losses.

4. OBJECTIVES

- To collect seed of pingao, undertake germination trials, and raise approximately 4500 seedlings for planting.
- To design and implement out-planting trials to be established on two sites in the North Island to test a range of duneland habitats, different planting stock, and different planting treatments.
- To interpret results and make recommendations to managers for rehabilitation of dunelands.
- To promote pingao as a wildland plant in its natural habitat and as a traditional fibre.

5. METHODS

5.1 Seed collection and raising plants

In December 1988, a large quantity of seed was collected from three North Island sites: Whatipu Beach (west of Auckland), Whanganui, and Waikawau Bay (Coromandel Peninsula). Smaller seed collections were made from other North Island sites.

Pingao seedlings were raised in rootrainers at the Tairawhiti Polytechnic Rural Studies Unit Nursery in Gisborne, in polythene planter bags at the Department of Conservation Nursery at Matawhero, and in rootrainers at the Department of Conservation Nursery, Taupo. A small number of seedlings of a wider range of provenances were also raised in rootrainers at the Forest Research Institute Nursery, Rotorua.

Most seedlots were sown mid to late summer into seed trays kept in unheated glasshouses. Germination started within 10 days for some seedlots and continued for up to 2 months. Seedlings were pricked into containers 6-8 weeks after sowing. For some provenances up to three size classes of seedlings were raised by placing seedlings in different size containers. All seedlings were approximately 18 months old when planted out.

5.2 Germination trials

A small quantity of seed of five provenances was collected from throughout the North Island and tested for germination at the FRI Nursery, Rotorua. The provenances were Whatipu, Waikawau Bay, Whangamata, Hawkes Bay, and Whanganui. Seed collected between December and February, was sown in mid-February into seed trays containing equal quantities of peat and sand, which were placed in an unheated glasshouse. Date of initial germination was recorded for each provenance, and numbers of germinated seedlings were assessed weekly for up to 6 weeks after sowing.

5.3 Planting trials

Two sites were selected for the planting trial. The main site was at Nuhiti Beach on the East Coast. The 1.5-km beach comprises a narrow dune system. A stable dune on the landward side is covered in short grasses, particularly Indian daob (*Cynodon dactylon*) and harestail (*Lagurus ovatus*). The foredune has steep banks with a sporadic cover of spinifex (*Spinifex sericeus*). Sand sedge (*Carex pumila*) was common on the foredune. Some 3300 seedlings were planted in groups of 30 in August 1990.

The second site was at Waikawau Bay on the Coromandel Peninsula. The 3-km beach is managed by the Department of Conservation as a recreation area and has an extensive dune system, which is fenced off. Scattered small patches of vigorous pingao plants occurred naturally along foredunes amongst *Spinifex*. Some 1400 pingao seedlings were planted in groups of 25 in August 1990.

5.4 Planting treatments

The trials were designed to measure differences in survival and growth amongst the following factors:

5.4.1 Seedling type

The five seedling types planted at the Nuhiti Beach trial were:

- Large Whanganui seedlings raised in polythene bags PB 2s ex Matawhero Nursery.
- Medium-size Whanganui seedlings raised in polythene bags PB 0.75s ex Matawhero Nursery.
- Small Whanganui seedlings raised in Hillsons rootrainers ex Forest Research Institute Nursery.
- Large Whatipu seedlings raised in Tinus rootrainers ex Tairawhiti Polytechnic Nursery.
- Small Whatipu seedlings raised in Hillsons rootrainers ex Tairawhiti Polytechnic Nursery.

The three seedling types planted at the Waikawau Bay trial were:

- Small Waikawau-1 seedlings raised in Hillsons rootrainers ex DOC Nursery, Taupo.
- Small Waikawau-2 seedlings raised in Hillsons rootrainers ex FRI Nursery.
- Small Waikawau-3 seedlings raised in Hillsons rootrainers ex Tairawhiti Polytechnic Nursery.

5.4.2 Habitat type

Seedlings were planted on unstable foredunes that had sparse vegetation, and on stable inland dunes that were usually more sheltered and were vegetated.

5.4.3 Fertiliser

For selected groups 30 g of a slow-release NPK fertiliser (Magamp medium) was incorporated with the sand when each seedling was planted.

5.4.4 Hydrogel

About 150 ml of Broadleaf P4 hydrogel was applied in hydrated form around the root system of selected seedling groups. Hydrogels are water-storing materials that may be tapped for water by plant roots in dry periods.

5.5 Trial design

The trial was a split plot design. At each site, an unstable foredune and a more stable inland dune were planted. Each area was divided into blocks, nine at Nuhiti Beach and seven at Waikawau Bay. Each block was planted with a single seedling type, those with large numbers of seedlings being assigned to more than one block. The blocks contained several plots or clusters of 25 or 30 pingao plants. Each plot was given one of the four treatment combinations: no fertiliser or hydrogel, fertiliser only, hydrogel only, or fertiliser plus hydrogel.

Within plots seedlings were planted randomly around a central peg at a spacing of approximately 50 cm between plants. Each group was about 3 m in diameter, was compact, and was restricted to a single microsite.

At Nuhiti Beach only, several factors considered likely to influence seedling performance were assessed for each plot. These included shelter from onshore winds and salt spray (exposed, sheltered), sand movement (stable, unstable), and density of surrounding vegetation cover (none, sparse, moderate, dense).

5.6 Monitoring

At planting, the average leaf length in each seedling treatment group was sampled. Leaves were gently pulled straight from sand surface to leaf tip. Dead leaf tips were not included in the length measurement. Root-collar diameter was sampled for each treatment group.

The Nuhiti Beach site was inspected 4 and 8 months after planting. Numbers of surviving plants were recorded for each planted group at each inspection. For surviving plants, leaf length and root-collar diameters were measured, and health (good, intermediate, poor) and colour of foliage (green, intermediate, yellow) were assessed subjectively. The number of plants in each plot with two or more shoots was counted to give a further measure of plant growth and vigour. Browsing damage and flowering status were noted. Occasional seedlings were excavated to determine root-system development since planting.

Because of severe rabbit browsing, Waikawau Bay was inspected only once, 4 months after planting, and not all factors were assessed.

6. RESULTS

6.1 Germination trials

Germination ranged from 25% to 93% for the five provenances tested at the FRI Nursery (Table 1). Germination started 11 to 20 days after sowing and most seedlings appeared between 2 and 4 weeks after sowing.

TABLE 1. Germination of pingao seed collected from five North Island sites, FRI Nursery, Rotorua

Provenance name	Grid reference	Collection date	Germination started after sowing (up to 6 days)	Total germination (weeks)
Whatipu	N41/46 020360	4-12-88	17	93
Waikawau Bay	N40 035907	16-12-88	20	50
Whangamata	N49 367178	6-2-89	11	25
Whanganui	N137 500870	18-12-88	14	69
Hawkes Bay	N135 443133	20-12-88	14	36

6.2 Nuhiti planting trial

6.2.1 Design factors

Leaf length may not be a very useful measure of growth for pingao as mean leaf length declined for seedling types in all treatment groups as a result of tip dieback. Although root-collar diameter increased for most seedling types, the most suitable measure of growth and plant vigour seemed to be the number of seedlings in treatment groups that had developed multiple shoots. Results are therefore presented for survival and for multiple shoot development only. Details of the results for the other growth factors measured can be found in Appendix 11.1.

Neither fertiliser nor hydrogel had any significant effect on survival of planted pingao (Fig. 1). However, significantly more pingao survived on the unstable dune (87%) than on the stable dune (76%).

Fertiliser had a significant effect on the growth of pingao (Fig. 2). Sixty percent of plants in fertilised plots had multiple shoots compared with 43% in plots with no fertiliser. There was also a significantly greater number of seedlings with multiple shoots on the unstable dune than on the stable dune.

With a single exception, all planting stock showed very high survival at Nuhiti Beach 8 months after planting (Fig. 3). Only about half the small Whanganui provenance seedlings raised at FRI Nursery, which were severely hardened-off before planting, survived. For all seedling types, those planted on the unstable dune had better survival than those on the stable dune.

The small, prematurely hardened-off FRI seedlings performed poorly compared with the other seedling types. The rootrainer Whatipu seedlings had significantly fewer plants with multiple shoots than Whanganui seedlings raised in polythene bags (Fig. 4).

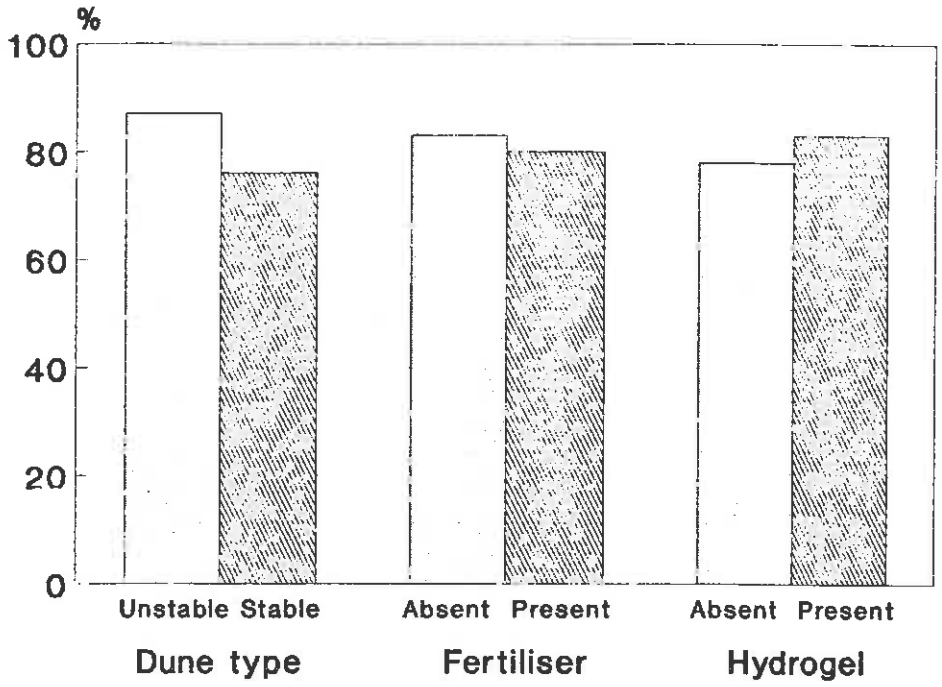

Fig. 1. The effect of design factors on % survival, Nuhiti Beach

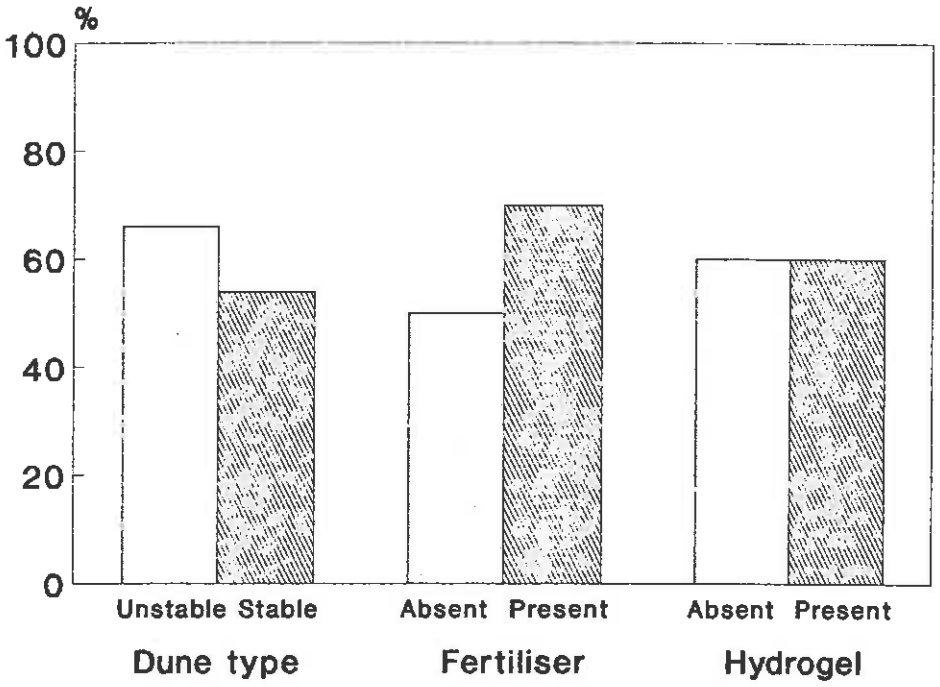

Fig. 2. The effect of design factors on % of plants with multiple shoots, Nuhiti Beach

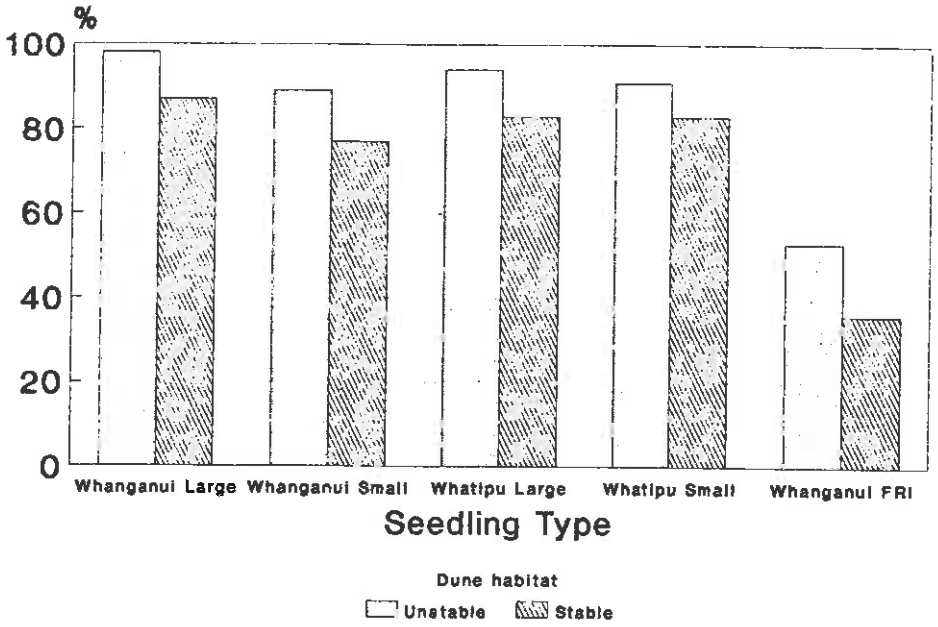

Fig. 3. The effect of planting stock and dune habitat on % survival, Nuhiti Beach

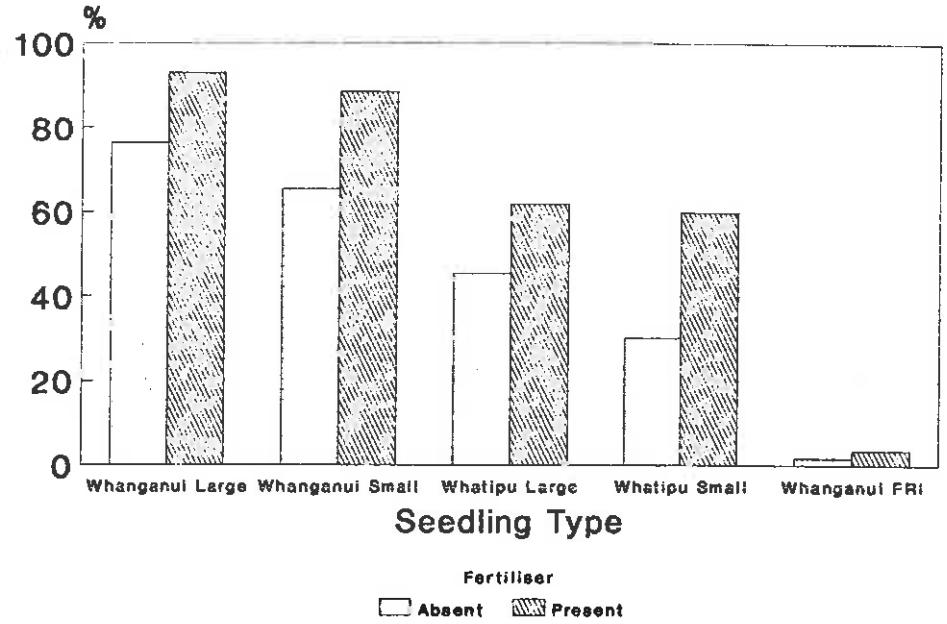

Fig. 4. The effect of planting stock and fertiliser on % of plants with multiple shoots. Nuhiti Beach

Except for FRI seedlings, application of fertiliser was significantly beneficial to growth for all seedling types and had the most pronounced effect with the smaller seedlings types (Fig. 4).

Seedlings excavated 8 months after planting showed massive root development and extension of more than 40 cm. Where hydrogel had been applied, some hydrated gel was still visible with root hairs penetrating the gel.

6.2.2 Plot factors

Seedlings planted on exposed sites had significantly longer leaves, better survival, more seedlings with multiple shoots, and were significantly healthier than seedlings planted on sheltered sites (see Appendix 11.1).

Growth, survival, and health were also better on unstable sandy sites and where vegetation cover was sparse or non-existent. Foliage of pingao planted on sites where there was no other vegetation present was significantly greener than pingao planted amongst existing sand-dune vegetation (Appendix 11.1).

6.3 Waikawau Bay trial

Rabbits severely browsed nearly all planted pingao seedlings at the Waikawau Bay site. Consequently, there were no significant differences in leaf length and survival of pingao 4 months after planting (Appendix 11.2). The only major differences detected were for colour of foliage and to a lesser extent seedling health. Seedling type Waikawau-2 produced more seedlings with yellow foliage than the other seedling types. Seedlings on the unstable dune habitat tended to have greener leaves and be healthier than those on the stable habitat. As for the Nuhiti Beach site, fertilised seedlings were greener than unfertilised seedlings and hydrogels had no effect on seedling performance.

7. CONCLUSIONS

Large variations in germination success have been reported previously for pingao (Courtney 1983, Oliphant 1988, Bicknell & Butcher 1986). It is likely that the poor germination of the Whangamata provenance was related to its late collection time, up to 2 months after the other provenances. This suggests that seed viability decreases rapidly with time. Courtney (1983) also found that despite very high initial viability, seed not sown immediately after collection often had germination rates of about 10%.

The small Whanganui seedlings hardened-off at the FRI Nursery performed poorly. This extreme treatment was included in the trial as we thought severely conditioned small seedlings could survive better in a harsh sand-dune site and would not be as palatable to rabbits or other grazing animals as larger 'softer' seedlings. However, the regularly fertilised, larger seedlings that had a supply of nutrients in the potting mix at planting fared significantly better. The greater volume of potting mix in the polythene bags than in rootrainers probably gave seedlings raised in bags an advantage over rootrainer-raised seedlings.

Pingao seedlings with the longest leaves did not perform as well as seedlings of shorter stature. Seedlings with a well-balanced shoot and root system and an adequate volume of potting mix appeared more suited for planting on dunelands than seedlings with long leaves.

Pingao is very site specific. Seedlings planted on the exposed, unstable foredune consistently out-performed seedlings planted on the stable dune. Healthy natural stands of pingao are invariably established on exposed foredunes. Sand blown by wind is trapped by the leaves, eventually building a mound. Pingao requires regular deposition of sand to keep the rooting zone within moist sand (Courtney 1983). Without some deposition of new sand, new roots grow into the top few centimetres where they are subject to desiccation, which limits the survival or growth of pingao.

The outstanding feature of the pingao trials was the contrasting colour and vigour of fertilised and unfertilised seedlings. Seedlings in fertilised plots had much better colour and vigour than unfertilised seedlings. It is highly likely that the effect would have been greater had it not been for the store of nutrients contained within the potting mix of seedlings that did not get fertilised at planting. However, it is not yet known whether the more vigorous fertilised pingao has a better chance of survival in the longer term than unfertilised plants.

Hydrogel did not improve growth performance of pingao in these trials. However, there were no prolonged dry spells on the East Coast during the 8 months after planting, as has happened in some previous years, and pingao may not have been moisture-stressed.

The severe browsing of planted seedlings at Waikawau Bay by rabbits, and the reported browsing of other pingao areas by a range of browsing animals demonstrates the need for animal control.

8. RECOMMENDATIONS

We are reluctant to offer management recommendations based on trials with less than 1 year of pingao growth. However, some tentative recommendations can be made.

- For North Island provenances, pingao seed should be collected early (in November-December) and sown in January-February, and most seed should germinate within 4 weeks of sowing.
- Eighteen-month-old seedlings raised in polythene bag sizes PB 0.75 or PB 2, or similar size containers with an adequate amount of potting mix, should give well-balanced seedlings that perform well after planting.
- Seedlings should be planted on unstable foredunes but sites must be selected to minimise the movement of sand by storms, which could reduce survival of plants.
- Late winter-early spring plantings with suitable stock may survive better than autumn plantings by evading winter storms in the first year.
- Group planting of 25-30 seedlings at about 50-cm spacing between plants was effective in dune building after 6 months.
- Application of 30 g per plant of a slow-release NPK fertiliser gives an almost immediate boosts to seedling growth and vigour, but has no effect on initial survivals.

- Hydrogel should not be discounted as a practical method for establishing pingao during prolonged dry periods.
- The preferred parameters for assessing performance of pingao include survival, proportion of plants with multiple shoots, and subjective assessments of seedling health and foliage colour.

9. ACKNOWLEDGEMENTS

The assistance and support of local DOC staff was appreciated in establishing pingao trials at both sites. Tairawhiti Polytechnic Rural Studies Unit, Gisborne, DOC nurseries at Matawhero and Taupo, and FRI Nursery, Rotorua, raised the pingao seedlings. J. Oliphant assisted with the literature survey, germination trials and planting. M. Kimberley analysed the data. J. Orwin the report.

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11. APPENDICES

11.1 Performance of pingao seedlings at Nuhiti Beach 8 months after planting. Initial leaf length and diameter are means of a sample of seedlings measured at plantings for each seedling type. Design factors were tested by analysis of variance, and plot factors by unbalanced analysis of variance (adjusting for effects of plant stock, fertiliser, and hydrogel). Lines indicate where significant differences occur between treatments.

			Leaf Length		Root-Collar Diameter		Survival	Seedlings with multiple shoots	Seedling health score[a]	Foliage colour score[b]
			initial (cm)	8 months (cm)	initial (mm)	8 months (mm)	(%)	(%)	(1-3)	(1-3)
DESIGN FACTORS	SEEDLING TYPE									
	Whanganui	Large	70	46	12.8	16.4	93	85	1.5	2.3
		Small	53	38	8.4	12.8	83	77	2.1	2.4
	Whatipu	Large	112	* 55	11.9	** 14.5	** 89	** 54	* 1.8	1.7
		Small	72	42	10.0	12.6	87	45	2.2	2.3
	Whanganui FRI	Small	32	26	7.2	7.2	44	3	2.8	2.8
	DUNE									
	Unstable Dune		63	43	9.5	12.9	** 87	* 66	2.0	2.2
	Stable Dune		63	* 37	9.5	12.6	76	54	2.2	2.4
	FERTILISER									
	Absent		63	36	9.5	** 11.6	83	** 50	** 2.3	** 2.6
	Present		63	* 37	9.5	13.8	80	70	1.9	2.0
	HYDROGEL									
	Absent		63	39	9.5	12.5	78	60	2.1	2.4
	Present		63	41	9.5	12.8	83	60	2.1	2.3
PLOT FACTORS	SHELTER									
	Exposed		63	** 42	9.5	12.7	** 87	** 64	* 2.0	2.2
	Sheltered		63	36	9.5	12.8	70	51	2.3	2.4
	STABILITY									
	Unstable sand		63	** 42	9.5	12.8	** 87	** 66	* 2.0	2.3
	Stable sand		63	37	9.5	12.7	71	51	2.3	2.4
	VEGETATION									
	None		63	51	9.5	15.0	93	69	1.4	1.7
	Sparse cover		63	40	9.5	11.7	86	64	2.1	2.5
	Moderate cover		63	** 36	9.5	12.4	** 81	** 60	** 2.3	** 2.3
	Dense cover		63	36	9.5	13.0	67	47	2.4	2.4

a Seedling health assessed as 1-good, 2-intermediate, 3-poor
b Foliage colour assessed as 1-green, 2-intermediate, 3-yellow
* Significantly different ($p < 0.05$)
** Significantly different ($p < 0.01$)

11.2 Performance of pingao seedlings at Waikawau Bay 4 months after planting. Initial leaf length is the mean of a sample of seedlings measured at planting for each seedling type. Lines indicate where significant differences occur between treatments (tested by analysis of variance).

		Leaf Length		Survival	Seedling health score[a] (1-3)	Foliage colour score[b] (1-3)
		initial (cm)	4 months (cm)	(%)		
DESIGN FACTORS	SEEDLING TYPE					
	Waikawau-1	65	22	45	1.9	1.8
	Waikawau-2	37	23	42	2.5 *	2.6
	Waikawau-3	49	27	69	1.7	1.7
	DUNE TYPE					
	Unstable dune	50	26	59	1.5	1.7
	Stable dune	50	26	64	* 2.3	* 2.0
	FERTILISER					
	Absent	50	27	64	2.0	2.4
	Present	50	24	60	1.7	** 1.4
	HYDROGEL					
	Absent	50	26	64	1.8	1.8
	Present	50	25	60	1.9	1.9

a Seedling health assessed as 1-good, 2-intermediate, 3-poor
b Foliage colour assessed as 1-green, 2-intermediate, 3-yellow

* Significantly different ($p < 0.05$)
** Significantly different ($p < 0.01$)