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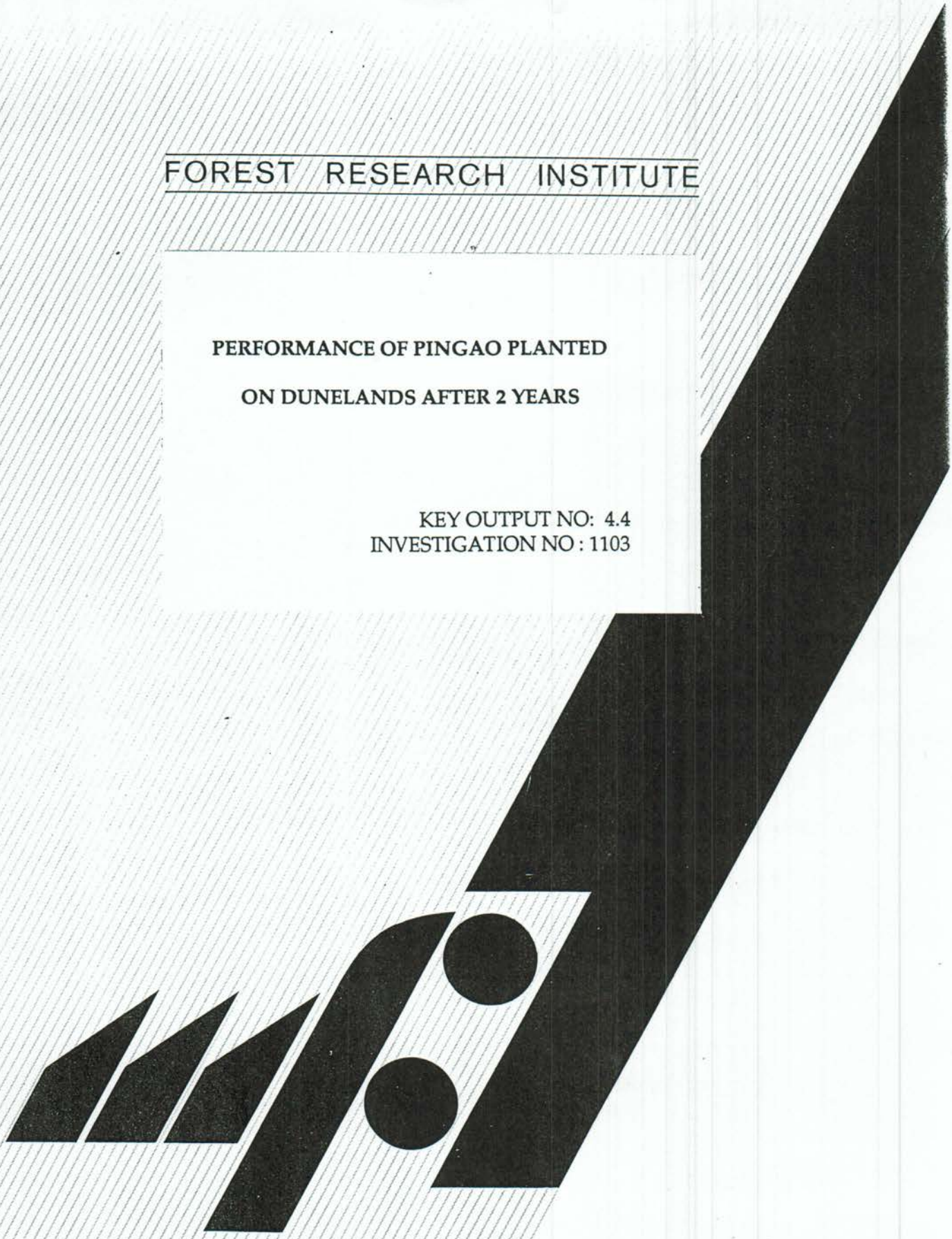
KEY OUTPUT NO: 4.4
INVESTIGATION NO : 1103



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Forest Research Institute Contract Report: FWE 92/18

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

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Ministry of Forestry
Forest Research Institute

FINAL EXECUTIVE SUMMARY

KEY OUTPUT NO: 4.4
INVESTIGATION NO: 1103

INVESTIGATION TITLE:	Performance of pingao planted on dunelands after 2 years
STUDY VENUE:	East Coast, Waikato
INVESTIGATION LEADER:	J.W. Herbert and D.O. Bergin, Northern Wildlands section, Forest Research Institute, Rotorua
INVESTIGATION STATUS:	Completed
CLIENT:	DoC, Science & Research Division

INVESTIGATION SUMMARY:

The performance of pingao seedlings (*Desmoschoenus spiralis*) established for nearly 2 years on dunelands was investigated by the Northern Wildlands section, Forest Research Institute, Rotorua. The project was initiated in 1988 and in mid 1990 two major out-planting trials were established, one on the East Coast and another on the Coromandel Peninsula.

OBJECTIVES:

1. To continue monitoring pingao planting trials established on the East Coast and Coromandel Peninsula.
2. To interpret results 2 years after planting and make recommendations on rehabilitation or enrichment of dunelands using pingao.

METHODS:

1. Two pingao planting trials were established at Nuhiti Beach (East Coast) and Waikawau Bay (Coromandel Peninsula) in August 1990. Fertiliser and hydrogel treatments were applied at planting, and the trials were assessed 4 and 8 months after planting. Preliminary results were presented in FRI Contract Report FWE 91/23.
2. Additional fertiliser (30 g of slow-release NPK) was applied 11 months after planting.
3. Trials were assessed 20 months after planting to compare performance differences between planting stock, dune habitat, fertiliser treatments, and other site factors.

FINAL RESULTS:

At Nuhiti, survival generally decreased during the second year. Survival and growth of pingao on the unstable dune was still significantly better 20 months after planting than on the stable dune.

The initial growth response to fertiliser applied at planting time is still apparent after 20 months. However, application of fertiliser 11 months after planting had no significant effect on survival or growth of pingao.

Seedlings raised in larger containers continued to perform better than seedlings raised in smaller containers and this continued into the second year. Larger well-nourished seedlings performed better than smaller hardened-off seedlings.

At Waikawau Bay, most plots on the unstable foredune were destroyed by a major change in the river channel. Most of the pingao in the few remaining plots have been buried by substantial accumulations of sand.

FINAL CONCLUSIONS:

- Pingao prefers exposed sites where there is little or no associated vegetation.
- Larger, well-nourished pingao seedlings perform better than smaller, hardened-off seedlings.
- Small-to-moderate accumulation of sand around the plants is essential for vigorous sustained growth. Planting pingao in compact groups allows seedlings to trap sand more effectively and build up small dunes.
- Identifying sites in exposed areas that will have a moderate amount of sand movement for optimal pingao growth is difficult. Planting larger numbers of seedlings to allow for some losses is recommended.
- Fertiliser applied at planting boosted growth, but there was no response to a post-planting application of a slow-release NPK fertiliser. Further research is required on post-planting application methods and fertiliser types.
- The larger quantity of potting mix available to seedlings raised in larger containers gives pingao a greater initial capacity to survive on these harsh dune sites.
- The high palatability of pingao highlights the need for effective control of all browsing animals, including rabbits, hares, and domestic stock.

PUBLICATIONS OR OTHER SIGNIFICANT OUTPUTS:

Bergin, D. O.; Herbert, J. W. 1991: Planting pingao on dunelands on the East Coast. Tairawhiti Conservation Quorum No. 4.

Herbert, J. W.; Bergin, D. O. 1991: Planting pingao on dunelands on two North Island sites. Science Faction Fiction, Department of Conservation, April 1991.

Herbert, J. W.; Bergin, D. O. 1991: Rehabilitation of dunelands using pingao - assessment of planting trial. Forest Research Institute Contract Report: FWE 91/23.

2. INTRODUCTION

Techniques for raising large numbers of pingao seedlings (*Desmoschoenus spiralis*) and establishing pingao on dunelands were investigated by the Northern Wildland section, Forest Research Institute, Rotorua, for the Department of Conservation between 1988 and 1992.

3. BACKGROUND

The project initially involved seed collection and raising of pingao seedlings at three nurseries for out-planting trials. Planting trials were established on two sites in the North Island in August 1990. The main site was located at Nuhiti Beach on the East Coast, where some 3300 seedlings were planted in groups of 30 seedlings. The second site was located at Waikawau Bay on the Coromandel Peninsula, where approximately 1400 pingao were planted in groups of 25 seedlings at one end of the 3-km beach.

Performance of seedlings was monitored for the first 8 months after planting. Detailed rationale, previous work, methodology, and results from seed collection, nursery-raising of seedlings and the planting trials were reported in J.W. Herbert & D.O. Bergin (1991, unpublished contract report). This report describes the performance of planting trials during the second year of establishment, based on an assessment 20 months after planting.

4. OBJECTIVES

- To continue monitoring pingao planting trials established on the East Coast and Coromandel Peninsula.
- To interpret results 2 years after planting, and make recommendations on rehabilitation or enrichment of dunelands using pingao.

5. METHODS

5.1 Planting treatments

A detailed description of planting treatments is given in J.W. Herbert & D.O. Bergin (1991, unpublished contract report). They are briefly summarised for this report for the successful Nuhiti trial.

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

- Planting stock - five seedling types were planted at the Nuhiti Beach trial: large Whanganui seedlings raised in polythene bags PB 2's; medium-size Whanganui seedlings raised in polythene bags PB 0.75's; small Whanganui seedlings raised in Hillsons rootrainers; large Whatipu seedlings raised in Tinus rootrainers; and small Whatipu seedlings raised in Hillsons rootrainers.

A further three seedling types were planted at Waikawau Bay.

- Habitat type - seedlings were planted on unstable foredunes and on stable inland dunes.
- Fertiliser - 30 g of Magamp fertiliser was applied to each seedling at planting, for selected groups.
- Hydrogel - About 150 ml of hydrogel (water-storing material) was applied to selected seedling groups.

5.2 Trial design

The trial was a split plot design. At each trial, two areas, an unstable foredune and a contiguous stable vegetated inland dune area, 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, with the more numerous types 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 around a central wooden peg at a spacing of approximately 50 cm. 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 degree of shelter from on-shore winds and salt spray (exposed, sheltered), degree of sand movement (stable, unstable) and density of surrounding vegetation cover (none, sparse, moderate, dense).

5.3 Post-planting treatments

In early August 1991 (approximately 11 months after planting) 25 g of medium granule Magamp fertiliser was applied to each seedling in selected groups on the unstable sites only. The fertiliser was placed in a 5-8 cm deep channel excavated by hand in a 25-30 cm radius of each seedling. Fertiliser was placed around seedlings on relatively flat areas or located on the upper side of seedlings on slopes, and was then covered with sand.

5.4 Monitoring

The Nuhiti Beach trial was assessed at 8 months and 20 months after planting. For the 20-month assessment, numbers of surviving plants were recorded for each planted group. A subjective assessment of health (good, intermediate, poor) and colour of foliage (green, intermediate, yellow) was also recorded. The number of plants with two or more shoots in each plot was counted to give a percentage of plants with multiple shoots.

After analysis of first-year results, measurement of leaf length was not considered a reliable parameter of growth because of tip dieback. Similarly, root-collar diameter was considered too inconsistent because of sprouting of new shoots and fluctuating sand levels, particularly on the exposed foredune. Browsing damage and flowering of plants were noted and degree of sand movement at each plot was recorded.

Most of the unstable site at Waikawau Bay was destroyed by a change in the course of the nearby stream. Consequently the trial was only partially assessed. This involved determining survival of seedlings in remaining plots and measuring the degree of sand accumulation at each plot.

5.5 Analysis

Analysis of variance was carried out to test the significance of treatments on survival, percentage of plants with multiple shoots, health score, and foliage colour.

6. RESULTS

6.1 Nuhiti planting trial

6.1.1 Design factors

Survival of pingao generally decreased between the 8 and 20-month assessments (Appendix 11.1). Survival remained significantly higher on the unstable site (71%) than on the stable site (64%) (Fig. 1). As for the first assessment, application of fertiliser or hydrogel at planting had no effect on survival of planted seedlings. Similarly, application of fertiliser 11 months after planting had no significant effect on survival on the unstable site.

Dune type also continued to have a significant effect on growth of seedlings in the second year since planting (Fig. 2). The difference in percentage of plants with multiple shoots on unstable (69%) and stable (49%) sites slightly increased, although overall percentage changed little since the first assessment. Groups fertilised at planting still had significantly more plants with multiple shoots than unfertilised plots on both unstable and stable sites after 20 months (Fig. 2). Pingao on the stable site appeared to have responded more than pingao on the unstable site to initial application of fertiliser. This probably reflected competition for nutrients by the other vegetation on the site, particularly Indian daob (*Cynodon dactylon*) and hares tail (*Lagurus ovatus*). However, there was no measurable response to the addition of fertiliser 11 months after planting on the unstable site.

The high survival of large Whanganui pingao raised in large planter bags was maintained into the second year (Appendix 11.1; Fig. 3). In contrast, survival of all other seedling types was reduced by 13-20 percentage points in the second year. Differences in survival between seedling types were still significant, but the smaller seedlings show greater losses than equivalent treatments where larger planting stock was used.

The growth response to applied fertiliser was consistent across all planting stock (Fig. 4). Whanganui plants in planter bags continued to be more likely to have a greater number of multiple shoots than Whatipu plants in rootrainers after 20 months.

Seedling health and foliage colour in the second year was similar to those of the first assessment (Appendix 11.1).

Sand levels increased by an average of 7.2 cm on the exposed site (range 0-25 cm) and 0.3 cm on sheltered sites.

Figure 1: The effect of dune type and fertilizer application on % survival at 20 months, Nuhiti Beach

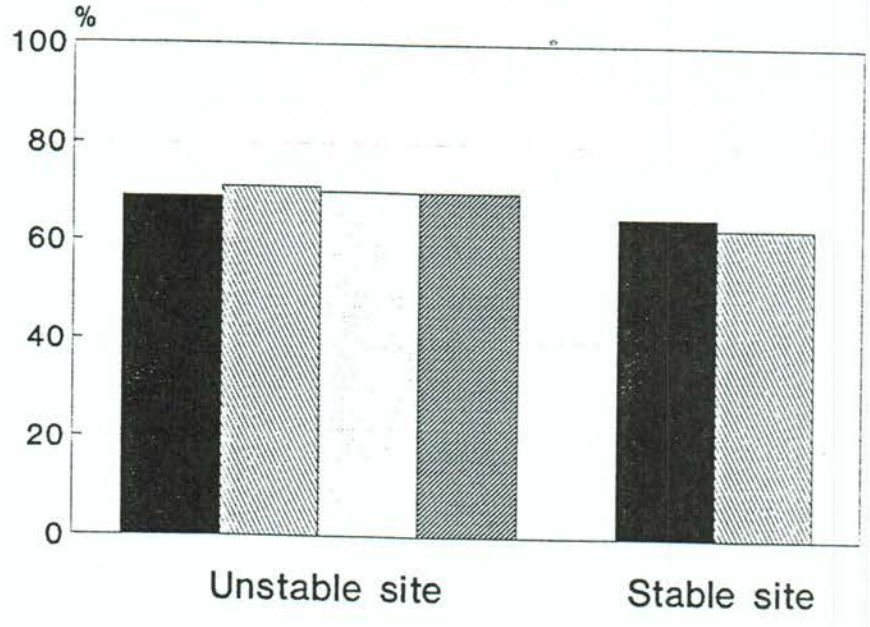


Figure 2: The effect of dune type and fertilizer on % multiple shoots at 20 months, Nuhiti Beach

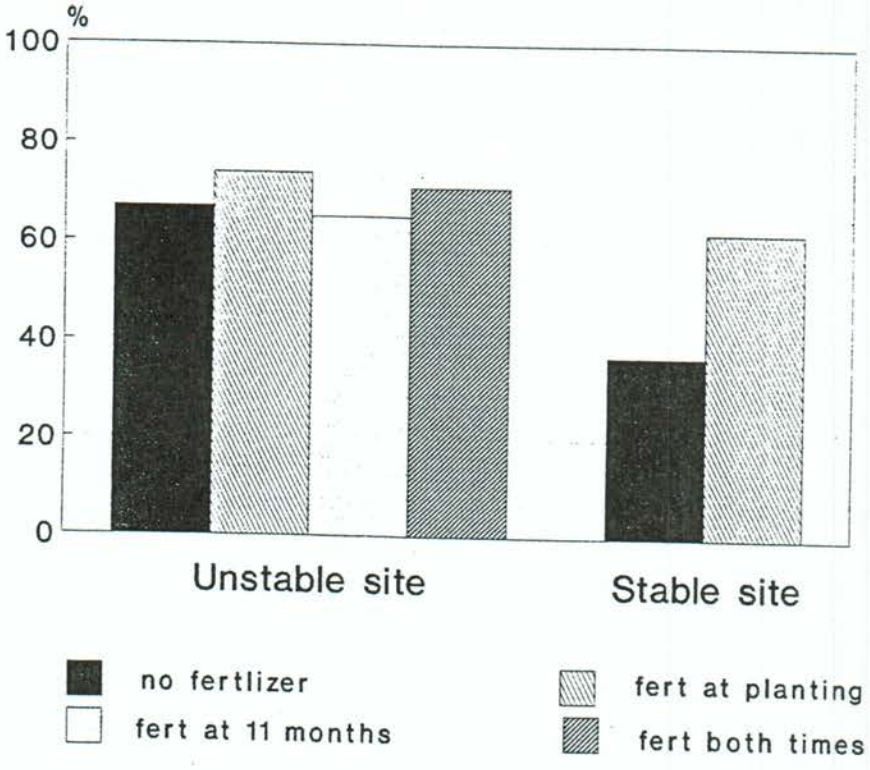


Figure 3: The effect of planting stock and dune type on % survival at 20 months, Nuhiti Beach

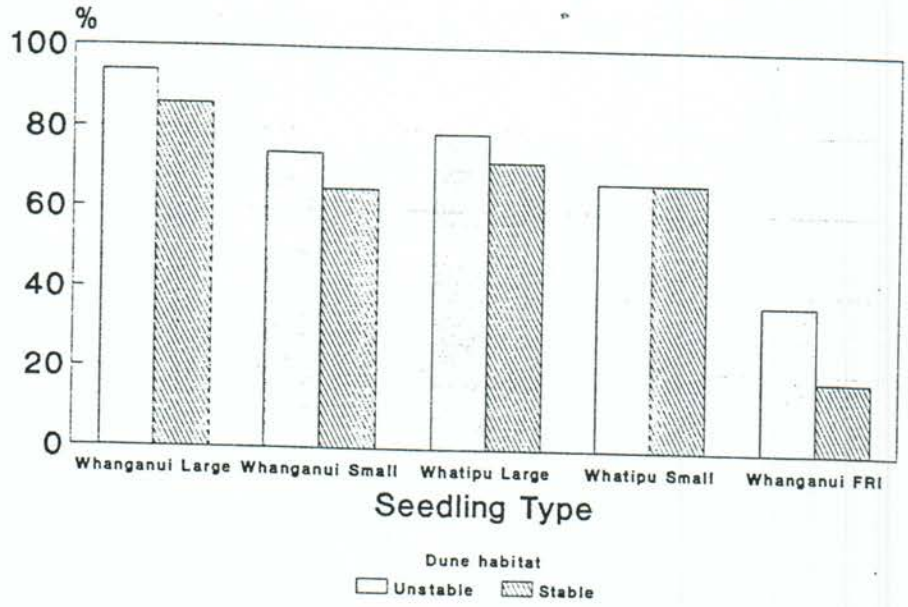
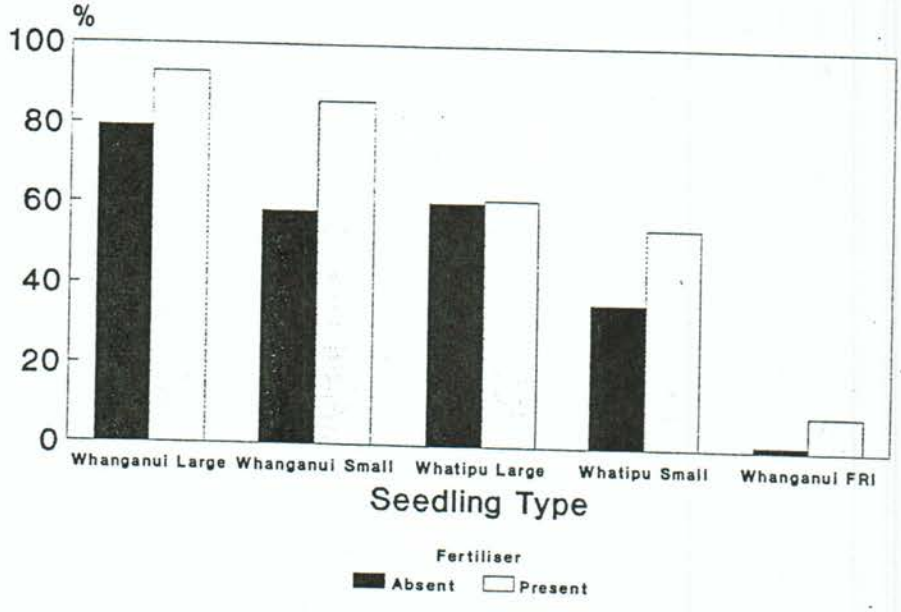


Figure 4: The effect of planting stock and fertilizer on % multiple shoots at 20 months, Nuhiti Beach



6.1.2 Plot factors

In general, performance of pingao at 20 months was similar to that at 8 months for factors assessed by plot, (shelter, sand stability and vegetation cover; Appendix 11.1). Pingao were more vigorous in plots classed either as exposed, with unstable sand or as having no or sparse associated vegetation.

6.2 Waikawau Bay trial

Only 19% of seedlings planted on the sheltered site at Waikawau Bay survived 20 months after planting. Growth of surviving plants was severely retarded, mainly because of poor recovery from initial rabbit browsing. However, browsing during the second year did not appear to be as severe as during the first year.

On the exposed site only a few plots remained after a change in the course of a river channel. Most of these remaining plots were subsequently affected by major accumulations of sand leading to high mortality of pingao. Up to 60 cm of sand accumulated on some plots and it was likely that some of the missing plots were submerged under greater depths of sand.

7. CONCLUSIONS

Pingao at Nuhiti showed a preference for exposed sites with little or no associated vegetation and a small-to-moderate amount of continually shifting sand. Pingao requires regular deposition of sand to keep the rooting zone within moist sand (Courtney 1983). Several pingao groups containing large numbers of seedlings accumulated up to 25 cm of sand, forming an incipient dune. The close proximity of plants within groups probably enhances their ability to trap sand and build up levels at a moderate rate that kept pace with the developing pingao. Although pingao planted in open sand on foredunes amongst scattered spinifex runners performed well, pingao planted amongst well-established but sparse spinifex was not vigorous.

There is considerable margin for error in identifying optimal sites and many losses of seedlings can be attributed to major sand movement. The best strategy therefore, may be to plant large numbers of seedlings over a wide area. Late winter-early spring plantings may survive better than autumn planting as seedlings would become better established before any major sand movement associated with winter storms.

The large initial boost to growth and vigour of pingao from fertiliser application at planting suggested that seedlings might also respond to a post-planting application. The lack of response could be due to either the application technique or the unsuitability of Magamp as a post-planting fertiliser on these sites. Up to 9 months after application, sand movement uncovered fertiliser, and the channels in which it was placed may not have been deep enough. The upper sand layer also remains dry for long periods if rainfall is infrequent. However, placing slow-release fertilisers such as Magamp at a deeper level within moist sand increases the risk that fertiliser could be placed below the root zone.

An alternative would be to apply a faster acting fertiliser when the sand is wet - soon after rain or before rain was expected. This method was successfully used for spinifex (Spinifex sericeus) being established on modified dunelands in Queensland, Australia (Barr & McKenzie 1980). The Australian work also suggested that a number of dressings during the period of active growth (August to April in Australia) may be more successful than just one post-plant application.

The continuing mortality in the second year mostly affected rootrainer and smaller planter bag seedlings. The larger quantity of potting mix in larger containers apparently gave pingao a greater capacity to survive on these harsh dune sites.

The small degree of sheep browsing at Nuhiti and the significant long-term detrimental effect of rabbit browsing at Waikawau Bay confirms the palatability of pingao to browsing animals and the need for their effective control.

8. RECOMMENDATIONS

- Well balanced pingao seedlings grown in containers such as polythene bags PB 2 or similar size should be used for planting dunes and should give good performance for up to 2 years after planting.
- Seedlings should be planted in group of 25-30 seedlings at about 50 cm spacing to allow mutual support, and to facilitate dune building where there is some sand movement. Planting sites should be regularly monitored to build up local experience in what constitutes an open site.
- Siting of groups should be flexible so that at least all the preferred sites in a planting area are occupied. The best sites are open, exposed sand away from other vegetation or amongst very scattered vegetation such as runners of spinifex.
- A slow release NPK fertiliser (30 g per plant) should be incorporated into the sand at planting to boost seedling growth and vigour. Clearly, further research is required on post-planting fertiliser application methods and other types of fertiliser.
- Dunelands to be planted in pingao must be fenced to exclude farm stock and rabbits must be controlled.

9. ACKNOWLEDGEMENTS

The authors thank the Nuhiti Q Trust Board for access to and support for establishing the trial at Nuhiti Beach. In particular, we wish to acknowledge Jules and Tawhai Ferris for their support and Patti and Kupu Lloyd for their interest and hospitality. The assistance and support of local DOC staff was appreciated in establishing pingao trials at both the East Coast and Coromandel sites. Mark Kimberley analysed and assisted with interpretation of the data. Joanna Orwin edited the report.

10. REFERENCES

BARR, D.A.; McKENZIE, J.B. 1980: The effects of the additions of nitrogenous fertiliser on the growth of sand spinifex grass (*Spinifex hirsutus*) and sand plain lupin (*Lupinis cosentii*). Pp. 94-120 *in* Beach Protection Authority of Queensland. Dune Stabilisation and Management Research Programme. Report Number D.02.6.

COURTNEY, S. 1983: Aspects of the ecology of *Desmoschoenus spiralis*. M.Sc thesis, University of Canterbury.

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11. APPENDIX

11.1 Performance of pingao seedlings at Nuhiti Beach 8 and 20 months after planting. 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.

			Survival (%) 8 months	Survival (%) 20 months	Seedlings with multiple shoots (%) 8 months	Seedlings with multiple shoots (%) 20 months	Seedling health score[a] (1-3) 8 months	Seedling health score[a] (1-3) 20 months	Foliage colour score[b] (1-3) 8 months	Foliage colour score[b] (1-3) 20 months
DESIGN FACTORS	SEEDLING TYPE									
	Whanganui	Large	93	90	85	86	1.5	1.8	2.3	2.4
		Small	83	70	77	72	2.1	2.3	2.4	2.6
	Whatipu	Large	** 89	** 76	** 54	* 61	* 1.8	* 2.4	1.7	2.2
		Small	87	67	45	45	2.2	2.3	2.3	2.4
	Whanganui FRI	Small	44	31	3	5	2.8	3.0	2.8	2.7
	DUNE									
	Unstable Dune		** 87	* 71	* 66	* 69	2.0	** 2.2	2.2	2.3
	Stable Dune		64	64	54	49	2.2	2.5	2.4	2.7
	FERTILISER									
	Absent		83	68	** 50	** 50	** 2.3	* 2.5	** 2.6	* 2.6
	Present		80	68	70	69	1.9	2.2	2.0	2.4
	HYDROGEL									
	Absent		78	66	60	56	2.1	2.4	2.4	2.6
	Present		83	67	60	61	2.1	2.3	2.3	2.6
PLOT FACTORS	SHELTER									
	Exposed		** 87	** 75	** 64	** 70	* 2.0	* 2.2	2.2	* 2.3
	Sheltered		70	60	51	47	2.3	2.5	2.4	2.7
	STABILITY									
	Unstable sand		** 87	** 72	** 66	** 70	* 2.0	** 2.1	2.3	* 2.3
	Stable sand		71	62	51	48	2.3	2.5	2.4	2.7
	VEGETATION									
	None		** 93	** 76	** 69	** 76	** 1.4	** 1.7	** 1.7	* 1.7
	Sparse cover		86	73	64	67	2.1	2.3	2.5	2.6
	Moderate cover		81	69	60	58	2.3	2.5	2.3	2.7
	Dense cover		67	52	47	36	2.4	2.9	2.4	3.0

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 ($p < 0.01$)