PASTURE AND LUCERNE RESEARCH ON SAND COUNTRY

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Abstract

Some of the results of ten years' experimental work on the major soils of the Flock House Field Research Area are presented and briefly discussed. High-producing pastures are readily maintained on the wetter sand plain soils with adequate surface drainage and annual additions of 350 to 450 kg/ha of 30% potassic superphosphate. A range of herbage species is being evaluated on the drier sand plains. Lucerne *(Medicago sativa* L.) in particular can markedly increase the productivity of these soils. Factors which affect soil moisture status at and after sowing have the greatest influence on lucerne establishment. Root-knot nematode (*Meloidogyne hapla* Chitwood) can inhibit lucerne tap-root development, though several chemicals give effective but expensive control of the nematode. To maintain high production, up to 1000 kg/ha of 50% potassic superphosphate is required annually if lucerne is hayed, though requirements may be less when the crop is mainly grazed.

INTRODUCTION

AT the 1965 conference of the New Zealand Grassland Association in Wanganui, Graham and Hopkins (1965) stated that large areas of sand country were relatively undeveloped and production was generally low although there existed great scope for improvement. The Ministry of Agriculture and Fisheries recognized the need to investigate problems associated with improving the productivity of sand country and established a Field Research Area at Flock House in 1967. Located within the Older Dune Complex (Cowie ef al., 1967), it includes soils representative of the dry dunes (Motuiti sand), the drier sand plains (Himatangi sand) and the wetter sand plains (Pukepuke black sand).

The major factors limiting development of sand country are unfavourable soil moisture conditions, plant nutrient deficiencies, and lack of soil stability. Much of the research carried out has been

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directed towards finding ways of overcoming these limitations. Although a high water-table results in winter wetness being a problem on the wetter sand plains, high producing pasture can be supported with adequate drainage and fertilizer. A more difficult problem is that of summer dryness on the drier sand plains and dunes, where the water-table occurs at greater depth. The resultant poorer moisture status of these soils is accentuated by their lower water-holding capacity, caused by a lower topsoil content of organic matter, and a shallower depth of topsoil (Cowie *et* al., 1967). The emphasis of research has therefore been directed at problems associated with the introduction and maintenance of drought-tolerant perennial species on these soils. Lucerne (*Medicago sativa* L.) has received most attention, though a range of pasture species is currently being evaluated.

Inflated estimates of available soil phosphorus by acid extractants are a feature of sand country soils, owing to the high proportion of poorly available calcium phosphates. Alkaline extractants (such as the Olsen soil test) give lower and more reliable estimates. The soils typically have low reserves of potassium (Cowie et al., 1967). Pasture and animal responses to phosphorus and potassium were measured in a six-year grazing trial with sheep, and rates, forms, and times of application of various nutrients have been compared in small plot trials on pasture and lucerne.

In this paper, results of some of the experimental work undertaken during the ten years since the Research Area was established at Flock House are presented.

PASTURES

PATTERN OF PASTURE GROWTH

The seasonal pattern of pasture growth measured in a grazing trial on an area of predominantly Pukepuke black sand, but including some Himatangi sand, is shown in Fig. 1. In a typical year, growth rates increase rapidly during spring but decrease equally rapidly in early summer. Growth rates are most variable during late summer and autumn, depending on the frequency and intensity of rainfall. The pattern of growth in a given situation will vary from that shown, particularly during summer and autumn, according to the proportion of moist and dry soils. On the welter Pukepuke soils, annual dry matter yields of 10 000 to 12 000 kg/ha are obtainable from high producing pastures.

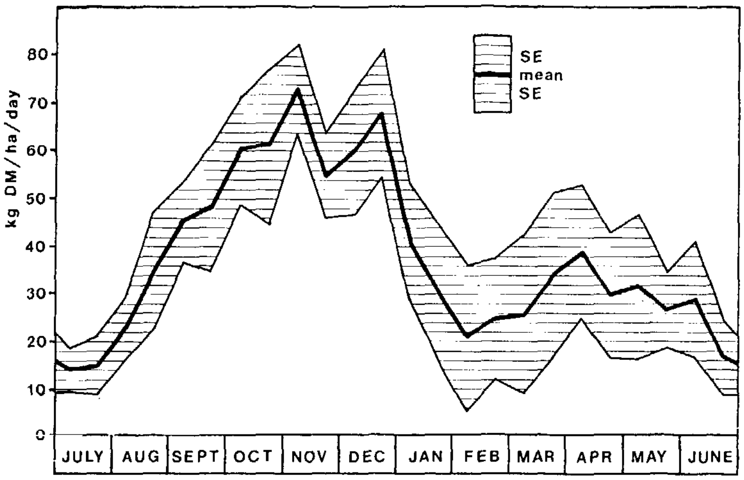

FIG. 1: *Seasonal distribution of pasture growth on Pukepuke black sand — Himatangi sand complex (5 year mean ± standard error).*

PASTURE FERTILIZER REQUIREMENTS

A grazing trial set-stocked with ewes at 22 and 27/ha on sown pasture compared the following annual fertilizer treatments:

250 and 750 kg/ha of superphosphate (22 and 67 kg P/ha)
0 and 250 kg/ha of potassium chloride (0 and 125 kg K/ha)

These rates were chosen as being above and below the rates of phosphate and potash normally applied in the district. Additional sulphur as gypsum was applied with the low rate of superphosphate to equalize the rate of sulphur in all treatments. Pasture production was measured three-weekly by the frame (or trim) technique (Lynch, 1966) in each of the 0.4 ha paddocks. Each treatment was replicated three times.

Pasture growth was not generally increased by the high rate of phosphate, though significant increases in ewe liveweight were recorded. More consistent pasture responses to potash occurred, particularly in spring when the yield increase averaged 14% for five of the six years; no response to potash in spring was recorded during the first year of the trial. Potash frequently increased lamb weight gains and sometimes ewe liveweights and fleece weights. Significant positive interactions between phosphate and potash on ewe liveweight were found in some years.

These results indicate a need for both phosphate and potash. Annual requirements of 25 to 35 kg P/ha and up to 60 kg K/ha for satisfactory production on these soils have been confirmed by small-plot mowing trials. Higher rates may be worth while under intensive dairying and on pastures cut for hay and silage.

A requirement for sulphur in terms of clover growth has been found in small-plot trials. Despite very low sulphur retention in these soils (W. M. H. Saunders, pers. comm.), elemental sulphur has not given greater pasture growth than the more soluble form gypsum applied annually in spring.

PASTURE SPECIES

Three 'Grasslands' perennial ryegrass (*Lolium perenne* L.) cultivars, Ariki, Ruanui, and Nui, were compared on two adjacent sites on Pukepuke black sand differing slightly in moisture status. On the "wetter" site, growth continued throughout the year, but on the "drier" site moisture deficits retarded growth during dry periods. The ryegrasses were sown with and without clovers, the latter treatments receiving artificial nitrogen. All plots were grazed by sheep for a short period after each cut.

Yields (total and according to components) recorded during the third year are shown in Fig. 2. Yield measurements were

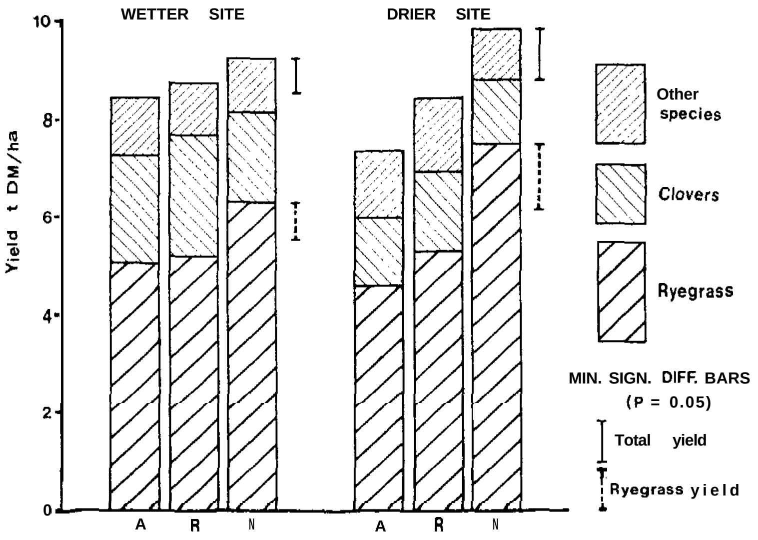

FIG. 2: *Yields of ryegrass, clover and other species for treatments sown with the ryegrass cultivars Ariki (A), Ruanui (R) and Nui (N).*

not continuous during the first two years, so these data are not presented here though the results were similar to those obtained in the third year.

The highest yield was obtained from Nui, its superiority being greatest on the drier site. Of the greater ryegrass production from Nui, compared with the standard cultivar, Ruanui, 78% on the drier site and 64% on the wetter site occurred in the summer-autumn period. Ariki was not significantly lower yielding than Ruanui. Being more summer active than Ruanui, Nui, by stronger competition, reduced clover production on the wetter site ($P < 0.01$) but not significantly so on the drier site where clover was less productive (Fig. 2).

Nui ryegrass, in comparison with five other grass species, is being evaluated further in newly established trials on Himatangi sand. On the basis of results obtained so far, Nui looks a suitable cultivar for these drier conditions also. In terms of yield relative to Nui ryegrass, 'Grasslands Matua' prairie grass (*Bromus catharticus* Vahl) , 'Grasslands Apanui' cocksfoot (*Dactylis glomerata* L.) and 'Grasslands 4710' tall fescue (*Festuca arundinacea* Schreb.) also show promise as grass species for the drier sand plains but their ability to persist under these conditions has yet to be tested.

LUCERNE

Because of its deep root system, lucerne can continue growing on the drier soils after moisture stress has curtailed the growth of most pasture species. Lucerne yields 12 000 to 16 000 kg/ha of dry matter, of which almost half is produced in summer. In contrast, typical pastures on Himatangi sand yield 4 000 to 6 000 kg/ha in the absence of irrigation, most of this growth occurring in spring.

Lucerne Establishment

The more important factors which influence lucerne establishment on sand country soils are:

1. Soil moisture.
2. Wind erosion of soil surface.
3. Soil temperatures after germination.
4. Insect pests and diseases.
5. Competition from weeds.

Because of the first three factors, seedbed preparation and time of sowing may have a pronounced effect on the success achieved.

TABLE 1: LUCERNE ESTABLISHMENT TREATMENTS

Sowing *times:* early and late spring (2/9/74, 29/10/74), early and late autumn (4/4/75, 14/5/75).
Seedbed preparation: minimal-cultivated and uncultivated (direct drilled after chemical desiccation).
Drill *tips:* chisel coulter and triple disc coulter.
Nematicide: untreated and treated.
Fungicide: untreated and treated seed.

Trials on Himatangi sand sown with coated Wairau lucerne seed at a bare seed rate of 9 kg/ha were carried out to investigate the effect of various cultivation and scedbed treatments. The treatments are shown in Table 1.

(a) *Time and Method of Sowing*

Time of sowing had the greatest influence on the number of emerged seedlings. Plant counts following both spring sowings revealed only half as many seedlings from the late sowing as from the earlier sowing (Table 2). In autumn, early sowing produced only two-thirds as many seedlings as the late sowing. These results illustrate the overriding influence of soil moisture on germination and initial establishment and emphasize the importance of selecting sowing times on this basis.

In practice, spring sowings are often made later than desired. Although no firm conclusions could be drawn regarding the effects of seedbed preparation, certain trends were apparent. When spring sowing was delayed, there appeared to be some advantage in favour of direct drilling, probably a reflection of the better moisture status of the uncultivated seedbed. At sowing, the surface 2.5 cm of soil contained 20.5% and 12.5% moisture in the uncultivated and cultivated seedbeds, respectively. Under the drier conditions that usually prevail with late spring sowings, the smaller erosion risks associated with direct drilling may further favour its use. However, there is a need for further trial

TABLE 2: EFFECT OF TIME OF SOWING ON LUCERNE SEEDLING NUMBERS (000/ha)

Time of Sowing	*Spring*	*Autumn*
Early	260 a*	139 b
Late	130 b	204 a

*Duncan's Multiple Range Test: within each season, means without a common letter differ significantly ($P < 0.05$).

work on this topic. There was no evidence that direct drilling improved establishment in autumn sowings.

No consistent differences between drill tips were found. In autumn sowings the chisel coulter gave higher seedling numbers than the triple disc coulter ($P < 0.01$), particularly in cultivated seedbeds, though there was no effect on subsequent yields of lucerne.

(b) *Pest and Disease Control*

Root-knot nematode *(Meloidogyne hapla* Chitwood) is present in sand country soils and is known to infect the root system of lucerne and other legumes during establishment. The effects of nematicide treatment are shown in Table 3. For the spring sowings; when a soil fumigant ("Telone") was applied before sowing, no effect on seedling numbers was observed but early production was markedly increased. A systemic insecticide, oxamyl, was used at sowing in autumn and, though it reduced seedling numbers, initial production was again increased. Grandison (1976) found that several chemicals, though costly, gave effective temporary control of root-knot nematode and thus permitted more effective tap-root development. Such plants would be expected to possess greater drought tolerance though evidence of this is lacking at present. Nematode research is continuing, including an evaluation of lucerne cultivars for resistance to nematode infection (G. S. Grandison, pers. comm.).

Seedling mortality during damp conditions, attributed to "damping off", has occurred following late autumn sowings at Flock House. However. the use of fungicidetreated seed had no beneficial effect on initial establishment and severely depressed production ($P < 0.01$) by inhibiting nodulation of the young seedlings.

TABLE 3: EFFECT OF NEMATICIDE ON LUCERNE SEEDLING NUMBERS (000/ha) AND DRY MATTER YIELDS (kg/ha)

	Nematicide	*Spring Sowings*	*Autumn Sowings*†
Seedling numbers	Untreated	200 a*	192 a
(3rd true leaf stage)	Treated	190 a	151 b
Yields in first cut	Untreated	1120 b	1170 b
(Nov. 1975)	Treated	1650 a	1410 a
Yields in first year	Untreated	5440 b	4910 a
(3 cuts)	Treated	6630 a	5000 a

*Duncan's letters refer only to differences within sowings.
†Yields for autumn sowings include companion species.

(c) *Bulldozed Sand Dunes*

Sand dunes in their natural state are considered marginal agricultural soils, often more suited for afforestation, particularly the unconsolidated dunes (Waitarere sand) of the Younger Dune Complex (Cowie *et al.,* 1967). As a possible alternative to forestry on some of these areas, a technique involving the contouring of dunes with a bulldozer before winter sowing of lucerne has been assessed.

On contoured dunes, lucerne establishment after a pioneer crop of lupins was observed to be unsuccessful except where lupin regrowth was present. In the absence of such protection, lucerne seedlings were destroyed by wind erosion and very high temperatures on the sand surface. Attempts to establish lucerne under cover crops such as lupins and mustard indicate that:

(1) The lucerne should be sown well in advance of when moisture stress is expected.

(2) The cover crop should have largely completed its growth before the onset of moisture stress, thereby minimizing competition with lucerne for available moisture.

However, the establishment and management of lucerne on contoured dune areas is a difficult proposition, mainly owing to lack of soil stability after topsoil removal and the associated risks of wind erosion. It would, therefore, be unwise to attempt such development on a large scale at any one time.

FERTILIZER REQUIREMENTS OF LUCERNE

No requirement for lime at sowing on sand country soils has been found but lime-reverted superphosphate or a lime-superphosphate mixture is commonly sown with the seed to avoid possible germination injury or damage to the inoculum. Similarly, economic responses to lime in established lucerne crops have not been demonstrated.

The fertilizer requirements of established lucerne on Himatangi sand have been reported by Allbrook and Stiefel (1977). Under a predominantly hay regime, 450 to 500 kg/ha of superphosphate (40 to 45 kg P/ha) is recommended; if applied in spring this also satisfies any requirement for sulphur. Althbugh different rates of potash were not tested, the application of 500 kg/ha of potassium chloride (250 kg K/ha) increased yields by 10% ($P < 0.01$) and about equalled the amount of potash removed each year in lucerne hay. The rate of potash required depends in part on the balancc between haying and grazing.

Where grazing predominates, lower rates of application are likely to be adequate. In some years boron increased summer lucerne yields, hence boronated superphosphate may be used to advantage on established crops.

CONCLUSION

The wetter sand plain soils are characterized by a seasonally high water-table and deficiencies of phosphate and potash. To obtain satisfactory pasture growth, surface drainage is usually required plus the addition of 350 to 450 kg/ha of 30% potassic superphosphate annually.

On the more elevated sand plains the soils have lower water-holding capacity and the water-table is beyond the reach of most pasture plants for several months of the year. Lucerne is particularly suited to the drier soils though several factors may influence the success with which it establishes. Root-knot nematode can inhibit normal tap-root development and chemical control, whilst effective, involves considerable cost, Lucerne should be sown on sand country in early spring or late autumn to ensure an adequate supply of soil moisture.

The fertilizer requirements of lucerne are high (up to 1000 kg/ha of 50% potassic superphosphate annually) if the crop is cut for hay, though less where it is mainly grazed. Inclusion of boron in the fertilizer mixture is recommended.

On the drier soils the scope for increased productivity through growing lucerne is considerable. There still remains much sand country potentiallv suitable for growing lucerne.

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