

## Response of Matua prairie grass and Ellett perennial ryegrass to excess soil moisture in sand, silt and clay soils

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**ABSTRACT** The response of 'Grasslands Matua' prairie grass to waterlogging on different soil types was determined and compared with that of Ellett perennial ryegrass in a glasshouse pot trial at Massey University. During the waterlogging, rate of leaf extension (mm/tiller/day) of Matua prairie grass plants decreased, senescence rate (mm/tiller/day) increased, shoot:root ratio increased, and percentage of total plant weight as dead material increased, compared with unwaterlogged plants. These responses were more extreme on a clay soil than a sand, and a long rather than a short soak treatment, and generally disappeared on removal of the waterlogging stress. Shoot:root ratio of ryegrass decreased in response to waterlogging, but changes in components of plant dry weight were minor compared with those of Matua prairie grass. Matua is more sensitive to waterlogging than Ellett ryegrass, and Matua must be sown in the correct environment for it to persist and perform.

**Keywords** Matua prairie grass, Ellett ryegrass, waterlogging, soil oxygen, shoot:root ratio, leaf elongation, leaf senescence

### INTRODUCTION

'Grasslands Matua' prairie grass (*Bromus willdenowii* Kunth.) has been used on many farms because of its potentially high herbage production and seasonally high winter/spring yields (Rys et al. 1978; Lancashire 1978). Despite Matua's high potential, farmers have frequently had problems with persistency of Matua swards. Alexander (1985) suggested poor persistency of Matua might be related to damage to growing points arising from grazing or treading.

More recently, farmers have been advised not to sow Matua on poorly drained soils, which may decrease dry matter production and persistency (Lancashire 1978; de Lacy 1985; Hume & Fraser 1985; Sellars 1988). Sellars (1988) noted that Matua persisted better on sandy soils than on finer-textured soils. Mwebaze (1986) found that high soil moisture levels reduced soil oxygen levels and Matua root and tiller production.

To provide further information on the apparent susceptibility of Matua to wet soil conditions a study was undertaken at Massey University in 1988 to determine: (1) How Matua responds to waterlogging; and (2) How Matua responses compare with those of Ellett ryegrass (*Lolium perenne* L.).

### METHODS AND MATERIALS

A pot trial was conducted in a ventilated unheated glasshouse from 5 May to 9 September 1988. Pots (300 mm lengths of 90 mm diam. PVC plastic pipe) were filled with either fine builders' sand, Manawatu silt loam B horizon (silt), or Tokomaru silt loam B horizon (clay). Extraneous material was removed by sieving the soil. Osmocote, a slow-release compound fertiliser (nutrient analysis 14-6-12) was added at a rate equivalent to 250 kg/ha. Pots were weighed after packing and if necessary were repacked to ensure a uniform bulk density calculated at approximately 1300 and 1100 kg/m<sup>3</sup> for sand and clay soils, respectively.

Each pot was planted with a cluster of 2-3 tillers weighing 2.0-3.0 g for Ellett ryegrass or 3.5-4.0 g for Matua prairie grass. Yates 'Liquid Lush' was applied once every 4 weeks, as a precaution against nutrient deficiency.

The design was a factorial combination of soil type, plant species, water stress level, and harvest date effects, but was unbalanced (some treatment combinations absent on some harvest dates). 120 pots were randomly allocated to the 3 treatments: (1) No soak (control) - 48 pots; (2) 9-day soak and 9 day recovery (short soak) - 36 pots; (3) 18-day soak and 14-day recovery (long soak) - 36 pots.

Pots were waterlogged by immersion in waterfilled drums. Water level was kept within 1.5 cm of the soil surface. Destructive harvests were taken at day 0, and after the soak phase and recovery phase of each treatment (i.e. at days 9, 18 and 32 from soaking). Plants were dissected into leaf, stem, root and dead material, before drying at 60°C for 24 hours, and weighing. Data were analysed using the general linear model (GLM) procedure of SAS, and standard errors of means calculated as  $\sqrt{EMS/n}$  in the normal way.

Leaf lengths were measured at 48-hour intervals for one tagged, randomly chosen, mature tiller of each plant. This enabled calculation of leaf extension (mm/tiller/day) from the start of the experiment, and leaf senescence from day 5.

All pots were fitted with gas equilibration chambers (Mwebaze 1986) and a time series of gas samples was

taken from 12 pots (4 reps of each soil type) chosen at random from the long soak treatment and assumed to be representative of all pots filled with the respective soil type. Gas samples were analysed on a Shimadzu GC-8A gas chromatograph to determine soil oxygen levels.

## RESULTS

As the results for the silt soil were generally intermediate between those for sand and clay, only data for the clay and sand media are reported. This also applies to results for the 'short soak' treatment which were intermediate between the 'no soak' and 'long soak' treatments. All results have been reported by Eccles (1988).

### Soil oxygen levels

Soil oxygen content decreased significantly in sand and clay soils ( $P < 0.01$ ) during the soak phase (Figure 1) and also in the silt soil (Eccles 1988). The soil oxygen levels fell more rapidly and to lower levels in the clay than the sand filled pots. Recovery of soil oxygen levels to pre-soak values in the clay soil took 9 days, compared with only 5 days for the sand (Figure 1).

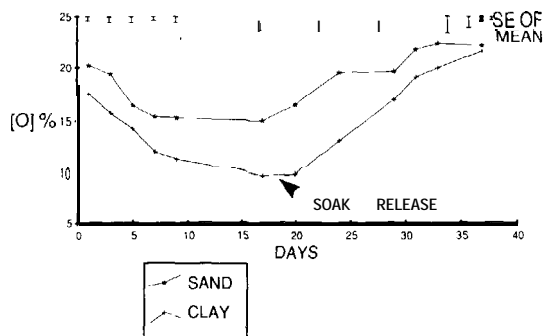


Figure 1 Soil oxygen concentrations [O] for the sand and clay soil types during the long soak treatment.

### Matua response to waterlogging

During the waterlogging phase, leaf extension rate of Matua significantly decreased from 22 mm/tiller/day to 16 mm/tiller/day ( $P < 0.05$ ), and increased once the stress was removed. Senescence rates were high for plants in waterlogged pots with soil oxygen levels below 15% (Eccles 1988) and this is shown by increased percentages of total plant dry weight as dead tissue (Figure 2a).

The plant weight results were variable, but effects were consistent when components were expressed as % total plant dry weight. On the clay soil after 18 days, percentages of leaf and root were less for soaked plants than control plants, while percentages of stem and dead material for soaked plants were higher than for control plants (Figure 2a). These changes were all statistically

significant. During recovery % dead material continued to increase (24% to 30%) and % leaf material continued to decline (24% to 20%), and as a result in the shoot:root ratio of Matua increased ( $P < 0.01$ ) during waterlogging and decreased during recovery (Table 1).

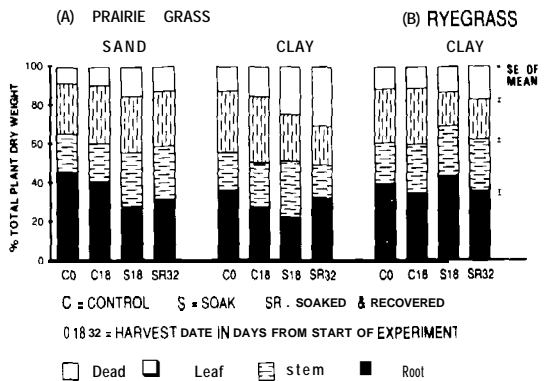


Figure 2 Components of total plant dry weight for ryegrass and prairie grass for the long soak treatment. Standard errors at right apply to all vertical bars (Matua and Ellett) for the component indicated.

On the sand soil the response of Matua to waterlogging was less pronounced. This is illustrated by the lack of change in % leaf during the experiment, by the decrease in % dead during the recovery period and by the fact that % root at the end of 18 days' soak was reduced to 23 % on the clay soil but was still 28 % on the sand soil (Figure 2a).

Table 1 Shoot:root ratios for ryegrass and prairie grass in the long soak treatment (mean of sand and clay soils).

Species	Treatment	Time elapsed (days)			
		0	9 (Soak)	18 (Soak)	32 soak & recovered)
Ryegrass	Control	1.73	1.76	1.31	—
	Soak	—	1.26	1.16	1.18
Prairie Grass	Control	1.54	1.48	1.56	—
	Soak	—	1.97	2.26	1.44

- (1) Day 0 value for soak treatment assumed same as control
- (2) Interaction significance (species x day x treatment):  $P < 0.05$
- (3) SE for all values in Table 1 = 0.20

### Comparison of prairie grass and ryegrass responses

On the sand soil waterlogging effects in ryegrass were scarcely discernible (Eccles 1988). On the clay soil, the proportion of dead material in the ryegrass plants

increased ( $P < 0.05$ ), and the proportion of leaf decreased ( $P < 0.01$ ), but these changes were much less pronounced than in Matua (Figure 2b). In ryegrass plants harvested after the soak phase proportion of root increased ( $P \sim 0.05$ ) (Figure 2b) and shoot:root ratio decreased (Table 1), the opposite response to that seen in Matua.

## DISCUSSION

The soil oxygen results show that different soils vary in their response to waterlogging in their oxygen depletion time and recovery rates. This is probably a reflection of the textural differences between the sand and clay, and the ability of sand to drain more quickly, thus increasing the rate of oxygen diffusion into the soil. Both soil types follow the same trend, but the extent and duration of the responses differs.

The results confirm that Matua and Ellett ryegrass do respond differently to the same waterlogging stress. Matua prairie grass showed water stress symptoms of decreased leaf growth rate, increased senescence rates, and decreased root:shoot ratio. These symptoms are similar to those reported for waterlogging damage in wheat by Trought & Drew (1980), in herb bennet (*Geum urbanum* L.) by Waldren et al. (1988), and in other herbaceous plants by Jackson & Drew (1984). Trought & Drew (1980) noted that in species sensitive to waterlogging a reduction in leaf elongation, as seen in this experiment for Matua, is widely reported, and might result from reduction in water uptake associated with low oxygen concentrations around the roots. They reported that in wheat plants shoot dry weight increased above that of controls during waterlogging and this effect was associated with starch accumulation. If the increased percentage dry weight as stem observed for Matua in this experiment also represents starch accumulation, then hard grazing after waterlogging would reduce plant reserves. This would explain Mwebaze's (1986) observation that hard grazing compounds the detrimental effects of waterlogging stress in Matua.

Other research on the effects of waterlogging on pasture species (Rogers & Evans 1973) has shown ryegrass to be more sensitive than cocksfoot (*Dactylis glomerata* L.) or timothy (*Phleumpratense* L.). The sensitivity of Matua to waterlogging is highlighted by the fact that in our experiment, a degree of waterlogging stress which affected ryegrass only mildly, had much more pronounced effects on Matua.

## APPLICATION

This experiment confirms the findings of Mwebaze (1986) and suggests that Matua prairie grass has a physiological sensitivity to waterlogging. The often reported poor persistence of Matua swards need not be explained in terms of physical damage during grazing, as Alexander (1985) suggested.

Furthermore, the fact that damage is likely to be greater on liner textured soils agrees with farmer experience. This adds weight to the growing body of opinion that Matua should not be sown in such soils. The results show that even on a light textured soil, Matua will be more susceptible to waterlogging damage than ryegrass.

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