Proceedings of the New Zealand Grassland Association 54: 121-125 (1992)

Forage shrubs for the South Island dry hill country: 2. salt/lime amendtnents have potential to improve the versatility of saltbush (*Atriplex halimus* L.)

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Abstract

Mediterranean saltbush (*Atriplex halimus* L.) seedlings were transplanted into a low-nutrient potting mixture amended with nine treatments of salt and/or lime, and magnesium sulphate. Plant growth parameters were measured at regular intervals and the experiment was terminated at week 20, after which the root:shoot ratio was determined. A low rate of salt/lime (0.25% w/w) produced significantly greater stem elongation than other treatments, most of this occurring during the first 13 weeks of the trial. On termination of the trial, shoot/plant dry weight from this treatment was also greater. Field trials have recently been established on Omarama YGE soils in the Mackenzie Basin and Blackstone YGE soils near the Upper Manorburn Dam, Central Otago to investigate the effectiveness and longevity of this response, and the likely level of maintenance applications necessary to retain good survival and productivity in soils previously considered poorly suited to saltbush. Investigation of environmental limitations for saltbush over a wider geographic range and integration of this data with a GIS database is planned. An ability to plant saltbush as a forage shrub into soil types not previously thought suitable using readily available, economical soil amendments may provide sustainable agricultural benefits for a wider dryland farming market than originally anticipated.

Keywords *Atriplex halimus L.*, Mediterranean saltbush, soil fertility amendments, lime/salt, forage shrubs, sustainable dryland farming

Introduction

Mediterranean saltbush (*Atriplex halimus* L.) has been under investigation for conservation uses since the early 1970s. Initial studies emphasised the selection of saltbush species and provenances for New Zealand conditions (Sheppard & Bulloch 1986). Interest insaltbushquickly developed beyond the immediate conservation values and, during the past decade, the forage value of the plant has been promoted and developed (Wills 1984; 1988; Wills *et al.* 1990; Sheppard *et al.* 1992).

Since the results reported in 1990. saltbush plantings in the South Island have increased severalfold. At that time the number of plants being established annually was about 3000400. In 1991 a single commercial grower produced approximately 15 000 seedlings and this year the total commercial production is estimated to be in excess of 25 000 plants.

Field plantings of saltbush were initially restricted to Central Otago/Waitaki region brown-grey earth and solonetzic soils but planting has since been extended to include several medium-high base rich yellow-grey earth soil types in Otago. South Canterbury, North Canterbury, and Marlborough. This saltbush is growing successfully and performing well on natural soils at all these sites.

Saltbush foliage is highly acceptable to Merino sheep (and most other breeds) and nutritionally it can provide a high quality stock forage virtually equal to that of lucerne (Wills et al. 1990). A significant advantage of the plant is its ability to carry standing forage through winter for spring utilisation, even in frost-prone localities like Central Otago. Constraints are that stock feeding on saltbush will require some supplementary water and that grazing is generally carried out (on a rotational basis) over only one or perhaps two short periods per block per year. Saltbush has also proved extremely valuable during recent snow falls in North Canterbury. A 10-month-old, 4-ha stand near Hawarden provided accessible, browseable forage for 600 Corriedale ewes for approximately 7 days, effectively doubling the previous carrying capacity of the dry, northerly face on which it was planted.

Because much farmer interest was expressed in growing saltbush in areas where soil types are not considered ideal, several soil mineral amendments were investigated for their potential effect on plant growth. The ability of saltbush to grow strongly in soils containing high levels of calcium. magnesium and sodium was recognised (Wills *et* al. 1990). These elements were therefore investigated as probable "fertiliser" sources to supplement soils currently considered marginal for saltbush.

Methods

Seedlings of ***Atriplex halimus were*** selected for uniformity of **size** and branching and were trimmed to 250 mm height. They were transplanted into P28 planter bags containing a proprietary growing medium supplemented with several **"fertilisers"** as described below. Six replicates were used per treatment. Each planter bag contained 9 kg of a low fertility seed raising mixture to which had been added 25% (v/v) of clean river sand. To reduce the probability of loosing the **"fertiliser"** via leaching, only the top **2/3rds** of the growing medium was amended to give rates equivalent to those below.

Nine treatments were established:

Treatment (Per planter bag)

1. **45 g common salt (0.5% w/w)**
2. **22.5** g common salt (0.25% w/w)
3. 45 g hydrated lime (0.5% w/w)
4. 22.5 g hydrated **lime** (0.25% w/w)
5. **45 g 50:50** mix of salt **+** lime (0.5% w/w)
6. **22.5 g 50:50 mix of salt + lime (0.25%** w/w)
7. 45 g magnesium sulphate (0.5% **w/w)**
8. 22.5 g magnesium sulphate (0.25% w/w)
9. No amendment • control

Planter bags were kept on pallets under natural conditions other than application of supplementary sprinkle irrigation. Standard soil mineral tests (MAF **"Quick-**test") were carried out on the growth medium treatments at week 1, **week** 11 and week 20 (experiment terminated). Leafmineral analysis was also carried out at week 20. Data collected included branching, growth of marked branches, plant height, **mainstem** diameter, leaf size **and dry** matter yield from ***roots.*** shoots and sub-fractions of the latter. Results were analysed by analysis of **variance/Tukey** HSD test.

Results and discussion

Growth medium and leaf mineral analysis

The results of the "Quicktest" growth medium analyses are given in Table 1. In the field, saltbushresponds most vigorously to Na. Mg and Ca and sites with one or ***more*** of these minerals in abundance enable the plant to grow well. Examples of soil tests from two sites, **Chatto** Ck and Riverside, on which **saltbush** grows very well, are shown for comparison.

The recorded levels of Ca changed little (slight increases were noted) from week 1 to week 19 but were not significant. Mg levels were more variable but with no clear trends evident. The **pH** increased slightly in most treatments but again not significantly. Some of

Table 1 "Quicktest" growth medium analyses at 1, 11 & 19 weeks for *Atriplex halimus* "fertiliser" amendment trial.

Treatment	pH			pH Units	Ca			Ca Units	K			K Units	P			P Units	Mg			Mg Units	Na			Na Units	S			S Units
	Wk 1	Wk 11	Wk 19	Change	Wk 1	Wk 11	Wk 19	Change	Wk 1	Wk 11	Wk 19	Change	Wk 1	Wk 11	Wk 19	Change	Wk 1	Wk 11	Wk 19	Change	Wk 1	Wk 11	Wk 19	Change	Wk 1	Wk 11	Wk 19	Change
1. 0.5% Salt	5.4	6.3	6.8	1.4	12	11	12	0	16	7	1	-15	60	14	4	-56	83	87	100	17	305	94	42	-263	332	28	2	-330
2. 0.25% Salt	5.4	6.8	6.4	1.0	12	10	12	0	19	6	2	-17	43	8	4	-39	95	78	90	-5	205	36	8	-197	443	5	4	-439
3. 0.5% Lime	6.8	6.9	6.8	0.0	17	15	18	1	16	7	1	-15	56	19	15	-41	90	85	80	-10	13	5	3	-10	290	21	20	-270
4. 0.25% Lime	6.5	6.9	6.6	0.1	12	15	15	3	16	7	2	-14	53	37	9	-44	86	83	89	3	12	4	3	-9	336	21	19	-317
5. 0.5% Salt/Lime	6.4	6.9	6.8	0.4	13	15	15	2	15	8	1	-14	51	16	6	-45	78	90	82	4	148	25	7	-141	306	14	5	-301
6. 0.25% Salt/Lime	6.1	6.7	6.4	0.3	12	11	13	1	16	6	1	-15	56	12	5	-51	85	73	84	-1	120	16	3	-117	345	9	2	-343
7. 0.5% Mag Sulphate	5.5	6.4	6.2	0.7	8	9	12	4	16	5	2	-14	45	11	7	-38	150	88	125	-25	11	3	2	-9	930	32	11	-919
8. 0.25% Mag Sulphate	5.6	6.3	6.3	0.7	8	9	12	4	16	6	2	-14	49	18	5	-44	110	90	115	5	13	4	2	-11	975	84	10	-965
9. Control	5.6	6.4	6.3	0.7	8	9	12	4	16	4	1	-15	62	6	6	-56	86	77	105	19	12	3	2	-10	300	11	4	-296
Field Sample - Chatto Ck		7.7				10				3				4				59				275				38		
Field Sample - Riverside		6				10				16				14				34				3				2		

Note: Field Samples are indicative of sites on which saltbush grows well.

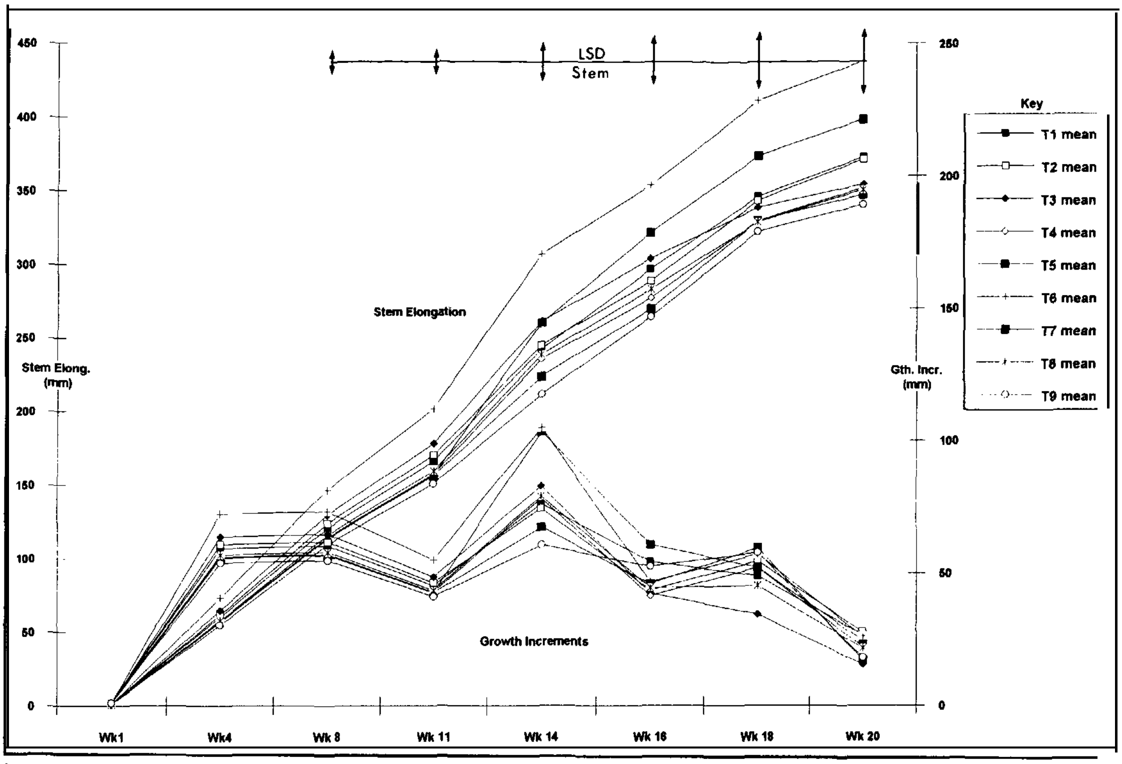

Figure 1 *Atriplex halimus* stem elongation and growth increments for "fertiliser" amendment trial.

these changes were probably related to leaching caused by irrigation. Most noticeable was the rapid loss of Na and S from the potting medium due to leaching - high Na and S treatments quickly reached levels consistent with those of low rate treatments. To date no field response has been evident from the application of S, thus it is unlikely the rapid decline in treatment S levels (particularly evident in treatments 7 and 8) had any effect on the saltbush. K and P levels declined fairly uniformly throughout the duration of the trial. Leaf mineral analysis was carried out but the only variation of note was a slight elevation in the level of Na in treatments 1 and 5, and to a lesser extent in treatments 2 and 6, thus it was physiologically active despite the relatively high rate of loss from the growing medium.

Plant growth parameters

Little difference was noted in the height to which plants finally grew in this experiment. Mean height (all treatments) was 630 mm and no treatments were significantly higher than the control. Most were similar to or slightly lower in height but additional side-branching and foliage production ultimately accounted for higher shoot weights in some treatments. At the mid-point of the trial, treatments 3 & 4 (high, low lime). 5 & 6 (high, low salt/lime mix) and 8 (low Mg) showed a significantly ($P=0.1$ for 3, 4, 8; $p=0.5$ for 5, 6) higher number of branches than the control. At the end of the trial, all of these except treatment 6 (NS) recorded greater numbers of branches than the control ($P=0.25$).

Measurements of stem elongation on marked branches produced significant ($P=0.001$) increases in growth (Figure 1) from treatments 5 and 6 (high, low salt/lime mix). In the case of treatment 6 this increase was significant prior to week 11, thus a growth response to the low level of salt/lime was occurring relatively early in the seedling establishment phase. The growth increments measured during the period of stem elongation exhibited a peak of extension at about week 14. tailing off beyond this.

Stem diameter was measured at 150mm above soil level. At 12 weeks two treatments, 4 (low lime) and 6 (low salt/lime), were significantly ($P=0.001$) different to the control. By the end of the trial, both salt/lime treatments (5 & 6) had mainstemdiameters significantly ($P=0.001$) greater than the control, along with the low salt treatment (2) and the low magnesium treatment (8).

Leaf parameters (length/breadth and dry weight) were measured on termination of the experiment. Only two treatments showed significantly ($P=0.001$) greater leaf width and leaf length, these being the two salt/lime ones (5 & 6). Their leaf dry weights were also signifi-

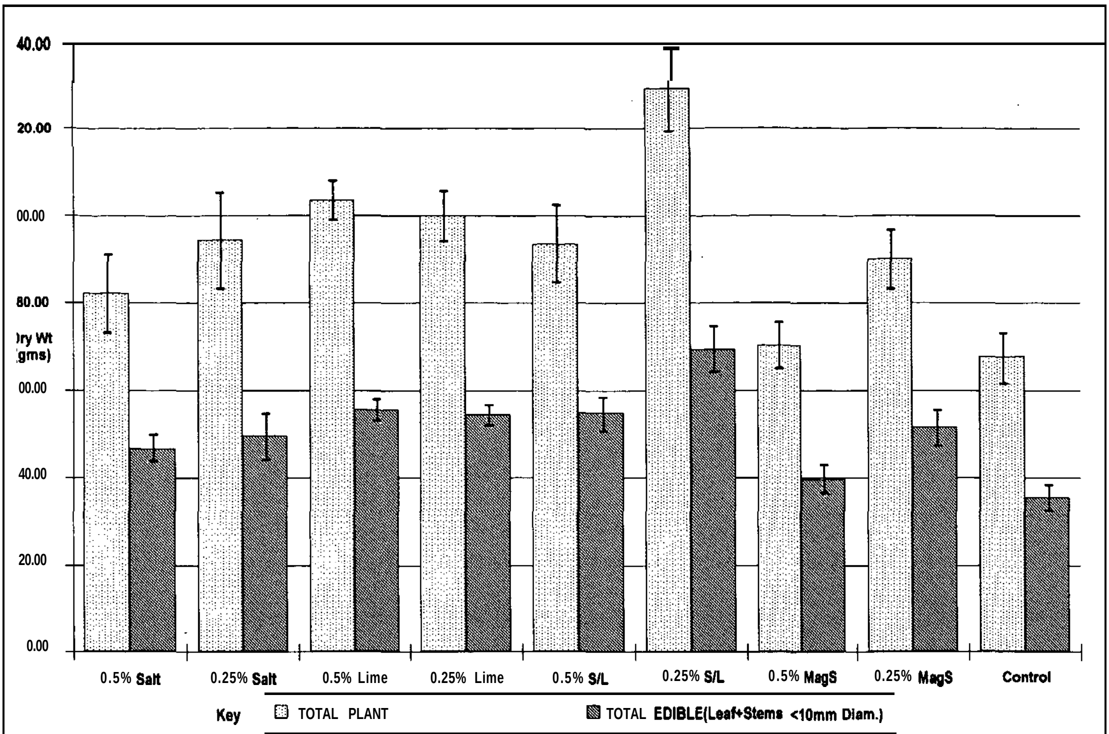

Figure 2 Dry weight at 20 weeks of whole plant and edible portion of *Atriplex halimus* with differing soil amendments.

cantly greater than that of the control, along with those of the two salt treatments (1 & 2) and one lime treatment (3).

On termination of the trial, plants were separated into root and shoot fractions which were then dried to constant weight and measured. The shoots comprised nearly 70% (range 64% to 74%) of the total plant weight (all treatments). Further separation of the shoot fraction into leaves, light stems and heavy stems was carried out. the leaves and smaller diameter (<10 mm) lignified stems being considered the "edible" portion of the plant, normally readily available to stock as forage.

The low salt/lime treatment (6) produced the greatest dry-weight gain for both the roots and the shoots. This was closely followed by the two lime treatments (3. 4) and the high salt/lime treatment (5), all four producing significantly (P=0.01) greater shoot fraction dry-matter yields than the control. For the root fraction, treatments 3, 4, 5 and 6 again produced significantly greater dry-matter yields than the control. In terms of total plant dry-matter yield (roots + shoots), treatment 6 produced significantly (P=0.05) more dry-matter than the next closest treatment. The increase over the control and high salt/high magnesium treatments (1, 7) was significant at the P=0.001 level.

Total plant dry-matter yield is compared with that of the "edible" portion of the plant in Figure 2. The "edible" portion comprised about 81% (range 77% to 83%) of the total shoot fraction (all treatments) and of this about 56% (range 52% to 62%) was leaf material. As noted above, several of the treatments produced significantly greater total dry-matter yields and more "edible" leaf and stem material than the control. This indicates that the use of salt/lime at a moderate rate as a soil amendment has the potential to improve plant establishment (with stronger root and shoot systems being formed in the first few months after planting) and possibly increase forage yields in the longer term on soil types currently not considered optimum for saltbush. Thus the main response from saltbush observed in this experiment was enhanced growth with the salt/lime mixture (low rate, treatment 6), particularly so during weeks 8-15.

Lime therefore appears to have an important role in the observed growth response of *Atriplex halimus* plants in this experiment, this being consistent with their good performance in the field in soils with elevated calcium levels. While a high salt level, both on its own and with lime (treatments 1, 5). did produce a positive growth increase when compared with the control, the two lime-only treatments (3.4) induced better growth responses. The lie-only treatments produced a dry-matter yield significantly greater than the high salt treatment (1) at the $p=0.05$ level. The fact that lime is less prone to leaching from the soil than salt is in its favour when extrapolating these results to the field situation.

Conclusions

An increase in saltbush productivity relating to the application of a low rate of salt/lime has been clearly demonstrated in this experiment. Extrapolated rates under field conditions suggest that 25 g of a 50:50 salt/ lime mixture per plant (or 25 kg/ha @ 1000 plants/ha) should ensure good saltbush establishment. In the field that rate has been doubled to 50 g per plant to ensure effectiveness; however, the "fertiliser" is incorporated 100-150 mm deep into the base of rip lines before seedlings are planted above it. Planted in this manner, sensitive young seedlings do not contact the salt/lime immediately and thus suffer any ill-effects.

While *benefits are* evident for saltbush seedlings during the establishment phase, the longevity and cost effectiveness of thii treatment has yet to be fully investigated. Early indications are that applications of lime alonemaybesufficientundermostfieldwnditions, thus reducing the cost of using this "fertiliser" further. At one 4 ha field site in North Canterbury, broadcast lime has been used to lift pH to a more suitable level. This site is being monitored by the Canterbury Regional Council and should provide some positive answers,

Using salt/lime as a soil amendment has resulted in **a survival rate of >95% for all saltbush seedlings planted** at field sites in spring 1991. On a hawkweed infested, YGE soil site at Black Forest Station in the Mackenzie Basin (altitude approx. 760 m asl). growth rates have only been moderate due to the dry summer. but plants have at least survived in a locality in which several prior attempts to establish them failed. A similar result was obtained on Galloway Station but growth has been even more restricted there due to the cold, extremely dry conditions.

While further field investigation is planned, it is encouraging to note the potential for more widespread plantings of saltbush. Based on its current success in North Otago, North Canterbury and Marlborough, Mediterranean saltbush *(Atriplex halimus)* should receive increased consideration as a viable and sustainable means of providing a perennial and nutritious source of stock forage. With its ability to keep well for long periods over winter or during droughts in dryland conditions and to provide "head-up" browse (thus avoiding ingestion of parasites from the ground) saltbush has the potential to fulfil an important role in providing forage at critical grazing times.

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