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SEEDLING GROWTH ON MULGA SOILS AND THE AMELIORATING EFFECTS OF LIME, PHOSPHATE FERTILIZER AND SURFACE SOIL FROM BENEATH POPLAR BOX TREES

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Abstract

Phosphate fertilizer, lime ($CaCO_3$), and soil from beneath poplar box trees (*Eucalyptus populnea*) were incorporated into the surface of an acid sandy red earth (mulga soil) in pots. The effect of these treatments was studied on the growth rate and yield of seedlings of 7 exotic pasture species, *Cenchrus ciliaris* cv. Biloela, *C. ciliaris* Q10087, *C. ciliaris* Q10077, *Schmidtia pappophoroides, Eragrostis curvula* CPI 30379, *Anthephora pubescens* and *Stylosanthes fruticosa*, plus 3 native species *Monachather paradoxa, Digitaria ammophila* and *Aristida armata.*

Phosphate fertilizer significantly increased growth rates and yields on all soils of all species except *E. curvula, S. fruticosa, M. paradoxa* and *A. armata.*

Lime, sufficient to raise the pH from 4.8 to 7.7, only slightly improved plant growth overall, although the effect was significant on the three *C. ciliaris* lines in the absence of added phosphorus. Box surface soil significantly increased growth rate and size of *C. ciliaris*, especially the cultivar Biloela, and to a lesser extent that of *A. pubescens, M. paradoxa* and *S. pappophoroides.* This improvement in seedling growth on soil from beneath box trees could be at least matched by the addition of phosphorus to mulga soil. Yet the shoots of seedlings growing in box surface soil appeared deficient in phosphorus, indicating a lower availability to plants of such phosphorus than chemical tests would indicate. Evidence in research literature indicates that the results obtained point to aluminium toxicity as being a major factor limiting seedling growth of *C. ciliaris* on mulga soils.

Introduction

Establishing exotic pasture species on red earth soils, particularly mulga soils, has proven very difficult in south-west Queensland. Christie (1975a) showed that buffel grass *(Cenchrus ciliaris* L.) seedling growth rate was severely restricted on mulga soils due to a lack of available phosphorus. Christie also obtained a significant improvement in seedling growth by liming the soil from pH 4.8 to 6.5, and by the addition of nitrogen, plus marginal responses to potassium and sulphur by the pre-flowering stage. The pH response was not due to an increase in availability of the trace elements Fe, Mn, Mo and B. Other grasses such as *Anthephora pubescens* and *Digitaria ammophila* also respond markedly to small amounts of applied phosphorus in the seedling stage (Silcock *et al.* 1976).

However, buffel grass unlike *A. pubescens* and *D. ammophila*, regularly colonises the area beneath poplar box trees *(Eucalyptus populnea)* growing on such soils. Ebersohn and Lucas (1965) showed that the surface soil beneath these and some other trees was significantly enriched with available phosphorus and exchangeable potassium and that soil pH was often higher. Christie (1975b) considered the improved buffel response under poplar box trees to be primarily due to the higher available phosphorus content of the soil. However, Silcock (unpublished data) has shown that, in pots, seedling growth of *A. pubescens* is not very markedly stimulated by soil from beneath poplar box trees (20 ppm available P - BSES acid extraction[1]). Hence the colonisation of areas beneath poplar box trees by buffel grass and not by many other phosphorus demanding species may not be primarily due to the enhancement of seedling growth by the greater available phosphorus levels in the soil. It may be that other soil or micro-environmental factors or some post-seedling persistence factor is determining the distribution of these grasses in the field.

No information about seedling growth in box surface soil has been published and present hypotheses are based on limited information derived from soil analyses. Hence, experiments were conducted to investigate some nutritional aspects of seedling growth on box tree soils and to determine whether seedlings of other grasses also respond markedly to surface soil from beneath poplar box trees.

[1] BSES Phosphorus = Bureau of Sugar Experiment Stations method i.e. 0.01N H_2SO_4 extraction – usually referred to as available phosphorus.

Methods

Experiment 1

Air dry (0.8% moisture) surface (0-10 cm) soil from under a mulga scrub growing on a sandy red earth was finely sieved and 2000 g placed into plastic pots lined with a polythene bag. Forty-eight pots were filled but then half had 500 g removed in an even layer (c. 3 cm) from the surface and this was replaced by 500 g of air dry (2.2% moisture) sieved, surface soil from beneath mature poplar box trees. The trees chosen were within the Charleville aerodrome from which domestic stock and kangaroos have been excluded for about 35 years. This sieved 'box' soil had a lower bulk density (1.2 cf. 1.4 g cc^{-1}), a better crumb structure and a slightly greater water holding capacity. Hence the two soils were not exactly comparable either physically or chemically. Chemical analyses (not shown) were conducted on the box and mulga surface soil from the aerodrome and the results were similar to those from Experiment 2 (Table 4).

The pots were brought to field capacity with tank water by weight and then planted in early February 1975 to either *Cenchrus ciliaris* cv. Biloela, *Anthephora pubescens* CPI 43713 or *Monachather paradoxa* (mulga oats). Two seeds were planted in the centre of each pot and then half of each group of pots was fertilized with $NaH_2PO_4.2H_2O$ solution at a P rate equivalent to that of 250 kg superphosphate ha^{-1}. Thus there were 3 grasses x 2 P rates x 2 soils x 4 blocks in a randomised block design in a plant house cooled below 38°C by evaporative coolers. The pots were watered daily to field capacity with tank water.

Observations were taken daily to record the date of emergence of each new main shoot leaf. Twenty eight days after sowing all plants were harvested and recordings made of tiller number and dry matter yield of tops. Tops were cut off below the crown, and oven dried for 36 hrs at 80°C. After weighing, the replicates were bulked together and then ground up and analysed for nitrogen, phosphorus and potassium in an autoanalyser.

All data except the chemical analyses were subjected to analysis of variance with appropriate account taken for missing values, and means were separated by Duncan's multiple range test.

Experiment 2

Another collection of surface soil from beneath mulga or poplar box trees was made from the Charleville aerodrome in October 1978. This time 24 large pots holding about 12 kg of soil were used. They were all partially filled with 9.6 kg of air dry mulga soil and then a 2.5 cm layer (1.7 kg) of either (i) box soil or (ii) limed (7.26 g ground $CaCO_3$) mulga soil or (iii) unameliorated mulga soil was added. The pots were then divided into two groups, one of which was fertilized prior to sowing with $NaH_2PO_4.2H_2O$ solution at rates equivalent to 25 kg P ha^{-1} (501 mg compound per pot), while the others received no phosphorus fertilizer. With four replicates, the design was thus 3 soils x 2 P levels x 4 blocks. The experiment was conducted in a glasshouse cooled by evaporative coolers so that the maximum air temperature remained below 33°C. Into each pot one germinated seedling of each of the following 9 pasture species was successfully planted:

Cenchrus ciliaris cv. Biloela
Cenchrus ciliaris Q10087 – ex. Rhodesia
Cenchrus ciliaris Q10077 – ex. Ethiopia
Schmidtia pappophoroides CPI 43715 – ex. Botswana
Eragrostis curvula CPI 30379 – ex. South Africa
Digitaria ammophila – native
Monachather paradoxa – native
Aristida armata – native
Stylosanthes fruticosa CPI 40615 – ex. Sudan

Other species, especially *Paspalidium constrictum* which preferentially colonises the drip-ring of box trees, were established in some pots but insufficient numbers germinated for them to be included in the formal results. The seedlings were evenly spaced around the pot and were grown until the fifth leaf on the main stem was fully expanded, when they were harvested. During this time the pots were watered daily with tank water and certain morphological data recorded for each plant including:

(a) Date of full expansion (ligule appearance) of leaves 2, 3, 4 and 5. Note: The cotyledons of *S. fruticosa* were regarded as leaf 1 and, as the trifoliate leaves subsequently expanded singly, they were called 2, 3, 4 and 5 respectively.

(b) Length and mid-leaf width of leaf 5 (L5) when it was fully expanded.

(c) Number of tillers when L5 was fully expanded.

(d) DM yield of tops when L5 fully expanded.

After all plants were harvested from each pot, the soil was allowed to dry out completely and then the surface 2 cm were sampled and analysed for pH, BSES phosphorus and extractable potassium. Statistical treatment of the results was the same as Experiment 1.

Results

Experiment 1

Box surface soil increased the rate of leaf production of all three species compared to that on mulga soil and was particularly effective on buffel grass (Table 1). There was a small additional response in the rate of leaf production by the addition of phosphorus to box soil. The treatment differences in the early stages of growth were small compared with those which followed. Twenty-eight days after sowing, a surface layer of box soil supported significantly smaller plants than mulga soil fertilized with 25 kg P ha^{-1} (Table 2). Also, dry matter yield of buffel seedlings on a layer of box soil plus phosphorus was 5 times that of pure mulga soil fortified with phosphorus. This compares with a two-fold yield increase in *Anthephora* and a 40% decline by mulga oats on the same soils. However, compared with unfertilized mulga soil, a 3 cm surface layer of box soil increased shoot yield 28 times in buffel but only 4 times for *Anthephora* and twice in mulga oats. This vast increase in buffel yield was due to a greater rate of leaf production and to increased individual leaf size rather than a greater number of tillers (Table 2).

Table 1. Effect of phosphate fertilizer and surface soil from beneath poplar box trees on the time (days) between sowing and leaf 4 appearance for three grasses grown on mulga soil (Exp. 1).

		Soil		
Grass	**Mulga**	**Mulga + P**	**Box**	**Box + P**
M. paradoxa	23.5d*	15.75b	18.75c	16.75bc
A. pubescens	24.5d	12.5ab	15.0b	12.5ab
C. ciliaris	30.0†e	13.75ab	11.75ab	10.5a
Treat. Mean	26.0r	14.0pq	15.2q	13.3p

* Values followed by the same letter are not significantly different ($P<0.05$).
† Where leaf 4 had not appeared a value of 30 days was used.

The concentration of potassium in buffel was greatly enhanced on the box tree soil compared with fertilized mulga soil but there was little or no increase in the other two grasses (Table 3). Nitrogen levels were considerably greater in plants growing on box soil, except in buffel where extra phosphorus greatly stimulated plant growth and thus diluted the additional N absorbed. Tissue phosphorus levels in plants growing on box soil were considerably lower than those of plants supplied with fertilizer phosphorus and similar to those reported for unfertilized seedlings growing in mulga soil under similar conditions (Silcock *et al.* 1976). This indicates a low level of available phosphorus for plants growing in box soil.

Experiment 2

At the conclusion of the experiment the nutrient status of the surface soil from the different treatments varied as shown in Table 4. The addition of soluble phosphate to a soil only increased available P and did not significantly affect any other measured parameter. However, the addition of lime reduced the level of extractable K, doubled the availability of phosphorus from 11 to 22 ppm on unfertilized mulga soil and raised the final pH by 2.9 units (Table 4).

Table 2. Effect of phosphate fertilizer and poplar box soil on shoot dry matter yield (mg) and morphological characteristics of three grasses 28 days after sowing on mulga soil (mean of 4 reps).

	Soil			
	Mulga	**Mulga + P**	**Box**	**Box + P**
M. paradoxa				
Shoot DM yield	21.2c*	193.6gh	48.9d	119.0f
Tiller number	0a	1.5c	0a	1.8c
Main shoot leaf number	4b	6.5d	4.8c	6.3d
A. pubescens				
Shoot DM yield	14.9b	344.2i	62.4e	607.1j
Tiller number	0a	0.8b	0a	3d
Main shoot leaf number	3.8b	7.5e	5.5cd	8.5f
C. ciliaris				
Shoot DM yield	5.7a	246.0h	161.9g	1244.5k
Tiller number	0a	0a	0a	1b
Main shoot leaf number	3a	8ef	7.5e	10g

* For each parameter, values followed by the same letter are not significantly different ($P<0.05$). (Duncan's multiple range test.)

Table 3. Effect of phosphate fertilizer and poplar box soil on the nitrogen, phosphorus and potassium content of the shoots of seedlings of three grasses 28 days after sowing on mulga soil (Exp. 1).

	Soil			
	Mulga	**Mulga + P**	**Box**	**Box + P**
Phosphorus %				
M. paradoxa	-†(0.27)*	0.60	0.10	0.27
A. pubescens	- (0.09)	0.18	0.09	0.19
C. ciliaris	- (0.10)	0.24	0.07	0.18
Nitrogen %				
M. paradoxa	- (4.64)	2.62	3.66	4.62
A. pubescens	- (2.76)	1.19	2.57	1.82
C. ciliaris	- (3.02)	1.24	2.34	0.95
Potassium %				
M. paradoxa	-	4.20	3.95	5.14
A. pubescens	-	3.92	4.60	4.40
C. ciliaris	-	3.42	6.11	4.30

† Insufficient dry matter for analysis.

* Values in parenthesis are taken from Silcock *et al.* (1976) for seedlings of a similar age growing under similar conditions.

A soluble fertilizer tended to increase the rate of leaf appearance of all species on all soils, often significantly (Table 5). The P effect was most obvious for the *C. ciliaris* lines and non-significant for *E. curvula, D. ammophila, M. paradoxa* and *A. armata*. If extra was supplied, soil type did not significantly influence rate of leaf appearance. However, without additional P, box soil was significantly ($P<0.01$) better for early seedling growth than limed mulga soil and both were significantly better ($P<0.01$) than unlimed mulga soil (Table 5). Lime alone significantly promoted the rate of leaf production of only *C. ciliaris* and was even slightly deleterious to *S. fruticosa*.

Phosphorus also tended to enhance tillering except in *A. armata* (Table 6) but lime did not. Note the early tillering of the increaser grass *A. armata*. Despite the stimulating effect of box soil on leaf expansion of *C. ciliaris*, it did not significantly enhance early tillering in this species. It did significantly enhance tillering of *E. curvula*, *S. pappophoroides* and *D. ammophila*. Phosphorus significantly increased yields of all species at the 5-leaf stage except *E. curvula* and *S. fruticosa* (Table 7). Lime significantly increased the yield of only *M. paradoxa* while box soil significantly increased yields of only *C. ciliaris* cv. Biloela, *C. ciliaris* Q10087, *S. pappophoroides* and *M. paradoxa* at a similar growth stage. Biloela buffel was outstanding in its response to fertility, mainly due to an increased size of individual leaves.

Table 4. Chemical properties, before and after the trial, of the soils used in Exp. 2. The soils used in Exp. 1 were of similar nutrient status and pH.

Soil	pH	Available P (ppm)	Extractable K (me%)	Available H_2O Range (%)
Original mulga soil	5.3	13	0.25	6.6
Original box soil	υ.7	20	0.61	6.4
Final mulga soil	4.8	11(96)*	0.42	-
Final box soil	6.3	26(56)	0.60	-
Final limed soil	7.7	22(108)	0.28	

* Values in parenthesis are means for soils which had soluble phosphorus added.

Discussion

The soil from beneath mature poplar box trees stimulated the seedling growth of most species and in particular that of Biloela buffel. Though the stimulation of early leaf production (Tables 1 and 5), was probably partly due to a greater level of available P in the box surface soil (Table 4), other components may have been more important in influencing buffel grass growth. Available nitrogen should not have been limiting for early growth in any of the soils and neither should have available potassium as the potassium levels in all the soils are quite adequate as were the plant concentrations (Table 3). In its natural state buffel grass colonises neutral to slightly alkaline soils (Bryzostowski 1962). There is a good reason to believe that a higher pH was indirectly the cause of the better growth of buffel on box surface soil. An increase in pH could have increased the amount of available phosphorus in the soil (Salter and Barnes 1935) or reduced the level of exchangeable aluminium (Rorison 1958, Reeve and Sumner 1970). The available phosphorus in the soil (Table 4) would support the former suggestion. However, the response to fertilizer phosphorus of some plants growing on box soil, notably Biloela buffel, *A. pubescens* and *M. paradoxa* indicates that phosphorus is still limiting for maximum seedling growth of some species on poplar box soils (Tables 2 and 7). The very low phosphorus content of the shoots of these species on box soil (Table 3) further highlights the unavailability of the soil phosphorus despite the relatively high value from the chemical test (Table 4).

Compared to other tropical grasses, the growth of Biloela buffel grass is severely reduced by low levels of soluble aluminium around its roots (Spain and Andrew 1978). Thus the higher pH of box surface soil and the limed soil may have minimised the amount of exchangeable, ionic aluminium in the soil (Reeve and Sumner 1970) at a time when buffel seedlings were very sensitive to it. Above a pH of about 5.5, exchangeable aluminium concentrations are very low (Rorison 1972). MacLeod and Bradfield (1964) found *Medicago sativa* and *Dactylis glomerata* to be very sensitive to aluminium in the seedling stage while older plants were not. This same situation may apply to buffel grass which usually persists on mulga soils once established. In Experiment 2, *E. curvula* did not respond significantly to box surface soil and it is known to be tolerant of high soil aluminium levels (Fleming *et al.* 1974). Phosphate fertilizers also precipitate ionic aluminium as insoluble phosphates and in the mulga soil plus P treatments (Tables 2 and 7) would have had the dual effect of removing toxic aluminium (Rorison 1958) while supplying the extra phosphate required by the young seedlings. In unfertilized mulga soil, excessive aluminium could exaggerate the endemic phosphate deficiency by preventing normal root growth and metabolism in a sensitive plant. Buffel grass, particularly the cultivar Biloela, and possibly *S. pappophoroides*, give indications of being sensitive to excessive levels of exchangeable aluminium in mulga soils.

Table 5. The effect of phosphate fertilizer on interval (days) between full expansion of leaves 2 and 5 of seedlings of nine pasture species growing on mulga soil amended by either lime or surface soil from beneath poplar box trees (Exp. 2).

Species	P level (kg ha^{-1})	Soil: Unamended mulga	Soil: Box surface layer	Soil: Limed surface layer
C. ciliaris	0	23.00	9.50	11.75
cv. Biloela	25	8.25	8.75	7.75
C. ciliaris	0	28.50	9.50	13.00
Q10087	25	9.25	8.50	8.50
C. ciliaris	0	25.00	10.25	16.00
Q10077	25	9.25	9.50	8.75
S. pappophoroides	0	16.00	9.50	12.00
	25	9.00	8.50	9.48
E. curvula	0	13.00	10.25	12.25
	25	10.25	10.25	9.25
D. ammophila	0	13.25	10.00	11.75
	25	9.25	9.00	9.25
M. paradoxa	0	18.00	12.50	14.75
	25	14.23	11.45	12.90
A. armata	0	14.00	12.75	13.00
	25	11.75	11.50	11.25
S. fruticosa	0	19.00	19.75	21.75
	25	17.50	14.50	19.50
$LSD_{0.05}$ = 4.721				
Means	0	18.86a*	11.55c	14.25b
	25	10.97c	10.22c	10.74c

* Values for the soil treatment means which are followed by the same letter are not significantly ($P<0.05$) different (Duncan's Multiple Range Test).

Table 6. Effect of applied soluble phosphate on mean tiller number of the grasses from Exp. 2 when they had five fully expanded main shoot leaves.

P. level (kg ha^{-1})	Species: *C. cil.* Biloela	*C. cil.* 10087	*C. cil.* 10077	*S. pap.*	*E. cur.*	*D. amm.*	*M. par.*	*A. arm.*
0	0	0.3	0.3	0.3	1.3	0.9	0.8	2.8
25	0.4	0.8	0.8	1.1	2.1	2.5	1.3	2.7

$LSD_{0.05}$ = 0.51

Compared with the other grasses all three buffels responded similarly to lime and phosphorus but none appear well adapted for vigorous seedling growth on mulga soil. Cultivars Q10087 and Q10077 were less responsive than Biloela having been selected from a wide range of buffel grass accessions for their better performance on unfertilized mulga soil. The results also confirm earlier work by Silcock *et al.* (1976) and Christie and Moorby (1975) that buffel grass is more demanding of P for optimal growth on mulga soil than many other species. For example, the addition of phosphorus fertilizer reduced the time to expand leaves 3, 4 and 5 by 44 to 50% for the buffels compared with 13 to 28% for the other grasses (Table 5).

As Lodge (1980) points out, relative plant response to fertility can vary markedly depending on the criterion chosen for the comparison. Thus buffel's response to fertility was much greater than that of *D. ammophila* if measured by rate of leaf appearance, leaf size or shoot yield but similar if measured by tiller number. Phosphorus was the nutrient in greatest demand overall for growth but it affected dry matter yield responses in a different way on each species. It increased yield mostly by a greatly increased leaf length in *A. armata*, by increased tillering in *E. curvula*, by increased length and width of leaves in all buffels, by increased tillering and leaf length in *S. pappophoroides* and by a combination of increased tillering, leaf length and leaf width in *D. ammophila*. In the semi-arid environment of inland Australia, earlier tillering and a more rapid rate of early leaf production are more desirable than greater yield for ensuring greater ease of establishment (Silcock 1975, Silcock and Williams 1976). Thus the use of phosphate fertilizer to establish pastures on mulga soil should disadvantage the undesirable *Aristida armata* and benefit the other desirable grasses.

Stylosanthes fruticosa did not respond significantly to lime or phosphorus, although it did grow better on box soil fertilized with phosphorus (Tables 5 and 7). This species has persisted better under grazing when growing beneath box trees in the Charleville area. However, heavy rates of phosphorus can be toxic to young plants (Jones 1974) and yield responses are never large even at lower rates of P application (Siddiqi 1978).

These experiments have shown that the nutritional requirements for establishing plants on mulga soils vary markedly with species and that the large amount of published work on Biloela buffel is not directly applicable to other grasses either commonly tested on or native to these soils. Also the absence of many pasture grasses from beneath poplar box trees is probably due to factors other than their nutritional requirements in the seedling stage. Further studies are required to confirm whether or not excessive soil aluminium is restricting the introduction of useful pasture species such as buffel grass into mulga country.

Table 7. Shoot dry matter yield (mg) of seedlings of nine pasture species when they had 5 fully expanded main tiller leaves, as affected by phosphorus fertilizer and amendment of the surface of mulga soils by lime or surface soil from beneath poplar box trees (Exp. 2).

			Soil	
Species	**P level (kg ha^{-1})**	**Unamended mulga**	**Box surface layer**	**Limed surface layer**
C. ciliaris	0	21.2	61.5	37.2
cv. Biloela	25	93.6	127.3	107.8
C. ciliaris	0	17.2	80.1	30.4
Q10087	25	88.1	72.0	89.9
C. ciliaris	0	13.5	65.8	26.6
Q10077	25	81.4	44.8	84.9
S. pappophoroides	0	21.5	64.3	30.1
	25	58.9	65.1	44.0
E. curvula	0	27.1	43.2	28.6
	25	35.6	38.7	33.1
D. ammophila	0	21.9	30.6	17.8
	25	43.8	42.4	40.3
M. paradoxa	0	52.3	57.0	70.9
	25	50.0	91.1	94.2
A. armata	0	53.3	59.2	64.5
	25	74.6	64.5	88.4
S. fruticosa	0	23.4	27.7	22.6
	25	32.6	40.3	24.4
$LSD_{0.05}$=26.4				
Means	0	27.9a*	58.0b	36.5a
	25	61.9b	65.0b	63.8b

* Values for the soil treatment means which are followed by the same letter are not significantly different (P<0.05) (Duncan's multiple range test).

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These experiments have shown that the nutritional requirements for establishing plants on mulga soils vary markedly with species and that the large amount of published work on Biloela buffel is not directly applicable to other grasses either commonly tested on or native to these soils. Also the absence of many pasture grasses from beneath poplar box trees is probably due to factors other than their nutritional requirements in the seedling stage. Further studies are required to confirm whether or not excessive soil aluminium is restricting the introduction of useful pasture species such as buffel grass into mulga country.

Table 7. Shoot dry matter yield (mg) of seedlings of nine pasture species when they had 5 fully expanded main tiller leaves, as affected by phosphorus fertilizer and amendment of the surface of mulga soils by lime or surface soil from beneath poplar box trees (Exp. 2).

Species	P level ($kg\ ha^{-1}$)	Soil: Unamended mulga	Soil: Box surface layer	Soil: Limed surface layer
C. ciliaris	0	21.2	61.5	37.2
cv. Biloela	25	93.6	127.3	107.8
C. ciliaris	0	17.2	80.1	30.4
Q10087	25	88.1	72.0	89.9
C. ciliaris	0	13.5	65.8	26.6
Q10077	25	81.4	44.8	84.9
S. pappophoroides	0	21.5	64.3	30.1
	25	58.9	65.1	44.0
E. curvula	0	27.1	43.2	28.6
	25	35.6	38.7	33.1
D. ammophila	0	21.9	30.6	17.8
	25	43.8	42.4	40.3
M. paradoxa	0	52.3	57.0	70.9
	25	50.0	91.1	94.2
A. armata	0	53.3	59.2	64.5
	25	74.6	64.5	88.4
S. fruticosa	0	23.4	27.7	22.6
	25	32.6	40.3	24.4
$LSD_{0.05}$=26.4				
Means	0	27.9a*	58.0b	36.5a
	25	61.9b	65.0b	63.8b

* Values for the soil treatment means which are followed by the same letter are not significantly different ($P<0.05$) (Duncan's multiple range test).

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