PRODUCTION OF ALFALFA (*Medicago sativa* L.) I. INFLUENCE OF ROW SPACING AND CULTIVAR[1] /

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Compendio

Después de un año de condiciones climáticas favorables en Canberra (Australia), fueron tomadas mediciones de producción de plantas en un experimento en el cual ovejas destetadas pastaron cuatro cultivos de alfalfa: Hunter River, Du Puits, Uruguay y Cancreep, sembrados a cuatro diferentes espaciamientos entre surcos: 15, 30, 45 y 60 cm, y cero alfalfa.

Conforme el espacio entre surcos disminuyó, la producción de alfalfa aumentó significativamente (P < 0.05). Aún cuando las diferencias absolutas fueron mínimas en invierno la alfalfa sembrada a 15 cm entre surcos sobrepasó significativamente (P < 0.05) en rendimiento a la sembrada a 45 ó 60 cm.

Cuando se incluyó alfalfa, los espacios entre surcos no afectaron la producción total de materia seca.

Todos los cultivos de alfalfa tuvieron comportamientos estacionales similares de producción, pero los totales de materia seca producida de Uruguay y Du Puits fueron significativamente (P < 0.05) mayores que los de Hunter River, el que a su vez sobrepasó a Cancreep significativamente (P < 0.05).

La cantidad o densidad de plantas Cancreep y Du Puits fue significativamente menor (P < 0.05) que la de las Hunter River y Uruguay.

El componente de alfalfa en todos los lotes fue más bajo en Cancreep.

Los efectos de las densidades de alfalfa en la producción de los lotes y la importancia del pastoreo en la evaluación de los cultivos de alfalfa son discutidos en el presente trabajo.

Introduction

Hunter River is the principal cultivar of alfalfa grown in Australia; agronomists and plant breeders now recognize the potential value of the genetic variation that is offered by alfalfa (13).

Because Hunter River was selected under cutting regimes there is an obvious need to compare other cultivars with it under grazing. The Southern Table lands around Canberra have some summer rainfall which suggest the likely success of the cultivar Du Puits (6, 5, 2). Uruguay, selected for grazing in South America, and Cancreep, selected in Australia for its creeping rooted habit (7), might be expected to prove more persistent and productive under grazing than Hunter River.

There is little information about the effects of plant density on the production of alfalfa. High

1 Received for publication August 18, 1980.

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density stands must intensify competition between individual plants and lead to smaller root systems. In drought years and dry summers, restricted exploitation of soil water could result in lower production. Moreover, in winter, production from high density alfalfa stands must be relatively low, and many sown or volunteer species, which could be associated with low density stands of alfalfa, might make mixed pastures more productive than alfalfa itself. Even if marked changes in production should occur at different spacings for grazing purposes, their importance could be measured only under grazing conditions.

This paper reports the dry matter production of the above cultivars at four different row spacings, over the first 12 months after the grazing treatment began.

Material and methods

The pastures were at the Ginninderra Experimental Station near Canberra. There were two replicates separated by about 400 m: replicate I on a gentle slope (3° to 5°) while replicate II was on moderately ondulating country. Both replicates were on soil derived from quartz-porphory. They consisted of sandy loam in the top 30-50 cm, with a medium heavy clay subsoil and somewhat restricted deep dranaige.

The climate of Canberra has been described by Slatyer (16) and data from the Bureau of Meteorology (1) are given in Table 1.

The plots were arranged in two Latin Squares (replicates I and II), each 5 x 5 with alfalfa row spacing of 15 cm, 30 cm, 45 cm, 60 cm and no alfalfa as the main treatments. Four alfalfa cultivars –Hunter River, Du Puits, Uruguay and Cancreep– were sown as split plots in main plots of 0.043 ha each. Constant seed rates per row were used, resulting in 5.5; 2.8; 1.8 and 1.4 kg/ha of seed being sown at the 15, 30, 45, and 60 cm spacings respectively. Superphosphate was applied each year in autumn (125 kg/ha).

Following the sowing of these swards in September 1967, a severe drought lasting throughout 1968 reduced the establishment of alfalfa. Regardless of row spacing or cultivar, 40-50 per cent of viable seeds became established. By October 1968, 12 months after sowing, only 15-20 per cent of sown viable seed survived as established plants and neither cultivar nor row spacing treatment significantly affected that percentage (9).

A rotational grazing system of 5 paddocks was used for each sequence of plots with the same alfalfa spacing; that is, 5 paddocks, each of 15 cm, 30 cm, 45 cm, 60 cm and no alfalfa spacings. Two rows of the Latin Squares (blocks), one from each replicate, were grazed simultaneously. Wether weaners were

Table 1. Meteorological data for Canberra.

MONTH	TEMPERATURE °C	Average of 37 years RAINFALL mm	EVAPORATION mm	RAINFALL mm 1969	1970
JAN.	21	54	201	22	92
FEB	20	54	157	104	42
MAR	18	63	128	56	46
APR.	14	54	83	104	61
MAY	10	49	49	61	47
JUNE	7	47	31	66	30
JULY	6	46	31	48	10
AUG.	7	49	44	31	77
SEPT.	10	47	71	20	155
OCT.	13	73	110	133	29
NOV	16	55	147	62	122
DEC.	19	54	185	45	75
TOTAL		645	1 237	752	787

allocated to the 10 groups by stratified random sampling, so that initial liveweight was similar for all groups of 3 Merinos plus 2 crossbreed weaners each. Once a group was formed it remained on a given row spacing treatment moving from plot to plot at constant intervals of 9, 9, 5, 5, and 7 days grazing on blocks A, B, C, D and E respectively (Fig. 1).

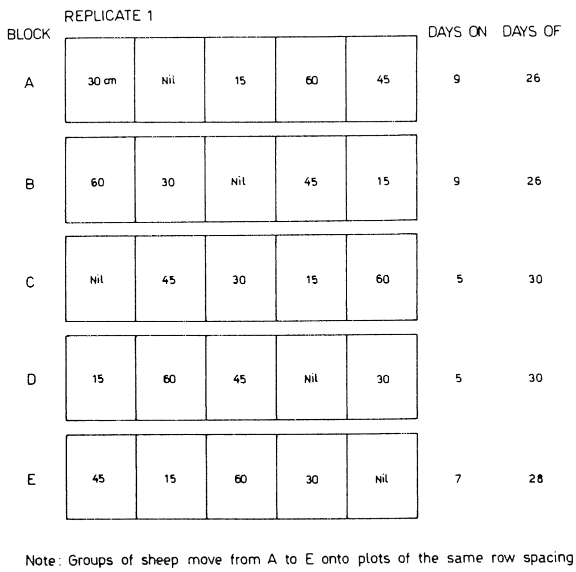

Fig. 1. Outline of grazing management.

Three grazing systems, confounded with block and time of grazing, were simulated by the following grazing management:

Block	Days on	Days off	Days of cycle	No. paddock simulated	Days of cycle simulated	Stocking rate weaners/ha
A, B	9	26	35	4	36	29
C, D	5	30	35	7	35	17
E	7	28	35	5	35	23

This management lasted from February 1969 until March 1970, except during the winter of 1969 when the grazing time, and therefore spelling time, was doubled. On December 29, 1969, all the animals were replaced by new wether weaners in the same fashion as above.

Yield of alfalfa and botanical composition were determined cutting two random quadrats for each variety at every spacing the day before grazing commenced in blocks B, C, and E of both replicates.

To avoid bias from different spacings of alfalfa two shapes of quadrats were used, one 60 x 60 cm for the 15 cm, 30 cm and 60 cm alfalfa spacings and 45 x 80 cm for the 45 cm alfalfa spacing between adjacent rows. In the no alfalfa plot, 8 random sites were cut within either quadrat.

The cuts were subsampled and dry matter yields were calculated for alfalfa, grasses, subterranean clover and miscellaneous species.

Mean values over the three grazing management treatments are presented.

The density of alfalfa plants had been estimated in October 1968 (10) and a final count was made in February 1970 on all alfalfa cultivars at each row spacing for two stocking rates (29 and 17 weaners/ha). Six 60 cm long random sites were sampled by trenching along both sides of the row to a depth of about 10-15 cm, and individual alfalfa plants were counted from tap roots.

Results

Row spacing:

Throughout the year, alfalfa yield increased as the density of rows increased (Figure 2). Whether production was high or low a four-fold increase in density of rows usually resulted in yield being approximately doubled (Figure 3). Although absolute differences were minimal in winter, alfalfa at 15 cm still significantly outyielded that at 45 or 60 cm, while during spring to summer period of high production the much larger differences between consecutive spacings were themselves not significant.

With a few exceptions during the year, where alfalfa was included row spacing did not significantly affect total dry matter production (Figura 4). However, except for midsummer, the plots without alfalfa consistently outyielded the others, and

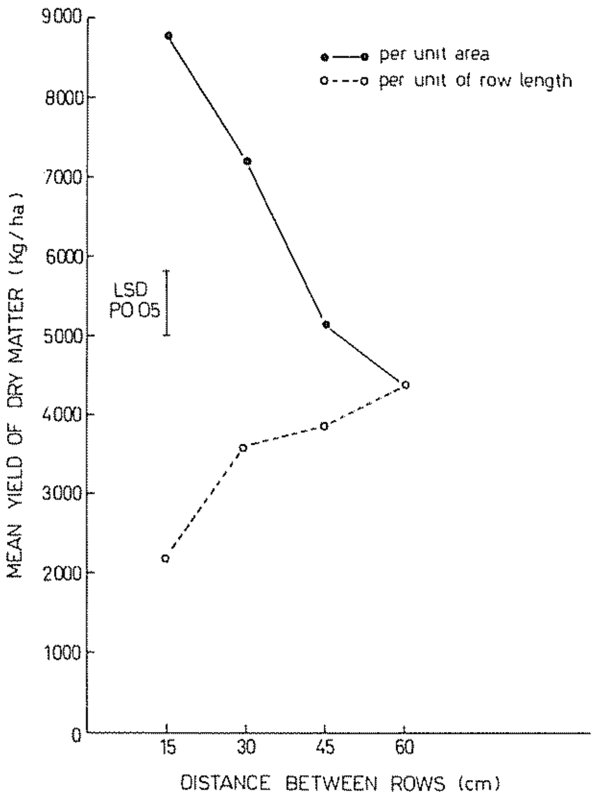

Fig. 2. Effect of row spacing on cumulative yield of alfalfa.

especially so in winter when dry matter availability tended to be lowest for the closest spacing.

When seasonal conditions allowed rapid growth of alfalfa it was the alfalfa component of the pasture which controlled the production of the annuals: the greater the density of alfalfa rows the lower was the contribution of the other species (Figure 5), and thus the greater was the space occupied by alfalfa. Presumably it was because it still occupied this ground space during winter that the relationship still held, even though alfalfa, being dormant, no longer competed actively for light with the much faster winter-growing species.

Alfalfa cultivars:

The total yield of Uruguay and Du Puits (7 000 kg/ha) were significantly greater than that of Hunter River (6 000) which in turn outyielded Cancreep (5 200) significantly. The poor performance of Cancreep with relatively low yields throughout the year was a prominent feature of the results (Figure 6). Although individual differences between varieties may not have been significant, either Du Puits or Uruguay was the highest yielding cultivar throughout the experimental period. These findings were not affected by row spacing: Du Puits and Uruguay were

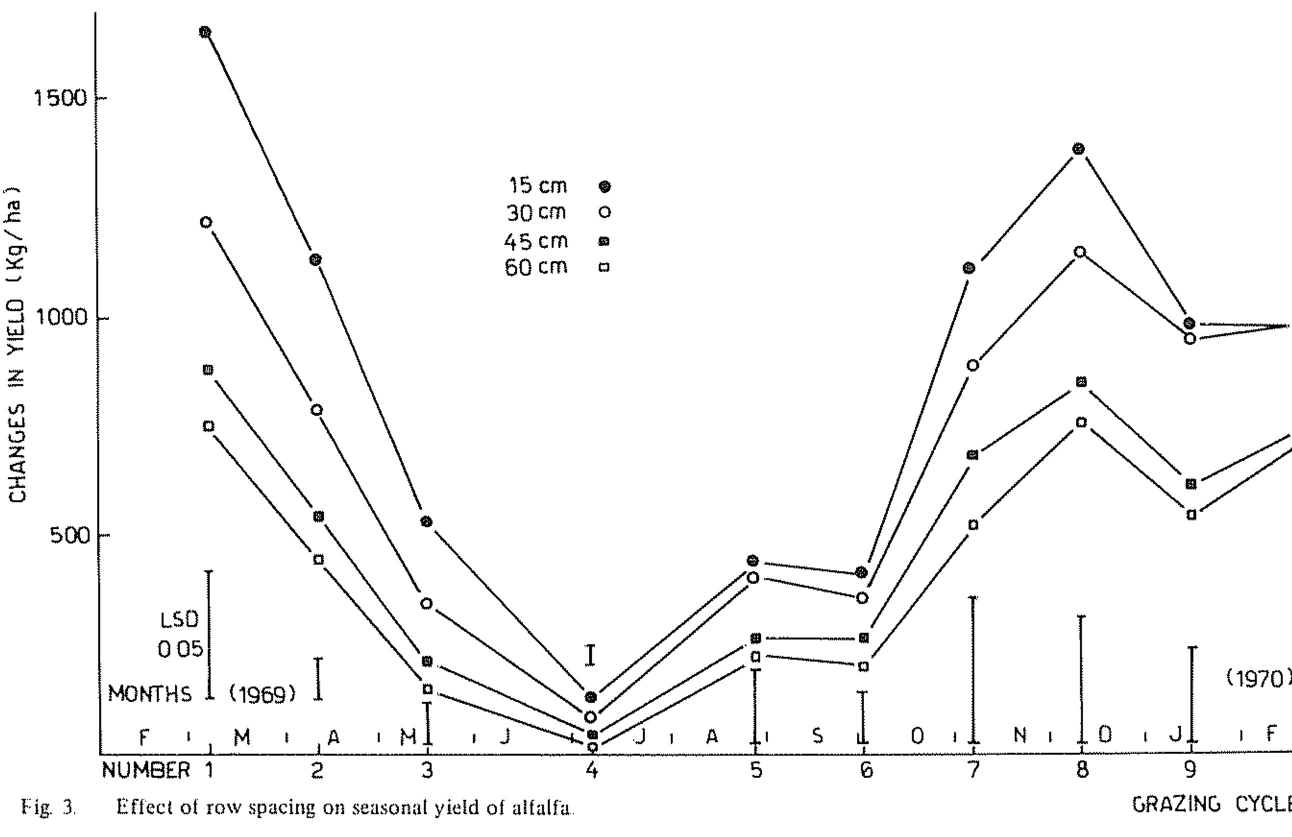

Fig. 3. Effect of row spacing on seasonal yield of alfalfa.

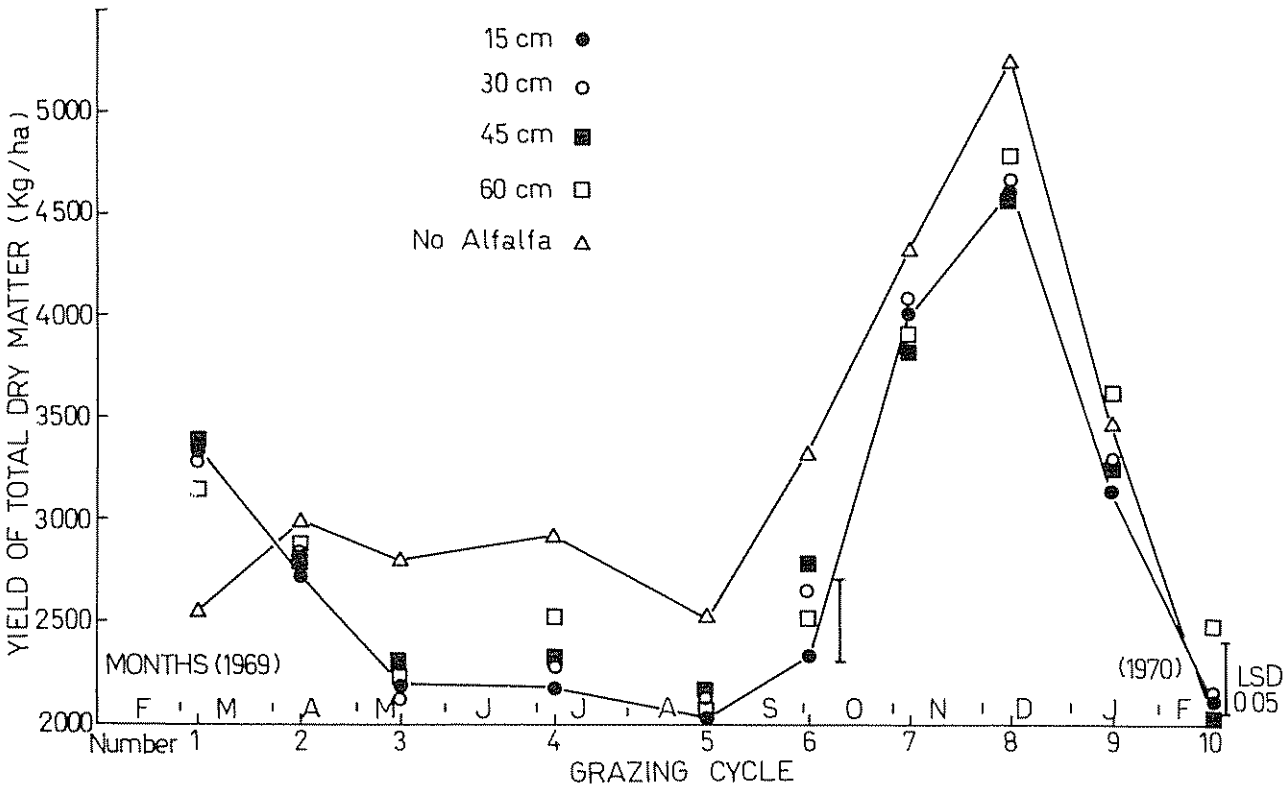

Fig. 4. Influence of alfalfa row spacing on total pasture yield.

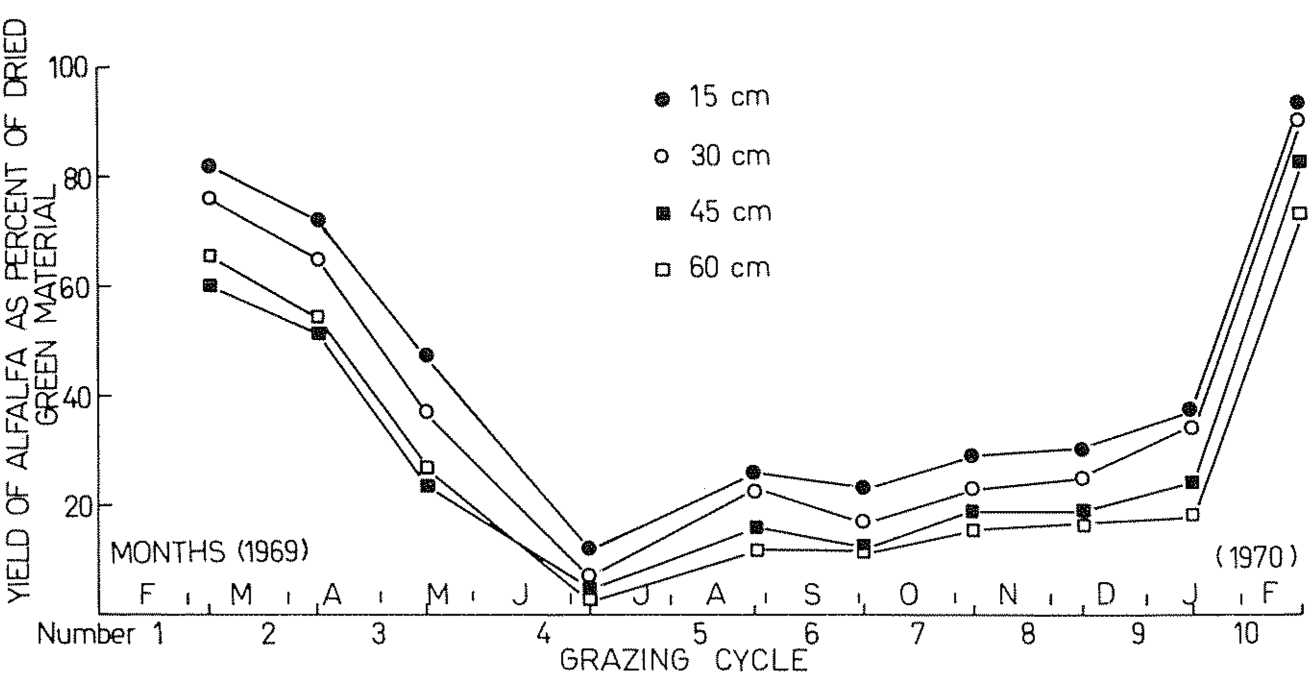

Fig. 5. Influence of row spacing on botanical composition.

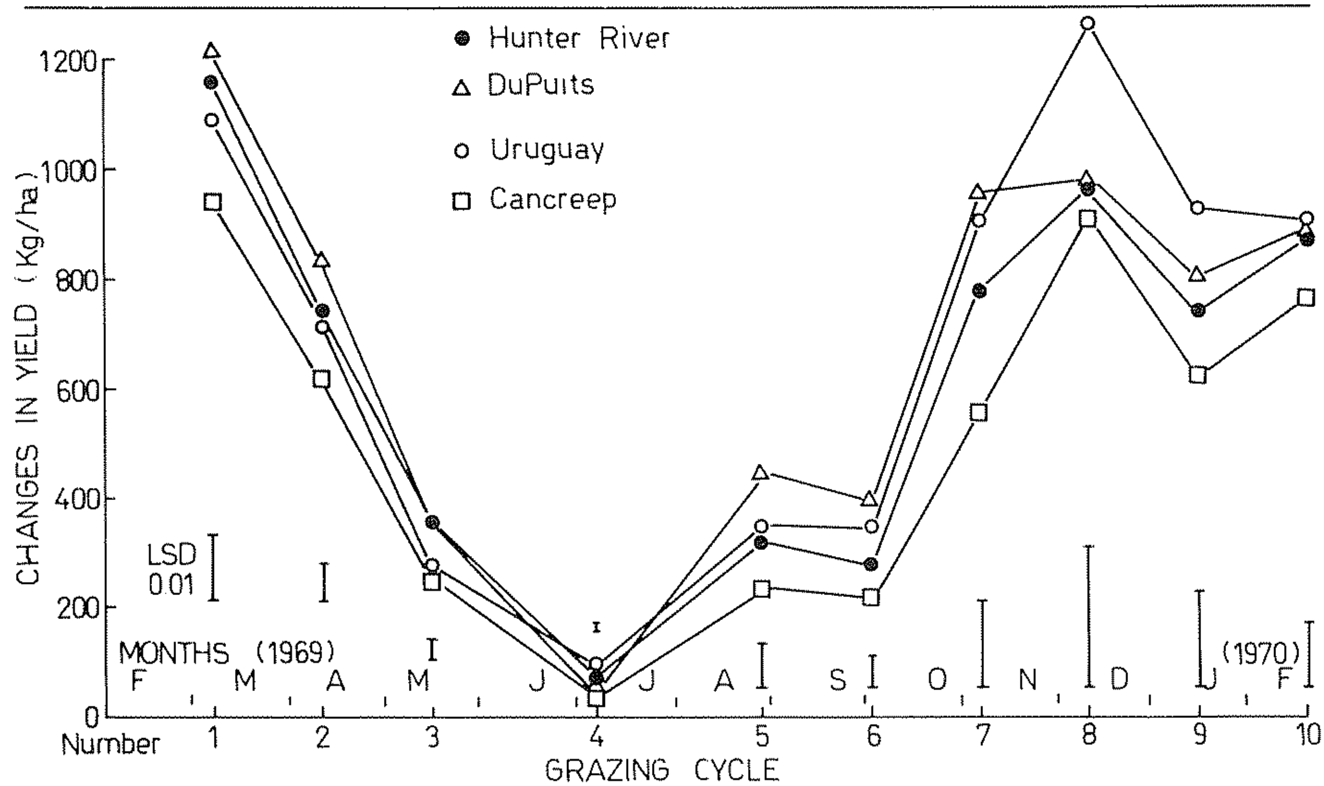

Fig. 6. Seasonal changes in harvested yields of four alfalfa cultivars.

consistently the best, followed by Hunter River, with Cancreep significantly being the lowest yielding (Figure 7).

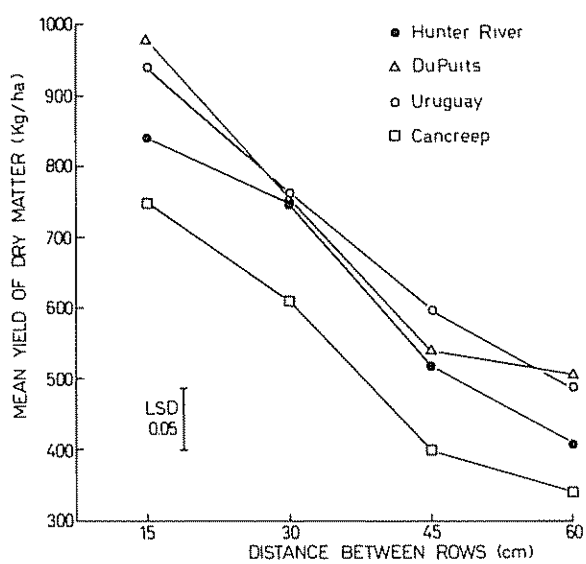

Fig. 7. Effect of row spacing on total harvested yield of different alfalfa cultivars.

Total dry matter production was not affected by alfalfa cultivar (Figure 8). However for any of the grazing cycles considered the contribution of sub-clover and grasses together was always greater under Cancreep than under the others.

Cultivars differed in survival, Uruguay was denser at all spacings than Hunter River though not significantly, and both were significantly denser at all spacings than Cancreep and Du Puits (Table 2).

Discussion

In this study alfalfa yield have been expressed in terms of availability of feed when sheep entered a plot. From observation, virtually all alfalfa above ground was eaten by sheep so that the error resulting from this assumption should be small.

Row spacing:

Row spacing had a marked influence on the yield of alfalfa harvested in the present study. Taking yield at 15 cm row spacing as 100, the relative yields at the other spacings were:

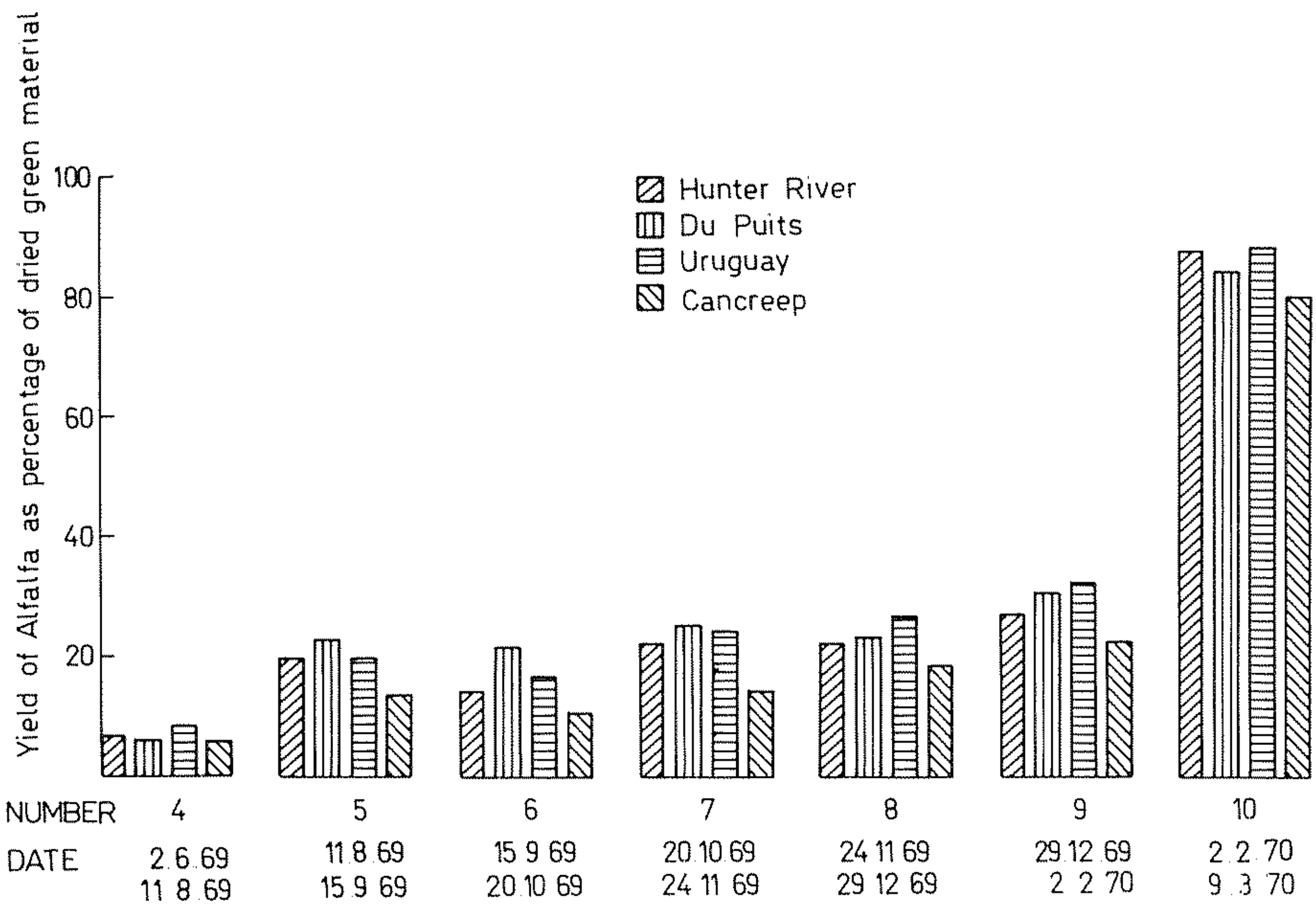

Fig. 8. Seasonal changes in total yield of pasture associated with different alfalfa cultivars.

Row spacing (cm)	15	30	45	60
Alfalfa yield/ha	100	82	58	50
Alfalfa yield/unit row length	100	163	173	200

It has been long recognized that generally the less favourable the environment the fewer the plants needed to exploit it. This relationship is commonly reflected in plant density within established communities and in seed rates generally used. For

Table 2. Density of alfalfa cultivars at different spacings

		Number of plants/60 cm of row				
	CULTIVAR	H. RIVER	DU PUITS	URUGUAY	CANCREEP	MEAN
	15	9.2	6.4	10.5	6.2	8.1
	30	8.5	4.6	8.6	6.8	7.1
	45	8.0	5.1	8.4	6.0	6.8
	60	9.1	5.5	10.4	5.5	7.6
	Mean	8.7	5.4	9.4	6.1	7.4
LSD (P = 0.05)		Space mean	1.8	Cultivar within same space		2.0
		Cultivar mean	1.0	Space within same cultivar		2.3

example in Australia alfalfa is sown at about 13 kg/ha on well-watered, fertile land, but only at 1-2 kg/ha at its lower rainfall limits. In these drier areas, dense stands change more rapidly towards a community of widely spaced plants. Since no effect of spacing on survival was recorded here, it supports the conclusion that environmental conditions well suited alfalfa growing in dense stands.

However as Clements *et al.* (3) reported, competition between plants becomes more intense as the density of the stands increases. This was reflected in decreased yields of alfalfa per unit of row, the individual plants being considerably smaller than those spaced more widely. Presumably all parts of the plants are much smaller in dense stands –roots, as well as the crowns and stems reported by Cowett and Sprague (4); Frankes *et al.* (8); and Rumbaugh (15).

As the yield of alfalfa per unit area increased with closer row spacing, that of associated species decreased, so that there was no difference in total yield of harvested pasture. The balance between alfalfa and other species was probably determined largely by competition for water and light. Whatever the factor concerned, alfalfa must be regarded as the dominant species since its density largely determined the yield of the other species. For the first eight grazing cycles the availability of subclover, grasses, and miscellaneous species was always negatively correlated with that of alfalfa, several times highly significant (Figure 9). This was not only in the periods of rapid growth of alfalfa (spring, summer, autumn), when alfalfa was an active competitor, but during its period of relative dormancy in winter when it must be regarded as a successful passive competitor; successful because it had already established its spatial requirements, which it continued to occupy in winter. It thus limited the yield of the other species by some mechanism other than competition for light.

Because alfalfa grew little in winter, but occupied space, total harvested yield of dry matter were lowest at the closest spacing, and highest in plots without alfalfa. Because winter can be regarded as a critical

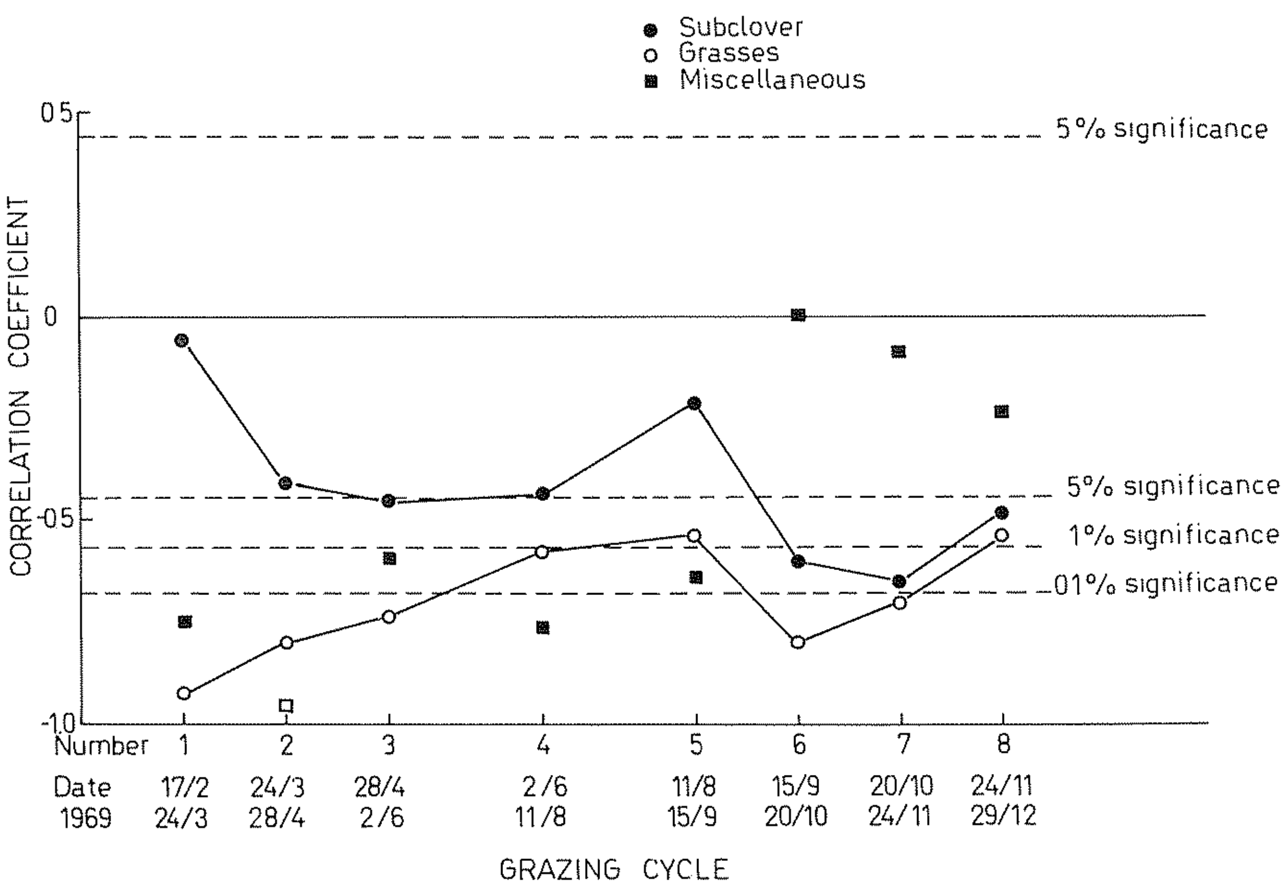

Fig. 9. Changes with time of the correlation coefficients between alfalfa availability and other components of the pasture.

period of feed shortage for grazing animals the wisdom of growing high density stands on a whole farm basis must be questioned. Again, in less favourable seasons than those encountered in this study, the larger root systems associated with less dense stands may be needed to exploit water and nutrients at depth. These should confer competitive advantage to alfalfa in rows more than 15 cm apart. Therefore intermediate row spacing (30 or 45 cm) may prove best.

Alfalfa cultivar:

An important and interesting feature of this study was that of the harvested yields recorded over the year. That of Cancreep was significantly the lowest, 5 200 kg/ha, compared with 6 300 for Hunter River and 7 000 for Du Puits and Uruguay.

In comparing the seasonal growth of Cancreep with other cultivars at different localities, Daday *et al.* (7) reported superior summer growth for Cancreep and Du Puits over Hunter River, and superior winter growth for Cancreep and Hunter River over Du Puits. Only at Adelaide did Cancreep produce significantly less than the other cultivars and this was attributed to a locality x cultivar interaction, with Cancreep assumed to be adversely sensitive to hot, dry summers. In fact, the two locations in Adelaide revealing low production from Cancreep were the only places where the cultivars were grazed; at all other sites they were cut. Leach (12) reported Hunter River performing better than Cancreep on dry matter production under cut or hard-grazed by a large mob of sheep with either five or eight-weeks intervals. The same author (13) always in South Australia found that Hunter River, Uruguay and Du Puits yielded more than Cancreep under standard cuts (6 to 9 –week intervals), and Hunter River and Du Puits yielded more than Cancreep under frequent cuts (3 to 4 –week intervals). Together with the results of the present study these strongly suggest that, relative to other cultivars, Cancreep performs poorly when it is subject to grazing, or more intensive defoliation management than one cut at flowering.

Of the other cultivars, Uruguay, which with Du Puits was one of the highest yielding cultivars in this study, has received little attention in the past. Rogers (14) included it in irrigated trials at Deniliquin; her results were similar in that in years 2-4 its yield resembled those of Du Puits, but dissimilar in that it yielded less than Hunter River, especially during winter.

Du Puits, the other highest yielding cultivar in this experiment, had already been reported by Daday *et al.* (6) as having 27% higher yields than Hunter River at Canberra (1957-60) and 19% more at Armidale (1958-60). In summer Daday reported a yield advantage of 29-35% to Du Puits at Canberra, yet only slightly higher summer yield was recorded here. The main differences which could have led to the different performances were first, that Daday's plots were periodically irrigated in summer leading to yields three times as high as those recorded here; and second, his plots were not grazed but cut at flowering.

Although no differences had been found in density of the different cultivars 12 months after sowing (9), at the end of the study the densities of Cancreep and Du Puits were significantly less than those of Hunter River and Uruguay. Again grazing seems to have had an adverse effect on Cancreep. These results are in agreement with those of Leach (11, 12, 13), who concluded referring to Cancreep that: "It appears that the creeping habit alone does not confer a better ability to survive grazing."

Grazing at a mean stocking rate of 23 weaners/ha in this experiment may well have reduced the expressions of differences in yield potential but yields under grazing are the only valid criteria for assessment. If differences are indicated by yields under cutting then cutting test must be considered irrelevant in the assessment of varieties of alfalfa for grazing.

Summary

Over a year of favourable climatic conditions at Canberra (Australia), measurements were taken of plant production in an experiment in which weaner sheep grazed four cultivars of alfalfa: Hunter River, Du Puits, Uruguay and Cancreep; sown at four different row spacings: 15, 30, 45 and 60 cm, and zero alfalfa.

As distance between rows decreased, alfalfa production increased significantly ($P < 0.05$). Although absolute differences were minimal in winter alfalfa at 15 cm still significantly ($P < 0.05$) outyielded that at 45 or 60 cm.

Where alfalfa was included row spacing did not affect total dry matter production.

All alfalfa cultivars had similar seasonal patterns of production, but the total dry matter yield of Uruguay and Du Puits were significantly ($P < 0.05$) greater than that of Hunter River which in turn outyielded Cancreep significantly ($P < 0.05$).

Plant densities of Cancreep and Du Puits were significantly ($P < 0.05$) less than those of Hunter River and Uruguay.

The alfalfa component of the whole pasture was lowest with Cancreep.

The effects of alfalfa densities on the production of the pasture and the importance of grazing in the evaluation of alfalfa cultivars are discussed.

Literature cited

1. BUREAU OF METEOROLOGY. Climatic Survey of Canberra and the Australian Capital Territory. 1968.

2. CAMERON, D. G. New lucernes for Queensland. Queensland Agricultural Journal 92:553. 1966.

3. CLEMENTS, F. E.; WEAVER, J. E. and HANSON, H. Plant Competition. Carnegie Institute of Washington, 1929. Pub. 398.

4. COWET, E. R. and SPRAGUE, M. A. Factors affecting tillering in alfalfa. Agronomy Journal 54:294-297. 1962.

5. DADAY, H. Performance of lucerne varieties on the South Coast N. S. W. Australian Journal of Experimental Agriculture and Animal Husbandry 5:44-45. 1965.

6. DADAY, H.; MOTTERSHEAD, B. E. and ROGERS, V. E. Performance and interactions in varieties of lucerne (*Medicago sativa* L.). Australian Journal of Experimental Agriculture and Animal Husbandry 1:67-72. 1961.

7. DADAY, H.; PEAK, J. W.; LAUNDERS, T.; CAMERON, D. G.; CAMBELL, G. B.; CRAWFORD, E. J. and RYAN, F. E. Seasonal growth of an Australian Cultivar of creeping-rooted lucerne (*Medicago sativa* L.). Australian Journal of Experimental Agriculture and Animal Husbandry 8:548-554. 1968.

8. FRANKES, R. V.; DAVIES, R. L. and PATTERSON, F. L. The breeding behaviour of yield and related variables in alfalfa. I Replicated clonal plants. Crop Science 1:205-207. 1961.

9. HUTCHINGS, R. J. and HICKS, J. S. Seedling losses during the establishment of lucerne. Ginninderra Guide. CSIRO Division of Plant Industry Canberra. Australia. 1969. p. 6.

10. HUTCHINGS, R. J. Personal communication. 1970.

11. LEACH, G. J. The survival in South Australia of Hunter River, African and creeping lucernes after extended periods of severe grazing. Australian Journal of Experimental Agriculture and Animal Husbandry 9:517-520. 1969.

12. LEACH, G. J. An evaluation of lucerne lines at Waite Agricultural Research Institute, South Australia. Australian Journal of Experimental Agriculture and Animal Husbandry 10:53-61. 1970.

13. LEACH, G. J. The yield and survival of lucerne lines in the upper south-east of South Australia. Australian Journal of Experimental Agriculture and Animal Husbandry 11:186-193. 1971.

14. ROGERS, V. E. Lucerne varieties trials at Deniliquin, N. S. W. Australian Journal of Experimental Agricultural and Animal Husbandry 1:60-66. 1961.

15. RUMBAUGH, M. D. Effect of population density on same components of yield of alfalfa. Crop Science 3:423-424. 1963.

16. SLAYTER, R. O. Agricultural climatology of the Yass Valley. CSIRO Division of Land Research and Regional Survey. Technical paper No. 6. 1960.