PLANT DENSITY AND HERBAGE PRODUCTION IN LUCERNE *(Medicago sativa L.)*

T.P. PALMER

CROP RESEARCH DIVISION, D.S.I.R.

SUMMARY

Viable lucerne seed was sown at rates ranging from 2.8 to 16.8 kg/ha in six field trials. The first trial was sown in 1966. Different seeding rates resulted in different densities of established plants. Death rates of established plants were similar over a range of plant densities and continued until a low plant density was reached. No differences in herbage yields were recorded from plant densities varying from 46 to 240 plants/m^2. In one trial, plants were planted at regular intervals at 8, 32, 64 and 128/m^2. In the second year, 8 plants/m^2 yielded 20% less than the other treatments. In the third year, it yielded 7% less. It is suggested that populations reach plant density equilibrium at about the plant density capable of giving maximum herbage production. This plant density could be obtained by sowing seed 1-2 kg/ha.

INTRODUCTION

At current sowing rates of seed about 11.2 kg/ha costs of seed are important in determining costs of lucerne establishment in New Zealand. Seeding rates used by farmers vary from about 5 kg/ha to 15 kg/ha. There is no local experimental evidence of the effect of varying seed rates on subsequent yields of lucerne.

There have been numerous studies on the effect of variations in plant density on crop yields. With forage crops generally, yields increase with increasing plant density until a plateau is reached, after which increases in density have no effect on yield. Donald (1963) reviewed such studies, most of which have been on annual crops or annual pasture species. There have been very few studies on lucerne.

Jarvis (1962) planted lucerne at square spacings of 2.5 x 2.5, 5 x 5, 7.5 x 7.5. 15 x 15, 22.5 x 22.5, 30 x 30, 60 x 60 and 90 x 90cm. These spacings represent establishment from 35gm to 40 kg of seed per hectare. Yields were recorded for three years. In all years yield from 2.5 x 2.5, 5 x 5, 7.5 x 7.5 and 15 x 15cm spacings were not significantly different. The wider spacings gave significantly lower yields. Extrapolating from the results from the first cut in the first year, which were the most regular, he concluded that maximum yield would be reached only when the plant population was infinite. Over the three year period death rates were higher in the denser plots.

Takasaki et. al. (1970) grew lucerne at spacings ranging from 2cm between plants to 16.7cm between plants. In the first year, higher densities gave significantly higher yields than lower densities. In the second and third years there were no differences in yield. Death rates of plants over the three year period were density dependent.

Cowett and Sprague (1962) recorded yields of 2600, 5300 and 6400 kg/ha of dry matter in one harvest from spacings of 10,40 and 80 plants/m^2.

Rumbaugh (1955), planted lucerne at 13 x 13, 27 x 27, 54 x 54 and 107 x 107cm. He obtained higher area yields from denser populations in two harvest years.

Zaleski (1959) sowed lucerne at 5.6, 11.2 and 16.8 kg/ha, and recorded substantially the same yields for all treatments over three years. Death rates over this period were 58%, 66% and 73% respectively.

Donald (1956) stated that stands with 40 plants/m^2 gave higher yields than stands with 100-150 plants/m^2, but presented no data supporting this statement.

At reasonably dense spacings, individual plants may increase in size to fill any free space available. Below a certain density plants may not be able to expand to fill very large gaps, and yields may decline with reductions in plant population beyond this point. Also yields from sparse stands may be relatively lower when moisture is adequate and efficiency of light utilisation is an important determinant of yield, and relatively higher when moisture stress limits production from denser stands.

The pertinent practical questions are: below what plant density do yields begin to decline: what seeding rates are needed to establish this plant density: is the equilibrium plant density influenced by seeding rate, and is it sufficient to give maximum production. Answers to these questions will determine the effect of variations in seeding rates on the productivity of stands.

MATERIAL AND METHODS

Two types of trials were conducted. Some trials were drilled in rows 17.8 cm apart at seeding rates varying from 2.8 to 16.8 kilos of viable seed per hectare. These seeding rate treatments were combined with various cover-crop and weed control treatments, the results of which are not reported here. Two trials were planted with plants regularly spaced at

4.4 x 17.8 cm, 8.9 x 17.8 cm, 17.8 x 17.8 cm and 35.6 x 35.6 cm.

All trials were on Templeton sandy loam soil with pH 5.8 or above. Seed was drilled with reverted superphosphate 250 kg per hectare, and trials received annual dressings of superphosphate 250 kg per hectare. There were no establishment problems in any of the trials. Trials were harvested with a forage harvester at the hay stage. Weeds made insignificant contributions to total herbage yields except in the second harvest from trial 6 (see Table 2).

Plant densities were determined by digging and counting plants from random lengths of drill rows.

Trial 1 was sown on 5 October 1966 at 5.6, 11.2 and 16.8 kilos of viable seed per hectare of Wairau lucerne. There were 20 replications of the sowing rate treatments. Trial 2 was sown on 20 December 1968 at 5.6 and 11.2 kilos per hectare of Wairau lucerne, and a strain selected for higher winter production. There were 12 replications of the sowing rate treatments. Trial 3 with eight replications was sown on 26 September 1969 at 5.6 and 11.2 kilos per hectare, and trial 4 with eight replications at 2.8, 5.6 and 11.2 kilos per hectare on 5 November1970.

Trial 5 was planted 5 October 1968 with plants spaced at 35.6 x 35.6, 17.8 x 17.8, 17.8 x 2.8 and 17.8 x 4.4 cm apart, and trial 6 on 29 October 1970 with spacings of 35.6 x 35.6, 17.8 x 17.8 and 17.8 x 8.9 cm.

RESULTS

Herbage Yields

Yields of dry matter in kilos per hectare are presented in tables 1 and 2.

TABLE 1: Herbage Yields From Seeding Rate Trials Dry Matter kg/ha.

Sowing Rate kg/ha	Trial 1				Trial 2		Trial3
	67/68	68/69	69/70	70/71	69/70	70/71	70/71
5.6	16500	15800	8600	13900	7800	12600	14000
11.2	15900	15400	8100	13500	8100	12600	14000
16.9	16500	15700	7900	13200			

There were no significant differences in yield from different sowing rates.

TABLE 2: Herbage Yields from Spacing Trials.
Dry Matter kg/ha

Spacing cm.	Equiv. Seeding Rate kg/ha	Trial 5 69/70	70/71	11.12.70	Trial 6 4.2.71 Lucerne	Weeds	Total
13.0x35.6	.28	8100b	17200	280c	800b	1220a	202a
17.8x17.8	1.12	10300a	18400	880b	1850a	290b	2140a
17.8x 8.9	2.24	10800a	18800	1130a	2050a	160b	2210a
17.8x 4.4	4.48	10400a	18500				

a significantly higher than b, than c.

In trial 5 in the year after establishment the plots with plants 25.6 x 25.6 cm. apart yielded significantly less than the others. In the next year the difference was smaller and non-significant. In trial 6, in the first cut after planting all spacings gave significantly different yields, but at the second harvest only the widest spacing yielded significantly less lucerne. The dominant weed at this harvest was storksbill (Erodium spp.), which compensated for the lower yield from the more widely spaced lucerne.

Plant Numbers

Numbers of plants per metre of row in the sown trials are given in Table 3.

TABLE 3: Numbers of Plants per Metre of Row.

Sowing rates kg/ha	Trial 1 Dec. 1966	June 1969	April 1971	Trial 2 March 1970	April 1971	Trial 4 March 1971
2.8						22.6
5.6	18.0c	10.2b	7.9b	32.1b	24.2b	38.4b
11.2	30.5b	17.4a	13.8a	10.2a	48.2a	54.1a
16.8	45.3a	21.6a	16.1a	12.2a		

Higher plant populations established from higher seeding rates.

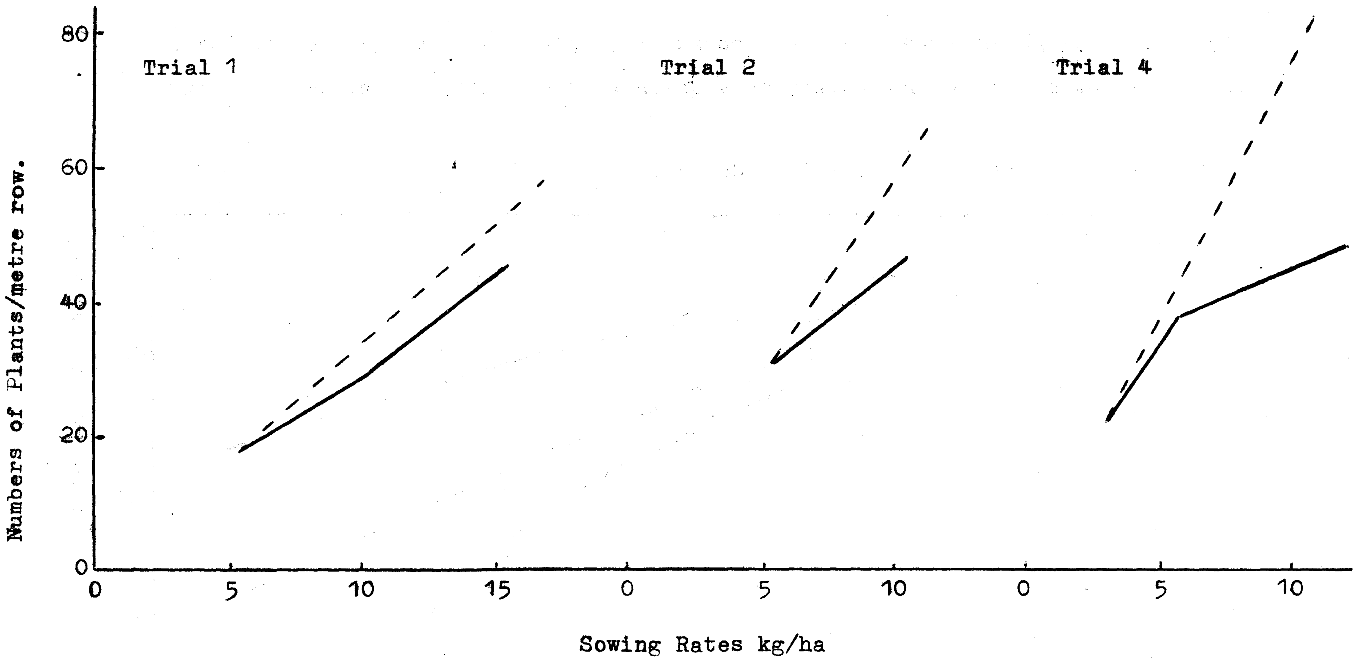

Fig. 1. Numbers of lucerne plants established/metre row from various sowing rates.
Observed numbers – Estimated numbers projected from lowest sowing rate - - -

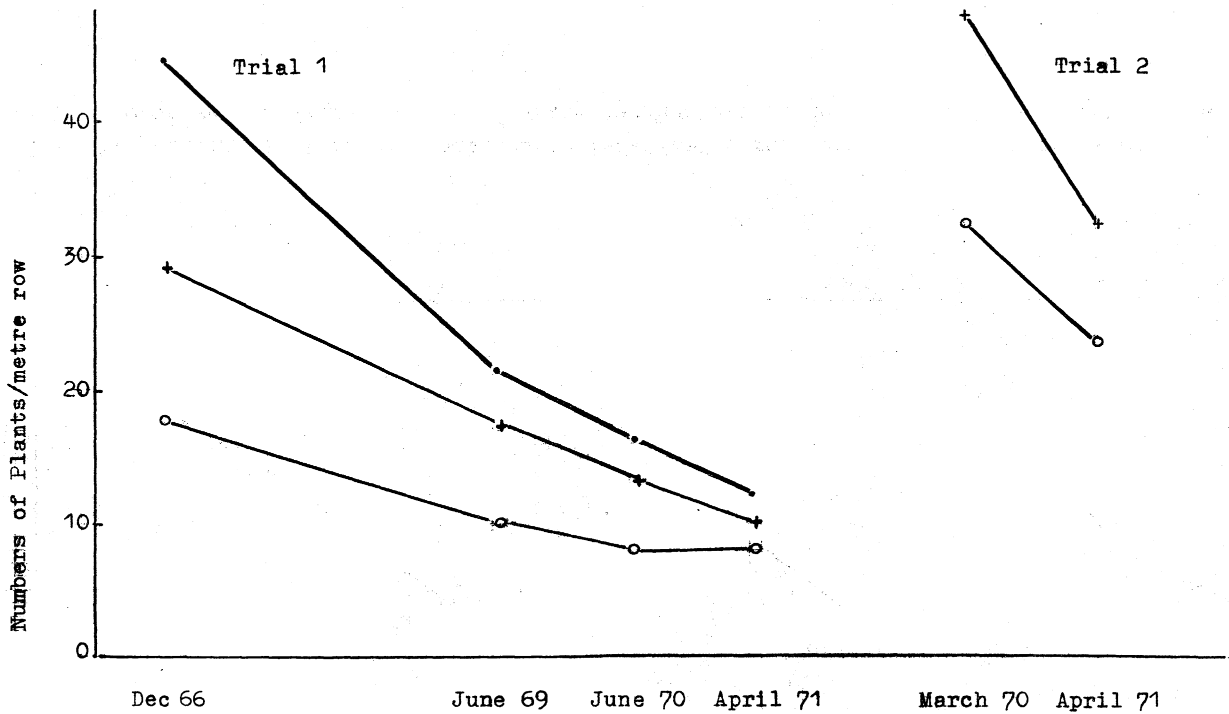

Fig. 2. Numbers of lucerne plants which established and persisted/metre row from Sowing rates 5.6 kg/ha 0 - 0 - 0, 11.2 kg/ha + - + - + and 16.8 kg/ha 0 - 0 - 0.

In the planted trial, plant numbers could not be counted in the spacings closer than 17.8 x 17.8 cm without digging up the plants. In the plots with plants spaced at 17.8 x 17.8 cm, 155 plants (4.5%) had died by December 1970, and 231 (6.6%) by April 1971. In the 35.6 x 35.6 cm spacing, 12 plants (1%) had died at both counting times.

DISCUSSION

There were no yield differences from different sowing rates despite large difference in plant densities. In the space planted trials, spacings of 35.6 x 35.6 cm gave lower yields than closer spacings in the first three years, but there was some indication that in later years this spacing may produce as much as closer spacings. If plants established from all seeds which were sown, maximum production would be obtained from seeding rates of about 1 kilo of seed per hectare.

If the death rate is a constant proportion of the number of plants per unit area, or if the death rate at any given density is proportional to the density, stands established from higher seeding rates will maintain higher populations indefinitely, and will remain productive longer. The advantage to be gained from higher seeding rates would then be greatest when death rates are lowest. Where death rates are likely to be high, increasing seeding rates would have least effect in prolonging the productive life of stands.

If on the other hand the death rate falls to zero at some particular plant density, stands from denser sowings will remain productive longer only if this equilibrium plant density is lower than that needed to give maximum production.

Numbers of plants established increased with increasing seeding rates. However, each additional increment of seed sown resulted in fewer established plants, so presumably competition with other lucerne seedlings was an important cause of mortality at the seeding rates used.

After establishment, death rates were similar from all seeding rates, with a loss of about a quarter of the population per year. However, in the oldest trial, there was a very low mortality in the sparsest population in the last year. This population may have reached the equilibrium level which this environment will support. If this is so, denser populations will also be expected to reach this density, which was sufficient to give maximum production. This plant density could have been obtained by sowing 1-2 kilos of seed per hectare, and stands sown at this low rate may have been as productive as those sown in these trials.

These results in general agree with those reported by most other workers, but do not support the suggestion of Jarvis (1962) that very high plant numbers are needed for maximum production, or the suggestion of Donald (1956) that production may be higher from lower plant numbers.

If the main competitive elimination of plants results from drought stress during dry years, or during the summer and autumn seasons, plants may be so thinned during the period of stress that there are not sufficient remaining to utilize completely the more readily available growth factors during seasons of greater moisture supply, so that stands may thin out to a level below that capable of giving maximum production. If this is so stands established from higher seeding rates will remain productive for longer periods, but so far there is no indication from these trials that this will be so. These sorts of trials would bear repitition on sites more subject to summer drought.

If lucerne stands cannot be maintained at a highly productive density on drier sites, a mixture of lucerne and winter growing annuals may give permanent high production. Erodium spp, Hordeum spp and Trifolium subteraneum can be high producing winter annuals, while annual ryegrasses may be usefully established in sparse lucerne stands in some years.

If perennial weeds had been a problem in these trials the results may again be different, as the denser stands resulting from higher seeding rates may be more resistant to weed invasion.

CONCLUSIONS

With some reservations arising from the short duration of these trials, and the doubts about the applicability of these results to markedly drier sites infested with perennial weeds, it can be concluded that lucerne established from sowing about 1-2 kilos of seed per hectare would have been as productive as stands established by sowing up to 15 kilos of seed per hectare.

REFERENCES

Cowett, E.R., and Sprague, M.A. 1962: Factors affecting tillering in alfalfa. Agron. J. 54: 294.

Donald C.M.,1956: Competition among pasture plants. Proc. 7th Intern. Grassld Cong.: 80.

Donald C.M., 1963: Competition among crop and pasture plants. Adv. in Agron. 15: 1.

Jarvis, R.H., 1962: Studies on lucerne and lucerne-grass leys V.Plant population studies with lucerne. J. agric. Sci., Camb. 59 : 281.

Rumbaugh, M.D., 1963: Effects of population density on some components of yield of alfalfa. Crop Sci. 3: 423.

Takasaki, Y., Takahashi, N. and Yokoyama, K., 1970: Studies on the performance of alfalfa swards I. Yield and change in plant numbers in alfalfa swards at different densities. Crop Sci. Soc. of Jap. 39: 144.

Zaleski, A., 1959: Lucerne investigations iv. Effect of germination and seed rates on establishment, mortality and yield of dry matter and protein per acre. J. agric. Sci., Camb. 53 : 260.