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Growth factors and management technique in relation to the developmental rhythm yield formation pattern of a seeding year lucerne stand

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Abstract. The investigation of seeding year lucerne stand development and yield formation pattern was carried out at the University of Helsinki in Viikki in 1973—74. The management techniques studied were the number of cuttings and the density of stand establishment. The variety used was Danish Isis-Daenfeldt. The maximum DM yield was obtained from a seeding rate of 20 kg/ha. The maximum DM yield produced under the favourable growing conditions in 1973 was 5. 7 tons/ha and under the less favourable conditions in 1974 3.3 tons/ha. No more than two cuts in the year of seeding are recommended. The radiation used by lucerne was 0.3—0.5 % of the total radiation reaching the surface. A 10 % decrease in radiation in 1974 resulted in a 50 % decrease in photosynthetic activity mainly due to differences in temperature and overabundant precipitation. The optimum LAI was obtained from seedingrates ≥ 5 kg/ha. From seeding to emergence a temperature sum of 120 °C is needed and from seeding to flowering a sum of 800°C. From cutting to the next flowering a sum of 600—700°C is needed. Three cuts provided forage 6.3 % units more digestible than two cuts.

Root carbohydrate levels suggest that the last cut should not be made later than mid-August.

I Introduction

Lucerne is generally accepted as one of the most important forage species for domestic animals in those areas where it may be successfully cultivated. The actual range where lucerne is cultivated extends between 30 and 60 degrees latitude in the northern and 20 and 40 degrees latitude in the southern hemisphere (SMITH 1962).

Lucerne is well adapted to different temperature regimes as its wide growing area illustrates. Lucerne thrives best in an area where the growing season's average temperature is 18—20°C. Germination begins already at 4—6°C, but its optimum temperature is 31—37°C. The optimum temperature for lucerne nitrogen fixing bacteria is 15—30°C (BOLTON 1962). A substantial reduction in bacteria activity is observed in temperature ranges of 10—12°C and 35—40°C because the nitrogen fixing capability is retarded (BOLTON 1962).

After wintering the specie's spring development begins when temperatures reach 8—10°C. Hardened lucerne can withstand freezing temperatures of up to —25°C on bare ground. After the hardening is lost in the spring the root meristematic area may suffer damage if the temperature falls to just ±0 °C (SMITH 1962). Young lucerne shoots are considerably more succeptible to cold spring nights than those of red clover. Nevertheless, the adaptatibility of lucerne is best illustrated by the fact that it is successfully cultivated in areas where winter temperatures exceed —40°C.

In areas such as Hungary, where the average annual temperature is 11°C, five harvests of lucerne are possible. Where the average annual temperature ranges from 7.5 to 9°C, as in Germany, 3—4 harvests are common. These average annual temperatures represent temperature sums of 4500—3000°C for growing seasons covering April to October (BOLTON 1962).

For flowering (BECKER–DILLINGER 1929) lucerne needs a temperature sum of 850—900°C and the same amount of heat for each of the following cuts. As the average temperature sum in southern Finland is 1900—2100°C, this means that at most two lucerne harvests are obtainable during the growing season.

Because of its deep growing (6—9 m) main root lucerne can withstand drought better than any other forage plant (SCHANTZ and PIEMESEL 1927). On the otherhand abundant ground and surface water are detrimental and one of the major obstacles to successful establishment of lucerne. According to SCHANTZ and PIEMESEL (1927) the evaporation coefficient for lucerne is equivalent to about 180 mm of precipitation per ton of dry matter. For areas where 2—3 cuts are made the precipitation needed ranges from 450—600 mm and in areas where more cuts are possible from 900—1200 mm. Investigations and practical cultivation have shown that 850—1000 mm of precipitation is the upper limit lucerne can tolerate without serious problems.

Because of its deeprootedness lucerne requires a growing medium where the subsoil is permeable. Lucerne is known to thrive also where the lime content of a permeable subsoil is high (MULTAMÄKI 1965). It requires a soil where the pH is ≥ 6.5. In the plough layer lime should be present in a concentration of 12 t/ha.

A lucerne harvest of 6 t/ha removes from the soil about 30 kg P/ha, 210 kg K/ha and 150 CaO/ha. At the same time it leaves 5—7 t/ha of organic matter and 300—400 kg N/ha. Lucerne obtains its nitrogen from nutrients in the soil or via its root bacteria which fixes it from the air. The nitrogen fixing capacity of lucerne is 40 and 84 % more efficient than for red clover and peas respectively.

Cultivation possibilities for lucerne in Finland have been investigated by HEIKINHEIMO (1955), TEITTINEN (1955), RAVANTTI (1955, 1960), MULTAMÄKI (1962, 1965, 1969, 1970), BÖCKELMAN (1967), RAININKO (1970) and PULLI (1973, 1977). All have shown that in areas where lucerne thrives its yield production has surpassed that of red clover and fescue. The factors which most seriously hinder lucerne growth are the low reaction of the soil, low nutrient content of the soil, too much groundwater, surface water, a poorly suited variety, short growing season, low temperatures and various factors resulting in poor wintering.

The purpose of this study was to determine the relationship between growth and growth factors in the early development of lucerne, in respect to the intraspecific compentition and other cultivation intensities. The study was conducted during 1973—74.

2. Materials and methods

2.1. Field arrangements

The field trials were established on the University Farm in Viikki in 1973. The plots were organized in the following ways:

	1973	1974
Experimental design:	Split-plot	
Main plot	Cutting treatments	
	1. 2-cut	1. 1-cut
	2. 3-cut	2. 2-cut
Sub-plot	Seeding rates	
	1 kg/ha	(40 seeds/m^2)
	5 "	(200 ")
	10 "	(400 ")
	20 "	(800 ")
	40 "	(1600 ")
Replications:	4	

The plots were established on May 22 in 1973 and May 14 in 1974. The soil type was fine sand. The lucerne variety was Danish Isis-Daenfeldt and the seed was inocculated prior to seeding.

Fertilization and plant production:

The experimental field was fertilized with NPK at a rate of 1000 kg/ha (2-17-15). The herbicide Dinoseb was used for weed control at 4.5 l/ha. The plots were irrigated 4 × 30 min in 1973.

Cutting and yield procedure:

	1973	1974
1-cut system:	–	6.8
2-cut system:		
1st cut	24.7	17.7
2nd cut	18.9	25.9
3-cut system:		
1st cut	9.7	–
2nd cut	9.8	–
3th cut	4.10	–

Crop growth and yield analyses:

For dry matter determinations two 200 samples of chopped forage material per plot were taken and dried for 24 h at 100°C. The 200 g samples intended for in vitro digestibility tests were dried for 24 h at 70°C.

The emergence measurements were carried out June 6 in both years.

Leaf area index (LAI) measurements were conducted weekly throughout the entire growing season in both test years. The LAI sample size per plot was 0.045 m^2. The overall height of the crop was measured daily in 1973, and twice weekly in 1974. The root samples for carbohydrate analysis and forage for in vitro digestibility tests were collected once a week throughout the entire growing season. Stand density and root yields were measured on Nov. 5 in 1973 and Nov. 21 in 1974. Meteorologic data was obtained from the weather station at nearby Seutula airport.

2.2. *Laboratory analyses*

Leaf area was measured with an optical leaf planimeter (Model Kl) designed and built by the Technical University of Helsinki.

Forage in vitro degestibility was determined according to the procedure of TILLEY and TERRY (1963). The reducing sugars of lucerne roots were measured with the calorimetric methods of NELSON (1944) and SOMOGYE (1952) as applied by SMITH (1969). The dry matter energy content of forage was determined with a PHILLIPSON oxygen microbomb calorimeter according to PHILLIPSON'S (1964) procedure.

3. Weather conditions

The weather conditions of the 1973 and 1974 growing seasons differed considerably from each other. Summer 1973 was warm and dry while summer 1974 was chilly and rainy (Tables 1, 2, 3). When comparing the temperature conditions in degree days (Table 4), the temperature sum of the 1974 growing season on Aug. 8 was one month late compared to that of 1973. Also radiation conditions were more favourable in 1973 than in 1974. Because of the weather conditions prevailing in 1973 several irrigation treatments were needed in order to meet the plant's water requirements.

4. Results and discussion

4.1. Yields and stand characteristics

Yields

The seeding-year yields (Table 5) during the favourable 1973 growing season varied in the 2-cut system at different seeding rates from 1.1—5.7 tons DM/ha and in the 3-cut system between 1.0 and 5.7 tons DM/ha. In 1974, which was a less favourable season for lucerne, the 1-cut system yielded 1.2 tons DM/ha and the 2-cut system 3.3 tons DM/ha. The yields of 5.7 and 3.3 tons DM/ha represent 70 and 30 % respectively of the average lucerne yield level in Finland (MULTAMÄKI 1969). According to TESAR and JACKOBS (1972), in the northern United States seeding-year lucerne yields average 4—5.8 tons DM/ha and represent 40—60 % of the yields from older stands. Under unfavourable conditions the seeding-year yield may be even less.

Of the seeding rates tested 20 kg/ha proved to be sufficient to obtain the maximum yield (Fig. 1, 2). These results represent a 5—10 kg less performance level than MULTAMÄKI's (1965) results but considerably higher seeding-year results than those reported by BOLTON (1962), TESAR (1972) and PULLI (1973) in the United States.

The tests showed that an above normal seeding rate did not increase the yield significantly but because of the increased interplant competition the roots remained smaller and wintering ability weakened. It was also found that in sparse stands the competition between lucerne and weeds reduced lucerne's growth vigor particularly when a low cutting frequency was used. On the basis of this finding two cuts is the optimum cutting frequency under favourable growing conditions.

Stand characteristics:

In both of the growing seasons (Table 6) lucerne required a temperature sum of about 120°C from seeding to emergence. The average temperature sum needed from seeding to flowering was 860°C. The sum required from the first cutting to flowering and the second cutting to flowering was about 610—650°C. These require-

Table 1. Average monthly temperatures and the deviation from the long term average in 1973 and 1974 in Helsinki.

Month	1973 Avg. temp.°C	1973 Deviation from avg.	1974 Avg. temp.°C	1974 Deviation from avg.
May	9.9	+0.6	7.6	−1.7
June	16.8	+2.3	14.7	+0.2
July	20.2	+2.4	16.2	−1.6
Aug.	15.6	−0.9	14.9	−1.9
Sept.	8.4	−3.3	13.3	+1.6

Table 2. Number of rainy days (prec > 1 mm) and amount of precipitation (mm) and deviation of precipitation from long term average in Helsinki in 1973 and 1974.

Month	1973 Rainy days	1973 Prec. mm	1973 Dev.	1974 Rainy days	1974 Prec. mm	1974 Dev.
May	7	34	− 3	6	34	− 3
June	4	22	−25	8	48	+ 1
July	5	24	−38	14	52	−10
Aug.	7	33	−33	12	49	−17
Sept.	14	117	+51	17	145	+79
Σ	37	230		57	328	

Table 3. Relative humidity (%) and solar radiation cal/cm^2 in Helsinki in 1973 and 1974.

Month	Avg. rel. hum. % 1973	Avg. rel. hum. % 1974	Solar radiation cal/cm^2 1973	Solar radiation cal/cm^2 1974
May	71	63	13690	14176
June	65	68	16973	15267
July	66	78	16903	11613
Aug.	74	82	11691	11334
Sept.	80	84	4825	5678
Avg.	71	75	64082	58068

Table 4. The temperature seen in degree days and deviation from the long term average during growing seasons 1973–74.

1973 $\Sigma \geq$ 5°C	1973 Dev.	Date	1974 $\Sigma \geq$ 5°C	1974 Dev.
111	+ 11	25/5	65	− 35
271	+ 60	9/6	147	− 65
351	+ 45	19/6	257	− 49
594	+125	4/7	415	− 55
834	+192	19/7	584	− 58
962	+205	29/7	682	− 76
1092	+224	8/8	762	−107
1216	+243	18/8	861	−112
1277	+207	28/8	955	−111
1336	+191	7/9	1062	− 82
1350	+147	17/9	1122	− 82
1359	+114	27/9	1184	− 60
1391	+118	7/10	1237	− 35

Table 5. Dry matter yields of seeding year lucerne stand at different seeding densities and cutting schedules in 1973–74.

Seeding rates		Cuts tons/ha		
kg/ha	Cut 1	Cut 2	Cut 3	Total
		1974		
1-cut system				
1	0.09 a			0.09 a
5	0.47 ab			0.47 ab
10	0.80 b			0.80 b
20	1.07 b			1.07 b
40	1.22 b			1.22 b
Avg.	0.73			0.73 A
2-cut system				
1	0.06 a	1.23 a		1.29 a
5	0.14 a	2.32 b		2.46 b
10	0.29 ab	2.58 bc		2.87 c
20	0.28 ab	2.82 bc		3.10 cd
40	0.36 b	2.95 c		3.31 d
Avg.	0.23	2.38		2.61 B
LSD$_{.05}$– Level				
		1973		
2-cut system				
1	0.44 a	0.67 a		1.11 a
5	1.26 a	2.28 b		3.54 b
10	1.63 ab	2.63 bc		4.26 b
20	2.16 b	2.89 bc		5.05 bc
40	2.49 b	3.21 c		5.70 c
Avg.	1.60	2.34		3.93 A
3-cut system				
1	0.12 a	0.34 a	0.50 a	0.96 a
5	0.47 a	1.14 b	1.68 b	3.29 b
10	0.88 ab	1.43 b	1.67 b	3.98 b
20	1.23 b	2.28 c	2.09 c	5.60 c
40	1.44 b	2.22 c	2.03 bc	5.69 c
Avg.	0.83	1.48	1.59	3.90 A
LSD$_{.05}$– level				

Table 6. Time and temperature requirements of lucerne stand in the seeding year growth and development in 1973–74.

Growth	Growing days		Avg. daily temp.°		Temp.	0°C
stage	1973	1974	1973	1974	1973	1974
Seeding-energence	8	13	14.9	9.1	120	118
Seeding-flowering	47	66	17.7	13.4	839	883
1st cut-flowering	28	50	21.1	14.0	592	702
2-cut-flowering	59		10.4		610	

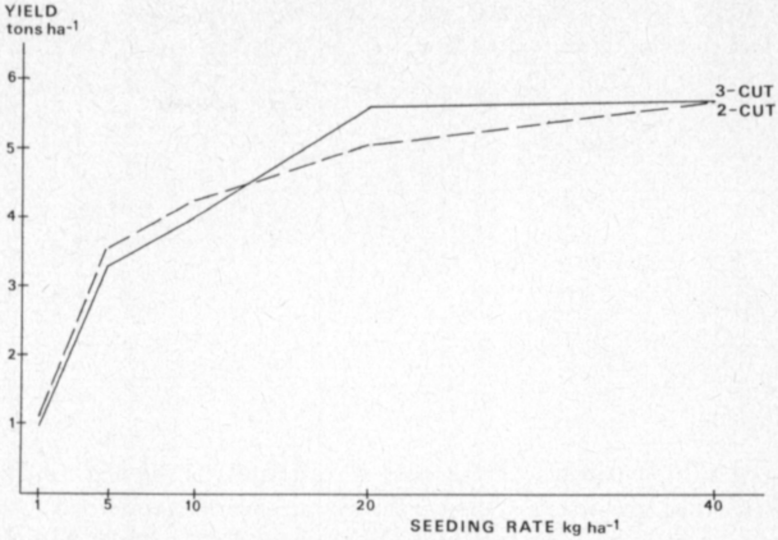

Fig. 1. Seeding year yields DM tons/ha in 1973 with different seeding rates cut two and three times during the first growing season

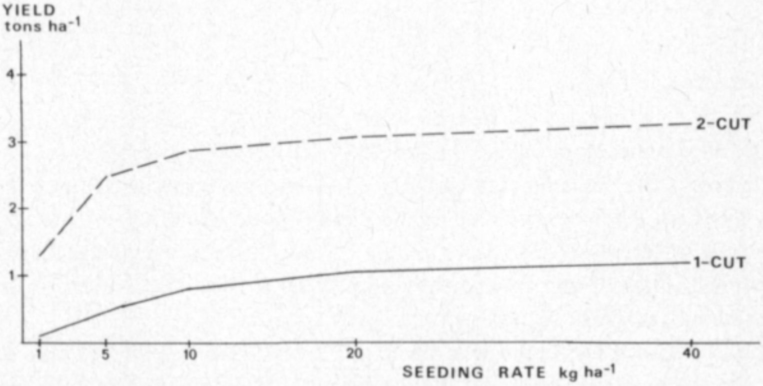

Fig. 2. Seeding year yields, DM tons/ha in 1974 with different seeding rates cut once and two times during the first growing season

ments were somewhat less than those reported by BECKER-DILLINGER (1929), first in regard to variety development and second as to whether the basis for observation is the onset of flowering or full flowering.

The population development of lucerne was studied very closely in 1973. According to the results of BROWN and STAFFORD (1970) the seedling development could be considered excellent.

Thinning of the stand which occurred by the autumn of the seeding-year was greatest at high seeding rates as shown earlier by PULLI (1973). The substantial thinning which occurred at the lowest seeding rate (1 kg/ha) was due to the severe competition with weeds in the spring.

The shooting of the stand (Table 7) at different seeding densities was clearly similar to results obtained in earlier studies, for example CLEMENTS et al. (1929) and COWETT and SPRAGUE (1962). Shoot formation on an individual basis was 3.9—9.3, depending on the seeding rate and cutting frequency.

Table 7. Population density development during the seeding year 1973 and number of shoots per plant in the autumn of the seeding year under different management practices.

Seeding rate kg/ha	% from seeding density		Number of shoots in the autumn		
	Emergence	Autumn 1st year	2-cut	3-cut	Avg.
1	80	65	9.3	8.2	8.7
5	78	88	6.8	5.8	6.3
10	74	80	5.7	4.7	5.2
20	73	64	6.6	5.2	5.9
40	67	49	5.4	3.9	4.7
Avg.	74	69	6.8	5.6	6.2

The primary development of the yield was strongest at the high seeding rates and weakest in the sparse stands, despite the fact that shooting increased at the same time, as also DAVIDSON and DONALD (1958) have shown. No LAI differences (Fig. 4) were observed in the final autumn cuttings of stands having seed amounts of 5 kg/ha or more and the yield differences were minor (Table 5). This supports PULLI's observations (1973) in the USA.

4.2. Photosynthetic efficiency

Lucerne used an average of 0.5 % and 0.3 % of the total radiation in 1973 and 1974 respectively for yield formation (Fig. 3). There were few differences between the cutting systems. The energy value of the yield ranged from 3.9—4.7 kcal/g in individual cuts at different seeding rates (Table 8), but differed very little for complete cutting systems. These results were very similar to those PULLI (1980) obtained with a mixed clover-grass stand.

The total radiation for 1974 was about 10 % less than in 1973 (Table 3), whereas stand radiation utilization in 1974 was almost 50 % less than in 1973 (Fig. 3). This is an indication that at Finnish latitudes radiation is not a limiting factor for lucerne photosynthesis, but that temperature and excess precipitation are, as CHANG (1968) reported.

The measured photosynthetic efficiencies were representative of those that NODDACK and KOMOR (1937), MAXIMOV (1938), RABINOWITCH (1945), WASSINK (1948), KAMEL (1959) and PULLI (1980) have found for other different plants.

4.3. LAI and Plant Height Relationships

Yields and LAI

The large temperature differences between 1973 and 1974 resulted in noticeably slower lucerne development in 1974. September of 1974, however, was exceptionally warm. The largest LAI value measured in 1973 was 4.3 and in 1974 5.2

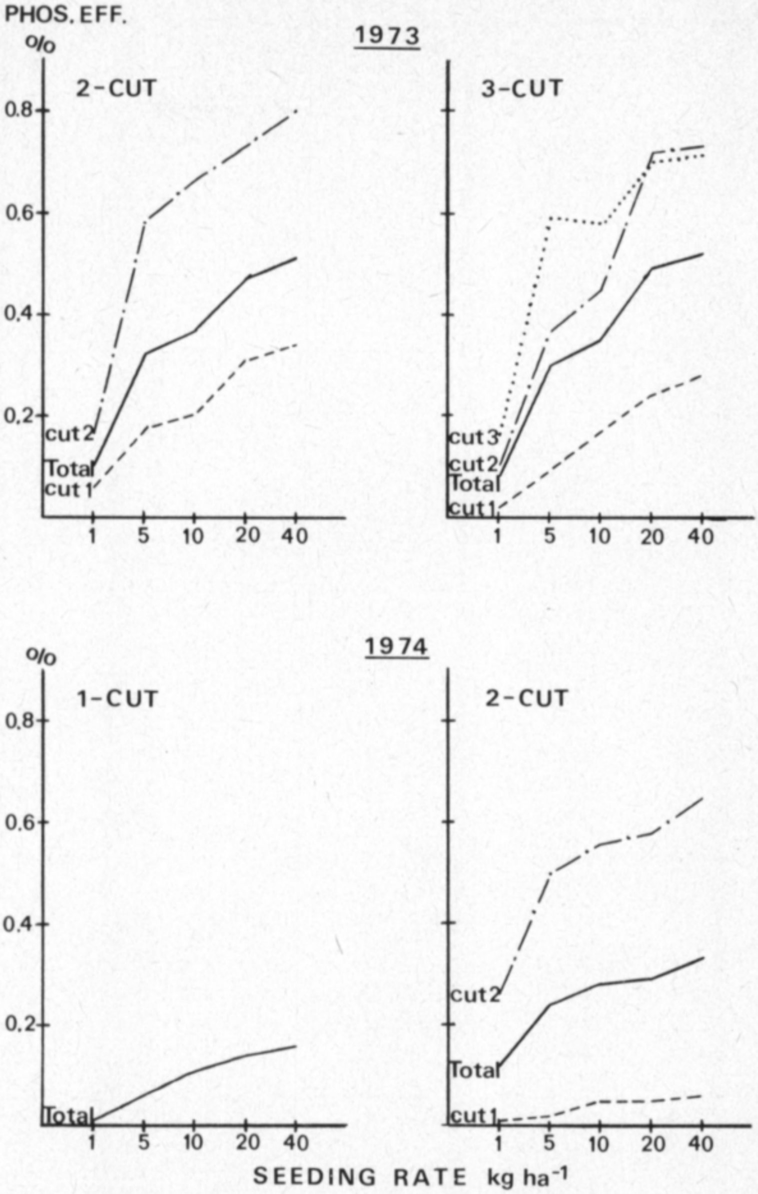

Fig. 3. Photosynthetic efficiency of a lucerne stand with different seeding rates cut 1—3 times in 1973—74

(Fig. 4, 5). At high seeding amounts maximum LAI was reached faster than in hinner stands. This tendency weakened with the arrival of autumn and in the last autumn cut at the end of the growing season all stands with seeding rates ≥ 5 kg/ha had developed nearly equal LAIs. This phenomenon was even more pronounced the more often the stands were cut (Fig. 4). The dry matter yields developed in very much the same way as LAI. This result differed from that of FUESS and TESAR (1968) where LAI reached its peak rather quickly after which the old leaves dropped off but the dry matter yield still increased. In Viikki lucerne's growth potential was obviously less and its growth rhythm slower and the maximum LAI values were

Table 8. Energy-value of lucerne stand kcal/g DM in invidual cuts at different seeding rates in 1973–74.

Seeding rate kg/ha	Cut 1	Cuts kcal/g DM Cut 2	Cut 3	Avg.
		1974		
1-cut system				
1	4.504			4.504
5	4.511			4.511
10	4.447			4.447
20	4.380			4.380
40	4.417			4.417
Avg.	4.451			4.451
2-cut system				
1	4.616	4.481		4.549
5	4.288	4.564		4.426
10	4.437	4.594		4.516
20	4.452	4.376		4.414
40	4.181	4.638		4.410
Avg.	4.395	4.531		4.463
		1973		
2-cut system				
1	4.345	4.733		4.539
5	4.363	4.624		4.494
10	3.904	4.573		4.239
20	4.588	4.611		4.600
40	4.349à.522		4.436	
Avg.	4.310	4.613		4.462
3-cut system				
1	4.663	4.567	4.726	4.652
5	4.731	4.674	4.802	4.736
10	4.604	4.579	4.705	4.629
20	4.662	4.577	4.576	4.605
40	4.626	4.743	4.776	4.715
Avg.	4.657	4.628	4.717	4.667

not reached. According the FUESS and TESAR (1968) the maximum LAI for lucerne is 5–6. In all cuts of the different cutting systems for both 1973 and 1974 the following linear relationship was obtained between dry matter yield (x) and LAI (y):

$Y = 0.57 + 1.26\ X \qquad (r = .915^{xxx})$

Plant height relationships:

The daily increase in plant height (Fig. 6), average temperature and the radiation amount followed each other well. Temperature alone accounted for 70–75 % of the increase as the following indicate; x = avg. daily temp (°C), y = daily height increment (cm):

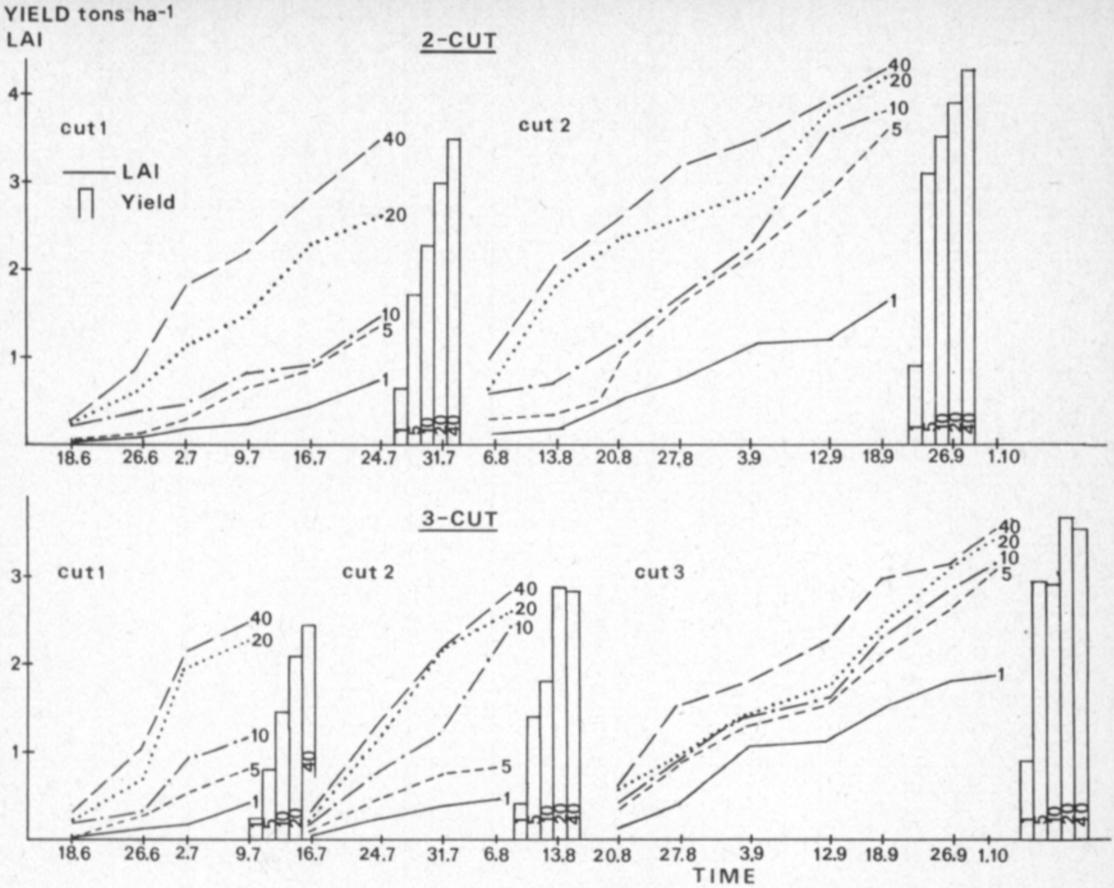

Fig. 4. Seeding year LAI development and yields tons/ha DM in individual cuts with different seeding rates in 1973

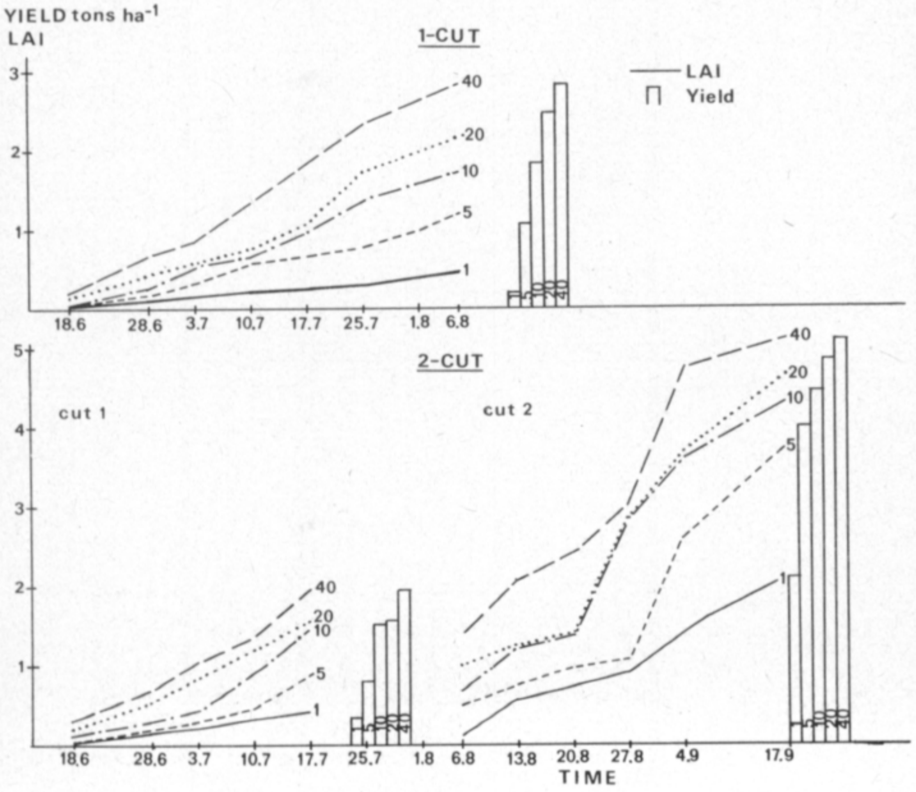

Fig. 5. Seeding year LAI development and yields tons/ha DM in individual cuts with different seeding rates

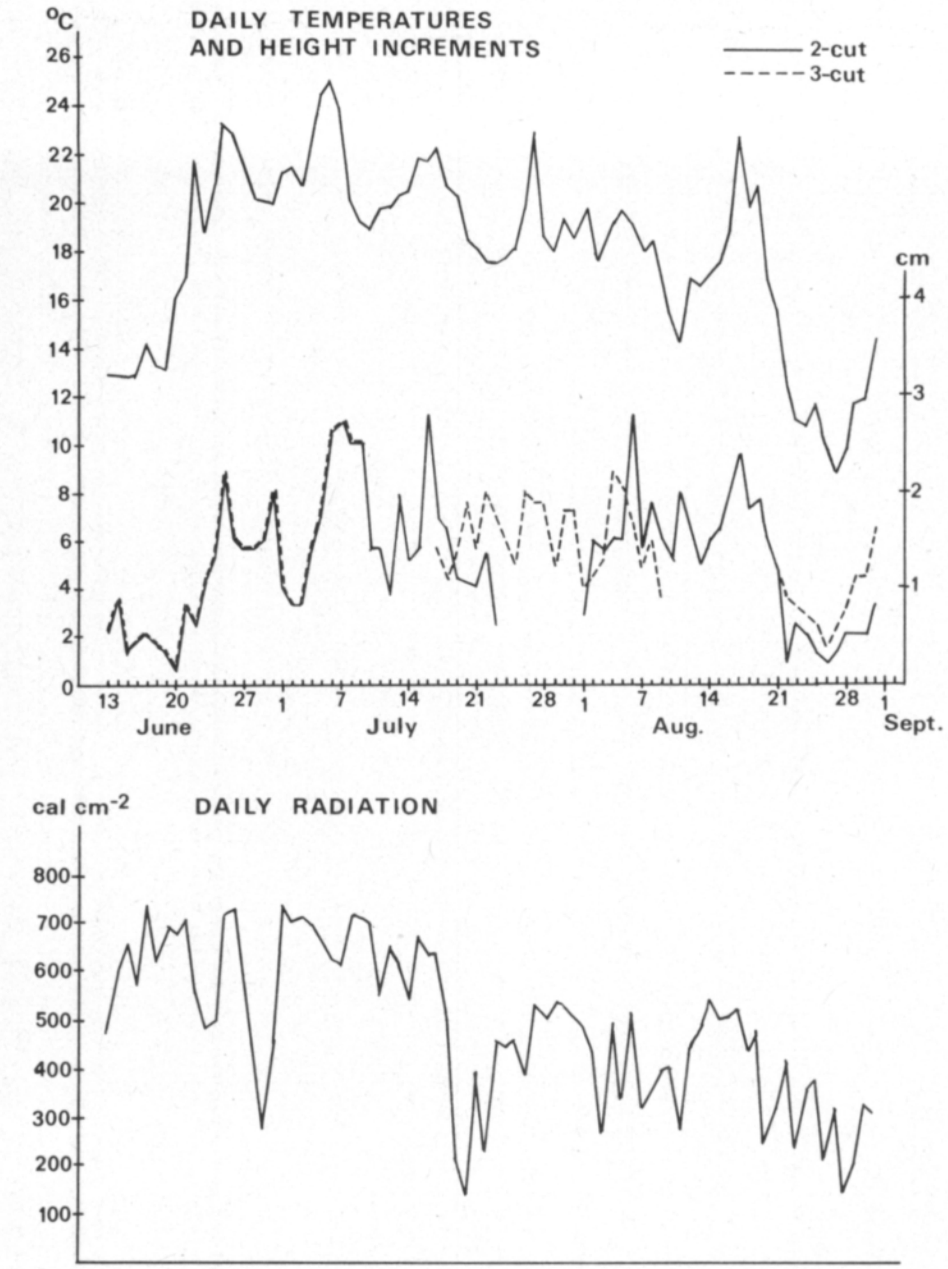

Fig. 6. Average daily temperatures and radiation and lucerne stand height increments during the seeding year development in 1973

Spring growth: $y = -1.33 + 0.135x$ ($r = .85^{xxx}$)
Summer growth: $y = -4.43 + 0.331x$ ($r = .87^{xxx}$)
Autumn growth: $y = -1.47 + 0.197x$ ($r = .84^{xxx}$)

These results agree with those of HARI and LEIKOLA (1974).

According to the calculated linear relationships the border temperatures for spring, summer and autumn growth are +10°C, +13°C and +8°C respectively. Of these the summer temperature value can be questioned. The high activation value most likely is a result of the abundant irrigation and relatively high daily temperatures in 1973. Strong midsummer height growth can also be seen in Table 9. Under favourable conditions height growth in the 2-cut system is steady throughout the entire growing season.

From Fig. 7 it can be seen that temperature exerted a strong influence into the autumn despite the fact that illumination had somewhat weakened. These results support those reported by PULLI (1980) for meadow fescue and a mixed clover-grass stand.

Table 9. Daily height increment (cm/day) in different cutting systems during the time 12.6—31.8 in 1973—74.

Cutting periods	1973 2-cut	1973 3-cut	1974 1-cut	1974 2-cut
I	1.26	1.26	1.13	0.93
II	1.24	1.59		1.10
III		0.90		
Avg.	1.25	1.25	1.13	1.02
Avg. cuts	1.25		1.08	

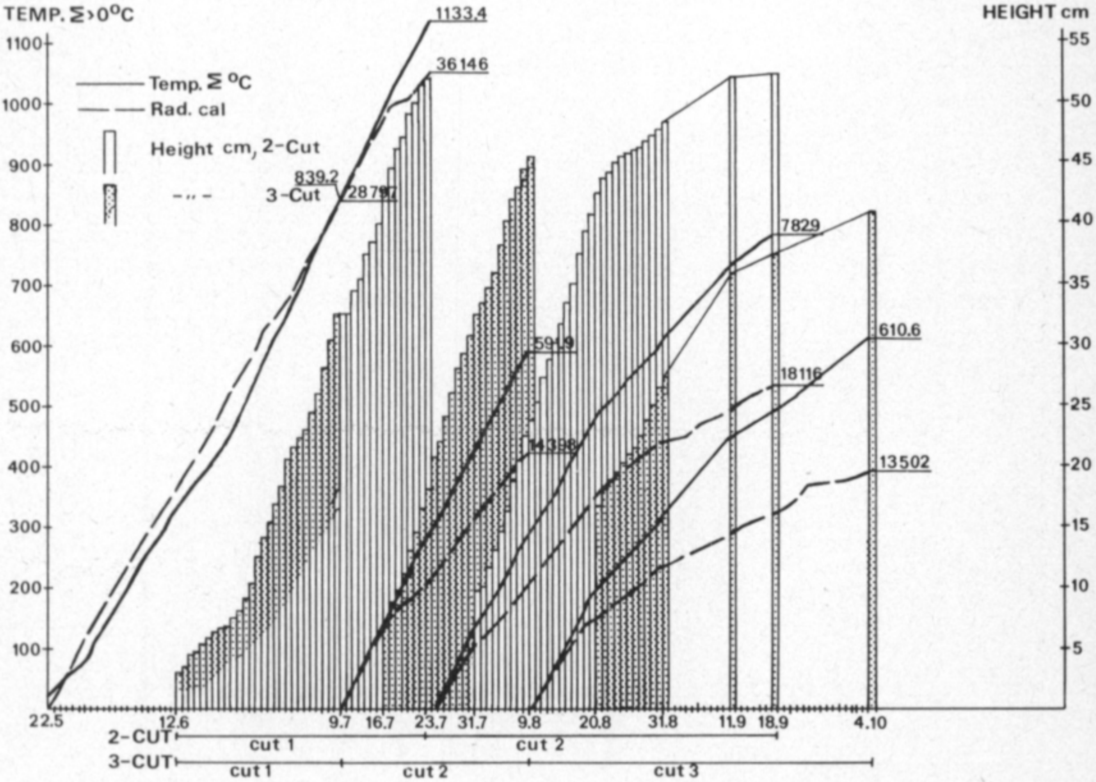

Fig. 7. Temperature sum in degree days (0°C) and radiation sum (cal/cm²/min) development compared to the height development of a seeding-year lucerne stand cut two and three times in 1973

4.4. Stand quality development

As part of this investigation the in vitro digestibility of lucerne was monitored weekly during the period 25.6.—4.10. The reduction in digestibility occurred evenly in the 2-cut system (Table 10), being less than 0.5 % in each cut. In the 3-cut system as the development progressed toward the autumn so too did the rate of change in digestibility, as the values of 0.20, 0.30 and 0.75 % for 1973 indicate. These digestibility changes agree with those observed by REID et al. (1959) and PULLI (1973) for lucerne and by countless others in studies of forage, for example HUOKUNA (1973), RAININKO (1973), SYRJÄLÄ et al. (1978). The large changes in digestibility during the early autumn were influenced by the strong growth potential of the stand combined with the favourable growing conditions.

The 3-cut system produced fodder about 6.3 % units more digestible than the 2-cut system (Table 11). Because the final cut of the 3-cut system was made on Oct. 4, abundant shoot development in September increased the digestibility of this final cut significantly. At the same time there was a loss of terminal shoot dominance.

4.5. Carbohydrate reserves in lucerne roots

GRANFIELD (1935) found that a substantial reserve nutrient level is a prerequisite for the successful wintering of lucerne in northern cultivation areas. In lucerne the carbohydrates available for growth should be about 35 % of the dry weight of the roots in order to assure satisfactory wintering (SMITH 1962). Carbohydrate reserves vary with the cuttings (GRABER et al. 1927) and too many cuttings during the growing season may result in a too low reserve nutrient level in the autumn and winter (SMITH 1962).

In the lucerne study at Viikki the reserve nutrient level of lucerne roots dropped by about 10 % of the total dry matter content following cutting (Fig. 8) in the favourable 1973 season, but then rose to a level exceeding 30 %. The rate of increase was slower in the 3-cut system than the 2-cut system. During the rainy and cool growing season of 1974 carbohydrate reserves were not used much for yield formation

Table 10. Changes in in vitro digestibility of lucerne stand % per day when cut two or three times during the growing season.

Cutting	Changes in in vitro digestibility % per day				
system	25/6—9/7	25/6—23/7	23/7—10/8	6/8—3/9	20/8—3/9
2-cut		—0.45		—0.48	
3-cut	—0.21		—0.30		—0.75

Table 11. In vitro digestibility (%) of lucerne stand in 1973 cut two and three times during the growing season.

Cutting	Cuttings			
system	Cut 1	Cut 2	Cut 3	Avg.
2-cut	62.1	68.8		65.4
3-cut	71.4	67.3	74.7	71.7

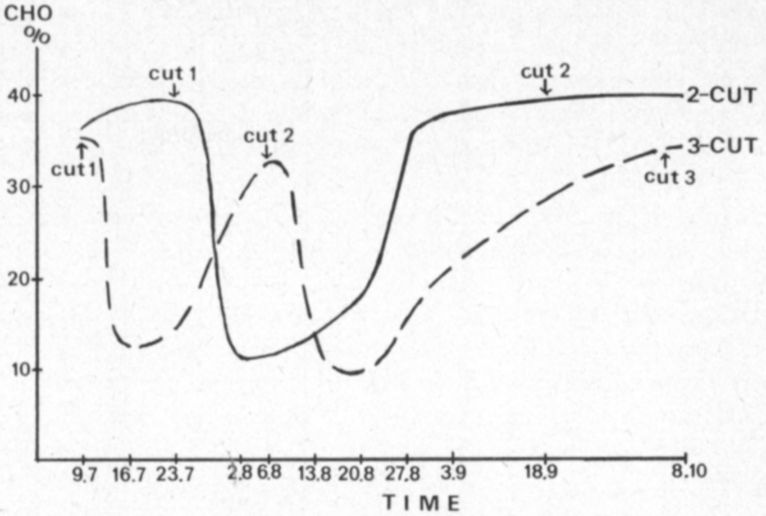

Fig. 8. Root carbohydrate levels of a lucerne stand cut two and three times during the seeding year 1973

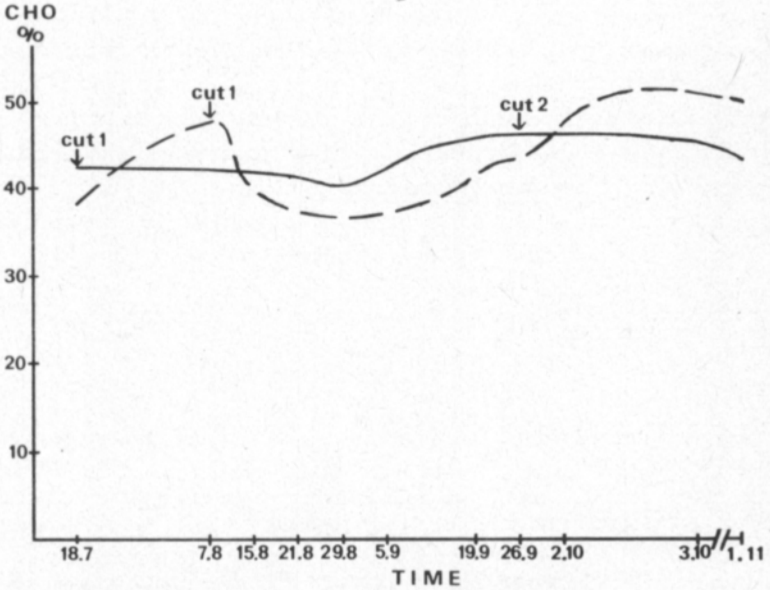

Fig. 9. Root carbohydrate levels of a lucerne stand cut once and two times during the seeding year 1974

and as a result the reserve level remained high throughout the entire growing season (Fig. 9). The carbohydrate level in lucerne roots in the Viikki test should have ensured good wintering. As satisfactory wintering did not occur the reasons are many. Good wintering always requires favourable growing conditions. In addition, making the last cut at the latest by mid-August appears to assure good wintering of lucerne. Having the last cut in mid-August means making only two cuts during the growing season.

5. Summary and conclusions

At the university farm in Viikki a test series was conducted during 1973—74 on the growth and development of lucerne during the seeding-year. The variety used was the Danish Isis-Daenfeldt lucerne. On the basis of the results the following conclusions can be made:

1.) The maximum dry matter yield was obtained from a seeding rate of 20 kg/ha. By the autumn of the seeding year the stand density was 60 % of the seeding density.
2.) For good wintering lucerne may be cut at most twice during the growing season. The last cut should be made by mid-August in order that 4 weeks of growth following the cut may be reached before the first frost.
3.) The radiation used by lucerne was 0.3—0.5 % of the total radiation reaching the surface. Differences in the utilization amounts of radiation are due to temperature differences.
4.) In both study years the optimum LAI was obtained from seeding rates ≥ 5 kg-/ha. The greatest measured LAI values were 4.3 and 5.2 in 1973 and 1974 respectively. LAI and the yield as well as LAI and height growth were closely correlated to each other.
5.) From seeding to emergence a temperature sum of 120°C is needed, and from seeding to flowering a sum of 800°C. From cutting to the next flowering a sum of 600—700°C is needed.
6.) Three cuts provided forage 6.3 % units more digestible than two cuts.
7.) Satisfactory wintering of lucerne requires high reserves of carbohydrates in the roots as well as good root development.

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SELOSTUS

Viljelytoimenpiteiden ja kasvutekijöiden vaikutus kylvövuoden sinimailasen kasvuun

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Helsingin yliopiston kasvinviljelytieteen laitoksella tutkittiin vuosina 1973—74 niittojen ja kylvötiheyden vaikutusta sinimailasen kylvövuoden sadonmuodostukseen sekä kasvun ja kehityksen suhdetta tärkeimpiin kasvutekijöihin kasvukauden eri ajankohtina. Tutkimuksesta voidaan vetää seuraavat johtopäätökset.

Korkein kuiva-ainesato saatiin kylvösiemenmäärällä 20 kg/ha. Suotuisan kasvukauden 1973 kylvövuoden kuiva-ainesato oli 5.7 tn/ha, kolean ja sateisen kasvukauden 1974 3.3 tn/ha. Sinimailasnurmen yhteyttämistehokkuus oli 0.3—0.5 % pinta-alalle tulleesta kokonaissäteilystä. Pilvisenä kesänä 1974 saatiin 10 % vähemmän säteilyä kuin 1973. Kun yhteyttämistehokkuus oli v. 1974 lähes 50 % vähemmän kuin 1973, sadonmenetys on täytynyt johtua ensisijassa alemmista keskilämpötiloista ja haitallisen suurista sademääristä. Tehokas yhteyttämispinta saavutettiin siemenmäärällä 5 kg/ha kylvövuoden syksyllä. Kylvöstä taimettumiseen tarvittiin 120°C ja kylvöstä kukkimiseen 800°C. Niitosta kukkimiseen tarvittiin 600—700°C lämpösumma.

Kylvövuoden sinimailasen juuriston vararavintovarat osoittavat, että sinimailanen voidaan niittää vain kahdesti, viimeisen niiton tapahtuessa elokuun puolivälissä.