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Seed yield and seed quality of subterranean clover (*Trifolium subterraneum* L.) in growing conditions of Finland

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Abstract. Seed yield and overwintering of seeds of 22 Australian subterranean clover varieties were investigated in 1986 and 1987 at the Viikki Experimental Farm of the University of Helsinki.

The seed yield varied remarkbly according to the variety and weather conditions of the two summers. Some varieties, such as Seaton Park, Woogenellup and Karridale, and during the summer of 1987 also the early variety Dalkeith, produced lots of seed. Some late varieties, e.g. Treeton, Tallarook and Esperance, produced very few seeds or no seeds at all.

A considerable proportion of the seeds degenerated during the wet autumn conditions, by the end of October. Many seeds showed embryo dormancy, but complete dormancy or hard seeds were found only exeptionally. In spring 1988, some seedlings which had developed from overwintered burrs were found. There seems to be little hope of finding self-seeding subterranean clovers suitable for Finnish growing conditions.

Index words: subterranean clover, seed yield, seed survival

Introduction

Subterranean clover is a winter annual clover growing in the Mediterranean climate zone. It includes three species, *Trifolium subterraneum* L., *T. yanninicum* Katzn. and *T. brachycalycinum* Katzn. and Morley. The species differ from each other with respect to their morphological characteristics and the growing conditions they require, but they are all geocarpic, with their seeds developing at or beneath the soil surface (McGUIRE 1985).

Subterranean clover grows during the rainy winter season. The seeds mature before the hot and dry summer; they survive beneath the soil surface, to start growing again in the autumn. A typical characteristic of the seeds is a long-lasting dormancy, which helps lots of the seeds to remain viable for several years (LANGER and HILL 1982).

In Australia, subterranean clover has been developed into a crop plant, which makes it

possible to grow pastures with low seed and nitrogen costs. It has adapted to the cropping system so that after the pasture phase it survives in the soil during the 2—3 years of arable cropping to come up spontaneously as the main species at the beginning of the pasture phase. It is well able to stand the grazing of sheep, and because of its growing habit it produces lots of seed in spite of grazing (GLADSTONES 1967, GLADSTONES and COLLINS 1983, TAYLOR 1984, BOYCE et al 1985).

In Europe, subterranean clover has spread naturally not only in the Mediterranean countries but even in France and the southern parts of the British Isles. In many European countries it is sown with imported seed for green manuring, but its seed production and self-seeding ability have been investigated only little (KATZNELSON 1974, MORGNER and SCHÄFER 1981).

Material and methods

Since 1980, subterranean clover has been investigated as a green manuring crop at the University of Helsinki, at the Department of Crop Husbandry (VARIS et al 1982, KAUPPILA 1983). At the beginning the varieties studied were those provided by German and Swiss seed suppliers such as Clare, but also varieties from Australia were studied. Some of them grew well and flowered well, and they also seemed to produce seed. Thus the growth, seed production, dormancy of seeds and the possible survival over the winter were studied more in detail.

Seeds for the study reported here were received from the Western Australian Department of Agriculture in Perth. The varieties were: Clare, which belongs to the subspecies *Trifolium brachycalycinum,* Dalkeith, Esperance, Green Range, Junee, Karridale, Nungarin, Seaton Park, Tallarook, Treeton and Woogenellup (subsp. T. *subterraneum*) and Larisa, Meteora and Trikkala (subsp. T. *yanninicum*). Eight lateflowering breeding lines were also included.

The first trial in 1986 was established with single plants. The seeds were sown in a greenhouse at the beginning of April. In the middle of May the seedlings were transplanted in the field as one plant plots, two meters apart, with four replicates. In addition, 5 m long rows, 1 m apart, were sown at the neighbouring field for studying the survival of the seeds. In 1987, the varieties were sown in the field at the end of May, in single rows of 5 meters, 20 plants/m with a row distance of one meter.

The flowering of the plants was observed during the summer. In the autumn of 1986, all subterranean clover plants were dug up from the field, with their roots and burrs, at the end of October. The plants were washed up and dried in 45°C, and their seeds and biomass were weighed. During the winter the number of burrs containing seeds were counted. The seeds were separated from the burrs manually. The yields of the seeds were weighed, and the average seed weights were determined. The seeds were germinated in a Jakobsen germinating basin, four times 100 seeds if there were enough seeds. The seeds were divided into four groups: normally germinated, swollen (emryo dormancy), hard (complete dormancy) and degenerated seeds. Samples of 0.5 m were taken from the rows sown in 1987, for yield and germinating analyses, respectively.

In the spring of 1987 and of 1988, the trial site was investigated to find out whether seeds survived.

Growing conditions

The trial site in 1986 was sandy clay, pH 6.1. In 1987, the trial field was fine sand soil, pH 5.9. The weather conditions of the growing seasons were totally different. In 1986, the effective temperature sum was 1318°C until October 27 and only 1097°C in 1987 until October 9; the latter was one of the lowest temperature sums of this century in southern Finland. The rain sums were 518 mm and 428 mm, respectively.

Results

The diameter and dry weight of the plants, the number of burrs, seed yield, and thousand seed weight from the 1986 trial are presented in Table 1. The varieties are classified in three classes according to the earliness of their flowering (early = commencement of flowering before July 2; middle = flowering started from July 2 to July 9; late = flowering after July 9). The varieties are listed according to their seed yields.

The earliness did not quite correspond with seed yields. Nevertheless, those varieties which produced few seeds or no seeds at all were late. The diameter of the plant, which reflects the length of runners, varied from 29 to 135 cm and the dry weight varied between 3.3 and 147.4 g. Frost and diseases damaged some varieties, which reflects in low yields. The seed yields varied highly. Seaton Park produced more than 1000 seeds per plant. Some late varieties, such as Treeton — the most abundant growing variety of the trial — did not produce any seeds.

The germinability of the seeds and the dormancy characteristics are presented in Table 2.

Most varieties had very few normally germinating seeds. Most of the seeds had degenerated in the wet field already during the autumn. Some of the seeds were healthy and swelled during the germination test; this was an indication of embryo dormancy. There were only some proper hard seeds which it could be assumed, would survive over the winter.

In the spring of 1987, no seedlings were found in the field, so that overwintering of the seeds seemed to be unlikely.

The results for summer 1987 are presented in Table 3. The results are expressed per row of 0.5 m, so the yields are not directly comparable with the figures of the previous year.

The best seed producers in the cool summer of 1987 were the early or fairly early varieties. The results were somewhat different from those of the previous year, apparently because of the exceptional temperature conditions of

Table 1. The biomass and seed yield of subterranean clover varieties in 1986.

Variety	Earliness E = early M = middle L = late	Diameter of plants	Dry weight g/plant	Burrs with seeds/ empty burrs per plant	Seed yield g/plant	1000 seed weight g
Seaton Park	M	120	119.5	524/162	6.97[a]	4.54
Woogenellup	M	111	110.0	329/166	4.11[ac]	5.10
Karridale	E	109	94.2	331/108	3.97[ace]	4.22
68103H	L	74	92.3	104/32	1.17[bce]	3.41
Nungarin	E	96	36.0	101/66	1.08[bce]	4.38
Junee	L	90	123.0	143/104	1.05[bce]	2.77
Trikkala	M	39	12.3	82/19	0.71[bde]	5.63
89774F	L	64	72.2	108/52	0.60[bdf]	2.85
Larisa	M	73	105.0	96/54	0.55[bdf]	4.28
89774B	L	73	41.5	107/46	0.53[bdf]	2.23
Green Range	M	55	75.9	49/17	0.50[bdf]	4.79
89777C	L	60	64.6	63/20	0.44[bdf]	3.57
Clare	E	135	28.3	37/18	0.28[bdf]	6.36
Dalkeith	E	29	3.3	35/12	0.23[bdf]	3.10
89816F	L	59	113.7	24/49	0.14[bdf]	2.40
Meteora	L	49	43.7	14/10	0.12[bdf]	5.76
89822H	L	57	45.5	20/14	0.12[bdf]	2.31
89880J	L	68	101.3	4/4	0.00[bdf]	1.14
Esperance	L	40	39.7	0/0	0	—
Tallarook	M	53	100.8	0/0	0	—
Treeton	L	79	147.4	0/0	0	—
GF 183 a-5	L	49	77.1	0/0	0	—

Table 2. The germinability and dormancy characteristics of subterranean clover seeds in 1986.

Variety	Normal %	Swollen %	Hard %	Degenerated %
Seaton Park	33	35	0	32
Woogenellup	46	0	0	54
Karridale	10	28	0	62
68103H	13	5	0	82
Nungarin	8	50	3	39
Junee	0	16	1	83
Trikkala	20	21	0	59
89774F	5	38	0	57
Larisa	4	30	0	66
89774B	2	32	0	66
Green Range	4	15	0	81
89777C	8	12	0	80
Clare	2	21	1	76
Dalkeith	2	32	2	64
89816F	0	15	0	85
Meteora	3	33	0	64
89822H	2	1	0	97
89880G	—	—	—	—
Esperance	—	—	—	—
Tallarook	—	—	—	—
Treeton	—	—	—	—
GF 183 a-5	—	—	—	—

Table 3. The biomass and seed yield of subterranean clover varieties in 1987.

Variety	Earliness E = early M = middle L = late	Dry weight g/0.5 row-meter	Burrs with seeds/ empty burrs per 0.5 m	Seed yield g/0.5 m	1000 seed weight g
Dalkeith	E	4.8	44/1	1.08	8.23
Green Range	E	12.1	36/19	.78	6.09
Karridale	M	17.0	61/38	.71	3.34
Woogenellup	M	19.2	27/38	.62	6.15
Meteora	M	58.4	49/58	.52	4.42
Nungarin	L	13.5	22/23	.40	5.02
Trikkala	M	9.0	15/17	.33	7.73
Seaton Park	M	25.4	30/68	.31	4.33
Larisa	L	18.0	21/30	.24	4.47
Clare	E	6.2	7/4	.12	6.71
Junee	M	12.2	11/16	.11	2.83
89816F	L	7.0	11/32	.11	2.88
GF 183 a-5	L	14.1	3/9	.6	5.04
89774F	L	10.9	6/31	.4	3.34
89774B	L	18.7	2/25	.2	3.47
89777C	L	16.2	2/17	.2	2.95
68103H	L	13.2	1/4	.1	2.42
89880J	L	8.9	1/17	.1	2.50
Esperance	E	16.3	1/1	0	0.75
89822H	L	8.5	0/6	0	3.71
Tallarook	L	16.3	0/2	0	0
Treeton	L	9.3	0/0	0	0

Table 4. The germinability and dormancy characteristics of subterranean clover seeds in 1987.

Variety	Normal %	Swollen %	Hard %	Degenerated %
Dalkeith	4	55	24	17
Green Range	0	15	0	75
Karridale	6	32	1	61
Woogenellup	8	20	0	72
Meteora	0	16	0	84
Nungarin	0	75	0	25
Trikkala	1	64	3	32
Seaton Park	2	20	1	77
Larisa	0	20	0	80
Junee	1	5	0	94
89816F	0	22	0	78
GF 183 a-5	2	3	0	95
89774F	0	34	0	66
89774B	0	19	0	81
89777C	0	5	0	95
68103H	0	0	0	100
89880J	0	2	0	98
Esperance	—	—	—	—
899822H	—	—	—	—
Tallarook	—	—	—	—
Treeton	—	—	—	—

the summer. Seaton Park produced lots of empty burrs although it had produced plenty of seed the year before. The early varieties, Dalkeith and Green Range, gave the best seed yields, Meteora grew well in wet conditions.

The results characterizing the quality of seeds are presented in Table 4.

There were few normally germinating seeds, but many varieties had plenty of swollen seeds indicating embryo dormancy. Dalkeith had exceptionally many hard seeds. The seed yield of many varieties had fully degenerated by the end of October. The unploughed trial site was examined in spring 1988 to check for seedlings. Six seedlings originating from burrs were found. Two of these plants kept growing when transplanted in the greenhouse, and produced seed during 1988.

Discussion

The results of these small-scale experiments show that many subterranean clover varieties were able to produce seed in Finnish growing conditions. The long day during the growing season hastens the flowering of several varieties (Aitken 1955, Evans 1959, Collins and Aitken 1970). Due to the considerable differences in the earliness of the varieties and to the highly variable temperature conditions, the seed yields of the varieties varied in the two trial years.

Most of the seeds degenerated during the wet autumn. To reach complete dormancy and to survive in the field, the seeds of subterranean clover have to dry (Hagon 1974, Collins and Quinlivan 1980); that apparently did not occur. In Finnish growing conditions embryo dormancy developed in many cases, but these seeds can hardly survive over the winter, due to damage caused by diseases and freezing of the soil in the winter. Only occassionally were there real hard seeds, the condition required for the self-seeding ability of subterranean clover (Williams and Elliot 1960). The fact that there were some seedlings which developed from overwintered seeds in spring 1988 may give some hope of finding types which can develop hard seeds and self-seed in more northern and wetter conditions

than is normally the case. On the other hand, it would be theoretically possible to harvest germinable seed of subterranean clover in Northern European conditions if the harvesting time were fitted to the maturation time of the actual variety.

References

Aitken, Y. 1955. Flower initiation in pasture legumes: 1. Factors affecting flower initiation in *Trifolium subterraneum* L. Aust. J. Agric. Res. 6: 212—244.

Boyce, K.G., Weber, G.D. & Lake, A.W.H. 1985. Transfer of the South Australian dryland farming technology of countries in West Asia and North Africa. Proceedings of the XV International Grassland Congress, August 24—31, 1985, Kyoto, Japan.

Collins, W.J. & Aitken, Y. 1970. The effect of leaf removal on flowering time in subterranean clover. Aust. J. Agric. Res. 21: 893—903.

Collins, W.J. & Quinlivan, B.J. 1980. The effects of a continued water supply during and beyond seed development on seed production and losses in subterranean clover swards. Aust. J. Agric. Res. 31: 287—295.

Evans, L.T. 1959. Flower initiation in *Trifolium subterraneum* L. 1. Analysis of the partial processes involved. Aust. J. Agric. Res. 10: 1—16.

Gladstones, J.S. 1967. Naturalized subterranean clover strains in Western Australia: a preliminary agronomic examination. Aust. J. Agric. Res. 18: 713—731.

Gladstones, J.S. & Collins, W.J. 1983. Subterranean clover as a naturalized plant in Australia. J. Aust. Inst. Agric. Sci. 49: 191—202.

Hagon, M.W. 1974. Regeneration of annual winter legumes at Tamworth, New South Wales. Aust. J. Exp. Agric. Anim. Husb. 14: 57—64.

Katznelson, J. 1974. Biological flora of Israel. 5. The subterranean clovers of *Trifolium* subsect. *Calycomorphum* Katzn. *Trifolium subterraneum* (L.) (s. l.) Isr. J. Bot. 23: 69—108.

Kauppila, R. 1983. Viherlannoituskasvit. Biologinen typensidonta peltokasvien viljelyssä. SA:n sopimustutkimuksen 383 loppuraportti: 175—192.

Langer, R.H.M. & Hill, G.D. 1982. Agricultural plants. 344 p. Cambridge.

McGuire, W.S. 1985. Subterranean clover science and technology. p. 515—534. Ed. Taylor, N.L. Madison, Wisconsin.

Morgner, F. & Schäfer, K. 1981. Bodenfrüchtiger Klee — eine aussichtsreiche Zwischenfrucht. Tierzüchter 33: 260—261.

Taylor, G.B. 1984. Effect of burial on the softening of hard seeds of subterranean clover. Aust. J. Agric. Res. 35: 201—210.

Varis, E., Hovinen, S., Kansanen, P. & Kauppila, R. 1982: Legumes in Finnish Agriculture. The Second National Symp. Biol. Nitr. Fix, Rep. 1: 219—231.

Williams, W.A. & Elliot, J.R. 1960. Ecological significance of seed coat impermeability to moisture in crimson, subterranean and rose clovers in a mediterranean-type climate. Ecology 41: 733—742.

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SELOSTUS

Maa-apilan (*Trifolium subterraneum* L.) siemenenmuodostus ja siementen laatu Suomen kasvuoloissa

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Helsingin yliopiston Viikin koetilalla tutkittiin vuosina 1986—87 22 austraalialaisen maa-apilalajikkeen ja linjan siemenenmuodostusta ja siementen talvehtimista.

Lajikkeiden siemensato vaihteli huomattavasti koevuosien kesken. Eräät lajikkeet, kuten Seaton Park, Woogenellup ja Karridale, ja kesällä 1987 myös aikainen lajike Dalkeith, tuottivat runsaasti siementä. Monet myöhäiset lajikkeet, kuten Treeton, Tallarook ja Esperance, tuottivat siementä hyvin vähän tai ei lainkaan.

Huomattava osa siemenistä pilaantui kosteissa syysoloissa lokakuun loppuun mennessä. Useissa siemenissä todettiin alkion dormanssia, mutta täydellistä dormanssia tai kovia siemeniä esiintyi vain satunnaisesti. Keväällä 1988 koealueelta löydettiin muutamia talvehtineista siemenistä kasvaneita taimia. Näyttää olevan vain vähän mahdollisuuksia löytää maa-apilasta Suomen oloissa itsesiementäviä muotoja, joita voitaisiin hyödyntää laiduntai viherlannoituskasveina.