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Time to flowering of *Medicago polymorpha* ecotypes and cultivars in response to temperature and photoperiod

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Summary: Time to flowering of nine Chilean accessions and two Australian cultivars of *Medicago polymorpha* was measured on twelve sequential outdoor sowings in Cauquenes (35°58'S, 72°17'W; elev. 177m), in the subhumid mediterranean region of Chile. The rate of progress to flowering (1/f), defined as the inverse of the time from emergence to flowering, was related to mean diurnal temperature (model 1) or to both mean diurnal temperature and mean photoperiod (model 2). There was a clear gradient in earliness among the Chilean accessions at all the sowing dates; Ovalle and Combarbalá, both from the arid mediterranean region, were the earliest flowering accessions, whereas Traiguen, from the humid mediterranean region, was the latest. Among the Australian cultivars, Santiago was the earliest flowering cultivar. Model 2 accounted for a great proportion (between 81 and 96%) of the observed variation in flowering within accessions. A great variation on the sensitivity of rate of flowering to temperature and photoperiod was found among the Chilean accessions and the Australian cultivars.

Key-words: annual medic, *Medicago polymorpha*, flowering, temperature, photoperiod

INTRODUCTION

Burr medic (*Medicago polymorpha*) is presently widely naturalized in the mediterranean region of Chile (Del Pozo et al, 1989a) and is the most valuable annual legume occurring in natural, pastures (Ovalle et al, 1990). It has been found particularly useful in the regeneration of degraded pastures in silvopastoral systems, dominated by the leguminous tree Acacia caven (Avendaño and Ovalle, 1992) , and also in ley farming systems (Del Pozo et al, 1989b). It is also an important cultivated forage in Western Australia on slightly acid soils in low rainfall areas (Ewing and Howieson, 1989).

From 53 accessions, collected along a N-S gradient extending from near La Serena (30°S, ca. 150 mm mean annual precipitation) to near Temuco (39°S, ca. 1200 mm), and tested under uniform conditions at Cauquenes (35°58'S, 72°17'W; elev. 177m), a considerable variability was found on phenology and in other ecophysiological parameters (Ovalle et al, 1993). Time to flowering ranged from 82 to 129 days, with a strong positive correlation (r2 = 0.79; $P < 0.01$) existing between days to flowering and the latitude of collection in a subsample of 32 accessions (Ovalle et al, 1993).

Temperature and photoperiod are the main environmental factors controlling phenology, and both differ greatly along the N-S gradient. Here we tested whether different accessions collected along a N-S gradient have different flowering response to temperature and photoperiod.

METHODS

Seeds from nine accessions of the naturalized annual medic M. polymorpha and from two Australian cultivars (Circle Valley and Santiago) of the same species, were sown in raised beds at Cauquenes (35°58'S, 72°17'W; elev. 177m), on twelve sequential sowings from May 1993 to April 1994. The Chilean accessions were from the arid (Ovalle, 30°33' S and Combarbalá, 31°09' S), semiarid (Batuco, 33°11' S), subhumid (Calleuque, 34°26' S, Santa Dolores, 35°52' S, Cauquenes, 35°58' S and Chanco, 35°41' S), humid (Cañete, 37°48' S) and perhumid (Traiguén, 38°09' S) mediterranean regions. One row 1.1 m long was sown to obtain 26 plants for each accession. There was one raised bed (4 x 1.1 m) per sowing date and the distance between rows (accessions) was 40 cm. Inoculum was applied diluted in water inmediately after sowing, and the same rhizobial strain was used in all the accessions. Fertilizer was mixed in the soil before sowing at a rate equivalent to 44 $kg.ha^{-1}$ of P and S as Normal Superphosphate. Plants were grown outdoor and watered as necessary.

Phenological observations were carried out on individual plants every three days. Emergence date was recorded when half of the plants in the row emerged. Time from emergence to the appereance of the first flower was recorded for each plant and the average time was calculated for each accession and sowing date. Maximum and minimum temperatures were recorded on a meteorological station located 1 km from the experimental site.

The rate of progress to flowering (1/f), defined as the inverse of the time from emergence to flowering, was related to mean diurnal temperature (T, °C) or to both mean diurnal temperature and mean photoperiod (P, $h.day^{-1}$), using linear models (Del Pozo *et al*, 1987; Summerfield *et al*, 1991). In accessions insensitive to photoperiod, the relationship is:

$$1/f = a + bT \qquad (1)$$

where a and b are specific constants to the accession.

In photoperiod-sensitive accessions, the rate of flowering can be described by:

$$1/f = a' + b'T + c'P \qquad (2)$$

where a', b' and c' are constants specific to each accession.

RESULTS AND DISCUSSION

Effect of sowing date on time to flowering

Time from emergence to first flower declined for all accessions as sowing date was delayed from May to December 1993, but then increased as sowing date advanced from January to April 1994 (Table 1). There was a clear gradient in earliness among the Chilean accessions at all the sowing dates; Ovalle and Combarbalá, both from the arid mediterranean region, were the earliest flowering accessions, whereas Traiguen, from the humid mediterranean region, was the latest. Among the Australian cultivars, Santiago was the earliest flowering cultivar.

Rate of progress towards flowering as a function of temperature and photoperiod

Mean temperature and mean photoperiod for the period emergence-first flower varied considerably within sowing dates, ranging from 9.4 to 21 °C, and from 10 to 14.4 h, respectively, with small variation between accessions.

Table 1: Days from emergence to first flower for sequential sowings, of nine Chilean accessions and two Australian cultivars of M. polymorpha.

Accession	Sowing date											
	6/5	7/6	5/7	6/8	6/9	5/10	4/11	6/12	5/1	4/2	4/3	4/4
Ovalle	84	68	56	42	37	35	29	24	27	27	44	62
Combarb.	92	74	61	47	41	37	35	25	33	28	58	88
Batuco	100	78	66	52	45	41	34	29	42	34	101	97
Calleuque	107	87	76	59	50	48	32	38	40	60	92	149
Sta Dol.	102	88	72	60	51	48	54	40	68	91	107	141
Cauquen.	112	87	77	60	52	48	49	40	68	47	86	118
Chanco	116	97	78	62	61	57	66	49	79	103	159	147
Cañete	117	99	80	63	57	55	60	50	44	112	151	148
Traiguén	122	102	85	68	62	59	58	49	78	133	174	152
Santiago	91	75	64	45	42	39	33	28	35	34	60	100
C. Valley	102	84	72	56	52	46	44	37	57	73	97	108

Temperature itself (model 1) explained a small proportion of the observed variation in flowering, except on early flowering accessions (Combarbalá and Santiago) where r^2 was greater than 0.7 (Table 2).

Table 2: Parameters values (x10^{-4}) and coefficient of determination (r^2) of models derived from regression of the rate progress to flowering (1/f) against mean temperature (model 1) or mean temperature and mean photoperiod (model 2), for each of the 11 accessions grown at 12 sequential sowings.

Accession	Model 1			Model 2			
	a	b	r^2	a'	b'	c'	r^2
Ovalle	-24.9	19.8	0.78	-359	7.2	42.8	0.96
Cambarbalá	-43.8	18.9	0.79	-320	8.1	35.8	0.92
Batuco	-8.2	14.4	0.61	-376	0.1	47.5	0.94
Calleuque	-6.1	12.4	0.51	-41	-2.6	51.5	0.91
Chanco	-39.1	6.2	0.33	-241	-503	36.9	0.84
Sta. Dolores	39.8	7.6	0.34	-288	-5.7	43.1	0.87
Cauquenes	35.4	8.1	0.37	-277	-4.6	41.2	0.92
Cañete	1.8	9.5	0.53	-258	-1.7	34.1	0.81
Traiguén	13.6	7.8	0.44	-286	-5.3	40.3	0.92
Santiago	-2.4	15.8	0.70	-340	3.0	42.7	0.95
Circle Valley	38.5	8.6	0.42	-284	-4.5	42.5	0.94

When temperature and photoperiod were included in the model (model 2), r^2 increased in all the accessions, but more markedly on late flowering accessions. The parameters b' and c' of model 2 varied between accessions indicating genotipic variation for sensitivity to both temperature and photoperiod. In the three earliest flowering accessions and in the Australian cv. Santiago, the parameters b' and c' were positive suggesting that the rate of progress to flowering was increased by temperature and photoperiod. On later flowering accessions b' was negative and c' was positive, suggesting that flowering rate was slowed by high temperatures, but promoted by photoperiod. In general, photoperiod per se (not shown) provided a better description of the data than temperature, indicating a greater sensitivity to photoperiod, particulary on late flowering accessions. Very similar results were obtained by Evans *et al* (1992) on earlier and later flowering cultivars of subterranean clover in Australia. Clearly, ecotypic differentiation in *M. polymorpha* for phenological adaptations have ocurred in Chile.

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