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TEMPERATURE EFFECTS ON GERMINATION OF NEW ZEALAND HERBAGE GRASSES

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Abstract

Percentage germination and germination rate (days to 75% germination) of 14 'Grasslands' cultivars from 9 grass species were assessed at constant temperatures of 5, 10, 15, 20, 25, 30°C and a fluctuating temperature of 5/10°C. Ryegrass germination did not differ significantly within the range of temperatures used. Germination of Kahu timothy and Maru phalaris was reduced at or below 10°C and at 30°C. Raki paspalum failed to germinate below 15°C. The germination of Apanui and Wana cocksfoot and Matua prairie grass was reduced at 30°C.

Germination rates for all species slowed as temperature moved away from the optimum, as did the number of days to the start of germination. Germination rate was greatest for the ryegrasses at all temperatures; for all other species the order was timothy, tall fescue> phalaris prairie grass and cocksfoot at 10°C, and timothy > phalaris, prairie grass>cocksfoot >tall fescue at 5°C. The implications of these results for pasture establishment are discussed.

Keywords: germination, germination rate, temperature, temperate grasses, pasture establishment.

INTRODUCTION

New Zealand farmers establish around one quarter of a million hectares of pasture each year. Establishment is the most critical phase of a pasture's life (Culleton and McCarthy 1983), because the result largely determines subsequent performance (Sears 1961). High quality seed is a basic requirement for successful pasture establishment (Scott et al. 1984); the expected returns from a first-class pasture far outweigh any saving which may result from sowing seed of inferior quality (Levy 1970).

Quality herbage seed should be certified and have a high planting value i.e., high purity, freedom from undesirable weed species, and high germination. These attributes are determined by careful analysis of a sample drawn from a seedlot, using internationally accepted procedures for sampling and testing (ISTA 1976). The germination capacity of a seedlot is determined by measuring the percentage of seeds growing normally under standardised, controlled laboratory conditions (Scott et al. 1984). This ensures that results are repeatable and reliable, which would not be possible with testing under field conditions.

Laboratory conditions for germination are set so that the seed is given every chance to germinate to its full potential. However, these conditions often differ from those in the field, where germination will depend on an interaction between the seed and its environment. The farmer often sows herbage seeds when temperature and moisture are less than ideal, and such conditions may greatly affect seedling establishment and subsequent performance.

Provided that water and nutrients are non-limiting, establishment of herbage species depends on ambient temperature and the germination, emergence and early growth characteristics of the genotype (Hill et al. 1985). As part of an investigation of the establishment of New Zealand herbage cultivars, the effects of temperature on the percentage and rate of germination of 'Grasslands' grass cultivars were examined.

TABLE 1: Total Number of Grass Seedlots Tested and Percentage of Seedlots with Germination 90% or Greater, 1983-1985.

Cultivars		Standard Germination temperature (°C)[2]	1983 Total[3] No.	1983 90 %	1984 Total No.	1984 90 %	1985[1] Total No.	1985[1] 90 %	3 year average 90 %	3 year average 80 %
Ryegrass										
Perennial	Nui	20/25	1027	64	686	64	211	68	65	88
	Ruanui	20125	133	83	107	79	49	78	80	92
Italian	Paroa	20/25	68	39	46	67	27	70	59	93
	Moata	20/25		26	154	57	87	79	54	79
Hybrid	Manawa	20/25	224	31	246	51	97	56	46	78
	Ariki		28	36	49	41	26	73	50	85
Westerwolds	Tama	20/25	47	25	78	67	52	75	56	66
Other Grasses										
Cocksfoot	Apanui	20/30	108	39	103	38	45	56	44	83
	Wana	20130	12	25	13	39	40	53	39	83
Phalaris	Maru	20/30	5	20	2	0	1	0	7	40
Prairie Grass	Matua	20/30	15	80	36	89	30	100	90	92
Tall Fescue	Roa	20/30	5	80	3	33	6	33	49	71
Timothy	Kahu	20125	22	68	20	40	9	77	62	83

1 To 1 June 1985 only
2 ISTA, 1976
3 Data are for official tests only, and do not include retests.

MATERIALS AND METHODS

The percentage germination (ISTA 1976) of 14 cultivars (listed in Table 1) from 9 grass species (*Lolium* perenne L., L. *multiflorum* Lam., *L.* X boucheanum Kunth., *Dactylis glomerata* L., Phalaris aquatica L., *Bromus wildenowii* Kunth., *Festuca arundinacea* Schreb., *Phleum pratense* L., *Paspalum dilatatum* Poir.) was determined at constant temperatures of 5°, 10°, 15°, 20°, 25°, 30°C, a fluctuating temperature of 5°/10°C (16h/8h per day), and standard germination temperatures for each species (Table 1). Up to 4 seedlots of each cultiwar were tested in a randomised complete block design which included 3 replicates of 100 seeds for each seedlot.

Normal seedlings (ISTA 1976) were counted and removed at regular intervals during the experiment which lasted a maximum of 50 days for the ryegrasses and 100 days for the other grass species. Final germination percentage and the number of days taken to reach 75% germination were determined, the latter being calculated from the viable seed portion only from within each seedlot.

A germination summary for the cultivars of the 9 grass species was obtained from Official Seed Testing Station records for 1983-1985.

RESULTS

Percentage Germination

Of the 13 cultivars tested during 1983-1985, germination was consistently greatest for Matua prairie grass seedlots, with an average 90% of samples having a germination of 90% or greater (Table 1). Germination was also consistent between years for the perennial ryegrasses Ruanui and Nui, with an average of 80% and 65% of seedlots respectively having a germination of 90% or greater. The germination of all other cultivars fluctuated markedly between years of production (Table 1). However, all cultivars except for Tama Westerwolds ryegrass, Roa tall fescue and Maru phalaris had a 3 year average of 75% or more of seedlots with a germination of more than 80%. No Raki paspalum seedlots were received for testing in these years.

The percentage germination of the ryegrass cultivars did not differ significantly within the range of germination temperatures (Table 2). Germination of Kahu timothy and Maru phalaris was reduced at or below 10°C. Raki paspalum failed to germinate below 15°C and its germination was highest at 30°C. At 30°C, the germination of Kahu timothy, Apanui and Wana cocksfoot, Maru phalaris and Matua prairie grass was significantly reduced.

Germination Rate

Germination rate for all species slowed as temperatures moved away from optimum, but was greater for ryegrasses than other grass species at all temperatures (Fig. 1, Table 3). Within ryegrass cultivars germination rate differed only at 30°C when Manawa was slower than other cultivars (Table 3). As temperature decreased, the delay in the onset of germination within the ryegrasses increased from 3 days at 25°C and 30°C to around 8 days at 10°C, IO-12 days at 5/10°C and 17-19 days at 5°C. Germination rate varied little between seedlots of ryegrass cultivars at temperatures between 5/10°C and 25°C. However, at 5°C, germination rate of Tama, Moata and Nui seedlots varied significantly, and differences between Moata seedlots were also significant at 30°C.

The other grass species varied more in the number of days to the start of germination which ranged from 4-6 days at 25°C to 7-14 days at 10°C, and 16-32 days at 5°C. Cultivars differed significantly in germination rate, with Kahu timothy having a similar response to the ryegrasses at all temperatures, while the other species were significantly slower at most temperatures (Table 3). The cocksfoot cultivars took longest to reach 75% germination, ranging from around 2 weeks at 20°C to 7-8 weeks at 5°C and 4-5 weeks as temperature increased to 30°C. The germination rate of Roa tall fescue, Matua praire grass and Maru phalaris was rapid at 20 and 25°C, but slowed as

TABLE 2: Final Percentage Germination of 14 Grass Cultivars Tested Over a Range of Temperatures.

Cultivars		Mean germination[1]	Temperature (°C) 5	5/10	10	15	20	25	30
Ryegrass									
Perennial	Nui	95	93	98	96	94	95	99	91
	Ruanui	95	90	97	89	95	96	97	93
Italian	Paroa	90	85	90	76	92	95	94	85
	Moata	75	68	79		78	75	76	76
Hybrid	Manawa	92	88	92	91	91	94	93	92
	Ariki	95	95	95	95	94	94	97	92
Westerwolds	Tama	93	96	90	95	94	93	94	90
Other Grasses			87		79	74			
Cocksfoot	Apanui	81	90	92	80	89	87	89	60[2]
	Wana	75		91			79	79	14[2]
Phalaris	Maru	74	67[2]	91	66[2]	81	79	80	51[2]
Prairie Grass	Matua	88	90	89	86	90	92	89	80[2]
Tall Fescue	Roa	87	84	80	82	92	94	91	87
Timothy	Kahu	61	28[2]	64	63	81	78	87	26[2]
Paspalum	Raki	20	—	—	—	3[2]	6[2]	28	44

[1] at temperatures shown in Table 1.
[2] Values significantly lower than the mean ($P<0.05$)

TABLE 3: Germination Rates of Grass Cultivars, Expressed as the Number of Days Taken to 75% Germination of Viable Seed.

Cultivars		Temperature (°C) 5	5/10	10	15	20	25	30
Ryegrass								
Perennial	Nui	23	13	11	6	4	3	5a
	Ruanui	24	13	8	6	5	3	bab
Italian	Paroa	21	12	10	7	3	3	4a
	Moata	24	15	10	6	4	4	4a
Hybrid	Manawa	23	14	9	6	4	4	16c
	Ariki	24	14	11	6	4	4	8b
Westerwolds	Tama	21	12	8	6	5	4	9b
Significance[1]		NS	NS	NS	NS	NS	NS	*
MEAN		23	13	10	6	4	4	7
Other Grasses								
Cocksfoot	Apanui	5bd	2bc	24c	14b	12c	13d	36d
	Wana	51c	27cd	22c	17c	14c	25e	30c
Phalaris	Maru	41b	20b	17b	9a	6a	6b	32c
Prairie Grass	Matua	40b	26c	22c	12b	8b	7b	10a
Tall Fescue	Roa	65e	29d	12a	9a	7b	7b	16b
Timothy	Kahu	35a	15a	12a	7a	4a	3a	14b
Paspalum	Raki	—	—	—		4a	10c	9a
Significance		***	***	***	[illegible] •	[illegible]	***	***
MEAN		41	20	15	10	8	10	20

[1] Within columns, values followed by different letters are significantly different at the levels indicated (* $P<0.05$ and *** $P<0.001$).

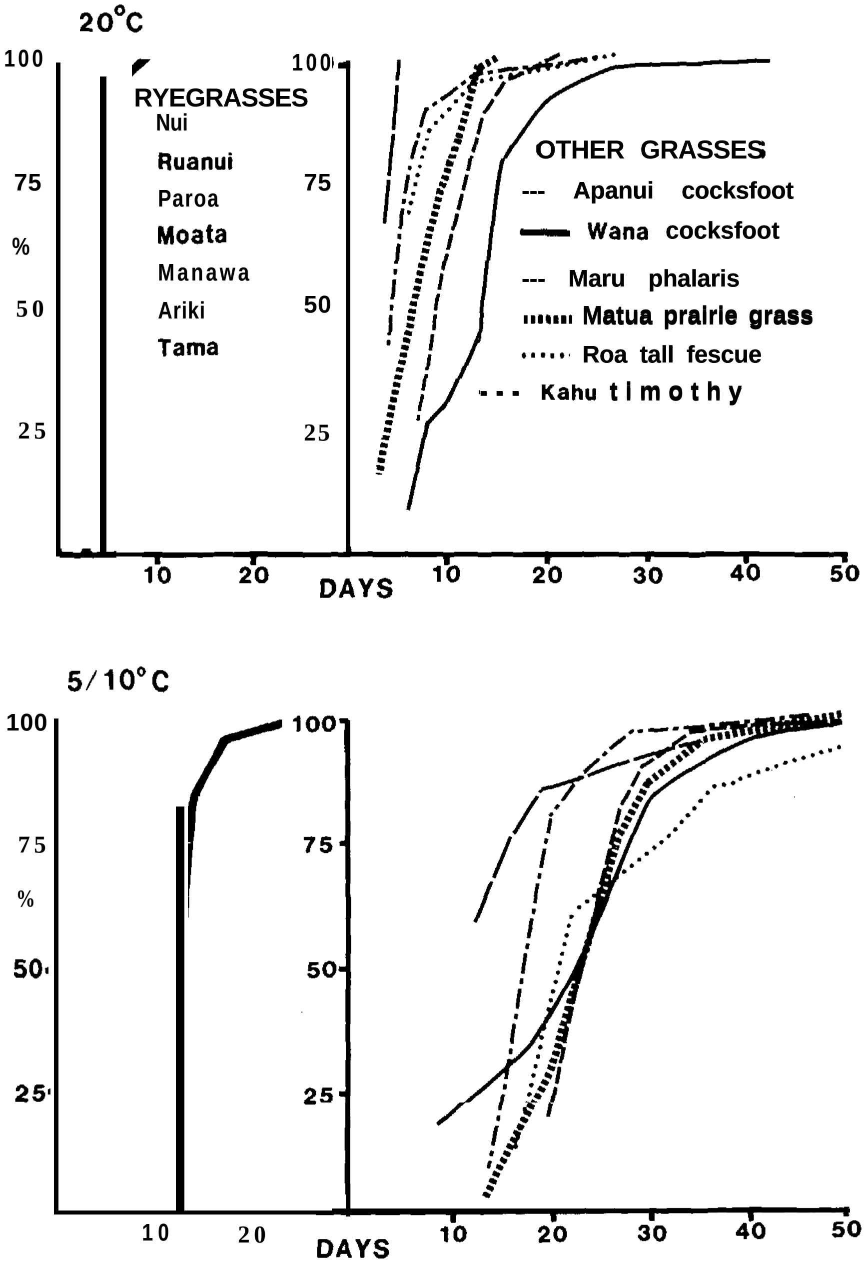

FIGURE 1: Germination of 14 grass cultivars at 20°C and 5/10°C (16h/8h daily).

temperature decreased, taking 6-9 weeks to reach 75% germination at 5°C. In contrast, Kahu timothy germinated rapidly between 10-30°C, but slowed markedly at 5°C. Germination rate varied between seedlots at 10°C and below, and all except Maru phalaris and Roa tall fescue showed significant differences at 30°C, particularly seedlots of Raki paspalum.

DISCUSSION

At optimal temperatures, marked differences in germination occur between grass species and cultivars. Germination can differ between years and regions of production (Hampton and Young 1985), as well as between certified and non-certified seedlots (Scott and Hampton 1985). Reasons for poor germination in New Zealand herbage seedlots have been recently discussed (Scott and Hampton 1985), and four problems identified: the presence of blind seed disease, the presence of immature seed, embryo damage during seed harvesting, and heating damage during seed storage (Hampton and Scott 1980; Hampton and Young 1985; Scott and Hampton 1985). Before purchasing seed, farmers should check the planting value of the seedlot by asking the vendor to supply a copy of the relevant seed analysis certificate (Scott et al. 1984).

In a recent survey, Sangakkara et ***al.*** (1982) found that 83% of farmers sowed pasture seeds in the autumn, irrespective of the region. White (1973) recommended that autumn sowing be completed by mid-March in the South Island to ensure good establishment and growth before winter frosts begin, but commented that the time of autumn sowing was not as critical in the North Island. In autumn in New Zealand, average 0.1m soil temperatures range from 12” to 17°C in March, 8” to 14°C in April and 4” to 11°C in May, depending on the location (Table 4). With the exception of Maru phalaris and Kahu timothy these autumn temperatures would not affect final germination of the grass species tested, but they would affect germination rate. For example, at 10°C, ryegrass would take around 10 days to reach 75% germination, Roa tall fescue and Kahu timothy 12 days, Maru phalaris 17 days and Matua prairie grass, Apanui and Wana cocksfoot 23 days. Diurnal temperature changes, e.g. 5/10°C, may further delay germination rate, although higher temperature alternations, e.g. 13/18°C (Hill et al. 1985), 18/27°C (Chippendale 1949), may enhance it.

In hill country, the predominant method for the introduction of pasture species is by hand or aerial oversowing (Charlton 1978), and establishment of grass species is usually poor (Suckling 1949, Charlton and Brock 1980). At the soil surface, temperatures during autumn are likely to be at least 5°C lower than 0. 1m soil temperatures for at least part of the germination period (Table 4). At 5°C, ryegrasses would take at least 3 weeks and other grasses from 5 to 9 weeks to reach 75% germination.

TABLE 4: Grass Minimum and 0.1 m Mean Soil Temperatures at Six New Zealand Sites in Autumn[1]. (°C)

Site	March Grass Min.	March 0.1m soil	April Grass Min.	April 0.1m soil	May Grass Min.	May 0.1m soil
Kaikohe	11.9	17.0	9.4	14.3	6.9	11.6
Aorangi, Manawatu	8.9	16.3	6.6	12.9	3.2	9.1
Ballantrae, near Woodville	9.7	15.1	7.7	12.7	4.3	9.4
Lincoln	6.4	14.3	3.6	11.0	0.9	7.4
Tara Hills, near Omarama	5.0	13.0	1.2	8.3	-1.9	4.0
Gore	6.3	12.2	4.3	9.3	1.4	6.1

[1] Anon., 1982

Sangakkara et al. (1982) found that 88% of farmers surveyed used more than one grass species when establishing new pastures, with most using 2-4 species, One or more ryegrass species were included in 98% of seed mixes, and other species used were cocksfoot, timothy and prairie grass. One of the major reasons for poor grass establishment is competition, both from existing pasture in the absence of cultivation (Campbell et al. 1983), or from more vigorous species when seed mixtures were sown (Chippendale 1932). Competition from existing species can be reduced by herbicide application and stock treading (Charlton 1982), while competition between sown species is affected primarily by temperature, e.g. Stapledon and Davies (1928) showed that Italian ryegrass suppressed the growth of timothy and fescue, the suppression being more intense as soil temperatures declined.

Within cultivar differences in germination and germination rate were found at the two temperature extremes (5°C and 30°C) for most species. Seed quality factors which may be associated with this response are seed vigour and seed weight (Scott and Hampton 1985). Naylor (1981) demonstrated that vigour differences existed between cultivars and between different seedlots of the same cultivar in Italian ryegrass, and showed that indices which estimated germination rate were good predictors of final field emergence. Veronesi et al. (1983) found a positive correlation between seed weight and germination which influenced establishment in perennial ryegrass, and Scott and Hampton (1985) showed that cocksfoot seedlot germination could be increased by increasing mean seedlot weight. Hampton (unpub. data) also demonstrated that at 5" and 10°C, germination and vigour of Moata ryegrass was greater for large than small seed. Genotypic characters such as seed size and quantity of seed reserves contribute to the varying abilities of temperate grasses to establish in competitive, multispecies swards (Ross and Harper 1972, Naylor 1980). From our results, it would appear that the possibility of selecting genotypes of some grass species, particularly cocksfoot and tall fescue, could be worthwhile.

Hill et al. (1985) concluded that in the absence of limitations due to water or nutrition, conditions conducive to rapid establishment of pasture grasses were favourable temperatures, rapid germination, rapid early growth rates, rapid tiller production, and the tolerance of growth processes to non-optimal temperatures. Favourable temperatures for rapid germination of the species tested are 15-20°C; rapid early growth rates are dependent, at least in part, on seed reserves, but are also affected by factors such as perenniality and ploidy (Hill et *al.* 1985); rapid tiller production and tolerance of growth processes to non-optimal conditions are also related to cultivars. For New Zealand conditions, autumn pasture sowings should be carried out in early March (White 1973) when air and soil temperatures (Anon 1982) will be closer to temperatures which are optimum for rapid germination of temperate grass species. Sowings later in the autumn will probably allow the successful establishment of ryegrass cultivars, but will not favour the establishment of other grass species, either as pure swards, or particularly in species mixtures.

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