EMERGENCE OF SMALL AND LARGE SEEDED GRASSES: IMPORTANCE OF SHOOT STRENGTH

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ABSTRACT

Inter-specific relationships between mean seed weight (MSW), coleoptile and mesocotyl length and width, shoot strength and emergence from 15 mm sowing depth were examined for six temperate pasture grass species ranging in MSW from 0.34 - 10.4 mg. For all species, coleoptile + mesocotyl length was greater for emerged than non-emerged seedlings. Across species, emergence % was not significantly correlated with coleoptile + mesocotyl length but it was significantly correlated with mean seed weight and coleoptile and mesocotyl width. Shoot strength increased with increased coleoptile width. It is proposed that decreased emergence % with decreased seed weight across species at 15 mm sowing depth is due primarily to decreased coleoptile and mesocotyl width resulting in decreased shoot strength and hence a reduced ability to penetrate the substrate.

KEYWORDS

Grass, emergence, seed size, seedling, coleoptile, mesocotyl

INTRODUCTION

In comparison with perennial ryegrass (*Lolium perenne* L.), cocksfoot (*Dactylis glomerata* L.) and timothy (*Phleum pratense* L.) often show low emergence and establishment % at 10-30 mm sowing depths (Robson *et al*., 1988; Langer, 1990). Usually, the primary leaf of a grass seedling extends within the coleoptile to a point close to the soil surface then emerges from the coleoptile and with little impedance to growth, emerges from the soil (Langer, 1990). For some grass species, the young shoot within the coleoptile can be carried to the soil surface by elongation of the mesocotyl, a subcoleoptile internode (Newman and Moser, 1988). If the primary leaf emerges underground, it is less likely to reach the soil surface as it is less rigid than the coleoptile and folds more easily. Potential mesocotyl elongation has been reported to increase with seed size across species (Robson *et al*., 1988). Mean seed weight is less for cocksfoot and timothy than for perennial ryegrass and it has been proposed that lower emergence % of these grasses in comparison with perennial ryegrass may be due to them having a shorter coleoptile + mesocotyl (Robson *et al*., 1988). The objective of the present study was to determine if inter-species relationships exist between emergence %, MSW, coleoptile and mesocotyl length and width and shoot strength.

METHODS

Seed of prairie grass (*Bromus willdenowii* Kunth. cv. Grasslands Matua, MSW 10.4 mg), annual ryegrass (*Lolium multiflorum* Lam. cv. Grasslands Tama, 5.20 mg), perennial ryegrass (cv. Grasslands Nui, 2.19 mg), tall fescue (*Festuca arundinacea* Schreb. cv. Grasslands Roa, 1.73 mg), cocksfoot (cv. Grasslands Wana, 0.77 mg) and timothy (cv. Grasslands Kahu, 0.34 mg) was obtained from the N.Z. Institute for Crop and Food Research Ltd, Lincoln, N.Z. Germination was > 80% for all seed lines except tall fescue (55%). All values presented for emergence % were standardised with respect to germination %.

In experiment 1, seed of each species was sown at 15 mm depth in 0.8 litre pots (10 seeds per pot) containing a vermiculite/perlite/sand (1:1:1 by volume) mix, soaked in a basal nutrient solution containing 5 mol m^{-3} potassium nitrate (Andrews *et al*., 1989). There were five replicate pots per treatment. The pots were maintained at 15 ± 1^{o}C in the dark in a controlled environment chamber and flushed with nutrient solution every 3 days. Emerged seedlings were counted each week until emergence % remained unchanged for 3 weeks. When counting had finished, coleoptile and mesocotyl length and width at the midpoint were determined for all emerged and all non-emerged plants which were recovered. Coleoptile and mesocotyl length were determined by rule or calipers, their widths were determined microscopically using an eyepiece graticule.

In experiment 2, seed of each species was germinated on filter paper in petri dishes at 15 ± 1^{o}C in a controlled environment chamber. When the coleoptile had reached a length of approximately 3 mm, shoot strength was determined by growing the shoot against a strain gauge transducer within a polypropylene tube. The strain gauge transducer was connected to a Grass 79D EEG/polygraph data recording system (Grass Instruments Co. Quincy, Massachusetts, USA). There were four replicate seedlings per species.

An analysis of variance was carried out on all data from both experiments. All effects discussed have a probability $P < 0.01$. An arcsine transformation was carried out on emergence % data prior to analysis in experiment 1: ranking of species is on the basis of a LSD ($P < 0.05$) value. Correlation and regression analysis were carried out on data from experiments 1 and 2 where appropriate; straight line and quadratic models were tested. All effects described for experiment 1 were obtained in a separate experiment carried out as for experiment 1 except that 10 and 30 mm sowing depths were used. Experiment 2 was repeated as described. Data were similar for the initial and repeat experiment 2 and were pooled for presentation (Fig. 1).

RESULTS AND DISCUSSION

Previously, emergence % was reported to be lower for cocksfoot and timothy than for perennial ryegrass (Robson *et al*., 1988; Langer, 1990). In experiment 1, emergence % was lower for cocksfoot and timothy than for perennial ryegrass, prairie grass, annual ryegrass and tall fescue (Table 1). Emergence % for the different grass species increased with increased mean seed weight up to around 5 mg then changed little with increased seed weight to 12 mg. A quadratic model of emergence % against mean seed weight gave a R^2 value of 92%.

For pasture grasses, potential mesocotyl elongation has been reported to increase with seed size across species and it has been proposed that low emergence % of small relative to large seeded grasses is due to them having a shorter mesocotyl (Robson *et al*., 1988). With the exception of prairie grass, at least some seedlings of all species showed mesocotyl extension in experiment 1 (Table 1). For all species, coleoptile + mesocotyl length was greater for emerged than non-emerged plants. However, across species, emergence % was not significantly correlated with coleoptile + mesocotyl length. For example, mean coleoptile + mesocotyl length was similar for prairie grass and timothy the largest and smallest seeded grasses respectively but emergence was 96% for prairie grass and only 22% for timothy. Therefore, low emergence % of cocksfoot and timothy relative to the other grasses cannot be explained by differences in coleoptile + mesocotyl length. Across species, there was a significant positive correlation between emergence % and coleoptile width (correlation coefficient = 97%, Table 1). There was also a significant positive correlation between emergence % and mesocotyl width (correlation coefficient = 97%, NB prairie grass could not be included in the analysis). It seemed likely that shoot strength would increase with increased coleoptile and mesocotyl width and this was shown to be the case in experiment 2 (correlation coefficient = 99%, Table 2). It is proposed that decreased emergence % with decreased seed weight across species at 15 mm sowing depth is due primarily to decreased coleoptile and mesocotyl width resulting in decreased shoot strength and hence a reduced ability to penetrate the substrate.

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Table 1
Emergence %, coleoptile + mesocotyl length and coleoptile and mesocotyl width of six pasture grasses of different mean seed weight (MSW) sown at 15 mm depth under controlled environment conditions. Variability quoted is SE, n=5.

Species	MSW (mg)	Emergence (%)	Coleoptile + mesocotyl length (mm)		Coleoptile width (mm)		Mesocotyl width (mm)	
			emerged	non-emerged	emerged	non-emerged	emerged	non-emerged
Prairie Grass	10.4	96±3.9	16.6± 1.31	11.0±1.00	0.85±0.034	0.71±0.065	-	-
Annual ryegrass	5.20	93±3.7	40.9±1.94	10.7±1.20	0.79±0.017	0.78±0.075	0.46±0.008	0.52±0.001
Perennial ryegrass	2.19	80±40	17.4±0.85	15.3±1.45	0.66±0.030	0.43±0.078	0.48±0.014	0.20±0.023
Tall Fescue	1.73	64±3.6	19.6±1.33	14.1±0.82	0.57±0.042	0.49±0.020	0.35±0.023	0.25±0.010
Cocksfoot	0.77	33±3.8	17.0±1.24	15.2±1.68	0.42±0.034	0.36±0.021	0.35±0.031	0.21±0.19
Timothy	0.34	22±2.8	17.2±1.22	15.7±1.33	0.40±0.016	0.33±0.022	0.32±0.025	0.20±0.020

Table 2
Relationship between coleoptile width and shoot strength for six pasture grasses of different mean seed weight (MSW) germinated in petri dishes. Variability quoted is SE, n=8.

Species	MSW (mg)	Coleoptile width (mm)	Shoot strength (g shoot^{-1})
Prairie grass	10.4	0.63 ± 0.028	1.15 ± 0.085
Annual ryegrass	5.20	0.57 ± 0.025	1.01 ± 0.081
Perennial ryegrass	2.19	0.47 ± 0.026	0.76 ± 0.055
Tall fescue	1.73	0.42 ± 0.024	0.70 ± 0.050
Cocksfoot	0.77	0.27 ± 0.025	0.46 ± 0.007
Timothy	0.34	0.22 ± 0.022	0.30 ± 0.034