

**THE EFFECT OF SEED DIAMETER ON GERMINATION RATE
AND EARLY GROWTH IN CALIFORNIAN THISTLE
(*CIRSIUM ARVENSE*)**

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Rapid early growth and establishment of seedlings are important factors in determining the outcome of interspecific and intraspecific plant competition, and hence, seedling survival (Parsons 1968). New seedlings are not generally considered to contribute significantly to Californian thistle infestations (Donald 1990) despite records of quite high (50-80%) viability (Hodgson 1964, 1968) and high germination (up to 95%) under controlled conditions (Hayden 1934). The survival of Californian thistle seedlings may, however, be an important factor in the reestablishment of a population following cultivation (Moore 1975; Kigel and Koller 1985). Characteristics of early plant growth, and in particular relative growth rates and shoot:root ratios, are both genetically and environmentally determined (Grime and Hunt 1975). Large seedling size, a major advantage in early competition (Spitters and Aerts 1983; Holt 1987) has been found to be positively correlated with seed weight in some species (Fenner 1983). The ability of a plant to secure nutrient resources is directly affected by the size of the seedling shoot and root systems (Seibert and Pearce 1993) and the latter has been shown to enhance seedling competitive ability (Trenbath 1976; Fenner 1983). Many authors have indicated that the relative growth rates of plants grown from seed collected from contrasting habitats and from different sized seeds often differ considerably (eg. Grime and Hunt 1975).

These investigations compared percentage germination, germination time and early shoot and root growth characteristics of Californian thistle plants grown from different seed sizes. The experiment was carried out between November 1993 and March 1994. The seed used was collected in March 1993 from a thistle population in pasture near Mosgiel, air-dried and stored in moisture and light proof containers at room temperature prior to use. Plants were germinated and grown on in a glasshouse (temperature range 10°C - 20°C) with only natural illumination. Seeds were divided into two size classes (0.71 - 1.0 mm and >1 mm) by sieving through 1 mm and 0.71 mm screens. Mean seed weights were calculated for ten replicates of fifty randomly selected seeds of each size class. These seeds (n = 3168) were then planted in a commercial peat-based seed raising mix (Yates 'Black Magic') in cell trays, with one seed per cell. Individual cells measured 2 x 2 x 4 cm, with 198 cells per tray (replicate). Nine trays were planted with large (>1mm) seeds and seven with small (0.71 - 1 mm) seeds, over a three day period (29 November - 1 December 1993). R.O. water (water purified by reverse osmosis) was applied *ad libitum* with a hand held sprinkler whenever the potting mix was dry to touch (every 2-3 days). A combined fungicide and insecticide, 'Shield' (4.4 g/litre myclobutanil + 9.6 g/litre tau-fluvalinate) was applied at 10 ml of product/litre water, every 2 weeks after first emergence to prevent damage to plants by fungal or insect pests.

Germination and emergence were recorded daily for 6 weeks. Any seeds not germinated after 6 weeks were discarded. Seedlings were transplanted into a peat : sand : bark (2:1:2 by vol.) potting mix in black polythene planter bags (10 cm³) (PB 1.5) approximately 6 weeks after sowing, when they were about 2 cm tall with a minimum of four true leaves. At this stage their fibrous root systems held the potting mix within the seed cell intact during transplanting. A standard foliar applied nutrient solution, 'Thrive' (N:P:K = 27:5.5:9, 2 g of product/litre of water) was applied at 2,

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4 and 6 weeks after transplanting to maintain excess nutrients. Plants were harvested 8 weeks after transplanting, roots were washed, aerial shoots counted, and the shoots and roots weighed separately. Plants were then dried overnight at 80°C and shoot (SDW) and root (RDW) dry matters recorded.

Mean seed weight was related to seed size (diameter). The mean weights of 50 seeds were 0.051 g for small seeds and 0.070 g for large seeds ($P < 0.001$). Diameter was, therefore, considered a reliable measure of seed size.

Average germination time (GT) for Californian thistle seed was 15 days (range 8 - 37, $n = 983$), with no significant difference between the size classes (Table 1). The effects of planting date on GT was not significant. Regression of GT and germination percentage (GP) on cell position within the trays showed no significant boundary effects, with no significant differences in GT or GP occurring within and across all trays. Position could, therefore, be eliminated as a component of variation in the assay. The overall mean GP for all trays and both seed sizes was 31.0% with no difference between the size classes (Table 1). Low mortalities were recorded in the first month after emergence for both seed sizes (1.5 % and 1.6 % respectively).

TABLE 1: Germination and early shoot and root growth parameters of Californian thistle in relation to seed size (diameter).

Germination and growth parameter	Seed size class		SED
	0.71 - 1.00 mm	>1.00 mm	
Mean seed weight (/50 seeds) mg)	50.5 (n = 500)	69.6 (n = 500)	0.348 ***
Percent germination (GP) (%)	31.7 (n = 1368)	30.5 (n = 1792)	0.036
Germination time (GT) (days)	15.30	14.71	0.813
Total plant dry weight (TPW) (g)	7.71	8.73	0.542
Shoot dry weight (SDW) (g)	4.66	5.51	0.287 *
Root dry weight (RDW) (g)	3.05	3.23	0.399
Shoot : root ratio (SRR ¹) (g)	2.72	2.71	0.475
Number aerial shoots (NAS)	4.98	5.72	0.457
Mean shoot weight (MSW) (g)	1.11	1.20	0.123

¹ SRR (shoot:root ratio) = $SDW (g) \div RDW (g)$.

² * Significantly different at $P < 0.05$, *** Significantly different at $P < 0.001$.

Differences in total plant dry weights, due largely to differences in shoot weights (Table 1) were not significantly different, but shoot dry weights were significantly higher in the large seed class. Both seed sizes resulted in plants with variable numbers of aerial shoots ranging from 2 - 10 shoots/plant from small seeds and 2 - 13 from large seeds. There was no significant difference in the mean number of aerial shoots, the mean weight per aerial shoot, root dry weights or the shoot : root ratios (Table 1) of plants germinated from small or large seeds.

The direct relationship shown between seed weight and seed size suggests higher seed reserves in larger, heavier seeds. Significant growth differences between small and large seeded species, shown by Seibert and Pearce (1993) were not, however, demonstrated in this experiment, although the seed size : weight relationship was reflected in the increased shoot dry weights of seedlings from the larger seed size. The fact that similar differences were not shown for the root dry weight, shoot : root ratios or number of aerial shoots/plant analyses implies that in early development the impetus is for rapid production of aerial growth as found by Spitters and Aerts (1983) and Holt (1987), in preference to development of a strong root system (Trenbath 1976; Fenner 1983).

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