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Effect of Seed Size on Germination, Emergence, Growth and Seedling Survival of *Senna occidentalis* Link.

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Abstract: Seed size variation and its effects on germination and seedling growth were examined in seeds collected from a population of *Senna occidantalis.* Seed size varied from 0.009-0.029 g per seed. Final germination percentage depended on seed size with large seeds having highest germination percentage, but germination velocity was higher for small seeds. Seedlings from large seeds produced longer roots and shoots than those from small seeds and were able to emerge more rapidly. The seed size had a clear effect on survival with seedlings from large seeds having the highest survival.

Key words: Seed size, germination, emergence, seedling survival

Introduction

Seed size is an important component in plant fitness. It is thought commonly to be an important focus of selection on the life histories of plants (Janzen, 1977), because the likelihood of dispersal (Howe and Kerckhove, 1980), germination (Putievsky, 1980) and survival (Schaal, 1980) can all depend on seed size.

Several laboratory studies have shown significant effects of seed size within a species on percent germination (Milberg and Andersson, 1994), rate of germination (Marshall, 1986), seedling size (Zhang and Maun, 1990) and seedling competative ability (Gross, 1984).

Seed size can show considerable variation within population and this variability is often associated with variability in seedling size (Schaal, 1980). The individual seed size (mass) in a species varies from nearly constant (Fenner, 1985) to as high as 16-fold (Thompson and Pellmyr, 1989).

Several studies have shown that species variation in seed size can be associated with time to germination (Stanton, 1985), viability (Wulff, 1986 b) and growth (Kromer and Gross, 1987).

Many factors such as competition among individual seeds for limited resources (Wulff, 1986a), time of ovule, fertilization (Thomson and Pellmyr, 1989) position of an ovule within the seed parent (Winn, 1991) differences in habitat, micro habitat (Mazer, 1989), genetic control (Krannitz *et al.*,1991) and tradeoff between seed size and seed number (Werner and Platt, 1976) may be responsible for this variation. However, large variation in seed size has been examined both within (Pitelka *et al.*, 1983) and among (Schimpf, 1977), plant populations and also within single plant since a small variation in seed size may cause variation in dispersal, seed-water relation as well as the ability to emerge from varied sowing depths (Wulff, 1973). Large seeds generally develop into large seedlings more quickly because large seeds would be favored in competitive situation rather than when colonizing open areas (Gross, 1984). Large seeded species also have an advantage in competitive environment and when seedlings experience defoliation (Armstrong and Westoby, 1993) shade (Leishman and Westoby, 1994) or moisture stress (Baker, 1972), The importance of seed weight variation in species depends on both the timing and magnitude of any seed weight effects on seedling growth and survival under field conditions and individuals from large seeds may gain an advantage early in their life-cycle particularly if seed weight effects seedling size and competitive ability (Gross, 1984).

An important effect of variation in seed size may be its influence on the kind of microsite in which germination and seedling establishment is possible (Gross, 1984). The present study focuses on the demographic consequences of variation with the following objectives: 1) to demonstrate the seed size variation pattern in a population of *Senna occidantalis*, 2) to evaluate the effect of seed size on germination and emergence and 3) to examine the relation between seed size and seedling survival and performance.

Materials and Methods

Seeds used in this study were obtained from mature fruits of *Senna occidentalis.* Fruits were collected randomly from different plants of the same population during October 1997 near Karachi University Campus.

Clean seeds were extracted from fruits, kept in glass bottles and stored at room temperature (25 ± 2°C) until used.

Seed weight: For the seed weight analysis, 100 seeds were selected randomly. Each seed was individually weighed with an electric balance. The frequency distribution of seed size was constructed and mean and dispersion statistics were calculated. Seeds in the sample were sorted into 4 non-overlapping size classes containing seeds weighing 0.009-0.015, 0.016-0.020, 0.021-0.025 and 0.026-0.029 g respectively.

Germination test: The seeds were mechanically scarified using sand paper No.1 and washed" several times with distilled water. Ten seeds with 5 replicates from each size class were placed on Whatman No.1 filter paper in 9.5 cm diameter Petri plates. The filter paper was moistened with 5 ml distilled water. The petri plates were kept randomly in a growth- chamber maintained at alternating temperature with 14h illumination (2000 Lux, cool white fluorescent tubes) at 30°C and 10h darkness at 25°C. Preliminary observations showed that seeds of *Senna occidentalis* germinated well under these environmental conditions. Germination of seeds in each size class was monitored daily up to 18 days when there was no chance for further germination. At 18th day root and shoot lengths of all germinated seedling were measured. Germination velocity (GV) was measured using the index proposed by Mugnisjah and Nakamura (1986).

Seedling emergence and survival: Twenty mechanically scarified seeds of different size category were placed in cylindrical plastic containers (25 cm diameter) filled with the sandy loam soil (sand 77.2%, silt 10.2 %, clay 12.6%). Seeds were sown at a depth of 1.5 cm. After one week when emergence had occurred, seedlings were thinned to 10 seedlings per pot. For each seed size category 8 replicates were kept. Subsequently, seedling survival was recorded at 15 day interval for four months. At the termination of the experiment root and shoot lengths of seedlings were measured.

Statistical analysis: Results are expressed as mean weight per seed ±1S.E and the differences among means were tested with the factorial analysis of variance (FANOVA) followed by Duncan's multiple range test (Zar, 1994). A Mantel-Haenszel chi-square test was performed to compare the survival rates between size categories (Deshpande *et al.*, 1995).

Result

Seed size/weight variation: Seed weight of *Senna occidentalis* varied between 0.009-0.029 g (Fig. 1). The mean seed weight of the population was (0.020±0.00037g) (mean±standard error). The coefficient variation (CV %) was low 18.35 percent. The standardized value of Wilcoxon signed rank statistic (W^{++}) was non-significant showing symmetrical distribution.

Germination Test: In all the 4 size categories germination started on 3rd day and was essentially completed by 10 days. The highest germination (96.6%) was observed in large seed category (0.026-0.029 g) and the lowest germination percentage was observed in the small seed category (0.009-0.0015 g) 73.4 percent. The germination velocities (GV) for large, medium 1, medium 2 and small seeds were found to be 15.15, 12.64, 14.76, 14.27 respectively, showing slightly greater germination velocity for large and medium 2 seeds as compared to medium and small seeds. The results of FANOVA showed significant effect of seed size on germination percentage ($F = 5.9$, $p<0.01$). Effect of time was highly significant ($F = 61.02$, $p<0.001$). The final germination percentage was significantly ($p<0.01$) greater in large seeds compared to medium and small seeds (Fig. 2).

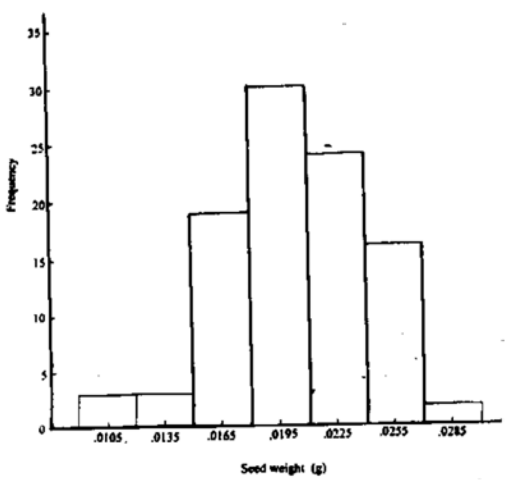

Fig. 1: Frequency distribution of seed weight in Senna occidentalis

Root and shoot length: Both root and shoot lengths of the seedlings obtained from large seeds were significantly greater than those of small or medium sized seeds ($p<0.05$) (Fig. 3). The root/shoot ratios did not differ significantly in the seedlings obtained from seeds of various size categories.

Seedling emergence and survival: Seed size had a marked effect on emergence percentage (Fig. 4). The larger seeds showed significantly greater emergence percentage over other seed size categories ($p<0.05$). Seedlings from large seeds had longer shoots and roots than those from small seeds.

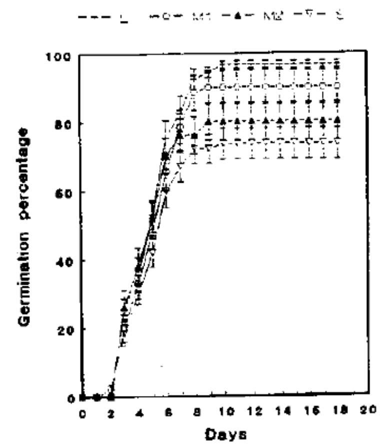

Fig. 2: Effect of seed size on germination percentage of *Senna occidentalis*
L = Large, M1 = medium 1, M2 = medium 2,
S = small

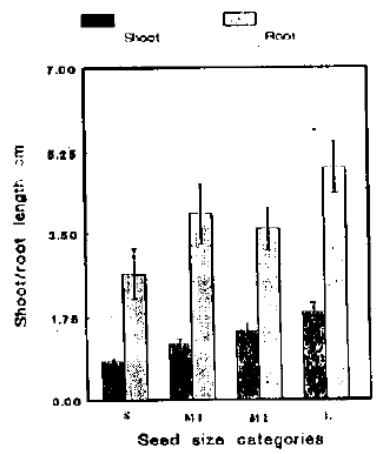

Fig. 3: Effect of seed size on shoot and root length of *Senn occidentalis*,
L = Large, M1 = medium 1, M2 = medium 2,
S = small

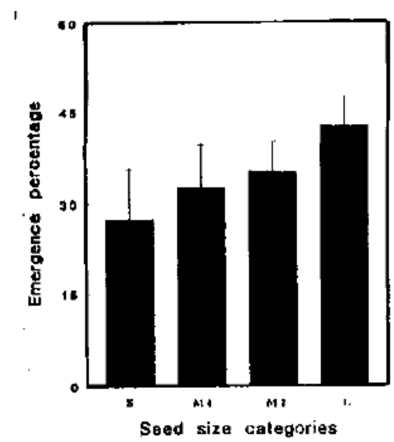

Fig. 4: Effect of seed size on emergence percentage of *Se occidentalis*
L = Large, M1 = medium 1, M2 = medium 2,
S = small

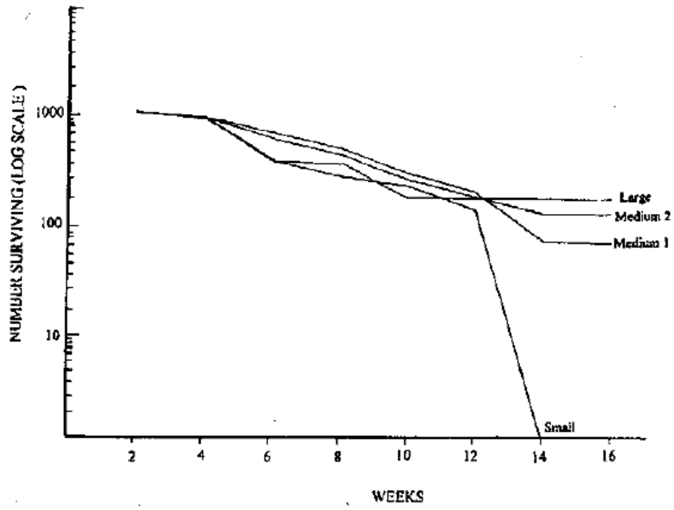

Fig. 5: Effect of seed size on survival of *Senna occidental's*

The survivorship curve pertaining to the small seed size category was close to Deevy type I curve with very high mortality in the end, but the curves for medium and large seeds corresponded to Deevy type II with more or lees constant age species mortality (Fig. 5). However, survivorship curves pertaining to medium 1 and medium 2 seeds were steeper than those for large seeds, indicating lesser age specific mortality in plants derived from large seeds.

The comparison of survivorship curves using Mentel-Haenszel chi-square test showed significant differences between the curves pertaining to small and those of large, medium 1 and medium 2 seed sizes (x^2 = 42.85, 37.52 and 34.87 respectively, $p<0.001$). A significant difference was found between the curves corresponding to medium 1 and large seeds (X^2 = 26.38, $p<0.01$) but not between those of medium 2 and large seeds (x^2 = 9.57n.s.). The final survival proportion was substantially higher in the plants derived from large seeds than those grown from the seeds of the rest of the size categories.

Discussion

Seed size/weight in *Senna occidental's* exhibited a significant effect on seed germination and emergence percentage with large seeds showing greater germination as well as emergence percentages. Similar results have been reported for other plant species (Springer, 1991). Contrary to these findings Zhang and Maun (1990) and Shipley and Parent (1991) found that seed germination percentage was not affected by seed size.

Probably the most generalized conclusion is that of Howe and Richter (1982) who stated that seed size/weight is effective only in determining the size of seedling for a very short time. The increased germination velocity for large seeds found here does not agrees with the findings of Stamp (1990) who found decreased rate of germination for large seeds in *Erodium brachycarpum.* Also reported Decreased germination rate with increasing seed size in *Medicago sativa.* Small seed category showed lesser seedling growth while large seeds showed greater seedling growth i.e., root and shoot growth of seedlings was greater in case of large seeds. Similarly, Mian and Nafziger (1994) reported a direct relationship between seed size of wheat *(Triticum aestivum L.*) and seedling shoot and root weight. Seedling root and shoot length for big bluestem *(Andropogon gerardii)* also have been shown to be positively correlated with seed size (Springer, 1991).

Seed size of *Senna occidentalis* had a clear effect on survivorship with seedlings from large seeds having the highest and seedlings from small seeds the lowest survival rate Marshall (1986) studied the relationship between seed size and survival and to some extent controlled for genetic versus environmental effects by comparing the effect of seed size differences within and among three species of *Sesbania.* Largest seeded species *(Sesbania vesicaria*) produced seedlings that survived the longest while the smallest seeded species *(Sesbania macrocarpa)* produced seedlings that were relatively short lived, Similarly, Schaal (1980) found larger seedlings to have higher survivorship in *Lupinus texnesis.* No effect of seed size on seedling survival in *Impatiens capensis.* Bonfil (1998) working with two species of *Quercus* found a clear effect of seed size on seedling survival with large seeds having the highest and seedlings from small seeds the lowest survival. The increase in root and shoot length with the increase in seed size observed here has also been reported for other species (Tecklin and McCreary, 1991).

We have taken a narrow view of seed size variation by considering only its effect on seedling performance as measured by emergence, shoot and root growth and survival. The importance of seed size/weight variation in a species depends on both the timing and magnitude of any seed size/weight effects on seedling growth and survival in the field. As the shoot growth of seedlings is faster in case of large seeds such a difference in seedling growth may be a significant factor in interspecific competition (Black, 1957). Individuals from large seeds may gain advantage early in life, particularly when seed weight effects seedling size and competitive ability (Gross, 1984), resistance to moisture stress (Armstrong and Westoby, 1993) or tolerance to shade (Saverimuttu and Westoby, 1996).

On the basis of this study it may be conjectured that the variation in seed size/weight has a great ecological significance in the establishment and maintenance of populations particularly in variable and patchy environments which in turn might play a significant role in the evolutionary success of a species.

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