Journal of Biological Sciences 7 (2): 438-441, 2007
ISSN 1727-3048

Seed Size Effects on Germination, Survival and Seedling Growth of *Castanea sativa* Mill.

[1]Emrah Çiçek and [2]Fahrettin Tilki
[1]Faculty of Forestry, Düzce University, 81620-Düzce, Turkey
[2]Faculty of Forestry, Kafkas University, 08000-Artvin, Turkey

Abstract: The effects of seed size on seed germination, and seedling survival and growth of *Castanea sativa* were studied in this study. The seeds were classified into small (< 5 g), medium (5-8 g) and large (> 8 g) classes. Germination parameters were significantly related to seed weight and large seeds germinated early and showed better germination than small seeds under laboratory conditions. Survival percentage and various morphological traits of the seedlings were investigated at the end of first growing season in nursery bed. It was found that seed size significantly affected seedling emergence, seedling survival, shoot height, root collar diameter and seedling dry weight but did not significantly affect shoot/root ratio and the average numbers of roots. Thus, it can be concluded that large seeds in *C. sativa* have better germination and survival, and the larger the seed, the larger the average seedling would be in seedling diameter, height and dry weight.

Key words: Germination performance, nursery, seedling morphology, seeds grading

INTRODUCTION

Castanea sativa Mill. (sweet chestnut) is one of the most important hardwoods in Turkey in terms of its valuable wood and fruit. Even if widespread, sweet chestnut has been neglected and scarcely studied in Turkish forestry and relatively little is known on its seed biology, seedling production, natural or artificial regeneration, etc.

Environmental influences during the development of seeds combined with genetic variability can result in variations in seed dimensions (Willan, 1985). The higher seed dimensions could be attributed to better differential seed filling based on locality or site factors. Bigger seed size indicated better quality and germination of seeds and genetic potential (Toon *et al*., 1990; Davidson *et al*., 1996), but quality of the seeds may be related to some other factors such as variations in seed nutrient content (Abideen *et al*., 1993), time of seed collection (Bellari and Tani, 1993) and genetic factors of the provenances (Farmer, 1980; Jayasankar *et al*., 1999).

Large seeds have traditionally been viewed as advantageous in closed communities, such as forests, whereas small seeds would be more suitable for open successional communities (Gross, 1984). There has been considerable information published on the effect of seed size on the germination and growth of various species and generally, in forest tree species size of seed and seed germination and seedling growth have been positively correlated (Singh *et al*., 1993; Ke and Werger, 1999; Navarro *et al*., 2006). But in some species large seed did not produce the highest germination and seedling growth (Shepard *et al*., 1989; Indira *et al*., 2000; Alptekin and Tilki, 2002). Little information is available on the effect of seed size on seed germination and seedling growth of sweet chestnut. Thus, the objective of this study was to determine the effect of seed size on seed germination, seedling survival and seedling growth of *C. sativa*.

MATERIALS AND METHODS

Seeds were collected from natural *C. sativa* stands in Duzce, Turkey (42° 54′ N, 31°10′ E, altitude 350 m) in mid-October 2004. Immediately after collection all seeds were washed and those obviously defective were discarded and the seeds were floated to remove debris and empty or weeviled seeds. The seeds were visually separated into three seed sizes: small (<5 g), medium (5-8 g) and large (>8 g) and the seeds belonging to each of these categories were weighted individually to the nearest 0.01 g (Table 1). Moisture contents were determined on two replicates each containing samples from five seeds, by oven drying for 17 h at 103°C (ISTA, 1996). The moisture content of seeds as a percentage of fresh weight at the beginning of storage was found to be 44%.

Seeds stored for two weeks in polyethylene bags at ±4°C until used were soaked in water for 48 h and the outer coat was removed and seeds were germinated in

Corresponding Author: Fahrettin Tilki, Faculty of Forestry, Kafkas University, 08000-Artvin, Turkey,
Tel: 90 466 2126949 Fax: 90 466 2126951

plastic trays containing sterilized sand, which was watered throughout the entire incubation period. The plastic trays were placed in a germination chamber in the dark at 30/20°C (8/16 h). A number of 240 seeds of each seed size, in 6 replications of 40 each, were used for standard germination test. The germinated seeds were counted every day for 21 days following first signs of germination (ISTA, 1996). Seeds were considered to have germinated when their radicle reached at least 10 mm long.

The germination data were calculated and expressed as Germination Percentage of seeds (GP) that had germinated at the end of the test and Germination Value (GV) which reflects both speed and completeness of germination, which was calculated as follows: $GV = (\Sigma DGS/N) \times GP \times 10$, where DGS is the daily germination speed, which is obtained by dividing the cumulative GP by the number of days since the beginning of the test and N is the number of DGS calculated for the germination test (Djavanshir and Pourbeik, 1976).

Seeds were sown in nursery beds to look at the effect of seedling size on emergence, survival and some seedling morphological characteristics after one growing season at Kocaman-Zonguldak Forest Nursery (41°07' N, 30°19' E, altitude 10 m). The nursery soil was sandy loam with a soil pH of 6 in the rooting zone. The climate is mild with humid summers. Annual precipitation averages approximately 1140 mm and the temperature averages 13.7°C.

The study consisted of a randomized complete block design with five replications. Seedbeds were standard 1.2 m wide with four rows and each plot (experimental units) was 4 m long. The seeds were hand sown at 60 seed m^{-2} density using marked sticks showing distances within row in December 2004. One seed were sown at each spot in 4-5 cm depth. During the vegetation period, following the sowing date, the only treatment given was irrigation and weed control-hoeing.

Seedling emergence in nursery was determined at the end of the April 2005 (after four weeks following first sign of germination). Seedling survival percentage was determined and a total of 150 seedlings were randomly hand-lifted without harming the roots from each weight class (a total of 450 seedlings) in December. The seedlings were examined in terms of their morphological traits such as root collar diameter, seedling height, seedling root and shoot dry weight and the number of lateral coarse roots (diameter ≥ 2 mm) and fine roots (diameter < 2 mm) which were longer than 5 cm. Root dry weight and number of roots were determined in roots pruned to 25 cm. Oven dry weights were determined after samples were oven-dried at 70°C for 24 h.

An analysis of variance was used to compare the germination response and morphological data to seed size class. Each of the variables was analyzed using analysis of variance to determine if there were significant differences among the treatments. When significant differences were found, Duncan' New Multiple Range Test was performed for comparison of the means. Percent data (germination percentage and survival) and count data (root number) were arcsine transformed before analyses.

RESULTS

The effects of seed size on germination showed that germination performance were significantly affected by seed size and maximum germination percentage and germination value were shown by large seeds (GP = 98.8% and GV = 68.7) and the lowest by small seeds (GP = 91.3%; GV = 51.5) (Table 2).

The effects of seed size classes on the emergence, survival, root collar diameter, seedling height, root dry weight, shoot dry weight and total dry of one-year-old sweet chestnut seedlings showed significant differences (Table 3). But shoot dry weight/root dry weight and numbers of roots didn't show significant differences. There was 71-80% seedling emergence (germination) and no seedlings died during the experiment. Large seed produced the highest survival (80%) and survival of the one-year-old seedlings produced from medium seed size classes was less (79%), but not significantly different. However, survival for the small seed size class was significantly less than the other seed size classes (71%). There was a measurable and significant increase in average first-year seedling height growth associated with larger seed size. Seedling height was the highest in large seed size class (86.4 cm) and seedling height of medium seed size class was less (78.5 cm), but not significantly different. However, seedling height was significantly less than for the other two seed size classes in small seed size

Table 1: Seed weight of *C. sativa* seed size classes

	Seed weight (g)			
Seed size	Mean	Min	Max	SD
Large	8.86a	8.00	11.54	0.68
Medium	6.55b	5.00	7.96	0.91
Small	4.35c	3.06	4.98	0.52

Means followed by the same letter are not significantly different at p<0.05

Table 2: Germination Percentage (GP) and Germination Value (GV) of *C. sativa* seed size classes

Seed size	GP	GV
Large	98.8a	68.7a
Medium	95.3b	60.9b
Small	91.3c	51.5c

Means in the same column followed by the same letter are not significantly different at p<0.05

Table 3: Effect of seed size on survival and various seedling characteristics of one-year-old *C. sativa* seedlings (RCD: Root Collar Diameter, SH: Shoot Height, RDw: Root Dry weight, SDw: Shoot Dry weight, TDw: Total Dry weight, FRN: Fine Root number, CRN: Coarse Root number)

Seed size	Survival (%)	RCD (mm)	SH (cm)	RDW (g)	SDW (g)	SDW/RDw	TDW (g)	FRN	CRN
Large	80.0a	13.4a	86.4a	22.2a	28.5a	1.3a	58.0a	18.4a	5.3a
Medium	79.0a	12.3b	78.5ab	18.7b	24.4b	1.3a	47.0b	17.2a	4.6a
Small	71.0b	11.7b	67.5b	14.7bc	15.9c	1.1a	35.1c	16.1a	4.2a

Means in the same column followed by the same letter are not significantly different at $p<0.05$

class (67.5 cm). Large seeds also produced the highest root collar diameter (13.4 mm). Larger seeds resulted in more root dry weight, shoot dry weight and total dry weight in this study. Although large seeds caused the highest number of fine roots and coarse roots, there were not significant differences among seed size classes (Table 3).

DISCUSSION

The higher seed dimensions could be attributed to better seed size indicates better quality and germination of seeds and genetic potential (Toon *et al*., 1990; Davidson *et al*., 1996). In some tree species larger seeds are regarded to produce greater seedlings and seedlings from larger seeds survive better and grow stronger as found in the present study (Dirik, 1993; Long and Jones, 1996; Singh, 1998; Karrfalt, 2004). Bencat and Tokar (1972) found similar results stated in the present study in terms of height growth that the heaviest seed produced the highest height growth in sweet chestnut. The better performance of larger seeds may simply be a reflection of the greater amount of nutrients available to the embryo (Abideen *et al*., 1993; Khan and Shankar, 2001). In some species large seed did not produce the highest germination (Chaisurisri *et al*., 1992; Jayasankar *et al*., 1999; Tilki and Alptekin, 2005), seedling survival and seedling growth (Krishan *et al*., 1995; Indira *et al*., 2000).

The production of seedlings that are both large and vigorous is important to the forester who will outplant at the end of the first growing season. Seedling size is critical from the standpoint of survival and the ability to withstand competition from other seedlings, grasses and weeds. Seed sizing appears to be a tool to the nursery manager to produce larger seedlings. However, discarding small seeds should not be practiced unless there is good genetic evidence to demonstrate the practice is not discarding whole families with possible good growth potential as said by Karrfalt (2004). Even the small seeds produced seedlings of acceptable size, although cull rates appeared to be higher in the small seed classes.

The heavier weight seed class performed significantly better than the medium and small seed size class in terms of germination percentage, germination value, seedling emergence, seedling survival and seedling growth in the present study. Thus, it can be stated that large seeds in *C. sativa* have better germination and survival and the larger the seed, the larger the average seedling would be in seedling diameter, height and dry weight for the one-year-old seedlings. This study suggests that sizing of *C. sativa* seeds into several categories may result in higher and more uniform germination within in a seedbed and appears to be a tool to the nursery manager to produce larger and more uniform seedlings.

REFERENCES

Abideen, M.Z., K. Gopikumar and V. Jamaludheen, 1993. Effect of seed character and its nutrient content on vigour of seedlings in *Pongamia pinnata* and *Tamarindas indica*. My Forest, 29: 225-230.

Alptekin, C. and F. Tilki, 2002. Effects of stratification and pericarp removal on germination of *Quercus libani* acorns. Silva Balc., 2: 21-28.

Bellari, C. and A. Tani, 1993. Influence of time of collection on the viability of seeds of *Alnus cordata*. Ann. Acad. Ital. Sci. For., 42: 259-285.

Bencat, F. and F. Tokar, 1972. Variability of growth and (size) correlations in one- and two-year seedlings of *Castanea sativa*. Lesnicky-Casopis, 18: 329-340.

Chaisurisri, K., D.G.W. Edwards and Y.A. El-Kassaby, 1992. Genetic control of seed size and germination in Sitka spruce. Silvae Genet., 4: 348-355.

Davidson, R.H., D.G.W. Edwards, O. Sziklai and Y.A. El-Kassaby, 1996. Variation in germination parameters among Pacific silver fir populations. Silvae Genet., 45: 165-171.

Dirik, H., 1993. The relationship between some important seedling properties and seedling performance in *Pinus brutia* Ten. I.U. Orm . Fak. Derg. Seri A, 2: 51-75.

Djavanshir, K. and H. Pourbeik, 1976. Germination value: A new formula. Silvae Genet., 25: 79-83.

Farmer, R.E.J., 1980. Comparative analysis of first year growth on 6 deciduous tree species. Can. J. For. Res., 10: 35-41.

Gross, K.L., 1984. Effects of seed size and growth form on seedling establishment of six monocarpic perennial plants. J. Ecol., 72: 369-387.

Indira, E.P., S.C. Basha and K.C. Chacko, 2000. Effect of seed size grading on the germination and growth of teak (*Tectona grandis*) seedlings. J. Trop. For. Sci., 12: 21-27.

ISTA, 1996. International rules for seed testing. Seed Sci. Technol., 24: supplement.

Jayasankar, S., L.C. Babu, K. Sudhakara and V.K.G. Unnithan, 1999. Provenance variation in seed and germination characteristics of teak (*T. grandis* L.F.). Seed Sci. Technol., 27: 131-139.

Karrfalt, R.P., 2004. How A corn Size Influences Seedling Size and Possible Seed Management Choices. In: National Proceedings: Forest and Conservation Nursery Associations-2003. Riley, I.E. (Ed.), USDA For. Serv. RMRS-P-33, Fort Collins, CO, pp: 117-118.

Ke, G. and M.J.A. Werger, 1999. Different responses to shade of evergreen and deciduous oak seedlings and the effect of acorn size. Acta Oecol., 20: 579-586.

Khan, M.L. and U. Shankar, 2001. Effect of seed weight, light regime and substratum microsite on germination and seedling growth of *Quercus semiserrata* Roxb. Trop. Ecol., 42: 117-125.

Krishan, B., V. Singh and B. Krishan, 1995. Effects of seed size and colour on germination and seedling growth in five tree species. Adv. Hortic. For., 4: 199-204.

Long, T.J. and R.H. Jones, 1996. Seedling growth strategies and seed size effects in fourteen oak species native to different soil moisture habitats. Trees, 11: 1-8.

Navarro, F.B., M.M. Jimenez, M.A. Ripoll, E. Ondono, E. Gallego and E. Simon, 2006. Direct sowing of holm oak acorns: Effects of acorn size and soil treatment. Ann. For. Sci., 63: 961-967.

Shepard, E., D.D. Miller, G. Miller and D. Miller, 1989. Effect of weight on emergence and seedling vigor of Chinese chestnut. Hortic. Sci., 24: 516-519.

Singh, S., O. Singh and V. Singh, 1993. Effect of seed weight on germination, survival and initial growth of horse chestnut (*Aesculus indica* Colebr.) in the nursery. Indian For., 119: 627-629.

Singh, O., 1998. Effect of seed weight on germination, survival and initial growth of *Quercus dilatata* in the nursery. Indian For., 124: 959-961.

Tilki, F. and C.U. Alptekin, 2005. Variation in acorn characteristics in provenances of *Quercus aucheri* Jaub. et Spach and provenance, temperature and storage effects on acorn germination. Seed Sci. Technol., 33: 441-447.

Toon, P.G., R.J. Haines and M.J. Dieters, 1990. Relationship between seed weight, germination and seedling-height growth in *Pinus caribae*. Morele. var. *hondurensis* barre and Golfri. Seed Sci. Technol., 19: 389-402.

Willan, R.L., 1985. A guide to forest seed handling. FAO Forestry Paper 20/2. Rome.