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Germination and Seedling Growth of Side and Wafer 'Willamette' Chestnuts

Michele R. Warmund[1]

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Abstract

Wafer nuts (i.e., central nuts) are often smaller than the outer two when three nuts are produced in Chinese chestnut (*Castanea mollissima* Blume) burs. Because small chestnuts of any type command a low price at retail markets, they are either processed or discarded. Most large chestnuts are sold fresh or for processing, leaving nuts used for propagating trees and seedling rootstocks in short supply. Thus, central and side 'Willamette' (*C. mollissima* x *dentata Borkh.)* chestnuts from 2 to 20 g fresh weight were germinated in a greenhouse in mid March and container-grown in a nursery until early November to determine if nut type or fresh weights influenced germination and seedling growth. Wafer nuts had higher odds for germinating than side nuts, but all chestnuts that weighed ≥ 10 g at harvest averaged more than 87% germination when grown in a greenhouse the following spring. Although shoots emerged most rapidly from side nuts weighing ≤ 9.9 g, mean days to emergence for all chestnuts only varied from 18 to 24 d. Wafer or side nuts weighing ≥ 10 g produced seedlings with large stem diameters (≥ 6.8 mm) that are desirable for grafting. Chestnuts weighing ≥ 14.0 g at harvest generally produced taller seedlings with greater dry weights than those weighing ≤ 11.9 g. Thus, side or wafer chestnuts that are ≥ 10 g can be used to produce rootstocks for grafted chestnut trees and nuts ≥ 14.0 g can be used to produce vigorous seedling trees.

Chestnuts are produced as a niche crop with 1350 ha grown in the United States (Warmund, 2011). Most grafted trees generally start producing a commercial nut crop at five years after planting. Chestnut trees generally begin their first period of flowering in early June and later develop burs containing one, two, or three nuts. In September, burs change from a green color to brown and as they mature, their four valves dehisce, and nuts and burs fall to the ground. Mature nuts have a brown, glossy shell (i.e., epicarp) with a basal hilum. Dried styles and perianth remnants at the apex of the nut are known as the torch. The kernel is covered by episperm or pellicle that can intrude into the cotyledonary tissue. A single, large nut within a bur is often called a marroni or marron. Marrons of European chestnut (*C. sativa* Mill.) or its hybrids may have pellicle intrusions, which are considered undesirable. When two nuts are produced in a bur, they are hemispherical and are generally smaller than marrons. In contrast, *C. mollisima* trees and hybrid trees of this species usually produce burs with three nuts, with two hemispherical outer nuts and a central flat nut. In North America, the central nut is known as a wafer (Fig. 1).

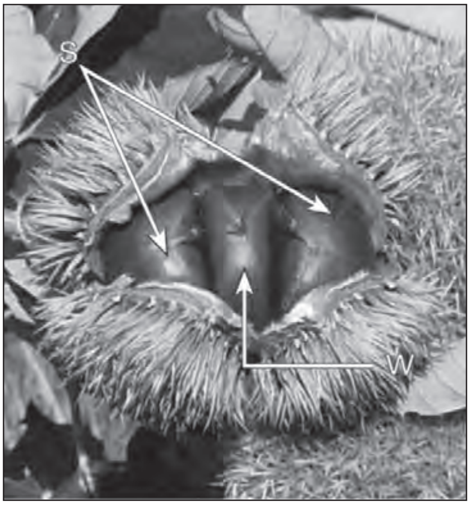

Fig. 1. 'Willamette' chestnut bur containing two side nut (s) and one central nut or wafer (w).

[1] Professor, Division of Plant Sciences, University of Missouri, Columbia, MO 65211

Currently, United States Department of Agriculture standards have not been established for grading chestnuts. Individual producers may sort their chestnuts by size, rather than by weight, and these size classes vary by year for retail and wholesale markets (M.A. Gold, personal communication).

A major problem in the chestnut industry, which limits expanded production, is the lack of nursery stock. Large chestnuts from superior trees are generally sold for as much as $14/kg at retail markets (Gold et al., 2006). Small or medium nuts may be discarded or processed into value-added products, although development and marketing of these products is not extensive. For the European nursery industry, medium-sized chestnuts are used to propagate *C. sativa* trees because the larger marrons with pellicle intrusions sometimes have two embryos (Bounous and Marinoni, 2005). Shepard et al. (1989) reported that Chinese chestnut (*C. mollissima*) seed weight, categorized as small, medium, and large (ranging from 1 to 7 g) was correlated with stem diameter and dry weight of seedlings grown for six weeks. However, Chinese chestnut trees and hybrid trees of this species currently grown in commercial orchards generally produce nuts weighing < 25 g (Miller, 2007). At harvest, chestnuts are ≈ 50%, 40%, and 2% water, starch and sugar by weight, respectively (Rutter et al., 1991). All nuts within a bur contain one or more embryos, but wafer nuts are often discarded or processed because they are usually smaller than side nuts. If these small chestnuts produce acceptable seedlings, they could be sold to propagators rather than being discarded. Thus, the objectives of this study were to determine if nut type (side versus wafer) or fresh weight influenced percent shoot emergence, days to shoot emergence, and various seedling characteristics at the end of one growing season.

Materials and Methods

Nuts from 8-year-old 'Willamette' chestnut/Miller 72-138 (seedling rootstock) chestnut trees planted in a repository at the Horticulture and Agroforestry Research Center (HARC), New Franklin, MO, were used for this study. Chestnuts were harvested from five trees on 19, 22, and 25 Sept. 2009. Each chestnut was weighed, sealed in a polyethylene bag, and stored at 4°C. On 18 Mar. 2010, side and wafer chestnuts harvested from each of the five trees were sorted into the following classes by nut fresh weight: 19.9 to 18.0; 17.9 to 16.0; 15.9 to 14.0; 13.9 to 12.0; 11.9 to 10.0; 9.9 to 8.0; 7.9 to 6.0; 5.9 to 4.0; and 3.9 to 2.0 g. Because few chestnuts weighing ≥ 20 g were produced, these were not included in the study. On 19 Mar., five replications of 15 side and 15 wafer nuts of each weight class were planted in 13 x 13 x 31-cm (depth) polyethylene containers (Stuewe & Sons, Tangent, OR) using a 8 pine bark: 4 perlite: 2 sphagnum peat moss: 1 vermiculite: 1 sand (v/v) medium amended with 2 kg Osmocote 13N-5.7P-10.8K, 1.5 kg Nitroform Blue Chip 38N-0P-0K (AgrEvo, Wilmington, DE), and 1.7 kg Micromax micronutrients (Scotts Co., Marysville, OH) per m^3. The various classes of nut mass were arranged in a randomized complete block design (RCBD) in a greenhouse maintained at 25°C under natural light and uniformly irrigated as needed. Shoot emergence was recorded daily until 19 Apr. when no additional emergence occurred for 7 d. Containerized seedlings were moved into a nursery area at HARC under 55% shade cloth (DeWitt Group, Sikeston, MO) in a RCBD. Supplemental irrigation was provided as needed. On Nov. 9 2010, seedling height and stem diameter at 1 cm above the soil surface were recorded. Seedlings were then harvested, roots were washed free of potting media, and plant tissue was oven-dried at 65°C for 48 h to determine seedling dry weights.

Because all nut classes had high percentages of shoot emergence, data were not normally distributed. Thus, the odds (i.e., probability) of shoot emergence of side and wafer nuts of each weight class were estimated, using the GLMMIX procedure of SAS with a link + logit function for a binomial distribu-

Table 1. Odds of shoot emergence, percent shoot emergence, and mean stem diameter of 'Willamette' chestnuts of various weight classes recorded on 9 Nov. 2010.[z]

Nut wt (g)	Odds of shoot emergence	Germination (%)	Stem diameter (mm)
19.9 – 18.0	7.4 abc	88.1	7.4 a
17.9 – 16.0	7.3 abc	88.0	7.1 ab
15.9 – 14.0	18.4 a	94.8	7.0 ab
13.9 –12.0	7.0 abc	87.5	6.8 b
11.9 – 10.0	9.7 ab	90.1	7.0 ab
9.9 – 8.0	3.7 cd	78.7	6.3 bc
7.9 – 6.0	5.1 bcd	83.6	6.0 cd
5.9 – 4.0	3.0 d	75.1	5.3 de
3.9 – 2.0	3.6 d	78.1	4.5 e
Significance[y]			
Nut type	**	---	NS
Weight class	**	---	***
Nut type x weight class	NS	---	NS

[z] Means represent five replications of 15 seeds per nut type and weight class. Odds were calculated from the antilog of the logit value and back-transformed [% shoot emergence = odds / (1 + odds)] to estimate shoot emergence percentage by weight class for side and wafer nuts. Mean differences among logits for percent shoot emergence were determined using the LSMEANS statement. Mean separation of stem diameters by Fisher's protected LSD test ($P \leq 0.05$).

[y] NS, ***,**, indicates non-significance and statistical significance at $P \leq 0.001$ or $P \leq 0.01$, respectively.

tion. Odds were calculated from the antilog of the logit value and back-transformed [% shoot emergence = odds / (1 + odds)] to estimate shoot emergence percentage by weight class for side and wafer nuts. Mean differences among logits were determined using the LSMEANS statement ($P \leq 0.05$). Mean days to shoot emergence, stem diameter, and seedling height and dry weight were subjected to analysis of variance (ANOVA) using the PROC GLM procedure of SAS and means were separated by Fisher's protected LSD test ($P \leq 0.05$).

Results and Discussion

Odds of shoot emergence and percent emergence varied by nut position and weight class (Table 1). Odds of shoot emergence from wafers were 2.1 (89.5% emergence), whereas odds for shoot emergence from side nuts was only 1.5 (82.0% emergence). Also, chestnuts weighing 15.9 to 14.0 g were more likely (i.e., higher odds) to emerge than those weighing ≤ 9.9 g. Mean days to shoot emergence ranged from 18 to 24 d (Table 2). Side nuts in the 15.9 to 14.0 g weight class and wafers in the 11.9 to 10.0 class required the most days for shoot emergence, while side nuts weighing ≤ 9.9 g emerged in the fewest days (18 to 20).

Mean stem diameters of seedlings produced from side (6.4 mm) and wafer (6.3 mm) chestnuts were similar (Table 1). However, chestnuts weighing ≥ 10 g produced seedlings with greater stem diameters than those produced from nuts weighing ≤ 7.9 g. Seedlings with greater stem diameters are desirable for rootstocks when nurseries are propagating trees using whip and tongue grafting (Warmund, 2011). Moreover, grafted trees are recommended because they are more precocious and have more uniform nut ripening and consistent yields than seedling trees (Hunt et al., 2012).

Seedling height ranged from 42 to 84 cm by 9 Nov. 2010 (Table 2). However, seedlings

Table 2. Mean days to shoot emergence, seedling height, and seedling dry weight of side and wafer 'Willamette' chestnuts of various weight classes harvested on 9 Nov. 2010.[z]

Nut type	Nut wt (g)	Shoot emergence (d)	Seedling ht. (cm)	Seedling dry wt. (g)
Side	19.9 – 18.0	21.3 bc	84.0 a	56.2 a
Wafer	19.9 – 18.0	23.0 ab	74.9 cde	56.7 a
Side	17.9 – 16.0	23.1 ab	80.5 ab	51.2 abc
Wafer	17.9 – 16.0	22.7 abc	77.4 bc	51.3 abc
Side	15.9 – 14.0	23.5 a	72.5 def	51.0 abc
Wafer	15.9 – 14.0	21.4 bc	78.9 bc	53.8 ab
Side	13.9 – 12.0	22.5 abc	68.1 fg	46.4 cde
Wafer	13.9 – 12.0	22.6 abc	75.6 cd	50.8 bcd
Side	11.9 – 10.0	21.1 bc	69.5 ef	45.9 def
Wafer	11.9 – 10.0	23.7 a	58.5 i	38.3 gh
Side	9.9 – 8.0	18.2 d	63.9 gh	41.2 fgh
Wafer	9.9 – 8.0	23.3 ab	62.9 ghi	42.1 efgh
Side	7.9 – 6.0	18.5 d	61.7 hi	40.0 gh
Wafer	7.9 – 6.0	20.1 cd	60.3 hi	43.7 defg
Side	5.9 – 4.0	20.1 cd	47.9 jk	29.7 i
Wafer	5.9 – 4.0	21.7 abc	49.7 j	34.5 hi
Side	3.9 – 2.0	18.1 d	42.5 k	28.1 ij
Wafer	3.9 – 2.0	22.2 abc	41.6 k	21.5 j
Significance[y]				
Nut type		***	*	NS
Weight class		***	***	***
Nut type x weight class		**	***	*

[z] Means represent days to shoot emergence, seedling height and seedling dry weight of five replications of 15 seeds per nut type and weight class. Mean separation within each column followed by different letters are significantly different ($P \leq 0.05$).

[y] NS, ***,**,*, indicates non-significance and statistical significance at $P \leq 0.001$, $P \leq 0.01$ $P \leq 0.05$, respectively.

produced from side nuts weighing 19.9 to 16.0 g and wafer nuts weighing 17.9 to 12.0 g were taller at the end of the growing season than those produced from all other weight classes except for wafers weighing 19.9 to 18.0 g or 13.9 to 12.0 g. Seedlings produced from side and wafer nuts weighing ≥ 14.0 g had greater dry weights by November 2010 than those grown from chestnuts weighing ≤ 11.9 g (Table 2). Results from this study generally agree with an earlier report (Shepard et al., 1989) in which nut fresh weight was correlated with seedling dry weight after germination and growth for six weeks.

In conclusion, wafers had higher odds for shoot emergence than side nuts. However, either type of chestnut that weighed ≥ 10 g at harvest averaged more than 87% shoot emergence when grown under greenhouse conditions. Nuts weighing ≥ 10.0 g produced seedlings with greater stem diameters than nuts weighing ≤ 7.9 g. Wafer or side nuts weighing ≥ 14.0 g at harvest generally produced seedlings with taller tree heights and greater dry weights by the end of the growing season than those weighing ≤ 11.9 g. Thus, side or wafer chestnuts weighing ≥ 10 produce a large diameter seedling rootstock suitable for grafting and nuts ≥ 14.0 g can be used to produce vigorous seedling trees.

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The Wilder medal is presented to individuals or organizations that have rendered outstanding service to horticulture in the area of pomology. Special consideration is given to work relating to the origination and introduction of meritorious fruit cultivars. Individuals associated with either commercial concerns or professional organizations will be considered if their introductions are truly superior and have been widely planted. Significant contributions to the science and practice of pomology other than through fruit breeding will also be considered. Such contributions may relate to any important area of fruit production such as rootstock development and evaluation, anatomical and morphological studies, or noteworthy publications in any of the above subjects. Information about the award, past recipients, etc. can be found on the APS website at:
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