

# RELATIONSHIPS OF FRUIT AND SEED FORM, SIZE, WEIGHT AND SOUNDNESS OF GRADED BASSWOOD FRUIT

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Many studies support a positive relationship between seed size and germination, height, weight, or other factors important to the survival and growth of seedlings. This study found that large seeds had the heavier embryos.

Data on American basswood (*Tilia americana* L.) are scarce. Number per pound, size, weight, and soundness are given in seed manuals (10, 6, 7), nursery guidelines (6, 3, 5) and isolated studies (1, 2, 3, 5, 6, 7, 8, 9, 11, 14). The fruit is nut-like, usually egg-shaped or round, and, infrequently, onion-shaped or conical, or, if ribbed, pentagonal. The woody fruit husk (pericarp) usually encloses a single seed, but sometimes two or three. The seed has a crustaceous seed coat (testa), a fleshy yellowish endosperm, and a well-developed embryo (16). Spaeth (12) was the first to tabulate detailed data on fruit having more than one seed. He differentiated weights, suggesting an effective relationship between fruit or seed size and weight. Information is absent on grading of fruit by size and weight governing the number of fruit and seed per pound.

This investigation presents information on basswood fruit and seed, supplementing seed manuals with additional data on form, size, weight, soundness, and number per pound. It suggests the use of

fruit-size and fruit-weight classes as a standard for collecting selected fruit lots, for studying the effect of seed weight on seedling development.

## Materials and Methods

*Collection.*-Fruit were collected in the fall of 1964, 1965, and 1966, from all parts of the crown of mature basswood trees standing in the field (open-grown) and trees cut in hardwood stands (forest-grown). Sixteen open-grown trees were separately recorded south, and thirty forest-grown trees north, of 44° 45' latitude in the Tweed Forest District, southeastern Ontario, a 3,500 square mile area of forested land. In addition, fruit from about twenty unrecorded trees were used for various preliminary tests. Several hundred fruit were collected from most trees, but from two forest-grown trees the number was less than two hundred.

*Grading and Weighing.*-Fruit were stored for several months exposed to air at room temperature. Two 50-fruit samples were withdrawn at random from each lot for grading and weighing, and two samples of 25 fruit for cutting tests to evaluate seed soundness and characteristics. Fruit were graded and weighed in air-dry condition. Moisture content varied from 9 to 12 percent. Between 5 and 7 percent moisture was contained in the air-dry seeds, which were extracted and oven-dried at 100°C. for 24 hours.

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Preliminary grading was done before the size of apertures through which the fruit should pass was decided. Fruit were separated into three size classes with a separator made of sheet metal one millimeter thick having circular apertures. The classes were (a) large, > 7.5 mm, (b) medium, 6.5 - 7.5 mm, (c) small, < 6.5 mm. With their longer diameter placed vertically, fruit were forced through the apertures by applying only a slight pressure of the finger. Fruit with swellings, seeds with chipped testae, and other defective individuals were discarded.

A microbalance (sensitivity 0.2 mg/dv.) was used for weighing. Diameters of fruit and seed were measured with a micrometer (tolerance  $\frac{1}{100}$  mm).

*Extraction and Dissection.*—Fruit were crushed with pliers. Seeds were extracted manually with the help of a small screwdriver and cleaned of pericarp residues. Seeds were then weighed, punctured with a pin, and placed in tap water at room temperature overnight to become imbibed before separating the testae from the endosperms and removing embryos. Naked kernels were obtained by chipping the testae from the endosperms with a scalpel; the endosperms were slit, and the embryos could then be pried out with a scalpel or dissecting needle. Fifty seeds selected randomly from each class of fruit were thus separated and the testae, endosperms, and embryos oven-dried and weighed as above.

### Results

*Form and Size.*—Trees tend to produce fruit of a particular form and size consistently from year to year. In this study, a great variety of forms of fruit were found. Fig. 1 illustrates the five most distinctive

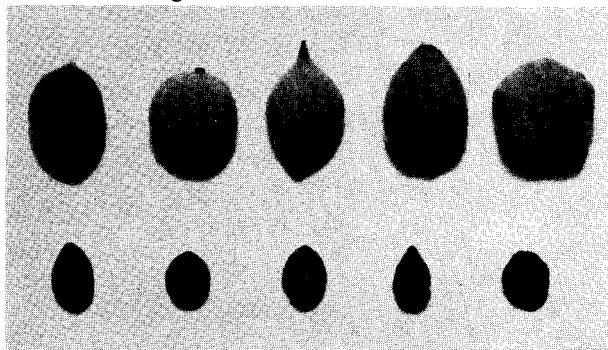


Figure 1.—Forms of fruit and seed: Egg-shaped, round, onion-shaped, conical and pentagonal.

forms of fruit and seed. The form of seeds seems to depend on the form of fruit, for example,

round and pentagonal one-seeded fruit envelop round seeds.

Figs. 2, 3, and 4 illustrate variations in form of seeds extracted from one-seeded and two-seeded fruit from the large, medium, and small size classes. The average proportions of fruit classes of samples from all trees were about 10 percent, 42 percent, and 48 percent, respectively (table 1, column 4). Samples from some individual trees had up to 78 percent large fruit, up to 80 percent medium fruit, and up to 96 percent small fruit. The uniformity of seeds is most apparent in one-seeded fruit of the large and medium size classes. Seed from two-seeded fruit are semi-globular; they are more uniform in fruit of the large size class than in the medium size class. Small fruit are almost always one-seeded and their seeds are of various forms. The greatest proportions of small fruit were produced by the majority of forest-grown trees.

Data on the diameters of fruit and seed in relation to their weight are presented in tables 2 and 3. Measurements of the latter refer to seeds from one-seeded fruit. Generally the larger the fruit size the larger the seed size, and this may also be true in

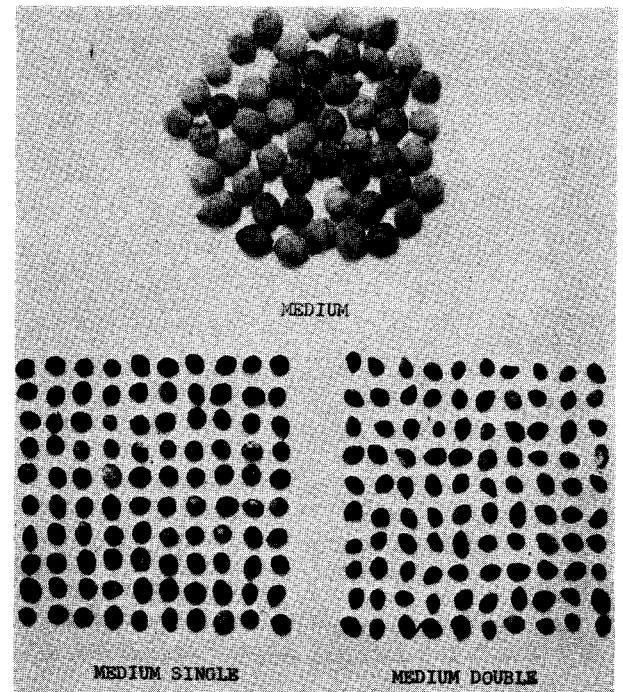


Figure 2.—Fruit of the large size class and seed from large one-seeded fruit (large single) and large two-seeded fruit (large double).

TABLE 1.—Class limits, number and weight of fruit in large, medium, and small size classes of fruit

Size class of fruit	Size of aperture		Fruit examined	Proportion of fruit in each class		Frequency <sup>1</sup>	Fruit		Fruit per pound
	Passed by	Retained by		Average—			weight	ratio	
				by number	by weight				
	mm.	mm.	No.	Percent	Percent	Percent	g.	Per one	No.
Large.....	—	7.5	655	10	16	59	0.151	2.28	3,004
Medium.....	7.5	6.5	2,798	42	49	100	0.102	1.54	4,447
Small.....	6.5	—	3,137	48	35	99	0.066	1.00	6,873
All.....	—	—	6,590	—	—	—	0.088	—	5,154

<sup>1</sup> Frequency indicates the percent of the total number of samples examined in which a size class of fruit occurred.

seeds from two-seeded fruit (figs. 2 and 3). Variety in seed size is most obvious in small fruit (fig. 4) in which a small but consistent number of seeds from most samples were of the size found in one-seeded medium fruit.

*Weight.*—The weight of fruit and seed (tables 2 and 3) shows that fruit of the large size class were heaviest and seeds extracted from them were also

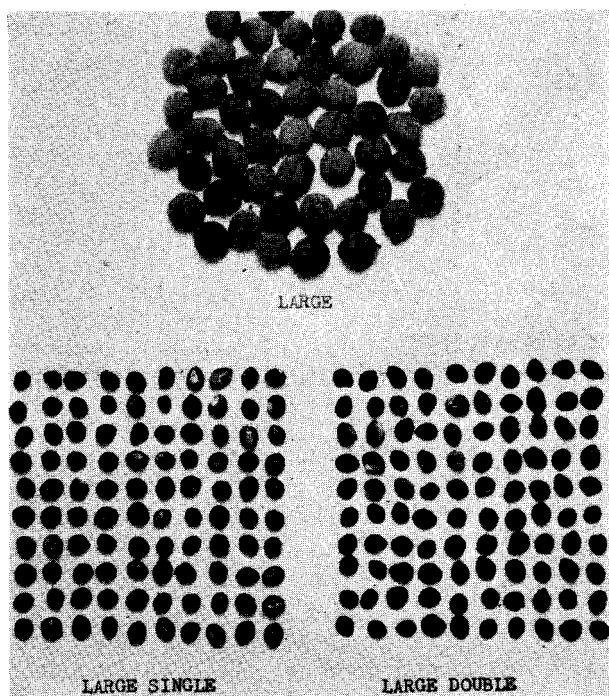


Figure 3.—Fruit of the medium size class and seed from medium one-seeded fruit (medium single) and medium two-seeded fruit (medium double).

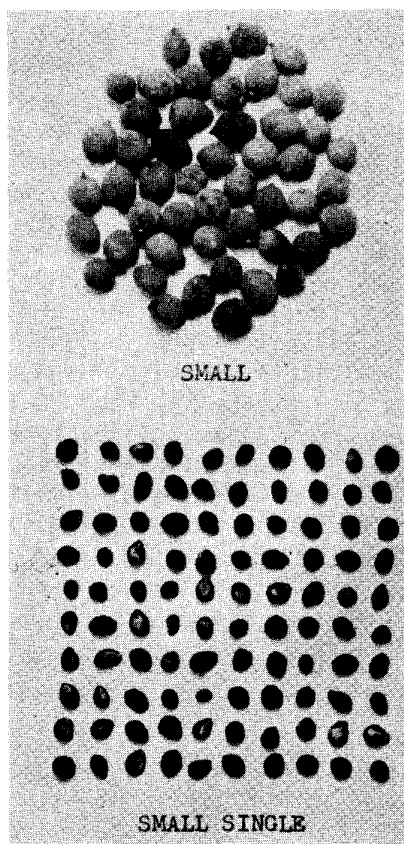


Figure 4.—Fruit of the small size class and seed from small one-seeded fruit (small single).

TABLE 2.—Maximum, minimum, and average diameter, and weight of fruit

Size class of fruit	Large			Medium			Small			Unsorted		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Diameter (mm.)	7.51	9.05	8.04	6.51	7.58	6.90	5.19	6.50	6.07	5.24	9.00	7.30
Shorter	7.831	11.56	9.12	6.52	10.45	8.00	5.82	8.51	7.06	5.82	11.52	7.71
Longer	0.095	0.185	0.151	0.070	0.137	0.102	0.048	0.104	0.066	0.048	0.185	0.088

TABLE 3.—Maximum, minimum, and average diameter, and weight of seed

Size class of fruit	Large			Medium			Small			Unsorted		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Diameter (mm.)	3.50	4.70	4.23	3.60	4.55	4.08	2.75	4.00	3.32	3.28	4.73	3.91
Shorter	4.65	6.05	5.12	4.30	5.50	4.82	3.20	4.95	4.04	3.45	5.95	4.63
Longer	0.024	0.055	0.037	0.014	0.040	0.030	0.011	0.030	0.021	0.011	0.055	0.027

TABLE 4.—Number of sound fruit and seed, and weight and ratio of seed from one-seeded and two-seeded fruit in large, medium, and small size class of fruit

Size class of fruit	Fruit examined	Fruit one-seeded and two-seeded		Fruit un-sound		Fruit sound	Seed sound	Seed						Sound seed from one pound of fruit	
		1	2	1	2			Weight Ratio						Difference (from table 3, col. 7)	Total
								1	2	Av.	1	2	Av.		
		No.	Pct.	Pct.	Pct.			Pct.	Pct.	Pct.	g.	g.	g.	Per one	Per one
Large	311	58	42	8	15	89	125	0.037	0.028	0.032	1.76	1.75	1.52	+25	3,755
Medium	847	88	12	15	3	86	98	0.030	0.020	0.028	1.43	1.25	1.33	-2	4,358
Small	884	99	1	15	0	85	86	0.021	0.016	0.021	1.00	1.00	1.00	-14	5,911
All	2,042	88	12	14	9	86	97	—	—	0.027	—	—	—	-3	4,999

Model values: 1) 17%, 2) 18%, 3) 21%, 4) 17%, 5) 16%.

heaviest. Small fruit were generally lightest. However, weighing of individual seeds extracted from one-seeded small fruit showed that four out of 100 seeds were as heavy as the average weight of a seed from one-seeded medium fruit. None of these 100 seeds reached the average weight of seeds from one-seeded large fruit. Table 4 shows the average

weight of seeds from one-seeded and two-seeded fruit. The number of three-seeded fruit in the large size class totaled less than one percent (0.023 g. per seed) and these were included in the table with the two-seeded large fruit. Only one fruit of the medium size class was found with three seeds-weighing 0.019 g. each.

TABLE 5.—Weight and ratio of testae, endosperms and embryos of 50 seeds in large, medium and small size classes of fruit

Size class of Fruit	Testae			Endosperms			Embryos			Total		
	Weight		Ratio	Weight		Ratio	Weight		Ratio	Weight		Ratio
	<i>g.</i>	<i>Percent</i>	<i>Per one</i>	<i>g.</i>	<i>Percent</i>	<i>Per one</i>	<i>g.</i>	<i>Percent</i>	<i>Per one</i>	<i>g.</i>	<i>Percent</i>	<i>Per one</i>
Large.....	0.6230	37	1.10	0.9206	54	1.67	0.1498	9	2.62	1.6934	100	1.44
Medium.....	0.6292	46	1.10	0.6518	48	1.19	0.0810	6	1.42	1.3620	100	1.16
Small.....	0.5700	48	1.00	0.5495	47	1.00	0.0571	5	1.00	1.1766	100	1.00
Total.....	1.8222	—	—	2.1219	—	—	0.2879	—	—	4.2320	—	—

The weight of fruit and seed from one-seeded small fruit was reduced to a common denominator of one to make a comparison of the ratios of fruit, seeds, etc., in each fruit class. Thus the ratios in tables 1 and 4 show the superior weight of fruit and seed of the large size class. The most impressive weight ratios were those of the embryos in the three size classes which were, respectively, 2.6:1.4:1.0 (table 5). The ratios of endosperms were less pronounced and differences of testae proved negligible.

*Soundness and Yield.*—Table 4 shows the percentage of all one-seeded and two-seeded fruit for each size class, and the percentage of unsound fruit. The quantity of sound two-seeded fruit increased the soundness in each class from 89 percent, 86 percent, and 85 percent to 131 percent, 98 percent, and 86 percent, respectively, of sound seeds, thus raising overall average soundness from 86 to 94 percent.

The average number of fruit per pound from all samples was computed and graphically plotted against the corresponding weight of a fruit. In the curve thus constructed, both criteria, size class of fruit and weight of fruit, can be used to obtain the number of fruit per pound (fig. 5). The maximum and minimum numbers were 9,450 and 2,452 fruit per pound. Table 1 shows the average number of fruit in each class, with an overall average of 5,154 fruit per pound. The increase or decrease in the number of seeds from the number of fruit in each class is shown in table 4, resulting in an overall average of 4,999 sound seeds from one pound of fruit.

The curve in fig. 6 was constructed by plotting the number of seeds per pound over the average weight of a seed. Here, the number of seeds per pound can be obtained. The maximum and mini-

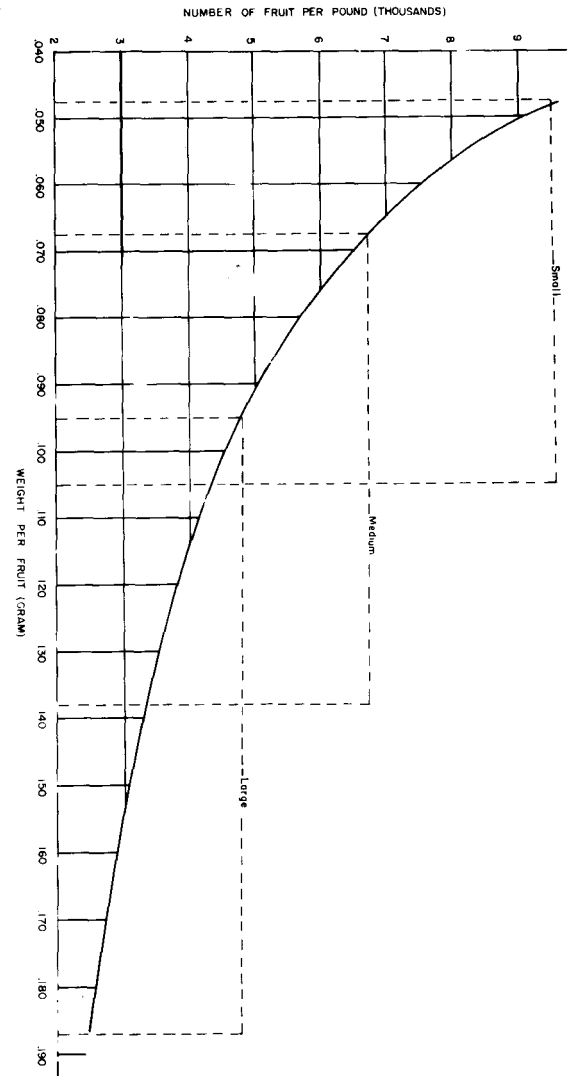


Figure 5.—Number of fruit per pound over weight of a fruit in large, medium, and small size classes of fruit.

num numbers were 41,236 and 8,245 seeds, with an average of 16,800 seeds per pound from all samples. The number per pound of a fruit lot can be obtained by locating the point corresponding to the average weight of a fruit and then reading the corresponding number on the left in fig. 5. The number per pound and the proportion of size classes can be determined more accurately by the following procedure:<sup>2</sup>

1. Grade a sample of fruit into large, medium, and small size classes by using the separator described previously;
2. Weigh all fruit in each size class and compute the average weight per fruit in each class;
3. Read the number of fruit per pound from the curve for each class;
4. Take the proportions of large, medium, and small size classes from (1) and convert them into percent;
5. Multiply the number of fruit per pound for each class, obtained from the curve, with the corresponding percent;
6. Add the individual results from (5) and divide the sum by one hundred, thus obtaining the final number of fruit per pound.

#### Discussion and Conclusions

A tree tends to consistently produce fruit of one form and size. The larger the fruit the larger and heavier the seeds, in both one-seeded and two-seeded fruit. Fruit of round form in the large or medium size classes envelop seeds most homogenous in form, size, and weight. However, exceptional trees produced round fruit in the small size class containing round seeds the size of those usually present in fruit in the medium size class.

The striking difference between open-grown trees and forest-grown trees was that most of the latter bore more than 50 percent small size fruit per tree. Fruit samples from one forest-grown tree were found to be exclusively two-seeded and sound and the seeds were uniform in size and weight. Only one (forest-grown) tree had 100 percent empty fruit.

<sup>2</sup> The results of this sampling method apply to fruit in air-dry condition, having a moisture content of from 9 to 12 percent.

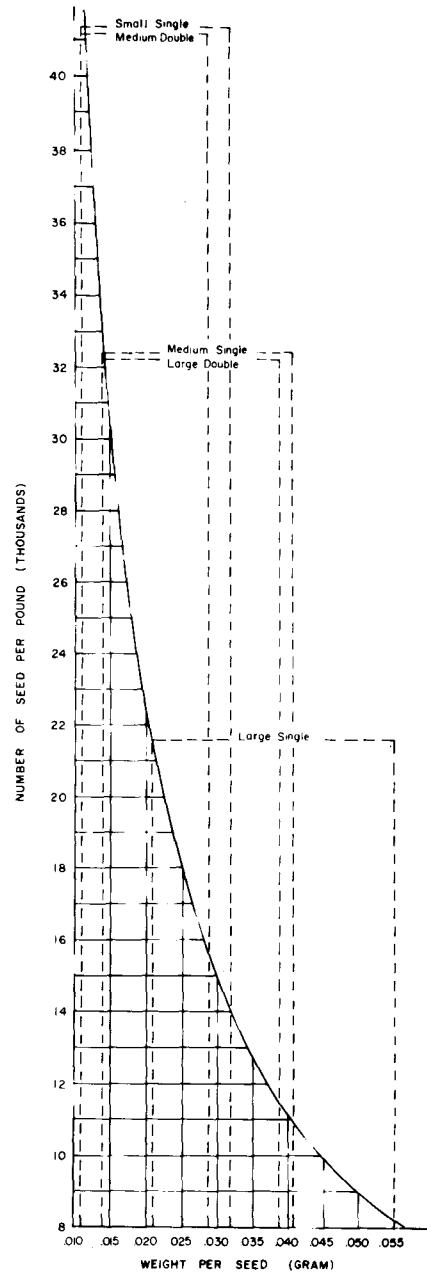


Figure 6.—Number of seed per pound over weight of a seed extracted from large one-seeded fruit (large single), medium one-seeded fruit (medium single), large two-seeded fruit (large double), medium two-seeded fruit (medium double), and small one-seeded fruit (small single).

The most common damage to fruit was the presence of a hole the size of a pinhead. In such fruit, a larva 3.5 mm. long was found, probably belonging to the genus *Phalonia* (3).

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