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Variability of *Quercus robur* L. and *Quercus petraea* (Matt.) Liebl. acorn size in the region of the Pomeranian plains

Abstract: The results of measurements of 5780 acorns confirm that *Quercus robur* has acorns of langer size, as componed with acorns of *Quercus petraea*. Their length varied from 1.90 to 3.50 cm, with the average 2.71 cm, while in case of *Q. petraea* this characteristic varied from 1.60 to 3.50 cm, with the average 2.43 cm. The diameter of acorns was similar for both species. Dry mass of *Q. robur* acorns ranged from 1.054 to 4.937 g, on average 2.5924 g; in the case of *Q. petraea* it ranged from 0.835 to 4.796 g, on average 1.8364 g. Taking into consideration the coefficient of variability of length and diameter, both species do not differ significantly. It ranged from 9 to 12%. In the case of dry mass the difference was larger and it was 23% and 28% for *Q. robur* and *Q. petraea*, respectively. The analysis of variance (F-test) showed, that the species taken as the source of variability influences significantly the length of acorns (in 17%) and dry mass (in 47%). Internal features determine these characteristics in 52% and 46%. F-test did not detect any dependence between oak species and the diameter of acorns.

Additional key words: oak, acorn length, acorn diameter, dry mass

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Introduction

The shape and size of tree fruits are elements which characterize the morphological features of trees. In the case of oaks this role is played by acorns, which create the "picture" of each species. Acorns can be characterized by: their length, diameter, the mass of 1000 fresh or dry acorns, their shape and their slenderness, expressed by the ratio of length to diameter. The size of acorns plays an important role in determining sowing density standards in forest nursery production. It may influence the size of planting material. Known research on oak fruits shows high variability of these characteristics in the case of both oak species growing in Poland: *Quercus robur* and *Q. petraea*. Goetz (1931) determined the extreme length of acorns between 8 and 35 mm, the diameter between 6 and 20 mm. Barzdajn (1993) found the length ranging from 19.9 to 33.4 mm and the diameter varying from 13.6 to 17.7 mm. For acorns of *Q. robur* the same author found in 1994 the length ranging from 15.5 to 40.8 mm and the diameter varying from 10.3 to 27.2 mm. The mass of 1000 acorns reached 1.5–5 kg (Tyszkiewicz 1949, Suszka 1994) in the case of sessile oak, and 2–7 kg for common oak. The dry mass of 1000 acorns for 69 population of common oak from all over Poland varied between 1767 and 4702 g (Barzdajn 1994). This study, aimed to assess some parameters of acorns originating from oak stands in the Choszczno Forest District and the influence of the stand, species and the individual trees on them.

Material and methods

In the autumn of 2000, the author collected 5780 acorns from 388 trees growing on the experimental plots established in 1998. Forty circular plots 0.05 ha

each, were located in 4 temporary seed production stands of oak in Forest District Choszczno marked by letters: A, B, C, D. The location of each tree was fixed by a letter representing the stand and two numbers identifying the circular plot and the particular tree. The numbers and the percentages of *Q. robur* in the particular stands were as follows: A – 64 trees – 50%, B –133 trees –13.5%, C – 93 trees –100% and D – 45 trees – 90%. The remaining trees represented *Q. petraea*. Besides, additional 30 trees of *Q. robur* were selected as samples – at the age of 273 years (III class of the site index, the mean diameter – 134 cm and mean height – 28 m) in the reserve "Dęby Sądowskie", and additional 20 trees of *Q. petraea* – at the age of 340 (I class of site index, the mean diameter 94 cm and mean height 37 m) in the reserve "Radęcin".

The stands mentioned above occupy fresh mixed broadleaved forest sites and the pattern stands occupy fresh broadleaved forest sites. Except oaks growing in Radęcin, all oak stands grow in the Pyrzyce Lowland, within the borders of Forest District Choszczno.

In total, 1200 acorns of each oak species were collected from pattern-trees, and in the seed production stands 1870 acorns of *Q. robur,* and 1510 acorns of *Q. petraea* were collected. For each of the 388 trees, acorn samples were respectively collected. The sample sizes were as follows: *Q. robur* – 40 acorns, *Q. petraea* – 60 acorns. Ten acorns were collected from each tree in plots of the temporary seed production stands.

Immediately after collection, the portions of acorns from the particular pattern-trees were weighed and the 1000 seed weight was calculated. During the weigh of fresh fruit, the average percentage of acorns with visible germs was determined. The length and the biggest diameters of all 5780 acorns were measured using the vernier calliper gauge and then their slenderness was calculated. Both lots of 1200 acorns each collected from pattern-trees were dried to the constant weight. The individual acorns were measured with the precision of 0.001 g and 1000 seed weight was calculated.

Results

The results of the measurements and calculations are presented in Tables 1–6 for both oak species, separately for the seed stands (A, B, C, D) and patterns.

The results demonstrate, that the length of acorns of both species is placed within the range of 16–35 mm. A somewhat narrower interval of the length characterizes *Q. robur*. The mean length of acorns of *Q. petraea* is about 10 to 15% smaller. Acorns from pattern plots were in average 1.3–1.5 mm longer than acorns from seed stands A, B, C and D.

The variability coefficient (V) for the length of acorns (Table 5), was lower for *Q. robur*, oscillating within the range from 8.72 to 10.81%. *Q. petraea* showed hi gher variability (V between 11.01 to 13.21%). Graphic presentation of the relation between the length of acorns of both species is presented on the histograms (Fig. 1 and Fig. 2). The percentage distribution of the acorn length in case of *Q. robur* is clearly shifted towards higher values comparing to the distribution for *Q. petraea*. Histograms are based on the measurements of 2400 acorns (patterns).

The measure of the diameter (Table 2) showed a little differentiation between oak species. The interval between the minimum and maximum diameter in case of *Q. robur* was 10.8 mm, while in case of *Q. petraea* it was 12.8 mm. The mean values of the diameter for both species were similar (the difference was 1–2%). In case of acorns of *Q. petraea* the extreme diameters were 9 and 21.8 mm. Temporary seed production stands, except for *Q. petraea* in D-stand, reached the mean diameter 5–7% lower comparing to the pattern stands. The variability coefficient (V) for the diameter (V=10%) was 1.34% higher for *Q. petraea*. Fig. 3 illustrates the diameter of acorns and confirms the small difference between species.

Results of the acorn slenderness calculation (Table 3) give the higher values of this characteristic for *Q. robur*, what is the consequence of data presented for the length and diameters. The fact should be noted occurrence of the individual cases of acorns of *Q. petraea* where this characteristic reached higher, maximum and average values comparing to *Q. robur* (2.667 – B-stand). During collection, it was observed, that the occurrence of the more longer acorns of *Q. petraea* can be attributed to the characteristic of individual trees. Coefficient of the variability (V) for the slenderness of acorns (Table 5) shows the higher variability of this feature in case of *Q. petraea* (to 14.32%) comparing to *Q. robur* (to 12.58%). The exception are the acorns from D-stand (6.63%). Acorns from temporary seed production stands showed lower variability than pattern stands.

Next results concern the masses of 1000 acorns and they are presented in Table 4.

The weight of 1000 acorns reached the range from 2800 to 6000 g in case of *Quercus robur* and from 2400 to 4800 g for *Q. petraea*. Calculated for both oak species the average weights of 1000 acorns allow to state that acorns of *Q. robur* are 37% heavier. Similar trend concerns average dry mass and then acorns of *Q. robur* are 41% heavier.

In spite of the fact that the average mass clearly differentiates both species, like their slenderness, there exist acorns of *Q. petraea* heavier than those of *Q. robur*. The variability of dry mass of acorns of both species reached much higher level than that of their length, diameter and slenderness. Coefficient of variability (V) for dry mass of acorns of *Q. petraea*

Table 1. Results of the measurements of acorn length (D)

Stand – place of collection	Minimum length [mm]			Maximum length [mm]			Mean length [mm]		
	Quercus robur	*Quercus petraea*	col. 2/3	*Quercus robur*	*Quercus petraea*	col. 5/6	*Quercus robur*	*Quercus petraea*	col. 8/9
1	2	3	4	5	6	7	8	9	10
A	21	16	1.31	32	31	1.03	26.3	23.0	1.15
B	19	16	1.19	32	32	1.00	25.0	22.7	1.10
C	19	0		35	0		25.6		
D	20	18	1.11	34	32	1.06	26.4	23.9	1.10
Temporary seed production stands Total	19	16	1.19	35	32	1.09	25.8	22.8	1.13
Patterns *Quercus robur/ Quercus petraea*	20	16	1.25	35	35	1.00	27.1	24.3	1.12

Table 2. Results of the measurements of acorn diameter (S)

Stand – place of collection	Minimum diameter [mm]			Maximum diameter [mm]			Mean diameter [mm]		
	Quercus robur	*Quercus petraea*	col. 2/3	*Quercus robur*	*Quercus petraea*	col. 5/6	*Quercus robur*	*Quercus petraea*	col. 8/9
1	2	3	4	5	6	7	8	9	10
A	10.7	11.7	0.91	18.4	19.2	0.96	14.42	14.7	0.98
B	10.5	9	1.17	18.3	20.3	0.90	14.25	14.2	1.00
C	9.3	0		18.8	0		13.88		
D	10.6	12.6	0.84	20.1	20.1	1.00	14.55	15.7	0.93
Temporary seed production stands Total	9.3	9.0	1.03	20.1	20.3	0.99	14.17	14.39	0.98
Patterns *Quercus robur/ Quercus petraea*	11.5	11.0	1.05	20.1	21.8	0.92	15.2	15.12	1.01

Table 3. Results of the calculation of acorn slenderness (D/S)

Stand – place of colection	Minimum slenderness [mm]			Maximum slenderness [mm]			Mean slenderness [mm]		
	Quercus robur	*Quercus petraea*	col. 2/3	*Quercus robur*	*Quercus petraea*	col. 5/6	*Quercus robur*	*Quercus petraea*	col. 8/9
1	2	3	4	5	6	7	8	9	10
A	1.437	1.127	1.28	2.460	2.000	1.23	1.8369	1.5679	1.17
B	1.313	1.081	1.21	2.286	2.667	0.86	1.7616	1.6046	1.10
C	1.361	0		2.688			1.8566		
D	1.327	1.338	0.99	2.411	1.825	1.32	1.8281	1.5233	1.20
Temporary seed production stands Total	1.313	1.081	1.21	2.688	2.667	1.01	1.8373	1.5941	1.15
Patterns *Quercus robur/ Quercus petraea*	1.361	1.026	1.33	2.583	2.640	0.98	1.7941	1.6197	1.11

(V=28.71) exceed more than 5% of the coefficient calculated for *Quercus robur*.

To estimate factors which determine variability of characteristics of acorns the analysis of variance was used. Among factors influencing variability were: oak species, internal features of the particular trees. Results of F-test for the length, diameter and dry mass of acorns are presented in Table 6.

Table 4. Results of the measurements of the acorn mass (per 1000 acorns)

Species	Average mass of 1000 fresh acorns [g]	Average mass of 1000 dry acorns [g]	Maximum mass of 1000 dry acorns [g]	Minimum mass of 1000 dry acorns [g]	Interval of mass of 1000 dry acorns [g]
Quercus robur	4633	2592	4937	1054	3883
Quercus petraea	3380	1836	4796	835	3961
Quercus robur/ Quercus petraea	1.3708	1.4120	1.0294	1.2623	0.9803

Table 5. Variability coefficients for parameters of acorn size and mass

Stand – place of colection	V for length of acorns [%]			V for diameter of acorns [%]			V mass of dry acorns [%]			V slenderness of acorns [%]		
	Quercus robur	*Quercus petraea*	col. 2/3	*Quercus robur*	*Quercus petraea*	col. 5/6	*Quercus robur*	*Quercus petraea*	col. 8/9	*Quercus robur*	*Quercus petraea*	col.11/12
1	2	3	4	5	6	7	8	9	10	11	12	13
A	8.72	11.01	0.79	9.48	9.97	0.95	0	0	0	9.78	10.34	0.95
B	9.95	11.78	0.84	9.58	10.09	0.95	0	0	0	10.60	12.79	0.83
C	9.40	0		10.28	0		0	0	0	11.59	0.00	
D	8.98	13.21	0.68	11.07	12.25	0.90	0	0	0	10.28	6.63	1.55
Temporary seed production stands Total	9.41	11.71	0.80	10.49	10.37	1.01	0	0	0	11.01	12.24	0.90
Patterns *Quercus robur/ Quercus petraea*	10.81	12.0	0.90	9.51	10.85	0.88	23.42	28.71	0.82	12.58	14.32	0.88

Table 6. Analysis of variance of selected characteristics of *Q. robur* and *Q. petraea*

Source of variability	Degrees of freedom	Sums of squares	Mean squares	Expected values of mean squares	Level of influencon variability [%]	Critical values of F – test		F – test
						= 0.05	= 0.01	calculated
Length of acorns								
Species	1	4819.55	4819.55	1.89	17.37	4.04	7.19	17,68
Trees within species	48	13088.31	272.67	5.69	52.35	1.35	1.52	82.83
Acorns within tree	2350	7735.64	3.29	3.29	30.28			
Diameter of acorns								
Species	1	4.77	4.77	0	0	4.04	7.19	0.08
Trees within species	48	2915.59	60.74	1.48	55.19	1.35	1.52	50.67
Acorns within tree	2350	2816.94	1.20	1.20	44.81			
Dry mass of acorns								
Species	1	342.92	342.92	0.28	46.72	4.04	7.19	24.30
Trees within species	48	677.28	14.11	0.28	46.42	1.35	1.52	337.80
Acorns within tree	2350	98.16	0.04	0.04	6.86			

Results of calculation showed that the species influence the variability at the level of significance a=0.01 (46.72%). The dependence of the diameter on species is not found.

One of the major factors influencing variability of acorns seem to be the internal features of trees.

The variability of acorn characteristics of both species is illustrated on Fig. 6 and Fig. 7.

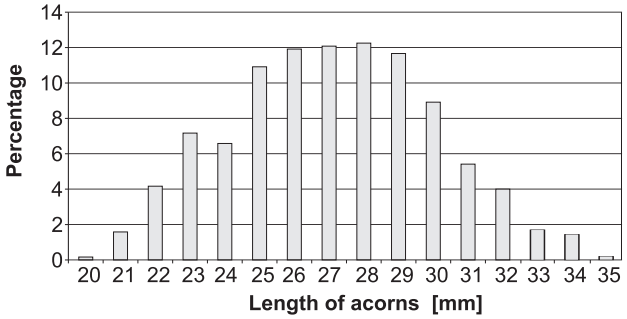

Fig. 1. Structure of the length of acorns (*Quercus robur*)

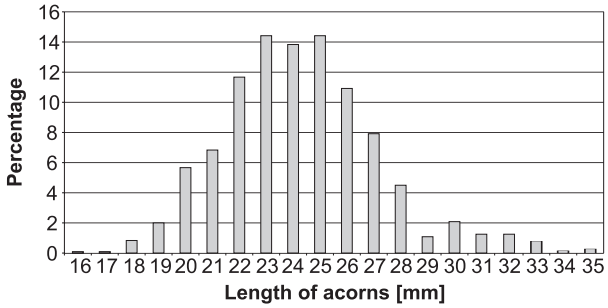

Fig. 2. Structure of the length of acorns (*Quercus petraea*)

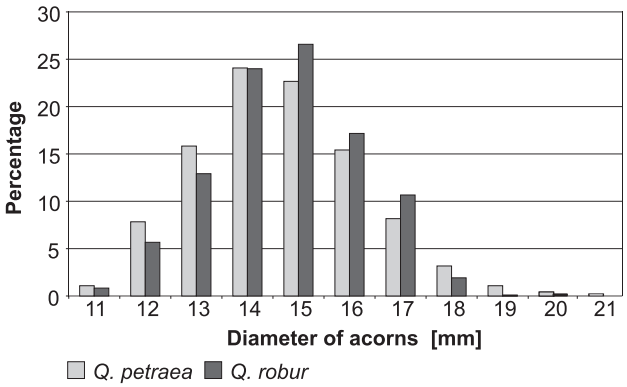

Fig. 3. Structure of the diameter of acorns (*Quercus petraea*)

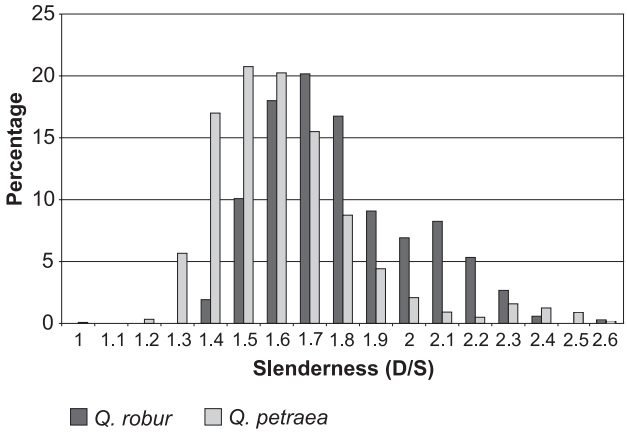

Fig. 4. Structure of the slenderness of acorns (D/S) *Quercus robur* and *Q. petraea*

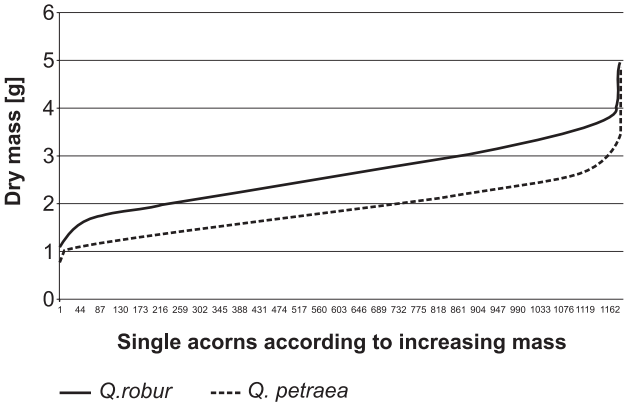

Fig. 5. Dry mass of acorns of *Quercus robur* and *Q. petraea*

Presented are groups of acorns from 8 trees of each species. The influence of the species and tree from which acorns were collected is stated. The percentage of acorns with a visiblegerm oscillated within the range of 0–40% (mean 20%) for *Q. robur* and 0–100% (mean 60%) for *Q. petraea*.

Fig. 6. The shapes of acorns from 8 trees of common oak (*Quercus robur*)

Fig. 7. The shapes of acorns from 8 trees of sessile oak (*Quercus petraea*)

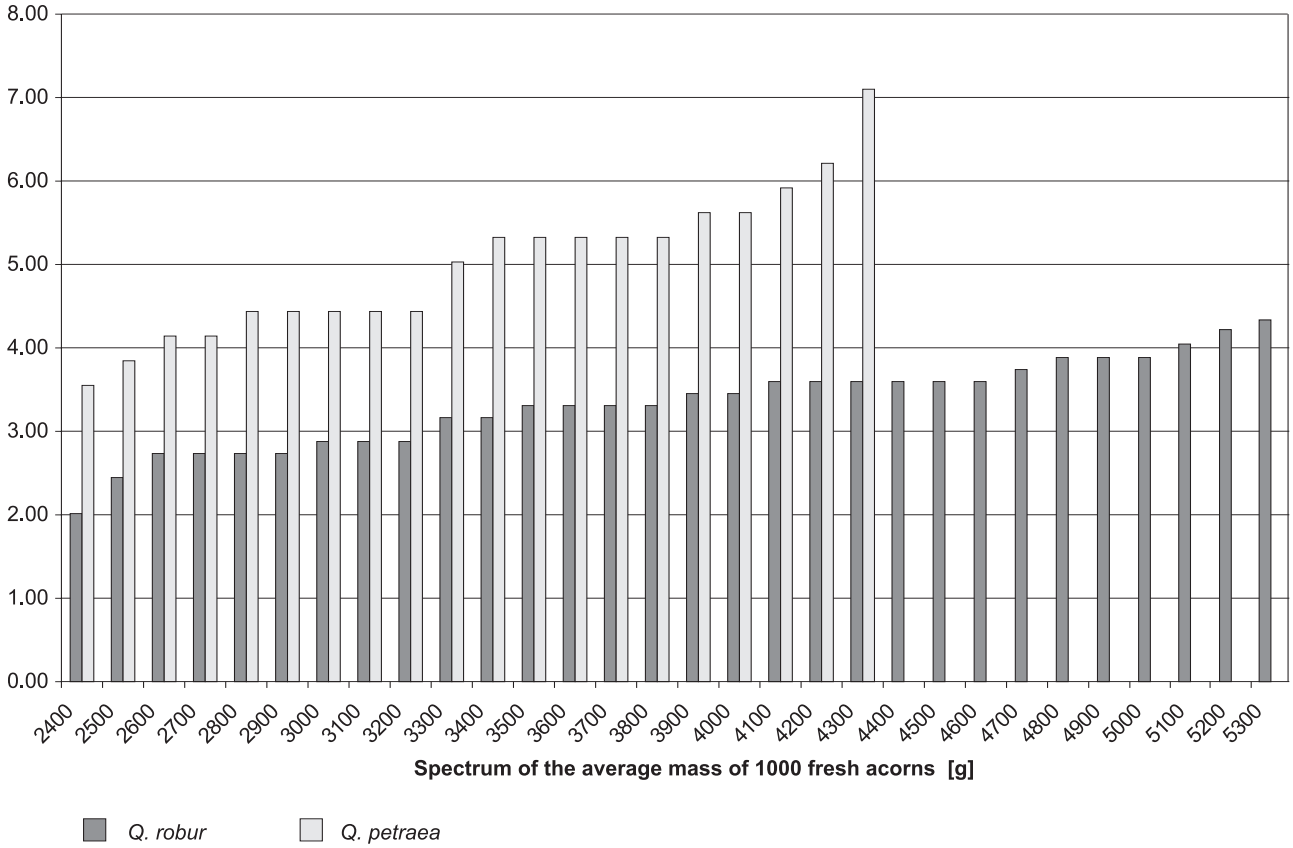

Fig. 8. Fresh mass of acorns of *Quercus robur* and *Q. petraea*

Discussion

Results basing on measurements and calculation confirm high variability of acorn sizes and their shape what is pointed out in literature. The recommended standards sowing density of acorns in the forest nursery, without differentiating the species (Tyszkiewicz, Obmiński 1963) differ even up to 100%. The average length of acorns equal 28 mm (Barzdajn 1994) was bigger (about 0.9 to 5.3 mm) than that presented here. Acorns of *Quercus robur* are longer than acorns of *Quercus petraea*. The statement of Shczepot'ev (1949) about the similarity of acorns of both species could not be confirmed, but in case of the diameter it is more clear. Average values for the diameter did not differ more than 2%. Elongated, cylindrical shape of acorns of *Q. robur* and more bulging, even round shape of acorns of *Q. petraea* described by Tyszkiewicz (1949) could be confirmed by calculated values of slenderness (D/S). His opinion about the similarity of acorns it the particular tree was not exactly confirmed. The mean difference in slenderness of the particular acorns of the same tree of *Q. robur* was 29% (extremely 54%). The greatest attention was paid by various authors to the mass of 1000 acorns. The average mass found author for fresh acorns was 12.7% bigger than described by Tochowicz (1951) for *Q. petraea* and 15.8% for *Q. robur*. Higher values of the mass were reached by *Q. robur*. This concerns especially data for the dry mass. The author observed a higher differentiation of the extreme values than Barzdajn (1994), who noted for this species the minimum and maximum values at the level of 1767 g and 4702 g, respectively. The dry mass of 1000 acorns of *Q. robur* outnumbers that of *Q. petraea* by 41%. Such a big difference between both species opens the question whether the 20% difference of sowing density standards recommended in silviculture principles is high enough. The coefficient of variability (V) for the described characteristics of acorns reaches the highest values for the dry mass, what was found also by Barzdajn (1994). Higher values of this indicator characterize acorns of *Q. petraea*. The analysis of variance for the length, diameter and dry mass of acorns allows to estimate the effect of the species and of individual trees on the characteristics.

The harvest of acorns was not the subject of this piece of research. However, in the above – mentioned year in the Forest District Choszczno, the harvest was said to be medium.

Conclusions

1. The variability of the dry mass of acorns is higher than the variability of their length, diameter and slenderness.

2. Fruits of *Quercus robur* are larger and heavier than acorns of *Q. petraea*.
3. The internal features of the individual trees influence highly the length, diameter and dry mass of acorns (from 46.4 to 52.3%).
4. The species of oak influences mostly the dry mass (46.4%) and length of acorns (17.4%).

References

Barzdajn W. 1993. Preliminary results of an experiment with Polish provenances of pedunculate oak (*Quercus robur* L.) and sessile oak (*Q. petraea* [*Matt*] Liebl). Ann. Sci. For.: 1–6.

Barzdajn W. 1994. Zmienność wielkości owoców dębu szypułkowego (*Quercus robur* L.) w Polsce [Variability of common oak acorn size in Poland]. Pozn. Tow. Przyj. Nauk Wydz. Nauk Roln. i Leśn. Prace Komisji Nauk Roln. i Komisji Nauk Leśnych 78: 6–13.

Goetz J. 1931. Zmienność owoców dębu szypułkowego (*Q. pedunculata* Ehrh.) [Variability of acorns of common oak]. Rocz. Pol. Tow. Dendrol. 4: 3–12.

Suszka B., Muller C., Bonnet-Masimbert M. 1994. Nasiona leśnych drzew liściastych – od zbioru do siewu [Seeds of Broadlived trees – from collection to sowing]. Wyd. Nauk. PWN, Warszawa–Poznań.

Shczepot'ev F.L. 1949. Dendrologia [Dendrology]. Goslesbumizdat Moskva–Leningrad.

Tochowicz H. 1951. Dąb [Oak]. PWRiL, Warszawa.

Tyszkiewicz S. 1936. Statystyka urodzaju, ocena wartości siewnej i normy wysiewu żołędzi [Crop statistics, estimation of sowing value and sowing standards of acorns]. Instytut Badawczy Lasów Państwowych, Seria A, Nr 18.

Tyszkiewicz S. 1949. Nasiennictwo leśne [Forest seed]. Inst. Bad. Leśnictwa, Warszawa.

Tyszkiewicz S., Obmiński Z. 1963. Hodowla i uprawa lasu [Silviculture]. PWRiL, Warszawa.

Zasady hodowli lasu [Silviculture principles]. 1988. PWRiL, Warszawa. Wyd. V.