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Cecilia Fărcaş

Morphological, physical and physiological changes during maturation and ripening of ash (*Fraxinus excelsior* L.) seeds

Abstract: The establishment of certain morphological, physical and physiological criteria was considered and this might allow us to determine more precisely the maturation degree as well as the optimum harvest and sowing period of seeds. The criteria for assessing the maturation degree of seeds presented earlier (the completely formed embryo, the prominent endosperm with a normal consistency) can now be completed with a new criterion, namely the one referring to the slight tendency of the seesds tegument to get yellow. This is due to the fact that the seed completes its growing sooner than the pericarp. The fact was proved both by the greater decrease the fresh mass of the pericarp than that of the seed and by the greater decrease of the moisture content of the seed than that of the pericarp during the four examined ripening phases.

Key words: embryo, genotype, maturation, pericarp, samaras

Address: The Research and Forest Management Institute of Brasov, Romania, *e-mail: seed@rdsbv.ro*

Introduction

Ash samaras harvested too early in autumn before reaching full maturation give poor results when sown immediately because of a great number of immature seeds. The seedlings do not emerge earlier than in the second spring. That is why we considered that it would be useful to establish morphological, physical and physiological criteria which might allow us to determine more precisely the maturation degree as well as the proper period of harvesting and of sowing the samaras in the same autumn, as it is done in the Romanian forest nurseries.

Seed origin

The samaras have been harvested from the Forest District of Brasov, Production Area V, Management Unity 8E (seeds reservation). The stand of natural origin is river meadow oak from the plain region mixed with European ash situated at an altitude of 500 m. The clay amphigleic soil could determine certain characteristics concerning seed dormancy. The average annual rainfall reaches 750 mm, during the vegetation season 435 mm. The average annual temperature is 6.8°C, during May–September 10°C and during October–April – 3°C.

Methods

The samaras were harvested from many individual trees, at different ripening phases (calendar data), in order to study the changes of the morphological characters during development and maturation, associated with certain relevant indicators such as: fresh mass, dry mass, moisture content and the elongation of the embryo.

Fresh mass, dry mass and moisture content were determined separately for the samaras, the seeds and the pericarps. For each variant we have analysed three replicates of 30 samaras, seeds and pericarps.

Moisture content of seeds was determined by drying them in a drying oven for 24 hours at a temperature of 105°C. The moisture content was expressed in percent of the fresh mass.

The length of the embryos and seeds was measured at digital positiometer.

In order to study the effect of the harvest date and of the stand as well as of the genotype on certain physical (fresh mass, dry mass) and physiological (moisture content of seeds) characters the components of variation were determined according to the calculation scheme proposed by Giurgiu (1972).

The determination of the significance of differences among means was established with the aid of the Duncan test at the confidence interval 95%.

The variation of the fresh mass of seeds according to the their moisture content was highlighted by the analysis of the correlation of the simple regression equations (y=a + bx).

Results

After the statistic calculation (ANOVA) of data we determined the variation components and their significance. These are presented in Table 1.

Considering data in Table 1 we can conclude that both the tree and the harvest date have a statistically significant effect (p=5%) on the fresh mass, the dry mass and the moisture content of seeds for most of the studied samaras, seeds and pericarps.

Table 1. The two factor analysis (tree x harvest date) of the variation of the fresh mass, of the dry mass and of the moisture content of samaras, of seeds and of the pericarps of ash, harvested from different trees at various ripening phases (calendar data)

Source of variation	Sum of Squares	Degrees of freedom	Mean square	F		
				Calculated	Theoretical	
					5%	1%
FRESH MASS (g)						
			a) samaras			
Tree	16.46	4	4.12	7.92**	3.26	5.41
Harvest date	16.28	3	5.43	10.44**	3.49	5.95
			b) seeds			
Tree	4.18	4	1.05	15.0**	3.26	5.41
Harvest date	2.04	3	0.68	9.7**	3.49	5.95
			c) pericarp			
Tree	3.71	4	0.92	4.38*	3.26	5.41
Harvest date	8.49	3	2.83	13.47**	3.49	5.95
DRY MASS (g)						
			a) samaras			
Tree	2.61	4	0.65	21.7**	3.26	5.41
Harvest date	0.12	3	0.04	1.3	3.49	5.95
			b) seeds			
Tree	1.16	4	0.29	48.3**	3.26	5.41
Harvest date	0.03	3	0.01	16.7**	3.49	5.95
			c) pericarp			
Tree	0.33	4	0.082	16.4**	3.26	5.41
Harvest date	0.02	3	0.007	1.4	3.49	5.95
MOISTURE CONTENT(%)						
			a) samaras			
Tree	509.48	4	127.37	5.04*	3.26	5.41
Harvest date	1399.90	3	466.63	18.47**	3.49	5.95
			b) seeds			
Tree	428.62	4	107.16	8.94**	3.26	5.41
Harvest data	962.47	3	320.82	26.76**	3.49	5.95
			c) pericarp			
Tree	646.95	4	161.74	3.68*	3.26	5.41
Harvest data	1929.44	3	643.15	14.63	3.49	5.95

When calculating the significance of the differences between objects and harvest phases (Fig. 1), we can notice that the fresh mass of seeds has decreased more slowly at the first harvest stages (insignificant differences) than that of the pericarp.

Studying the variation of the dry mass between harvest stages we can notice that its accumulation was greater for seeds (distinctly significant differences among certain harvest stages) than for the pericarp. The fresh mass variation shows that the pericarp has completed its development later than the seed. On the other hand dry mass accumulation in seeds diminished somehow the differences between the fresh mass of seeds found at different harvest stages.

The fresh mass of samaras has closely followed that of the pericarp taking into consideration the higher level of the latter.

As far as the moisture content is concerned we can notice that generally it has decreased intensively between the harvest stages, but more distinctly in the case of seeds than of the pericarps. This confirms the previous statement that the pericarp completes its development later than the seed. Studying the variation of the moisture content of samaras, of seeds and of the pericarps according to their fresh mass we have determined the existence of certain positive correlations statistically significant for all the studied objects (samaras, $r=0.9222^{*}$; seeds, $r=0.9953^{**}$; pericarp, $r=0.9927^{**}$).

The calculated regression equations:

$y=15.069x - 21.053$ (samaras),

$y=34.782x - 37.074$ (seeds),

$y=21.571x + 3.457$ (pericarp),

illustrate the fact that a reduction of the fresh mass of samaras, of seeds and of pericarps by 1 g, has been accompanied by a decrease of the moisture content of samaras reaching 15.1%, of seeds 34.8% and of the pericarp 21.6%.

Though at the first harvest date the moisture content of the pericarp has attained very high levels for all the investigated trees (62.5–69.9%), the moisture content of seeds was much lower (47.5–54.7%) and as we have previously found it continued to decrease from one harvest date to the other more distinctly

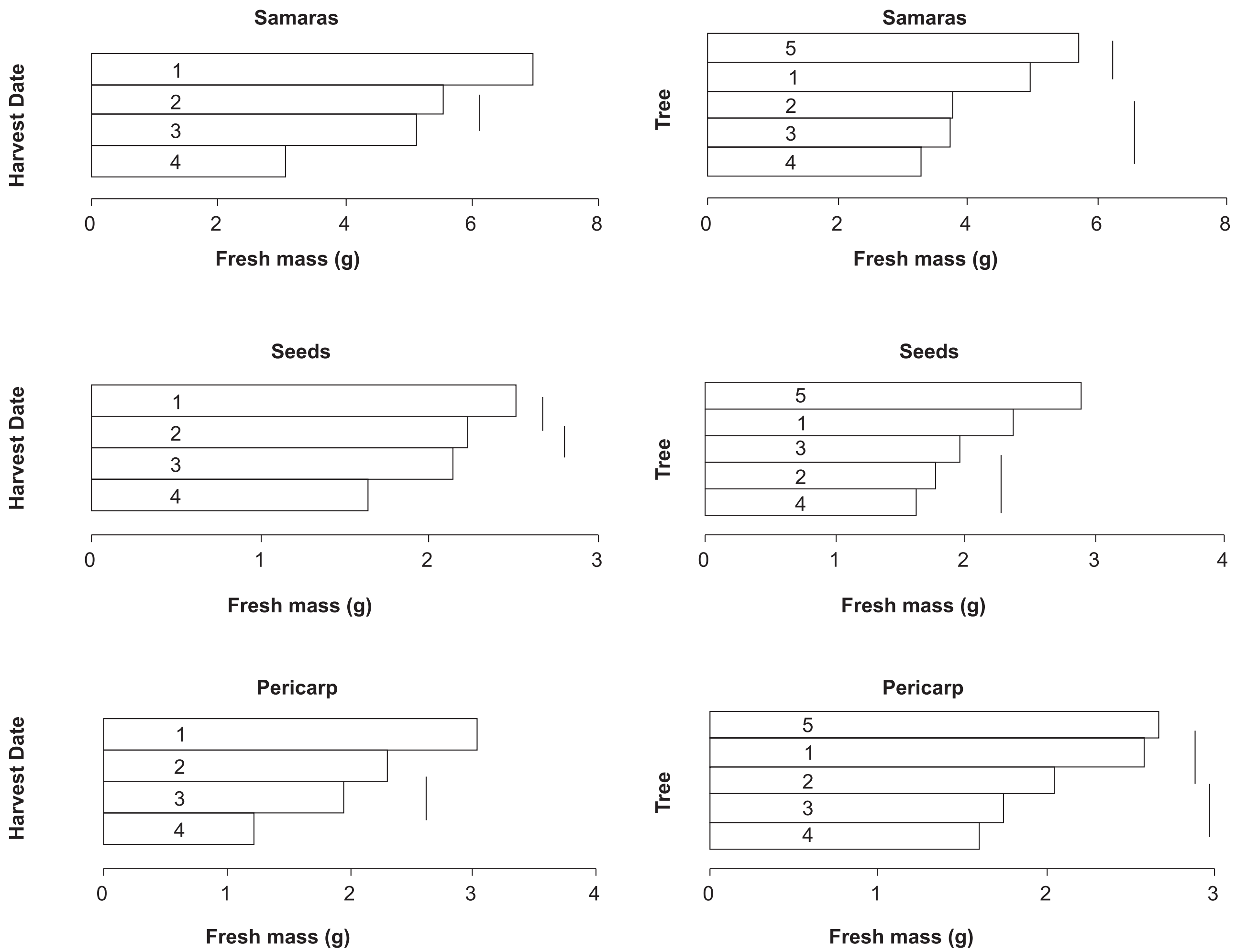

Fig. 1. The significance of differences of the mean values obtained for the fresh mass, the dry mass and the moisture content of ash samaras, seeds and pericarps, according to the harvest date and to the tree (Duncan test; confidence interval = 95%)

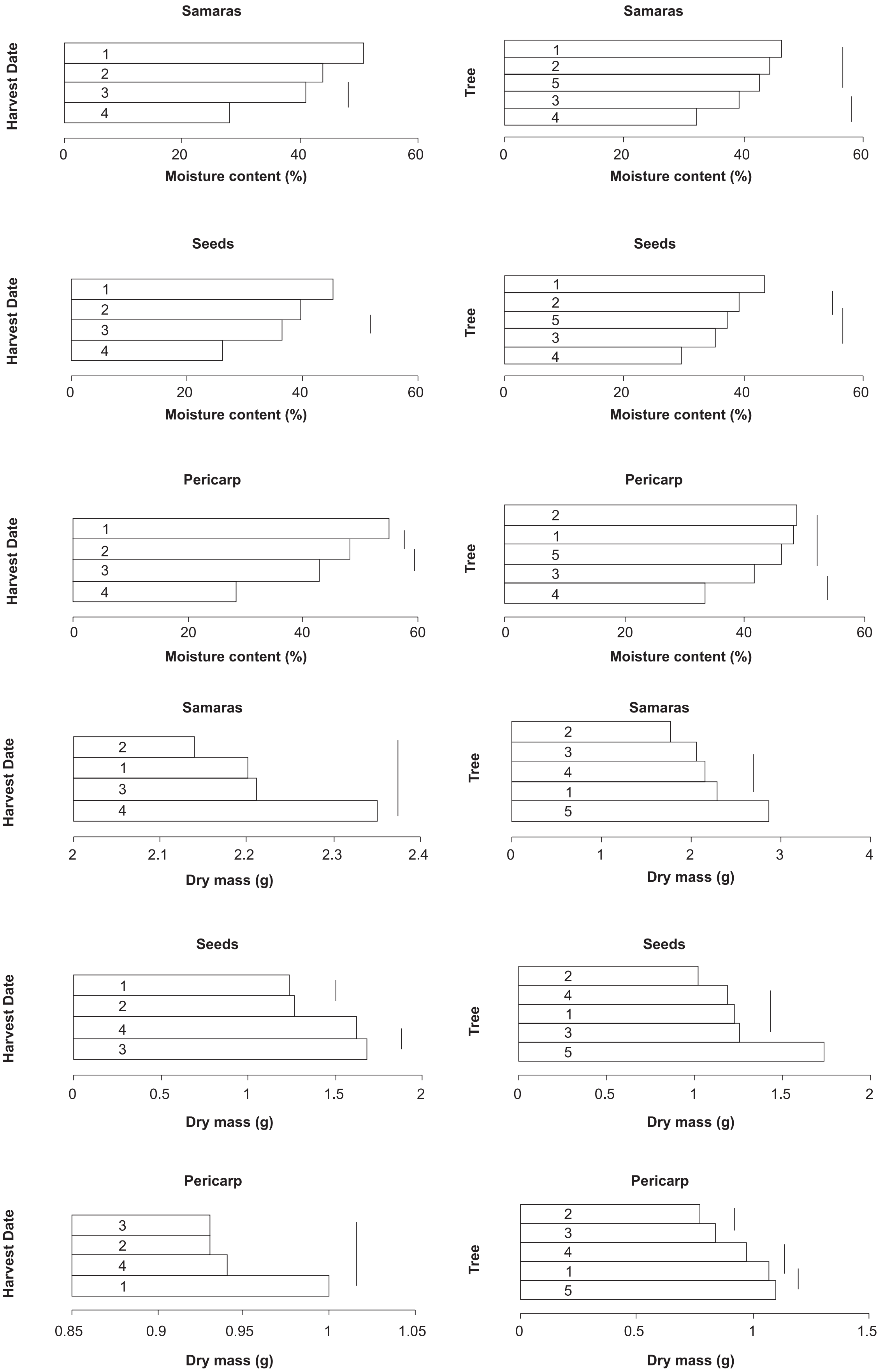

Fig. 1. (continuation) The significance of differences of the mean values obtained for the fresh mass, the dry mass and the moisture content of ash samaras, seeds and pericarps, according to the harvest date and to the tree (Duncan test; confidence interval = 95%)

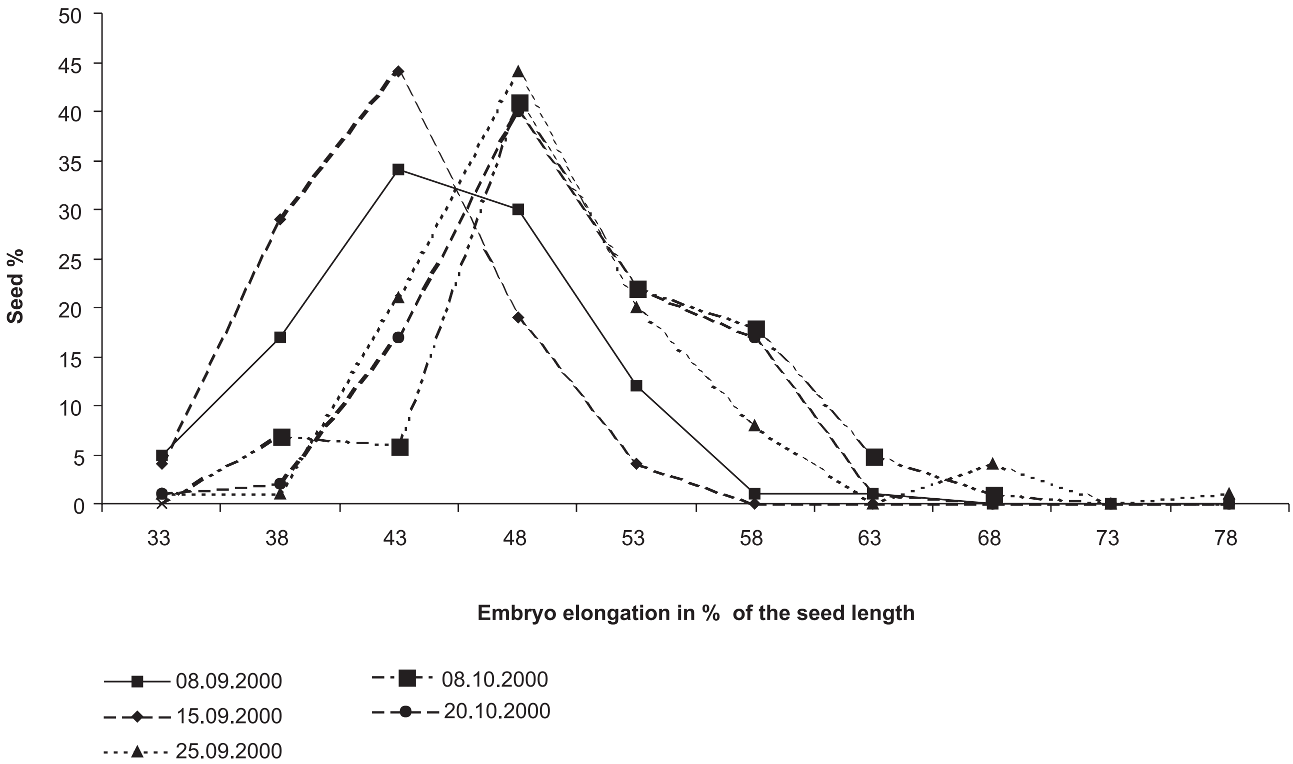

Fig. 2. The frequency curves of the elongation of the embryos in ash seeds, harvested at different ripening phases from a single tree

than the moisture content of the pericarp. The most intensive decrease of the moisture content of seeds was morphologically accompanied by an earlier change of the colour of seed tegument than that of the pericarp. The colour turned from green to yellow-brown and then brown. At a closer look we could observe through the semitransparent pericarp the darker colour of the seed tegument.

This criterion, together with those previously known (the formed embryo, the prominent endosperm of normal consistency (Ocskay et al. 1954) gives certain clues towards determining full maturation of seeds. Because seed maturation cannot occur simultaneously at all the trees producing fruits in the given year, there exists the possibility of choosing for the seed harvest an earlier date for those trees whose seeds are closer to the criteria presented here.

Concerning the differences among trees we can notice that generally fresh mass and dry mass of samaras, of seeds and of the pericarps were significantly different between trees 1 and 5 and all other investigated trees. It seems that these differences are mainly determined by the greater dimensions of samaras of trees 1 and 5.

As far as the moisture content of seeds is concerned it is significantly differentiated between trees 1 and 2 and trees 3, 4 and 5. These differences express the lateness degree (trees 1 and 2) or the earliness degree (trees 3, 4 and 5) of the trees as seed maturation is regarded.

The moisture content of the pericarp is much more homogenous. There exist significant differences only between tree 4 and the other investigated trees.

Concerning the elongation of the embryo, the measurements (Fig. 2) demonstrate that the embryo continued to grow up to 25.09. Afterwards it stopped its growth at a stage when the proportion between its length and the total length of the seed was 43–53%.

Conclusions

1. The criteria for appreciating the maturation degree of seeds presented earlier by Ocskay et al. (1954) – (the completely formed embryo, the prominent endosperm with a normal consistency – can now be completed with a new criterion, namely the one referring to the slight tendency of the seed tegument to get yellow.
2. All the criteria above are the result of the fact that the seed completes its growing sooner than the pericarp. This was proved both by the greater decrease of the fresh mass of the pericarp than that of the seed and by the greater decrease of the moisture content of the seed than of the pericarp during the four ripening phases.
3. The colour of the pericarp remains green for a long time and it cannot be considered a clue to the maturation of seeds.
4. Because maturation of seeds does not occur simultaneously on various trees producing fruits in a

given growing season, there exists the possibility of selecting for the earlier harvest trees with seeds closer to the criteria given above.

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