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## A study on the variation of morphological characteristics of silver fir (*Abies alba* Mill.) seeds and their internal structure determined by X-ray radiography in the Beskid Sądecki and Beskid Niski mountain ranges of the Carpathians (southern Poland)

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The variation of the morphological characteristics and internal structure of silver fir (*Abies alba* Mill.) seeds from 4 stands growing at the altitude of 625–750 m in the Beskid Sądecki and Beskid Niski mountain ranges of the Carpathians in southern Poland was estimated. Seeds were collected in the second half of September 2004. The weight of 1,000 air-dry seeds was determined and their viability was estimated with the use of X-ray radiography. The length and width of the embryo, endosperm and embryo cavity were measured on X-ray photographs. The morphological seed characteristics, i.e. length, width, volume, surface area, and wing colour (light-brown, brown, dark-brown, and cherry-red) were also included in the analysis. The statistically significant effect of the provenance on the parameters of the embryo, endosperm and embryo cavity as well as on the occurrence of full and insect-attacked seeds was found. The weight of 1,000 seeds was below 55 g which is considered to be a long-term mean for silver fir in Poland. It was positively correlated with the length and width of the embryo, endosperm and embryo cavity as well as with the degree of filling of the embryo cavity with the embryo. The weight of seeds was also positively correlated with their length, width and surface area. It was found that the wing colour was correlated with the weight of 1,000 seeds as well as with the proportion of insect-attacked and empty seeds. The proportion of seeds with brown wings was negatively correlated with the weight of 1,000 seeds and numbers of full seeds, while it was positively correlated with numbers of seeds infested by insects and empty seeds. The occurrence of light-brown and cherry-red wings was associated with a high proportion of full seeds. The results of the correlation between seed parameters and selected characteristics of test trees indicated statistically significant relationships. A positive correlation was found between the proportion of full seeds and the height, crown shape, dbh, and bark thickness of trees while the correlation between these tree characteristics and the proportion of insect-attacked seeds was negative.

**Keywords:**

*Abies alba*; X-ray; seed viability; internal seed structure; seed morphological characteristics; Carpathians

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