DIFFERENCES IN NITROGEN AND PHOSPHORUS CONCENTRATIONS IN THE WHOLE GRAIN OF *AEGILOPS* AND *TRITICUM* SPECIES

Putnik-Delić Marina[1], Maksimović Ivana[1], Kastori Rudolf[1], Milan Mirosavljević[2]

[1]University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, Novi Sad, Serbia,
[2]Institute of Field and Vegetable Crops, Novi Sad, Serbia
putnikdelic@polj.uns.ac.rs

Abstract

This study examined the accumulation of nitrogen (N) and phosphorus (P) in the grain of *Aegilops* and *Triticum* species bearing different genomes (AA, BB, BBAA, BBAADD and DD). Twenty different genotypes were included in a two-year field experiment. The highest concentrations of N and P were found in the grain of *Aegilops* and lower in modern cultivated *Triticum* genotypes. There was a negative relationship between N and P concentrations in the grain and in thousand-grain weight (TGW).

Introduction

Wheat is one of the most important cultivated plants, since it covers the the largest area harvested worldwide, at just over 219 million hectares (in 2022), and it is one of the basis of human nutrition. The increase in yield in the modern common hexaploid wheat has been accompanied by a reduction in the content of important nutrients proteins, minerals, vitamins, etc. (dilute effect) in the grain, with negative consequences for its nutritional quality. This can be remedied by biofortification - cultivating wheat genotypes with higher nutrient accumulation in the seed (Biel et al., 2021). This has led to interest in the wild diploid *Aegilops* species which are less productive, but have a grain of higher nutritional value. The knowledge of the genetic variability of wheat grain nutrient content is important for the success of developing new wheat cultivars with nutrient-rich grain.

Material and methods

Six diploid genotypes of wheat with different genomes (BB, AA, or DD), five tetraploids (BBAA), and nine hexaploids (BBAADD) were used in the experiment. Among the diploid wheat, four were wild and one (*Triticum monococcum* var. monococcum) was a primitive cultivated wheat. Among the tetraploids, two genotypes were cultivated. All hexaploids were cultivated genotypes. This choice of genotypes allowed an evaluation of the variation of grain nitrogen and phosphorus accumulation ability in wild and primitive genotypes compared to modern wheat cultivars (Tab. 1).

The experiments were established on calcareous, gleyic chernozem. Nitrogen concentration was assessed by the method of Kjeldahl, phosphorus by the vanadate-molybdate method, and TGW in dry grains.

Statistical analyses of data were carried out using Statistica 14 software. All data were subjected to ANOVA and comparison of means was done using Duncan's least significant difference test. Relation between the concentrations of elements and TGW were analyzed by calculating correlation coefficients.

Table 1. Genotypes of *Aegilops* and *Triticum* species examined in the experiment

No	Species and subtaxa	Genome	No	Species and subtaxa	Genome	No	Species and subtaxa	Genome
1	*Aegilops speltoides* TAUSCH var. *speltoides*	BB (D)*	8	*Triticum turgidum* L. var. *rubralbum*	BBAA (RS)	15	*Triticum aestivum* L.	BBAADD (RUS)
2	*Aegilops speltoides* TAUSCH var. *speltoides*	BB (D)	9	*Triticum turgidum* L. var. *turgidum*	BBAA (RS)	16	*Triticum aestivum* L.	BBAADD (MEX)
3	*Triticum urartu* THUM	AA (RS)	10	*Triticum turgidum* L.	BBAA (D)	17	*Triticum aestivum* L.	BBAADD (D)
4	*Triticum monococcum* L.	AA (RS)	11	*Triticum durum* DESF. var. *pseudosalomonis*	BBAA (RS)	18	*Triticum aestivum* L. var. *aestivum*	BBAADD (F)
5	*Triticum monococcum* L. var. *monococcum*	AA (RS)	12	*Triticum spelta* L. var. *duhamelianum*	BBAADD (RS)	19	*Triticum aestivum* L.	BBAADD (AUS)
6	*Aegilops tauschii* COSS.	DD (D)	13	*Triticum aestivum* L. var. *lutescens*	BBAADD (RS)	20	*Triticum aestivum* L.	BBAADD (TR)
7	*Triticum dicoccoides* (KOERN) SCHWEINF.	BBAA (D)	14	*Triticum aestivum* L. var. *lutescens*	BBAADD (H)			

* In the brackets is the label of the country from whose collection the seeds were taken for the experiment

Results and discussion

The highest concentration of N and P was found in the wild *Aegilops speltoides* (BB genome) and *Triticum turgidum* L. (BBAA genome), whereas hexaploids had lower and similar values (Fig. 1 and 2). The TGW and grain morphology in wheat depend on genetic, ecological, and agrotechnical factors.

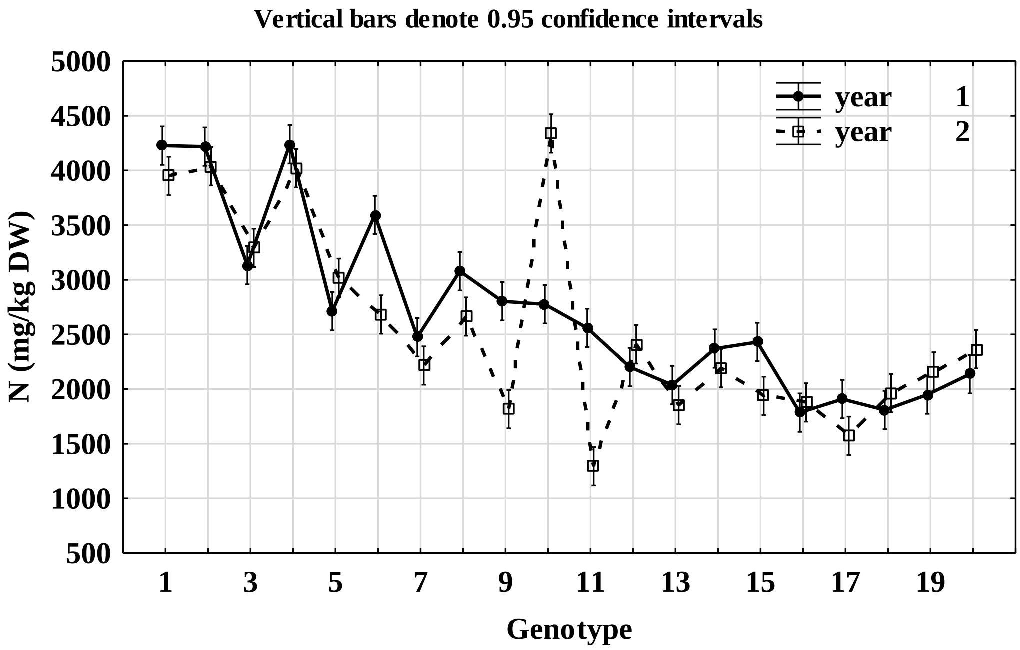

Figure 1. Nitrogen concentration of whole grains of *Aegilops* and *Triticum* species over 2 years

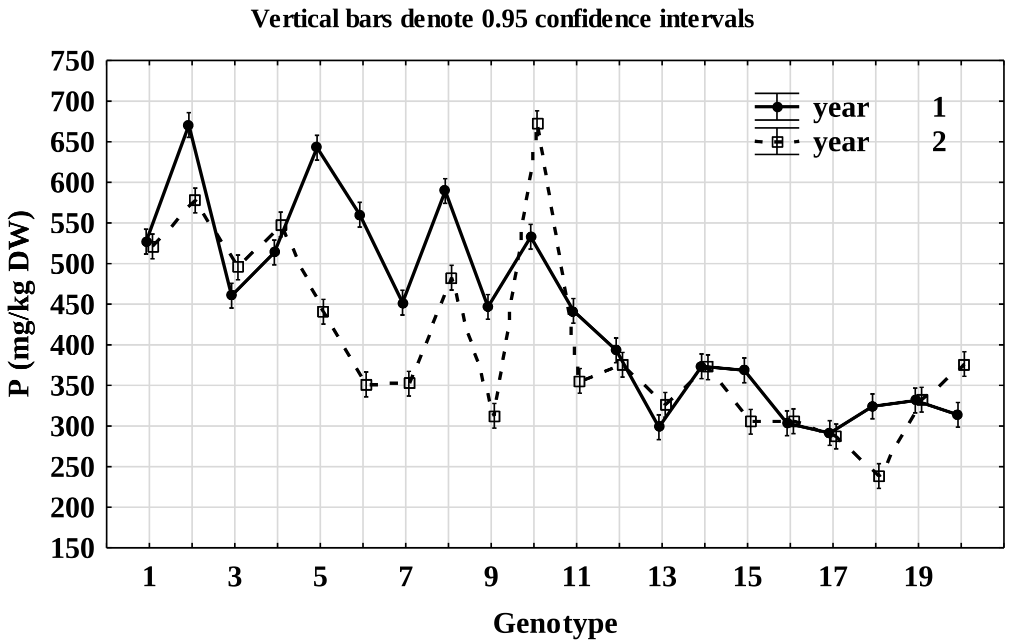

Figure 2. Phosphorus concentration of whole grains of *Aegilops* and *Triticum* species over 2 years

The TGW depends primarily on the grain size and to a lesser extent on its chemical composition. According to Simmonds et al. (2016), a splice acceptor site mutation in TaGW2-A1 gen increases TGW in tetraploid and hexaploid wheat through wider and longer grains. The TGW varied significantly among the examined genotypes (Fig. 3).

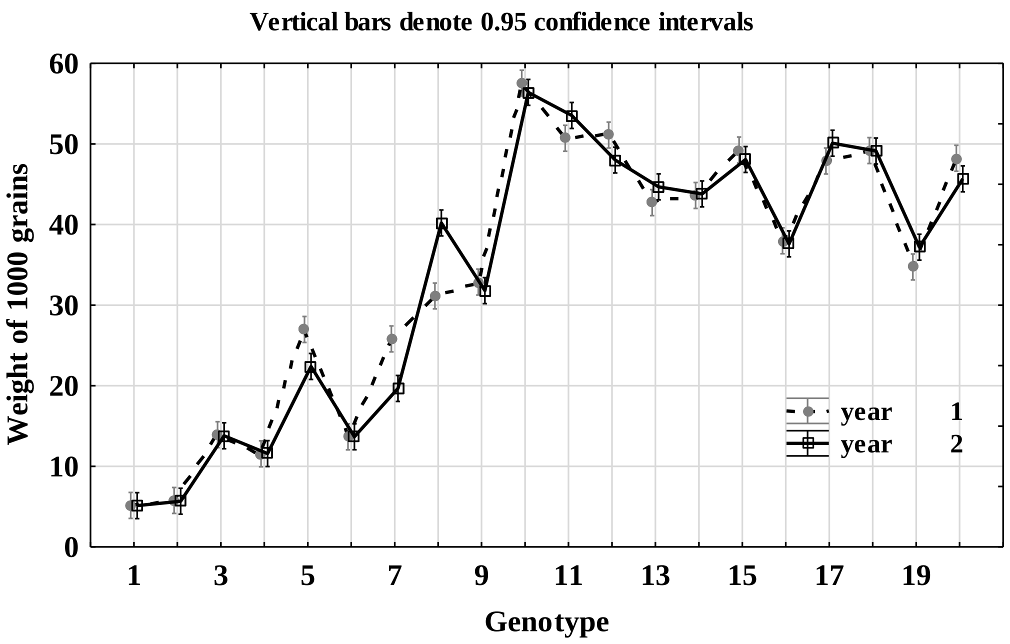

Figure 3. Weight of 1000 grains of *Aegilops* and *Triticum* species over 2 years.

It was the lowest in ancient diploid species, and the highest in cultivated hexaploid genotypes. There was a negative correlation between TGW and the concentration of N and P in grain (Fig. 4 and 5). The highest N and P concentration was found in grains of ancient species whose average TGW was the lowest.

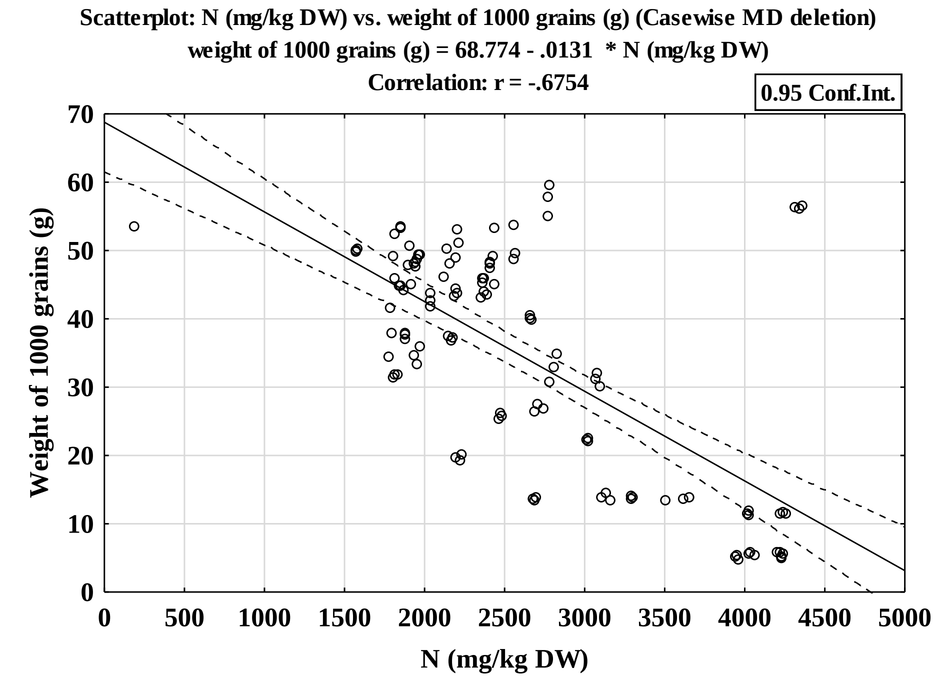

Figure 4. Relation between nitrogen concentration in whole grains of *Aegilops* and *Triticum* species and weight of 1000 grains over 2 years

The concentration of mineral substances in whole grains depends also on the ratio of the peripheral part (seed coat and aleuron layer) and endosperm because in wheat grains the mineral substances are concentrated in the peripheral part of the grain (Khalid et al., 2023). The smaller the grain, the greater the mass of the peripheral part in the total mass of the grain, which can contribute to a higher concentration of minerals in the grain as a whole.

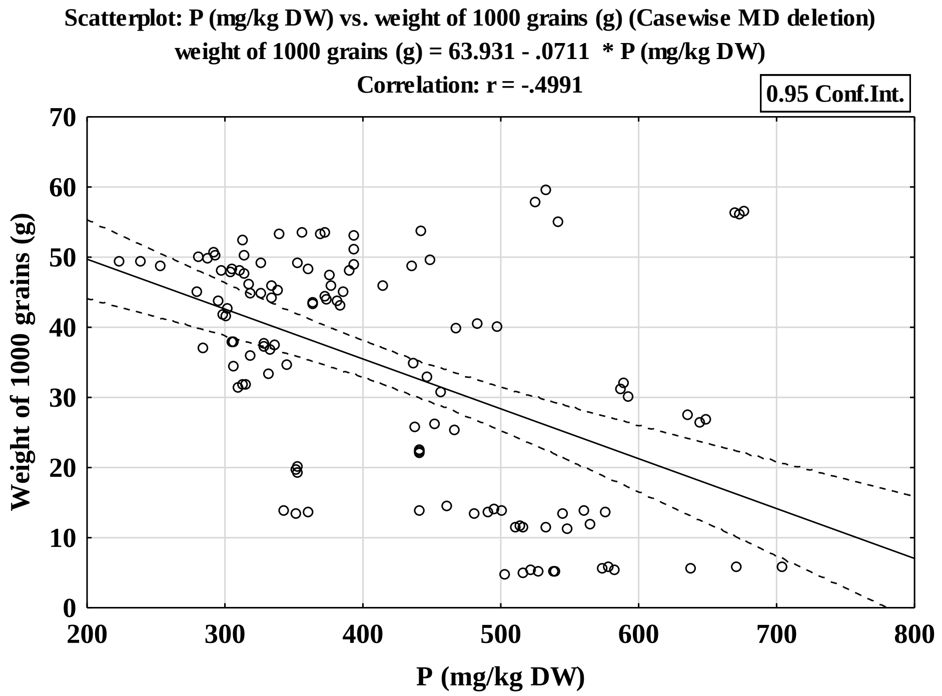

Figure 5. Relation between phosphorus concentration in whole grains of *Aegilops* and *Triticum* species and weight of 1000 grains over 2 years

Higher concentrations in smaller wheat grains were reported also for microelements (Svečnjak et al.,2013), aluminum (Maksimović et al., 2020), and iron (Kastori et al., 2021).

Conclusion

The analyzed *Aegilops* and *Triticum* genotypes differ significantly with respect to the N and P accumulation in grains, which can be used in breeding to increase its concentration in wheat cultivars. The highest concentration of N and P was found in the wild primitive diploid *Aegilops* species. The presence of lower N and P concentrations in the grains of tetraploid and hexaploid species with respect to diploid ancestors suggests that during the increase in ploidy and higher productivity, its concentration decreases (dilution effect). There was a negative correlation between N and P concentration in grain and TWG.

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