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THE SIGNIFICANCE OF HETEROSIS IN CABBAGE SEED PRODUCTION

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Abstract: In order to examine the importance of hybrid vigor - heterosis in the production of cabbage seeds, three cabbage hybrids (Scc x N, B x N, Scc x B) were created in diallel. The vernalization pathway of flowering was used in the ame to activate the flowering gene during the winter. Five traits of seed yield components were monitored: number of siliques per plant, seed yield per plant (g plant $^{-1}$), number of seeds per silique, seed yield per plant (g plant^{-1}), seed germination energy (%). The Scc x N hybrid, according to the calculated heterozoic values, proved to be superior in all characteristics, especially for the weight of seeds per plant with a value of relative heterosis Hr=113.42%, the number of siliques per plant 91.61%, as well as the energy of germination, which has a value of Hr=21.93%. The influence of heterosis on the increase in germination energy of hybrids compared to parents has been shown to be important information in plant breeding. In the case of the Scc x N hybrid, heterosis contributed to the achievement of the prescribed seed quality according to the ISTA rules as a condition for seed commercialization.

Keywords: cabbage seeds, heterosis, yield components, germination energy

Introduction

Seed production of *Brassicaca oleracea* is based on the activation of a special flowering mechanism that is blocked by FLC flowering repressor genes (Ahn et al., 2024). In order to overcome the influence of repression, it is necessary to expose the plants to positive low temperatures over the winter (Kang et al., 2022). FLC keeps the plant in a vegetative state, but under the influence of low temperatures, the expression of the FLC gene weakens and the plant at that moment activates the basic FT flowering locus - the vernalization pathway of flowering. In the morphological sense, in cabbage *Brassica oleracea* var. *capitata*

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L., after the wintering stage, in March, the head does not form, but the flower-branches and flowering-buds form (Adžić et al., 2020).

The use of heterosis in the selection of heterotic hybrids is the most frequently used classical method in plant breeding (Labroo et al., 2021). Heterosis represents a qualitative and quantitative improvement of the hybrid's traits compared to the parents' traits, and arises as a result of differences in the potential of genetic variability and divergence of homologous loci with additive effect (Gu et al., 2024).

Cabbage seed production in conditions of abiotic stress, most freezing winters, with prolonged frost, can be reflected in the structure of the plants and the quality of the features that make up the yield and yield components. The selection of lines with good combining abilities is one of the solutions that can reduce or eliminate abiotic stress and stabilize risky, in this case seed bioproduction (Das and Biwas, 2022).

This paper will present the characteristics and influence of heterosis on yield components and cabbage seed yield in three diallel-selected hybrids with three parental lines that are divergent in terms of geographic origin, length of the vegetation period, and morphological characteristics.

Materials and methods

Three stabilized genotypes were selected as initial material for diallel selection for parental genotypes: 1) Scc – genotype of mid-late white cabbage with a vegetation period of 135 days from seed sowing originating from central Serbia; 2) B – genotype of mid-late white cabbage, the length of the vegetation period is 130 days from sowing, originating from northeastern Bosnia and Herzegovina; 3) N – genotype of mid-early white cabbage, the length of the vegetation period is 100 days from sowing, originating from the Moscow region of Russia. Three hybrids were selected in diallel: Scc x N; Scc x B; B x N. Experiment of 6 genotypes were sown on September 1st and sown in an open field on October 20th according to a random block arrangement in three repetitions in three temperature-different seasons: S1 – average air temperature values in the period December-February; S2 – extremely low air temperatures during February; S3 – very high air temperatures during January compared to the average. A total of five traits were monitored: number of siliques per plant, length of siliques (cm), number of seeds per silique, yield of seeds per plant (g plant^{-1}), and germination energy (%). Ha – absolute heterosis calculated as the difference in the value of the hybrid trait compared to the parental average. Hr – relative heterosis calculated as the difference in the value of the hybrid trait in relation to the parental average, calculated as a percentage. The significance of the F1 hybrid in relation to the mean value of the parents was tested with the T-test (Begna, 2021; Jinks, 1954).

Results and discussion

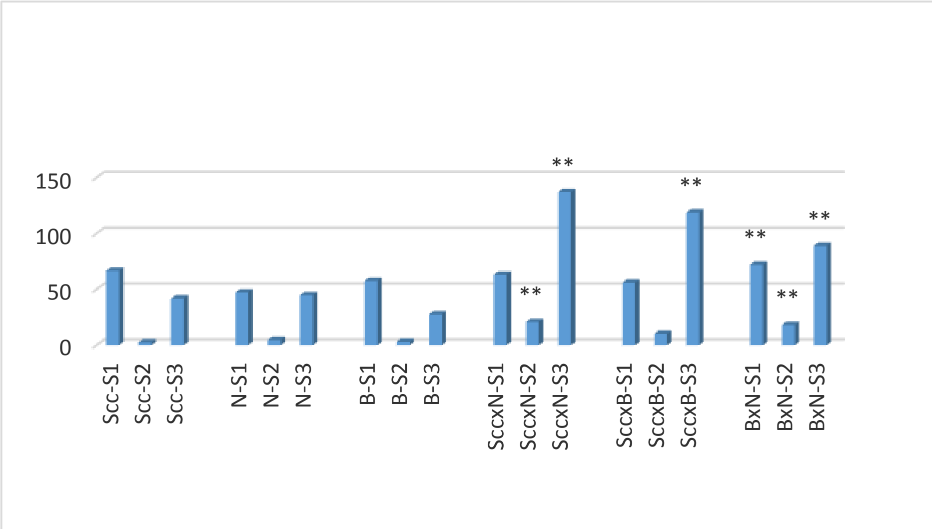
Based on the total values of heterosis, for all three research seasons, table 1, for all three experimental hybrids, high statistical significance was determined for the characteristics of silique length and yield of seed per plant (Sharie et al., 2002). In the Scc x N hybrid, a high statistical significance was found in the heterosis for the germination energy trait, and in the Scc x B hybrid, a statistical significance was found. In a practical sense, the energy of germination, according to the Ha value indicator - absolute heterosis, increased in the case of hybrids: B x N by more than 10%, hybrid Scc x B by more than 14%, and in the case of hybrid Scc x N by almost 22%. The increase in germination energy value in hybrids compared to parental genotypes represents an important fact that can be counted on when it comes to stabilizing the production of high quality seeds under different conditions of abiotic stress (Nelson et al., 2022).

Table 1. Heterosis and its significance for the tested traits

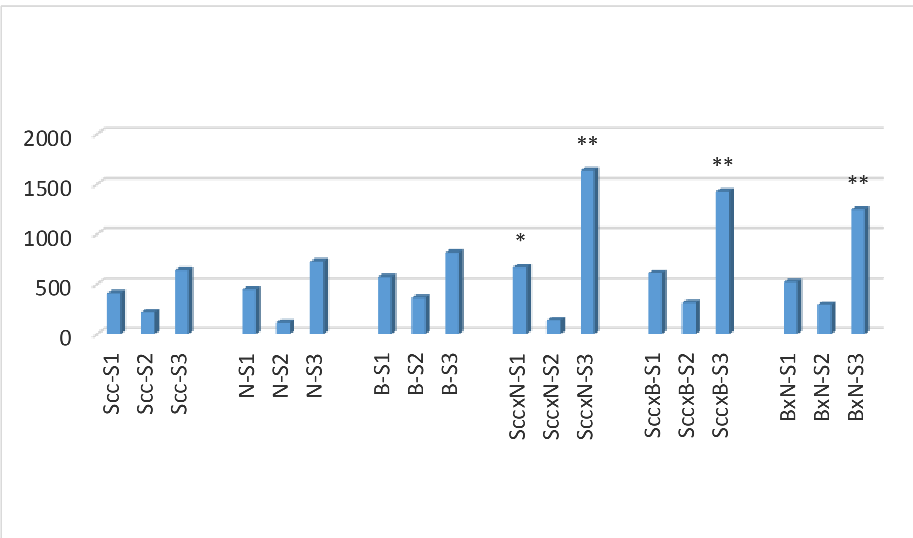
F1	Scc x N		Scc x B		B x N	
heterosis	Ha	Hr	Ha	Hr	Ha	Hr
siliques length (cm)	1.27**	18.52**	1.83**	28.52**	1.14**	17.04**
number of siliques per plant	389.72	91.61*	266.41	51.56	166.46	32.05
number of seeds per silique	5.5*	23.15*	4.49	19.14	3,,78	16.16
seed mass per plant (g plant^{-1})	39,12**	113,42**	26,94**	77.57**	27.25**	84.12**
germination energy (%)	14,89**	21,94**	9,87*	14,66*	6,98	10,3

Ha- absolute heterosis; Hr-relative heterosis (%); ** - p>0.01; * - p>0.05;

The increase in the values of the hybrid traits compared to the parental values, Graphs 1 and 2, showed a statistically significant increase in all three seasons of the test.



Graph 1. Seed yield per plant (g plant^{-1}) (** - p>0.01)



Graph 2. Number of siliques per plant (** - p>0.01, * - p>0.05)

Agroecological conditions or warm winter, had the effect that in S3 there was a statistically significant increase in the number of siliques per plant and thus the seed yield per plant in all three hybrids.

Above-average warm January in the S3 season enabled a natural decrease in the intensity of abiotic stress, i.e. the negative impact of low temperatures on the wintering of plants as well as the process of vernalization, which require positive low temperatures of 5-8°C continuously for 10-14 weeks (Wohlfeiler et al., 2022). In terms of value and statistics, the seed yield of hybrids, according to the value of relative heterosis Hr, increased by 113.42% in Scc x N hybrids, 77.57% in Scc x B hybrids, and 84.12% in B x N hybrids in relation to the values of the parental average, according to the value of the relative heterosis Hr. A significant characteristic of the hybrid vigor compared to the parents is that in the temperature-stressed S3 season, the two hybrids showed a statistically significant increase in seed yield per plant, which largely justifies the use of heterosis as a selection method in foreign-fruited plants from the Brassicaceae family and in cabbage, but especially in oilseed rape, all with the aim of increasing seed yield.

Conclusion

The use of heterosis in order to stabilize the production of quality seeds in the examined cabbage hybrids shows its justification through the increase in the value of the component properties and the yield itself in all agroecological conditions, thereby reducing the character of risky production.

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