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MULTIVARIATE ANALYSIS FOR HEAD WEIGHT AND YIELD PERFORMANCE OF EXPERIMENTAL CABBAGE HYBRIDS (*Brassica oleracea* var. *capitata* L.)

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This paper reviews characters of 18 cabbage genotypes (9 experimental hybrids vs 4 cultivars and 5 hybrids from the domestic commercial production). The experimental genotypes differed in head weight, growing season and yield performance. The analysis of variability of the characters was performed by the PCA method. The two characters selected by the scree test accounted for 57.7% of the variability. Based on

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head weight and yield performance, the tested hybrids were classified into two clusters that differed quantitatively.

Key words: experimental hybrids, clustering, cabbage, PCA analysis

INTRODUCTION

For intensive cabbage production it is necessary to have appropriate cultivars. Although the available domestic cultivars are suitable for fresh consumption and sauerkraut making, local growers prefer to grow foreign cultivars.

Process of breeding involves a comparison of experimental hybrids against commercial cultivars and hybrids. According to GOWERS (2000), emphasis should be placed in the breeding of cole crops on the uniformity of the desirable characters. Higher heterosis values can be obtained if our crosses include a higher number of lines with high GCA values. This would produce combinations with the largest number of desirable genes. The higher number of combinations exhibiting heterosis for the traits would enable the selection of cultivars with the best yield components and the correct choice of parents in developing F_1 hybrids with certain traits, (ČERVENSKI *et al.,* 2003).

Results of (TANAKA *et al,* 2009) suggesting that useful criterion for the selection of parents for early-head-forming F1 hybrid cultivars is the leaf position at which head formation start. They concluded that this trait is inherited additively with high narrow-sense heritability. The earliness of head formation is defined as the number of days after transplanting required for the head to attain the target commercial weight.

Similar research was done on the other vegetable crop-bean. When the breeding for a particular set of growing conditions, it is highly important to know and use the local populations, since in them the relationships among yield components are balanced and in harmony with the effects of the specific climatic and edaphic factors, (VASIĆ *et al.,* 2008).

The objective of this study was to compare the head weight and yield performance of experimental cabbage hybrids with those of commercial cultivars.

MATERIALS AND METHODS

Eighteen cabbage genotypes were tested in this study, 9 experimental hybrids and 4 cultivars and 5 hybrids from commercial production. The selected material was crossed in the course of 2004 and 2005. The trial was established at the experiment field of Institute of Field and Vegetable Crops in 2005, in five replications. Several characters were monitored in the trial, but this paper deals only with head weight and yield of heads. The obtained results were statistically processed by the multivariate analysis. PCA was used in order to establish total variability, i.e., which characters of the tested material were most variable. Genetic divergence of the tested genotypes was determined by the hierarchical clustering method, using Euclidean distance as a measure of distance since it reflects the best

the differences among the groups (KENDAL 1980, GVOZDANOVIĆ-VARGA, 2004). Experimental data were processed by the statistical package SYSTAT, modules CLUSTER and FACTOR (1986).

RESULTS AND DISCUSSION

Head weight is a major component of the yield of cabbage. In the study, the values of head weight of the experimental hybrids ranged from 1669 g (H15) to 2671.33 g (H7). The commercial cultivars were considerably more variable, their values of head weight ranging from 429.67 g (Elisa F1) to 2416.67 g (Coronet F1) (Table 1). Here it should be noted that the latter group included cultivars with different growing seasons, both early and late. This is important to mention because the early hybrids and cultivars have much smaller and lighter heads than the late ones.

In an earlier study, ČERVENSKI *et al.* (1998) found highly significant correlations between head weight and total yield. It was worthwhile to test the same characters in different plant material.

Table 1. Characteristics of experimental hybrids, commercial cultivars and commercial hybrids of cabbage

No.	Genotype	Head weight (g)	Yield (t/ha)
1	H1	1962.00	64.77
2	H3	2347.67	77.47
3	H5	2670.67	88.10
4	H7	**2671.33**	**88.23**
5	H9	1994.33	55.83
6	H10	2110.67	69.57
7	H13	1786.67	58.97
8	H14	2406.00	79.43
9	H15	**1669.00**	**55.10**
10	Ditmar-R	540.67	17.83
11	Prva žetva-R	1083.83	35.77
12	Elisa-F1-R	**429.67**	**14.20**
13	Nosomi-F1-R	543.67	17.97
14	Pructor-F1-L	823.33	27.17
15	Tucana-F1-L	864.67	28.53
16	Coronet-F1-K	**2416.67**	**67.67**
17	SM-10-K	1639.67	45.90
18	Futoški-K	2250.00	63.03

Large differences were also observed in yield performance. This was due to the fact that the study included early and late genotypes which differed in head weight. Among the experimental hybrids, the highest and the lowest yields were

achieved by H7 and H15, 88.23 t/ha and 55.10 t/ha, respectively. Among the commercial genotypes, the highest and the lowest yields were achieved by the cultivar Futoški and the hybrid Elisa, 67.67 t/ha and 14.20 t/ha, respectively.

On the ground of the experimental results regarding the yield performances of all early cabbage hybrids cultivated in field conditions, POSTA et al., 2006 concluded that yield is considered a genetic trait and depends on physiological and morphological characters, and the last being easier to evaluate. They also find that head weight was significantly correlated with efficiency and head volume.

In the PCA of the studied cabbage characters, the first principal component was yield (0.858) and the second was head diameter (0.840). Both characters were highly significantly and positively correlated (Table 2). TANAKA and NIIKURA (2003) analyzed the cabbage characters associated with head form and weight. The characters were then analyzed for correlations using the PCA. Their results for head weight are in agreement with the results from our study.

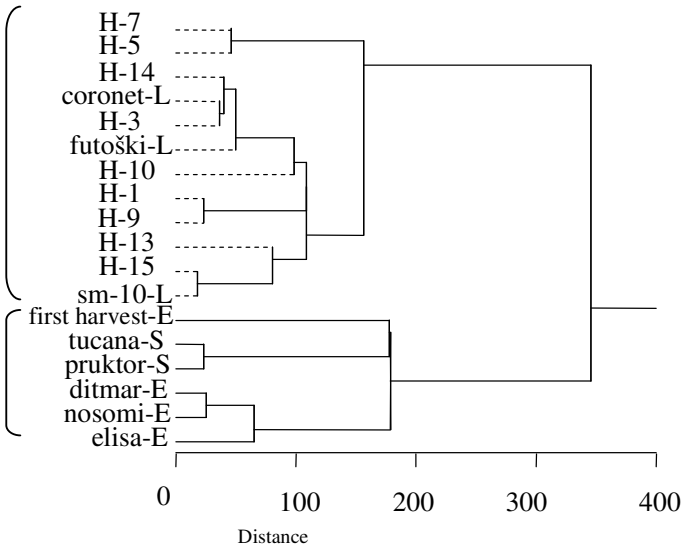
Table 2. PCA of cabbage characters

	PCA 1	PCA 2
Head weight	0.807	0.586
Usable part of head	0.793	0.607
Head diameter	0.541	0.840
Yield	0.858	0.506
Latent roots (eigenvalues)	2.311	1.674
% of total variance explained	57.76	41.86

To differentiate the experimental and commercial genotypes as clearly as possible, the method of hierarchical clustering was applied. The dendrogram in (Figure 2) clustered the genotypes on the basis of all characters under examination (head weight, usable part of the head, head diameter, yield). Two clusters were formed. The first included the experimental hybrids, two commercial cultivars (Futoški and SM-10) and one commercial hybrid (Coronet-F1). The second included the commercial hybrids and the other two commercial cultivars.

The dendrograms obtained on the basis of the PCA of four characters divided the tested genotypes in two clusters. The two clusters differed in the distances among individual genotypes. The upper cluster of the dendrogram (Figure 1) had a larger number of distances for the analyzed yield components, but these distances were not large. In the lower cluster, the number of distances was smaller but the distances were larger than those in the former cluster.

The differences in distance magnitude were attributable to differences in origin and growing season among the studied genotypes. Similar conclusions were obtained by ČERVENSKI *et al.* (2006) in a study that compared total head weight with the weight of the usable part of the head.



(E-early cabbage; S-spring cabbage; L-late cabbage)

Figure 1 Dendrogram of head weight, usable part of head, head diameter and yield

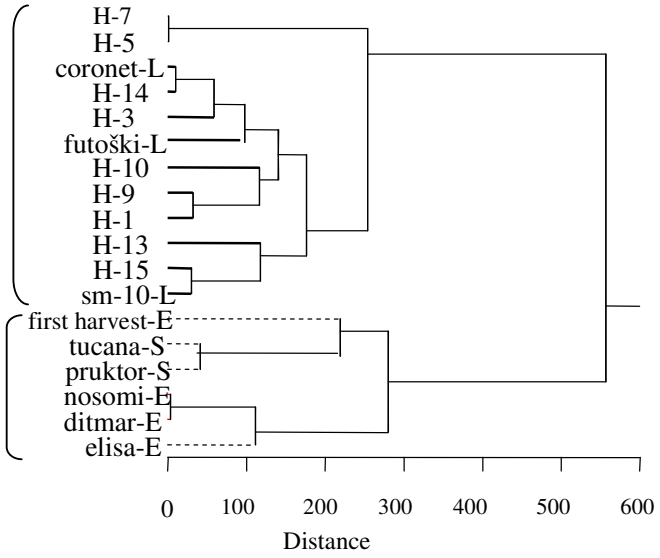
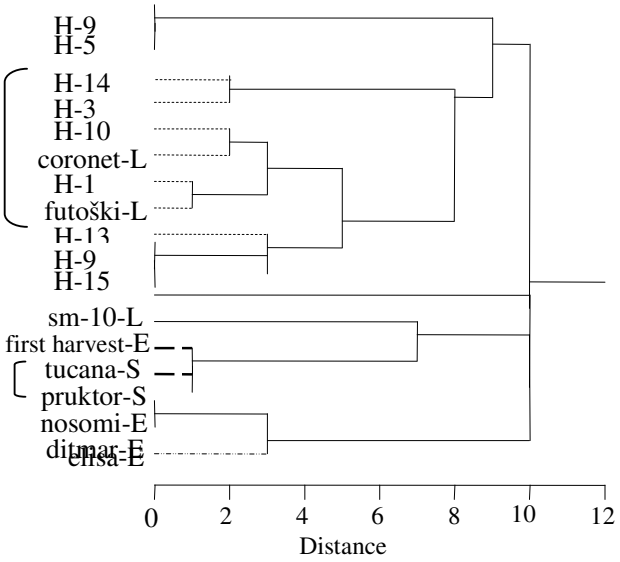


Figure 2.Dendrogram of head weight

The dendrogram of yield of heads consisted of four main clusters. The top cluster included all experimental hybrids, one commercial hybrid (Coronet) and one commercial cultivar (SM-10). The dendrogram was arranged according to yield level. The experimental hybrids in the upper part of the dendrogram had highest yields, the genotypes in the lower part had low yields (Figure 3).



(E-early cabbage; S-spring cabbage; L-late cabbage)

Figure 3. Dendrogram of yield

The dendrogram of yield of heads showed different distances between individual genotypes. Only a few hybrids had similar distances. This was due to the features of yield, which is a complex character which depends on other characters as well as on conditions of growing. As the experimental hybrids differed in both growing season length and head weight, the different distances could be expected.

CONCLUSION

The dendrograms for head weight and yield both had two clearly separated clusters. However, both the experimental hybrids and the commercial cultivars in these clusters differed mutually in distance length.

The dendrograms contained only a few small distances, which indicated the similarity of genotypes, or, possibly, similarities in crop cultivation and crop reaction to the conditions of growing.

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MULTIVARIACIONA ANALIZA MASE GLAVICE I PRINOSA EKSPERIMENTALNIH HIBRIDA KUPUSA (*Brassica oleracea* var. *capitata* L.)

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I z v o d

Masa glavice i prinos su najznačajnija svojstva ekonomskog prinosa kupusa. Tokom procesa oplemenjivanja ispituju se eksperimentalni hibridi u poređenju sa aktualno gajenim sortama i hibridima u proizvodnji. U ovom radu su prikazane karakteristike 18 genotipova kupusa, (9 eksperimentalnih hibrida, 4 sorte i 5 hibrida iz šire proizvodnje). Genotipovi kupusa u ogledu su različite mase glavice a samim tim i prinosa, obzirom da su i različite dužine vegetacije. Analiza varijabilnosti osobina vršena je PCA metodom, gde je na osnovu *scree* testa, odabrano dve glavne komponente kojima je definisano 57.7% varijabilnosti. Masa glavice i prinos su osobine na osnovu kojih su ispitivani hibridi razvrstani u kvantitativno različite grupe, čime su bliže određene njihove vrednosti.

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