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Full Length Research Paper

Local cabbage *(Brassica oleracea* var*. capitata* L.) populations from Serbian Province of Vojvodina

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In previous experiments, we were able to augment cabbages (*Brassica oleracea* L. var. *capitata* L.) with two new local open pollinated (OP) populations and one cultivar. The type of use indicated that these are cabbages with thinner and juicier leaves, which predisposes their heads for fine grating and also makes their leaves readily bendable and easy to roll up when pickled. The populations were collected in Vojvodina, North Province of Serbia, country located at the crossroads of Central and Southeastern Europe. Fresh cabbages are late-maturing white cabbages suitable for fresh consumption and biological fermentation. The third is a newly developed cultivar, bred by family selection. This cultivar has slight coloring by anthocyan that is red coloring of the head and rosette leaves. The fourth genotype in our trial was the local cultivar NS-Futoski. The morphological characters among OP populations were analysed by using principal component analysis (PCA). The first three principal components (PCs) gave Eigen values greater than 1.0 and explained 99.99% of the total variability among the cultivars and populations for all the traits investigated.

Key words: Cabbage, local population, head characteristics.

INTRODUCTION

Ecological and environmental diversity in Serbia and Montenegro, and various logographic and climatic characteristics make this area an extraordinary floristic resource, with great diversity of plant species and vegetables. This area is a centre for some vegetable species that are primary (Brassicae, lettuce, carrot, leek, beet) and for some secondary species (garlic), it (the area) is known as centre of domestication (Markovic et al., 2007).

Cabbage production in Serbia is carried out in an area of around 20,000 hectares, which is about 10% of the country's total acreage in vegetables- (www.rzs. stat.gov.rs). Old varieties and populations are grown alongside an increasing number of foreign culti-vars, which are slowly supplanting the former, resulting in genetic erosion. These evaluations could assist breeders to select and identify genotypes with desirable characterristics for inclusions in variety breeding programs.

Throughout the centuries, farmers have been the major keepers of genetic diversity. The extinction of traditional agro-farming systems, the aging and declining of rural population plus globalization and environmental degradation have led to the extinction of many landraces, (Koutsika-Sotiriou et al., 2010).

The tradition of growing cultivars and populations is primarily due to their intended use, which is fresh consumption, and sauerkraut making as well. In this way, local OP populations of cabbage or cultivars are specific to a particular cabbage-growing area (Cervenski et al., 1997). Cabbage and cabbage products are interesting from both marketing and dietary points of view because cabbage has many beneficial effects on health. From a traditional point of view, cabbage in the form of sauerkraut is one of the best known traditional foods (Jevšnik et al, 2009). As in other Eastern European areas (Luczaj and Szyman´ski, 2007; Pieroni, 2008), in Vojvodina, most vegetables are preserved for consumption during the winter via lacto-fermentation. Cucumbers, cabbages, tomatoes, turnips, and sometimes egg plants are harvested, stored in barrels of salt water, and left to ferment. On the other hand, the people of Vojvodina have retained a few traditions surrounding their use of local plant resources. Although, the available local OP populations of cabbage are suitable for fresh consumption

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and sauerkraut making, local growers prefer to grow foreign cultivars (Cervenski et al., 2010).

In order to determine the genetic variability of cabbage grown in Serbia for the purposes of breeding, efforts are under way to preserve the existing gene pool consisting of old varieties and populations. The objective of this paper was to study the diversity in four Serbian local OP populations of cabbage. The morphological characters among OP populations were analysed by using principal component analysis (PCA).

MATERIALS AND METHODS

Plant material and experimental design

The studied material consisted of 4 local OP populations of cabbage: Curuski cabbage, Deronjski cabbage, Futoski cabbage and Orion cabbage, which are suitable for fresh use in late season as well as for pickling, and with a history of having been grown in the country for more than 30 years now. Seeds were collected directly from growers (places are shown in Figure 1).

Trials were carried out on chernozem at the Rimski Sancevi Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad, Serbia, 45°19'N latitude and 19°50'E longitude, at altitude 79 m above mean sea level. The horizons in which most of the root system of cabbage develops are neutral in reaction and slightly calcareous. The soil has a medium supply of total nitrogen, an optimum supply of readily available phosphorus, and a high readily available potassium content (Vasin et al, 2002).

The trial was carried out over a two-year period (2006, and 2007), using a randomized block design with three replications. The experimental units for the late cabbage genotypes were plots 10.5 m^2 in size. Each plot had three rows with 30 plants in total (70 x 50 cm; 28500 plants per hectar). The varieties were grown from transplants in May 20. Throughout the entire period of growing the transplants, the plants were provided with optimal temperature and moisture conditions. The transplants were transferred into the open field in July 9.

Before the planting, the plots were fertilized prior to primary tillage using NPK (8:16:24) at 600 kg per hectare. During the season, the crops were top-dressed on two occasions, and they were protected from diseases and pests as well. After the transplantation, irrigation was applied. The crops were also irrigated in the course of the growing season on several occasions, depending on the soil moisture status and plant water requirements. The time and degree of head maturity were determined based on visual observation and head compactness. Thirty (30) plants were analyzed per replicate and genotype. The fifteen basic plant characteristics from the "Descriptors for Brassica and Raphanus"(IPGRI 1990) were studied: plant height (cm), plant diameter (cm), number of developed leaves, weight of total plant (kg), weight of head (kg), useful portion of head (kg), head stem length (cm), length of plant stem (cm), head length (cm), head width (cm), harvest index (weight of head/weight of total plant), head length/width ratio, head stem length/head length ratio, usable portion of head/ head weight ratio, yield (tons/ha).

The experimental field has a temperate continental climate with some specific characteristics, such as a wide interval between the highest and lowest mean monthly temperature (21.4°C in July and -1.3°C in January, respectively). In the Vojvodina Province (where the experimental field is located), the precipitation regime in general and the distribution of precipitation in particular are in part typical of those found in Central Europe/ the Danube region, that is there are extremely rainy periods in early summer (June) and periods with little or no precipitation (October and March) (www.hidmet.gov.rs.).

Statistical analysis

Trait variability analysis was performed by the PCA method, with the number of principal components being chosen based on the scree test (Kovacic, 1994). Hierarchical cluster analysis was used to determine differences and similarities among the genotypes, and the distance measure used was Euclidean distance as the parameter that best reflects differences existing among the genotypes (Kendall, 1980). Statistical analyses were performed using the Statistica program ver.9.1 (StatSoft, Inc., Tulsa, Oklahoma, USA).

RESULTS

The trial involved four local OP populations of cabbage (*Brassica oleracea* L. var. *capitata* L.) and 15 cabbage traits. The populations all came from a geographically narrow area, so we analyzed them together. The variability of each trait was expressed by standard deviation and the coefficient of variation. The lowest values of standard deviation were recorded in the cases of the head weight/total plant weight ratio (0.07) and the head length/head diameter ratio (0.07). The highest standard deviation value was that for yield (13.85). The coefficients of variation were the lowest for the ratio of the usable portion of the head to total head weight (3.39) and plant diameter (4.98). The highest variation coefficient values were those for yield (19.85) and head stem length (19.14) (Table 1).

PCA was applied to identify the traits which were the main source of the variability and to explain the genetic diversity among populations. PCA confirmed that the genotypes were highly variable. The first three principal components (PCs) gave Eigen values greater than 1.0 and explained 99.99% of the total variability among the cultivars and populations for all the traits investigated. The principal components analysis places focus on the variability of the first principal component. The first principal component explains as much as possible the variability of all traits. The first PC, which is the most important component, accounted for 50.22% of the total variability and was associated with plant height, plant diameter, number of developed leaves, weight of total plant, weight of head, head width, harvest index (weight of head) / weight of total plant and yield (Table 2). Our results are in agreement with those of Vasic et al., (2008), who named the first principal component of the yield component.

The second principal component explained most of the remaining variance (27.92%) and was associated with head stem length, harvest index (weight of head/ weight of total plant) and head stem length/head length ratio (Table 2).

The third principal component explained the rest of the variance, which was 21.85%. This principal component was associated with head length, head length/width ratio and usable portion of head/head weight ratio (Table 2). Eigen values, percent of total variance was explained and cumulative variation in our results are very similar with values of Koutsos et al. (2001), who analysed genetic

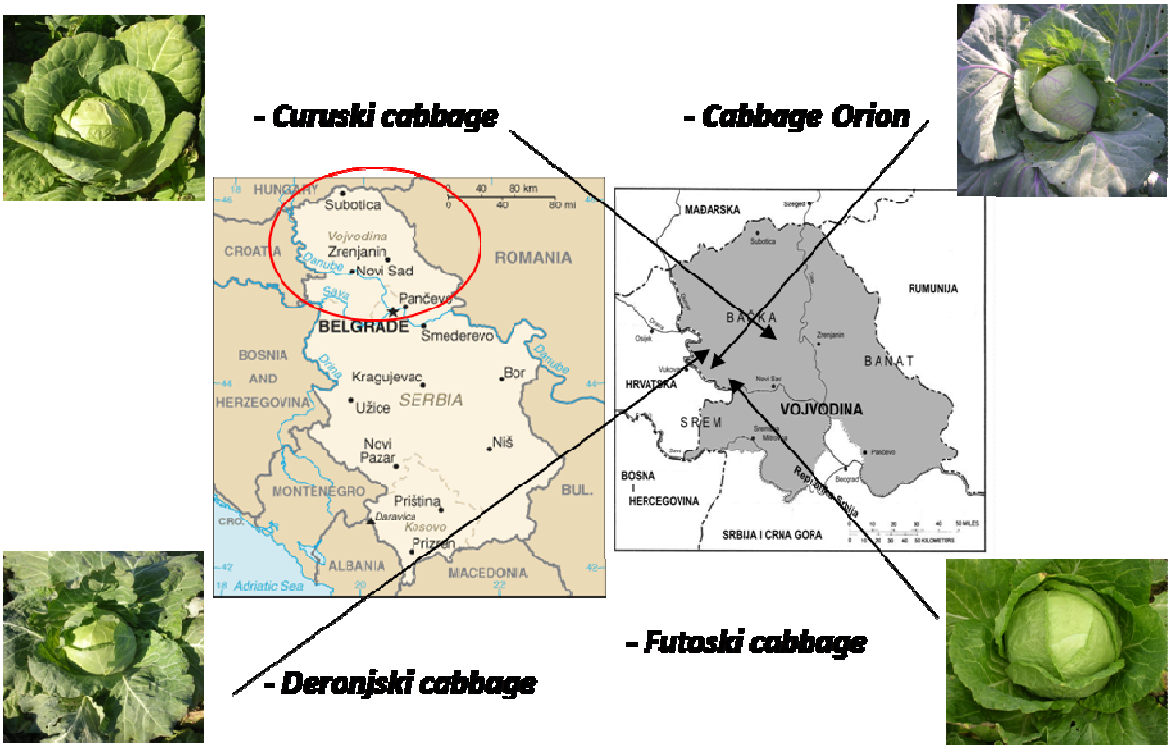

Figure 1. Local populations of white cabbage localize and collect in previous period

Table 1. Indicators of variability of cabbage traits studied.

Plant characteristic	Mean*	st.dev.	CV (%)	Min	Max
Plant height (cm)	24.66	1.53	6.20	22	26.9
Plant diameter (cm)	83.48	4.16	4.98	76.2	91.4
Number of developed leaves	13	0.78	5.87	12	14
Weight of total plant (kg)	3.10	0.40	12.9	2.57	3.89
Weight of head (kg)	2.26	0.32	14.16	1.83	2.29
Useful portion of head (kg)	1.83	0.26	14.21	1.52	2.34
Head stem length (cm)	9.09	1.74	19.14	6.9	11.84
Length of plant stem (cm)	10.2	1.86	18.24	7.58	13.47
Head length (cm)	17.27	1.30	7.53	15.93	19.9
Head diameter (cm)	20.28	1.17	5.77	18.9	23.13
Harvest index= Weight of head/weight of total plant	1.36	0.07	5.15	1.26	1.48
Head length/diameter ratio	0.86	0.07	8.14	0.77	1.00
Head stem length/ Head length ratio	58.65	8.02	13.67	47.5	69.29
Usable portion of head/ head weight ratio	80.42	2.73	3.39	76.39	85.36
Yield (tons/hectare)	69.76	13.85	19.85	55.5	98.1

*Mean, arithmetic mean; st. dev., standard deviation; CV, coefficient of variation; min-minimum value; max-maximum value.

diversity in four open pollination cabbage populations

A comparison of the traits and populations analyzed produced a graph with three distinct clusters of traits and two distinct clusters of populations. The first cluster of traits comprised total plant weight, head weight, the useful portion of head, the head weight/total plant weight ratio, and the head length/head width ratio. These traits have a great influence on the formation of yield and are cultivar-specific (Figure 1). The second cluster consisted of six traits that define the external appearance of the cabbage plant, namely plant height, head length, plant stem length, head diameter, head stem length, and number of developed leaves (Figure 1).

The third group incorporated the following traits: Yield,

Table 2. Principal component analysis of cabbage traits studied.

S/N	Plant characteristic	PCA 1	PCA 2	PCA 3
1	Plant height	0.816	0.421	0.396
2	Plant diameter	0.948	0.131	0.291
3	Number of developed leaves	0.707	-0.136	-0.695
4	Weight of total plant	0.940	0.226	0.255
5	Weight of head	0.992	0.104	0.069
6	Useful portion of head	0.930	0.119	0.347
7	Head stem length	0.191	0.952	0.239
8	Length of plant stem	0.199	0.894	0.401
9	Head length	0.542	0.397	0.741
10	Head width	0.824	-0.411	-0.390
11	Harvest index (Weight of head/ weight of total plant)	-0.717	0.696	-0.034
12	Head length/width ratio	0.080	0.600	0.796
13	Head stem length/ Head length ratio	0.060	0.986	0.155
14	Usable portion of head/ head weight ratio	0.425	0.198	0.883
15	Yield	0.992	0.098	0.076
	Latent roots (Eigen values)	7.534	4.188	3.278
	Percent of total variance explained	50.23	27.92	21.85
	Cumulative variation (%)	50,22	78,14	99,99

plant diameter, the usable portion of head/head weight ratio, and the head stem length/head length ratio. Based on the similarity of their traits, the populations were divided into two groups. The first consisted of the populations Curuski cabbage and Futoski cabbage, while the second incorporated Deronjski cabbage and the Orion cabbage (Figure 2).

DISCUSSION

Cabbage populations have been improved by farmers through mass selection for centuries. Their cultivation as a percentage of the entire cultivated area for cabbage is reducing. Compared with commercial hybrids, the local populations of cabbage are less productive and their heads lack uniformity and field durability, but they have thinner head leaves that are crisper and juicier. The type of use indicates that these are cabbages with thinner and juicier leaves, which predisposes their heads for fine grating and also makes their leaves readily bendable and easy to roll up when pickled. It is characteristics like those that give the local populations an advantage over hybrids (Koutsos et al., 2001). These populations of cabbages are a valuable genetic resource and should either be registered and released as commercial cultivars, after evaluation and selection, or conserved in the Seed GenBank for use in future breeding programmes (Balkaya et al., 2005). Morphological characterization is the first step in description and classification of genetic resources (Arslanoglu et al., 2011).

Landraces are open pollinated populations that have not been selected whereas commercial varieties are hybrids selected for head appearance, uniformity and production synchrony. In order to choose the best landraces to be included in breeding programs, differences among them are important. However, for characters related to crop uniformity (head appearance, days to harvest, and synchrony of production), commercial hybrids did better than landraces (Padilla et al., 2007). In addition to head mass, head shape is another major consideration in cabbage breeding, since the first thing in cabbage that customers see is the appearance of the head. These populations, all of different origins, represent a potential source of desira-ble gene combinations for future work (Cervenski et al., 2007).

To be useful for plant breeders, genetic resources must be characterized by morphological and agronomic traits (Martins et al., 2006). For this reason, there is need to collect, characterize and evaluate remnant local genotypes before they disappear (Balkaya and Ergun, 2008).

In conclusion, fresh cabbage from the production area of Vojvodina is a good raw material for fresh use and biological fermentation. The climatic and pedological characteristics of the typical and traditional production area favor the production of late cabbage cultivars, suitable for this purpose. New varieties with implanted genetic resistance for most important diseases are selected for special use, fresh consumption and proceeding. The main source of breeding for good quality traits such as taste, look, purpose were local populations. Their uses are mainly for preparing cooked meals or salads. Besides, conservation and maintenance of this valuable genetic material is necessary, because these populations are an important diversity source which could be used in breeding programmes. Based on the similarity of their traits,

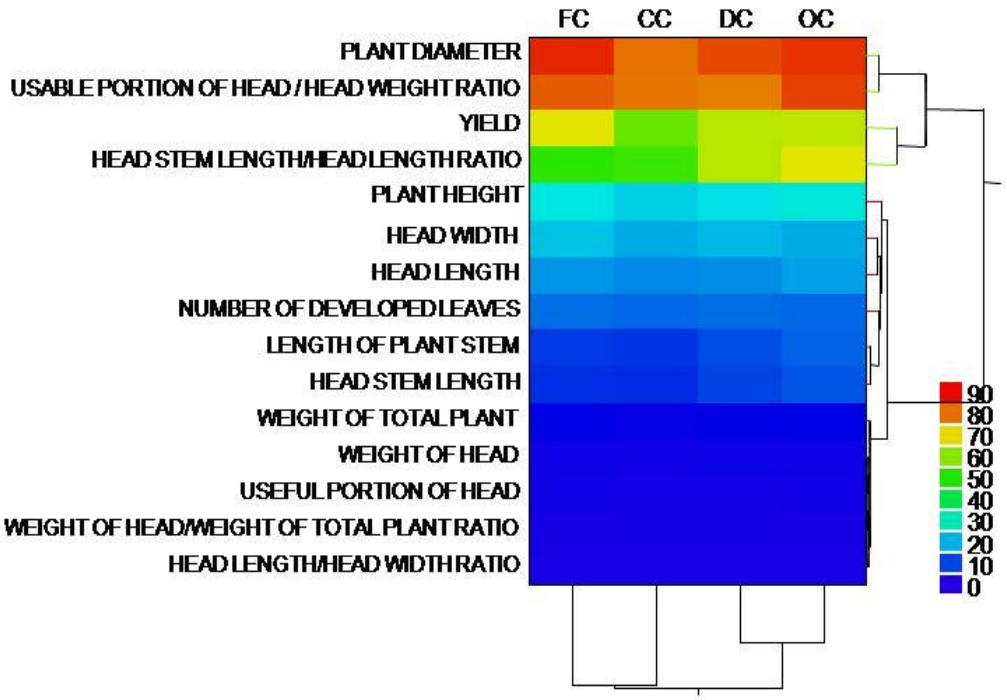

Figure 2. Hierarchical classification of OP populations and cabbage traits studied (FC, Futoski cabbage; CC, Curuski cabbage; DC, Deronjski cabbage; OC, Orion cabbage).

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