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Differences in growth and productivity between genotypes of common bean (*Phaseolus vulgaris* L.) and cowpea (*Vigna unguiculata* L.) in the Sadovo region of Bulgaria

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ABSTRACT

The study examined the differences between 10 accessions of common bean and cowpea during the vegetation period. Different stages of development and elements of yield were analysed in the climatic conditions of Sadovo (Bulgaria), which is characterised by hot summers and insufficient rainfalls. All genotypes were planted in the second 10 days of April. They emerged 10-15 days after sowing. The flowering stage occurred after 28-34 days in common bean and 45-60 days in cowpea. The vegetation period duration was much longer in cowpea (over 98 days) than in the common bean (less then 80 days). The reproductive organs (number of pods and seeds per plant, size of pods and seeds, weight of pods and seeds per plant) were quite different for the two crops. The mean number of pods per plant was 8.84 in common beans and 13.22 for cowpea; the number of seeds per pod was 4.05 for beans 10.56 for cowpea; the number of seeds per plant was 25.65 for beans and 93.47 for cowpea. The bean seeds were larger than the cowpea seeds, with 100-seed weights of 41.86 g and 15.73 g, respectively. Under the climatic conditions of Sadovo, the cowpea accessions showed a more stable yield, resulting in more pods and seeds per plant and weight of seeds per plant, when compared with common bean accessions.

Key words: genetic resources, morphological traits, principal component analysis, yield

INTRODUCTION

Climate change connected with global warming was predicted 20 years ago. It affects all spheres of the economy, as the most affected one is the agriculture and its production. The warming of the global climate places crops under conditions that are unfavourable for their development. Among legumes, beans are cultivated around the world. The common bean (*Ph. vulgaris* L.) is also more popular and traditional for Bulgarian people (Genchev and Kiryakov 2005). Landraces of common bean are grown almost all over the country (Ganeva 1983). Nevertheless, common beans are very sensitive to meteorological conditions. During vegetation, plants are subjected to high daytime temperatures and low air humidity, which leads to flower and fruit abortion. Cultivars not possessing good drought tolerance and better plasticity reduce their reproductive organs, and thus affect substantially yields. Cowpea is another legume crop, but it is not as common in Bulgaria. The only regions where it has been grown from time immemorial are the

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VERSITA

Svilengrad, Dimitrovgrad and Petrich regions mainly in the southern part of the country. Scientific evidence exists for its good drought tolerance. Our results from the national collections of common bean (*Ph. vulgaris* L.) and cowpea (*V. unguiculata* L.) at the Institute of Plant Genetic Resources in Sadovo (Berova et al. 2001 a, b) confirm this. The better drought tolerance of cowpea compared to common bean gives it an advantage and ensures a more stable yield.

The rational use of germplasm collections requires a good knowledge about their characteristics. Genetic diversity can be analysed statistically by several methods. Germplasm collections are traditionally characterised by morphological and agronomic traits that are of high interest for plant breeders.

The objective of this study was to morphologically characterise accessions from common bean (*Ph. vulgaris* L.) and cowpea (*V. unguiculata* L.) of different origin in order to show the most suitable plants for growing in the Sadovo climatic region, with high temperatures during the summer and very low air humidity.

MATERIAL AND METHODS

Ten genotypes from common bean (*Ph. vulgaris* L.) and ten from cowpea (*V. unguiculata* L.) were evaluated in the present study. The bean accessions were of different geographical origin: Nos. 91-064, 91-088, 91-089, 91-091, 91-102, 91-104 and 91-117 were from CIAT, Colombia; 93-012 from Hungary, 95-005 and Dobrudjanski 7 (St.Dobr.7) of Bulgarian origin. The cowpea accessions: Nos. 87-007, 87-052, 91-010, 95-017, 95-023, 95-045, 95-073 and 95-095 were from IITA, Nigeria, except for A4-007 and A4E-008, which were of local origin.

The experiment was carried out at the experimental field at the Institute of Plant Genetic Resources (IPGR), Sadovo, Bulgaria during 2006-2008. The meteorological conditions were characterised by high daily temperatures, as in May it was 31°C with 37.2 mm rainfall for the investigated period, in June the maximum temperature was 36.2°C with rainfall of 74.1 mm and during July the average maximum temperature was 31.5°C with 34.5 mm rainfall.

The field trials were carried out in a randomised complete block design in three replications. Each accession was grown in two-row plots. In each genotype, 10 plants per replication were randomly chosen for biometric measurements. Observations were made for 18 characters: days to flowering from sowing date, days to maturity, plant height, number of branches, height of the 1st pod, biological yield, weight of plant without pods, number of pods per plant, weight of pods per plant, pod length, pod width, number of seeds per pod, number of seeds per plant, seed length, seed width, weight of seeds per plant, weight of 100 seeds, weight of 1000 seeds. Sample evaluation was done according to the IBPGR descriptors of *Phaseolus vulgaris* L. (1982) and *Vigna unguiculata* L. (1983).

Data were analysed by numerical taxonomy techniques, using the NTSYSpc package, version 2.01 (Rohlf 1997). Principal component analysis (PCA) was applied using the standardised quantitative characters. Similarities among accessions were calculated using the average taxonomic distance; an unweighted pair-group method of the arithmetic average clustering procedure (UPGMA) was employed in order to present the results in the form of a dendrogram.

RESULTS AND DISCUSSION

The samples analysed and the results obtained from common bean (Fig. 1) and from cowpea (Fig. 3) enabled us to not only characterise but also to select the most interesting accessions in order to be included in a breeding program. PCA allows an opportunity to observe the distribution of the samples in two figures according to their parameters. In the principal component analysis of common bean, the two first principal components explained 51.8% of the total variation presented in the accessions.

Bean samples 93-012 and 95-005 were of special interest due to their high positive values along the first principal component (PC1) (Fig. 1). The accession 93-012 was characterised with a low value of days to flowering, a characteristic that was very important for grain legumes under abiotic stress factors (Stoilova 2007, Angelova and Stoilova 2009).

The minimum number of days to flowering was 28.00, which was the smallest of the observed accessions (Tab. 1). This is an advantage, as high temperatures and low air humidity during flowering and pod-forming stages may be avoided. This characteristic led to a higher number of pods and seeds, and finally to a higher seed yield. The accession with the early flowering stage was 93-012. The accession 95-005 possessed bigger seeds and a higher 100-seed weight as compared to the others (Fig. 1). The two characters with high importance for yield productivity, i.e. the number of pods and number of seeds per plant, were situated

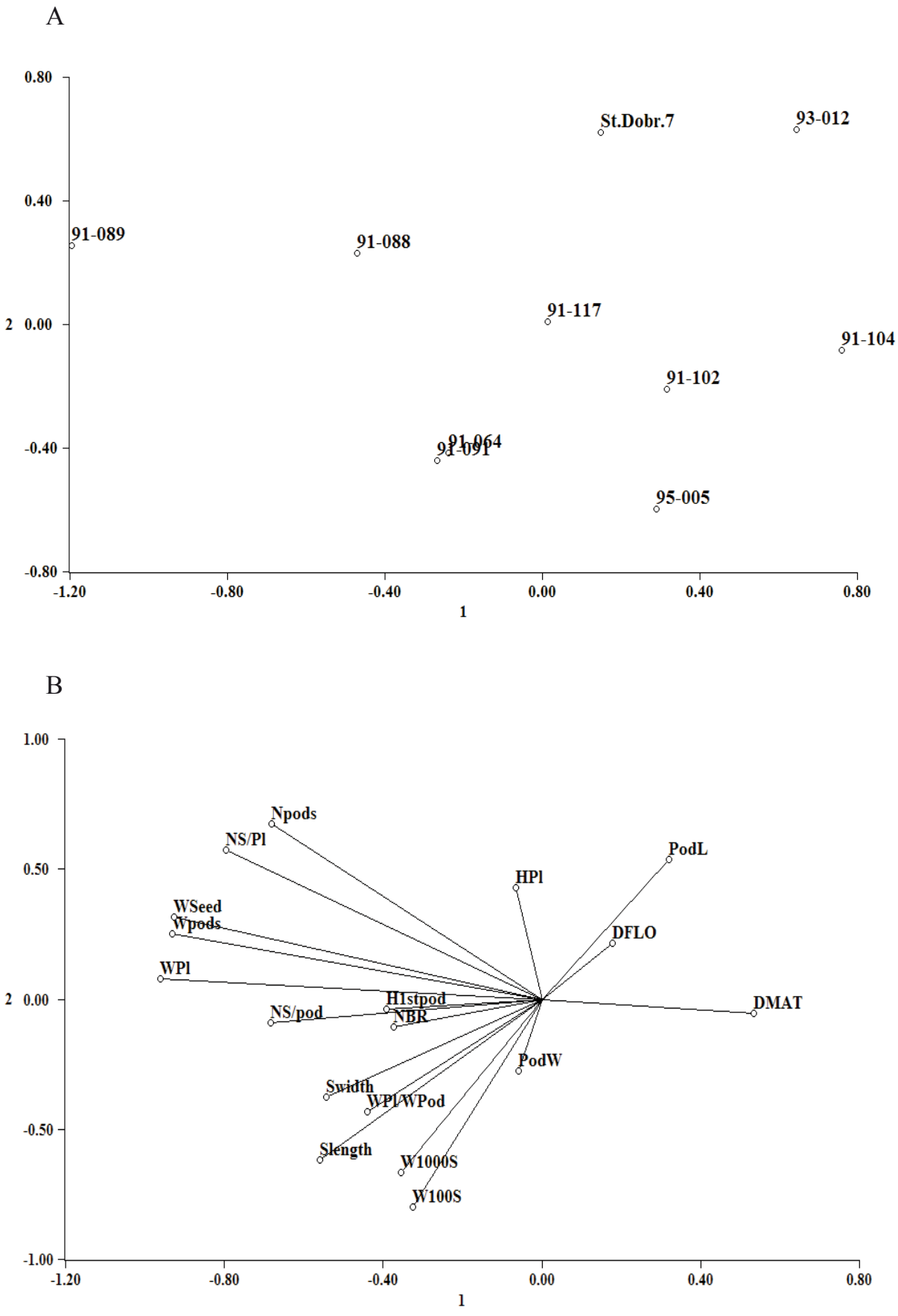

Figure 1. Principal component analysis (PC1 and PC2) of common bean accessions (A) using 18 quantitative traits (B)

Table 1. Trait characteristics of *Phaseolus vulgaris* L.

Variable	Abbreviation	Mean	Min	Max	CV (%)
Days to flowering	DFLO	32.03	28.00	34.00	5.1
Days to maturity	DMAT	79.63	76.00	103.00	10.4
Plant height (cm)	HP1	37.05	30.80	66.80	28.8
Biological yield (g)	WP1	19.33	15.40	24.50	14.5
Number of branches	NBR	2.34	1.60	3.10	20.5
Weight of plant without pods (g)	WP1/WP	5.04	3.50	6.00	14.9
Height of the 1st pod (cm)	H1stpod	13.14	9.30	18.60	23.9
Number of pods per plant	Npods	8.84	7.30	11.80	17.3
Weight of pods per plant (g)	Wpods	14.25	10.75	19.20	17.7
Pod length (cm)	PodL	0.93	9.50	33.50	7.6
Pod width (cm)	PodW	0.91	0.75	1.06	8.9
Number of seeds per pod	NS/pod	4.05	3.53	4.50	6.5
Number of seeds per plant	NS/Pl	25.65	19.50	36.50	20.0
Seed length (cm)	Slength	1.36	1.10	1.50	9.2
Seed width (cm)	Swidth	0.73	0.70	0.80	6.3
Weight of seeds per plant (g)	WSeed	10.05	7.50	14.30	20.1
Weight of 100 seeds (g)	W100S	41.86	35.70	48.40	9.9
Weight of 1000 seeds (g)	W1000S	367.44	315.40	441.70	11.5

closely and the accessions in this quadrant were 91-088 and 91-089. Accession 91-104 with a longer vegetation cycle was situated on the opposite side. On the lower central part of the graphic were 91-091 and 91-064 according to their seed length and seed width, weight of plant and weight of pods. The plants that were more productive, with a higher number of pods and seeds per plant, were those that had a shorter time to maturity.

The dendogram of common bean showed that accessions 91-088, 91-102, 91-091 91-117 and 91-064 were in one group; this means they had more similarity in some characters than in others, which showed big differences (Fig. 2). These results are in agreement with those obtained after PCA (Fig. 1).

These observations were completely different for *V. unguiculata* L.; this species was characterised with mean number of days to flowering ranging from 46.00 to 64.00 days, with low CV – 8.8% (Tab. 2). These plants began flowering and forming pods under high daily temperatures (higher than 32°C) and continue vegetation for 98.30 days (mean value)

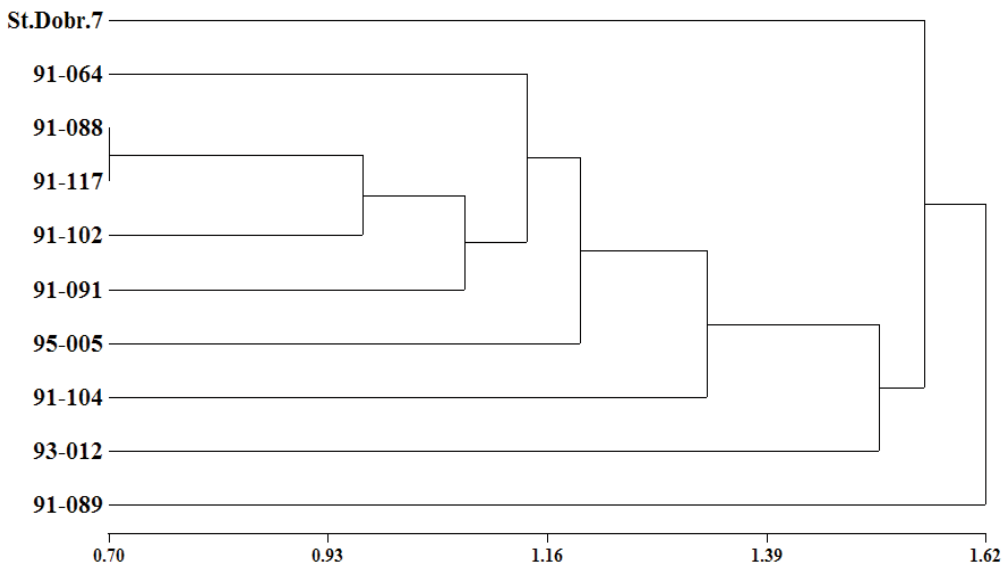

Figure 2. Dendogram of common beans obtained by cluster analysis

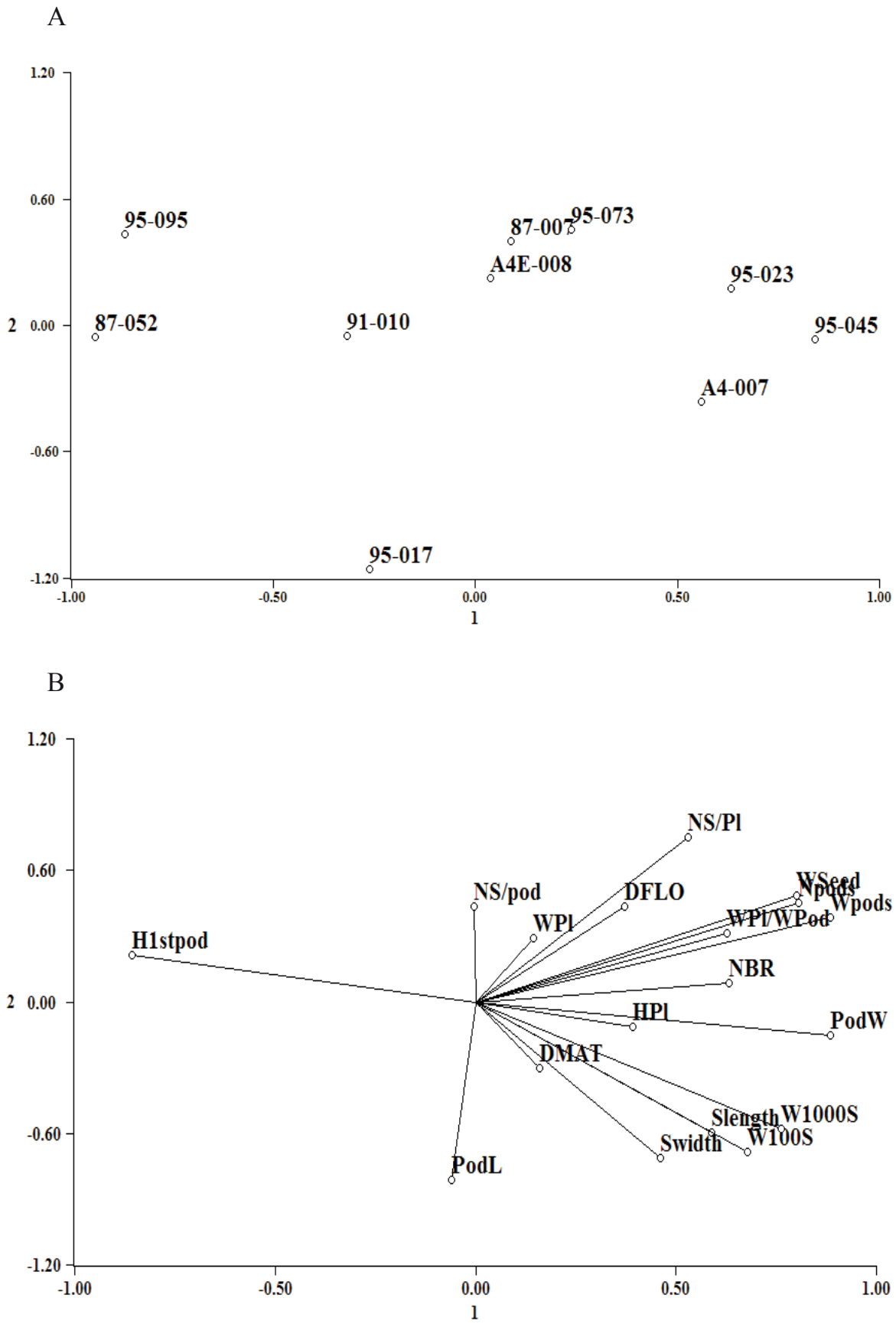

Figure 3. Principal component analysis (PC1 and PC2) of ten cowpea accessions (A) using 18 quantitative traits (B)

Table 2. Trait characteristics of *Vigna unguiculata* L.

Variable	Abbreviation	Mean	Min	Max	CV (%)
Days to flowering from sowing	DFLO	55.80	46.00	64.00	8.8
Days to maturity	DMAT	98.30	81.00	108.00	9.8
Plant height (cm)	HP1	84.16	62.30	103.10	18.5
Biological yield (g)	WP1	40.49	25.20	62.30	28.3
Number of branches	NBR	5.99	4.10	7.80	19.5
Weight of plant without pods (g)	WPl/WP	19.55	11.60	29.05	26.6
Height of the 1st pod (cm)	H1stpod	39.29	33.70	44.30	9.0
Number of pods per plant	Npods	13.22	7.60	17.00	25.2
Weight of pods per plant (g)	Wpods	17.08	7.80	26.70	34.0
Pod length (cm)	PodL	16.30	11.40	40.00	51.6
Pod width (cm)	PodW	0.74	0.60	0.83	11.7
Number of seeds per pod	NS/pod	10.56	7.70	12.10	12.0
Number of seeds per plant	NS/Pl	93.47	51.10	115.40	22.4
Seed length (cm)	Slength	0.82	0.70	0.95	11.1
Seed width (cm)	Swidth	0.59	0.50	0.70	12.7
Weight of seeds per plant (g)	WSeed	13.00	6.60	19.50	33.0
Weight of 100 seeds (g)	W100S	15.73	9.95	21.95	28.0
Weight of 1000 seeds (g)	W1000S	145.77	100.30	201.60	23.5

or more until the maturity stage. Similar results were described by other researches for these crops (Berova and Stoilova 2004, Berova et al. 2005), where CV value for the number of pods and seeds per plant in both crops was similar (20-22%). The number of seeds per pod for common bean was 4.05 (mean value) and 10.56 per cowpea; the number of pods per plant followed the same trend, with 8.84 in common bean and 13.22 in cowpea, resulting in the number of seeds per plant to be 25.65 for beans and 93.47 for cowpea. The seeds of *Phaseolus* were bigger than *Vigna* and the mean weight of 100 seeds was 41.86 g and 15.73 g, respectively.

The accession with bigger seeds, pod length and pod width was A4-007, of local origin (Fig. 3). In the principal component analysis of cowpea, the two first principal components explained 60.1% of the total variation presented in the accessions. The accession with the largest pod was 95-017, while 95-023 and 95-045 had short periods to reach the flowering stage. The accessions 95-095 and 87-052 showed similar characteristics and had close

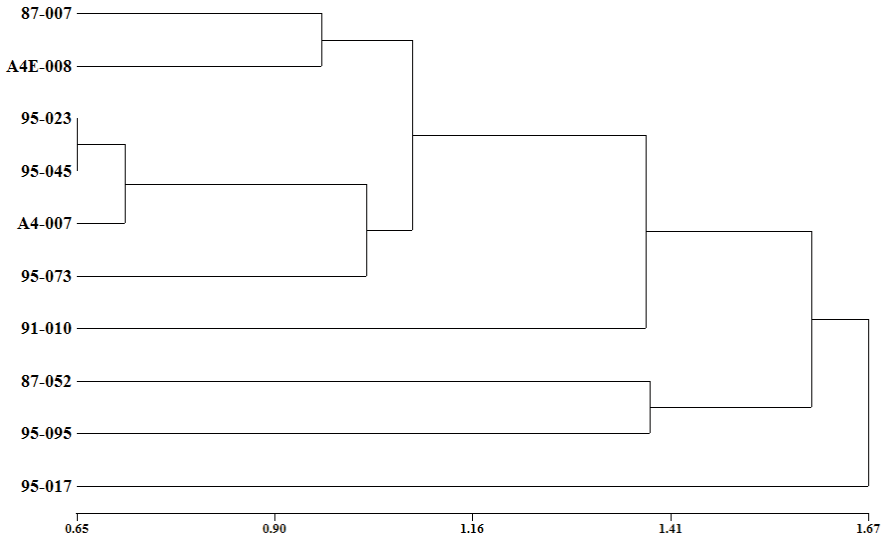

Figure 4. Dendogram of cowpea obtained by cluster analysis

positions in the graphic. We can observe a positive correlation between the number of pods and the number of seeds per plant.

The dendogram of this species (Fig. 4) based on morphological data obtained during the entire vegetation period determined one group from accessions 95-023, 95-045 and 95-073.

CONCLUSIONS

1. The present research provided information on germplasm of *Ph. vulgaris* L. and *V. unguiculata* L. from national collections. The evaluation of phenotypic variability by multivariate analysis gave us the possibility to identify the most economically important accessions to be included in future breeding programs, or for direct use.
2. The accessions of *Ph. vulgaris* showing better earliness and more pods and seeds per plant were 93-012 and 95-005.
3. Under the climatic conditions of Sadovo, the cowpea accessions showed more stable yield, resulting in more pods and seeds per plant and weight of seeds per plant as compared to the common bean accessions.
4. The accession A4-007 of *V. unguiculata* of local origin possessed bigger seeds than the others and appeared in one group with accessions 95-023 and 95-045.

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RÓŻNICE W TEMPIE WZROSTU I PLENNOŚCI POMIĘDZY GENOTYPAMI FASOLI (*PHASEOLUS VULGARIS* L.) I WSPIĘGI (*VIGNA UNGUICULATA* L.) UPRAWIANYCH W MIEJSCOWOŚCI SADOVO NA TERENIE BUŁGARII

Streszczenie: Badaniami objęto 10 populacji fasoli zwykłej oraz wspięgi chińskiej (fasolnik chiński) uprawianych w miejscowości Sadovo (Bułgaria), w warunkach klimatycznych charakteryzujących się gorącym i suchym latem. Obserwacje prowadzone w czasie wegetacji obejmowały kolejne etapy rozwoju roślin oraz cechy plonu. Wszystkie genotypy wysiano w drugiej dekadzie kwietnia. Wschody roślin obserwowano po 10-15 dniach po wysiewie. Rośliny fasoli zakwitły po 28-34 dniach, a wspięgi po 45-60 dniach. Okres wegetacji wspięgi chińskiej był znacznie dłuższy (ponad 98 dni) niż fasoli zwykłej (prawie 80 dni). Wyniki obejmujące liczbę strąków i nasion na roślinie, wielkość strąków i nasion oraz masę strąków i nasion na roślinie znacząco różniły się dla obu gatunków. Średnia liczba strąków na roślinie wynosiła 8,84 u fasoli i 13,22 u wspięgi, liczba nasion w strąku odpowiednio 4,05 i 10,56, a liczba nasion na roślinie 25,65 i 93,47. Nasiona fasoli były większe niż nasiona wspięgi, waga 100 nasion wynosiła odpowiednio 41,86 g oraz 15,73 g. W warunkach klimatycznych miejscowości Sadovo, populacje wspięgi były bardziej stabilne pod względem plonowania, wykształciły one więcej strąków i nasion na roślinie i wyższą masę nasion z rośliny, w porównaniu z populacjami fasoli.

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