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VARIABILITY OF SELECTED CHARACTERS OF 18 LOCAL POPULATIONS OF BEAN (Phaseolus ssp.)

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ABSTRACT

In the years 1999-2001 at August Cieszkowski Agricultural University of Poznań the selected characters of 18 local populations of bean (*Phaseolus* ssp.) were tested. These were dwarf types grown for dry seeds. The tested materials came from submontane areas of Poland, Slovak and Ukraine. As the standard, the Polish cultivar ‘Igołomska’ was used. The following characters were evaluated: plant height, height of setting of the first pod, beginning and length of the blooming period, time needed to get useful and physiological ripenesses, mean number of pods per plant, total seed yield per plant, pod’s length and width, thickness of the pod`s wall, numbers of seeds per pod, seed colour and 1000 seeds weight. The resistance to antracnose [*Colletotrichum lindemuthianum* (Sacc. et Magn) Briosi] and halo blight [*Pseudomonas syringae pv. phaseolicola* (Burkh.) Young, Dye] were also evaluated. The tested materials` seeds were also evaluated for their tolerance to germination at 12°C. Two populations differed from the others by their plants` height, two – by the height of setting the first pod, two - by the lenght of their blooming period, one – by the time needed to get the physiological ripeness. One population, in comparison to other ones, differed by a number of seeds in a pod; one – by a seed yield per plant. The biggest variability of the tested characters was found for the pod`s length, the smallest – for the thickness of the pod`s wall. The tested accessions did not differ in their resistance to antracnose, although 4 of them had slightly better and 2 – slightly worse – tolerance to halo blight. Seeds of the 5 populations from Slovak had the smallest sensibility to the low temperature; they germinated completely at 12°C.

Key words: bean, *Phaseolus* ssp., local population

INTRODUCTION

In resent years, there has been an increasing interest in the world for gene banks [7]. They are found by countries leading in plant breeding as very valuable sources of variability and protection of one's own germplasm. Collections of husbandry important agricultural and horticultural species are also carried out by large seed companies for breeding purposes. Especially valuable accessions in such collections are local cultivars and populations. They have been found to be precious and useful starting material for breeding works [21].

In 1984, at August Cieszkowski Agricultural University of Poznań, the working collection was established for common (*Phaseolus vulgaris* L.) and runner (*Phaseolus coccineus* L.) beans. The collection is a part of the National Gene Bank kept by the Institute of Plant Breeding and Acclimatization in Radzików near Warsaw. In 2003 the collection had over 1000 accessions [6]. Most of them are local populations collected during research expeditions carried out by Polish scientists to Slovak, Czech, Ukraine and China. Part of the accessions also came from exchanging materials with other gene banks in the US, Germany and France. In the early 90s, there were at least 23 large professional collections of common bean in the world [5].

The main goal of this research was to determine the variability of selected characters of 18 local populations of bean.

MATERIALS AND METHODS

The experiments were carried out in the years 1999-2001 at Agricultural Experiment Station – Baranowo, which belongs to August Cieszkowski Agricultural University of Poznań. The research was done on the selected accessions from the collection. These were 18 local populations of bean (*Phaseolus* ssp.) of a dwarf type grown for dry seeds. They came from submontane areas of Poland (BES, ZAM), Slovak (SLOKAR, SLOKYS, SLOSIT) and Ukraine (UKR, UKAR). The accession UKAR 156 was not even. It consisted of large, black (fig. 1) and smaller, brown seeds. The first ones germinated typically for runner bean, the latter – for common bean. The Polish cultivar 'Igołomska' was used as a standard.

Each of the population was grown on fair soil created from clayey sands placed on light clay with the humus level of 0.9-1.0%, on the plot of the sizes 2.5 × 2 m. On the field, green maturing was used prior to growing beans, facelia (*Phacelia tanacetifolia* Benth., *Hydrophyllaceae*) was grown over summer, next in autumn, it was ploughed in. In the years before growing beans: onion grown for seeds, cabbage and potatoes were grown in the first, second and the third year, respectively.

The observations included the most important morphological characters of the populations, their phenological stages and some yielding parameters and resistance to antracnose [*Colletotrichum lindemuthianum* (Sacc. et Magn) Briosi] and halo blight [*Pseudomonas syringae pv. phaseolicola* (Burkh.) Young, Dye] were carried out on 10 randomized plants. There were the following characters tested: a plants` height, measured from the soil level to the highest point of the plant, the height of the set of the first (lowest) pod, a total number of pods on a plant and a total fresh weight of seeds per 1 plant. Characters concerning a pod were measured on 30 selected pods in the stage of their processing use. At this stage, the pods were light yellow with hard seeds. At the phenological observations, the beginning of blooming was described when 50% of plants had blooming flowers, whereas the end – when 50% of the flowers had completed their blooming. Additionally, seeds of the tested populations were evaluated for their tolerance to germinate at 12°C. Ten seeds were placed in the blotter paper rulons soaked with the distilled water and placed at 12°C in the darkness. The test was run in 8 replications: each of 10 seeds. After 10 days, the percentages of germinating healthy seeds, germinating, infected ones, ungerminated, healthy ones and the dead ones were counted.

The weather conditions for bean seed production at Agricultural Experiment Station Baranowo in the years of carrying out the experiment were medium favourable to favourable. In 1999, there were strong rains in June and July, but temperature was higher than the mean value for the last 10 years. The rains at first helped vegetation but then complicated drying the seeds and their harvest. In 2000, in turn, the spring was hot and very dry what slowed down the plants` vegetation, then heavy rains at the beginning of July lowered pollination efficiency but eventually helped setting seeds in bean pods and the final seed harvest was good. In 2001, spring was relatively warm but very dry. The summer was medium hot, in comparison to the mean value for the last ten years. Heavy rains in August and September together with lower than average temperatures made the seed harvest long and difficult.

For the received results, the variance was calculated. The smallest significant differences were calculated based on the Duncan's range test at the significance level of $\alpha = 0.05$.

RESULTS

Out of the tested populations, 2 were higher than the others (tab. 1). All the accessions had the same height of setting the first pod on the plant. However, there were some tendencies here amongst the 2 populations. SLOSIT 116 and ZAM 6 had set pods slightly lower, whereas UKR 220 – slightly higher – than all the other accessions tested. The time of beginning the flowering was the same for all the tested accessions with a tendency to be a little earlier for SLOKYS 071 and little later for UKR 220. Some differences were observed in the length of the blooming period. It varied from 13.7 days to 30.3 days. SLOKAR 453 and UKAR 156 came into the blooming period later than the standard cultivar – 'Igołomska'. It means that all the other populations reached this stage evenly. The ripeness for use for the tested accessions and the standards was reached at the same time. The only acceptation here was the population SLOKYS 071, which seeds were ripen earlier than the standard seeds. The physiological maturity of the 10 tested accessions for all the tested populations was reached at the same time as the standard population. Seven populations: SLOKYS 071, SLOSIT 021, SOLSIT 134, SLOSIT 173, BES 033, UKR 220 and ZAM 6, had only tendency to be earlier than the standard and one population – the UKAR 156 – had a tendency to be later. The mean number of pods per plant was a very stable character and did not differ from the standard. The only acception here was the Slovak population SLOKAR 453, which plants had higher mean number of pods per plant than the standard cultivar 'Igołomska'. The accession SLOKAR 427A had a tendency to have slightly lower number of pods per plant. All but one population had seed yield per 1 plant the same as the standard seeds. The acception here was SLOKAR 453, which yielded higher than the standard cultivar. The following populations had a tendency of higher yielding than the standard cultivar: SLOSIT 173 (132.2%) and UKAR 156 (139.4%), and lower yielding: SLOKAR 427A (53.1%) and SLOKYS 071 (54.4%) (tab. 1).

All the tested populations had the same resistance to antracnose. With the resistance to halo blight, the variation was slightly better: SLOKYS 071 and UKAR 007 had worse resistance to the disease whereas 4 populations: SLOSIT 114, SLOSIT 116, ZAM 6 and UKAR 156 had a tendency to be less susceptible than the standard cultivar.

The table 2 contains the results concerning the structure of the yielding. There was a big variability of length and width of the pods of the tested populations. One population – BES 033 – had longer pods than the standard, whereas two populations: SLOKAR 535 and SLOSIT 116 had shorter pods than the Igołomska cultivar. The population SLOKAR 405 had a tendency to have shorter pods than the standard. The width of pods was found to be a rather stable character of the tested populations. Only one of them – UKAR 156 – had bigger width than the standard cultivar's pods. One of them, though – BES 033 – had a tendency to have this character smaller and 6 others: SLOKAR 480, SLOKYS 071, SLOSIT 116, SLOSIT 152, SLOSIT 173 and UKR 007 – had a tendency to have wider pods than the standard cultivar. No differences in the thickness of the pod's wall were observed in comparison with the standard cultivar. Six populations tested had lower number of seeds per pod than the pods of the standard variety. These were: SLOKAR 405, SLOKAR 427A, SLOKYS 071, SLOSIT 152, UKR 007 and UKAR 156 (tab. 2). All the rest of the tested populations had a tendency to have lower number of seeds per pod. The best, in terms of having the least difference in comparison to the standard, were 3 populations: SLOSIT 134, SLOSIT 173 and ZAM 6.

Table 1. Characteristics of 18 local populations of bean (*Phaseolus ssp.*) of dwarf type used for dry seeds. Means of the years 1999-2001

Accession number[1]	Number in the gene bank[2]	Level of the resistance to[3]		Plants` height (cm)	Height of setting of the first pod (cm)	Beginning of the flowering (number of days from sowing)	Length of the blooming period (days)	Time till getting full ripeness (number of days from sowing)		Mean number of pods per plant	Seeds yeld per plant (g)
		Colletotrichum lindemuthianum	*Pseudomonas syringae pv. phaseolicola*					for use	physiological		
SLOKAR 405	180455	5.7 a[4]	6.4 bc	50.8 a	18.6 ab	50.0 ab	17.0 ab	63.0 b	104.7ab	12.3ab	20.1 a-c
SLOKAR427A	180460	7.7a	5.0 ab	50.0 a	21.6 ab	47.7 ab	13.7 a	67.7 b	103.0 ab	8.2a	16.3 a
SLOKAR 453	180471	6.4 a	6.4 bc	86.3 b	19.4 ab	49.3 ab	30.3 d	70.3 b	115.3 ab	26.5d	78.6 d
SLOKAR 480	180497	6.4 a	5.0 ab	49.8 a	17.4 ab	43.3 ab	19.3 a-d	62.3 b	102.0 ab	8.8ab	28.6 a-c
SLOKAR 535	180482	6.4 a	6.4 bc	49.9 a	22.1 ab	46.0 ab	21.3 a-d	63.0 b	103.7 ab	9.2ab	22.4 a-c
SLOKYS 071	180582	6.4 a	4.4 a	49.2 a	17.2 ab	34.3 a	14.7 a	49.0 a	98.0 a	8.7ab	16.4 a
SLOSIT 021	180527	7.0 a	5.7 a-c	54.6 a	31.7 ab	45.3 ab	16.0 ab	67.7 b	97.7 a	12.6ab	20.2 a-c
SLOSIT 114	180541	7.0 a	7.0 c	50.8 a	20.2 ab	39.3 ab	21.0 a-d	67.7 b	100.3 ab	12.6ab	22.7 a-c
SLOSIT 116	180542	7.7 a	7.0 c	47.9 a	13.3 a	39.7 ab	24.0 a-d	64.0 b	100.3 ab	11.7ab	22.4 a-c
SLOSIT 134	180553	5.7 a	6.4 bc	51.0 a	22.5 ab	43.3 ab	16.7 ab	67.0 b	93.0 a	10.5ab	17.4 ab
SLOSIT 152	180558	6.4 a	5.7 a-c	58.5 a	22.7 ab	43.0 ab	21.3 a-d	67.3 b	109.3 ab	16.9bc	28.4 a-c
SLOSIT 165	180563	7.0 a	5.7 a-c	54.4 a	21.5 ab	43.7 ab	16.0 ab	66.7 b	102.0 ab	16.1a-c	25.4 a-c
SLOSIT 173	180565	5.7 a	5.7 a-c	51.2 a	21.8 ab	40.3 ab	21.7 a-d	68.3 b	92.7 a	16.4a-c	40.6 bc
UKR 007	180586	7.0 a	4.4 a	55.3 a	26.7 ab	39.3 ab	24.0 a-d	68.0 b	102.0 ab	8.4ab	17.7 ab
UKR 220	180609	7.0 a	5.7 a-c	90.6 b	34.7 b	58.0 b	26.3 b-d	67.7 b	96.3 a	14.3a-c	31.9 a-c
BES 033	180506	7.0 a	5.0 ab	45.8 a	17.3 ab	46.0 ab	18.7 a-c	67.0 b	96.3 a	11.4ab	19.1 a-c
ZAM 6	180625	7.7 a	7.0 c	45.2 a	15.7 a	38.3 ab	22.0 a-d	68.3 b	97.3 a	13.0ab	19.4 a-c
UKAR 156	180421	7.7 a	7.0 c	58.9 a	30.9 ab	49.7 ab	29.3 cd	72.7 b	123.7 b	21.7cd	42.8 c
Igołomska(standard)	-	6.4 a	6.4 bc	49.2 a	20.3 ab	35.3 ab	17.7 ab	69.0 b	102.3 ab	16.5a-c	30.7a-c

[1] origin: Poland (BES, ZAM), Slovak (SLOKAR, SLOKYS, SLOSIT), Ukraine (UKR, UKAR)
[2] located at the Institute of Plant Breeding and Acclimatization in Radzików near Warsaw
[3] degree of resistance: 1 – very low, over 75% of the infected plants, 3 – low, 51-75% of the infected plants, 5 – medium, 26-50% of the infected plants, 7 – high, up to 25% of the infected plants, 9 – very high, lack of the infected plants
[4] Means followed in the column by the some letters are not significantly different following the Duncan’s test for $\alpha = 0.05$

Table 2. Characteristics of pods and seeds of 18 local populations of bean (*Phaseolus ssp.*) of dwarf type used for dry seeds. Means of the years 1999-2001

Accession number[1]	Number in the gene bank[2]	Pod			Numbers of seeds per pod	Colour of seeds	Weight of 1000 seeds, g
		length, cm	width, mm	thickness of the pod`s wall, mm			
SLOKAR 405	180455	10.0 a-c[3]	12.8 a-c	2.1 a	3.6 a-c	olive	449.5 a-d
SLOKAR427 A	180460	13.2 gh	13.1 a-c	2.0 a	3.8 a-d	dark cherry	497.3 a-d
SLOKAR 453	180471	11.6 c-h	12.1 ab	1.9 a	3.9 a-e	creamy with a cherry mosaic	642.9 d
SLOKAR 480	180497	11.4 c-g	13.6 bc	2.0 a	4.4 b-e	light brown with a cherry mosaic	538.2 a-d
SLOKAR 535	180482	9.0 ab	12.8 a-c	2.3 a	3.9 a-e	creamy with a violet mosaic	528.3 a-d
SLOKYS 071	180582	11.5 c-h	13.8 bc	2.1 a	3.5 ab	light brown	547.9 a-d
SLOSIT 021	180527	12.1 d-h	10.6 ab	2.2 a	4.1 a-e	pink	363.7 ab
SLOSIT 114	180541	12.8 e-h	13.1 a-c	1.6 a	4.5 b-e	light brown with a cherry mosaic	461.2 a-d
SLOSIT 116	180542	8.6 a	13.4 bc	2.0 a	3.9 a-e	ashen with a violet mosaic	474.2 a-d
SLOSIT 134	180553	11.5 c-h	10.7 ab	2.8 a	4.8 de	black with a violet mosaic	331.9 a
SLOSIT 152	180558	12.1 d-h	13.5 bc	2.0 a	3.7 a-c	beige	624.2 cd
SLOSIT 165	180563	13.4 h	12.6 ab	1.9 a	4.7 c-e	light brown with a cherry mosaic	437.1 a-d
SLOSIT 173	180565	12.9 f-h	13.3 bc	2.2 a	4.8 de	white with a cherry mosaic	475.7 a-d
UKR 007	180586	11.1 c-f	13.7 bc	2.4 a	3.3 a	white with a brown hilum	619.7 b-d
UKR 220	180609	10.7 b-d	11.6 ab	1.8 a	4.5 b-e	white	358.5 a
BES 033	180506	15.7 i	9.4 a	2.3 a	4.2 a-e	black	382.4 a-c
ZAM 6	180625	10.9 c-e	11.2 ab	2.2 a	4.8 de	white	302.6 a
UKAR 156	180421	11.6 c-h	16.3 c	2.5 a	3.8 a-d	black-brown	1006.8 e
'Igołomska' (standard)	-	11.7 c-h	10.7 ab	2.5 a	5.0 e	white	415.6 a-d

origin: Poland (BES, ZAM), Slovak (SLOKAR, SLOKYS, SLOSIT), Ukraine (UKR, UKAR)
[2] located at the Institute of Plant Breeding and Acclimatization in Radzików near Warsaw
[3] Means followed in the column by the some letters are not significantly different following the Duncan's test for α = 0.05

There was a big variability in colour of the seeds of the evaluated populations. Their colour varied from purily white till completely black (fig. 1 and 2). That was also accompanied by differences in the seeds` shape, size and 1000 seeds weight (fig. 1).

Fig. 1. Seeds of the local populations of bean (*Phaseolus* ssp.) of dwarf type used for dry seeds with different colour of their testa and seed size

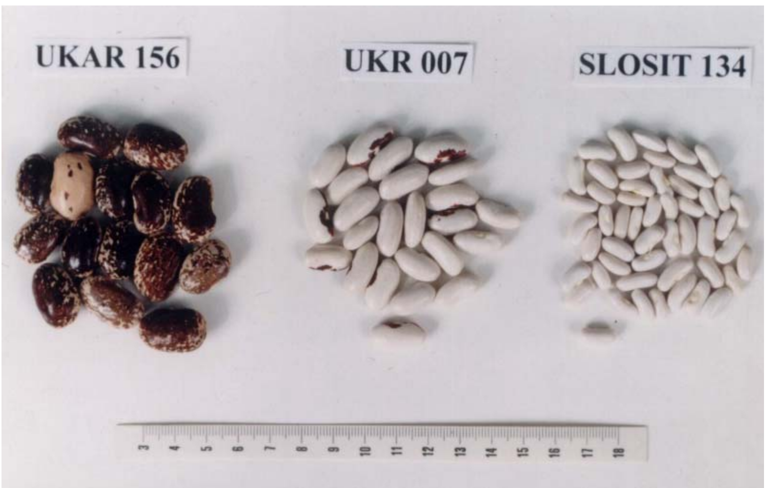

Fig. 2. Seeds of the local populations of bean (*Phaseolus* ssp.) of dwarf type used for dry seeds with different colour of their testa

The 1000 seeds weight results were the same as for the standard cultivar and only for 1 populations – UKAR 156 – they differed significantly. Although, its seeds were not even. There were also 3 populations: ZAM 6, UKR 220 and SLOSIT 134 which had a tendency to have smaller seeds than the standard cultivar and 1 population – SLOKAR 453 – with a tendency to have the least difference in 1000 seeds weight in comparison to the standard seeds (tab. 2).

Table 3. Seed germination at 12°C of 18 local populations of bean (*Phaseolus* ssp.) of dwarf type used for dry seeds

Accessionnumber[1]	Number inthe genebank[2]	Germinating healthy seeds	Germinating infected seeds	Ungerminating, healthy seeds	Dead seeds
		%			
SLOKAR 405	180455	99 ef [3]	0 a	1 a	0 a
SLOKAR427A	180460	82 b	0 a	0 a	18 c
SLOKAR 453	180471	94 c-f	1 a	0 a	5 ab
SLOKAR 480	180497	95 d-f	0 a	0 a	5 ab
SLOKAR 535	180482	100 f	0 a	0 a	0 a
SLOKYS 071	180582	100 f	0 a	0 a	0 a
SLOSIT 021	180527	84 bc	0 a	0 a	16 c
SLOSIT 114	180541	87 b-d	0 a	0 a	13 bc
SLOSIT 116	180542	100 f	0 a	0 a	0 a
SLOSIT 134	180553	91 b-f	0 a	0 a	9 a-c
SLOSIT 152	180558	89 b-e	1 a	0 a	10 a-c
SLOSIT 165	180563	100 f	0 a	0 a	0 a
SLOSIT 173	180565	100 f	0 a	0 a	0 a
UKR 007	180586	99 ef	0 a	0 a	1 a
UKR 220	180609	97 d-f	0 a	1 a	2 a
BES 033	180506	95 d-f	1 a	0 a	4 ab
ZAM 6	180625	99 e-f	0 a	0 a	1 a
UKAR 156	180421	67 a	0 a	0 a	33 d
'Igołomska' (standard)	-	89 b-e	1 a	0 a	10 a-c

[1] origin: Poland (BES, ZAM), Slovak (SLOKAR, SLOKYS, SLOSIT), Ukraine (UKR, UKAR)
[2] located at the Institute of Plant Breeding and Acclimatization in Radzików near Warsaw
[3] Means followed in the column by the some letters are not significantly different following the Duncan's test for $\alpha = 0.05$

The table 3 contains the results of germinating seeds of the tested populations at 12°C. There was a big variability in germination capacity of the seeds of the tested populations. This value, of germinating, healthy seeds, hesitated from 67 to 100%. All populations had very low percentages of germinating, infected and ungerminating, unhealthy seeds. No differences with the standard seeds were found there. One population though – UKAR 156 – had higher than the standard seeds percentage of dead seeds and three other populations had a tendency to have higher than the standard cultivar percentage of dead seeds (tab. 3). Seeds of the 5 populations: Slovak: SLOKAR 535, SLOKYS 071, SLOSIT 116, SLOSIT 165 and SLOSIT 173 had the samllest sensibility to the low temperature; they germinated completely at 12°C.

DISCUSSION

Importance of use of wild species of bean (*Phaseolus* sp.) in breeding works has been known for sometime. In recent years, this has been extended to use of local populations of the cultivated beans. The seed company breeders prefer today to work with local populations of beans mostly due to their closer genetic relation to commercial cultivars. This, in turn, is a result of speeding up breeding works to meet increasing competition on the seed market [9].

The carried out evaluation clearly showed that there is a variability in the tested populations, so welcome amongst bean breeders [17, 20]. Although, their seeds are slightly smaller than the standard cultivar Igołomska and they, in many cases, had lower number of seeds per pod, still they have very desired by contemporary breeders characters such as similar to the standard cultivar 1000 seeds weight, some level of resistance to halo blight and, what is even more important today, high potential of germination at suboptimal temperatures. The last character can be already today used in a common practice: there is a urgent need to develop a common bean cultivar with good seed germination for pod production to be forced under unheated plastic tunnels. Research in this area includes both theory and practice [14, 15, 18].

The received results did not answer the question whether the seeds of the tested populations which completely germinated at 12°C, could germinate at lower temperatures. Common bean seeds of some cultivars and lines can germinate at 8-10°C [4, 10, 13]. This, hower does not nesessairily mean that their seedlings will be able to survive cold and grow at suboptimal conditions [11].

Another interesting observation that may come out of this research is a relation of colour of the bean seed testa with some useful characters. Common bean lines with cold tolerance used in breeding works by Silbernagel [16], Klein [12], Baumuk-Wende [1] and Hołubowicz [8] had small, dark or black seeds. In some way, this observation has been confirmed by our results. None of the 5 populations with the highest germination at suboptimal temperatures has seeds completely white. On the other hand, also the UKAR 156 seeds, with the poorest germination at 12°C, are dark and brown. The dark colour of common bean seeds is also related with better vigor of seeds [3] and their resistance to diseases [2, 19].

The described in this paper local populations can be use in a breeding programme for selected characters, e.g. mechanical harvesting or/and disease resistance. Traditional commercial cultivars collections are becoming less and less efficient. With so many materials collected in the world, there is an increasing probability that new collected materials will carry alleles and genes to be found in already existing accessions. In these circumstances, the importance of wild and local populations input into breeding achievements increases [2].

CONCLUSIONS

1. Three years long observations made possible to describe 18 local populations of the bean (*Phaseolus* ssp.) morphological characters, phenological stages, yielding structure, resistance to antrancnose and helo blight and seed germination at 12°C.
2. The carried out research made possible to select local populations of bean (*Phaseolus* ssp.), which could be a source of valuable characters in breeding new cultivars.

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