СЕЛСКОСТОПАНСКА АКАДЕМИЯ
AGRICULTURAL ACADEMY
РАСТЕНИЕВЪДНИ НАУКИ, **50**, 13-18
PLANT SCIECE, **50**, 13-18
София, 2013, Sofia

NATIONAL RYE COLLECTION – CHARACTERISTIC EVALUATION AND USES

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Abstract

Bulgarian ex situ rye collection is the forth in Europe and occupied seventh place in the world. Botanical diversity cover all taxons, spread in the largest collections. The biggest taxon is Secale cereale subsp. cereale. The advantage of our collection is preserved endemic and relict species Secale rhodopaeum Delipavlov. Eighteen quantitative traits were studied for 53 local unique landraces and improved varieties (created and collected till 1957 year). Accessions have a low variation for 8 traits: stem nodes – number on main stem; days to heading; ear – length, cm and grain quality traits – 1000 grain mass, g, test weight, kg/hl, protein and lyzine and histidin content in grain. Varieties are with the most valuable traits: medium-high stem, short vegetative period and high ear productivity. In the dendrogram these accessions are well separated. The most determinant traits that contribute diversion for the first and second components included: internode – length; days to heading; ear – length, cm; seeds per ear in number and grams. For Bulgarian rye local genotypes the most important traits were heading date, plant height, panicle/ear seed capacity, TGW and protein content. The accessions compensate lower absolute mass with high protein content.

Key words: rye, local germplasm, evaluations, genetic resources

INTRODUCTION

Unlike wheat, rye are newer agricultural crops, but for Bulgarian conditions with oats they are some of the oldest cereals (N. I. Vavilov, 1987; H. Dobrev, 1958). After the foundation of the Agricultural stations introduction attempts were carried out, namely, import and testing of a limited number of West-European rye varieties. A great popularity was enjoyed by the so-called Petcus rye, until the Second World War even considered a universal variety. Significant breeding work dates from 1930. Breeders, having noted the disadvantages of the West-European varieties, turned their attention to the hitherto neglected local genetic material. Genetic improvement work began with the active collection and research of local genotypes. (H. Mitkov, 1942; Yo. Hristov, 1942). Thus, as a result of purposeful selection of local genotypes, some of them naturally pollinated with Petcus rye, a number of varieties were created, producing a considerably bigger yield (up to 20%) than the universally accepted Petcus rye. The Bulgarian low-stemmed rye is still present in the pedigree of a number of modern varieties (V. D. Kobilyanskii, 1989; McLeod, Payne, 1996; McLeod et al., 2000).

The national rye collection includes over 1200 accessions (Knüpffer, 2011). Polish Gene Bank was designated as a crop germplasm centre for rye and recommended collation of passport data from other European rye collections (Podima, 2000). The adopted database structure contains 29 descriptors, which are based on the multicrop passport descriptors (Lipman et al., 1997)

The aim of the present research was to show current status of Bulgarian rye collection and to study the potential of common Bulgarian local old rye varieties and populations.

MATERIAL AND METHODS

This research was carried out in 1988 – 2010 years at IPGR "K. Malkov", Sadovo. Rye plant material included 42 local populations (collected from joint Bulgarian-Russian expedition in Bulgaria in 1959 year and during 2001 year accessions were repartition from VIR "N. I. Vavilov", Petersburg, Russia), 4 varieties originated from Bulgarian local populations (Sadovo No 362 (1939), Sadovo No 19 (1946), Sadovo 2 (1957) and Lozen 14 (1947); and 2 varieties: Sofia No 59 (1946) and Sadovo No 70 (1949), natural hybrids between local rye and Petcus rye (H. Dobrev, 1958; Popov et al., 1958). All accessions are diploids (2n = 14), Secale cereale subsp. cereale, var. vulgare. Were evaluated: 1) Internode – length (upper), cm (InnoLup); 2) Internode – length (2nd from bottom), cm (INNoLbo); 3) Internode – thickness (2nd from bottom), cm (Innofbo); 4) Stem nodes – number on main stem (StNodes); 5) Plant – height, cm (HP); 6) Days to heading (DH); 7) Ear – length, cm (Lear); 8) Seeds per ear, number (NSedEar); 9) Seeds per ear, g (Gear); 10) Seeds from plant, g (GPlant); 11) 1000 grain mass, g (GW); 12) Test weight, kg/hl (TW); 13) Protein content in grain, % (Pr); 14) Lyzine and histidin content in grain, % (LzNistid); 15) Lyzine and histidin content in protein, % (LzHisinPr); 16) Fats, % (Fats); 17) Cellulose, % (Cellulos); 18) Minerals, % (Minerals), according to Rye descriptors (IBPGR, 1985).

Variation, correlation and cluster analysis (Ward´s clustering method, Euclidean distance), were used to assess differences between similar cultivar clusters and the traits that contribute most to a total variability.

RESULTS AND DISCUSSION

Bulgarian rye collection now is 1282 total number of the accessions. According Knüpffer (2011), Bulgarian rye collection occupy seventh place in the world (Table 1). Total world number Secale ex situ accessions is 22.254. They are distributed in 94 genebanks in 46 countries. In 66 European genebanks are 71% from total rye accessions and 16% in North America in 6 genebanks (Knüpffer, 2011). During latest 20 years, Bulgarian Secale collection arise more than 5 times. Accessions originated from 30 countries, but collections from 6 countries have biggest meaning – Bulgaria, Russia, Germany, Poland, Canada and Belarus (Table 2). In Europe, Bulgarian rye collection is on the fourth place after, Russia (3300) accessions), Poland (2424) and Germany (2409) (Zaczyński, 2011). The National collection is represented with taxons (according Kobylyanskyi, 1989, Loskutov, 2011) from I secton Oplismenolepis Nevski: 1) S. silvestre Host; 2) S. iranicum Kobyl; 3) S. montanum Guss. s. I. S. cereale L. s. I forms II-nd Section Cerealia Roshev – Secale cereal. Bulgarian endemic and relict rye S. rhodopaeum Delipav. belongs to the series of perennial varieties of rye, ser. Kuprijanovia Roshev. (Delipavlov, 1966). According Mansfeld DB, GRIN-Tax and Knüpffer, 2011 world collection includes: 1) Secale cereale; 2) S. strictum; 3) S. derzhavinii; 4) S. silvestre; 5) S. vavilovii. All this taxons are covers in BGR collection with main subspecies and varieties (Table 3). Secale cereale subsp. cereale is the main taxon.

Forty seven local populations and 6 obsolete improved varieties originated from Bulgaria (all acces-

Table 1. Largest rye collections (> 1000 accessions)

FAO code; Institute	Number of accessions
RUS001 Vavilov Institute of Plant Industry, *St. Petersburg, Russian Federation*	3300
DEU146 Leibniz Institute of Plant Genetics and Crop Plant Research, *Gatersleben, Germany*	2392
POL003 Plant Breeding and Acclimatization Institute, *Radzików, Poland*	2226
USA029 USDA-ARS, National Small Grains Collection, *Aberdeen, Idaho, USA*	2114
POL001 Botanical Garden, Polish Academy of Sciences, *Warsaw, Poland*	1631
CAN004 Plant Gene Resources of Canada, *Saskatoon, Saskatchewan, Canada*	1440
BGR001 Institute for Plant Genetic Resources, *Sadovo, Bulgaria*	1282
33 genebanks with more than 100 accessions	

Table 2. Bulgarian Secale ex situ collection

Country of origin	Number of accessions	Country of origin	Number of accessions
Afghanistan	2	Italy	4
Australia	4	Japan	1
Austria	3	Korea	1
Belarus	**10**	Netherlands	5
Belgium	1	**Poland**	**21**
Bulgaria	**795**	Portugal	3
Canada	**11**	Romania	4
China	2	**Russia**	**90**
Czech Republic	9	South Africa	2
Finland	3	Sweden	3
Former Yugoslavia	3	Turkey	5
France	4	U.S.	5
Germany	**29**	Uruguay	1
Hungary	6	**Unknown**	**257**
Iran	1	Zimbabwe	1
Israel	1		

Table 3. Number of accessions per Secale taxon

Taxon (Synonym)	Number of accessions
Secale sp.	466
Secale afghanicum (Secale cereale subsp. afghanicum)	3
Secale africanum (Secale strictum subsp. africanum)	1
Secale anatolicum (Secale strictum subsp. anatolicum)	6
Secale rhodopaeum	1
Secale ancestrale (Secale cereale subsp. ancestrale)	7
Secale derzhavinii	1
Secale montanum (Secale strictum)	1
Secale cereale subsp. vavilovii	1
var. asiaticum	1
Secale cereale subsp. tetraploidum	13
Secale cereale var. clansopaeatum	1
Secale cereale var. tuberculatum	4
Secale cereale var. fuscum	1
Secale cereale subsp. cereale	763
var. multicaule	3
var. bruneum	1
var. pseudoalbispicum	1
Secale strictum subsp. kuprijanovii	1
Secale sylvestre (Secale fragile)	4

Table 4. Mean values and variability for traits in rye

No	Indexes/ Caracters	Mean	Min	Max	R	Variance	V C %
1.	Internode - length (upper), cm (InnoLup)	44.4 ± 1.49	25.2	64.7	39.5	118.2	**24**
2.	Internode - length (2nd from bottom), cm (INNoLbo)	20.9 ± 0.39	16.2	28.2	12.0	7.9	13
3.	Internode - thickness (2nd from bottom), cm (Innofbo)	0.5 ± 0.01	0.4	0.7	0.3	0.0	11
4.	Stem nodes - number on main stem (StNodes)	4.6 ± 0.06	3.6	5.5	1.9	0.2	9
5.	Plant – height, cm (HP)	155.2 ± 2.29	105.0	182.3	77.3	278.1	**11**
6.	Days to heading (DH)	120.0 ± 0.37	114.3	127.3	13.0	7.3	2
7.	Ear – length, cm (Lear)	13.3 ± 0.13	11.4	15.6	4.2	0.9	7
8.	Seeds per ear, number (NSedEar)	48.5 ± 0.99	26.4	62.6	36.2	52.1	**15**
9.	Seeds per ear, g (Gear)	1.5 ± 0.05	0.7	2.2	1.5	0.1	23
10.	Seeds from plant, g (GPlant)	4.6 ± 0.29	0.5	9.6	9.1	4.5	46
11.	1000 grain mass, g (GW)	29.2 ± 0.27	25.0	34.0	9.0	3.8	7
12.	Test weight, kg/hl (TW)	66.5 ± 0.17	64.2	70.0	5.8	1.5	2
13.	Protein content in grain, % (Pr)	14.8 ± 0.08	13.0	15.9	2.9	0.4	4
14.	Lyzine and histidin content in grain, % (LzNistid)	1.0 ± 0.01	0.8	1.3	0.5	0.0	9
15.	Lyzine and histidin content in protein, % (LzHisinPr)	6.4 ± 0.08	5.2	8.4	3.2	0.4	9
16.	Fats, % (Fats)	1.6 ± 0.04	0.9	2.2	1.3	0.1	19
17.	Cellulose, % (Cellulos)	1.8 ± 0.04	1.0	2.5	1.5	0.1	17
18.	Minerals, % (Minerals)	1.7 ± 0.03	1.3	2.4	1.0	0.0	13

Table 5. Mean values and deviation of the total average of rye in groups of similar

Groups of similarity	Traits												
	plant height, cm	days to heading	ear length, cm	seeds/ear number	seeds/ear, g	abs. mass, g	test weight, kg/l	protein grain, %	lysine and histidin in grain	lysine and histidin in prot	fats, %	cellulose, %	minerals, %
I group (8) ±D	159.7 1.8	122.2 2.2	12.4 -1.0	44.4 -4.1	1.2 -0.2	28.3 -0.9	65.2 -1.4	15.1 0.2	1.1 0.1	7.1 0.7	1.6 0.0	2.0 0.3	1.8 0.0
II group (20) ±D	157.7 -0.1	119.1 -0.9	13.9 0.6	45.0 -3.5	1.3 -0.1	29.2 0.0	66.9 0.3	14.8 0.0	1.0 0.0	6.4 0.0	1.6 0.0	1.6 -0.1	1.8 0.0
III group (14) ±D	153.9 -3.9	119.5 -0.5	13.4 0.0	50.4 1.9	1.4 0.0	28.3 -0.9	66.6 0.1	15.0 0.1	1.0 0.0	6.3 -0.1	1.5 -0.1	1.8 0.1	1.8 0.0
IV group (11) ±D	159.8 2.0	120.6 0.7	13.0 -0.4	53.7 5.2	1.6 0.2	30.7 1.5	66.5 0.0	14.3 -0.5	0.9 -0.1	6.2 -0.2	1.9 0.3	1.6 -0.1	1.6 -0.1

sions are unique) were estimated. Main values and standard deviation strong with internodes-length (upper), plant height from 105 to 182 cm number seeds per ear and seeds per tillers (Table 4). With insignificant variation are 8 traits: Stem nodes – number on main stem (StNodes); Days to heading (DH); Ear – length, cm (Lear) and grain quality traits – 1000 grain mass, g (GW), Test weight, kg/hl (TW), protein and Lyzine and histidin content in grain. This can possibly be explained with meteorological condition and natural breeding tendency. From the cluster analysis accessions with similar adaptation for 18 quantitative characteristics form 2 major clusters (Figure 2). The first major cluster has 4 subgroups, (41 local populations), with the exception of Sadovo 2, situated at the borderline of the second major cluster. The latter has 2 subgroups, the first one including Lozen 14 and 6 local populations. Lozen 14 is genetically very similar to number 38999. It show that landraces as well as improved varieties have a high heterozygosity. but they are separated in the dendrogram into different clusters (Persson, von Bothmer, 2002). The second subgroup consists of the very similar varieties No 19, Sadovo No 362, Sofia No 59, and the relatively more distant Sadovo No 70. This cluster contained the most valuable traits: medium-high stem, short vegetative period and high ear productivity. The data set was reduced to 7 significant principal components that cumulatively

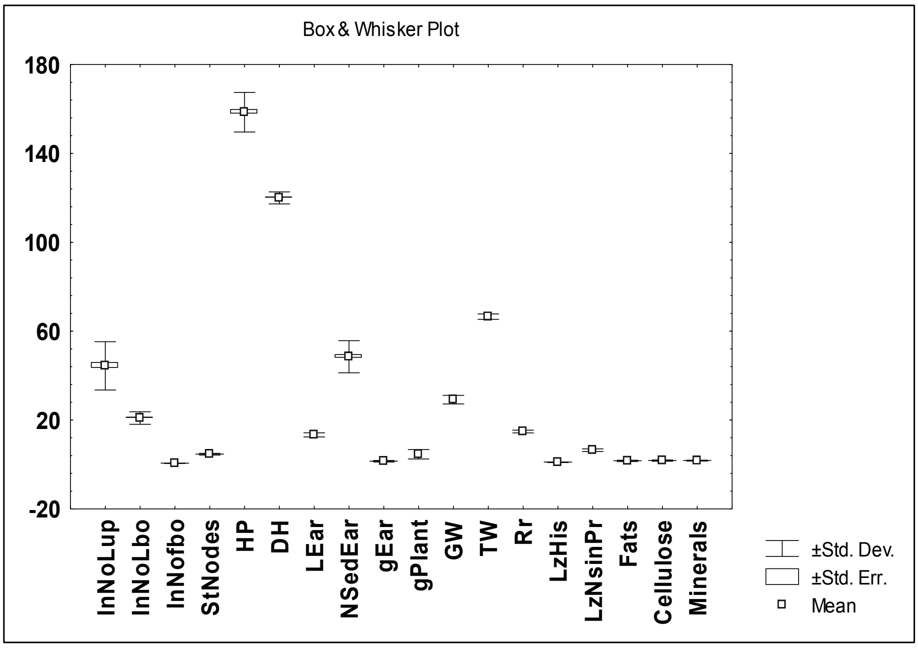

Fig.1. Mean values and standard deviation of accessions traits

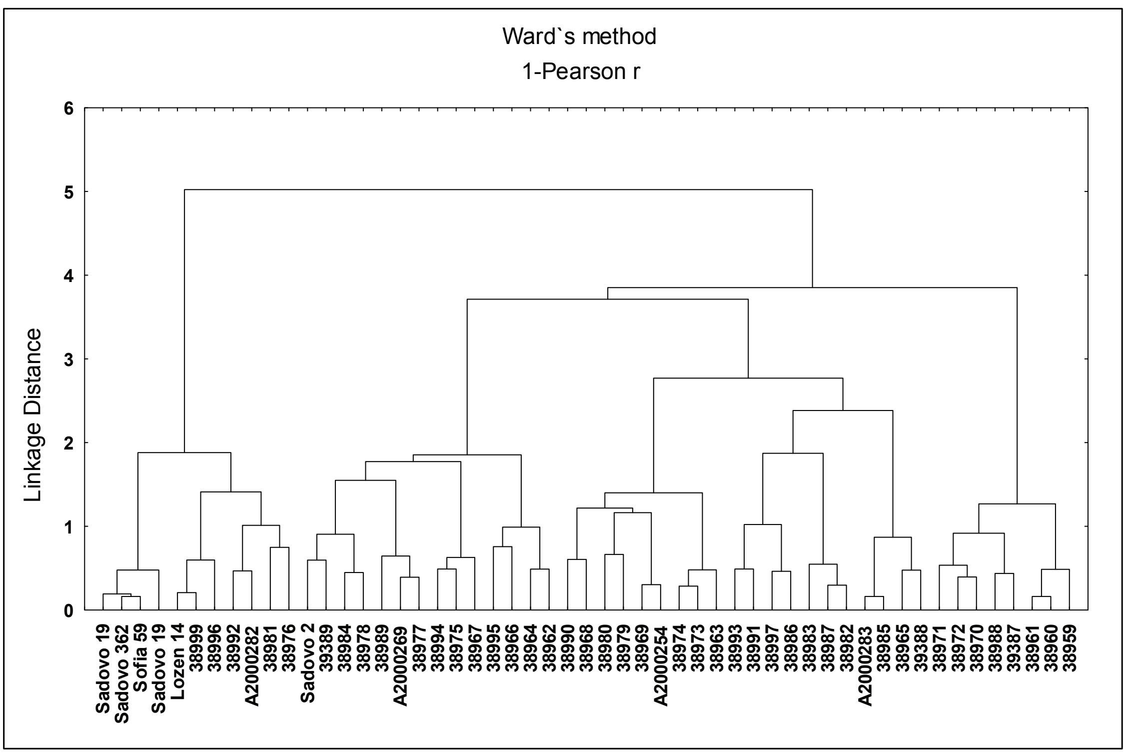

Fig. 2. Dendrogram of 53 rye accessions according 18 traits

explained 73% of the variance. Regression of the morphological distance was R^2 = 0.72%. The most determinant traits that contribute for the first and second components included: internode – length (2nd from bottom), cm (INNoLbo); days to heading (DH); ear – length, cm (Lear); seeds per ear, number (NSedEar); seeds per ear, g (Gear); test weight, kg/hl (TW); lysine and histidin content in grain, % (LzNistid); lysine and histidin content in protein, % (LzHisinPr). The scored traits for the next components: plant - height, cm (HP); protein content in grain, % (Pr); fats, % (Fats) (Figure 2).

Generally, the tested rye genotypes had short to

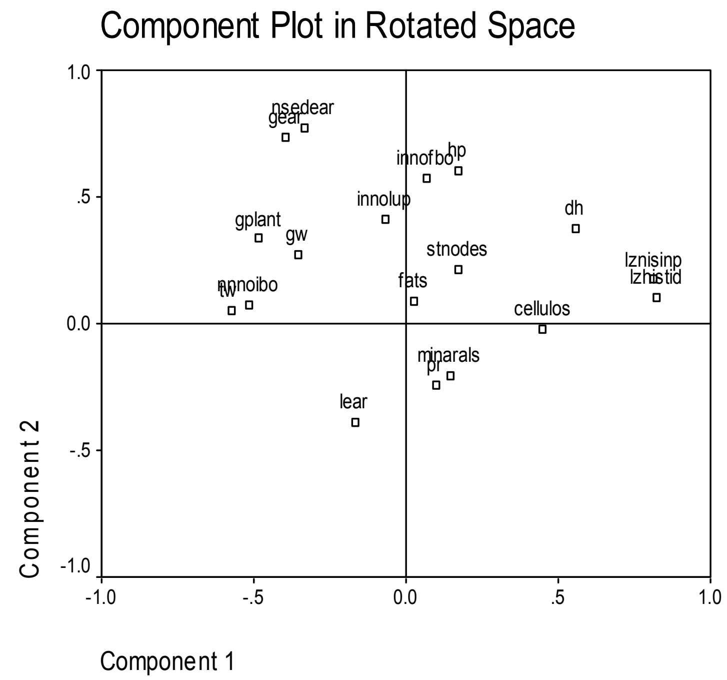

Fig. 3. Component plot in rotated space

Table 6. Component matrix

Traits	Components	
	1	2
Internode – length (upper), cm (InnoLup)	0.23	0.35
Internode – length (2nd from bottom), cm (INNoLbo)	**0.50**	-0.14
Internode – thickness (2nd from bottom), cm (Innofbo)	0.17	0.55
Stem nodes – number on main stem (StNodes)	-0.07	0.26
Plant – height, cm (HP)	0.09	0.62
Days to heading (DH)	-0.35	0.57
Ear – length, cm (Lear)	-0.01	-0.43
Seeds per ear, number (NSedEar)	**0.62**	**0.57**
Seeds per ear, g (Gear)	**0.66**	**0.51**
Seeds from plant, g (GPlant)	**0.58**	0.11
1000 grain mass, g (GW)	**0.43**	0.10
Test weight, kg/hl (TW)	**0.55**	-0.19
Protein content in grain, % (Pr)	-0.19	-0.18
Lyzine and histidin content in grain, % (LzNistid)	-0.71	0.43
Lyzine and histidin content in protein, % (LzHisinPr)	-0.67	0.49
Fats, % (Fats)	0.01	0.09
Cellulose, % (Cellulos)	-0.42	0.16
Minerals, % (Minerals)	-0.22	-0.13

above average medium length of the upper internode, very long internode (2nd from bottom), below medium thickness of internode (2nd from bottom), number of stem nodes – medium to many, short-stemmed to very long plant height, very early to intermediate vegetative period, medium length ear with little to above medium number of seeds and weight, little to medium 1000 grain mass, very high protein and lysine and histidin content in grain.

For Bulgarian rye local genotypes the most important traits were heading date, plant heigh, panicle/ear seed capacity, TGW and protein content (Mangova, Antonova, 2011). According to V. D. Kobilyanskii (1989) the decrease of 1000 grain mass with the decrease of latitude is probably in connection with temperature and moisture during ripening. This explains the small-to-medium thousand grain weight and, in compensation, high protein, lysine and histidin content.

CONCLUSIONS

Bulgarian ex situ rye collection is the forth in Europe and occupied seventh place in the world. Botanical diversity cover all taxons, spread in the largest collections. The biggest taxon is Secale cereale subsp. cereale. The advantage of our collection is preserved endemic and relict species Secale rhodopaeum Delipavlov. Local unique landraces and improved varieties have a low variation for 8 traits: stem nodes – number on main stem; days to heading; ear – length, cm and grain quality traits – 1000 grain mass, g, test weight, kg/hl, protein and lyzine and histidin content in grain. Varieties are with the most valuable traits: medium-high stem, short vegetative period and high ear productivity. In the dendrogram these accessions are well separated.

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