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GERMINATION AND QUALITY OF SPELT SEEDS UNDER SOUTH-WESTERN UKRAINE CONDITIONS

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Summary: Three spelt landraces having different origin from the Plant Production Institute nd.a. V.Ya.Yuriev of UAAS collection were studied. Two commercial winter wheat (*Triticum aestivum L.*) check cultivars (Kuyalnik and Selyanka) were also investigated. The study was conducted in 2011-2012 at one location of Odessa region. Field data showed that in the climatic conditions of Odessa region for this period spelt normally passed all phenological phases of development and matured later than the commercial wheat cultivars. Seed productivity of spelt landraces was lower than for bread wheat cultivars. The after-ripening period showed differences for bread wheat and spelt wheat. Spelt seeds after ripening showed high germinability and spelt seedlings were characterized by higher chlorophyll content. Harvested spelt grain was characterized by lower grain hardness, higher protein content, and higher content of proteins soluble in 1-isopropanol compared to the commercial wheat cultivars. Zeleny value for spelt landraces showed probable low gluten strength for spelt grain.

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Key words: *H*ulled wheats; germination potential; grain hardness; protein content; seed development; *Spelt wheat* (*Triticum spelta L.*).

Abbreviations: PI – insoluble protein; PS – soluble protein; AR – after-ripening; D – days.

INTRODUCTION

In the last 20 years the cultivation of hulled wheat is increasing for the higher feeding value, suitability for organic agriculture and as a gene sourse for selection.

Spelt is hexaploid wheat with a genome composition homological to common wheat. The main characteristics of hulled wheat are that they maintain the glumes adhered to the grain after threshing and their semi-brittle rachis (Caro-Baroja, 1972). Compared with wheat, spelt is taller, has long, lax ears, a brittle rachis and adherent glumes

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(Kohajdova Z. et al., 2008). European spelt wheat cultivars are medium high to high, with an erect to dropping spike, with good winter hardness, and lower or medium lodging resistance. They are rather late, and more resistant to sprouting. They withstand higher rainfall and do not depend on soil fertility (Smolkova et al., 1998). The hull protects the spelt grain from pollutants and insects, enhances the retention of nutrients in the kernel and improves freshness (Abdel-Aal et al., 1997). However, hulled wheat shows disadvantages related to the harvesting techniques used and the need to dehisce the spikelets to obtain the grain for human consumption. Grain must undergo a costly dehulling procedure before being introduced into the milling process (Ranhorta et al., 1995).

It was shown that the nutritive value of spelt wheat is high and it contains all basic components which are necessary for human beings such as sugars, proteins, lipids, vitamins and minerals (Bojñanskà et al., 2002). The spelt grains are flinty, with high protein content and medium wet gluten content (Smolkova et al., 1998).

Spelt is cultivated in many ecological farms in Poland, Spain, Germany and other European countries not only because of the higher feeding value in comparison with common wheat, but also due to its higher resistance to some environmental factors, especially low soil demands and wet conditions. The sensitivity of hulled wheat to drought has not been studied enough. There is lack of data on spelt growth potential in south-western Ukraine conditions particularly in Odessa region.

The productivity and efficiency of cereals depends on many site-specific factors, such as soil fertility, climate and management style. It is known that the technical indicators of grain and its nutritional value depend not only on the species and variety, but also on the growth conditions (Lacko-Bartošová et al., 2010). The aim of this work was to investigate spelt wheat seed productivity under field conditions in Odessa region, physiological properties and quality parameters of grain and the seedlings parameters.

MATERIAL AND METHODS

Three spelt landraces from the Plant Production Institute nd. a. V. Ya. Yuriev of UAAS collection were studied. The catalogue numbers of spelt landraces were as follows: UA 0300306 - №1; UA 0300259 - №2; UA 0300101 - №3. Spelt wheat landraces had different geographical origin. Two commercial winter wheat check cultivars (Kuyalnik and Selyanka) were also planted.

The study was conducted in 2011-2012 at one location of Odessa region. In the field experiments, each landrace was planted in two replicates in a randomized complete block design. Plots consisted of single rows 2 m long. Rows were spaced 0.5 m apart. Fifty seeds were planted per row. Fertilization practices were standard for commercial wheat cultivars. There was no application of growth regulators.

We studied development and productivity parameters of spelt plants under Odessa region conditions: phenological phases of plant development, morphometrical parameters of spikes, spikelets and grain productivity.

After harvesting seeds were tested for

duration of physiological dormancy after ripening with and without stratification. Wheat seeds from different species and cultivars harvested from plants grown in Odessa region were tested for some biochemical and technological parameters: grain hardness, protein content, content of soluble in 1-isopropanol proteins, dry gluten content and Zeleny test (ISO 5529). Protein content was determined by the Kjeldahl technique (ISO 20483). The content of dry gluten (ISO 21415), and grain hardness (ISO 8611) was determined using an infrared analyzer Inframatic.

Harvested seeds were tested for their germinability, biomorphological seedlings parameters and total chlorophyll content (a+b). Germination and seedling biomorphology were studied under laboratory conditions. Seeds were grown after ripening during 7 days in Petri dishes at 24°C. Then seedling biomorphology was tested. Total chlorophyll content (a+b) was measured on the 14^{th} day after germination and expressed in mg/g fresh weight.

RESULTS

Field data showed that in 2011 - 2012 in Odessa region spelt plants passed normally all phases of development. Spelt plants were characterized by a longer period of tillering during spring vegetation as well as by later dates of stem elongation and flowering phase onset. In Odessa region climatic conditions in 2011-2012 spelt plants had later maturity date compared to commercial wheat cultivars (Table 1).

Spike length of the studied spelt landraces was by 24-74% higher compared to bread wheat cultivars, whereas spelt spike density was by 16-37% lower than in common wheat cultivars. The amount of spikelets per spike was without statistical difference between the studied spelt landraces and wheat cultivars (18 pcs. average). Grain weights of all studied spelt landraces counted per spike and per one plant were lower than in both check wheat cultivars: 31-59% depending on spelt landrace. The highest indicators

Table 1. Development phases of wheat plants.

Triticum aestivum L.

May 2012				June 2012			
Weeks				Weeks			
I	II	III	IV	I	II	III	IV
SE	SE/H	H	Ant	Ant/MR	DPh	WR	R

Triticum spelta L.

May 2012				June 2012				July 2012	
Weeks				Weeks				Weeks	
I	II	III	IV	I	II	III	IV	I	II
			SE	H/Ant	Ant/MR	MR/DPh	DPh/WR	R	

SE – stem elongation, H – heading, Ant – anthesis, MR – milk ripeness, DPh – dough phase, WR – wax ripeness, R – ripeness.

of spike grain productivity among spelt landraces were obtained for landrace № 1 (31% lower compared to check cultivar Selyanka) (Table 2).

The biochemical characteristics of grain included grain hardness, protein content, dry gluten content, content of soluble in 1-propanol protein fraction and Zeleny test (Table 3). Our results showed that grain hardness of the studied spelt landraces was lower than in winter wheat cultivars (from -11 to 5 units compared to 49-61 units). Protein content in spelt seeds was by 3.8- 4.7% higher than in

Table 2. Morphometrical parameters and productivity of spelt wheat and common wheat spikes.

Parameters	Cultivar, landrace				
	T. aestivum L.		*T. spelta* L.		
	Selyanka	Kuyalnik	№1 UA 0300306	№2 UA 0300259	№3 UA 0300101
Spike length (main shoot) [cm]	9.1±0.3	9.1±0.3	15.9±1.0*	15.3±1.5*	11.3±0.4*
Amount of spikes [psc]	17.7±0.8	17.7±0.8	19.6±0.8	17.6±0.8	17.6±0.8
Spike density [psc/cm]	1.9±0.09	1.9±0.09	1.2±0.05*	1.2±0.05*	1.6±0.07*
Amount of grain in the main shoot spike [psc]	57.3±2.5	56.0±2.9	73.3±6.8*	29.6±4.2	28.3±0.9
1000 grain weight	39.3±3.2	41.5±3.1	20.8±3.9*	41.9±1.9	34.5±4.4*
Grain weight in the main shoot spike [g]	2.26±0.27	2.32±0.15	1.56±0.36*	1.26±0.05*	0.98±0.09*

* – Differences significant at p <0.1 compared to Selyanka cultivar.

Table 3. Biochemical characteristics of spelt wheat and common wheat grain harvested in Odessa region in 2012.

Parameters	Cultivar, landrace				
	T. aestivum L.		*T. spelta* L.		
	Selyanka	Kuyalnik	№1 UA 0300306	№2 UA 0300259	№3 UA 0300101
I	II	III	IV	V	VI
Grain hardness [units]	61	49	-11	12	5
Protein content [%]	16.0±0.1	16.5±0.3	20.1±0.1*	20.7±0.2*	19.8±0.1*
Zeleny value [ml]	43	41	25	24	27
Dry gluten content [%]	9.2±0.2	9.7±0.3	15.9±0.3	14.9±0.1	16.8±0.4
PS in 1-isopropanol [%]	21.7±0.5	25.8±0.6	46.0±0.8	55.0±0.4	49.2±0.6

* – Differences significant at p <0.1 compared to Selyanka cultivar.

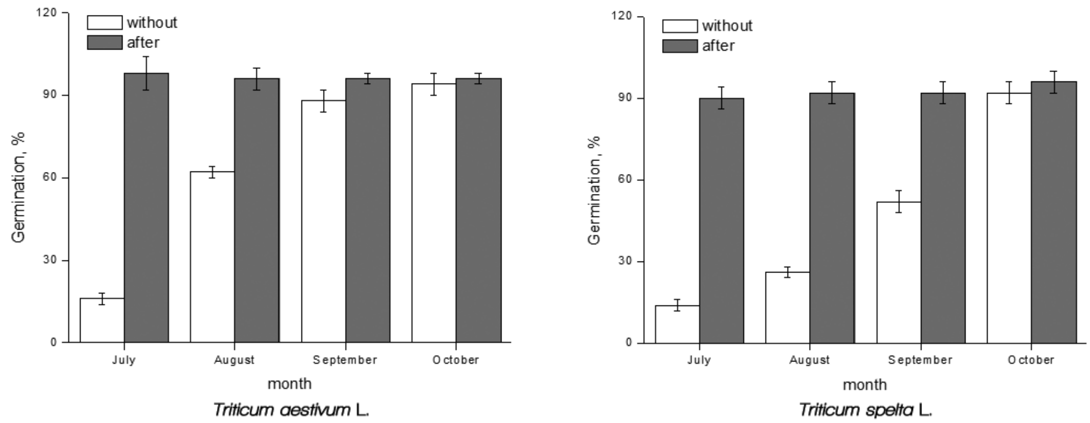

Figure 1. Germination after the physiological dormancy period tested in *Triticum aestivum* L. and *Triticum spelta* L. seeds with and without stratification.

winter wheat check cultivars. Dry gluten content in spelt seeds was up to 7.6% higher than in common wheat seeds. Content of soluble in 1-propanol protein fraction (monomeric proteins) measured in spelt grains was 2 times higher than in modern winter wheat. Zeleny value in spelt was lower compared to common wheat.

The duration and deepness of physiological dormancy was different in the studied spelt landraces and wheat cultivars (Fig. 1). Germination potential of bread wheat seeds and spelt wheat seeds after harvesting was found to be 14-16% without statistical difference between the studied species. One and two months after ripening all seed samples showed increasing germination potential, but it was different for wheat species; germination potential of spelt seeds was by 36% lower than in bread wheat seeds. Three months after ripening all studied samples showed maximum germination potential. Implication of stratification (3 days at +5°C) for tested seeds resulted in increased seed germination potential to its maximal indicators (95% in average) regardless of species or cultivar (landrace) studied.

When the period of post-harvest dormancy ended, harvested wheat seeds from both species were tested for seedling biomorphology and chlorophyll content (Table 4). Spelt was characterized by a higher seedling length (33-51%) compared to commercial winter wheat. Total chlorophyll content (a + b) in spelt seedlings was higher compared to bread wheat: 12-24 % depending on the cultivar in seedlings cultivated under laboratory conditions (14th day after germination).

DISCUSSION

South-western Ukraine region belongs to the steppe zone and is characterized by low average annual rainfall, frequent draughts in the spring and high annual temperatures which is unusual for spelt growth more related to cold and wet regions (Campbell, 1997).

The period of investigation (2011-2012) was characterized by extremely unfavorable weather conditions for the formation of grain harvest crop due to drought fall, the absence of the necessary conditions for hardening of plants, severe

Table 4. Germination, seedling biomorphology and chlorophyll content of *Triticum spelta* L. and *Triticum aestivum* L. seeds harvested in Odessa region in 2012 tested under laboratory conditions.

Parameters	Cultivar, landrace				
	T. aestivum L.		*T. spelta* L.		
	Selyanka	Kuyalnik	№1 UA 0300306	№2 UA 0300259	№3 UA 0300101
Germination potential [%]	94±4	88±6	99±1	96±3	96±3
Shoot length [cm]	11.1±0.2	10.5±0.5	15.9±0.6	14.0±0.4*	14.8±0.5*
Root length [cm]	43.7±1.2	44.7±1.6	50.56±2.7*	57.6±1.2*	38.5±1.5*
Shoot weight [g per 100 pcs]	11.5±0.3	11.6±0.4	10.0±0.5	9.5±0.2	7.8±0.4*
Root weight [g per 100 pcs]	7.9±0.2	6.8±0.4	7.4±0.1	8.1±0.4	4.2±0.2*
Chlorophyll content (a+b) [mg/g]	1.00±0.05	0.82±0.04	1.24±0.06	1.12±0.06	1.09±0.05

* – Differences significant at $p < 0.1$ compared to Selyanka cultivar.

winter frosts, lack of necessary snow cover in the coldest days, and abnormally warm spring (Soil and climatic conditions, http://sgi.od.ua/).

During development wheat plants passed the following phases: germination, seedling tillering, stem elongation, booting, heading, anthesis, milk, dough, ripening. Despite unfavorable climatic conditions our data showed that in 2011-2012 spelt normally passed all development phases. Spelt matured later than commercial wheat which corresponds to the data of other authors (Smolkova et al., 1998; Olivera, 2001). In May 2012 common wheat already passed the heading phase and almost passed the anthesis phase whereas spelt just started heading. Spelt wheat had a longer tillering phase compared to common wheat. So, according to our results spelt wheat plants were tolerant to the unfavorable conditions, drought and frost in the Odessa region for this harvest year. The mismatch of development phases of spelt and common wheat is a very important factor which affects the assessment of optimal timing for sowing. Earliness of commercial wheat, measured as days to heading, may be a disadvantage due to grain shedding and preharvest sprouting.

Grain productivity depends to a large extent on appropriate weather conditions for crops growth. In literature spelt is characterized as a crop with grain productivity 30-60% lower compared to commercial bread wheat cultivars (Jorgensen, 1997). To assess the potential productivity of plants spike density, seed productivity per spike and grain weight per spike must be taken into account. According to our results spelt had longer spikes with lower density. Grain weight of all studied spelt landraces counted per spike and per one plant was lower than in both check wheat cultivars. So, under south-western Ukraine conditions in 2011-2012 spelt had lower grain productivity counted for spike (31-57 % depending on landrace studied) compared to bread wheat which corresponded to literature data (Smolkova et al., 1998).

Probably one of the main reasons for the increased growth of hulled wheat was the high nutritional value of its grain compared to commercial wheat cultivars.

It is known that the technical indicators of grain and its nutritional value depend not only on species and variety, but also on the growth conditions. Since wheat end-use quality is strongly influenced by environment, grain of spelt and common wheat harvested in Odessa region in 2011-2012 was analyzed for hardness, protein content, content of soluble in 1-isopropanol proteins and Zeleny test.

Grain hardness forms the fundamental basis of differentiating world trade of wheat grain. It is common to differentiate "soft" and "hard" hexaploid wheats, and "very hard" durum wheat as three distinct qualitative classes (Morris C. et al., 2002). According to our results spelt grain hardness was 37-72 units lower than in check winter wheat cultivars grain, and up to 90 units compared to durum wheat. Protein content is one of the most important characteristics of the grain which corresponds to its nutritional value. Our data showed that the spelt grain had up to 4.6% higher protein content compared to the analyzed commercial bread wheat seeds. The high protein content of spelt was in good agreement with other investigations where spelt was always superior to wheat (Rüegger et al., 1990; Galterio et al., 1994).

It should to be mentioned that the nutritional value of grain is determined not only by the amount of protein, but to a large extent by its quality. The bread-making quality of flour is influenced by both protein content and protein type, but for a given protein content, wheat quality largely depends on the nature of the gluten composition (Oliveira, 2001). To assess protein quality we determined dry gluten content, content of proteins soluble in 1-isopropanol and Zeleny value. Separation of proteins in 50 % (v/v) 1-propanol was shown to be a good method for fractionation of monomeric (albumins, globulins and gliadins) and polymeric (native unreduced) glutenin proteins. The proteins soluble in 1-propanol (50 PS) were a mixture of monomeric proteins and polymeric glutenin, whereas insoluble in 1-propanol proteins (50 PI) were essentially free of monomeric proteins and comprised mainly of glutenin (Fu et al., 1996). So, spelt grain seemed to be richer of monomeric proteins. The lower Zeleny value in spelt landraces than in commercial wheat cultivars showed probable low gluten strength of the flour. Indeed, the Zeleny value is generally considered an indirect measure of gluten strength. Our result was in agreement with other authors (Rüegger et al., 1993) who found that spelt had lower Zeleny values compared to wheat (Oliveira, 2001).

After harvesting wheat seeds usually are in physiological dormancy stage. However, modern bread wheat cultivars are characterized by a very short dormancy period. The lack of adequate seed dormancy is the major reason for pre-harvest sprouting in the field under wet weather conditions. Pre-harvest sprouting results in a significant economic loss for the grain industry in the world. According to our results seeds of checked spelt landraces and bread wheat cultivars after harvesting were characterized by low indicators of germination (14-16%). After 1 and 2 month of storage all seed samples showed increasing germination potential, but it was different for wheat species; germination potential determined for spelt seeds was by 36% lower than for bread wheat seeds. Three months after ripening all studied samples showed maximum germination potential. Physiological dormancy of spelt and bread wheat seeds was easily disrupted by 3-days stratification at a temperature of +5°C. After stratification all studied seed samples showed germinability of 95% average without significant differences between species, landraces and cultivars. These results indicated that spelt seemed to be more resistant to pre-harvest sprouting which corresponded to data obtained by other authors (Smolková et al., 1998).

Post-harvested seeds harvested in Odessa region in 2011-2012 were germinated in laboratory conditions and tested for seedling biomorphology and chlorophyll content (a+b). Our results showed that spelt landraces were characterized by greater lengths of seedlings in field and laboratory conditions (33-51%) compared to commercial winter wheat. Chlorophyll content is an important indicator of plant organism vital activity. The data obtained showed higher content of chlorophylls (a+b) in green seedlings of spelt under laboratory conditions.

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