ORGANIC WHEAT SEED QUALITY

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Abstract

The Council Regulation (EC) No. 834/2007, and the Commission Regulation (EC) No. 889/2008, are the most important European legislative instructions addressing organic farming. EU regulation lay down the law to solely use organic seeds in order to establish organic crop stands. The seed must originate from plants being grown in compliance with the organic farming rules for at least one generation. It is extremely difficult to get high-quality certified organic seeds. However, organic farmers are not allowed to use any other seeds than the certified organic seeds. Certified organic seeds are rare and organic farmers usually have to use conventional untreated seeds or farm seeds in order to establish their crop stands. For this reason, we evaluated health and biological characteristics of SW Kadrilj variety of bread wheat (*Triticum aestivum* L.) within the three-year trial (2010-2012). The experimental crop stands were established in three different localities within the Czech Republic. There were minimum differences (not statistically significant) in the level of seed contamination with colonies of the most frequent pathogens. There were also low differences in biological quality of seed only in case of some years there were small differences in energy of germination and laboratory germination. Results of the trials have shown the sufficient quality of all the tested seeds origin. However, they must come from the farms applying high-quality agrotechnologies.

Key words: seed quality, organic farming, bread wheat

At least 2.5 million hectares of main cereal species are under organic management (including in-conversion areas) (Willer H. and Kilcher L., 2012). As some of the world's largest cereal producers (such as India, China and the Russian Federation) do not provide land use details, it can be assumed that the area is larger than shown here (Willer H. and Kilcher L., 2009). Comparing this figure with the FAO's figure for the world's harvested cereal area of 707 million hectares (FAOSTAT, 2014), 0.4 percent of the total cereal area is under organic management.

Triticum L., and bread wheat (*Triticum aestivum* L.) in particular, is the most frequent crop in organic farming, the same as in conventional farming. It is grown on a total surface of more than 1 million hectares (Willer H. and Kilcher L., 2012).It is the most frequent crop in the Czech organic farming system. The bread wheat growing area represents 6,993 hectares and its average yield rate represents 2.98 t/ha.

The organic seeds used in order to establish organic crop stands must originate from plants being grown in compliance with the organic farming rules for at least one generation. Seed multiplication is an extremely difficult process. The reproduction crop stand and seed must meet the requirements of the seed certification and authorization procedure as conventional plants and seed do, but organic farming does not allow the use of any pesticides or mineral nitrogenous fertilizers, etc. Organic farmers may use certified organic seeds or farm seeds in order to establish the crop stand. They may also apply for an exception (derogation) and use the conventional untreated seed (Capouchová I. et al, 2012).

The paragraph above indicates a lower productivity of the organically grown cereal crop stands. A deficiency of certified organic seeds and a serious necessity of an application of own farm saved seed are the factors that might provoke it. For this reason, a question of quality in various provenances of seed is to be answered in this paper.

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MATERIAL AND METHOD

Tested varieties: We evaluated quality of spring wheat variety – SW Kadrilj. We used various seeds to establish our exact field trials – certified organic seeds, farm organic seeds and conventional untreated seeds. The certified organic seeds and the farm organic seeds were provided by the PRO-BIO company. The conventional untreated seeds were provided by breeding companies.

Establishment of trials: We used the above mentioned seeds to establish the exact field trials which were carried out in three different localities between 2010 and 2012: the Research Institute of Crop Production in Prague, the University of South Bohemia in České Budějovice and the Prague Life Science University (the research station in Prague-Uhříněves). The exact field trials were based on a method of randomized blocs. We used the seeding rate of 350 germinable (viable) seeds per square meter and the rows were in a distance of 125 mm from each other. Mixture of peas and beans was used as a forgoing crop in the location of the Prague Life Science University (the research station in Prague-Uhříněves). Oat was used as a forgoing crop in the location of the Research Institute of Crop Production in Prague. Leguminous plants were used as forgoing crops in the location of the University of South Bohemia in České Budějovice. The field trials complied with the European legislation, the Council Regulation (EC) No. 834/2007 and the Commission Regulation (EC) No. 889/2008. Characteristics of the trial localities are specified in the following table (*table 1*).

Laboratory analyses of seed health: Before sowing trial seeds, we studied health of those seeds by a method of isolation of micromycetes on the artificial nutrient substance. We used a universal nutrient substance – PDA (Potato Dextrose Agar). We repeated every seed sample test five times. There were 10 seeds in every sample test. Incubation lasted 7 – 10 days (in absolute dark, at 20°C). We evaluated the number of isolated colonies visually. We determined genera of micromycetes with microscopes, on the basis of their microscopic morphological features. After harvesting the exact field trials from three trial locations, we tested and evaluated health of grown seeds by the same method.

Laboratory analyses of seed biological characteristics: We determined the laboratory germination capacity and the energy of emergence. We accepted the following ČSN requirements No. 46 0610 – Testing of seed. One hundred caryopses of every sample (every sample repeated itself four times in the trial) were put on wet folded filtration paper into plastic bowls with a perforated cover. The bowls were put into an air-conditioning box where temperature was 20°C. Energy of emergence was counted four days later. Germinated caryopses which were developed normally were subtracted. Laboratory germination capacity was counted eight days later by the same method. Laboratory emergence and energy of emergence were determined in another stage of the trial. One hundred caryopses of every sample (every sample repeated itself four times in the trial) were put into coarse sand, 3 cm deep into the sand. Sand layer which was 1 cm high was put onto the bowl bottom. Sand was wet (moisture of 60 %). The caryopses were put onto the sand layer, they were pushed slightly into the sand and covered with dry sand. The bowls were put into the air-conditioning box and left there (in 15°C). Energy of emergence was counted seven days later and laboratory emergence was counted 14 days later by subtracting the emerged caryopses.

Statistical data analysis: Results of the study of seed health, biological characteristics, as well as results of yield, were assessed statistically. We applied a method of polyfactorial analysis of variance. Provability of differences in mean figures was verified by Tukey *HSD* test.

Table 1

Characteristics of trial localities

Production locality	Genetic soil type	Soil type	Altitude (metres above sea level)	Average annual temperature (°C)	Average precipitation rate (mm)
Prague Life Science University, Prague - Uhříněves					
beet	brown earth	clay loam	295	8.3	575
Research Institute of Crop Production, Prague - Ruzyně					
beet	degraded black earth	clay loam	340	7.8	472
University of South Bohemia, České Budějovice					
potato	pseudogley cambisol	loam sand	388	8.2	620

RESULTS AND DISCUSSIONS

SW Kadrilj, a spring bread wheat variety, was used as an indicator of health and biological characteristics of the seeds of various provenances. Health of seeds was evaluated, before the seeds were sown into the exact field trials. Results of the evaluation are shown in *table 1*.

There was a quite low number of colonies of genera of micromycetes in the tested SW Kadrilj seeds – the lowest number of *Fusarium spp*. colonies was detected in the SW Kadrilj seeds. The farm and the certified organic seeds contained a little bit more colonies of micromycetes. There were statistically significant differences between the years too. Evaluating the number of *Alternaria* spp. colonies, we came to similar conclusions. The farm seeds also contained a little bit more *Alternaria* spp. colonies. There were differences between the years too. Contamination with *Cladosporium* spp. colonies was strongest in the tested conventional seeds, whereas lowest in the tested farm seeds. There were differences between the years too.

Biological characteristics of the bread wheat seeds were evaluated, before the seeds were sown into the exact field trials. Results of the evaluation are shown in *table 3*. Germination capacity of the farm seeds was much larger than the germination capacity of the certified organic and the conventional seeds. Concerning laboratory germination capacity, there were not such dramatic differences between the seed types. The certified organic seeds were slightly better in laboratory germination capacity than the farm seeds. Energy of germination and laboratory emergence of the certified organic seeds and the farm seeds were statistically and significantly higher than energy of germination and laboratory emergence of the conventional seeds. There were statistically significant differences between the years. Figures in *table 2*, showing the health of seeds do not indicate any mutual relation between the differences in biological characteristics of seeds and the contamination of the seeds with pathogen micromycetes. The differences are not necessarily provoked by more serious contamination with micromycetes. They might be provoked by various vitality of the seed samples. Vitality of the seeds is determined by growing conditions in a particular locality, nutrient conditions, etc.

We also evaluated health of the seeds grown in the exact field trials in the experimental locations in the Research Institute of Crop Production in Prague, the Prague Life Science University in Prague-Uhříněves and the University of South Bohemia in České Budějovice. Results of this evaluation are shown in Table No. 4. Evaluating health of the grown seeds, we also paid attention to these genera of micromycetes that mostly affected bread wheat caryopses: *Fusarium spp., Alternaria spp.* and *Cladosporium spp*. Besides those, we detected other genera of micromycetes as well: *Epicoccum, Ulocladium*, *Bipolaris, Aspergillus, Rhizopus* and *Penicillium,* in particular. They might have a negative impact on the seed germination capacity (Mathre, 1991; Bhat Y. and Fazal M., 2011).

There was quite a low number of *Fusarium* spp. colonies in the tested grown seeds (almost one colony per 10 caryopses on an average). Seed provenance, year and locality had a minimum and statistically non-significant effect on contamination of caryopses with *Fusarium* spp. The grown seeds were a little contaminated with *Cladosporium* spp. micromycetes. Provenance of seeds had a minor impact; year and locality had more significant impact on it.

The grown seeds were mostly contaminated with *Alternaria* spp. (four colonies per 10 caryopses on an average, i.e. one colony more than the sown seeds). Impact of seed provenance was non-significant, year had more significant impact on the contamination rate

We evaluated biological characteristics of the grown seeds too. Results of this evaluation are shown in *table 5*. Energy of germination and laboratory emergence reached high figures. There were statistically non-significant differences between the seed provenance and the experimental localities. There were slight differences between the years. The reached figures were, nevertheless, high.

The seed provenance had a minor statistically non-significant impact on the yield rate. There were notable differences between the years: in 2010, the mean yield was 1–1.5 t/ha lower than it was in 2011 and 2012. Grain yield was considerably influenced by the trial locality: it reached double figures in the Prague Life Science University in Prague-Uhříněves (compared to the other two trial localities). High-quality uncontrolled farm seeds were surprising to us. The reproductive effort mechanism might explain it (Renno J.F. and Winkel T., 1996). A plant grown from the worst quality caryopses provided a lower yield rate but good quality production. Therefore, the farm seeds may be applied to grow extensive crops (Thorsted M.D. et al, 2002; Erol A. et al, 2009). However, such growing has to be done very carefully. Minimum negative impacts on the crop stand yield rate can be expected.

Table 2

Evaluation of health of seeds (before they were sown in the exact field trials)

Factor / Parameter		Fusarium spp. (number of colonies per 10 caryopses)	Alternaria spp. (number of colonies per 10 caryopses)	Cladosporium spp. (number of colonies per 10 caryopses)
Seed origin	EC	0.66±0.64a	0.56±0.51a	1.98±1.44a
	K	0.24±0.21a	1.11±1.02a	2.06±1.42a
	F	1.83±1.15b	2.03±0.96b	0.81±1.04b
Year	2010	1.43±1.05b	1.97±0.90b	1.70±1.47b
	2011	0.92±0.78ab	0.73±1.27a	2.70±0.75c
	2012	0.39±0.10a	1.00±0.33a	0.44±1.75a
Total		0.91±0.67	1.23±0.83	1.61±1.30
Letters indicate the statistically significant differences between the studied data files. The significance level is P≤0.05.				

Table 3

Evaluation of biological characteristics of seeds (before they were sown in the exact field trials)

Factor / Parameter		Energy of germination (%)	Laboratory germination capacity (%)	Energy of emergence (%)	Laboratory emergence (%)
Seed origin	EC	79.97±31.52b	98.70±1.22b	84.43±4.02b	88.37±10.45b
	K	65.37±28.86a	86.60±20.87a	68.97±34.26a	69.10±22.5a
	F	97.47±1.80c	97.90±1.56b	83.43±5.24b	86.87±5.95b
Year	2010	95.20±5.35b	98.33±2.99b	79.50±1.75b	79.07±3.80a
	2011	75.07±24.92a	85.60±20.01a	68.32±21.03a	72.33±26.25a
	2012	72.53±32.02a	99.27±0.45b	88.98±2.06c	93.07±8.77b
Total		80.94±20.72	94.40±7.88	78.94±8.24	81.45±12.97
Letters indicate the statistically significant differences between the studied data files. The significance level is P≤0.05.					

Table 4

Evaluation of health of seeds (after harvest) (isolation of colonies on artificial nutrient substance)

Factor / Parameter		*Fusarium* spp. (number of colonies per 10 caryopses)	*Alternaria* spp. (number of colonies per 10 caryopses)	*Cladosporium* spp. (number of colonies per 10 caryopses)
Seed origin	EC	0.82±0.66a	3.94±2.33a	2.66±2.41a
	K	0.71±0.47a	3.95±1.81a	2.21±2.14a
	F	0.89±0.43a	4.13±1.89a	2.57±2.19a
Year	2010	0.78±0.61a	4.82±2.00b	5.49±3.44b
	2011	0.66±0.40a	5.01±2.08b	0.88±1.51a
	2012	1.01±0.63a	2.20±1.97a	1.07±1.88a
Location	ČZU	1.00±0.50a	4.65±1.90 b	2.66±3.01b
	JU	0.69±0.58a	4.07±2.12ab	0.66±0.57a
	VÚRV	0.52±0.50a	3.36±1.98a	3.96±3.77c
Total		0.81±0.52	4.01±2.01	2.48±2.25
Letters indicate the statistically significant differences between the studied data files. The significance level is P≤0.05.				

Table 5

Evaluation of biological characteristics of seeds (after harvest)

Factor / Parameter		Energy of germination (%)	Laboratory germination (%)	Energy of emergence (%)	Laboratory emergence (%)	Yield rate ($t.ha^{-1}$)
Seed origin	EC	97.28±2.51a	97.99±1.75a	83.68±10.14a	87.47±7.92a	4.07±2.04a
	K	96.94±2.70a	97.73±2.00a	83.83±11.20a	88.41±5.93a	3.87±1.92a
	F	97.34±2.55a	97.89±1.82a	87.42±5.14a	90.94±3.01a	4.08±1.95a
Year	2010	98.47±1.98a	98.90±1.81a	75.49±9.83a	82.38±5.95a	3.17±1.84a
	2011	95.43±2.91a	96.53±1.93a	89.28±6.80b	92.56±4.95b	4.58±1.63b
	2012	97.67±2.79a	98.18±1.66a	90.17±9.96b	91.89±5.94b	4.27±2.40b
Location	ČZU	98.86±2.04a	98.99±1.44a	86.71±9.10a	90.61±5.73a	6.37±2.75b
	JU	97.27±2.09a	98.02±1.74a	84.28±11.15a	87.56±8.08a	2.88±1.34a
	VÚRV	95.44±3.37a	96.60±2.39a	83.94±6.55a	88.66±3.27a	2.78±1.85a
Total		97.19±2.59	97.87±1.86	84.98±8.83	88.94±5.62	4.01±1.97
Letters indicate the statistically significant differences between the studied data files. The significance level is P≤0.05.						

CONCLUSIONS

We studied and evaluate the spring bread wheat seeds of various provenance. Results of our three-year trial have shown the farm seeds are in good health. They do not reach lower figures of seed parameters than the certified organic or the conventional seeds. Crop stands grown from the farm seeds provide similar yield rate as crop stands grown from the certified organic and the conventional seeds.

Results of our trial have shown that the farm organic seeds might be of as good quality as the certified organic seeds. Provided that we draw up suitable cropping, we choose suitable forgoing crops and we respect principles of agrotechnology (including weeds kept under control). Years and localities which are characterised by more pathogens and microorganisms might be a problem. The pathogens worsening and weakening capacity of germination and emergence of seeds are the worst – i.e. *Fusarium* spp. In case that we use the farm seeds there (which have not undergone any authorization procedure), they might be in worse health, have worse emergence capacity, such a crop stand might have smaller capacity of production and such grown seeds might be of worse quality.

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REFERENCES

Bhat Y., Fazal M., 2011 - *Effect of Aspergillus flavus metabolites on wheat seed germination and seedlings growth.* Arab Journal of Plant Protection, vol. 29, p. 139-140.

Capouchová I., Konvalina P., Stehno Z., Prokinová, E., Janovská D., Honsová H., Bláha L., Káš M. 2012 - *Organic cereal seed quality and production.* In: Konvalina, P. (Ed.): Organic Farming and Food Production, Intech, Rijeka, Croatia, p. 25-45

Erol A., Kaplan M., Kizilsimsek M., 2009 - *Oats (Avena sativa) - Common vetch (Vicia sativa) mixtures grown on a low-input basis for sustainable agriculture.* Tropical Grasslands vol. 43, p. 191-196.

Ionescu A.C., Popescu D., 2002 - *The evolution of main soil physical and chemical characteristics as influenced by tillage systems and fertilizers*, Lucr. şt., seria Agronomie, vol. 45, U.S.A.M.V. Iasi, p. 20-26.

Kettnerová M. Ed. 2013 - *Ročenka ekologického zemědělství v České republice (Czech Organic Yearbook).* MZe ČR, Praha, 52 p.

Mathre D. E., Johnston R. H. 1991 - *Control of dry seed decay of wheat*. Plant Diseases vol. 75, p. 957-959.

Renno J.F., Winkel T., 1996 - *Phenology and reproductive effort of cultivated and wild forms of Pennisetum Glaucum under experimental conditions in Sahel: Implications for the maintenance of polymorhysm in the species.* Canadian Journal of Botany vol. 74, p. 959-964.

Thorsted M.D., Olesen J.E., Koefoed N., 2002 - *Effects of white clover cultivars on biomass and yield in oat/clover intercrops*. Journal of Agricultural Science vol. 138, p. 261-267.

Willer H., Kilcher L, 2012 - *The World of Organic Agriculture. Statistics and Emerging Trends. FiBL- IFOAM Report,* Research Institute of Organic Agriculture (FiBL), Frick, and International Federation of Organic Agriculture Movements (IFOAM), Bonn, 338 p.

Willer H., Kilcher L. 2009 - *The world of organic agriculture. Statistics and emerging trends 2009*, Bonn and Frick: IFOAM and FiBL, 309 p.

***** - Faostat 2014**: http://faostat.fao.org/ (accessed 8 June 2014).