Chapter 2

Organic Cereal Seed Quality and Production

Ivana Capouchová, Petr Konvalina, Zdeněk Stehno,
Evženie Prokinová, Dagmar Janovská,
Hana Honsová, Ladislav Bláha and Martin Káš

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/53073

1. Introduction

At least 1.8 million hectares of main cereal species are under organic management (including in-conversion areas). As some of the world's large cereal producers (such as India, China and the Russian Federation) did not provide land use details, it can be assumed that the area is larger than shown here [1]. Comparing this figure with FAO's figure for the world's harvested cereal area of 384 million hectares [2], 0.5 percent of the total cereal area is under organic management.

Wheat (*Triticum* L.) in general 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 area of more than 700 000 ha [1]. Bread wheat is the most important crop in the Czech Republic as well. In 2010, it represented almost 25 % of the organic farming land [3]. An organically grown bread wheat provides a low yield rate (3.26 $t.ha^{-1}$) [3]. As for the conventional farming, the yield rate amounts to 5.24 $t.ha^{-1}$ [4]. The organically grown bread wheat yield rate achieves 62 % of the conventionally grown bread wheat. Foreign literary sources often mention the organically grown bread wheat achieving up to 80 % of the yield rate provided by the conventionally grown bread wheat [5].

Oat is one of the most suitable cereal species for organic farming [6]. As it has low requirements on growing conditions, it is a suitable crop for organic farming in Central Europe [7]. There is a relatively wide range of use of oat. Naked oat is a suitable food crop [8]. Common oat is mostly used as a fodder crop [9]. It is the second most frequent crop (just after bread wheat) in the Czech organic farming system. The common oat growing area represents 5,000 hectares and its average yield rate represents 2.5 t/ha [3].

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 chapter.

2. Legislation of use of seed in organic farming

The Council Regulation (EC) No. 834/2007 of the 28th of June 2007, and the Commission Regulation (EC) No. 889/2008, of the 5th of September 2008, are the most important European legislative instructions addressing organic farming, and are binding for all member states of the European Union. They 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. 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 seed in order to establish the crop stand. They may also apply for an exception (derogation) and use the conventional untreated seed.

2.1. Farm saved seed use

Use of the farm seeds (the seeds produced at a own organic farm) is allowed and any obligatory application for authorization is not required. A farmer should, however, take into account that repeated application of the farm seeds may have a negative effect on the yield rate and health of the crop stand. If the farm seeds of a registered variety are used, a farmer must pay fees to the owner of the breeding rights. Such fees are lower than the standard price for the license (it is even included in the price for the certified organic seeds). The fees (which are usually obligatory but reasonable) for the application of the farm seeds and potato seedlings are not obligatory for small farmers. Moreover, each member state of the European Union has regularized the amount of the fees with legislative regulations.

2.2. Conventional seed use

If there are not any organic seeds available, or left from the previous farming years, seeds coming from the conventional crop stands are allowed. Anyway, the seed needn't be treated with any plant treatment, which are not allowed by the organic farming regulation. An application for an exception to be made,regarding the use of the conventional seeds within the organic farming system, is considered and granted by a public authority (it is usually an accredited organisational unit of the Czech Ministry of Agriculture). The total amount of exceptions tends to be limited, but there is a deficiency of the organic seeds available on the market.

http://dx.doi.org/10.5772/53073

2.3. Information on the availability of the certified organic seeds

Each member state of the European Union is obliged to set up „a database of organic seeds“ (Database). A producer or a supplier of the organic seeds is obliged to insert all the varieties into the Database (the variety missing in the Database is considered as an unavailable variety). Before registering the variety (i. e. inserting it into the Database), the farmer has to provide proof at a review he was put under. The control system must comply with the regulations of the European Union. Moreover, the farmer must prove his seeds meet all the legislative requirements for reproductive material. Data inserted into the Database are regularly updated. There is a list of the obligatory items: the scientific name of the species and variety, the supplier's name and contact, the country which the variety has been registered in, the date the seeds have been available from, the amount of seeds, the name and number code of the control institution which has executed the least control and has issued the certificate on the organic seeds and potato seedlings. If the variety is missing in the official Database, an exception can be granted and the conventional seeds are allowed to be applied. Each member state of the European Union has set up its own database. There is a list of the certified organic seeds databases available in EU member states (Table 1).

3. Production of cereal seeds - An example from the Czech Republic

An increasing number of existing organic farms indicates that certified organic farming has been becoming more and more attractive. The number of Czech organic farms amounts to 3,920 and the organic farms cover a total area of 482,927 ha which represents 11.40 % of the whole agricultural land area [4]. Arable land, nevertheless, covers only 12.27 % of the total area (it means 59,281 ha). The above-mentioned data reflect an unsuitable structure of the organic farming. It has arisen from the previous setting of subventional instruments but also the fact that the arable land farming has always been very difficult and required specific knowledge.

The total area of land where the organic cereals are grown amounts to almost 30,000 ha. Bread wheat is the most frequent cereal species grown in accordance with the organic farming principles in the Czech Republic. In 2010, it covered 8,872 ha of the organic land and represented 22 % of all the organically grown cereal species in the Czech Republic [4]. Although it belongs to the most demanding cereal species, it is able to provide an even higher yield rate than the other organically grown cereal species (e. g. bread wheat – 3.26 $t.ha^{-1}$, spelt wheat – 2.91 $t.ha^{-1}$, rye – 2.82 $t.ha^{-1}$, barley – 2.82 $t.ha^{-1}$, oat – 2.54 $t.ha^{-1}$, triticale – 2.95 $t.ha^{-1}$; all the above-mentioned yield rate values were measured in 2010).

3.1. Supply of organic seeds in the Czech Republic

Data concerning the structure of multiplication crop stands, certified seed and the range of seed at the market, were obtained from the Department of seed and planting materials of the Central Institute for Supervising and Testing in Agriculture and the Ministry of Agriculture of the Czech Republic.

Country	Link
Austria	http://www.ages.at
Belgium	http://www.organicxseeds.com
Bulgaria	http://www.organicxseeds.com
Cyprus	http://www.moa.gov.cy
Czech Republic	http://www.ukzuz.cz
Denmark	http://planteapp.dlbr.dk
Estonia	http://www.plant.agri.ee
Finland	http://www.evira.fi
France	http://www.semences-biologiques.org
Germany	http://www.organicxseeds.com
Greece	http://www.minagric.gr
Hungary	http://www.nebih.gov.hu
Ireland	http://www.organicseeds.agriculture.gov.ie
Italy	http://www.ense.it
Latvia	http://www.vaad.gov.lv
Luxembourg	http://www.organicxseeds.com
Netherlands	http://www.biodatabase.nl
Poland	http://ec.europa.eu/agriculture/organic
Portugal	http://www.dgadr.pt
Slovak Republic	http://www.uksup.sk
Slovenia	http://www.arhiv.mkgp.gov.si
Spain	http://www.magrama.gob.es
Sweden	http://www.jordbruksverket.se
United Kingdom	http://www.organicxseeds.com

Table 1. Database of the certified organic seeds registered in each member state of the European Union (data updated within 1st July 2012)

Between 2008/09 and 2010/11 there was a gradual increase in the land area used for organic cereal seed production. Nevertheless, they represented 1.5 % (349 ha) of the total organic land area in 2009 in the Czech Republic. Regarding the average model seeding rate of 220 $kg.ha^{-1}$, we would need 5,008 t of seed to plant the entire area of cereals in a particular year. In 2009, the average grain yield of organic cereals in the Czech Republic represented 2.94 $t.ha^{-1}$[10]. It means we would need a multiplication area of 1,703 ha providing that 100% of the seed were certified as organic seed. In 2009, seed were reproduced on 20.5% of the required land area. It is unrealistic that 100% of grown seed will be certified as organic. A comparison between the allowed multiplication land surface and amounts of allowed winter wheat seed shows that the major part of harvested seed have not been certified as organic seed in 2009 (Table 2). In the same year, 90.95 t of the winter wheat seed were certified as organic. However, this winter wheat was grown on 125 ha of land. It means that the major part of the harvested material did not meet the requirements of the seed certification procedure (same as the major part of the other cereal species). The range of the reproduced organic cereal species is very narrow. The growing of the suitable varieties on the local farm land and under local climatic conditions is strongly limited, because of limited organic seed availability.

Since 2009, organic farmers have asked for permit to use a lot of conventional untreated seed. In 2009, 398 exceptions for 1,664 t of seed were granted (Table 3). Except for the certified organic seed (Table 2) and conventional untreated seed (Table 3), the organic farmers also used their own (saved) seed in order to establish the crop stands. There is not enough information on the applied amount of farm saved seed. Therefore, the following model amount of seeds was used for 2009: amount of certified organic seed = 281 t/seeding rate of 0.22 $t.ha^{-1}$ = 1,277 ha of the seeded surface; amount of conventional untreated seed = 1,664 t/ seeding rate of 0.22 $t.ha^{-1}$ = 7,564 ha of the sown surface. The area of grown cereals represented 22,762 ha - 1,227 ha - 7,564 ha = 13,971 ha where the farm saved seed were used. The share of each seed type is presented in Figure 1.

Species	2008-2009				2009-2010				2010-2011[2]	
	Seed production		Certified seed		Seed production		Certified seed		Seed production	
	NV[1]	ha	NV	t	NV	ha	NV	t	NV	ha
Winter wheat	5	72	4	73	7	125	5	91	4	102
Spring wheat	1	13	1	23	-	-	-	-	1	15
Spelt	2	66	2	159	2	89	2	79	3	143
Spring barley	2	21	1	21	2	26	-		3	20
Triticale	-	-	-	-	1	18	1	8	2	45
Winter rye	-	-	-	-	1	8	1	8	2	37
Naked oat	2	28	2	23	2	34	2	28	1	15
Oat	2	27	-	-	2	50	2	40	2	44
Total	14	**227**	**10**	**299**	**17**	**349**	**13**	**254**	**18**	**422**

Remark: [1]NV = number of varieties; [2]no seed certified

Table 2. Seed production and certified seed offered in the Czech Republic

The use of organic seed becomes more important in many European countries thanks to the legislative measures and increasing demand for the organic products [11]. It is, nevertheless, one of the most developing parts of organic agriculture [12]. However, the total supply of organic seed is still quite low. The high proportion of common farm seed coming from repeated seeding contributes to a reduction of the yield rate of the crop stands [13]. The seed certification process is very demanding, as the organic seed undergo the review of the Central Institute for Supervising and Testing in Agriculture of organic farming [14], but organic farming regulations do not allow the use of any pesticides, etc. [15].

Species	2009		2010	
	Number of exceptions	Seed (t)	Number of exceptions	Seed (t)
Bread wheat	66	271	112	515
Spelt	5	78	9	8
Barley	47	129	77	319
Triticale	86	651	76	455
Rye	23	12	20	42
Oat	161	523	174	444
Total	398	1664	468	1783

Table 3. Exceptions for conventional untreated seed use in the Czech Republic

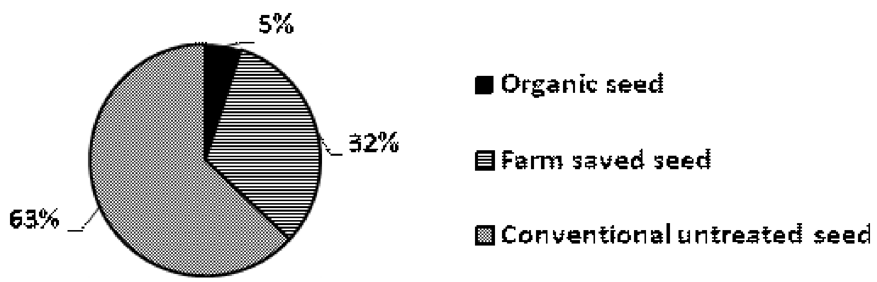

Figure 1. Seed use in organic farming in the Czech Republic (2009) (%)

3.2. Preference and expectations of the Czech organic farmers related to seeds

A questionnaire survey was carried out between 2009 and 2010; 329 questionnaires were sent to organic farmers working on arable land, of which 42% were sent back. The farmers were asked to answer nine questions. The questionnaires were converted into electronic versions and assessed by the contingency tables in the Excel program.

A further part of the questionnaire aimed to find out how organic farmers find and gather information on seeds. The main information resources are as follow: the internet, consultancy, from the Association of Organic Farmers and seed companies. The official database of the certified organic seed (http://www.ukzuz.cz/Folders/2295-1-Ekologicke+osivo.aspx) is also frequently used by the organic farmers (Table 4). The obligation to document the absence

http://dx.doi.org/10.5772/53073

of the certified organic seed when applying for a exception in the conventional untreated seed use, is one of the important reasons. Most of the organic farmers (75% of the farms) would prefer the certified organic seed if the supply was sufficient and prices favourable (Table 4). Only 14% of the farms explicitly prefer conventional untreated seed. The suitability of varieties and transport distance are other reasons for the farm saved seed preference (Table 4).

Reason for farm saved seed use (%)		Use of organic seed database (%)		Would you prefer organic seed ? (%)	
Suitability of varieties	16	Yes, I use the database	51	Yes, I would	75
Seed price	37	Yes, I sometimes use	16	No, I would not	14
Transport distance	18	I know but I do not use	20	I do not know	11
Supply	24	I have no access	7		
Others	5	Others	6		

Table 4. Organic farmers' attitudes to seed issues

4. Quality of organic seed – Results of experiments

Data and outcomes being analysed in this chapter have resulted from the trials executed by the authors, and they are described in detail below. They are based on A) results of standard seed laboratory test (biological traits and health), B) results of the field trials.

4.1. Material

Used varieties and seed provenances are described in Table 5. Three categories of seeds were collected in the Czech Republic: the certified organic seeds (O), the conventional untreated seeds (C) and the organic farm seeds (Farm seed I., Farm seed II.). The following cereals species were tested in the research trials and analysed: bread wheat (*Triticum aestivum* L.) – SW Kadrilj variety; two varieties of hulled oat (*Avena sativa* L.) – Neklan and Vok varieties; naked oat (*Avena nuda* L.) –Izak and Saul varieties; and spring barley (*Hordeum vulgare* L.) –Pribina variety.

4.1.1. Methods

Field trials were sown during the experimental years 2010 and 2011 in a randomized, complete block design on organic certified trial field in two locations in Prague (Czech University of Life Sciences Prague; Crop Research Institute in Prague) and in Ceske Budejovice (University of South Bohemia in České Budějovice). The seeding rate was adjusted for a density of 350 germinable grains per m^2. Rows were 125 mm wide. The plots were treated in compliance with European legislation - European Council Regulation (EC) No. 834/2007 and European Commission Regulation (EC) No. 889/2008.

Crop	Cultivar	Seed provenance
Naked oat	Saul	Organic certified (EC), conventional untreated (C), Farm saved seed from better growing conditions (Farm seed I.), Farm saved seed from worse growing conditions (Farm seed II.)
	Izák	
Hulled oat	Vok	
	Neklan	
Bread wheat	SW Kadrilj	
Barley	Pribina	

Table 5. Analysed cultivars and provenances

Characteristics of the trial stations: The Czech University of Life Sciences Prague (50°04´N,14°62´E): warm and mid-dry climate, soil type - brown soil, kind of soil - loamy clay soil, altitude of 295 m. The Crop Research Institute in Prague - Ruzyne (50°08´N,14°30´E): warm mid-dry climate, soil type - degraded chernozem, kind of soil - clay and loamy soil, altitude of 340 m. The University of South Bohemia in Ceske Budejovice (48°98´N, 14°45´E): Mild warm climate, soil type – pseudogley cambisols, kind of soil - loamy sand soil, altitude of 388 m.

Analyses of seed contamination with fungi (before seeding and after harvest): The method of isolation of micromycets inside an cultivation media was applied in order to evaluate the rate of grain contamination with microscopic fungi. A universal cultivation media - PDA (Potato Dextrose Agar - HiMedia) was used in the experiment. Incubation lasted from seven to ten days and it was run in a dark room and in a temperature of 20^{o}C. Each sample was repeated five times, there were ten grains included in each repetition. Mixed colonies were cleaned and sorted before the determination, clean isolates of fungi were determined, therefore. The number of isolated colonies was visually determined, the determination of micromycets was executed with microscopes and it was based on the microscopical morphological traits.

Laboratory germination and energy of germination (before seeding and after harvest): 100 caryopses of each sample were used and repeated four times, they were put into plastic bowls with perforated caps, on wet folded filtration paper. The bowls were placed into a ventilated air-conditioned box where 20°C was the inside temperature. The energy of germination was assessed four days later (by counting of usual germinated caryopses). Laboratory germination was assessed by the same procedure eight days later.

Laboratory emergence and energy of emergence (before seeding and after harvest): 100 caryopses of each sample were put in coarse sand, 3 cm deep, four times. A 1 cm wide wet sand layer (characterised by 60% humidity) was placed at the bottom of the bowl. The caryopses were put onto the sand layer; they were slightly pressed and covered with dry sand. The laboratory emergence was determined at the temperature of 15°C. Seven days later, the energy of emergence was assessed, and 14 days later, the laboratory emergence was determined by deduction of the emerged caryopses.

The Statistica 9.0 (StatSoft. Inc., USA) program was used for statistical data analysis. Regression and correlation analyses provided the evaluation of interdependence. The comparison of varieties and their division into statistically different categories were provided by the *Tukey HSD* test.

4.2. Oat (*Avena sativa* L., *Avena sativa* var. *nuda*)

Results of the evaluation of the microscopical fungi occurrence on seeds, found out by isolation and cultivation of colonies on the cultivation media, are shown in Table 6. The seeds were most seriously affected by *Penicillium* spp. colonies. 6.3 colonies per 10 grains – this was the mean number of colonies (*Fusarium* spp., *Alternaria* spp., *Penicillium* spp.) occurring on the seeds before to direct seeding. The hulled oat was more seriously affected than the naked oat. The individual varieties were affected by a similar situation. Neklan was the most seriously affected variety. There were negligible differences between the seed categories (certified organic seeds, conventional untreated seeds, farm seeds originating from organic production) seen from the seed origin point of view. Differences in *Alternaria* spp. occurrence rate between the individual oat species were detected ($P < 0.05$) (*Tukey HSD* test). The common oat caryopses‘affection was double to the naked oat caryopses. [16] gives a possible explanation. The microscopical fungi occurrence is stronger on the surface of hulls. The hulled oat is harvested despite the affected hulls, whereas the naked oat caryopses lose their hulls during harvest; therefore, the harvested grains are less contaminated with fungi. Both oat species were characterised by a similar rate of contamination with the other microscopical fungi species (e.g. *Penicillium* spp.). *Rhizopus nigricans* was also detected in most of the samples. Results of the correlation analysis (Table 8) show a strong relationship between the individual biological traits. We have also detected a positive middle correlation between the occurrence of *Alternaria* spp. fungi, germination and emergence rate.

The research was aimed also at the detection of the transmission of fungi micromycets onto the following seed generation. When studying and evaluating the first generation of seed,we found that the seed contamination rate was not influenced by the growing technology applied on the parent seed crop stands (Tables 6 and 7). As for the following seed generation (Tables 9 and 10), it was not significantly influenced by the seed origin – *Tukey HSD* test ($P < 0.05$). As for the following seed generation, a difference in the occurrence rate of *Fusarium* spp. colonies between the oat species has been found out. The hulled oat was more seriously affected because of the harvest of grains covered with the contaminated hulls [16]. There were not any significant correlations between the microscopical fungi contamination rate and the biological traits of seeds (Table 11).

The influence of seed health conditions on an expansion of diseases throughout the growing period has not yet been ascertained. No varieties or localities were affected by any diseases being caused by the pathogens we had determined on the seeds. They were not affected by any other pathogens being trasmitted by seeds either. The total rate of contamination of the caryopses with microscopical fungi was influenced by weather conditions during vegetation period. The year of 2010 had been wetter, which caused a higher rate of grain contamination. The hulled oat was more seriously contaminated than the naked oat; it was caused by a fact that the hulled oat caryopses get less dry, that makes ideal conditions for an expansion of the fungi pathogens [16]. The strong rate of caryopses' contamination with *Penicillium* spp. colonies was surprising, as these fungi are considered as waste disposal pathogens.

Factor		*Fusarium* spp. (no. colonies/10 grains)	*Alternaria spp. (no. colonies/10 grains)*	*Penicillium spp. (no. colonies/10 grains)*
Oat	Hulled	0.7±0.6[a]	2.0±0.7[b]	4.3±2.4[a]
	Naked	0.4±0.3[a]	1.1±0.7[a]	4.1±3.4[a]
Variety	Izak	0.5±0.4[a]	1.1±0.7[a]	3.7±2.2[a]
	Saul	0.3±0.2[a]	1.2±0.8[a]	4.5±4.5[a]
	Vok	0.5±0.6[a]	2.0±1.0[a]	2.9±1.4[a]
	Neklan	0.8±0.6[a]	2.0±0.3[a]	5.7±2.4[a]
Seed	Organic	0.5±0.6[a]	1.7±1.1[a]	4.8±3.6[a]
	Conventional	0.6±0.5[a]	1.6±0.8[a]	4.1±2.0[a]
	Farm saved seed	0.5±0.4[a]	1.4±0.6[a]	3.7±3.2[a]
Year	2010	0.3±0.5[a]	2.0±0.7[a]	5.1±3.3[b]
	2011	0.8±0.4[b]	1.2±0.8[b]	3.3±2.2[a]
Total		0.5±0.5	1.6±0.8	4.2±2.9

Remark: Different letters show the statistical differences in *Tukey HSD* test between varieties, $P < 0.05$;

Table 6. Contamination of seed by microscopic fungi colonies - seed before seeding (mean + SD)

Our research has not ascertained any transmission of micromycets or pathogens onto the emerged plants or the following seed generation either. Such a finding is, nevertheless, relevant to oat which is extensive [17] and less bred than the other cereal species. The contamination of seeds with *Penicillium* spp. colonies usually leads to a reduction of germination and emergence. The contamination of caryopses with *Fusarium* spp. colonies did not cause any serious reduction of germination or emergence during the trials. The Czech legal notice on the marketing of cereal seeds (Regulation No. 369/2009), based on the European Union legislation, does not stipulate any limits of the rate of occurrence of *Fusarium* for oat grains. As for the other cereal species, the limit of 10 % has been set by law. We have based our research on the fact that the same limit may be accepted by oat too. Concerning the health conditions of seeds, the occurrence of *Fusarium* spp. was one of the studied and evaluated pathogens. The detected amount of *Fusarium* spp. did not have any negative effect on the seeds. The experiment has also shown that the rate of contamination with *Fusarium* did not reach the limit of 10 percent in the organic farming system in 2011 either. However, the year of 2011 was characterised by a high precipitation rate in June and July, which played a positive role for *Fusarium* expansion within spikes. The average rate of contamination of the naked oat grains with *Fusarium* reached 1.3 percent in 2011, whereas it reached 8.3 percent within the common oat grains the same year. Therefore, it is highly recommended to use own farm saved seed in order to establish a crop stand if there is a deficiency of the certified organic seeds. We have to take the rate of occurrence of *Penicillium* spp. into account. However, the proper farm seeds must come from the crop stands being grown in accordance with the principles of rmultiplication agrotechnology. According to [14], such principles include a good-quality cropping, a parcel rid of post-harvest residues, ideal land-climatic conditions, a careful harvest, etc.

Factor	Parameter	Energy of Germination (%)	Germination (%)	Energy of Emergence (%)	Emergence (%)
Oat	Hulled	77 ± 24^{a}	85 ± 13^{a}	69 ± 12^{a}	78 ± 11^{a}
	Naked	78 ± 28^{a}	82 ± 25^{a}	65 ± 28^{a}	71 ± 28^{a}
Variety	Izak	93 ± 7^{a}	96 ± 2^{a}	84 ± 4^{b}	87 ± 3^{b}
	Saul	63 ± 33^{a}	68 ± 29^{a}	46 ± 30^{a}	55 ± 3^{a}
	Vok	69 ± 30^{a}	81 ± 16^{a}	65 ± 12^{ab}	73 ± 13^{ab}
	Neklan	85 ± 14^{a}	90 ± 8^{a}	74 ± 10^{ab}	82 ± 8^{ab}
Seed	Organic	75 ± 30^{a}	84 ± 18^{a}	67 ± 21^{a}	74 ± 21^{a}
	Conventional	86 ± 25^{a}	88 ± 23^{a}	73 ± 25^{a}	79 ± 24^{a}
	Farm seed	71 ± 21^{a}	79 ± 17^{a}	62 ± 19^{a}	70 ± 18^{a}
Year	2010	92 ± 8^{a}	93 ± 7^{a}	73 ± 7^{a}	82 ± 6^{a}
	2011	63 ± 29^{b}	75 ± 23^{b}	61 ± 28^{a}	66 ± 27^{a}
Total		78±25	84±19	67±21	74±21

Remark: Different letters show the statistical differences in *Tukey HSD* test between varieties, *$P < 0.05$;*

Table 7. Biological traits - seed before seeding (mean + SD)

Parameter		Mean+SD	1	2	3	4	5	6
Fusarium spp.	1	0.5±0.5						
Alternaria spp.	2	1.6±0.9	-0.23^{ns}					
Penicillium spp.	3	4.2±2.9	-0.10^{ns}	0.32^{ns}				
EG^{1}(%)	4	78±25	-0.24^{ns}	0.44^{*}	0.33^{ns}			
Germination(%)	5	84±19	-0.10^{ns}	0.42^{*}	0.33^{ns}	0.93^{**}		
EE^{2}(%)	6	67±21	0.07^{ns}	0.29^{ns}	0.35^{ns}	0.83^{**}	0.95^{**}	
Emergence(%)		74±21	0.04^{ns}	0.41^{*}	0.36^{ns}	0.86^{**}	0.97^{**}	0.98^{**}

Remark: $^{*}P < 0.05$; $^{**}P < 0.01$; ^{ns} not significant; ^{1}EG = energy of germination; ^{2}EE = energy of emergence

Table 8. Results of the correlation analysis (seed before seeding)

Factor		*Fusarium spp. (no. colonies/10 grains)*	*Alternaria spp. (no. colonies/10 grains)*	*Penicilium spp. (no.colonies/10 grains)*
Oat	Hulled	1.4±0.8[b]	4.6±2.2[b]	2.9±2.4[a]
	Naked	0.7±0.7[a]	2.4±1.8[a]	4.3±2.9[b]
Variety	Izak	0.8±0.5[ab]	2.4±1.5[a]	4.2±2.1[a]
	Saul	0.6±0.9[b]	2.4±2.4[a]	2.3±3.0[a]
	Vok	1.4±0.8[a]	4.9±2.0[b]	2.6±3.6[a]
	Neklan	1.3±0.8[a]	4.4±2.1[b]	3.3±1.8[a]
Seed	Organic	1.0±0.7[a]	3.5±2.6[a]	3.6±2.8[a]
	Conventional	1.2±0.7[a]	3.4±2.3[a]	3.9±2.9[a]
	Farm saved seed	0.9±1.0[a]	3.7±2.0[a]	3.3±2.6[a]
Year	2010	1.2±0.9[a]	3.2±2.7[a]	3.7±3.3[a]
	2011	1.0±0.8[a]	3.8±1.8[a]	3.5±2.1[a]
Locality	CULS	1.5±1.0[a]	3.2±2.4[a]	4.3±2.9[a]
	USB	0.9±0.7[a]	3.7±2.6[a]	4.2±3.0[a]
	CRI	0.7±0.5[a]	3.6±1.9[a]	2.3±1.8[a]
Total		1.1±0.8	3.5±2.3	3.6±2.7

Remark: Different letters show the statistical differences in *Tukey HSD* test between varieties, $P < 0.05$;

Table 9. Contamination of seed by microscopical fungi colonies - harvested seed (mean + SD)

Factor		Energy of Germination (%)	Germination (%)	Energy of Emergence (%)	Emergence (%)
Oat	Hulled	88±17[a]	90±16[a]	78±14[a]	84±13[a]
	Naked	92±5[a]	93±4[a]	78±11[a]	85±8[a]
Variety	Izak	93±4[a]	95±3[a]	81±8[a]	88±4[a]
	Saul	90±13[a]	92±10[a]	75±13[a]	83±12[a]
	Vok	84±5[a]	87±4[a]	76±13[a]	82±10[a]
	Neklan	92±20[a]	94±20[a]	81±15[a]	87±15[a]
Seed	Organic	90±12[a]	93±9[a]	79±12[a]	86±10[a]
	Conv.	89±8[a]	91±7[a]	76±5[a]	84±5[a]
	Farm	90±16[a]	92±16[a]	78±17[a]	85±16[a]
Year	2010	93±4[b]	95±3[b]	77±7[a]	86±7[a]
	2011	87±16[a]	89±15[a]	79±16[a]	84±14[a]
Locality	CULS	91±4[a]	93±4[a]	80±9[a]	86±8[a]
	USB	94±4[a]	95±3[a]	82±7[a]	87±4[a]
	CRI	85±20[a]	87±18[a]	73±17[a]	82±17[a]
Total		90±12	92±11	78±12	85±11

Remark: Different letters show the statistical differences in *Tukey HSD* test between varieties, $P < 0.05$;

Table 10. Biological traits of seed - harvested seed (mean + SD)

Parameter		Mean + SD	1	2	3	4	5	6
Fusarium spp.	1	1.1±0,8						
Alternaria spp.	2	3.5±2,3	0.47**					
Penicilium spp.	3	3.6±2,7	-0.05ns	-0.16ns				
EG[1] (%)	4	90±12	0.03ns	-0.04ns	-0.01ns			
Germination (%)	5	92±11	0.06ns	-0.04ns	-0.01ns	0.99**		
EE[2] (%)	6	78±12	0.03ns	0.07ns	-0.11ns	0.74**	0.72**	
Emergence (%)		85±11	0.01ns	0.01ns	-0.12ns	0.84**	0.83**	0.93**

Remark: *$P<0.05$; **$P<0.01$; ns not significant; [1]EG = energy of germination; [2]EE = energy of emergence

Table 11. Results of the correlation analysis (harvested seed)

4.3. Bread wheat (*Triticum aestivum* L.)

The spring wheat cultivar SW Kadrilj registered in the Czech Republic has been selected as a model variety. The experiments aimed at the evaluation of selected diseases and seed quality were organised in 3 localities for 2 years (2010 and 2011). Experimental plots in particular localities were sown with seeds of different origin (organic certified, farm saved seed and conventional untreated) whose health state and quality is described in Tables 12 and 13.

Factor		*Fusarium spp. (no. colonies/10 grains)*	*Alternaria spp. (no. colonies/10 grains)*
Year	2010	1.4±1.1[a]	2.0±1.0[a]
	2011	0.1±0.2[a]	0.7±1.3[a]
Seed origin	Organic	0.7±1.0[a]	0.5±0.7[a]
	Conventional	0.2±0.3[a]	1.0±1.4[a]
	Farm saved seed	1.5±1.5[a]	2.6±0.5[a]
Total		0.8±1.0	1.4±1.0

Table 12. Contamination of seed with *Fusarium* spp. and *Alternaria* spp. (seed before seeding)

Factor		Energy of Germination (%)	Germination (%)	Energy of Emergence (%)	Emergence (%)
Year	2010	98±1[a]	98±1[a]	78±2[a]	79±1[a]
	2011	82±25[a]	86±20[a]	68±32[a]	74±26[a]
Seed origin	Organic	98±2[a]	98±2[a]	83±5[a]	83±5[a]
	Conventional	76±32[a]	81±26[a]	54±31[a]	61±24[a]
	Farm seed	96±1[a]	97±0[a]	82±7[a]	85±7[a]
Total		90±18	92±15	73±21	77±17

Table 13. Biological traits (seed before seeding)

Infestation of the seed used for seeding with *Fusarium* spp. and *Alternaria* spp. depended on seed provenance. The farm seed was more infested in both years (Table 12). On the other hand seed quality parameters were very similar in categories of seed origin in 2010 but in 2011 the conventional seed had very low seed quality growing to bad conditions during harvest.

In grain after the harvest of experimental plots, there were determined the same parameters as in the initial seed and the obtained data were statisicaly evaluated (Tables 13 and 14).

Factor		***Fusarium* spp. (no. colonies/10 grains)**	***Alternaria* spp. (no. colonies/10 grains)**
Locality	CRI	0.4±0.4[a]	4.3±0.8[a]
	USB	0.9±0.7[a]	4.9±1.5[a]
	CULS	0.8±0,6[a]	5.6±1.8[a]
Year	2010	0.8±0.7[a]	4.9±1.9[a]
	2011	0.6±0.4[a]	5.0±0.9[a]
Seed origin	Organic	0.6±0.7[a]	5.2±1.7[a]
	Conv.	0.9±0.5[a]	4.6±1.9[a]
	Farm	1.0±0.4[a]	5.1±0.8[a]
Total		0.7±0.6	4.9±1.5

Remark: Different letters show the statistical differences in *Tukey HSD* test among parameters within categories. $P < 0.05$;

Table 14. Contamination of seed by microscopical fungi colonies - harvested seed (mean + SD)

Variability within particular categories (locality, year and seed origin) was relatively high. Consequently, no significant differences within the categories were identified (Table 15). Nevertheless, we can observe that in grain harvested from plots sown with farm saved seed, the infestation with *Fusarium* spp. was higher than in the other two categories (Table 15).

In 2010 there was evaluated in addition to *Fusarium* spp. and *Alternaria* spp. also the occurrence of *Cladosporium* spp. that widely infested seed in that year. Micromycets of all three species appeared on seed used for seeding in very similar quantities (Figure 2). *Fusarium* spp. contaminated harvested grain lightly. A higher occurrence has been observed in the case of *Alternaria* spp., *Cladosporium* spp. was prevailing in the CRI localilty.

A similar situation as in 2010 was observed in 2011, mainly as it concerns *Fusarium* spp. (Figure 3). Instead of *Cladosporium* spp. the *Penicilium* spp. was prevailing at that year because it contaminated harvested seed relatively strongly.

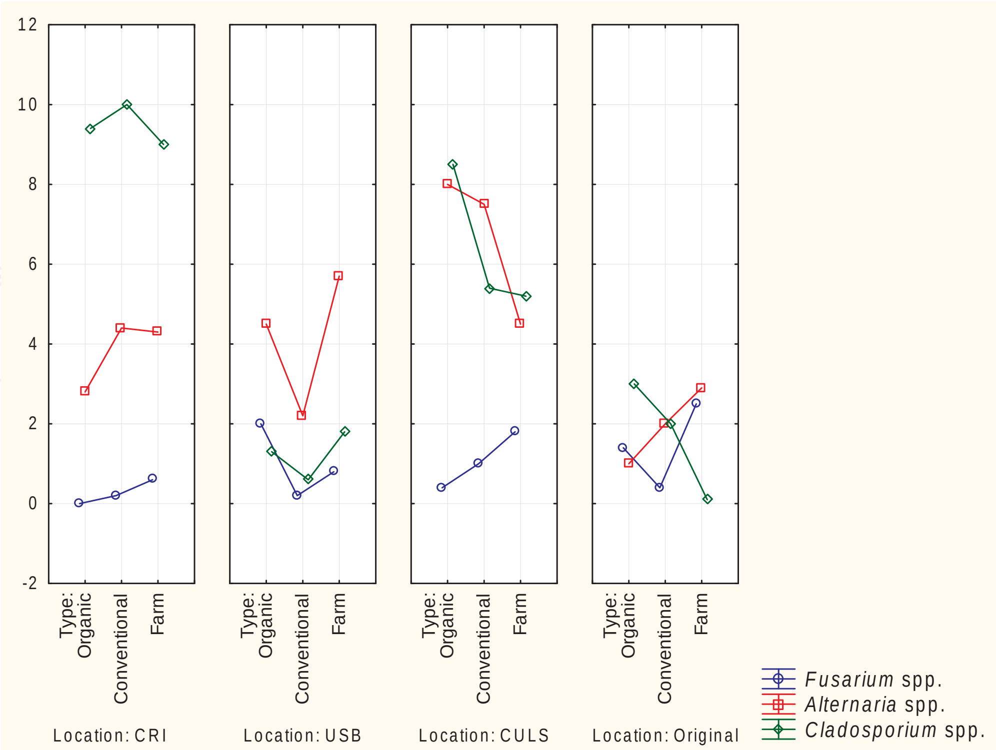

Figure 2. Comparison of infestation in harvested seed of different provenance in 2010 (no.of colonies/10 grains)

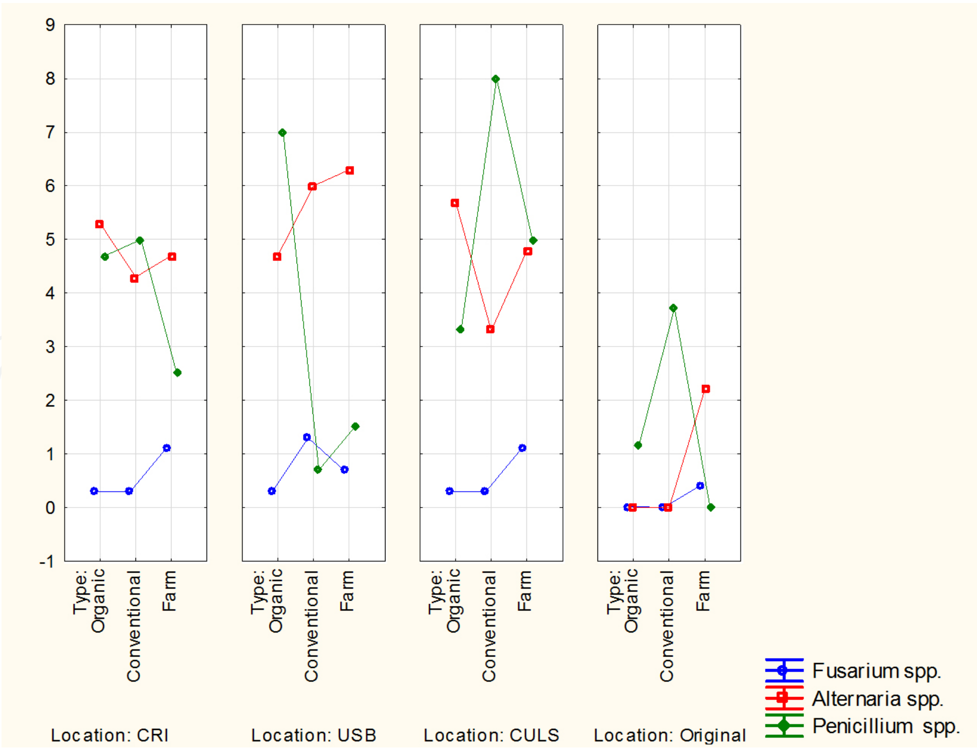

Figure 3. Comparison of infestation in harvested seed of different provenance in 2011

<table>
<tr><th colspan="2">Factor</th><th>Energy of Germina-tion (%)</th><th>Germina-tion (%)</th><th>Energy of Emergence (%)</th><th>Emergence (%)</th><th>Yield (t.ha-1)</th></tr>
<tr><td rowspan="2">Location</td><td>CRI</td><td>95±5a</td><td>97±3a</td><td>82±7a</td><td>88±4a</td><td>2.8±0.6a</td></tr>
<tr><td>CULS</td><td>97±1b</td><td>99±1b</td><td>85±11a</td><td>89±7a</td><td>5.8±0.7b</td></tr>
<tr><td rowspan="2">Year</td><td>2010</td><td>99±0b</td><td>100±0b</td><td>77±8a</td><td>85±5a</td><td>3.8±1.6a</td></tr>
<tr><td>2011</td><td>94±4a</td><td>96±2a</td><td>89±5b</td><td>92±2b</td><td>4.8±1.9b</td></tr>
<tr><td rowspan="3">Seed origin</td><td>Organic</td><td>97±4a</td><td>98±2a</td><td>77±13a</td><td>87±8a</td><td>4.3±2.0a</td></tr>
<tr><td>Conventional</td><td>97±4a</td><td>98±3a</td><td>84±6a</td><td>88±5a</td><td>4.2±1.9a</td></tr>
<tr><td>Farm saved seed</td><td>97±5a</td><td>98±3a</td><td>88±4a</td><td>91±2a</td><td>4.4±1.8a</td></tr>
<tr><td colspan="2">Total</td><td>97±4</td><td>98±2</td><td>83±9</td><td>89±5</td><td>4.3±1.7</td></tr>
</table>

Remark: Different letters show the statistical differences in *Tukey HSD* testbetween varieties. $P < 0.05$;

Table 15. Biological traits - harvested seed (mean + SD)

Differences among localities in seed quality parameters were not significant. Nevertheless, higher seed quality was determined in seed from CULS – locality Prague – Uhřiněves. In general, final values (germination and emergence) were higher than the energy of germination and energy of emergence, respectively. Different conditions during the vegetation period in 2010 and 2011 caused significant differences between the years. Higher germination and energy of germination was not manifested in higher energy of laboratory tested energy of emergence and emergence. Different origin of seed did not influence significantly seed quality parameters.

4.4. Barley (*Hordeum vulgare* L.)

The spring barley variety Xanadu registered in the Czech Republic has been selected as a model variety. As in the case of spring wheat, the experiments aimed at the evaluation of the most important diseases and seed quality were organised in 2 experimental localities (Crop Research Institute Prague – CRI and Czech University of Life Sciences Prague – CULS) for 2 years (2010 and 2011). Experimental plots in both of the localities were sown with seed of different origin (organic certified, organic farm farm saved and conventional untreated) whose health and quality is described in Tables 16 and 17.

Infestation of barley seed used for seeding with *Fusarium* spp. depended more on the year than on seed provenance. Differences between the individual seed provenances were minimal. On the other hand, infestation of barley seed used for seeding with *Alternaria* spp. depended particularly on seed provenance – farm saved seed was more infested in both years. Infestation of the seed with *Penicillium* spp. was affected more by year (Table 16). The quality of the seed used for seeding depended more on the year – values of all the evaluated parameters in 2011 were lower and worse in comparison with the year 2010. The effect of the seed provenance on evaluated seed quality parameters was minimal.

Factor		*Fusarium spp. (no. colonies/10 grains)*	*Alternaria spp. (no. colonies/10 grains)*	*Penicillium spp. (no. colonies/10 grains)*
Year	2010	0.7±0.1[a]	0.6±0.4[a]	1.9±0.6[a]
	2011	0.1±0.1[a]	0.8±1.4[a]	0.2±0.2[b]
Seed origin	Organic	0.4±0.4[a]	0.2±0.3[a]	1.4±1.8[a]
	Conventional	0.4±0.6[a]	0.2±0.3[a]	1.1±0.8[a]
	Farm saved seed	0.4±0.3[a]	1.7±1.0[a]	0.8±0.9[a]
Total		0.4±0.3	0.7±0.9	1.1±1.0

Table 16. Contamination of seed by microscopical fungi (seed before seeding)

Factor		Energy of Germination (%)	Germination (%)	Energy of Emergence (%)	Emergence (%)
Year	2010	99±1[a]	99±1[a]	82±3[a]	87±2[a]
	2011	68±3[b]	89±3[a]	70±2[a]	76±3[a]
Seed origin	Organic	85±20[a]	96±5[a]	76±5[a]	82±4[a]
	Conventional	84±22[a]	93±8[a]	77±8[a]	81±11[a]
	Farm saved seed	81±23[a]	92±8[a]	76±10[a]	81±9[a]
Total		83±16	94±6	76±7	81±6

Table 17. Biological traits (seed before seeding)

In grain, harvested on both of the experimental localities, there were determined the same parameters as in seeds used for seeding. Obtained data are given in Tables 18 and 19 and in Figure 4. Variability within particular categories (locality, year and seed origin) was not high in *Fusarium* spp. infestation of harvested grain (in 2011 was higher, but the differences between both years were not significant). In the case of *Alternaria* spp., there was observed a relatively high (but not significant) difference between both years, and a significant difference between both localities. Differences between the seed origins were relatively small and insignificant. In *Penicillium* spp. infestation of harvested grain was relatively high, statistically significant difference between both years was observed; statistically significant difference between both localities was also observed. On the other hand, the effect of the seed origin was lower (Table 18).

It is evident from the comparison of fungal infestation in harvested seed and seed used for seeding of different provenance (Figure 4), infestation of barley seed used for seeding with

Fusarium spp., *Alternaria* spp. and *Penicillium* spp. was in general lower than infestation of harvested seed on both localities.

Factor		*Fusarium spp. (no. colonies/10 grains)*	*Alternaria spp. (no. colonies/10 grains)*	*Penicillium spp. (no. colonies/10 grains)*
Year	2010	0.4±0.6a	5.1±2.7[a]	2.2±1.7[a]
	2011	1.3±0.9[a]	2.7±2.1[a]	6.2±2.0[b]
Location	CULS	0.9±1.1[a]	2.2±2.4[a]	5.5±2.8[b]
	CRI	0.8±0.6[a]	5.5±1.8[b]	2.8±2.1[a]
Seed origin	Organic	0.7±0.8[a]	3.7±2.5[a]	4.2±3.6[a]
	Conventional	0.9±0.6[a]	3.6±3.9[a]	3.6±3.3[a]
	Farm seed	1.1±1.2[a]	4.4±2.0[a]	4.7±1.6[a]
Total		0.9±0.8	3.9±2.6	4.2±2.7

Table 18. Contamination of seed by microscopical fungi - harvested seed (mean + SD)

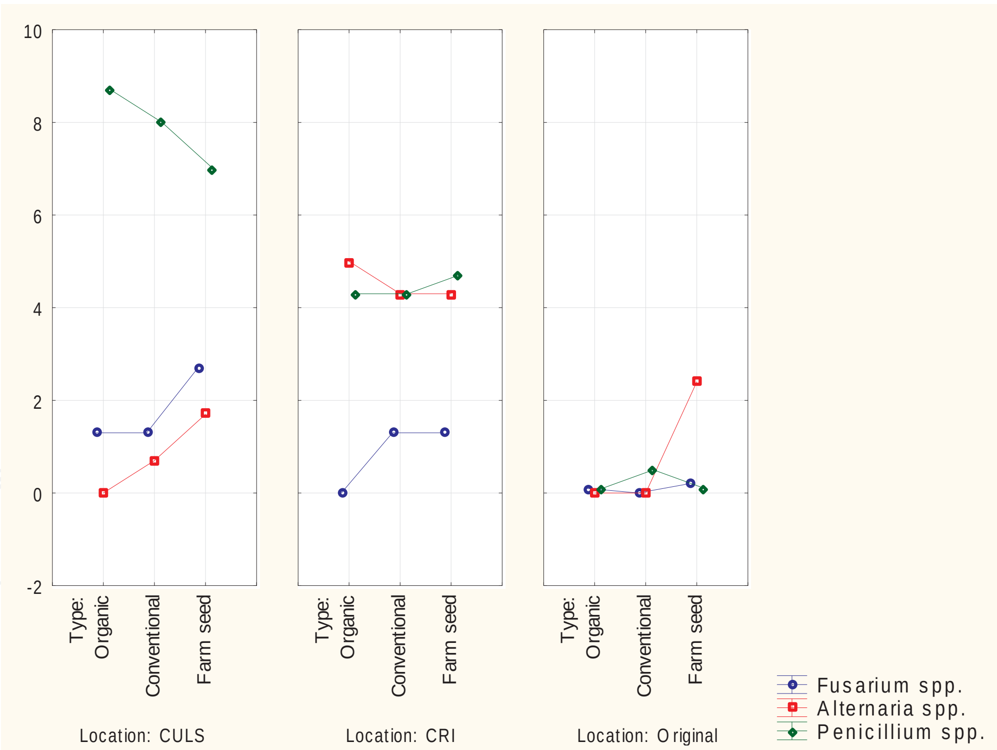

Figure 4. Comparison of infestation in harvested seed of different provenance

Results of quality evaluation of harvested seed are given in Table 18. It is evident from these results, that the effect of locality and year on values of all of evaluated seed quality parameters was higher than the effect of the seed origin. The same situation was observed in the yield of harvested grain – effect of year and locality was relatively high and statistically significant, effect of the seed origin on yield of harvested grain was low.

Factor		Energy of Germination (%)	Germination (%)	Energy of Emergence (%)	Emergence (%)	Yield ($t.ha^{-1}$)
Location	CULS	81±6[a]	87±3[a]	73±10[a]	77±7[a]	6.0±0.4[b]
	CRI	92±3[b]	94±2[b]	77±14[a]	83±10[a]	3.0±1.1[a]
Year	2010	87±10[a]	92±4[a]	66±9[a]	74±6[a]	3.9±2.2[a]
	2011	86±5[a]	89±5[a]	83±7[b]	86±7[b]	5.0±1.2[b]
Origin	Organic	84±12[a]	90±6[a]	74±14[a]	80±10[a]	4.4±1.4[a]
	Conv.	88±4[a]	91±4[a]	79±12[a]	83±8[a]	4.5±2.1[a]
	Farm	88±5[a]	91±5[a]	71±12[a]	78±10[a]	4.5±2.2[a]
Total		86±7	90±4	75±12	80±9	4.5±1.7

Remark: Different letters show the statistical differences in *Tukey HSD* test between varieties. $P < 0.05$;

Table 19. Biological traits of seed - harvested seed (mean + SD)

5. Conclusion

The organic farming has been developing very fast worldwide. There has been, nevertheless, a serious deficiency of certified organic seeds of most of the crops in most of the countries. It also concerns the cereals belonging to the most frequent crops being grown on the organic farms.

There has been the longtime deficiency of the certified organic seeds in the Czech Republic too. The parcels intended for multiplication of seeds cover an insufficient area. Most of the seeds have not been certified because they are highly infected with the diseases transmitted by the seeds themselves. Strict norms for the organic seed certification process should be changed in the near future. Nowadays, the same norms are valid in the organic and conventional farming but any supportive instruments being applied by the conventional farming system are not permitted by the organic farming system (e. g. mineral fertilizers, pesticides, etc.).

The own farm saved seed or the conventional untreated seeds are usually used in order to establish the crop stand because there is a serious deficiency of certified organic seeds. However, the application of conventional untreated seeds does not comply with the organic farming principles. Therefore, the European Union currently started putting permanent pressure on the conventional untreated seeds to be limited. Therefore, if the deficiency of organic seeds persists, a percentage of the applied uncontrolled own farm saved seed is to increase.

Our trials aimed at the evaluation of the influence the seed provenance (the certified organic seeds, the conventional untreated seeds, the farm saved seed) had on the seed parameters and health. Four spring forms of cereals were tested (hulled and naked oat, bread wheat, and barley). The influence of the various seed provenance on the crop stand quality was particularly studied. Moreover, a possible effect of the various seed provenance on seed parameters and health of the following seed generation were also evaluated.

Study of the influence of biological characteristics on the following seed generation has shown that all the seed categories achieve a good-quality level. The seeds originating from certified organic seeds have the best biological characteristics of all. The oat seeds coming from the own farm saved seed had also good qualitative parameters. We have come to similar findings as for the health state of the crop stand. There is not any correlation between the intensity of seed infestation with pathogens and the health state of the following seed generation.

If the laws get more strict, or the conventional untreated seeds are absolutely forbidden by the organic farming system, the deficiency of the certified organic seeds will have to be compensated by the own farm saved seed supply. Anyway, the farm seeds must be reproduced on the parcels having good qualitative parameters and careful agrotechnological methods will be indispensable.

Acknowledgements

Supported by the Ministry of Agriculture of the Czech Republic – NAZV, Grant No. QI 91C123.

Author details

Ivana Capouchová[1], Petr Konvalina[2], Zdeněk Stehno[3], Evženie Prokinová[1],
Dagmar Janovská[3], Hana Honsová[1], Ladislav Bláha[3] and Martin Káš[3]

1 Czech University of Life Sciences in Prague, Praha 6-Suchdol, Czech Republic

2 University of South Bohemia in České Budějovice, Č. Budějovice, Czech Republic

3 Crop Research Institute in Prague, Praha 6-Ruzyně, Czech Republic

References

[1] Willer H, Kilcher L., editors. The World of Organic Agriculture. Statistics and Emerging Trends 2009. Bonn and Frick: IFOAM and FiBL; 2009, 309 p.

[2] FAOSTAT: http://faostat.fao.org/ (accesed 15 June 2011).

[3] Hrabalová A. Ročenka ekologického zemědělství v České republice 2010 (Czech Organic Yearbook 2010). Brno: ÚKZÚZ. 2011, 46 p.

[4] MZe. Situační a výhledovázprávaobiloviny 2009 (Cereals yearbook 2009). Praha: MZe, 2009;104 p.

[5] Ingver A, Tamm I, Tamm Ü. Effect of organic and conventional production on yield and the quality of spring cereals. Agronomijas Vēstis (Latvian Journal of Agronomy) 2008;11: 61-67.

[6] Lockeretz W, Shearer G, Kohl DH. Organic Farming in the Corn Belt. Science 1981;211: 540-547.

[7] Leistrumaitė A, Liatukas Ž, Razbadauskienė K. The spring cereal traits of soil cover, disease resistance and yielding essential for organic growing. Agronomy Research 2009;7: 374-380.

[8] Batalova GA, Changzhong R, Rusakova II, Krotova NV. Breeding of naked oats. Russian Agricultural Sciences 2010; 36: 93-95.

[9] Stevens EJ, Armstrong KW,Bezar HJ, GriffinWB, Hampton JB. Fodder Oats: an overview. In: Suttie JM, Reynolds SG. (eds.) Fodder Oats: A World Overview, Plant Production and Protection Series. Rome: FAO; 2004.pp. 11–18.

[10] MZe. Ročenka ekologické zemědělství 2009 (Czech organic yearbook 2009). Praha: MZe ČR, 2009, 44 p.

[11] Václavík, T. (2008): Ročenka českýtrh s biopotravinami. Green marketing, Praha, 65 p.

[12] Shamash J. Developments in seed production. Horticulture Week 2008;41: 2.

[13] Lammerts van Bueren ET, Struik PC, Tiemens-Hulscher M, Jacobsen NE. Concepts of intrinsic value and integrity of plants in organic plant breeding and propagation. Crop Sciences 2003; 43: 1922-1929.

[14] Houba M, Hosnedl V. Osivo a sadba (Seed and Seedlings). Prague: Profi Press. 2002, 186 p.

[15] Lampkin N. Organic farming. Ipswich:Farming press, 1990, 701 p.

[16] Adler A, Lew H, Moudrý J, Štěrba Z, Vrátilová K, Edinger W, Brodacz W, Kiendler E. Microbiological and mycotoxicological quality parameters of naked and covered oats with regard to the production of bran and flakes. Die Bodenkultur 2003; 54: 41-48.

[17] Pszczółkowska A, Fordoński G, Olszewski J, Kulik T, Konopka I. Productivity and seed health of husked oats (*Avena sativa*L.) grown under different soil moisture conditions. Acta Agrobotanica 2010; 63: 127-133.

IntechOpen