Influence of seed’s biological traits of oat on next seed generation in organic farming

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Abstract
Lately, the organic cereals field has been progressively developing. A limitation of conventional untreated seed application plays an important role there. On the other hand, there has been a longtime deficiency of certified organic seeds. Therefore, oat was experimentally used as a model crop in order to demonstrate results of the assessment of particular biological traits of various seed categories (certified organic, conventional untreated, farm). The seeds’ biological traits (energy of germination, germination, energy of emergence, emergence, thousand grain weight - TGW) were assessed before seeding and the impact of the seed quality on the grown seeds was also studied. Small-plot trials including four varieties of naked and hulled (common) oat were set up in three localities in the Czech Republic between 2010 and 2011. As for the quality of the seeds serving for the establishment of the small-plot trials, the conventional untreated seeds proved the highest quality for the energy of germination (86.3%), the germination (88.3%), the energy of emergence (72.8%), the emergence (79.1%) and the TGW (31.9 g). On the other hand, as for the organic seeds, these originating from the certified organic crop stands proved the highest quality for the energy of germination (90.4%), the germination (92.6%), the energy of emergence (79.4%), the emergence (85.8%) and the TGW (30.8 g), just as these originating from the farm crop stand the energy of germination (90.2%), the germination (88.3%), the energy of emergence (79.2%), the emergence (85.4%) and the TGW (30.4 g). The energy of germination, the germination and the energy of laboratory emergence were (p<0.05) influenced by a locality factor (ANOVA). The impact of the other factors was not significant, however, as the research results demonstrated an obvious trend. Moreover, the correlation analysis demonstrated an obvious positive correlation (r = 0.65-0.95) between the individual parameters of hulled oat (the energy of germination, the germination, the energy of emergence and the emergence). Correlations between the TGW and the energy of emergence (r = 0.69), just as the emergence (r = 0.60), were also proved by the test. As for naked oat, close correlations were detected between the tested parameters of the germination and the emergence. On the other hand, any correlation between the TGW and the emergence was statistically not significant and weak. The organic seeds originating from the certified organic crop stands proved the best biological characteristics. The farm oat seeds achieved a good qualitative level too. If the conventional untreated seeds are banned in the organic farming system, the rare organic oat seeds might be substituted by the farm oat seeds.

Key words: Organic farming, seed, germination, emergence, naked oat, hulled oat.

Introduction
The share of organic farming on farm land has been progressively increasing worldwide. Thirty-five million hectares of the farming land is represented by organic fields, whereas more than 7.5 million hectares within the European Union (EU 27). Generally said, the share of organic land on farm land has already achieved 4.3% within the European Union (EU 27) 1. In Central European countries has been noticed a similar trend. For example, 448 000 hectares of organic fields are registered in the Czech Republic nowadays. In 2010, the proportion of the arable land surface on the total organic land surface represented 12% (55 000 ha) 2. Cereals are the basic organic crops grown in Europe 3. In 2010, 25 000 hectares of cereals were grown in the Czech Republic 2.

Oat is one of the most suitable cereal species for organic farming 4. As it has low requirements on growing conditions, it is a suitable crop for organic farming in Central Europe 3. There is a relatively wide range of use of oat. Naked oat is a suitable food crop 6. Common oat is mostly used as a fodder crop 7. It is the second most frequent crop (just after bread wheat) in the Czech organic farming system. The common oat growing surface represents 5000 hectares and its mean yield rate represents 2.5 t/ha 2.

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 reproduction is an extremely difficult process 8. 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. 9. 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.

Not only the Czech Republic, but also most of the European countries are affected by the longtime deficiency of certified organic seeds, as stipulated by the European Union. The conventional untreated seeds or “uncontrolled” farm (own) seeds are very often applied. For this reason, a question of quality in various categories of common and naked oat seeds (certified organic seeds, conventional untreated and farm ones) is to be answered in this article. A question of influence of the seeds quality on the grown and harvested seeds is also to be answered by the same article.

**Materials and Methods**

**Varieties and seeds:** Three categories of seeds have been found in the Czech Republic: certified organic seeds, conventional untreated seeds and farm seeds. Two varieties of hulled oat (*Avena sativa L.*) (Neklan, Vok) and two varieties of naked oat (*Avena sativa var. nuda*) (Izak, Saul) were used in the research.

**Field trials:** Varieties were sown in a randomized, complete block design on organic certified trial parcels in two locations in Prague (Czech University of Live Sciences Prague and Crop Research Institute) and Ceske Budejovice (University of South Bohemia) during 2010 and 2011. The seeding rate was adjusted for a density of 350 germinable grains per m². Rows were 125 mm wide. The crop stands were treated in compliance with European legislation (European Council Regulation (EC) No. 834/2007 and European Commission Regulation (EC) No. 889/2008).

**Characteristics of the trial stations:** 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. 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 Research Institute of Crop Production 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.

**Analyses of seeds before seeding and after harvest:** Selected parameters of the seeds studied were the laboratory germination and the energy of germination, the laboratory emergence and the thousand grain weight. The biological laboratory trials were set up in plastic bowls having perforated caps and were put into ventilated air-conditioned boxes. The bowls were 18 cm long, 11 cm wide and 5 cm deep. Coarse silicious sand was used in order to determine laboratory emergence, or a filtration paper was used in order to determine laboratory germination in the trials.

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

**Laboratory emergence and energy of emergence:** When the energy of emergence and the laboratory emergence were determined, 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 bowl bottom. 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.

**Thousand grain weight:** TGW was determined according to CSN 40 0610, by deduction of 500 caryopses twice (it means one thousand caryopses), with an automatic counter of the seeds and by weighing of the seeds.

**Statistical data assessment:** Elementary analyses and the Statistica 9.0 (StatSoft, Inc., USA) program provided the statistical data processing. Regression and correlation analyses provided the evaluation of interdependence. The comparison of varieties and their division into statistically different categories were provided by the LSD test.

**Results and Discussion**

The biological quality of the oat seeds, used between 2010 and 2011 in order to set up the small-plot trials, was reduced due to a one-year seed storage. As Table 1 shows, there is a difference in the tested parameters. The energy of germination decreased the most (20%) by 31% due to one-year storage. The other parameters decreased by 17% (the energy of emergence) or 20% (the germination and the laboratory emergence) (Table 1). On the other hand, thousand grain weight (TGW) proved to be a stable parameter, as it is influenced by the genetics and growing conditions, not by the storage conditions 10. As for the species characteristics (common oat compared to naked oat), common oat was characterised by lower energy of germination (76.9%) than naked oat (78.1%). However, the germination, the energy of laboratory emergence and the laboratory emergence of naked oat were lower than the ones of common oat. For example 11, deal with the reduction of the biological quality of naked oat seeds. It is usually a consequence of mechanical damage, as naked oat is not protected by any hulls, therefore, the seeds are very sensitive. A correlation analysis was also executed (Table 2). The results showed the positive correlation (r = 0.65-0.95) of common oat parameters (the energy of germination, the laboratory germination, the energy of emergence and the laboratory emergence). The positive correlation was also proved between the thousand grain weight and the energy of emergence (r = 0.69), just as the emergence (r = 0.60). As for naked oat, close correlations between the tested parameters of the germination and the emergence were also noticed. Contrary to hulled oat varieties, there was no obvious correlation between the thousand grain weight and the emergence (Table 3).

The assessment of the biological traits of the individual seeds categories (certified organic seeds, conventional untreated seeds, farm seeds), applied in the small-plot trials (Table 1), has shown the highest quality of the conventional untreated seeds all the tested parameters reached the highest values: the energy

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of germination (86.3%), the germination (88.3%), the energy of emergence (72.8%), the laboratory emergence (79.1%) and the TGW (31.9 g). The energy of germination and the energy of emergence are significant factors of the fast growth and development of young plants. The favourable (high) TGW also contributes to the development of plants. On the other hand, the farm seeds proved to have the worst biological traits of all seed categories (certified organic seeds, conventional untreated seeds, farm seeds) (Table 1), the analy...
biological traits of the seeds originating from the conventional untreated seeds were about 3 percent lower: the energy of germination (88.5%), the germination (90.5%), the energy of emergence (75.7%), the laboratory emergence (83.5%), and the TGW (29.6 g). The quality of the harvested seeds was tested by correlation analysis. The result was similar to the result of the test executed with the seeds to be seeded, however, there were weaker correlations in the seeds grown afresh (Tables 2 and 3).

When comparing the quality of the grown seeds of both oat species, we realised that the hulled oat energy of laboratory emergence was higher. On the other hand, the naked oat energy of germination, the laboratory germination and the hulled oat laboratory emergence were higher. The TGW was a specific parameter, hulled oat seeds achieved higher values. Such differences in the seeds biological traits between hulled and naked oat are partly determined by harvest conditions and postharvest treatment procedures, as naked oat is more inclined to having its seeds damaged 11. In 2010, more favourable seed biological traits (the energy of germination, the laboratory germination, the laboratory emergence) were achieved. On the other hand, higher values of the energy of emergence and the TGW were reached.

As the summarizing assessment of the biological traits of the individual seeds categories to be seeded showed, the conventional untreated seeds were the best quality ones, whereas the certified organic seeds were the worst quality ones. Concerning the grown seeds, the crop stands set up from the best quality seeds (the conventional untreated ones) provided the worst quality grown seeds themselves and vice versa - the crop stands set up from the worst quality seeds (the certified organic ones) provided the best quality grown seeds themselves. The “reproductive effort” mechanism might explain such findings 15. A plant grown from the worst quality carposperms provided a lower yield rate but good quality production. The differences in the TGW might also play a role there. The good quality of the uncontrolled farm seeds was another favourable research finding. Therefore, the farm seeds may be applied to grow extensive 16, 17 and less bred 18 crops (e.g. oat). However, such growing has to be done very carefully. Minimum negative impacts on the crop stand yield rate can be expected.

**Table 5. Biological traits of the grown seeds (3 localities in the individual years).**

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<td>Conventional untreated seeds</td>
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<td>Farm seeds</td>
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Remark: Different letters show the statistical differences in LSD tests between varieties, p<0.05; Remark: EG - the energy of germination; G - the germination; EE - the energy of emergence; E - the emergence; TGW the thousand grain weight.

Conclusions

Nowadays, the provision of good quality seeds for organic farming has been paid more attention to than it was before. Generally said, there is a significant deficiency of certified organic seeds. Therefore, farmers are very often obliged to use conventional untreated seeds in order to set up the crop stands. The use of the conventional untreated seeds is, nevertheless, inconsistent with the organic farming principles. For that reason, the uncontrolled farm seeds are frequently used in the farming system. Concerning the seeds biological traits, and their impact on the follow-up seeds generation, all the mentioned-above seed categories should achieve a good quality level. The seeds grown from the certified organic seeds proved the best biological traits in the research. The oat farm seeds also reached a good qualitative level. If the requirements for the use of the conventional untreated seeds in the organic farming system are tightened up, or if it is absolutely banned, the deficiency of the certified organic seeds may be compensated for by farm seeds (such compensation is recommended). However, the farm seeds should be reproduced using careful agrotechnology on the best-quality parcels.

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