AGTEC-Org – AGronomical and TEChnological methods to improve Organic wheat quality

A project of the research network CORE organic

Techniques to improve technological and sanitary quality

Summary

The demand for high quality organic bread cereals is increasing. In spite of variable grain protein contents, baking quality of organic wheat was found to be acceptable to good. Mycotoxin (DON) contents were generally low on tested grain samples. Choice of the wheat cultivar is the most efficient way to obtain higher grain quality. Fertilization with readily available nitrogen and, to a lower extent, association with legumes and green manuring with mixtures containing fodder legumes can also improve grain quality. Reduced tillage affects soil quality and wheat yield but has little effects on grain quality.

Context and challenges of the AGTEC-Org project

From the last two decades, demand for organic bread cereals has developed fast throughout Europe (Willer et al., 2008). The organic bread wheat market has been diversified over time throughout the emergence of different sale channels. Requirements from processors and consumers on quality and safety are getting higher for organic bread wheat. Even though European countries` consumption varies, quality requirements on baking value, nutritional aspects and safety risk are quite common. To respond to the domestic demand from Western European countries, organic bread wheat production has to be developed by new conversion and yield improvement while quality could be improved by agronomical and technological methods. Nitrogen deficiency and weed infestation are the main limiting factors for wheat grain yield and grain protein content (Casagrande et al., 2009). Moreover, mycotoxin is often considered to impair sanitary quality of grain. **The overall objective of AGTEC-Org was to identify agronomical and technological ways to improve the performance of organic wheat and flour. The findings will contribute to an enhanced baking quality and nutritional value of organic flour, as well as the prevention of mycotoxin contamination to fulfil consumers' expectations of providing safe and healthy products.** The project involved 9 research centres or universities from 5 European countries for a total budget of about 1.5 million €. This leaflet summarizes the relevant information of the AGTEC-Org project on three main agronomical techniques to improve organic wheat quality which are (i) reduced tillage, (ii) organic fertilization, use of cover crop and green manure, and (iii) association with legumes.

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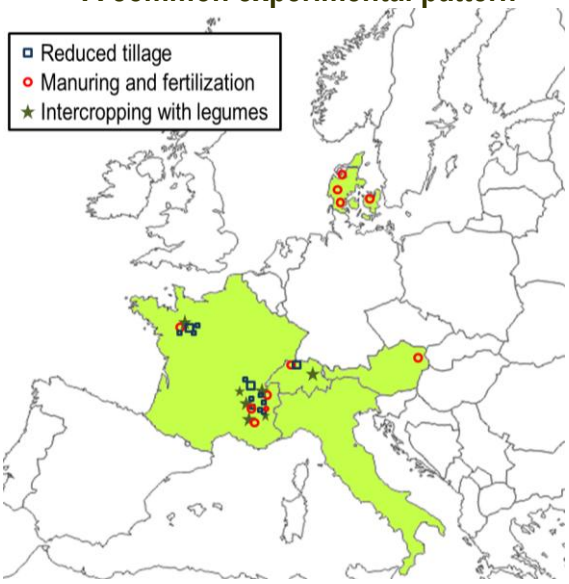
Assessing the effects of agronomical techniques on wheat grain quality

Crop management techniques were studied on 11 long-term field experiments and 12 farmers' field trials in four different countries (Austria, Denmark, France and Switzerland) to assess their effect on wheat grain and flour quality. All together over 150 treatments were tested. On-going long-term field experiments considered cumulative effects of tillage and/or nutrition regimes on wheat performance and quality but also on soil fertility. The use of farmers' field experiments enabled us to test innovative practices (e.g. minimum tillage) and evaluate their economic impact under real conditions with varying farming structure, market and policy (e.g. France and Switzerland).

A common experimental pattern



23 field experiments developed all over Europe

Cultivar choice, climate and soil conditions strongly influenced grain quality

In general, the location, soil type and cultivars appeared to have a high influence on grain yield and grain protein content obtained in the different long-term field experiments. Thus the protein content of the samples from all experiments and years strongly varied, ranging from 6.7 to 15.8 g/100 g of dry matter.

The effects of reduced tillage

Weed competition and soil texture were the main factors on wheat performance under reduced tillage. If weeds are well controlled, reduced tillage generally obtained similar results compared to traditional ploughing.

Reduced tillage improved soil structure in the top-layer (up to 10 cm) of heavy clay soil, resulting in a higher germination rate and improved grain yields. On the contrary, soil compaction might appear in sandy and silty soils. The positive effect of reduced tillage on soil fertility could directly affect crop nutrition by good rooting, if initial soil structure was good. Direct seeding and the insertion of a cover crop can significantly increase earthworms' density and activity.

Wheat quality parameters were less affected by soil management than by grain yield. Protein content and most of the commonly used quality indicators like Zeleny Index or Falling number didn`t show any difference between reduced tillage and traditional ploughing.

A significant increase in mycotoxin content (DON) due to reduced tillage was only detected on sites with the precrops maize and lupin. However, the DON contamination level never exceeded the European threshold. In general, wheat quality was satisfying under different soil management treatments.

Systems with traditional ploughing vs reduced tillage obtained minor differences in production costs. Machinery costs did not significantly differ at French sites, while they were reduced by 10 % on average in case of reduced tillage at Swiss sites. Reduced tillage systems had little impact on labour time in both situations. In fact, systems` economic performances mainly are the consequence of the rate of the yield.

- *Reduced tillage should be established in organic systems with successful weed control on the basis of mechanical weeding or diverse crop rotation, and good soil structure.*
- *Reduced tillage not significantly affected wheat quality.*
- *The economic outcome mainly depends on the effect of tillage on grain yield.*

Consequences of organic fertilization and green manure

Organic grain systems are frequently characterized by temporary N deficiency with consequences on wheat yield and grain protein content. The effects of nitrogen fertilization with composted farmyard manures were only marginal to moderate on yield and baking quality parameters, with quality parameters being less affected. But the use of organic fertilizers with quick mineralization might improve grain yield and quality.

On a Chernozemic highly fertile soil, a lucerne mulching system was equivalent to a farmyard manuring system regarding wheat productivity and quality. On less fertile soils, the location / soil type appeared to have a major influence on grain yield. Catch crops used as green manure affected yield and quality only if clover was included.

- *Fertilization with readily available nitrogen sources (e.g. application of slurry at late growth stage) seems to be more advisable than green manuring to improve bread wheat yield and quality.*

Intercropping with legumes and consequences on organic wheat

Despite various ecological and agronomic services, the size of areas cultivated with legumes is decreasing in organic cereal systems. Intercropping systems with legumes and wheat may permit to grow profitable wheat crops due to benefitting from legumes` services. Legume intercropping was assessed in three different systems: (i) wheat-pea intercrops, (ii) wheat – undersown forage legumes, and (iii) wheat sown in a legume living mulch.

Due to the additional pea yield of wheat-pea intercrops, total yield was positively affected compared to sole crop conditions. Wheat yield, however, can be impaired by a high (more than 50 %) proportion of pea in the intercrops. The effects of this association on grain quality were similar to those of N fertilization in a single wheat crop, but less pronounced. Some wheat quality parameters such as gluten content, falling number and Zeleny index were increased. Applying a small amount of N at spring time entailed values similar to a fertilized wheat single wheat crop.

Undersowing legumes in wheat crops avoids direct competition and offers benefits of the soil covering during the period after wheat harvest (green manure use and weed mitigation). However, wheat grain yield and quality are impacted marginally. Spring fertilization in such a system reduces the extent of weed control due to the legume cover but leads to significantly increased grain yield without impairing protein content.

Sowing wheat in clover living mulch can significantly impair wheat yield, if the living mulch growth is not controlled efficiently. The clover sowing density has to be adapted to soil fertility. The impact of this kind of association on grain

quality is generally positive, partly because of a concentration effect due to lower yields.

- *The mode of legume intercropping strongly affects wheat grain yield and quality.*
- *Wheat-pea intercrops are an efficient method to produce organic pea. Wheat yield is not impaired unless pea is dominating the intercrop. Wheat quality can be improved moderately.*
- *The insertion of forage legumes in wheat crops is an efficient method to reduce weed infestation. The impact on wheat crop is sparse and strongly depends on the competition for soil resources.*
- *Living legume mulch systems may improve wheat quality, usually at the expense of wheat yield.*

Organic wheat grain presents an overall good quality

The broad range of treatments and situations assessed (more than 400 treatments), suggests that DON contamination of organic grain wheat is limited at field scale. Low levels of DON were generally observed on tested grain samples (95 % of grain samples presented DON levels below 500 ppb, more than 75 % DON levels lower than 200 ppb). However, large variations of DON levels occurred due to climate, edaphic and genetic conditions. Consequently, it was difficult to highlight significant impacts of the tested agronomical practices on DON contamination.

Despite highly variable and sometimes low protein contents, organic flour samples presented acceptable to good baking quality and loaf volume.

The analyses of grain technological properties also gave evidence that the indicators usually used in conventional practices to predict the baking quality of wheat are not always suitable in organic conditions. Further studies must be carried out to link biochemical parameters to semi-scale rheological measurements. For the accurate prediction of bread making quality of wheat produced under organic practices, those quality parameters need to be identified that are highly correlated with the bread making performance and can replace or complement the protein content and Zeleny index presently used by millers to evaluate wheat flour.

Selected publications

Celette F, Goulevant G, Amosse C and David C (2010) Associating wheat crop and undersown forage legumes in organic agriculture: Incidence of forage legumes species. In: Wery J, Shili-Touzi I and Perrin A (Eds). Proceedings of AGRO2010, XIth Congress of the European Society of Agronomy, Montpellier, France, August 31-September 3 2010. Agropolis International Editions, Montpellier, France. ISBN: 978-2-909613-01-7. http://orgprints.org/18891/

David C, Celette F, Abecassis J, Carcea M, Friedel J, Corre-Hellou G, Hiltbrunner J, Messmer M, Peigné J, Samson MF, Schweinzer A, Thomsen IK and Thommen A (2011) New challenges to improve organic bread wheat production in Europe. In: 3rd ISOFAR Scientific Conference in the frame of the 17th IFOAM Organic World Congress, Gyeonggi Paldang, South Korea, September 26-October 5 2011. http://orgprints.org/19483/

Naudin C and Corre-Hellou G (2011) Producing organic wheat with high grain protein content: the significance of intercropping and the need for diagnostic tools. In: 3rd ISOFAR Scientific Conference in the frame of the 17th IFOAM Organic World Congress, Gyeonggi Paldang, South Korea, September 26-October 5 2011. http://orgprints.org/19416/

Thomsen IK, Samson MF, Carcea M, Narducci V. (2011). The influence of long-term inputs of catch crops and cereal straw on yield, protein composition and technological quality of a spring and a winter wheat. International Journal of Food Science and Technology. 46: 216–220. http://orgprints.org/18803/

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