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*Topic 2 - Product and process quality in Organic Agriculture: methods and challenges*

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### WHAT SHOULD ORGANIC FARMERS GROW: HERITAGE OR MODERN SPRING WHEAT VARIETIES? REPORT FROM A STUDY COMPARING YIELDS, GRAIN AND BREAD QUALITY.

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**Abstract:** For a 100% organic value chain, we need more varieties suitable for organic cultivation. Varieties bred for organic growing is a challenge in small markets. Many breeding goals are equal for organic and conventional cereals. Hence, accessions failing qualification as commercial varieties may perform well in organic growing. A field experiment over two years was performed at two growing sites to compare 25 accessions of spring wheat, ranging from old heritage varieties to modern breeding lines. We assessed yield and agronomic characteristics, artisan bread baking quality and sensory characteristics. Modern accessions gave best yields. Old varieties had smaller kernels, less grain filling, lower falling numbers and SDS-sedimentation volumes, but higher concentrations of minerals, although the growing site has a strong effect. Bread from modern accessions performed best in a baking test. Several sensory characteristics such as juiciness, chew resistance, firmness, acid taste and vinegar odor varied between varieties. Heritage varieties have an important cultural value, and many consumers are willing to pay a significant premium price for such products. A premium price is required, since yield levels are often considerably lower.

**Introduction:** Wheat is an important food crop, and the main ingredient in Norwegian bread. Some organic growers prefer heritage varieties due to a different protein quality and higher mineral content. Will this imply a significant loss of yield and income? Are modern accessions actually less well suited for artisan baking than heritage varieties? Can accessions failing to become approved for conventional growing perform well in organic growing, with artisan baking? We designed an experiment to study these questions. Most breeding goals, such as grain yield, earliness, straw strength, weather damage resistance and resistance against fungal diseases are equal across farming systems, whereas organic farmers may emphasize longer straw and denser canopies to compete with weeds.

There is no separate breeding of organic cereals in Norway, but the national breeding company Graminor Ltd. assess their breeding lines of spring wheat under organic growing conditions. The assessments include characteristics listed above (grain yield etc.) as well as grain quality (SDS etc.), but no baking test.

The project was funded by the Norwegian Agricultural Authority's genetic resources development program, the County Governor of Oppland who organized a program on organic cereal growing, and the County Governor of Trøndelag (mid-Norway). The project brought together actors from the whole value chain of organic cereals and strengthened relationships between actors who formerly had not been much in contact.

The main aim of this study was to increase the diversity of accessions used for growing of organic cereals, by searching for modern accessions possibly performing well under organic growing conditions and with artisan baking in Mid-Norway. In this paper, we want to present the output of this 3-year project.

**Material and methods:** 25 accessions of spring wheat were compared in a field experiment 2017-2018, at two sites in Mid-Norway, with organic management. The experimental setup was a lattice-design, where the 25 accessions, each of plot size 1.5 x 8 m, were randomized within each of two blocks. Growing spring wheat for bread baking in this region, around 64°N, is a big challenge due to short growing seasons with cold weather, and commonly humid weather during harvest. For rural welfare and food security, however, local production of grain for food is important, and some heritage varieties of spring wheat adapted to rough climatic conditions are available. The selection of accessions in our study comprised heritage varieties often used in organic growing for artisan baking (Dala landhvetet, Fram II), some other older Norwegian varieties (Norrøna - approved 1940, Møystad - approved 1967, Runar - approved 1972), two Swedish varieties (Polkka, Sport) with a "softer" gluten quality than most modern Norwegian varieties, and two common market varieties in Norway in 2017, Mirakel and Seniorita. The selection further comprised 16 breeding lines from Graminor, where 3 were promising in former testing in organic growing, 4 were new accessions with «soft» gluten, and 9 were selected during early growth in another study in 2016 due to early, vigorous growth and leaves covering the ground. Experimental plots were regularly observed, and characteristics recorded such as early growth pattern (upright, or leaves covering the ground), earliness, length of straw, lodging and ability to compete with weeds. After recording of yield, the quality of the grain was recorded as water content at harvest, test weight, thousand grain weight, starch quality (falling number), protein content and technological protein quality measured as SDS-sedimentation volume (SDS = sodium dodecyl sulphate). 20 accessions were selected for a baking test (leaving out the 5 least promising modern accessions), and grain from both experimental sites grown in 2017 was used to produce flour and sourdough breads, which were assessed for quality. The samples of grain, mixed samples of the two replicates on each site, were treated anonymously. Several evaluation criteria were merged into a character between 1 (least good bread, raw, with poor raising, not keeping the initial spherical form well) and 5 (best bread, well baked, well raised and keeping the form). Six breads from one site, made from Runar, Fram II, Seniorita, Mirakel, Polkka and Sport, were subject to sensory analysis (ISO 13299:2003). The 20 accessions being test-baked were also subject to analysis of the concentrations of macro- and microminerals.

**Results:** In 2017, cereal yields were generally satisfactory in the region, while 2018 was a year with low grain yields due to a dry summer and very wet harvesting conditions. Both experimental sites gave results in each year which could be used to compare the accessions (Table 1). Runar was the earliest accession in our selection, maturing 5 days before Mirakel and yielding on average 3.33 tons of grains per hectare (15% water content) in 2017. Earliness is a very important characteristic for cereal varieties grown this far to the north, and we recommend that organic farmers could start to use this variety, which also had a good ability to cover the soil during early growth (Løes et al. 2019). Mirakel, and the breeding lines GN06557 and GN16503 gave the highest yields, but the old variety Norrøna was not far behind. Average yields for these accessions (across two sites in 2017) were 3.55, 3.70, 3.58 and 3.52 tons/ha. Møystad (3.42 tons/ha) also yielded better than Dala landhvetet and Fram II, which had the lowest yields; 2.35 and 2.63 tons/ha.

Breeding for increased yields of grains tends to reduce the protein concentration, which was also found in our study. Old varieties had high concentration of protein, but the protein quality was generally poor, and the varieties are susceptible to pre-harvest sprouting damage under humid weather conditions (indicated by low falling numbers).

The grain quality was lower in the old varieties. They had usually smaller kernels, with a lower degree of grain filling than modern accessions. However, the concentrations of phosphorus, zink and iron were higher in old varieties, although the growing site also has a significant effect which may be larger than the effect of variety. As found for protein content, the content of minerals also tended to decrease with higher grain yield in our study (dilution effect).

By the test baking, palatable breads were produced from all the 20 accessions. The grade 1 was given to 4 varieties, 2 to 6 varieties, and 5 to 16 varieties. Bread made from Runar, Seniorita, Mirakel and some breeding lines achieved the best evaluations, with positive remarks such as "perfect form and crust" in addition to the grade 5.

By sensory analysis, several characteristics such as juiciness, chew resistance, firmness, acid taste and vinegar odor differed significantly. Largest differences were found for juiciness, where Runar produced the juiciest bread, and Polkka the least juicy. Polkka also gave bread with less acid taste than the other five samples. Mirakel had the weakest vinegar odor, and Seniorita the strongest. Swedish varieties (Polkka, Sport), with different protein quality due to different breeding aims in Norway and Sweden, were harder (larger resistance to chewing) than Norwegian accessions.

*Table 1. Wheat grain yield for 25 varieties of spring wheat at 15 % water content at the two sites (1 and 2) in 2017 and 2018. Coefficient of variation, CV, and least significant difference are included in the table.*

Variety	Yield (tons/ha)			
	2017		2018	
	1	2	1	2
Dala landhvetet	2.25	2.43	2.18	.98
Fram II	2.24	3.02	1.90	1.03
Norrøna	3.17	3.84	2.07	1.11
Møystad	3.22	3.61	2.07	1.00
Runar	2.82	3.79	2.26	1.02
Polkka	2.37	4.25	2.30	1.17
Sport	2.55	3.42	2.27	.80
Mirakel	2.84	4.26	2.74	1.22
GN03503	2.69	3.80	2.58	1.21
Seniorita	2.71	3.51	1.95	1.02
GN06557	2.92	4.46	2.26	1.00
GN10603	2.81	3.72	2.26	1.15
GN12741	2.94	3.77	2.00	.90
GN12759	2.32	3.71	2.23	.91
GN12760	2.29	3.61	2.30	.97
GN13618	2.86	3.81	2.36	1.36
GN14529	2.49	3.26	2.19	1.13
GN14649	2.36	3.77	2.41	1.00
GN12634	2.37	3.27	2.35	.99
GN15621	2.92	3.79	2.15	1.02
GN16503	3.14	4.00	2.75	1.06
GN17632	2.52	3.54	2.37	.99
GN17633	2.94	3.53	2.39	1.10
GN17634	2.57	3.31	1.85	.91
GN17635	2.98	3.59	1.81	.90
<b>Average</b>	2.69	3.64	2.24	1.04
<b>CV</b>	4.5	8.4	8.3	5.6
<b>LSD</b>	27	19	32	10

**Discussion:** The main aim of this study was to increase the diversity of accessions used for growing of organic cereals, by searching for modern accessions possibly performing well under organic growing conditions and with artisan baking in Mid-Norway. Our assessments, of agronomic traits, grain quality, baking quality and sensory characteristics, revealed that modern accessions and varieties yield more grains, have stronger straw, less risk for lodging and pre-harvest sprouting damage, and better grain quality. They also perform well with artisan baking. It is interesting that differences in sensory characteristics can be related to variety. We recommend to expand the number of varieties grown organically, and to introduce new stories about some interesting varieties, e.g. Runar which is a successful example of early modern cereal breeding in Norway.

Six varieties have been selected for a follow-up project during 2019-2021 (Dala landhvet, Runar, Mirakel, Seniorita, GN16503 and GN17635), due to their potential in organic growing for artisan baking.

**References:** Løes AK, Frøseth RB, Dieseth JA, Lindö C, Skaret J (2019): Kvalitetskorn til mat – muligheter i ikke-kommersialisert norsk sortsmateriale. Forsøk med vårhvete til økologisk dyrking og håndverksbakst (Quality grains for food - the potential of non-commercialized Norwegian varietal material. Studies of spring wheat for organic growing and artisan baking) (In Norwegian, with English summary). NORSØK report 5 (4) 2019.

**Image:** A selection of sour-dough breads in the study, given with the highest character of quality (5).



**Disclosure of Interest:** None Declared

**Keywords:** breeding, cereals, grains, Norway