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A PARTICIPATORY WHEAT VARIETY TESTING PROGRAMME WITH BRITISH ORGANIC FARMERS

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Abstract: In organic farming, crop adaptation to the growing environment and resilience towards changing climate are key in ensuring a sustainable and profitable agriculture in the absence of external inputs. Varietal choice is the major crop specific management decision organic farmers can make on a short-term basis to manage crop performance.

Here, we present the results of two years of field-scale variety testing of winter wheat in England, which is the arable crop with the largest acreage, yet with a very small and shrinking organic acreage. In the framework of the H2020 LIVESEED project, we started a collective experiment in which varieties were tested by organic farmers at a commercial field scale. This programme is currently in its third year and expanding, it involves 14 farmers and has tested 15 varieties.

In the first two years, this work has paved the way to better understand winter wheat production and thereby build decision support frameworks and feedback to breeders on useful traits. It has also been a powerful tool for co-learning between researchers, farmers and supply chain stakeholders. Collective experiments can empower the organic sector to independently produce the evidence needed for on-farm decision making.

Introduction: Organic and low-input farmers struggle to reliably predict the best performing cereal variety to grow on their farm. This jeopardises organic arable production in terms of yield and quality reliability (Knapp and Van der Heijden 2018, Wilbois and Schmidt 2019), with a shrinking acreage and a shortage of UK grown cereals, especially wheat, in the organic supply chain.

To improve support for informed decision making with a structured, integrated approach, we designed a decentralised, participatory field-scale experiment, alongside a traditional plot trial, starting from the following hypotheses: (i) varietal performance in organic farming does not correspond to varietal performance in conventional farming, as optimal trait architectures are different (e.g. straw strength, weed competitiveness, nutrient efficiency in low fertility) (Murphy et al. 2007); (ii) organic cropping systems are characterised by greater variation than conventional systems, which implies the need to test varieties across a range of environments (Wolfe et al. 2008); (iii) results generated through plot-scale trials are much less consistent with field-scale performance in organic and low-input than in conventional input-intensive farming, which calls for a strengthened emphasis on field-scale experimentation (Kravchenko et al. 2017). In our trials, we have aimed to further fest hypotheses 2 and 3 by coordinating a network of British organic farmers in field-scale testing wheat varieties.

Material and methods: The work is organised as a cycle of participatory research arranged as follows: (1) **setup**, choosing varieties and allocating them to farmers to drill and manage according to their farm best practice and with their own machinery; (2) **monitoring varieties growth and development**, through farmers' observations across the growing season and the Organic Research Centre team surveys in late spring; (3) **measuring yield and quality**, by farmers harvesting varieties separately and collecting grain samples for quality analyses; (4) **data analysis** and sharing the results and lessons learned, thereby feeding into the setup of the new season. The experiment included seven farms and seven varieties in 2017/18, and 13 farms and 10 varieties in 2018/19. Besides varieties included in the national lists, we included varieties of foreign origin, historic varieties and genetically heterogeneous populations.

In parallel, one organic plot-scale trial was run in both years including the same varieties distributed to the farms. A second plot-scale trial with 22 varieties, including the same varieties of the farm network, was run in 2018/19.

The field-scale experiment has been set up as an incomplete block design, in which every farm was allocated a subset of varieties. Variables assessed included crop cover, height, ear density, foliar diseases severity, weed abundance and community composition, grain yield, protein, specific weight and Hagberg's falling number. Data were analysed through linear mixed models with residual maximum likelihood estimation (REML), assuming year, farm and variety as fixed terms, farm as random intercept and year within farm as a random slope. Estimated marginal means by variety were calculated instead of mean values to correct for the bias of incomplete blocks.

Results: The participating farms were clustered in two crop management groups: one adopting a drilling system of wide rows (25 cm) coupled with inter-row hoeing weed control, and one adopting a system of narrow rows (between 10 and 15 cm) and spring-tine harrowing. The 'wide rows' farms showed significantly higher yields and lower weed abundance than the 'narrow-rows' farms, irrespective of the wheat varieties grown. Farms were also differentiated in their organic fertilisation strategy: those applying organic fertilisers (manure or compost) in rotation on crops other than winter wheat obtained higher protein content than those who do not apply any organic fertiliser, whereas those applying organic fertiliser directly to wheat showed intermediate, non-significant results.

The tested varieties clustered in a high-yielding group with low protein content and a high-protein group with lower yields. The first group included major feed varieties a the potentially bread-making variety, and showed an overall yield ranging between 4 and 5 t ha-1 and protein content ranging between 8.5 and 9.5 %. The second group, including the German bread-making variety Montana, as well as the historic British variety Maris Widgeon and the Composite Cross Population (CCP) ORC Wakelyns Population, showed yields ranging between 3 and 4 t ha-1 and protein content between 10 and 11.5% (estimated marginal means averaged across years and farms).

The trial went through a first year characterised by a cold winter and warm and dry summer, and a second year with a very rainy summer. Across these two very different seasons, the interaction between variety and year was significant for grain yield, that seemed to change more for the high-yielding varieties than for the high-protein varieties. Instead, change in grain protein between the two growing seasons was consistent across varieties.

The main parameter explaining the overall yield variability across all observations was crop canopy cover at anthesis. In fact, although not being significantly differentiated by variety, crop cover was positively associated with grain yield and negatively associated with weed abundance, which makes it a key management target.

Whilst yield results from the second plot trial in 2018/19 were roughly overlapping with the outcomes of the farms network, the yield ranking of the first plot trial were drastically different.

Discussion: By testing varieties in real farms at a field scale, this work has captured differences in varietal performance and interesting trends and correlations As the number of farms and varieties grows, and comparison with climatic and environmental data is conducted, this will allow farm-focused predictions and management recommendations possible also for farms outside the network, as well as varietal recommendation to seed producers and recommendations to breeders in terms of critical traits. Moreover, results can also help dissect the contribution of varietal choice and management decisions towards different performance indicators. For example, the significant interaction between year and varieties for yield, but not for protein content, is a result that can already help farmers better calibrate the risks of varietal choice face to unpredictable climate.

Different varietal yield rankings between the two plot trials, and between one plot trial and the farms, highlight the impact of the specific pedo-climatic characteristic of the plot trial location. This is a shortcoming of relying on individual plot trials which, before the start of this project, were the only tool used to test varieties in organic systems in the UK. Individual plot trials are not to be relied upon for predicting yields and overall performance, whereas they are still a precious tool to test a larger number of varieties and to better look into their traits, especially their growth cycles and the progression of diseases symptoms. To optimise the integration between plot-scale and field-scale, we keep running a plot trial in the location that gave a ranking more consistent with the farms network, to test 25 varieties and late breeding lines in an organic field, and to select the ones that are worth testing in the field-scale network.

So far, this work is a successful proof of concept of how farmers, in collaboration with research, can generate the evidence they need to support their decision making. In fact, with some attention to experimental design, participatory research can generate robust data whilst being easily accessible to farmers and ultimately empowering them to improve their adaptive capacity (Van Etten et al. 2019) and consequently foster the transition towards more sustainable food systems.

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