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Adapting Value for Cultivation and Use testing to stimulate the release of improved varieties for the organic sector. The case of spring wheat in The Netherlands

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Abstract Value for Cultivation and Use (VCU), the mandatory variety testing system for agricultural crops in the European Union (EU), has been used as a policy instrument by favouring the release of variety types that enable socially desirable developments, such as reducing fungicide use. With this paper, we aim to assess whether VCU can be used to enhance the availability of varieties suitable to organic farming. Therefore, we analyse data of an organic spring wheat VCU project that was conducted between 2001 and 2004 at three locations in the Netherlands. Varieties selected through organic VCU were clearly more suitable for organic production than those registered through the conventional procedure. However, new varieties could not match the baking quality of the organic standard variety. We conclude that enhancing the number of suitable varieties for the organic sector requires adapting both conventional breeding programmes as well as the VCU system.

Keywords Variety testing · Value for Cultivation and Use · EU seed legislation · Spring wheat · Organic production

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Introduction

To produce results that are relevant to farmers, traders and processors, variety tests should represent growing conditions in farmers' fields and handling and processing practices further down the production chain. Variety testing systems may be biased towards certain plant types, either in a positive or negative sense (Louwaars 2007). As national and regional variety tests are usually designed to reflect the prevailing crop production system, these may select against variety types that fit newly emerging cropping systems. The variety testing system in the European Union (EU), the so-called Value for Cultivation and Use (VCU) testing, has hampered the release of varieties adapted to organic farming. In the opinion of various cereal breeders, candidate varieties with traits favoured by organic farmers, such as weed

suppression or baking quality, would be rejected in conventional VCU for not matching the minimum requirements for yield (Löschenberger et al. 2008; Rey et al. 2008; Rolland et al. 2008).

VCU testing is a mandatory step in the variety release procedure of field crops, regulated by EU and national legislation (see Box). In this system, varieties that fail to pass VCU testing will not become available to farmers, because the marketing of these varieties is prohibited by law. To overcome this barrier to market release, organic VCU testing protocols have been developed in several European countries including the evaluation of additional traits specific to organic production (Osman and Lammerts van Bueren 2003; Steinberger 2003; Kleijer and Schwärzel 2006; Schwärzel et al. 2006; Löschenberger et al. 2008; Fontaine et al. 2010). Whether and how organic VCU is implemented varies from country to country (Mariegaard Pedersen 2012). Differences between countries include evaluation criteria, setup (separate or additional part of the conventional VCU procedure) and fee amount.

Box: Definition of Value for Cultivation and Use within the EU

Within the EU, passing Value for Cultivation and Use (VCU) testing is mandatory for field crops (cereals, potato, legumes, fodder crops, etc.), but not for vegetable crops. This is defined and regulated through the two Council Directives 2002/53/EC (Council 2002) and 2003/90/EC) (EC 2003).

According to **Council Directive 2002/53/EC on the common catalogue of agricultural plant species,** VCU of a variety ¨shall be regarded as satisfactory if, compared to other varieties accepted in the catalogue of the Member State in question, its qualities, taken as a whole, offer, at least as far as production in any given region is concerned, a clear improvement either for cultivation or as regards the uses which can be made of the crops or the products derived there from. Where other, superior characteristics are present, individual inferior characteristics may be disregarded.

Annex 3 of **Council Directive 2003/90/EC** roughly defines criteria that should be considered:

- Yield;
- Resistance to harmful organisms;
- Behaviour with respect to factors in the physical environment;
- Quality characteristics.

The above shows that the EU directives addressing VCU (Council directives 2002/53/EC and 2003/90/EC) only give a general definition of VCU and how it should be implemented, which provides member states the possibility to adapt VCU testing procedures to their specific conditions and leaves flexibility to address new needs.

VCU has played an important role in supporting agricultural policy (Wiskerke 2003; FCEC 2008). Only allowing the most productive varieties on the market prevented and protected farmers from growing lower yielding varieties. In this way, VCU contributed to one of the main original EU policy goals, namely achieving food security. From the 1980s onwards, VCU testing also has been used to address environmental issues like reducing fungicide and fertiliser use (Oskam et al. 1998; Van Waes 2011). Also in current times, EU authorities consider VCU "…an important tool to guide the breeding process to a more sustainable direction" (EC 2013, p.7). The objective of this paper is to analyse whether and how VCU testing can be used as a policy instrument to support organic farming by enhancing the availability of varieties with traits specifically required by the organic sector.

The analysis is based on the case of adapting the VCU testing protocol for spring wheat in the Netherlands to the needs of the organic sector. Spring wheat was chosen for this study, because, together with potato, it is one of the major organic field crops in the Netherlands that is subjected to obligatory VCU testing. In contrast to their conventional colleagues who mainly produce for the animal feed industry, Dutch organic farmers are looking for high baking quality varieties, with traits that contribute to weed suppression (rapid early growth, plant length, leafiness) and a less compact plant architecture (Osman et al. 2014). The latter is thought to slow down the development of diseases.

At the start of our research in 2001, organic farmers and Agrifirm (a farmer cooperative that was the main supplier of organic wheat seeds as well as the main trader of organic wheat harvest) considered only one out of the five varieties on the Dutch Recommended List of Varieties of Field Crops suitable for organic farming (A. den Bakker, Agrifirm, pers. comm.). To diminish its reliance on one single variety and to enhance genetic diversity, the organic sector was looking for other suitable varieties released in neighbouring countries (C. van Woerden, president of the organic farmers' wheat advisory committee of Agrifirm, pers. comm.). This orientation on foreign lists illustrates the limited value of the spring wheat section of the Recommended List for Dutch organic farmers at that time.

In this paper, we first describe the Dutch VCU system and the possibilities for innovation, namely adapting the spring wheat VCU protocol to the needs of the organic production chain. We will then analyse whether the implementation of 4 years of organic spring wheat VCU enhanced the availability of varieties matching the needs of the organic sector. Finally, we

reflect on the perspectives for improving the VCU system.

The VCU system in the Netherlands

In the Netherlands, the Plant Variety Board (*Raad voor Plantenrassen*, a government agency), is responsible for the registration of new varieties. Since the introduction of the new Dutch Seeds and Plant Materials Act in 2006, VCU tests are fully financed by the main stakeholders in the crop production chain (breeders, farmers, traders, processors). While individual breeding companies make a direct financial contribution, the other stakeholders finance the system indirectly through levies collected through their professional organisations. As a result, contributing parties also have a large influence on testing protocols and release criteria through representation in the Committee for the Compilation of the Recommended List of Varieties (CSAR) and crop-specific advisory groups, linked to both CSAR and the Plant Variety Board.

Successfully passing 2 years of VCU testing leads to registration in the National List of varieties, which is a prerequisite for market release. However, all breeders go for an optional third year of testing for inclusion in the Recommended List of Varieties because most conventional farmers only choose varieties from the latter list (Wiskerke 2003). The National List is compiled by the Plant Variety Board. Since the Recommended List is not a legal obligation, the Dutch government has transferred the compilation of the Recommended List to the private sector, represented by CSAR. As a consequence, criteria for national listing are set by the Plant Variety Board and the criteria for the Recommended List are developed by CSAR. The Plant Variety Board is primarily bound by EU regulations (see Box). The Board distinguishes between traits considered of public interest and traits of private interest. The first type of traits includes characteristics related to food safety (e.g. resistance against diseases producing mycotoxins) and resistances against plant diseases that spread beyond the boundary of individual farms (e.g. resistance against airborne diseases). Grain yield is an example of a trait considered of private interest. Criteria for traits of public interest do not differ between the National and Recommended Lists, while criteria for traits considered of private interest are less stringent for the National List than for the Recommended List.

The official and most direct route to adopt VCU testing protocols for organic farming is by discussions within the crop-specific VCU advisory groups, which are officially linked to the Plant Variety Board as well as to the CSAR. As an alternative, the Dutch system offers many options to (organised) stakeholders to propose VCU testing protocols adapted to their specific needs, provided they can finance the implementation. The organic spring wheat VCU project followed the latter route as including it in the structure of VCU—advisory groups was not acceptable for the parties already represented in this structure.

The current Dutch VCU has been operative since 2006. At the time of the research project described in this paper (2001–2004), the same private sector parties, which are currently represented in the CSAR, were also involved in developing VCU protocols and advising on admission in the Recommended List. However, in contrast to the current situation, compiling the Recommended List was still the responsibility of the predecessor of the current Plant Variety Board, the Variety List Commission (*Commissie voor de Samenstelling van de Rassenlijst voor Landbouwgewassen*, also a government agency).

Material and methods

The organic spring wheat VCU protocol and its implementation

The organic VCU protocol was developed in a participatory manner. A committee of three experienced organic wheat growers and the first author elaborated a first draft protocol, which was presented and discussed in a plenary session with organic farmers, the main trader, conventional breeders and a representative of the Variety List Commission (15 persons). The improved final version was submitted to the Variety List Commission which endorsed this protocol in 2001. Table 1 shows the adaptations to the conventional protocol that consisted of the following:

(a) Adapting the protocol for the organic growing conditions, including field and crop management and seed treatment
(b) Adapting the testing procedure for baking quality to most common organic bread-making practices, i.e. main product is whole-meal bread and most

Table 1 Differences between the conventional spring wheat VCU protocol and the organic protocol proposed by stakeholders of the organic bread wheat production chain (adapted from Osman and Lammerts van Bueren 2003)

	Organic VCU protocol	Conventional VCU protocol
Field and crop management		
Trial site	Managed organically for at least 3 years, in accordance with EU regulation 2092/91 (Council 1991)	Managed conventionally with mineral fertilisers and herbicides. In order to evaluate disease and lodging resistance fungicides and growth regulators are applied to only half of the replicates.
Seed treatment	Not chemically treated	Treated with fungicide
Field evaluation	Inclusion of the following additional traits: • Early soil coverage • Leafiness • Peduncle length • Ear density • Resistance against sprouting	
Baking quality test	Evaluation on whole meal bread without artificial bread improvers	Evaluation on white bread with addition of ascorbic acid

bakers prefer to restrict the use of additives and processing aids

(c) Including additional traits of relevance for organic agriculture in the field evaluation

The organic spring wheat VCU testing was implemented between 2001 and 2004 as a research project financed by the Dutch Ministry of Agriculture, Nature Conservation and Fisheries, the Commodity Board for Arable Crops (HPA) and the Foundation for Experimental Farms for Arable Crops in the Northern Region of the Netherlands (SPNA). A working group consisting of representatives of the organic wheat production chain, Variety List Commission and research institutions, guided the implementation of organic VCU. Breeders actively participated in improving the drafts of the organic VCU protocol, but declined the invitation to nominate a representative in the organic VCU working group.

Field experiments

Setup of variety testing

The experimental organic VCU testing was conducted at three certified organic farms during 2001–2004. All farms were situated on clay soils in the main organic wheat growing areas of the country: Kollumerwaard (northeast), Nagele (central polders) and Schoondijke (southwestern part of the Netherlands). Sites with other soil types were not included; as in the Netherlands, almost all organic wheat is sown on clay soils. At the experimental farm at Nagele the trials were sown both under organic and conventional growing conditions. Data of Kollumerwaard was not used in the final analysis (see "Statistical analysis of results" section).

Like the regular VCU testing in the Netherlands, the organic VCU testing followed a two-step approach that consisted of a pre-screening of new candidate varieties at Nagele, followed by a comprehensive screening at three locations of the most promising lines in the following years. In the pre-screening, each new accession was only tested for 1 year and either transferred to the comprehensive screening or discarded (Fig. 1). As a result of this procedure, the composition of the set of varieties in the comprehensive test slightly changed over the period of 4 years. The pre-screening was conducted in the first 3 years of the project and the comprehensive screening was done during all 4 years. All trials were sown in a randomised complete block design. The pre-screening was sown in two replicates and the comprehensive screening in three replicates.

Traits that were evaluated are listed in Table 2. Grain quality analyses were conducted by the laboratory of an industrial mill (Krijger Molenaars, Renesse), following ICC standard methods. Baking tests were conducted and evaluated by an experienced professional test baker (R. Bottemanne, Fontys Hogescholen, Wageningen),

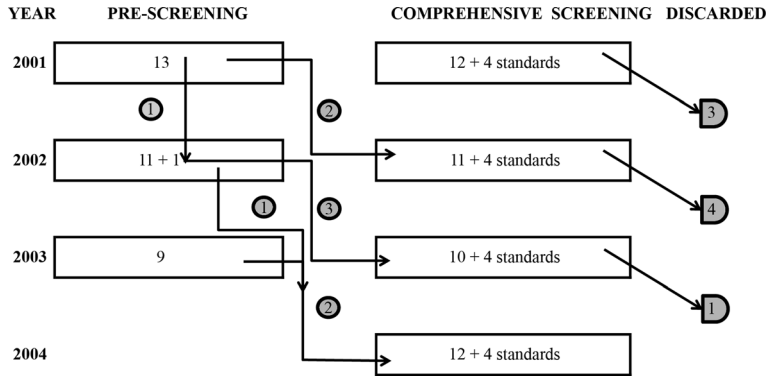

Fig. 1 Number of accessions per trial and flow of accessions between trials (additions to the comprehensive screening in *circles*, deletions in *half circles*)

following a standard protocol developed for traditional mills (Osman et al. 2005).

Varieties

Between 2001 and 2003, each year (candidate), varieties were obtained from six Dutch seed companies: one company with a spring wheat breeding programme in the Netherlands and the other five companies representing German, Swedish and UK breeders. All six companies were asked to provide material which would meet the requirements set by an organic variety profile developed by organic end users (Table 3; Osman et al. 2014). Furthermore, four varieties listed in the Dutch Recommended List of varieties were included as standards. Of these four varieties, only *Lavett* was

Table 2 Evaluated characteristics in the organic VCU trials

Characteristic	Evaluation method and dimension
Field traits	
Emergence	Visual on a scale 1–9 where 9=100 % emergence
Early soil coverage	Visual on a scale 1–9 where 9=good coverage
Leafiness after ear emergence	Visual on a scale 1–9 where 9=dense
Ear density[a]	Visual on a scale 1–9 where 9=lax
Peduncle length	Measurement in cm
Plant length	Measurement in cm
Lodging	Visual on a scale 1–9 where 9=no lodging
Earliness ripening	Visual on a scale 1–9 where 9 = early
Infection with diseases Yellow rust (*Puccinia striiformis*) Brown rust *(Puccinia triticina)* Septoria tritici blotch (*Mycosphaerella graminicola*)	Visual on a scale 1–9 where 9 = no infection (only evaluated when disease was present)
Sprouting[a]	Visual on scale 1–9 where 9=no sprouts
Grain yield	Measurement in kg/plot
Baking quality traits	
Specific weight[a]	Measurement in kg/hl
Protein content	NIRS in %
Zeleny sedimentation	Measurement in ml
Hagberg falling number[a]	Measurement in s
Loaf volume[a]	Measurement in cm^3
Bread quality[a]	Bakers' overall impression on a scale 1–9 where 9=combination of high loaf volume, and good crust, crumb and dough properties

[a]Only evaluated in the comprehensive screening

Table 3 Organic spring wheat variety profile provided to breeders to select candidate varieties for testing in the organic VCU

Traits	Preferred phenotype	Priority
Supporting weed management		
Tolerance to harrowing	Firmly rooted and able to recover rapidly from burial	+
Tillering capacity	Able to compensate for a poor stand with extra tillers	++
Vigorous early growth	Able to emerge and cover soil rapidly	++
Canopy density	Dense	++
Plant length (also to reduce ear diseases)	±100 cm (= standard variety Lavett)	+
Reducing risk of diseases		
Plant length (also because of weed suppression)	±100 cm (= standard variety Lavett)	+
Peduncle length	±20 cm	++
Ear density	Lax	+
Resistance against		
Yellow rust (*Puccinia striiformis*)	Resistant	++
Brown rust (*Puccinia triticina*)	Resistant	++
Septoria tritici blotch (*Mycosphaerella graminicola*)	Resistant	++
Fusarium head blight (*Fusarium* spp.)	Resistant	++
Powdery mildew (*Blumeria graminis*)	Resistant	+
Reducing risks at harvest		
Lodging resistance	Resistant	++
Ripening	Early (harvestable first week of August)	++
Pre-harvest sprouting	Resistant	++
Productivity		
Manure use efficiency	Ability to achieve desired production and quality with as low manuring level as possible	++
Stay green of leaves	Upper leaves healthy as long as possible	++
Grain yield	Like the variety Lavett (±6 tonnes/ha)	++
Milling and baking quality		
Specific weight	≥76 kg/hl	++
Hagberg falling number	≥260 s	++
Protein content	≥11.5 %	++
Zeleny sedimentation value	≥35 ml	++
Marketable loaf of wholemeal bread	Loaf volume like variety Lavett	++

The variety Lavett which is appreciated and widely grown by organic farmers was taken as point of reference.

Adapted from Osman and Lammerts van Bueren 2003

widely grown by organic farmers and according to farmers, traders and millers, this variety performed well for all required traits. Therefore, *Lavett* was used as a benchmark for a spring wheat variety suitable for organic production.

Statistical analysis of results

Data were analysed with the software package GenStat (fourteenth edition). To study whether the VCU protocol stimulated breeders to submit varieties with traits preferred by organic end-users the following procedure was implemented. Separate two-way ANOVAs were conducted, with variety and cropping system (organic, conventional) as treatments, for each of the three prescreening trials and the first year of the comprehensive testing, including calculation of means and protected LSD values ($P<0.05$). The LSD values were used to distinguish accessions that were significantly better than, equal to or inferior to the mean of the standard

variety *Lavett*. Baking quality variables were not statistically analysed, because the baking tests were carried out without repetitions.

To study whether varieties included in the Recommended List of Varieties through the organic VCU procedure better matched the needs of the organic sector, data of the organic sites of the comprehensive screening were submitted to a mixed model analysis, with variety and location as fixed factors and year and block as random factors. Due to the large number of missing values, data of Kollumerwaard was not included in the final analysis presented in this paper.

Qualitative data

Feedback from breeders was gathered through qualitative interviews with three breeders and participant observations during annual field visits and project meetings (about 20–30 participants per meeting, including breeders, traders, organic farmers and millers).

Results

Effect of the implementation of organic VCU

In this section, we examine whether organic VCU improved the availability of suitable varieties for the organic sector. We will first analyse whether the organic VCU stimulated breeders to submit lines with the required traits. Secondly, we assess whether the adapted VCU protocol allowed the inscription of better suited varieties in the Recommended List of Varieties.

Did organic VCU testing stimulate breeders to send in lines with traits preferred by organic end-users?

During the whole trial period breeders presented 45 accessions for organic VCU that were not listed yet in the Netherlands: 33 accessions for the three pre-screenings and 12 accessions for the comprehensive screening of the first year (Fig. 1). A relatively large proportion of the accessions showed improved lodging resistance (44 %) and resistance to brown rust (*Puccinia triticina*) (31 %) (Fig. 2). Also, 28 % of the accessions had a longer peduncle, whereas 39 % had a shorter peduncle than *Lavett*. This variation probably indicates that breeders did not select for peduncle length. A relatively large proportion of the accessions were deficient in traits that contribute to weed competition like early ground cover (44 %) and tall plants (69 %). This shows that breeders did not manage to provide a large proportion of accessions from their breeding programmes that were distinct from the lines they would send in for conventional VCU testing.

Candidate varieties without major shortcomings for the evaluated traits passed from the pre-screening to the comprehensive screening. In total, eight out of the 33 (24 %) accessions tested in the pre-screening passed to the next phase of VCU testing (Fig. 1). This percentage only slightly varied between years, ranging between 21 and 27 %.

Did organic VCU testing enhance the number of varieties suitable for the organic sector on the Recommended List of Varieties?

The Variety List Commission used the results of the organic VCU testing project to introduce an organic spring wheat section in the Recommended List of Varieties (Bonthuis et al. 2005). The new organic section included six varieties. Three of these six cultivars (*Melon*, *Quattro*, *Thasos*) were new registrations, while the other three varieties (*Lavett*, *Pasteur*, *Tybalt*) were already listed in the conventional section (see also Table 4). During the same period, four new varieties were added to the conventional spring wheat section of the Dutch variety list (*Pasteur*, *Tybalt*, *Zirrus*, *Quattro*). *Quattro* is a special case. Its representative first offered this variety for organic VCU. After 2 years of satisfactory performance in both the organic and conventional trials of the VCU project, the seed company decided to apply also for conventional VCU for *Quattro*.

Table 4 shows that varieties selected through the organic VCU (group A) differed from the varieties that entered the Recommended List through the conventional VCU (group B) for early soil coverage and plant length, which contribute to weed suppression. Group A varieties were also less compact with a more open ear and a longer distance between ear and leaf canopy than group B varieties. On the other hand, the two newer varieties (*Tybalt*, *Zirrus*) that were approved through the conventional VCU procedure were higher yielding and more resistant to pre-harvest sprouting than group A varieties. Also, two of the group B varieties (*Pasteur*, *Tybalt*) showed the highest resistance to brown rust.

In comparison to the organic standard *Lavett*, the new varieties in the organic section of the Recommended

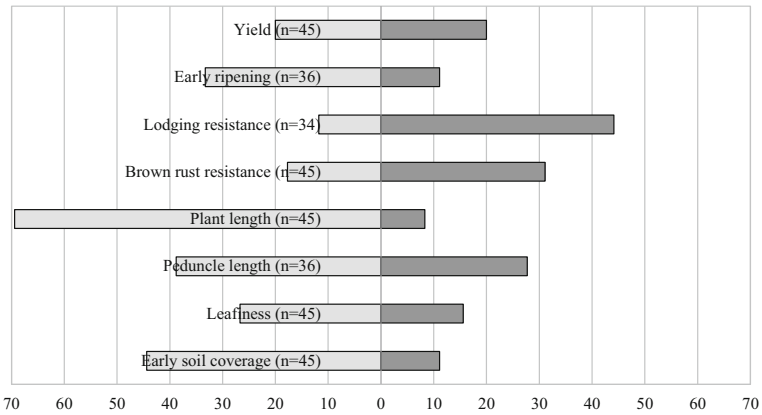

Fig. 2 Percentage of lines that performed better (*dark grey*) or worse (*light grey*) than *Lavett* (protected LSD values; $P<0.05$). (n=total number of lines)

List performed similarly for weed competition, plant health traits and yield, but were slightly later ripening and inferior in bread quality.

Feedback from breeders on the organic VCU testing project

Breeders considered it interesting to learn about the performance of their material under organic growing conditions. At the beginning of the project, they did not exactly know which of their lines fulfilled the requirements of the Dutch organic sector. In interviews, participants indicated that field trial visits and annual project meetings improved their understanding of the needs of the organic sector.

Breeders were asked to submit lines that matched the organic spring wheat variety profile provided to them at the onset of the project (Table 3). However, they admitted that they had added their own requirements to the organic variety profile: for them, the submitted lines also needed to be of interest for the conventional market, which meant that they looked for high-yielding varieties. During meetings, breeders made clear that they considered the Dutch organic spring wheat market (about 2000 ha in 2004) too small to maintain and multiply varieties that are only of interest to the organic sector. Indeed, in two occasions, candidate lines selected by the project for the next phase were withdrawn, because the seed company considered grain yield of these lines too low to compete with other varieties already available on the market.

In addition to seed multiplication costs, breeders also argued that cost of VCU itself would be too high to economically justify submission of specific varieties for the organic sector. They clearly indicated that they would not apply for specific organic VCU testing in the future if this would involve costs, due to the small acreage of organic spring wheat in the Netherlands. As for organic farmers financing spring wheat VCU testing was not an option either, up to the date of this publication, no new trials were set up.

Discussion

Within the EU, Austria has the longest history of a functional yearly organic VCU. The organic procedure enabled the registration of 12 winter wheat varieties between 2006 and 2011 (AGES 2012). According to Löschenberger et al. (2008), varieties that passed the Austrian organic VCU would not have passed conventional VCU tests due to their lower yield. The results of the Dutch spring wheat case, presented above, also show that adapting the VCU testing protocol can bring about changes in the assortment of recommended varieties. However, none of the newly recommended varieties reached the required baking quality level of the organic standard *Lavett*. Moreover, the varieties that entered the Dutch Recommended List of Varieties through the organic procedure, *Melon*, *Thasos* and *Quattro*, were newly listed in the Netherlands, but not quite new because all three were already included in the German Recommended List of Varieties between 1994 and 1997. This is quite worrying for the organic sector, as it indicates that current spring wheat breeding programmes are unable to provide suitable new varieties for the organic sector.

At the start of the VCU project, we expected that breeders would send in accessions that better matched specific requirements of the organic sector. However,

Table 4 Spring wheat varieties that entered the Dutch Recommended List of Varieties between 2002 and 2006

Varieties included in the Recommended List between 2002 and 2006	Cultivar	Early Soil coverage	Leafiness	Plant length (cm)	Ear density	Peduncle length (cm)	Brown rust resistance	Septoria resistance	Lodging resistance	Sprouting resistance	Earliness ripening	Grain yield (kg/plot)	Protein content (%)	Zeleny-sedimentation (ml)	Bread quality
A: First application through organic VCU	Melon	6.1	6.2	93	6.4	21	7.8	6.6	8.6	4.7	6.5	15.7	10.6	36	6.2
	Thasos	6.3	6.5	100	5.9	22	6.6	7.0	7.3	4.2	6.9	15.7	11.1	39	6.7
	Quattro	6.3	6.5	100	7.6	25	7.5	7.8	7.1	3.8	5.5	15.8	10.1	37	6.9
B: Listed through conventional VCU	Pasteur	4.7	5.8	91	5.4	18	8.8	8.1	7.9	4.6	5.9	15.5	11.4	39	4.7
	Tybalt	5.8	7.4	87	4.5	14	9.0	7.1	7.9	6.2	6.3	17.4	10.5	33	6.2
	Zirrus	5.6	6.9	90	6.2	18	6.2	7.0	7.3	5.4	5.8	17.5	9.5	34	6.1
Organic standard	Lavett	6.4	6.6	101	8.0	22	8.3	6.1	7.7	4.6	7.5	15.2	10.7	38	8.2
Mean A		6.2	6.4	98	6.7	23	7.3	7.1	7.6	4.2	6.3	15.7	10.6	37	6.6
Mean B		5.4	6.7	89	5.4	17	8.0	7.4	7.7	5.4	6.0	16.8	10.5	35	5.6
SED		0.3	0.4	0.9	0.3	0.5	0.5	0.4	0.5	0.6	0.4	0.4	0.3	2.3	0.6

Mean values of two organic locations (Nagele, Schoondijke) and 4 years (2001–2004)

SED standard error of the difference between means

breeders failed to submit accessions that were too distinct from the ones they send in for regular VCU. According to breeders, they needed the information of the field trials and discussions during meetings to learn about the performance of their material under organic growing conditions and to better understand the needs of the organic sector. However, the percentage of submitted lines with desired traits did not increase from the first to the third year of pre-screening. So, apparently, a better understanding of the needs of the organic sector was not sufficient to affect the submission of lines that matched the organic variety profile. According to Osman et al. (2014) conventional breeders are not able to deliver spring wheat varieties that match the organic sector's needs, because breeding goals for the conventional market conflict with improving traits required by the organic sector. Therefore, breeders would need to adjust their breeding approach (prioritise other criteria, change selection environment) to be able to provide varieties adapted to the needs of the Dutch organic sector. Thus, it would take several years before results of such interventions in the ongoing breeding programmes would become visible. However, seed companies are only prepared to invest in this change in their selection programme, when there are sufficient market perspectives for the resulting varieties, which for wheat means a market segment of about 50,000 ha, according to participating breeders.

In addition, both organic farmers and breeders considered costs of VCU procedures not in proportion to its economic benefits. The spring wheat VCU system which was developed by the project was abandoned when subsidies stopped as both breeders and the organic sector were not able or prepared to bear the costs. Also, in other EU countries, cost of VCU testing was considered a bottle neck for the relatively small organic sector (Rey et al. 2008). One option to reduce trial costs would be combining information on variety performance of a limited number of formal trials with information gathered from private trials conducted by breeders and growers (FCEC 2008; Rey et al. 2008; ECO-PB 2012) or complementing data from organic variety trials with information from conventional VCU (Przystalski et al. 2008; Lammerts van Bueren et al. 2012).

Application and testing costs also influence the number of varieties that breeders submit. For the current conventional spring wheat VCU testing, participating seed companies have limited the total number of candidate varieties to four per year to reduce costs of the VCU

system. This is considerably lower than the 45 (candidate varieties) they submitted during the 4 years of the organic VCU project. Hence, the Dutch spring wheat case shows that subsidising organic VCU stimulated seed companies to submit more candidate varieties than they usually send in for conventional VCU.

Conclusions: can variety testing be used as a policy instrument to direct variety development?

Mandatory VCU testing may prohibit the release of better adapted varieties for emerging cropping systems with only relatively small acreages. This paper demonstrates that adapting the VCU testing protocol enhanced the availability of suitable varieties for the organic sector. However, the spring wheat case study shows that adapting VCU testing to the needs of the organic sector is not sufficient to enhance the variety assortment. Breeders also would need to make adjustments in their selection programme to be able to provide appropriate lines adapted to organic and low-input farming systems.

Implementing adapted protocols will only be feasible for small market segments when costs of a formal trial system are in proportion to market size and expected benefits. For small market segments, a combination of formal trials and data gathered from breeders and growers may be a way to bring costs more in line with benefits.

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