AARHUS
UNIVERSITET
DCA - NATIONALT CENTER
FOR FØDEVARER OG JORDBRUG

Til Landbrugsstyrelsen

Værdiafprøvning af populationer af kulturplanter (heterogent materiale)

DCA - Nationalt Center for Fødevarer og Jordbrug

Claus Bo Andreasen
Chefkonsulent

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Direkte tlf.: +45 8715 1278
Mobiltlf.: +45 4079 8032
E-mail: clausbo.andreasen@dca.au.dk
Web: au.dk/clausbo.andreasen@dca

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Landbrugsstyrelsen har via bestilling sendt den 28. august 2015 bedt DCA – Nationalt Center for Fødevarer og Jordbrug om gennemføre en værdiafprøvning af populationer af kulturplanter.

En værdiafprøvningen kan bl.a. belyse om der kan være fordele ved at anvende plantepopulationer; fx for at mindske spredningen af plantesygdomme inden for økologisk produktion.

Baggrunden for bestillingen er at fra 1. januar 2015 har producenter af sædekorn fået mulighed for i en treårig periode at producere og markedsføre populationer. Det er et krav i Kommissionens forsøgsordning, at der udføres en værdiafprøvning af populationerne, så der indsamles data som grundlag for fastlæggelse af en permanent ordning på sigt.

Via en litteraturgennemgang beskriver vedlagte rapport indledningsvist de internationale erfaringer med anvendelse af populationer af kulturplanter; efterfølgende opsummerer de danske erfaringer på området. Interessen blandt danske forædlere for at værdiafprøvet populationer har dog været yderst begrænset, hvilket har reduceret mulighederne for at udføre værdiafprøvninger i perioden.

Rapporten er udarbejdet af lektor Johannes Ravn Jørgensen, Institut for Agroøkologi og lektor Ulla Kidmose, Institut for Fødevarer.

Rapporten er fagfællekommenteret af seniorforsker Birthe Boelt, Institut for Agroøkologi.

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Venlig hilsen

Claus Bo Andreasen
Chefkonsulent

Testing of plant populations of self-pollinated cereal crops for value for cultivation and use

Johannes Ravn Jørgensen and Ulla Kidmose

The present report summarize the Danish experiences regarding the temporary experiment for certain derogations for the marketing of plant populations, which the Commission started in 2015 with the Decision COM2014/150/EU for four cereal crops (wheat, barley, oats and maize), and which will expire at the end of 2018 (BEK nr 1710 af 20/12/2016 § 40- § 50; Appendix 6).

Introduction

Crop populations are hypothesized to be advantageous to varieties in organic and low-input systems as increasingly uncertain environmental conditions require crops with high adaptability to unpredictable biotic and abiotic stresses (Østergård et al. 2009). It is stated that genetically uniform crops often cannot adequately fulfil this requirement (Döring et al. 2011; Finckh 2008). The large-scale use of monocultures of single plant genotypes, and thus of single resistance genes, generates strong selective pressure for pathogenic pathotypes that may overcome this resistance (Hovmøller 2001; Wolfe and McDermott 1994). As a consequence, variety resistances have to be renewed constantly (Mille et al. 2006), whereas increased genetic diversity in crops may help to buffer both biotic and abiotic stresses (Østergård et al. 2009). Cropping systems that are able to achieve this diversity include multilines, variety mixtures and genetically diverse populations produced under dynamic management such as composite cross populations (CCP) (Creissen et al. 2016; Finckh 2008; Raggi et al. 2017). However, low input and organic agriculture has suffered from a lack of varieties adapted to the environmental variability on farms (Chable et al. 2014; Lammerts van Bueren et al. 2011; Wolfe et al. 2006). Under organic or low-input conditions, the variability of the environment often has a more pronounced influence on crop yield than under conventional conditions (Newton et al. 1998; Wolfe et al. 2008), leading to a lack of stability in crop performance (Soliman and Allard 1991). Consequently, approaches need to be developed for organic or low-input cropping systems that can stabilize the crop performance across, and buffer against, environmental fluctuations (Döring et al. 2015). The usefulness of mixtures (multiline varieties and variety mixtures) for disease management has been demonstrated successfully for rusts and powdery mildews of cereal crops (Mundt 2002).

Multilines are lines that are agronomically similar to each other but differ genetically as regards their resistance to different races of pathogens. Each line has specific resistance to a particular pathogen, and when several lines are mixed together they form a “multiline”. Yellow rust-resistant wheat multilines Tumult and Crew were released in Holland in 1979 and USA in 1982 respectively (Groenewegen 1977; Mundt and Browning 1985). In Iowa, USA, 13 multiline varieties of oats were released in two maturity classes. These were grown in up to 0.4 milion ha (Browning 1988). However, the development and utilization of multiline varieties was not successful mainly because of the time-consuming and expensive development process. Besides, the genetic diversity of multilines was very much reduced because of its pure line nature (Mehta 2014).

Variety mixtures of varieties with differing characteristics have been demonstrated as a potential means of increasing as well as stabilizing crop yield over environments and variety mixtures are being used with success in many parts of the world, reducing diseases and stabilizing yields (Finckh et al. 2000; Kiær et al. 2009; Smithson and Lenne 1996). In a Danish investigation with spring barley, one of six tested two-variety mixtures out-yielded all of its component varieties in almost half of the 17 trial environments (Kiær et al. 2012). A study in UK with winter wheat showed that multi-component mixtures tested at four sites (two organically-managed and two conventionally-managed) over three years significantly out-yielded the mean of the respective components across 12 environments by 3.6% (Döring et al. 2015). The general experimental evidence of more stable yields of variety mixtures than the average of their pure stand

component varieties may justify large-scale cultivation of variety mixtures in variable environments, such as organic farm systems. However, mixtures would be even more advantageous to farmers in general if, in addition, mixture yields were comparable to the highest yields of component varieties (Kiær et al. 2012).

Selling of seed mixtures was generally not allowed in Denmark (although labelled mixtures can be traded within member states of the EU according to legislation introduced in the 1970s). However, because of the continuous breakdown of powdery mildew resistant barley varieties in Denmark, interest in mixtures grew in the 1970s (Welling et al. 1983) and, from 1979, seed companies were allowed to produce and sell mixtures of spring barley and, from 1988, winter barley mixtures. Winter wheat mixtures were allowed for the first time in the autumn of 1998. The variety mixtures are approved mixtures of spring barley, winter barley and winter wheat respectively marketed based on listed varieties of the respective crops (BEK nr 1710 af 20/12/2016; § 20 and § 26).

Genetically diverse populations / Composite cross populations

The term "evolutionary breeding" describes the creation of genetically diverse populations of single crops undergoing both artificial and natural selection under different environmental conditions, but having the added advantage of carefully selected parents for traits such as high yield and quality combined in a composite cross scheme (Phillips and Wolfe 2005; Suneson 1956). Composite cross populations of self-pollinating cereals include higher levels of diversity if compared to pure lines and mixtures and are able to develop themselves in time by adapting to the respective environment (Wolfe et al. 2008). Composite cross populations are formed by assembling seed stocks with diverse evolutionary origins and characteristics, recombination of these stocks by cross pollination, the bulking of F_1 progenies, and subsequent propagation of the bulked progenies in successive natural cropping environments (Phillips and Wolfe 2005). The value of composite cross populations in achieving these aims is dependent on the outcome of mass trials by artificial and natural selection acting upon the heterogeneous mixture (Phillips and Wolfe 2005). Natural selection takes place if more adapted genotypes produce more progenies than less adapted ones. Composite cross populations can provide dynamic gene pools, which in turn provide a means of conserving genetic resources *in situ* (Lammerts van Bueren et al. 2011).

A CCP of barley was produced in Iowa in the 1920s through the paired crossing of 28 barley varieties in all possible combinations (barley composite cross II) (Harlan and Martini 1929). The effects of natural selection on grain yield of this composite cross population of various generations of this barley was in a comparison to commercial varieties investigated at Davis University, USA over a six- year period to determine the relationship between the amount of genetic diversity and yield and stability of yield (Soliman and Allard 1991). The composite crosses continued to show a marked yield increase over generations, perhaps as a result of increased adaptation. The average yield over six years of the most productive population was only 85% in comparison to the best yielding commercial variety, but CCPs were in general more stable than commercial varieties. The commercial varieties were more similar to one another than they were to the composite crosses, and vice versa. However, the year of creation of the CCP has to be taken into account. It was concluded that the composite cross populations offer an opportunity to produce varieties that show little or no genotype-environment interaction, but when they become more homogeneous, their stability is decreased.

In 2002, six CCPs were developed by the John Innes Centre (Norwich, UK) in co-operation with the Elm Farm Research Centre (Newbury, UK) based on 20 diverse winter wheat parents (Wolfe et al. 2006). When compared the (locally non-predictable) best-yielding pure line, the wheat CCPs and mixtures exhibited lower mean yield and somewhat lower yield reliability but comparable superiority values (Döring et al. 2015). However, yield advantage by 2.4% on average over 12 environments and higher yield stability for CCP's in comparison to parental mean were shown. The results demonstrate that using increased within-

crop genetic diversity can produce wheat crops with improved yield stability and good yield reliability across variable and unpredictable cropping environments.

Composite cross populations of barley have been developed by crossing parental populations highly productive under low-input conditions in Central Italy and diverse for several morpho-phenological traits in an evolutionary breeding programme, carried out over 24 years, to select barley heterogeneous populations and lines characterized by high grain yield and yield stability across different environments under organic and low-input conditions (Raggi et al. 2017). The main conclusion of this work is that evolutionary breeding is indeed a low-cost and effective approach to develop both populations and lines for sustainable agriculture especially when carried out under low-input conditions.

Genetic diversity within released cereal varieties of barley, wheat and oats is relatively small because they are self-pollinating species and homogeneity is an essential requirement for variety release, as tested for by testing distinctness, homogeneity and stability (DUC). The testing for DUC is mandatory by present laws like the Union for the Protection of New Varieties (UPOV) guidelines, EU rules (Regulation 2100/94/EC) or the Plant Varietal Protection Act (PVPA) in the USA, which require that a variety must be phenotypically uniform, stable and distinguishable from other varieties in order to be officially released. These regulations hamper the development of genetically diverse varieties as CCPs strongly. Political efforts are undertaken to change this strict legislation (Lammerts van Bueren et al. 2011) which have led to the Commission implementing decision of 18 March 2014 on the organization of a temporary experiment providing for certain derogations for the marketing of populations of the plant species wheat, barley, oats and maize pursuant to Council Directive 66/402/EEC.

In a UK study of the suitability of CCP wheat populations for different end uses, including bread making, malting, distilling and animal feed, it was not shown that the CCPs offers something 'new' to the malting industry. In fact, in terms of overall values for key malting parameters, the results indicate they have limited potential for use in distilling or malting (Girling et al. 2014). Furthermore, studies of wheat CCPs' performance of baking quality are very limited (Girling et al. 2014; Migliorini et al. 2016). In general, high baking quality is indicated by high protein and gluten content and potential good bread making quality of CCPs is indicated by high grain protein content (Döring et al. 2015) but not sufficient to draw any conclusions on the baking quality of CCPs. According to (Migliorini et al. 2016) old varieties scored highest in consumer preference in a comparison with CCPs and modern varieties; however, it might not be related to the highest baking quality. It should also be noted that millers or maltsters do generally not accept variety mixtures.

Danish experiences with tests of value for cultivation and use of genetically diverse populations

In the temporary experiment for certain derogations for the marketing of plant populations, which the Commission started in 2015 until the growing season 2016/17, there have been a total of six applications to the Danish AgriFish Agency, Plant Novelty Board, Teglværksvej 10, 4230 Skælskør, for addition to the National List (table 1).

Table 1. Applications for Protection and/or for Addition to the National List (Danish gazette / Meddelelser fra Sortsafprøvningen 5/2015).

Variety code	E:*Applicant - PBR* V: *Applicant – NL* R: *Agent*	*Applied with proposed denomination / breeders' reference*	*Date of application as regards to*	
			PBR	*NL*
Agricultural Species				
OATS - Avena sativa L. Winter oats – population				
30571 S	V:Agrologica/R:Agrologica	Vinterhavre-Popkorn nr 1		17/04/15

BARLEY - Hordeum vulgare L.				
Spring barley – population				
30569	S	V:Agrologica/R:Agrologica	Vårbyg-Popkorn nr 1	17/04/15
30572	S	V:Agrologica/R:Agrologica	Nøgen Vårbyg-Popkorn nr 1	17/04/15
WHEAT - Triticum aestivum L.				
Winter wheat – population				
30573	S	V:Agrologica/R:Agrologica	Vinterhvede Popkorn nr 1	17/04/15
WHEAT - Triticum aestivum L				
Spring wheat – population				
30568	S	V:Agrologica/R:Agrologica	Vårhvede-Popkorn nr 1	17/04/15
30570	S	V:Agrologica/R:Agrologica	Purpur Vårhvede-Popkorn nr 1	17/04/15

Of these applications winter oats 'Vinterhavre-Popkorn nr 1' (variety code 30571), winter wheat 'Vinterhvede Popkorn nr 1' (variety code 30573) and spring wheat 'Vårhvede-Popkorn nr 1' (variety code 30568) entered the observation plots (OBS) for springsown varieties 2016 and wintersown varieties 2016 respectively. All six applications for Addition to the National List have been withdrawn in 2016 (table 2). Agrologica have been the applicant for all six varieties to the national list. Agrologica have withdrawn all six varieties due to unsatisfying yield in breeders' own trials (personal com. Anders Borgen, Agrologica). However, yield tests have not been a part of the testing for value for cultivation and use (VCU) which the applicants have undertaken.

Supplementary tests of yellow rust susceptibility (smitteforsøg) of Vinterhvede Popkorn nr 1, Vårhvede-Popkorn nr 1 and Purpur Vårhvede-Popkorn nr 1 have in 2016 been performed at Aarhus University, Flakkebjerg (Meddelelser fra Sortsafprøvningen 11/2016).

Table 2. Withdrawal of Applications for Protection and/or for Addition to the National List (Danish gazette / Meddelelser fra Sortsafprøvningen 11/2016).

Variety code	E:*Applicant - PBR* V: *Applicant – NL* R: *Agent*	*Applied with proposed denomination / breeders' reference*	*Date of withdrawal as regards to*	
			PBR	*NL*
Agricultural Species				
OATS - Avena sativa L.				
Winter oats – population				
30571 S	V:Agrologica/R:Agrologica	Vinterhavre-Popkorn nr 1		10/10/16
BARLEY - Hordeum vulgare L.				
Spring barley – population				
30569 S	V:Agrologica/R:Agrologica	Vårbyg-Popkorn nr 1		10/10/16
30572 S	V:Agrologica/R:Agrologica	Nøgen Vårbyg-Popkorn nr 1		10/10/16
WHEAT - Triticum aestivum L.				
Winter wheat – population				
30573 S	V:Agrologica/R:Agrologica	Vinterhvede Popkorn nr 1		10/10/16
WHEAT - Triticum aestivum L				
Spring wheat – population				
30568 S	V:Agrologica/R:Agrologica	Vårhvede-Popkorn nr 1		10/10/16
30570 S	V:Agrologica/R:Agrologica	Purpur Vårhvede-Popkorn nr 1		10/10/16

No grain quality and baking tests have been performed on applicant plant populations in the period of the temporary experiment for certain derogations for the marketing of plant populations as all applications have been withdrawn. A challenge for quantitative studies as baking studies is the variable nature of CCPs from generation to generation and between years and thus to test whether their performance is depleted or improved continuously in order to evaluate their suitability as commercial prospects.

Comments on the performed testing for value for cultivation and use (VCU) of applicant plant populations at Tystofte, 2016 and the supplementary test of yellow rust susceptibility at Aarhus University, Flakkebjerg, 2016.

Oats VUC test (appendix 1)

The tested population candidate line "Vinterhavre-Popkorn nr. 1" was tested against two winter oats from the UK. A high percentage of the plants died over winter. Hovewer, Vinterhavre-Popkorn nr. 1 showed slightly better winter resistance than the other varieties. Vinterhavre-Popkorn nr. 1 is the tallest variety, susceptible to mildew and leaf spot. Overall performance of Vinterhavre-Popkorn nr. 1 is not impressive but not significantly different from the other tested varieties.

Winter wheat VCU test (appendix 2)

The tested population candidate line "Vinterhvede-Popkorn nr. 1" was tested against all other applicants and reference varieties in the official VCU test of observation plots. In total of 108 varieties Vinterhvede-Popkorn nr. 1 was the tallest variety, had some tendency to lodging and was moderately susceptible to mildew, yellow rust, septoria and brown rust.

Winter wheat supplementary test of yellow rust susceptibility (appendix 3)

The tested population candidate line "Vinterhvede-Popkorn nr. 1" was tested against the two yellow rust races Kranich and Warrier(-) and was moderately susceptible to both races of yellow rust.

Spring wheat VCU test (appendix 4)

The tested population candidate line "Vårhvede-Popkorn nr. 1" was tested against all other applicants and reference varieties in the official VCU test of observation plots. In total 15 varieties. Vårhvede-Popkorn nr. 1 was the tallest variety, showed high susceptibility to mildew and yellow rust compared to the other tested varieties, but was less susceptible to septoria than all other varieties. Vårhvede-Popkorn nr. 1 was susceptible to cereal cyst nematodes.

Spring wheat supplementary test of yellow rust susceptibility (appendix 5)

The tested population candidate lines lines "Purpur Vårrhvede-Popkorn nr. 1" and "Vårhvede-Popkorn nr. 1" were tested against the yellow rust race Kranich and a variant of the Warrier race (Triticale2015) and both were susceptible to both races of yellow rust.

Conclusion

The interest from breeders or agents to sign up applicants in the period for the temporary experiment aimed at certain derogations for the marketing of plant populations has been very limited. In fact, only one breeder has utilized the option, and all applicant lines have been withdrawn due to unsatisfying yield in breeders' own trials. The results from the official testing of the few candidates for plant populations have not provided evident results supporting that the currently available CCPs could provide an advantage in organic or low-input farming systems. However, it should be stated that variety mixtures provide a proven advantage to organic or low-input farming systems. Most studies of variety mixtures show that they have advantages in terms of leaf disease control and yield stability across environments in comparison to the average of components. Furthermore, variety mixtures have the advantage that they can easily be altered based on approved varieties without getting into conflict with the regulation of marketing of varieties.

The reported research on the economic, agronomic and environmental value of CCPs is not sufficient to support the benefit of CCPs as a better alternative to varieties passing the normal DUC and VUC system or approved mixtures of spring barley, winter barley and winter wheat marketed based on listed varieties for

organic or low-input farming systems. Further studies of the possibilities to increase sustainability and competitive ability of the varieties by increasing the genetic diversity are needed. In addition, it is also necessary to test the quality of the end-use products such as bread, malt etc. in order to have an overall evaluation of the CCPs.

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Appendix 1. Winter oat - Table with results from the VCU testing at Tystoftefonden (Sortsforsøg Korn, bælgsæd og olieplanter, 2016).

OBSERVATIONSPARCELLER

VINTERHAVRE	DØDE PLANTER EFTER VINTEREN, PCT.	MODNINGS-DATO	STRÅLÆNGDE (CM)	LEJESÆD (0-10)	PCT. DÆKNING MELDUG	PCT. DÆKNING BLADPLET
Antal forsøg						
Gerald	54.2	24/7	80	7.5	17	7
Mascani	42.0	24/7	80	4.2	1.4	9
Vinterhavre-Popkorn nr. 1	36.3	24/7	86	6.5	10	18

Appendix 2. Winter wheat - Table with results from the VCU testing at Tystoftefonden (Sortsforsøg Korn, bælgsæd og olieplanter, 2016).

OBSERVATIONSPARCELLER

VINTERHVEDE	MODNINGS-DATO	STRÅLÆNG-DE (CM)	LEJESÆD (0-10)	PROCENT DÆKNING			
				MELDUG	GULRUST	SEPTORIA	BRUNRUST
Antal forsøg	*6*	*4*	*8*	*4*	*12*	*6*	*4*
Antal forsøg	4	5	3	3	10	14	3
Anja *	1/8	93	3.3	10	39	5	0
Benchmark	2/8	75	0.3	3.0	2.0	12	1.7
Blanding	3/8	71	0.0	8	0.09	14	1.3
Bonanza ***	2/8	76	0.3	0	4.0	15	0
Cardos	31/7	70	0.3	0.3	40	6	0
Creator	31/7	75	2.0	1.7	2.4	3.4	1.7
Dunston	2/8	68	0.0	6	0.02	12	0
Elixer	4/8	78	1.3	3.5	0.06	7	0.01
Evolution **	31/7	66	1.7	2.7	0.01	23	0
Florida *	31/7	85	2.3	26	79	2.7	0
Graham	1/8	69	0.3	0.3	0.06	10	0.2
Halvar	2/8	73	3.3	0	0.01	14	0
Hardwicke	2/8	59	0.0	9	0	12	0.01
Hereford	31/7	67	0.7	6	0.01	24	1.7
Jensen	2/8	75	0.7	2.8	1.1	13	0.3
KWS Blanche	2/8	59	0.0	4.3	0.01	15	0.3
KWS Cleveland	31/7	67	0.7	2.7	0.01	17	0
KWS Crispin	2/8	69	0.0	2.7	0.06	8	0
KWS Dacanto	31/7	74	1.7	9	0.05	19	0
KWS Jive **	2/8	68	0.7	3.5	0	13	0.2
KWS Kerrin	1/8	65	0.0	1.2	0.01	19	0
KWS Lili	2/8	62	0.0	0	0.9	8	2.0
KWS Montana	1/8	75	1.0	3.4	0	16	0.2
KWS Nils	2/8	81	1.0	2.7	1.1	16	0.2
KWS Renegade **	1/8	66	0.3	1.7	1.1	10	0.3
KWS Silverstone	31/7	67	1.3	2.7	0.01	24	0
KWS Siskin	31/7	62	0.0	0.03	0.01	8	0.4
KWS Zyatt	2/8	65	0.3	0.3	1.0	14	0
Kadett	31/7	70	5.3	15	3.1	19	0.03
Kalmar	4/8	70	0.0	6	0.2	5	0
MS brunrust	1/8	75	6.3	1.7	0	4.3	50
MS-septoria	31/7	65	1.3	11	11	38	0.2
Manitou	2/8	74	0.7	3.3	13	11	0
Mariboss	1/8	71	2.3	8	0	25	1.3
Nakskov	31/7	72	2.0	3.7	0.01	22	0.03
Nuffield	3/8	72	2.3	9	0.4	19	4.3
Ohio	2/8	79	0.3	7	0.02	8	0
Olympus	2/8	70	1.3	0.03	0.01	4.8	0
Output	3/8	73	0.3	6	2.6	17	1.7
Pistoria	1/8	72	1.0	1.7	0.01	12	3.7
Pragtor	1/8	66	0.3	1.3	0	14	0.01
RGT Gradient	2/8	62	0.0	12	0.4	10	0.01
Ragnar	31/7	64	1.7	1.0	0.01	24	0
Savello	31/7	64	1.0	1.2	0.01	16	1.3
Sheriff	2/8	70	0.3	0.3	0.2	2.8	3.3
Substance	3/8	85	2.7	2.7	64	8	0
Torp	3/8	67	0.7	11	1.0	13	3.7
Ure	1/8	89	2.7	9	54	7	0
Viborg	3/8	66	0.3	0.01	0.01	6	0
BB 7766.13 W	23/7	76	1.0	9	0.5	7	0.04
Br10092p91	25/7	70	0.3	0	0.01	7	0
Br10101p83	3/8	81	0.0	0.2	0.01	4.1	0.03
Br9569/40 **	5/8	80	0.7	1.8	0.2	11	0.03
DSV 30118	3/8	66	0.0	2.7	0	13	1.7

OBSERVATIONSPARCELLER

VINTERHVEDE	MODNINGS-DATO	STRÅLÆNGDE (CM)	LEJESÆD (0-10)	PROCENT DÆKNING			
				MELDUG	GULRUST	SEPTORIA	BRUNRUST
DSV 316111	1/8	69	1.3	1.7	0.01	9	0
DSV 316115 **	2/8	73	0.3	0.3	0.01	9	0.2
DSV 316123 **	4/8	60	0.0	13	0	6	0
KW 2228-14	1/8	63	0.0	3.7	0.01	9	1.0
KW 2919-14	31/7	72	0.0	0.03	0.3	18	0
KWS W287	3/8	66	0.0	3.5	0.01	12	0.01
KWS W314	3/8	69	0.3	1.7	0.01	10	0.2
KWS W319	3/8	65	0.0	0.07	0.04	9	0
KWS W323**	3/8	68	0.3	2.7	0.01	8	0.01
KWS W324**	3/8	61	0.0	2.7	0.01	7	0
LEU 41706 **	2/8	77	1.0	12	2.9	15	1.7
LEU 51223 **	31/7	75	1.3	8	0.9	13	1.1
LGW104	1/8	68	0.0	9	0.03	10	7
LGW108	4/8	72	0.3	12	0.4	16	0.2
LGWD12-15312-D	3/8	73	0.0	6	3.2	11	0
MH 15-39	1/8	70	0.0	0.03	0.01	5.0	0
MH 15-50**	3/8	70	0.0	7	0	4.7	0
MH 15-63	3/8	70	0.3	1.0	0.01	9	0.2
NIC10-6030-A	2/8	78	0.7	1.7	0.01	18	0
NIC11-12484-D	2/8	72	0.0	2.9	0.2	14	0
NOS 17063.17	1/8	67	0.7	2.7	0.01	21	0.2
NOS 18039.11	4/8	64	0.7	3.3	0.03	10	0.03
NOS 18039.13 **	1/8	68	1.3	7	3.1	14	1.3
NOS 509011.08	2/8	67	0.3	1.7	0.07	12	9
NOS 509103.20**	4/8	63	2.0	3.6	0	19	0.01
NOS 509120.16	1/8	68	0.0	6	0	8	0.2
NOS 509130.09**	2/8	73	6.0	10	0.01	20	0
NOS 509133.05	3/8	80	2.0	1.7	0	9	0
NOS 7050-08 22	3/8	71	0.3	0	13	10	0
NOS 7093-08 06	2/8	70	0.3	13	0.1	12	3.3
NOS 7094-08 20	2/8	66	0.3	9	0.01	15	0
NOS 7191-06 28	4/8	68	0.3	0.2	0.01	3.3	0
RW41476 **	2/8	66	1.0	1.8	0.01	11	0.2
RW41498	2/8	69	0.7	12	0.01	11	0.07
RW41548	2/8	67	1.7	6	0	17	0
RW41572 **	3/8	66	0.0	3.7	0.01	7	0
RW41587	2/8	62	2.0	6	0.01	8	0.2
SC 2520	30/7	67	3.7	0	0.9	11	0
SC 2526**	4/8	62	0.0	0.2	0	20	0
SG-S1684-13 **	2/8	74	1.7	11	0.8	11	0
SY113014	1/8	61	1.0	3.5	0.01	24	0.4
Sj 13572002**	1/8	67	2.7	0.2	0.04	8	0
Sj 13845003**	1/8	69	3.7	0	0.01	14	2.3
Sj 13874003	31/7	63	1.3	0.03	0.08	9	0
Sj 1391 **	1/8	78	0.3	3.0	0.04	6	0
Sj 8576003 **	4/8	69	1.0	1.0	0.4	20	0
Sj K0255	2/8	68	2.7	9	0	19	1.3
Sj K0376	1/8	76	0.0	0	2.8	9	0.03
Sj K161	3/8	80	1.0	1.2	0.01	8	1.3
Sj K170**	3/8	66	0.0	3.3	0.03	16	0.2
Sj L110	3/8	64	0.3	1.3	0.01	13	3.5
Sj L123	1/8	67	1.3	8	0.01	17	1.5
Sj L288	2/8	71	4.3	0	0.2	7	2.7
Vinterhvede Popkorn nr. 1	3/8	105	2.3	2.7	3.6	7	1.7

Blanding: KWS Dacanto, Mariboss, Benchmark og Torp
*Afmeldt dansk sortsliste
**Afmeldt afprøvning til dansk sortslisteoptagelse
***Afvist optagelse på dansk sortsliste

Appendix 3. Winter wheat - Table with results from the supplementary test of yellow rust susceptibility (smitteforsøg) performed at Aarhus University, Flakkebjerg (Sortsforsøg Korn, bælgsæd og olieplanter, 2016).

SMITTEFORSØG, GULRUST

Resultater fra markforsøg med vinterhvedesorter i dansk sortsResultater fra markforsøg med vinterhvedesorter i dansk sortsafprøvning. Procent dækning af gulrust på de 3-4 øverste blade efter smitte med to smitteracer, Kranich og Warrior(-). Tallene er et gennemsnit over tre gentagelser og tre bedømmelsestidspunkter i maj-juni, Flakkebjerg 2016. Kilde: Aarhus Universitet

VINTERHVEDE	KRANICH	WARRIOR (-)
Ambition (Kontrol)	11	1,6
Anja (Kontrol)	6	5,8
Cardos (Kontrol)	15,7	5
Benchmark	3,9	0,3
Bonanza	4,8	0,2
Br 10101p83	0	0
Creator	2,1	2,4
DSV 30118	0	0
Dunston	0,6	0
Elixer	0,3	0
Evolution	0,6	0
Graham	0,5	0
Hereford	0,3	0
Jensen	0,2	0,8
Kalmar	0,1	0,1
KWS Cleveland	0,2	0
KWS Crispin	0	0
KWS Dacanto	0	0
KWS Lili	0,6	0,4
KWS Montana	0	0
KWS Nils	2,8	0,4
KWS Silverstone	0,6	0
KWS W293	0	0
KWS W295	1	1,1
KWS W298	0	0
Mariboss	0	0
Nakskov	0,7	0
NIC11-12484-D	3,8	0
NOS 15009.02	1,8	1,4
NOS 17063.17	0	0
NOS 7050-08 22	2	3,1
NOS 7093-08 06	0	0,1
NOS 7094-08 20	0	0
NOS 7191-06 28	0,1	0
Nuffield	0	0,4
Ohio	0	0
Olympus	0	0
Pistoria	0	0
Ragnar	0	0,2
RW41394	0	0
RW41498	0,8	0
SEC G0584 LT3	10,1	1,1
Sheriff	0,4	0,3
Sj 13572002	0,2	0,1
Sj 13845003	0	0
Sj 13874003	0,1	0,1
Sj 8576003	2	0
Sj K0255	0	0
Sj K0376	1,1	0
Substance	8	14,6
Torp	0,1	1
UN232R-32	0,5	0
Viborg	0	0
Vinterhvede-Popkorn nr 1	4,3	3,7

Appendix 4. Spring wheat - Table with results from the VCU testing at Tystoftefonden (Sortsforsøg Korn, bælgsæd og olieplanter, 2016).

OBSERVATIONSPARCELLER

VÅRHVEDE	MODNINGS-DATO	STRÅ-LÆNGDE (CM)	PROCENT DÆKNING			RESISTENS MOD HAVRENEMATODER[4]	
			MELDUG	GULRUST	SEPTORIA	RACE I	RACE II
Antal forsøg	*3*	*7*	*7*	*6*	*10*		
AC Vista *	13/8	76	45	4.3	5	m	m
Alondra	15/8	69	0.06	4.5	7	-	-
Amantis	15/8	81	4.1	0.5	10	m	m
Cornetto	18/8	77	0.5	16	4.4	-	-
Dafne	16/8	79	1.6	0.1	8	-	-
Happy	15/8	85	0	9	7		
Harenda	19/8	81	0.9	0.06	6		
Healey	16/8	80	1.0	3.3	16		
KWS Bittern	16/8	80	0.8	0.6	11	-	-
KWS Chilham	19/8	75	0.05	0.4	6	-	-
KWS Willow	19/8	78	0.3	0.2	12	-	-
Trappe	20/8	79	1.9	13	5	m	m
KWS W332	17/8	76	0.08	0.01	8		
STRU 093734s7	16/8	76	0.9	0.01	11	m	m
Vårhvede-Popkorn nr. 1	19/8	100	3.1	6	3.5	m	m

* Afmeldt dansk sortsliste

Appendix 5. Spring wheat - Table with results from the Supplementary test of yellow rust susceptibility (smitteforsøg) performed at Aarhus University, Flakkebjerg (Sortsforsøg Korn, bælgsæd og olieplanter, 2016).

SMITTEFORSØG, GULRUST

Resultater fra markforsøg med sorter af vårhvede. Procent dækning af gulrust på de 3-4 øverste blade efter smitte med en variant af Warrior smitteracen. Tallene er et gennemsnit over tre gentagelser og tre bedømmelsestidspunkter i juni-juli. Kilde: Aarhus Universitet, Flakkebjerg 2015.

VÅRHVEDE	KRANICH	TRITICALE2015
AC Vista (kontrol)	15	16,1
Trappe (Kontrol)	2,9	4,2
Avocet S (Kontrol)	57,5	59,7
Alondra	0,9	0,4
Amantis	0,1	0,1
Cornetto	1,7	1,8
Dafne	1	0,2
Happy	1,3	2,6
Harenda	0	0
Healey	2,6	1,2
KWS Bittern	2,3	2
KWS Chilham	0,1	0
KWS W332	0,1	0
KWS Willow	0,8	0,6
Purpur Vårhvede-Popkorn nr. 1	4,5	3,8
STRU 093734s7	0	0
Vårhvede-Popkorn nr. 1	5,2	4,2

Appendix 6. BEK nr 1710 af 20/12/2016 § 40- § 50 - ***Tidsbegrænset forsøg med produktion og handel med populationer***

§ 40. Nøgen havre, alm. havre, purhavre, alm. byg, alm. hvede, durumhvede, spelt og majs, må i en forsøgsperiode indtil 31. december 2017 produceres og handles som populationer efter bestemmelserne i §§ 40-50.

Stk. 2. Ved »populationer« forstås her bestande af planter, der opfylder følgende krav:

1) De stammer fra en given kombination af genotyper.

2) De betragtes som enheder for så vidt angår deres egnethed til at blive reproduceret uforandret, når de er etableret i en given produktionsregion med specifikke agroklimatiske forhold.

Stk. 3. Populationer kan frembringes ved hjælp af en af følgende teknikker:

1) Krydsning af fem eller flere sorter i alle kombinationer efterfulgt af samling af afkommet og udsættelse af materialet for naturlig udvælgelse i flere generationer.

2) Fælles dyrkning af mindst fem sorter af en overvejende fremmedbestøvende art, samling af afkommet, gentagen nysåning og udsættelse af materialet for naturlig udvælgelse, indtil der ikke er flere planter af de oprindelige sorter til stede.

3) Krydsning af fem eller flere sorter ved hjælp af krydsningsprotokoller, der afviger fra protokollerne i nr. 1 eller 2, med henblik på at producere en tilsvarende forskelligartet population, der ikke indeholder sorter.

Stk. 4. En population skal kunne identificeres på grundlag af

1) de sorter, der indgår i krydsningen til frembringelse af populationen,

2) de forædlingsprogrammer, der er defineret i de respektive protokoller,

3) produktionsområde,

4) graden af heterogenitet, navnlig i selvbestøvende arter, og

5) dens karakteristika, jf. § 41, stk. 2, nr. 6.

§ 41. Populationer skal godkendes af TystofteFonden.

Stk. 2. Ansøgning om godkendelse skal indgives til TystofteFonden og skal omfatte:

1) Ansøgers navn og adresse.

2) Art og betegnelse for populationen.

3) En beskrivelse af den type teknik, der anvendes til at frembringe populationen, med henvisning til § 40, stk. 3, hvis det er relevant.

4) Forædlingsprogrammets målsætninger.

5) Forædlings- og produktionsmetode, det vil sige forædlingsprogram, som defineret i de respektive protokoller, sorter, der anvendes til at forædle og producere populationen, samt virksomhedens produktionskontrolprogram.

6) En beskrivelse af populationens karakteristika, som, ansøgeren mener, er vigtige med hensyn til udbytte, kvalitet, ydeevne, egnethed for systemer med lavt input, modstandsdygtighed over for sygdomme, udbyttestabilitet, smag og farve.

7) Forsøgsresultater vedrørende de i nr. 6 nævnte karakteristika.

8) Produktionsområde.

9) En erklæring fra ansøgeren om korrektheden af de elementer, der er omhandlet i nr. 1-7.

10) En repræsentativ prøve af populationen.

11) Navn og adresse på den person, der er ansvarlig for forædling, produktion og vedligeholdelse.

Stk. 3. Ansøgning om godkendelse af vårsæd skal indgives årligt senest den 1. november, og ansøgning om godkendelse af vintersæd skal indgives årligt senest den 1. maj, jf. stk. 2.

Stk. 4. Ansøgninger bedømmes ud fra at sikre en ligelig repræsentation af arter og virksomheder inden for forsøgets ramme.

Stk. 5. Ansøgers forslag til betegnelse, jf. stk. 2, nr. 2, godkendes efter § 2 i bekendtgørelse om plantesortsnavne. Ordet »population« skal tilføjes i slutningen af hver betegnelse.

§ 42. Et parti af en population må sælges som »population« uden forudgående officiel godkendelse.

Stk. 2. Partiet skal overholde avlsnormerne i bilag 3, del I, afsnit A og afsnit C, nr. 2.

Stk. 3. Partiet skal overholde EU-kvalitetsnormerne, som nævnt i bilag 5, del I-IV og del VI, til certificering af »certificeret sædekorn 1. generation« for majs, og af »certificeret sædekorn 2. generation« for andre arter end majs, samt normerne vedrørende flyvehavre, gold havre og gold hejre.

Stk. 4. Partiet skal være tilstrækkelig ensartet, og partiets vægt må ikke overstige vægtgrænserne i § 10, stk. 2.

§ 43. Populationer må kun bringes i handel i lukkede pakninger eller beholdere og skal være forseglet således, at forseglingen ødelægges ved åbning og ikke kan anvendes igen. Pakningen skal være mærket efter bestemmelserne i bilag 12, del II.

§ 44. Virksomheden skal foranledige, at der udtages en prøve af partiet til undersøgelse af, om partiet overholder EU-kvalitetsnormerne, jf. § 42, stk. 3. Prøven udtages og undersøges af virksomheden. Virksomheden kan anmode TystofteFonden om at udtage prøven. Omkostningerne til prøvetagning og analyse afholdes af virksomheden.

Stk. 2. Prøven skal udtages efter bestemmelserne i TystofteFondens instruks i prøvetagning af frø og skal undersøges i overensstemmelse med gældende internationale metoder og TystofteFondens anvisninger.

Stk. 3. Virksomheden skal, efter anmodning fra TystofteFonden, fremsende kopi af analysebeviset. Prøven skal opbevares i mindst to år til brug for eventuel kontrol.

Stk. 4. Virksomhederne skal senest 14 dage efter lukning af et parti af en population, anmelde det til TystofteFonden med oplysning om art, sort, mængde, referencenummer og datoen for lukning af partiet. Datoen for lukning af partiet må ikke være senere end datoen for den seneste undersøgelse af partiet for spireevne.

§ 45. Virksomheder, der producerer populationer, skal, inden begyndelsen af hver produktionssæson, indberette oplysninger om størrelsen og beliggenheden af produktionsarealet, samt den mængde korn, der forventes at kunne blive bragt i handel, til TystofteFonden. Indberetningen skal indgives senest 1. januar for vårafgrøder og senest 1. juli for vinterafgrøder.

Stk. 2. TystofteFonden meddeler, på grundlag af de i stk. 1 anførte indberetninger, den mængde udsæd af populationen, virksomheden må bringe i handel i den efterfølgende sæson. Den samlede mængde udsæd, der bringes i handel, må ikke overstige det i bilag 12, del I, anførte.

Stk. 3. Ansøgninger bedømmes ud fra at sikre en ligelig repræsentation af arter og virksomheder indenfor de givne mængdebegrænsninger, jf. stk. 2, ansøgningens rettidighed og forsøgets tilskudsramme.

§ 46. En virksomhed, der bringer sædekorn af populationer i handelen, skal

1) sikre, at de pågældende partier kan spores, og

2) opbevare oplysninger, der gør det muligt at identificere de personer, der har leveret dem, og til hvem de har leveret sædekorn af en population.

Stk. 2. Oplysningerne skal efter anmodning stilles til rådighed for TystofteFonden.

§ 47. Forædlere, producenter og personer med ansvar for vedligeholdelse af populationer, skal være registreret ved TystofteFonden. Ansøgning om optagelse i registeret skal indgives til TystofteFonden og skal omfatte:

1) Navn, adresse og kontaktoplysninger.

2) Betegnelse for den pågældende population.

§ 48. Den person, der er ansvarlig for vedligeholdelse af populationen, skal

1) vedligeholde populationen i hele forsøgsperioden, vedligeholdelsen skal være i overensstemmelse med accepteret praksis for den pågældende art, og

2) føre fortegnelser vedrørende vedligeholdelsen af populationerne.

Stk. 2. Oplysningerne i stk. 1, nr. 2 skal efter anmodning stilles til rådighed for TystofteFonden.

§ 49. TystofteFonden kontrollerer, om partiet overholder § 40, stk. 3, for så vidt angår identitet, og § 42, stk. 3, for så vidt angår kvalitet.

§ 50. Virksomhederne skal senest den 1. september indberette, hvilken mængde sædekorn af hver population, der er bragt i handelen i den afsluttede produktionssæson.

Stk. 2. Indberetningen skal indeholde de i bilag 12, del III, anførte oplysninger.