Deep Phenotypic Evaluation of a Worldwide Bread Wheat Core Collection

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Objective and Background

The objective was to evaluate for important traits, the available genetic diversity of the core collection of 372 accessions (372CC), selected by Balfourier et al. (2007) on passport and SSR marker data, to see whether it was suitable for conduct association genetic studies. The 372CC accessions are both landraces from the 19th century and cultivars from the beginning to the end of the 20th century originating from 70 different countries. The agronomic and quality traits assessed during the vegetative period, on grain and on wholmealflour were: date of ear emergence, date of flowering, lodging, disease susceptibility, pre-harvest sprouting, thousand kernel weight, test weight, grain hardness, grain protein content, pentosan viscosity and grain colour. The rheological properties of the derived white flours were also estimated using mixograph and alveograph tests (Bordes et al 2008).

Tab 1 Mean, range and variation coefficient of some agronomic traits

	Unit	Mean	Range	CV (%)
AGRONOMIC				
Ear-emergence (Ear)	Day from January 1st	140,4	127,4 - 160,0	5,1
Flowering date (Fl)	Day from January 1st	147,1	131,4 - 166,0	5,0
Plant height (Ht)	Cm	93,7	49,0 - 150,0	22,7
Root lodging (Lodg)	Scale 1-9	4,1	1,0 - 9,0	70,9
Powdery mildew (P mild)	Scale 1-9	4,7	2,0 - 9,0	33,1
Yellow rust (Y rust)	Scale 1-9	3,5	1,0 - 9,0	72,9
Brown rust (B rust)	Scale 1-9	3	1,0 - 8,0	57,2
Septoria (Septo)	Scale 1-9	2,7	1,0 - 7,0	53,9
Pre harvest sprouting (PHS)	% germinated grains	8,5	0,0 - 61,3	141,7
GRAIN				
Kernel weight (KW)	Kg	3,2	0,9 – 5,1	27,9
Thousand-kernel weight (TKW)	grams	40,0	22,7 - 54,2	14,1
Specific weight (SW)	Kg x hl^{-1}	78,7	71,0 - 84,0	2,8
Grain protein content (Prot)	%	14,5	10,9 - 19,2	11,0
Grain hardness (Hard)	-	51,3	1,5 - 99,9	51,0
Colour L*	black (0) to white (100)	54,2	42,9 - 65,8	6,3
Colour a*	green(-) to red (+)	8,2	5,3 - 10,6	12,7
Colour b*	blue (-) to yellow (+)	26,3	19,0 - 32,8	9,0
Viscosity useful potential (Visc)	See text	2,6	1,1 - 4,7	24,8
MIXOGRAPH				
Midline left value (MLV)	% Height	35,9	17,5 - 52,2	14,9
Midline left width (MLW)	% Height	26,4	12,0 - 50,5	31,3
Midline peak value (MPV)	% Height	41,8	29,2 - 61,0	12,8
Midline peak width (MPW)	% Height	19,6	10,5 - 34,6	25,4
Midline right value (MRV)	% Height	36,5	23,3 - 50,7	11,9
Midline right width (MRW)	% Height	10,9	2,1 - 28,3	40,5
Midline time x = 8 min value (MTxV)	% Height	33,4	20,5 - 46,4	12,5
Midline time x = 8 min width (MTxW)	% Height	7,3	1,6 - 21,3	61,1
Middle time x = 8 min integral (MTxI)	See text	276,0	184,1 - 379,9	11,3
Midline peak time (MPT)	Minutes	2,8	0,9 - 8,0	42,2
Weakening slope (WS)	% Height	5,4	0,3 - 13,8	53,0
ALVEOGRAPH				
Tenacity (P)	mm H_2O	57,8	22,0 - 143,0	36,9
Extensibility (L)	mm	122,3	32,0 - 269,0	33,6
Dough swelling (G)	cm^3	24,2	12,5 - 36,4	17,2
Dough strength (W)	10^{-4}J	186,2	46,0 - 652,0	52,8
Ratio P/L	mm H_2Omm^{-3}	0,55	0,14 - 3,29	67,7
Elasticity index (Ie)	See text	46,2	0,0 - 78,5	26,3

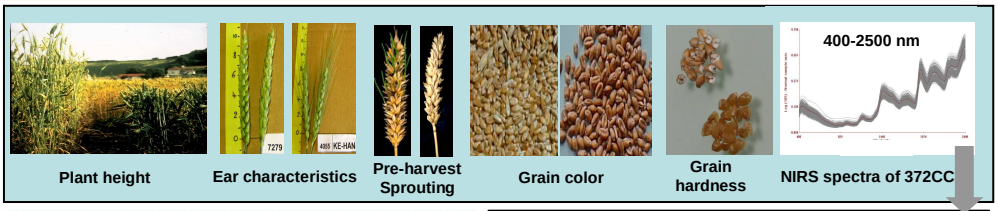
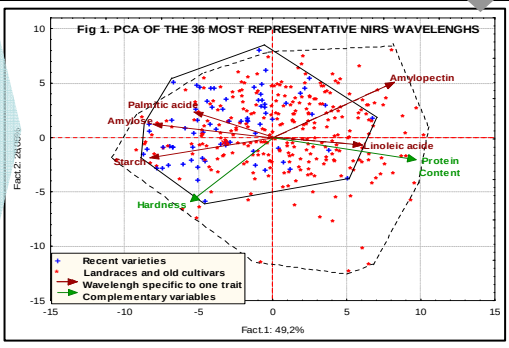
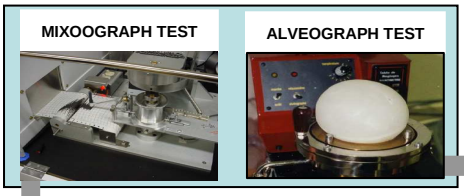
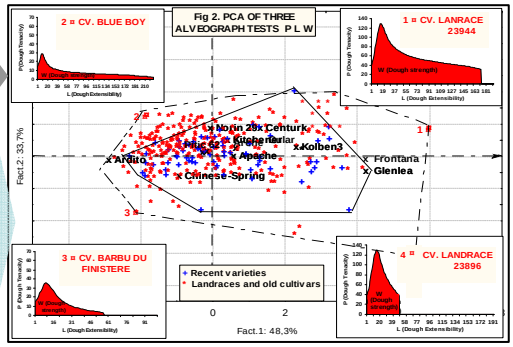


Figure 1. Dispersion of the 372CC in a Principal Component Analyse (PCA) of NIRS wavelenghs. Protein content and grain hardness are positionned as complementary variables. Wavelenghs observed in publish data as relating to certain traits are also positionned. The first axis can be explained by the protein content and by the starch content. The second axis is mainly influenced by the grain hardness. The delimited area of the modern varieties is smaller than that of the other accessions. The modern wheats tends to be poorer in protein, richer in starch, amylose and palmitic acide than the other accessions. At the opposite the landrace and old cultivars are poorer in starch and richer in protein, linoleic acide and amylopectin.







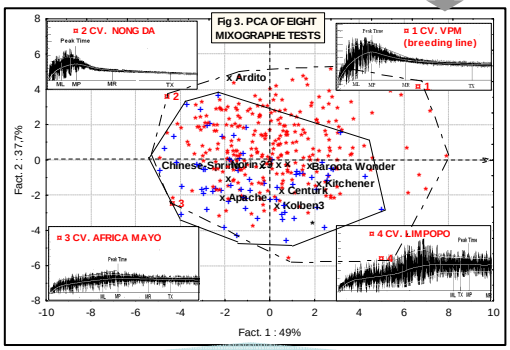


Figure 2. Dispersion of the 372CC in a PCA of the three alveograph parameters: P (tenacity), L (extensibility) and W (dough strengh). The horizontal axis is mainly explained by P (height of the curve) increasing from left to right. The vertical axis is mainly explained by L, increasing from the bottom to the top. The delimited area of the recent varieties is smaller than that of the other accessions. For bread making quality, the quality of the accessions increases from bottom-left to top-right.

Figure 3. Dispersion of the 372CC in a PCA of the eight relevant mixograph parameters (height and width of the curve). The horizontal axis is mainly explained by the height of the curve after peack time increasing from left to right. The vertical axis is partly explained by the width of the curve, increasing from the top to the bottom. The delimited area of the recent varieties is smaller than that of the other accessions. For bread making quality, the quality of the accessions increases from the left to the right.

Discussion

The large phenotypic variation for most of the traits studied (Table 1 and Figure 1 to 3) is indicative of the wide diversity of the core collection. Several parameters made it easier to discriminate between the cultivars. For example, for the alveograph tests, which are the main predictor of bread-making quality in wheat flours, the genotypes ranged from those producing very bad quality, tough and inelastic dough only suitable for animal feed, to those with excellent bread-making potential. The same results were also observed for the mixograph tests. In addition, a useful variability for important traits can be found in the landraces and old accessions illustrating the need to conserve such collections for improving grain composition. The largest ranges of variation in landraces and old cultivars rather than in more recent varieties indicates that there is sufficient variability available for those alleles which have been eliminated in breeding modern varieties. Moreover, the additional informations given by NIRS on components that were significantly different between modern varieties and old accessions, show that for certain molecular components, the whole collection has larger variations than do the modern varieties alone.

Conclusion

With this phenotypic variability of wheat "concentrated" into a subset of manageable size, the core collection, genotyped for a large set of markers (DArTs, SSRs and SNP) could thus be considered in future prospects as a very powerful tool for association genetics studies

References: Balfourier et al. (TAG, 2007); Bordes et al (JCS, 2008).

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