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Evaluation of the climatic and genetic effect on technological quality of spelt (*Triticum spelta* L.): Tuscany case study

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Introduction

Due to the high adaptability to marginal lands, the low management requirements and the high nutraceutical properties, spelt (*Triticum spelta* L.) is gaining growing interest from the market (Bonafaccia et al., 2000; Swieca et al. 2014; Wiwart et al., 2017; Andruszczak, 2018). Technological quality of spelt, especially the needs to ensure vitreousness, is the main factor affecting transformation processes (Wiwart et al., 2017). Indeed, floury structure of grains drives transformation process towards bread production. Following the growing market interest for spelt-derived pasta, vitreousness of grains is a precious characteristic. However, the lack of vitreous spelt accessions is a criticism for the production process. In addition, floury/vitreousness structures of grains is strongly affected by environment, especially precipitation and temperature, and by genotype (Turnbull and Rahman, 2002; Greffeuille et al., 2006; Chisci et al., 2010. Warechowska et al., 2016; Wiwart et al., 2017). For these reasons, the identification of spelt accession behaviours based on the climate, and the definition of which varieties ensure vitreousness regardless of environmental conditions is crucial. In this experiment, we analysed the effect of genetic and environmental conditions (precipitation and temperatures) on technological quality of 36 spelt accessions in Tuscany.

Materials and Methods

The experimentation included 36 accessions of spelt cultivated in two different locations in Tuscany: (i) Pomarance (~100m ASL) in the province of Pisa and (ii) Firenzuola (~860 m ASL) in the province of Florence. Sowing of spelt was carried out between 13th and 16th January, and harvest between 12th August and 22nd July for Firenzuola and Pomarance, respectively. Average monthly temperatures and cumulative precipitations during the growing cycle for the two locations are reported in table 1.

Table 1. Climatic information (monthly precipitations, mm, and monthly average temperatures, °C) of the two locations.

	Average monthly temperature (°C)		Cumulative precipitation (mm)	
	Firenzuola	Pomarance	Firenzuola	Pomarance
January	5.1	7.7	75.8	41.8
February	6.1	9.8	119	20.8
March	5.7	9.8	177.8	90.4
April	10.6	13.1	72.0	36.8
June	13.9	18.2	112.2	46.2
July	16.5	20.3	76.2	100.4
August	20.2	23.7	45.0	15.4

Technological quality of grains (floury/vitreousness) were determined cutting grains with scalpel and numbers of grains with floury and vitreous endosperm texture were counted in a sample of 20 elements for each accession. The visual evaluation of grain texture included three classes for technological quality assessment: (i) vitreous; (ii) floury; (iii) inhomogeneous. Vitreous grains had higher resistance to cut and showed translucent and amber colour with homogenous endosperm. Floury grains were softer than the previous and endosperm texture was white with a starchy aspect. Inhomogeneous class was referred to those grains with a non-uniform aspect with alternation of amber and white regions within the grain.

Each class has been assigned a value of 1 (floury), 2 (inhomogeneous) and 3 (vitreous). Those values were used in Eq. 1 to obtain a quality index:

$$Quality\ index = \frac{1 * X_1 + 2 * X_2 + 3 * X_3}{N} \qquad \text{Equation 1}$$

where: 1, 2, 3 were the values assigned to each class, X_1 is floury grains number, X_2 is inhomogeneous grains number, X_3 is vitreous grains number, and N was number of analysed grains (20). The quality index was calculated for each accession in order support technological quality characterization. As much as the quality index is close to 1 as much the accession is floury and vice versa; accessions with quality index close to 3 have higher vitreousness. Five different classes were defined for all values between 1 and 3 in order to classify the accession characteristics (Table 2).

Table 2. Vitreousness classes.

Classes	Range
Floury	1.0-1.4
Semi-floury	1.4-1.8
Inhomogeneous	1.8-2.2
Semi-Vitreous	2.2-2.6
Vitreous	2.6-3.0

Results

Most of the accessions, 32 out of 36, showed different quality index results between the two locations. In particular, the quality index of the same accession cultivated at Firenzuola increased from floury or semi-floury classes to higher values when cultivated at Pomarance. Thus, at Firenzuola we observed a general floury trend, while at Pomarance the predominance of quality index was oriented on the vitreous classes. This trend suggested focusing the analysis on the environmental characteristics of the two locations that were characterized by markedly different conditions. Obviously, the differences in altitude has clear effect on climatic conditions. Firenzuola was characterized by higher cumulative precipitation (roughly 85% more) and generally lower average monthly temperatures by 4-5°C during the entire growing season. From these results, we concluded that cool and rainy climate favours the floury structure of grains. On the other hand, hot climate with limited precipitations ensures the vitreousness of grains structure. Nevertheless, a genetic effect was observed on six accessions that showed a more stable quality (either floury or vitreous), with the same quality index in both locations, suggesting their adaptability to different climatic conditions.

Conclusions

The identification of quality index based on climatic conditions provided informative results to improve the spelt production chain. Knowing the accession behaviour and local climatic conditions, farmers can select accessions based on market needs and trends (e.g. pasta or bread/biscuits production). However, a strong limitation of this work is the lack of data on soil, that probably has some effects on spelt quality.

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