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WHEAT GRAIN SIZE AND DIMENSIONS IN CONTRASTING ENVIRONMENTS OF EASTERN AND WESTERN EUROPE

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ABSTRACT

We compared grain weight and dimensions, measured in a warmer temperate continental climate at Fundulea (Romania) in four wheat cultivars, with published data on the same cultivars, measured in the cooler temperate maritime climate of England. The weight of thousand grains (TGW) was on average smaller by 23.6% in the Romanian location, as compared with the Western Europe location. The response of the studied components of TGW to the two contrasting environments was different: grain length showed the lowest reduction in the warmer environment (on average by 11.1%), while grain width was smaller by 16.9%, and grain projection area by 27.4%. The reductions in grain dimensions were partially compensated by an average increase of 4% of the Factor describing the differences in grain density and/or deviation from a cylindrical form.

The reduction of kernel weight, most probably due to higher temperatures during grain filling, could explain an important part of the known wheat yield difference between Eastern and Western Europe. Differences were noticed among cultivars in the reduction of TGW and grain dimensions, suggesting possibilities of breeding to minimize the effects of higher temperatures during grain filling.

Key words: grains size, high temperatures, wheat, grains filling.

INTRODUCTION

Grain yield is the product of various yield components, including the number of spikes per unit area, grain number per spike and grain weight, often expressed as weight of thousand grains (TGW). Larger grains have favourable effects on milling quality of wheat, but also on seedling vigour and early growth, thereby favouring yield stability. TGW is mainly determined by grain length (GL), grain width (GW), and grain thickness (GT) (Campbell et al., 1999; Dholakia et al., 2003), but also by the grain shape and density. All these traits are positively correlated with TGW (Breseghello and Sorrells, 2006; Sun et al., 2009), the strength of the correlations depending on genotypes and environment.

TGW is considered to be less influenced by environment than the other yield components, such as number of spikes per unit area or grain number per spike (Racz et al., 2015), but is nevertheless very much dependent on temperatures during grain filling (Sofield et al., 1977; Wiegand and Cuellar, 1981; Zahedi and Jenner, 2003). However, few reports that studied the effect of environment on TGW, also studied the environmental influence on the grain dimensions that determine TGW. Our aim was to analyse the response of the grain traits that determine TGW to widely different environments of two locations, representatives of Eastern and Western Europe.

MATHERIAL AND METHODS

Gegas et al. (2010), in their comprehensive analysis of the genetic framework for grain size and shape variation in wheat, published data on TGW and its components in a large number of wheat cultivars. Information about the methods used can be found in this publication. Four of the cultivars analysed by Gegas et al. (2010), namely Capo, Soissons, Cezanne and Renan, were also tested in Fundulea, Romania, during 2014-2015 and 2015-2016 seasons. TGW was determined from the average weight of two samples of 250 grains each. Grain length, grain width, and grain projection area were determined by image

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analysis,using the program ImageJ (http://imagej.nih.gov/ij/). To take into account the differences in grain density and the deviation of a shape from a cylindrical form we calculated a Factor Form Density using the formula: grain weight/ (grain length * grain width) (Giura and Saulescu, 1996).

RESULTS AND DISCUSSION

As seen in Table 1, TGW was on average smaller by 23.6% in the Romanian location, as compared with the data of Gegas et al. (2010), measured in Western Europe.

The response of the studied components of TGW to the two contrasting environments was different. Grain length showed the lowest reduction in the warmer environment (on average by 11.1%), while grain width was smaller by 16.9%, and grain projection area by 27.4%. This is in agreement with the fact that grain length is the first trait to stabilize after anthesis (Hasan et al., 2011), being less exposed to the increasingly higher temperatures of the Eastern European location during grain filling. This would suggest that breeding for increased grain length could improve the stability of grain weight.

Interestingly, the reductions in grain dimensions were partially compensated by an average increase of 4% of the Factor describing the differences in grain density and/or deviation from a cylindrical form.

Differences among the cultivars in the amount of TGW and grain dimensions reduction in the Eastern European location were noticed. The most affected was Renan for all grain traits, while the least affected was Soissons for TGW, grain width, grain projection area and the factor form-density, and Capo for grain length (Table 1). Part of this differential cultivar behaviour could be due to earliness differences, but other cultivar traits could also be involved.

Table 1. Grain weight and its components in two contrasting locations of Western and Eastern Europe

Trait	Location	Cultivar								All cultivars average	
		Renan		Cezanne		Capo		Soissons			
			%		%		%		%		%
TGW (g)	England*	57.83	100	50.09	100	49.33	100	48.95	100	51.55	100
	Romania	39.35	**68.0**	36.80	**73.5**	40.15	**81.4**	41.15	**84.1**	39.36	**76.36**
Grain length (mm)	England	8.0	100	7.2	100	7.2	100	7.2	100	7.40	100
	Romania	6.9	**86.0**	6.2	**86.7**	6.9	**95.4**	6.3	**87.0**	6.57	**88.85**
Grain width (mm)	England	4.1	100	4.1	100	3.9	100	3.9	100	4.00	100
	Romania	3.2	**77.7**	3.4	**82.2**	3.2	**82.8**	3.5	**89.3**	3.32	**83.12**
Grain projection area (mm^2)	England	25.9	100	23.7	100	22.9	100	22.3	100	23.70	100
	Romania	17.3	**66.8**	16.7	**70.6**	17.5	**76.6**	17.3	**77.7**	17.20	**72.57**
Factor form-density	England	1.76	100	1.70	100	1.76	100	1.74	100	1.74	100
	Romania	1.80	**102.1**	1.75	**102.9**	1.82	**103.5**	1.87	**107.1**	1.81	**104.0**

* Data for England are from Gegas et al. (2010).

Much of the reduction in grain traits could be explained by higher temperatures of Eastern Europe during the grain filling. Wiegand and Cuellar (1981) reported that kernel decreased by up to 2.8 mg per kernel for each degree C increase in temperature. High temperatures reduce grain weight predominantly through shortening the duration of grain filling (Sofield et al., 1977), each 1°C increase in mean temperature decreasing the duration of grain filling by about 3 days (Wiegand & Cuellar, 1981).

Weather data corresponding to the data on grain traits published by Gegas et al. (2010) were not available to us, so instead we used public data (Met Office, 2012, cited from https://en.wikipedia.org). Same source was also used for average weather data in South Roamania. The overall climate in England is described as temperate maritime, and this means temperatures not much higher than 32°C in summer, with a summer average maximum temperature of about 20.1°C, while in South Romania climate is temperate continental, with summers generally warm to hot, the average maxima being around 29 °C, and frequent temperatures over 35 °C.

During the grain filling period, which takes place roughly in June-July in England and May-June in South Romania, maximum temperatures are on average about 6°C higher in Romania, while average minimum temperatures are no so different (Table 2). Of course, besides temperatures, differences in water availability between the two locations could have also played a role.

Table 2. Average maximum and minimum temperatures during the monthsof wheat grain filling in England and South Romania

Specification	Country	May	June	July
Average maximum temperature, °C	England	15.8	**18.6**	**20.9**
	Romania	**24.0**	**27.7**	29.8
Average minimum temperature, °C	England	6.7	**9.5**	**11.7**
	Romania	**9.6**	**13.6**	15.4

Data cited from https://en.wikipedia.org

CONCLUSIONS

Grain weight and size of some wheat cultivars grown in Fundulea – Romania was much smaller, as compared to published data on the same cultivars grown in England. The reduction of grain weight (16 to 32% depending on cultivar) was related to a reduction of grain projection area (22 to 33%), which was mainly due to smaller grain width (11 to 22%), and less to reduced grain length (5 to 14%). The reduction of grain dimensions was partially compensated by an improvement of grain density and/or form (2 to 7%).

The reduction of grain weight and size seems to be a consequence of higher temperatures during grain filling, and could explain an important part of the known wheat yield difference between Eastern and Western Europe. Our observations suggest possibilities of breeding to reduce the effect of higher temperatures during grain filling and increase the stability of grain weight, in order to face future climate changes.

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REFERENCES

Breseghello, F., and Sorrells, M.E., 2006. *Association Mapping of Kernel Size and Milling Quality in Wheat (Triticum aestivum L.) Cultivars.* Genetics, 172(2): 1165-1177.

Campbell, K.G., Bergman, C.J., Gualberto, D.G., Anderson, J.A., Giroux, M.J., Hareland, G., Fulcher, R.G., Sorrells, M.E. and Finney, P.L., 1999. *Quantitative Trait Loci Associated with Kernel Traits in a Soft x Hard Wheat Cross*. Crop Sci., 39: 1184-1195.

Dholakia, B.B., Ammiraju, J.S.S., Singh, H., Lagu, M.D., Röder, M.S., Rao, V.S., Dhaliwal, H.S., Ranjekar, P.K., Gupta, V.S., and Weber, W.E., 2003. *Molecular marker analysis of kernel size and shape in bread wheat*. Plant Breeding, 122(5): 392-395.

Gagas, V.C., Nazari, A., Griffiths, S., Simmonds, J., Fish, L., Orford, S., Sayers, L., Doonan, J.H., and Snape, J.W., 2010. *A Genetic Framework for Grain Size and Shape Variation in Wheat*. The Plant Cell, 22: 1046-1056, Supplemental Table 9.

Giura, A. and Saulescu, N.N., 1996. *Chromosomal location of genes controlling grain size in a large grained selection of wheat (Triticum aestivum L.).* Euphytica, 89: 77-80.

Hasan, A.K., Herrera, J., Lizana, C., Calderini, D.F., 2011. *Carpel weight, grain length and stabilized grain water content are physiological drivers of grain weight determination of wheat.* Field Crops Research, 123(3): 241-247.

Racz, I., Kadar, R., Vasile Moldovan, V., Haş, I., 2015. *Performance and stability of grain yield and yield components in some winter wheat varieties*. Romanian Agricultural Research, 32: 11-18.

Sofield I., Evans, LT., Cook, M.G. and Wardlaw, I.F., 1977. *Factors Influencing the Rate and Duration of Grain Filling in Wheat*. Australian Journal of Plant Physiology, 4(5): 785-797.

Sun, X.Y., Wu, K., Zhao, Y., Kong, F.M., Han, G.Z., Jiang, H.M., Huang, X.J., Li, R.J., Wang, H.G., Li, S.S., 2009. *QTL analysis of kernel shape and weight using recombinant inbred lines in wheat.* Euphytica, 165: 615.

Wiegand, C.L., and Cuellar., J.A., 1981. *Duration of Grain Filling and Kernel Weight of Wheat as Affected by Temperature.* Crop Sci., 21: 95-101. DOI:10.2135/cropsci1981.0011183X001100010027x

Zahedi, M. and Jenner, C., 2003. *Analysis of effects in wheat of high temperature on grain filling attributes estimated from mathematical models of grain filling*. Journal of Agricultural Science, 141(2): 203-212.

http://imagej.nih.gov/ij/. *Java image processing program.* National Institute of Mental Health. Bethesda. Maryland, USA. (last accessed 14.04.2016).

https://en.wikipedia.org. (last accessed 6.10.2017).