

CONTENT OF MACRO- AND MICROELEMENTS IN A COLLECTION OF DURUM WHEAT CULTIVARS

DBM Ficco, C Riefolo, G Nicastro, AM Di Gesù, R Beleggia, V De Simone, V Menga, L Cattivelli, P De Vita*
CRA - Centre for Cereal Research, S.S. 16 km 675 - 71100 Foggia (Italy); *pasquale.devita@entecra.it



The objectives of this study were to: i) determine the variability in grain mineral cations (Ca, K, Mg, Mn, Na, Cu, Zn and Fe) and inorganic phosphorous (Pi) concentrations in a collection of durum wheat (*Triticum durum* Desf.) genotypes representative of old and modern germplasm adapted to the Mediterranean conditions; ii) estimate the magnitude of genotype x environment interaction effects; and (iii) examine the interrelationships among mineral concentrations in durum wheat.

Table 1. Genotypes included in the study and grouped in old, modern and advanced

“Old” Varietà rilasciate tra il 1900-1973

Aziziah, Cannizzara, Capeti8, Cappelli, Grifoni235, Matarese, Russello, Taganrog, Timilia, Trinakria.

“Modern” Varietà a taglia ridotta rilasciate tra il 1974 e il 2000

Adamello, Arcobaleno, Bradano, Brindur, Bronte, Ciccio, Cirillo, Claudio, Colorado, Colosseo, Cosmodur, Creso, Duilio, Dupri, Fortore, Gargano, Gianni, Giotto, Giusto, Grazia, Iride, Italo, Karel, Latino, Lesina, Marco, Matarrese, Messapia, Nefer, Neodur, Ofanto, Parsifal, Platani, Polesine, Preco, Primadur, Produora, Quadrato, Radio, Rusticano, S.Carlo, Saadi, Sansone, Simeto, Solex, Svevo, Tiziana, Torrebianca, Tresor, Valforte, Valgerardo, Valnova, Varano, Verdi, Vesuvio, Vetroud, Vitromax, Zenit.

“Advanced” Linee in avanzata fase di selezione

5BIL-28, 5BIL-46, 5BIL-85, 5BIL-90, CTA432, CTA440, CTA478, CTA491, CTA503, CTA529, L102, L29, L38, L83, L89, L91, L95.

Results and Discussion

Variability in GY and mineral concentrations

Table 2 presents the descriptive statistics for the traits evaluated from 84 durum wheat cultivars ranked in three group, as reported in Table 1, and cultivated under the same environmental conditions. Within the genotypes tested, there was about two-fold differences in Fe, Zn, Mn, suggesting for these elements some genetic potential to increase the concentrations of these elements in durum wheat grains.

Genotype x environment interactions

The differences in the expression of the traits considered were, for about 50%, due to G x E interaction with a very small effect of E on total variance (ranged from 4 to 23% for Zn and Cu, respectively) and a considerable influence of G on the phenotypic values observed. This implies that for Fe, Zn, Cu, Mg, Ca more than Na, Mn and K the rankings of durum wheat genotypes were influenced by environment. Moreover, comparing the best Fe genotypes with the best Zn genotypes for durum wheat there were two genotypes in common (Italo and L89) indicating a relationship between gain Fe and Zn concentration. Although breeding activity for Fe and Zn would be difficult because G x E interactions are more prevalent for these two minerals the evaluation of large germplasm collection could guarantee the achievement of this objective.

Correlations of mineral elements with grain yield and kernel weight

Higher GY and TKW tended to be associated with a general decrease in concentration of mineral element even if the relationship was statistically significant only for GY suggesting that among the genotypes evaluated there was not a direct influence of the seed weight on the mineral concentrations. Different authors have already mentioned a negative correlation between yield and grain mineral concentrations (Oury et al., 2006). Fortunately, the Pi concentration also decreases (-0.31**) confirming the previous experiences (Liu et al., 2006) and the overall effect on the bioavailability of Fe and other microelements is therefore difficult to predict (**Table 3**).

Particularly interesting appeared the highly significant and positive correlation between Zn and Pi (0.40***), Ca (0.63***), Cu (0.28*), Fe (0.49***), Mg (0.76***) and Mn (0.44***) suggesting that some genetic factors for different minerals are co-segregating, and that selection for one element (for example, Zn) will in fact result in an increase in other element (such as Fe, Mg and Mn).

Table 2. Grain yield (GY), thousand kernel weight (TKW) and mineral concentrations in 3 groups of durum wheat cultivars grown in Italy.

	Old (n=10)			Modern (n=57)			Advanced (n=17)		
	Media	Range	CV %	Media	Range	CV %	Media	Range	CV %
GY (t/ha)	4.09	3.67-4.55	8.4	5.21	3.56-5.86	7.9	5.45	5.03-6.26	6.0
TKW (g)	43.7	35.0-48.9	10.6	45.1	35.8-53.0	8.3	46.2	39.0-50.8	7.6
Pi (mg/g)	0.62	0.48-0.69	9.9	0.59	0.47-0.76	9.1	0.55	0.46-0.66	9.4
Ca (mg/kg)	507	415-619	12.1	488	406-639	10.0	470	388-640	13
Cu (mg/kg)	7.4	5.9-10.4	19.7	7.5	5.8-14.0	18.4	7.1	6.0-9.6	12.4
Fe (mg/kg)	46.6	41.6-60.6	12.3	43.3	33.6-65.6	13.5	42.5	36.6-51.3	10.1
K (mg/kg)	4420	4061-5023	6.6	4772	4087-5274	4.7	4587	4062-5208	7.1
Mg (mg/kg)	1337	1248-1535	6.5	1171	1056-1417	5.7	1169	1056-1481	8.9
Mn (mg/kg)	49.3	43.0-57.8	8.8	47.8	41.3-57.4	7.8	47.7	42.9-59.8	9.0
Na (mg/kg)	29.4	21.6-36.9	17.3	26.1	19.2-37.7	14.0	26.6	21.6-33.8	16.7
Zn (mg/kg)	36.4	33.7-41.4	6.3	33.9	28.5-46.3	8.3	32.7	29.1-40.9	8.7

Table 3. Pearson correlation coefficients among GY, TKW, Pi, Ca, Cu, Fe, K, Mg, Mn, Na and Zn of 84 durum wheat genotypes across 3 environments in Italy.

	GY	TKW	Pi	Ca	Cu	Fe	K	Mg	Mn	Na	Zn
GY	1.00										
TKW	0.39***	1.00									
Pi	-0.31**	-0.27*	1.00								
Ca	-0.24*	-0.16ns	0.33**	1.00							
Cu	-0.06ns	-0.06ns	-0.01ns	0.33**	1.00						
Fe	-0.19ns	0.16ns	0.20ns	0.28*	0.08ns	1.00					
K	0.08ns	-0.12ns	0.03ns	0.06ns	0.07ns	-0.18ns	1.00				
Mg	-0.53***	-0.10ns	0.16ns	0.54***	0.35***	0.44***	-0.23*	1.00			
Mn	-0.15ns	-0.16ns	0.03ns	0.27*	0.19ns	0.25*	-0.13ns	0.52***	1.00		
Na	-0.37***	-0.02ns	0.19ns	0.10ns	-0.11ns	0.15ns	-0.02ns	0.16ns	0.00ns	1.00	
Zn	-0.41***	-0.08ns	0.40***	0.63***	0.28*	0.49***	-0.06ns	0.76***	0.44***	0.18ns	1.00

* P<0.05; ** P<0.01; *** P<0.001; ns = not significant.

Conclusions

In our search for genetic material with high mineral content in durum wheat grains we have identified genotypes with high Fe and Zn concentrations. A positive correlation has been found between Fe and Zn concentration in the grain of durum wheat, suggesting that these two traits may be combined relatively easily during breeding. However the complexity of the inheritance of grain mineral concentration plus the large environment and G x E interaction effects, slow progress in the genetic analysis of these traits.

Acknowledgments

This research was supported by the European Commission (VI Framework program) with the project **DEVELONUTRI** "Development of High Throughput Approaches to Optimise the Nutritional Value of Crops and Crop-based foods" and by the Italian Ministry of Educational, University and Research (MIUR) with the project **AGROGEN** (Laboratorio di GENOMICA per caratteri di importanza AGROnomica in frumento duro: identificazione di geni utili, analisi funzionale e selezione assistita con marcatori molecolari per lo sviluppo della filiera sementiera nazionale).