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Progress in yield components and yield potential in bread wheat and durum wheat genotypes

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SUMMARY – During the 45 years of wheat selection in the 80 year-old Cereal Research Non-profit Co. (CRNC) the bread and durum wheat varieties' grain yields increased significantly. The demands (high grain yield, bread and pasta making quality, higher agronomical claims, tolerance for biotic and abiotic stresses, etc.) marked new priorities for breeding as both the economical and ecological environment changed. In this work the structure and most important components of genetical advance were studied and the answers were tried to find, that as the grain yields increased significantly, how the main yield components changed, and the changes of which characters affected significantly the tolerance to stresses, grain yield, biological yield capacity, and harvest index (HI).

Introduction

The yields of winter wheat in Hungary progressively increased from the end of Second World War similarly to other European countries (Canevara *et al.*, 1994; Shearman *et al.*, 2005). Comparison of old and new varieties have been carried out in many countries (Balla *et al.*, 1986; Shearman *et al.*, 2005) to investigate the main sources and compounds of the increase.

Materials and methods

Under low and high input conditions 70 genotypes of winter type bread and durum wheat were tested in two consecutive years. Low input treatment means a lower rate of fertilizing (70 + 70 + 70 kg NPK active ingredients per hectare) with no protection to leaf diseases, while high input modeled the conventional wheat technology followed by most farmers in the country, adding plus 120 kg nitrogen fertilizer and two fungicide treatments against diseases. In the four replicated field trials the plot sizes were 6.5 m^2 in both years. Among the 70 varieties [62 bread wheats (*Triticum aestivum* L.) and 8 durum wheats (*Triticum durum* Desf.)] besides the latest genotypes, all the CRNC-bred varieties were represented which had a significant success in history of Hungarian wheat production and some old genotypes which remarkably affected our breeding work. The seeds of all the genotypes were taken from our genotype collection and were multiplied in the previous year under uniform conditions. To compare the performance of the varieties from the different decades of the twentieth and twenty first centuries, five variety groups were formed with different numbers of entries: (i) "old" varieties which were registered before 1970; (ii) varieties from the seventies; (iii) varieties from the eighties; (iv) varieties from the nineties; and (v) "modern" or latest genotypes.

Results and discussion

Ought to the very different weather conditions of the two years in the field trials a favorable opportunity has been offered to compare the genotypes from the point of view of their high input utilization and ability to cope with weather anomalies.

Because of the extremely cold winter in 2002/2003, followed by serious drought conditions wheat plants could not employ profitably the high inputs, and practically no differences were found between the two treatments in yield, yield components biological yield or HI. In the hot and dry summer of 2003 the cumulated heat amount was significantly higher than the 30 years average and precipitation during the growing period did not reach the half of the long term average or one third of the next year's amount (Figs 1 and 2). Contrast with the previous year the 2003/2004 wheat season was close to optimal at our locations. Due to these stress-free weather conditions we could measure much higher grain yields than the long term averages. In this year the high input treatments caused a significant increase in grain yield and in yield components. On the average of the 70 genotypes the high input treatment caused 860 kg/ha (12.6%) increase in grain yield. The ample precipitation exercised much stronger effect on the yields; the average grain yield from 3.13 t/ha raised up to 7.58 t/ha which means a 142% increase (Fig. 3). Among the varieties we found high differences in yielding ability, general adaptability, stability in yield, and stability of technological quality too. Variety groups which were grown in the different ages remarkably differed in yield capacity, yield components, disease resistance and technological quality too.

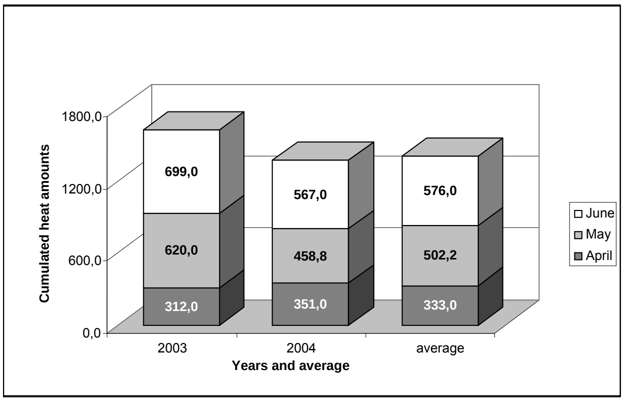


Fig. 1. The cumulated heat amounts in 2003 and 2004 and the long term average.

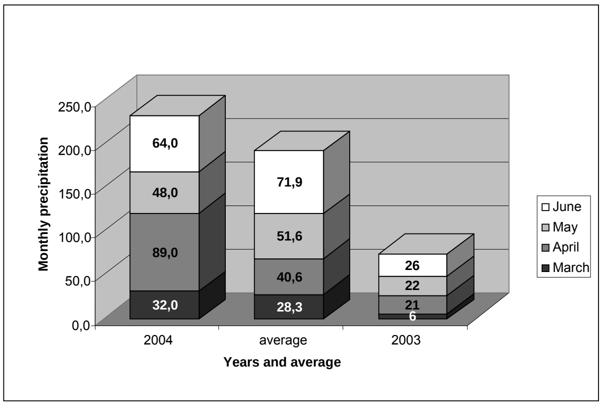


Fig. 2. Monthly precipitation data (Szeged, 2003, 2004 and average).

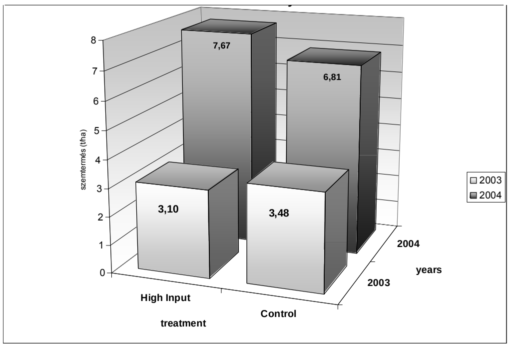


Fig. 3. Changes in grain yield of different wheat genotipes due to the treatmeants and years.

If we separate yield changes of the durum wheat varieties – which were thinned by the long and serious winter of 2002/2003 year, the bread wheat growth in yield was 127% while 300% in case of durum wheat. Spike number/m^2 data also shows the same tendency: while average bread wheat spike number increased from 310 to 447, in case of durum wheat from 139 to 447 (44% and 193% increase respectively). Besides head number, also significantly changed seed number per ear (33%) thousand kernel mass (21%) and grain yield per ear (26%) too.

By all means not only the grain yield components, but plant height and biological yield increased significantly as well. While the grand average of plant height was 56.6 cm in 2003 this value reached 98.3 cm in 2004. It means that plant height increased by 66.5% due to the better weather conditions (Table 1).

Among the studied traits biological yield (dry weight of all biomass over the ground level) had the most significant increase. The average dry weight of a shoot was 66 g in 2003 this value was 181 g in 2004. It means nearly a 172% growth. Because this increase was higher than the grain yield growth, HI value decreased slightly in 2004. The average HI value was 50.4% in 2003 while 49.8% int he next year.

Table 1. Changes of some quantity traits of the 70 wheat varieties due to the different year effect (Szeged, 2003-2004)

	2003	2004
Quantity traits		
Biological yield (g)	66.6	181
Grain yield (g)	33.5	89.2
HI (%)	50.4	49.8
Grain yield/spike (g)	1.1	1.4
Thousand kernel mass (g)	37.6	45.5
Grain number/head (db)	30.0	39.9
Plant height (cm)	56.6	98.3
Quality traits		
Hardness of the grain	46.74	81.3
Protein content (%)	13.33	12.96
Wet glutain content (%)	31.91	31.72

If we compare the variety groups' performance we may make some conclusion on changes or genetic advance of yield capacities and yield components in time. According to the comparison among group averages, the modern varieties' grain yield increased materially. While the two years average yield of the old varieties' group was 3.73 t/ha, the modern varieties and genotypes from the nineties yielded 5.59 t/ha. The tendency is the very same in case of the durum varieties (Fig. 4). Similarly biological yield increased too, but since the proportion of grain weight became higher HI raised moderately (Fig. 5).

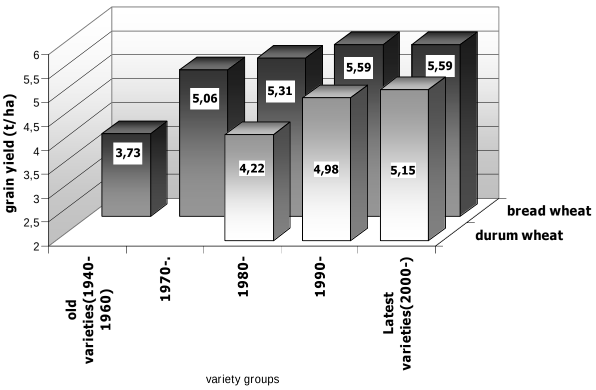


Fig. 4. Grain yield data of different variety groups of bread and durum wheat (2003-2004).

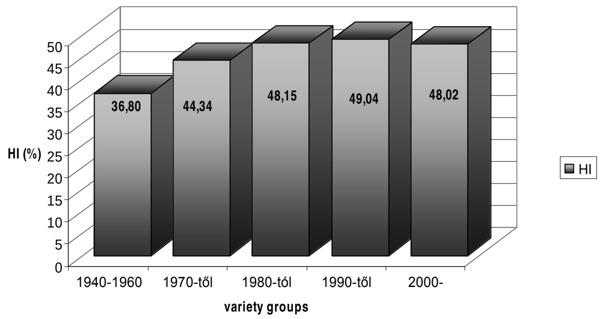
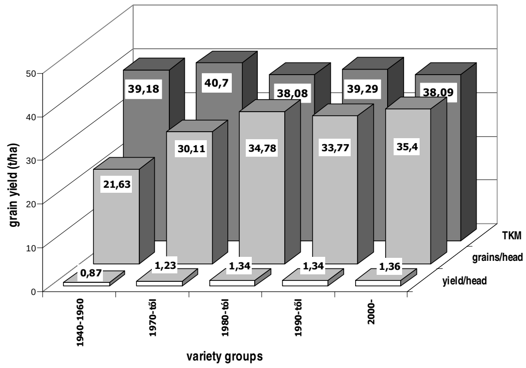


Fig. 5. HI data of old and new wheat genotypes (Szeged, 2003/2004).

Among the yield components the most significant development in time were found in head number per unit surface and seed number per head. Thousand kernel mass became lower in modern genotypes (Fig. 6). If calculating regression between the two years yield data, no relation can be found (r = 0.00211). Figure 7 can group the 70 genotypes on their abiotic stress tolerance by their in two years (stressed and stress free) performance.

All the genotypes which present int he upper right part of Fig. 7 have the highest yielding ability and the best adaptability (stability of yields) since they performed over the average in both years. In the upper left part are the lower yield capacity genotypes with good yield stability under any conditions (extensive genotypes). In the right lower corner are the "super intensive" varieties which have no good adaptability and perform well only under optimal conditions. One part of the left lower corner varieties has a high tolerance to abiotic stresses but yield on a very low level, but the other ones have a quite good yielding ability with a very poor adaptability.



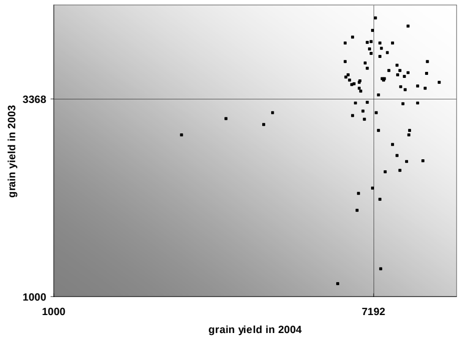


Fig. 6. Grain yield per spike, grain number per spike and 1000 kernel mass in different variety groups of wheat (Szeged, 2003/2004).

Fig. 7. Grain yields of the 70 wheat genotypes (Szeged, 2003-2004).

Yield potential significantly increased mostly due to the increase in seed number per spike and seed weight per spike, and spike number per square meter. Biological yield also increased but since the progress in grain yield was more intensive, HI also increased. Based on the yield stability data there are more tolerant genotypes to abiotic stresses among the oldest and the recently bred modern varieties. Breeding could answer the climatic changes of the latest years: recently released stress tolerant varieties ('GK Kalász', 'GK Verecke', 'GK Petur', 'GK Csongrád') mark that the gain in yield capacity may be increased together the improvement in abiotic stress tolerance and high technological quality.

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