Interrelationships of important agronomic traits and kernel yield in winter wheat

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ABSTRACT

Winter wheat yield is a complex, quantitative trait directly or indirectly influenced by other plant traits. An understanding of the interrelationships between important agronomic traits and yield of winter wheat could help to improve breeding results. The objectives of this paper were to examine correlations between several winter wheat traits and their direct and indirect effects on kernel yield. Research work was conducted during two growing seasons in East Croatia (2005/06 and 2006/07) on 11 winter wheat genotypes. Nine genotypes were advanced breeding lines and two registrated Croatian cultivars Žitarka and Srpanjka. Six traits were included in investigation: ear number per m^2, plant height, number of spikelets per ear, number of kernels per ear, 1000 kernel weight and kernel yield. Path-coefficient analysis was used to evaluate relations between examined traits. Positive and significant correlation was found between ear number per m^2 and 1000 kernel weight, ear number per m^2 and kernel yield, number of kernels per ear and kernel weight. Ear number per m^2 was in significant negative correlation with plant height and spikelets number per ear. Number of kernels per ear and ear number per m^2 had significant positive direct effects on 1000 kernel weight and kernel yield, while the spikelets number per ear had negative direct effect on kernel yield.

INTRODUCTION

One of the main goals in all winter wheat breeding programs is increase of kernel yield. Winter wheat kernel yield is a complex trait influenced by genetic composition of the plant, environmental conditions and interaction between genotype and environment. Kernel yield in wheat can be analysed in terms of three main components: number of ears per area unit, kernel number per ear and 1000 kernel weight (Simane et al., 1993). In order to increase kernel yield wheat breeders need to evaluate agronomic performance of breeding lines, need to indentify the causes of variability in kernel yield (Gebeyehou et al., 1982), need to define correlations among important traits and need to analyse indirect and direct effects of important plant traits on kernel yield. Agronomic performance could be evaluated by path analysis (García del Moral et al., 2005), additive main effects and multiplicative interactions (Haile et al., 2007; Hoffman et al., 2005), multiple cluster analysis (Hühn and Truberg, 2002) and other methods. A considerable amount of studies in winter wheat include correlations between kernel yield and its related traits without dividing correlation coefficient in direct and indirect effects. Coefficient of correlation is helpful in determining main traits influencing kernel yield, but it provides incomplete information regarding relative importance of direct and indirect effects on individual factors involved. On the other hand, path coefficient analysis revealed a complex pattern of relationships among traits and divides the correlation coefficients into direct and indirect effects. Path coefficient analysis was used for identification of complex relationships among traits in winter wheat (Akanda and Mundt, 1996, Li et al., 2006; Aycicek and Yildirim, 2006), durum wheat (García del Moral et al., 2005), landraces of bread wheat (Moghaddam et al., 1997), barley (García del Moral et al., 1991); bean (Önder and Babaoglu, 2001), sunflower (Mijić, et al., 2006) and other agricultural crops.

The objectives of this paper were: (i) to examine correlations between six winter wheat traits, (ii) to perform path coefficient analysis and divide correlation coefficient in direct and indirect effects, (iii) to discuss interrelationships among examined traits.

MATERIALS AND METHODS

Research work was conducted during two growing seasons in East Croatia (2005/06 and 2006/07; field trials near Osijek; soil type - eutric cambisol) on 11 winter wheat genotypes. Nine genotypes were advanced breeding lines and two were recognized Croatian cultivars Žitarka and Srpanjka. The experimental design was a randomised block design with four repetitions and basic plot of 7.56 m^2. In both vegetation years sowing was conducted in optimal sowing time and common agricultural practice for winter wheat in East Croatia was used. Plant height and number of ears per m^2 were counted few days before harvesting. After that, 50 ears were taken randomly from each plot for further measurements (number of spikelets per ear, number of kernels per ear and 1000 kernel weight). In both vegetation years for each genotype 400 ears were analysed, or in total 4.400 ears were analysed for this research. Yield was calculated in kilograms per plot. Collected data were used for calculation of phenotypic correlation coefficients among examined traits. Direct and indirect path coefficients were calculated as described by Dewey et al. (1959). Statistical data were processed by SAS program.

RESULTS

Results for coefficient of correlation and path coefficient analysis are shown in Table 1. Kernel yield was in positive correlation with ear number/m^2, kernel weight and number of kernels per ear. Negative correlation existed between kernel yield and number of spikelets per ear. Strong positive correlation was between ear number per m^2 and 1000 kernel weight. Path coefficient analysis provides information on internal relation among investigated traits as well as their effects on certain trait. Interrelations of six traits are shown at Picture 1.

Table 1 Coefficient of correlation and path coefficient analysis of direct and indirect effects among six traits

Variable vs. 3	Coefficient of correlation	Direct effect	Indirect effect	
			1	2
		P[1]	p	p
1	-0.42**	-0.48**	-	0.06
2	-0.08$^{n.s}$	-0.21**	0.13	-

Variable vs. 4	Coefficient of correlation	Direct effect	Indirect effect		
		P[1]	1	2	3
			p	p	p
1	0.14$^{n.s}$	0.27**	-	0.02	- 0.15
2	- 0.18$^{n.s}$	- 0.07**	- 0.08	-	- 0.03
3	0.26*	0.36**	- 0.11	0.01	-

Variable vs. 5	Coefficient of correlation	Direct effect	Indirect effect		
		P[1]	1	3	4
			p	p	p
1	0.71**	0.69**	-	- 0.01	0.03
3	- 0.22**	0.03**	- 0.30	-	0.05
4	0.28**	0.17**	0.10	0.01	-

Variable vs. 6	Coefficient of correlation	Direct effect	Indirect effect			
		P[1]	1	3	4	5
			p	p	p	p
1	0.48**	0.32*	-	0.02	0.10	0.04
3	- 0.30**	- 0.23**	- 0.13	-	0.07	- 0.01
4	0.26*	0.27**	0.05	- 0.07	-	0.01
5	0.38**	0.03$^{n.s}$	0.23	0.05	0.07	-

1=ear number per m^2; 2=plant height; 3=spikelets per ear; 4=kernels per ear; 5=kernel weight; 6=kernel yield

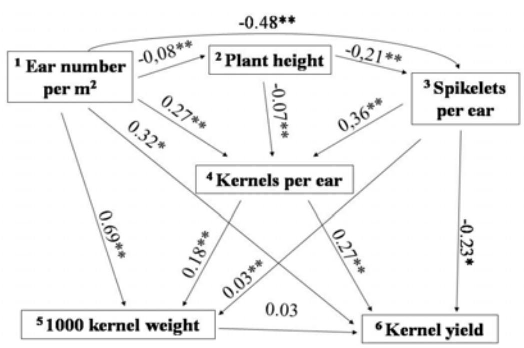

Figure 1 Path coefficient diagram showing the interrelation of six traits

As it can be seen from the Table 1 and Figure 1 highest direct effect on kernel yield had ear number per m^2 (0.32*). Number of kernels per ear also have positive and statistically significant (0.27**) direct effect on kernel yield. Number of spikelets per ear showed negative and significant direct effect (- 0.23**) on kernel yield. 1000 kernel weight did not have significant direct effects on kernel yield but it has the highest indirect effects on kernel yield, particularly through ear number per m^2 (0.23). Positive correlation between these two traits was mainly due to this indirect effect. Ear number per m^2 had significant and positive direct effect on kernel weight (0.69**) and number of kernels per ear (0.27**), while it has significant and negative direct effect on number of spikelets per ear (-0.48**). Number of spikelets per ear showed positive direct effect on 1000 kernel weight (0.03**). However, this positive direct effect was counterbalanced by its negative indirect effects through ear number per m^2 (-0.30). Positive direct effect of number of spikelets per ear on number of kernels per ear (0.36**) was partially counterbalanced by its negative indirect effect via ear number per m^2 (-0.11). Also, positive direct effect of ear number per m^2 on number of kernels per ear was counterbalanced by indirect negative effect via number of spikelets per ear (-0.15).

DISCUSSION

This study had three objectives. First was to investigate correlation between examined traits. In this study, main yield components showed positive correlation with kernel yield. Similar results were reported by Moghaddam et al. (1997) and Aycicek and Yildirim (2006). Ear number per m^2 and 1000 kernel weight showed the highest positive correlation of all examined traits. Also, both traits were in positive correlations with kernel yield indicating that selection for one of these traits can improve kernel yield. Opposite results were reported by Gebeyehou et al. (1982). In their study increasing spikes per m^2 resulted in decrease in kernels per spike and kernel weight. Highest negative correlation existed between ear number per m^2 and number of spikelets per ear. Although number of kernels was not influenced by ear number per m^2, with lowering of spikelet number per ear, ears probably had more kernels per spikelet and with that they compensate lower number of spikelets. That should be evaluated in future studies. Second objective was to divide correlation coefficients in direct and indirect effects. Two main yield components, ear number per m^2 and number of kernels per ear, showed positive direct effect on kernel yield. In research work of Moghaddam et al. (1997) all three main components of wheat kernel yield had high direct effects on kernel yield. Similar results were reported by Akanda and Mundt (1996). In their study number of ears per unit area had the largest direct influence on yield which is similar to our research. In our study 1000 kernel weight did not have significant influence of kernel yield but it has, of all measured traits, highest indirect effect via ear number per m^2. In most cases in this research if the traits had showed significant correlation than their direct effects was also significant. Number of spikelets per ear showed the highest negative, direct effects on kernel yield.

Interrelation analysis of six winter wheat traits provided by path coefficient analysis shows complex and dynamic manner of relations between traits. Direct effects obtained in path-coefficient analysis indicate that kernel yield in examined winter wheat genotypes mainly depends on ear number per m^2. According to the obtained results increasing ear number per m^2 will increase kernel weight and kernel yield. To confirm these results it is necessary to continue with this research and to include more winter wheat traits in examination.

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REFERENCES

Akanda, S.I., Mundt, C.C. (1996): Path coefficient analysis of the effects of stripe rust and cultivar mixtures on yield and yield components of winter wheat. TAG 92(6): 666-672.

Aycicek, M., Yildirim, T. (2006): Path coefficient analysis of yield and yield components in bread wheat (*Triticum aestivum* L.) genotypes. Pakistan Journal of Botany 38(2):417-424.

Dewey, D.R., Lu, K.H. (1959): A correlation and path analysis of components of crested wheatgrass seed production. Agron.J. 51:515-518.

García del Moral, L.F., Ramos, J.M., García del Moral, M.B., Jiménez-Tejada, M.P. (1991): Ontogenetic approach to grain production in spring barley based on path-coefficient analysis. Crop Sci. 31: 1179-1185.

García del Moral, L.F., Rharrabti,Y., Elhani, S., Martos, V., Royo, C. (2005): Yield formation in Mediterranean durum wheats under two contrasting water regimes based on path-coefficient analysis. Euphytica 146:203-212.

Gebeyehou, G., Knott, D.R., Baker, R.J. (1982): Relationships among durations of vegetative and grain filling phases, yield components and grain yield in durum wheat cultivars. Crop Sci. 22:287-290.

Haile, J.K., Sarial, A.K., Assefa, S. (2007): AMMI analysis for stability and locations effect on grain protein content of durum wheat genotypes. Cereal Research Communications 35: 4. 1661-1673.

Hoffmann, B., Burucs, Z. (2005): Adaptation of wheat (*Triticum aestivum* L.) genotypes and related species to water deficiency. Cereal Research Communications, 33: 4. 681-687.

Hühn, M., Truberg, B. (2002): Contribution to the analysis of genotype x environment interactions: theoretical results of the application and comparison of clustering techniques for the stratification of field test sites. J.Agron.Crop Sci. 188:65-72.

Li, W., Yan, Z.-H., Wei, Y.- M., Lan, X.-J., Zheng, Y.-L. (2006): Evaluation of genotype x environment interactions in Chinese spring wheat by AMMI model, correlation and path analysis. J.Agronomy & Crop Science 192: 221-227.

Mijić, A., Krizmanić, M., Guberac, V., Marić, S. (2006): Path coefficient analysis of several components oil yield in sunflower (*Helianthus annuus* l.). Poljoprivreda 12(1): 11-15.

Moghaddam, M., Ehdaie, B., Waines, J.G. (1997): Genetic variation and interrelationships of agronomic characters in landraces of bread wheat from southeastern Iran. Euphytica 95: 361-369.

Önder, M., Babaoglu, M. (2001): Interactions amongst grain variables in various dwarf dry bean (*Phaseolus vulgaris* L.) cultivars. J.Agronomy & Crop Science 187: 19-23.

Simane, B., Struik, P.C., Nachit, M.M., Peacock, J.M. (1993): Ontogenic analysis of field components and yield stability of durum wheat in water-limited environments. Euphytica 71: 211-219.