RESEARCH REGARDING TO SOME MORPHO-PHYSIOLOGICAL AND QUALITY TRAITS IN WINTER WHEAT COLLECTION FROM AGRICULTURAL RESEARCH AND DEVELOPMENT STATION TURDA

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Abstract: *Evaluation of morpho-physiological and quality traits at winter wheat collection is a priority in wheat breeding programs,specially to identify useful germplasm which may be used in crosses to obtain a large range of genetic diversity for desired traits. The main purpose of this research which is also the object of a Ph.D. thesis, to study the morpho-physiological traits that has an influence on winter wheat quality. For this study approximately 1040 cultivars of common winter wheat of different origin and representing a large range of agronomic types were grown in years 2006 and 2008 at Agricultural Research and Development Station (ARDS) Turda in the collection in screening nursery. These cultivars were sown on plots of equal size without replications. The local check variety* ***Ariesan*** *was included from 10 to 10 plots, which resulted in 115 individual plots. Ariesan it is an early and productive variety with high protein and gluten content. The analyzed morphophysiological traits for years 2006 and 2008 were: biological yield, number of grain/spike, grain weight/spike, 1000 grain weight, test weight, harvest index (HI), protein content, nitrogen use efficiency (NUE), wet gluten content and falling number. The protein content of wheat grain is the most important factor in bread making quality. For wheat grain protein content we obtained a renge of variability between 9.47 and 16.7%. Statistical analyses were made for the 1040 genotypes in winter wheat collection compared with the 115 plots of check variety Ariesan. Simple correlation coefficients (r) were calculated in order to provide a measure of the degree of association for the above mentioned traits. The results indicate a high variability between the 1040 cultivars in the common winter wheat collection for all studied characters. Coefficients of variation were higher in the case of common wheat collection as compared with the check variety, Ariesan, for all characters studied, revealing the expression of large genetic variability for qualitative characters in the collection of winter wheat. The calculated correlation coefficients indicate a significant and complex relationships does exist between the analyzed characters. The correlation coefficient between protein content of wheat and its content of wet gluten was 0.72. Protein content was correlated positive with heading date and had a negative relation with harvest index.*

Key words: *winter wheat, protein content, gluten content, nitrogen use efficiency(NUE)*

INTRODUCTION

Food is quite important worldwidely because it is necessary in everyday life, especially in overpopulated countries where there is increasing number of population to be fed. In terms of planting area and yield, the importance of wheat is the second crop. The wheat grain quality parameters influence not only the quality of bread, dumpling and others, but also the flour process in factory. The wheat grain protein yield is a measure to evaluate the life nutrition status. Now in many countries, the wheat with high protein content will be given more premiums in deal. By comparing the relationship between protein content and other parameters of variability, there were difference to the same parameters. This was because the difference of climate in different year. Understanding the genetics of grain protein content in wheat has proven to be one of the most difficult characteristics to study, since it has a low heritability and is very sensitive to environmental conditions, both in terms of soil mineral status and plant growth characteristics, such as the strong negative correlation between yield and protein content. Many researchers tried to find a solution to avoid the possibilities to select protein rich but unproductive genotypes, one of these researchs regards to evaluation of NUE, (SANFORD and MACKOWN, 1986, KHALEQUE et al., 2008, ARNALL et al. 2009). Breeding strategy for such a character as grain protein content assume the existence and identification of a useful genetic variability in the winter wheat collection for breeding programs. VOGEL et al. (1973) tried to identify the variability does exist in a sample of 12613 genotypes from world wheat collection. They find a variability for grain protein content between 6.9 and 22% with mean values 12.97%. Genotype and environment and their interactions affected all traits. Harvest index (HI) is defined as percentage grain in the total plant biomass. Genetic improvement of grain yield in winter wheat has been closely associated with increases in HI, but not with increases in total biomass. Thus, the adoption of semidwarf wheat cultivars is due to their increased biological efficiency, as these shorter cultivars tend to produce less straw per unit of grain than conventional height cultivars. The trend of achieving higher grain yield by increasing HI is not sustainable, and recommended total biomass be considered in breeding programs to assure long term yield improvement.

MATERIAL AND METHODS

For this study , approximately 1040 genotypes of common winter wheat of both local and foreign origin and representing a wide range of agronomic types were grown in the years 2006 and 2008 at ARDS Turda, in a collection-screening nursery. These sources (varieties and lines) in 2005 were sown with the sowing machine SCE-8 for cereal experience. Harvesting was made by hand with scissors, we cut 200 spikes from each plot and made the analyses for morphophysiological and quality characters using these spikes. In 2007 the collection was sowned by hand in unreplicated plots (1 m^2) consisting of 2 rows, 2 m long, with 25 cm between rows. In an unreplicated trial each of these 1040 genotypes was grown in a single plot across the experimental site, except for the control variety “Ariesan” that was sown systematically in every tenth plot (i.e. 10, 20, 30,…, 1150), which resulted in 115 control plots uniformly distributed throughout the trial. At maturity, plants in all plots were cut with a sickle 5 cm above the ground. In this way, a small part of the straw is lost from the biological yield, resulting in an over-estimate of harvest index. The harvested material was weighed to determine biological yield and threshed, after this the grain result from threshing was weighed again in this way we obtain the grain yield. Harvest index was determined as the ratio between grain yield and total plot yield (plant biomass) with formula:

$$HI = \frac{Grain\ yield\ (g/plot)}{Biological\ yield\ (g/plot)}$$

In the same time N use efficiency we obtained as an arithmetical product between harvest index and protein content with formula suggested by SAULESCU et al., 1984.

$$NUE = Harvest\ index \times Protein\ content$$

The climatic features for the two years of experimentation were favourable to research.

Plant height was measured for each entry before harvest, because it can be related to the harvest index owing to the effects of the *Rht* genes on yield. Statistical analysis was carried out for the 1040-line wheat collection compared with the 115 plots of the check variety “Ariesan”. Mean, standard deviation, range and coefficient of variation (CV) were computed for characters such as: grain number/spike, grain weight/spike (g), 1000 grain weight (g), test weight (kg/hl), protein content (%) and wet gluten content (%) for year 2006. In 2008 beside the characters mentioned above were computed mean,standard deviation, range and coefficient of variation (CV) for biological yield (g/plot), grain yield (g/plot), HI, NUE and falling number (s). Simple correlation coefficients (r) were calculated to provide a measure of the degree of association of these traits with each other. A regression analysis was done to determine more precisely the relationship of harvest index to each studied trait. First degree polynomial model was used. The equation for this polynomial is follow:

$$Y = a + b_1 x$$

Where b = regression coefficients; a = the intercept; x = the independent variable; and y = the dependent variable. The regression model chosen to represent a particular relationship can be based on the coefficient of determination (r^2) values, which are the proportions of the sum of squares of the dependent variable that can be attributed to variation in the independent variables. A maximum value for the coefficient of determination provided the best fit for a particular regression equation relating any two variables.

RESULTS AND DISCUSSIONS

Results of winter wheat collection screening nursery grown at ARDS Turda in 2006, regarding mean, standard deviation, range and coefficient of variation (CV) values for grain number/spike, grain weight/spike, 1000 grain weight, test weight, protein content and wet gluten content of 1041 common wheats, compared with 115 individual plots of the control variety “Ariesan” are shown in Table 1.

Table 1

Parameters of variability for some quality traits in 1041 genotypes and 115 sites of check variety Ariesan in winter wheat collection (Turda, 2006)

Character	Statistical population	Mean	Standard deviation	Range		Coefficient of variation (CV)
				minimum	maximum	
Grain number/spike	1041 genotypes	37.75	7.80	18	81	20.66
	115 check variety	29.03	4.10	17	37	14.12
Grain weight/spike	1041 genotypes	1.48	0.33	0.63	2.85	22.29
	115 check variety	1.44	0.24	0.78	1.92	16.66
1000 grain weight (g)	1041 genotypes	39.27	4.20	21.93	68.76	10.69
	115 check variety	49.93	2.97	32.46	54.90	5.94
Test weight (kg/hl)	1041 genotypes	78.13	3.32	66.6	87	4.24
	115 check variety	78.82	3.31	74.6	84.9	4.19
Protein content (%)	1041 genotypes	11.66	0.74	9.47	14.2	6.36
	115 check variety	11.70	0.45	10.57	12.67	3.84
Wet gluten content (%)	1041 genotypes	25.60	3.00	16	38.2	11.71
	115 check variety	26.86	2.00	22.38	31.48	7.44

In the same way, for the year 2008 mean, standard deviation, range and coefficient of variation (CV) values for biological yield (biomass), grain yield, HI, protein content, NUE, grain number/spike, grain weight/spike, 1000 grain weight, test weight, wet gluten content and falling number of 1035 common wheats, compared with 115 individual plots of the control variety “Ariesan” are shown in Table 2.

These results indicate considerable variability between the 1040 genotypes in the winter wheat collection for all characters studied. The obtained values are the results of phenotypic expression of the analyzed characters. The phenotypic expression of a trait can be considered as a linear function of the genotype and the environment in which the genotype was grown. With only one measurement made on each entry, the genotypic effect can not be separated from the environment and the genotype x environment interaction effects. Thus, part of the variability in the winter wheat collection presented here is non genetic in origin. The parameters of variability of the 115 sites of the control variety "Ariesan" reflected this non genetic variability due to the microenvironmental effects plus random error of measurement. Comparison of the variability parameters of the 1040 genotypes of winter wheat with the variability in the 115 sites of check variety "Ariesan" would indicate that the winter wheat lines studied contain an important amount of genetic variability for the studied characters.

Table 2

Parameters of variability for some quality traits in 1035 genotypes and 115 sites of check variety Ariesan from winter wheat collection (Turda, 2008)

Character	Statistical population	Mean	Standard deviation	Range		Coefficient of variation (CV)
				minimum	maximum	
Biological yield (g/plot)	1035 genotypes	1453.14	442.24	310	2770	30.43
	115 check variety	1419.48	376.48	510	2340	26.52
Grain yield (g/plot)	1035 genotypes	665.58	207.98	103	1083	31.24
	115 check variety	660.56	183.85	239	1088	27.83
Harvest index (%)	1035 genotypes	0.46	0.05	0.26	0.66	10.86
	115 check variety	0.46	0.04	0.32	0.56	8.69
Protein content (%)	1035 genotypes	12.26	0.94	9.8	16.7	7.66
	115 check variety	12.50	0.72	10.7	15.6	5.76
N use efficiency (%)	1035 genotypes	5.61	0.64	3.46	8.63	11.40
	115 check variety	5.81	0.56	4.14	7.30	9.63
Grain number/spike	1035 genotypes	54.23	8.19	27.7	83.7	15.10
	115 check variety	43.83	4.97	33.9	58.5	11.33
Grain weight/spike (g)	1035 genotypes	2.29	0.42	0.94	3.91	18.34
	115 check variety	2.52	0.29	1.82	3.3	11.50
1000 grain weight (g)	1035 genotypes	42.28	4.86	20.76	58.08	11.49
	115 check variety	57.48	3.29	47.45	63.93	5.72
Test weight (kg/hl)	1035 genotypes	75.04	2.71	62.76	82.47	3.61
	115 check variety	74.24	1.99	67.31	78.08	2.68
Wet gluten content (%)	1035 genotypes	33.14	4.63	15.4	53.7	13.97
	115 check variety	35.83	3.05	29.9	48.3	8.51
Falling number (s)	1035 genotypes	278.82	105.66	62	544	37.89
	115 check variety	204.60	51.13	82	311	24.99

The magnitude of this variability can be illustrated by comparing the wide range of values for the winter wheat collection with the in general smaller range obtained for the tester. Coefficients of variation were also more or less higher in the case of the 1040 genotypes from winter wheat collection compared with the check variety "Ariesan" for all characters studied, revealing the expression of large genetic variability for quality in the collection of winter wheats. Protein content serves as a good example of the difficulties encountered in breeding for the desired level of quality factor exhibiting limited genetic variation, and being extremly sensitive to environmental influences.In the year 2006 the protein content was between 9.47 and 14.2%, while in 2008 the values were between 9.8 and 16.7% in winter wheat collection. Useful genetic variability for the quality characters in the collection is located between the mean values of characters and upper limits of range values. Frequency distribution for protein content in winter wheat collection for years 2006 and 2008 are presented in Fig 1. and 2.

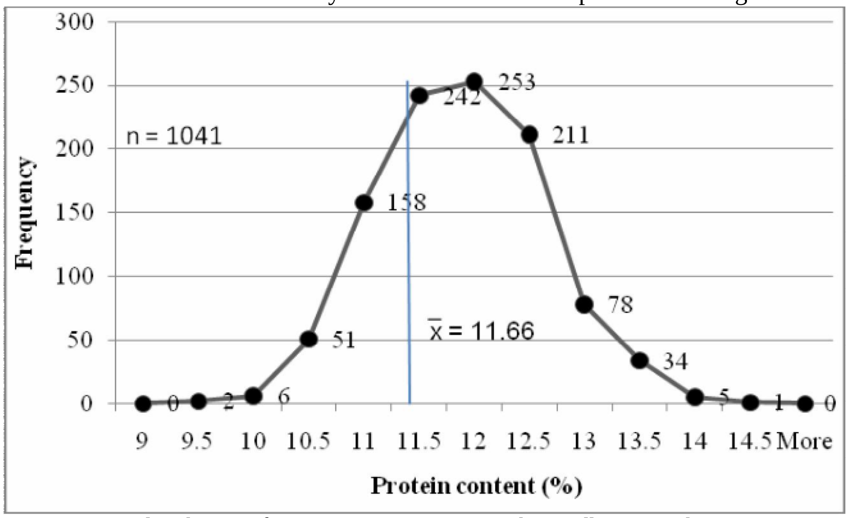

Figure 1: Frequency distribution of 1041genotypes in winter wheat collection in the 2006 experiment for grain protein content (Turda, 2006)

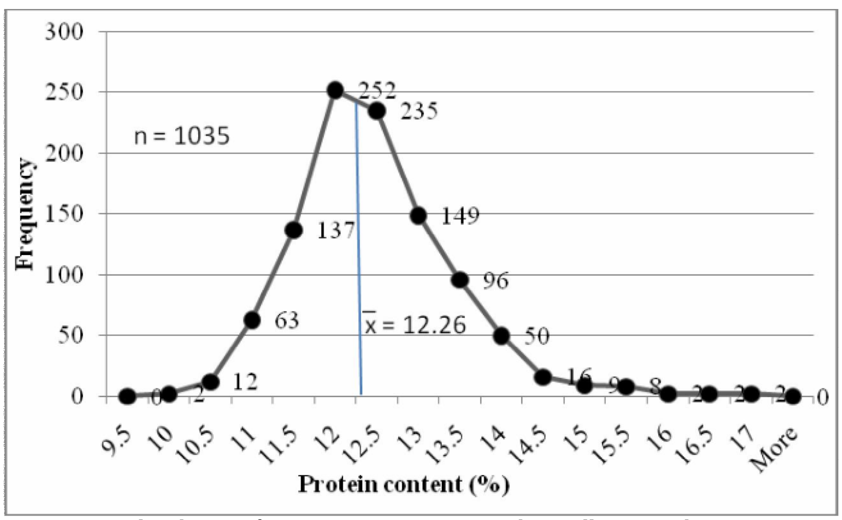

Figure 2: Frequency distribution of 1035 genotypes in winter wheat collection in the 2008 experiment for grain protein content (Turda, 2008)

The frequency distribution of percent protein in winter wheat collection for both years approximate normal distributions. The results of this study allow identifications of wheats likely to be genetically superior in their ability to produce high protein content and for use in breeding for high protein content varieties. The wheat protein content is one of the most important quality character, influenced by many other morphophysiological traits which are related between them. Correlation coefficients (r) between the analysed characters for years 2006 and 2008 are presented in table 3 and 4.

Table 3

Correlation coefficients (r) between morphophysiological and quality traits in 1041 genotypes from winter wheat collection (Turda, 2006)

Character	Grain number/spike	Grain weight/spike (g)	1000 grain weight (g)	Test weight (kg/hl)	Protein content (%)	Wet gluten content (%)
Grain number/spike	1					
Grain weight/spike (g)	0.87**	1				
1000 grain weight (g)	-0.04	0.44**	1			
Test weight (kg/hl)	0.16**	0.21**	0.16**	1		
Protein content (%)	0.03	-0.08	-0.21**	-0.01	1	
Wet gluten content (%)	-0.19**	-0.21**	-0.07	-0.03	0.69**	1

** significant at P = 1%

Table 4

Correlation coefficients (r) between morphophysiological and quality traits in 1035 genotypes from winter wheat collection (Turda, 2008)

Character	Biological yield (g/plot)	Grain yield (g/plot)	Harvest index (%)	Protein content (%)	N use efficiency (%)	Grain number/spike	Grain weight/spike (g)	1000 grain weight (g)	Test weight (kg/hl)	Wet gluten content (%)
Grain yield (g/plot)	0.93**	1								
Harvest index	-0.06	0.28**	1							
Protein content (%)	-0.39**	-0.49**	-0.37**	1						
N use efficiency	-0.30**	-0.03	0.79**	0.26**	1					
Grain number/spike	-0.27**	-0.26**	-0.03	0.27**	0.15**	1				
Grain weight/spike (g)	-0.14**	-0.10*	0.09	0.13**	0.19**	0.77**	1			
1000 grain weight (g)	0.13**	0.19**	0.18**	-0.14**	0.09	-0.07	0.57**	1		
Test weight (kg/hl)	0.29**	0.38**	0.33**	-0.48**	0.04	-0.23**	-0.04	0.23**	1	
Wet gluten content (%)	-0.37**	-0.40**	-0.17**	0.72**	0.28**	0.23**	0.14**	-0.07	-0.25**	1
Falling number (s)	0.18**	0.15**	-0.07	-0.02	-0.09	-0.03	-0.05	-0.05	0.07	0.01

* significant at P = 5%
** significant at P = 1%

Many of these relationships have been reported before, but not for wheats representing such a wide range of agronomic types, all grown in the same year and in the same location. A significant and complex relationship was found between the analyzed characters. Significant and strong correlation between harvest index and N use efficicency was detected in wheat collection (r=0.79) which makes it useful selection criterion in breeding for improved quality potential. There is well known the negative correlation between biological yield, grain yield and protein content. Therefore we computed NUE, which is direct correlated with protein content (r=0.26). In this way is possible to select genotypes with high protein content, associated with good productivity. The relationship between harvest index and grain protein content is ilustrated in Fig. 3. It shows that varieties with high harvest index tend to produce grain with low protein content.. The relationship between NUE and protein content is illustrated in Fig. 4. These results offers the opportunity to identify varieties with the largest positive deviation of their harvest index values which are the most desired sources of genes for quality ability. There must underlined that the high HI values may be as results of low biological yield which are associated with early genotypes. (MOLDOVAN et al., 2002).

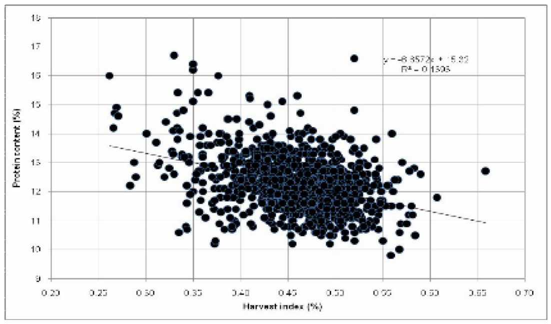

Figure 3: Correlation between HI and protein content in the winter wheat collection (Turda, 2008)

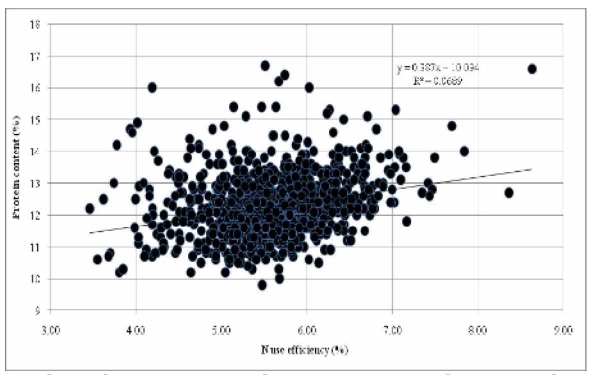

Figure 4: Correlation between NUE and protein content in the winter wheat collection (Turda, 2008)

CONCLUSIONS

•The obtained results indicate a large range of variability between the 1040 genotypes in the winter wheat collection for all the studied characters in both years. This range of variability is the result of phenotypic expression of the analysed characters, so it includes a part of nongenetic variability due to “genotype x environment” interaction effects.

•Comparison with the variability resulted in case of 115 sites of check variety Ariesan demonstrate the size of this variability which is nongenetic in origin. For all the analysed characters its obvious a bigger or smaller portion of variability due to genotype.

•In this study considering the emphasis on variation for quality characters we proceed to represent the frequency distribution of protein content for the studied genotypes in years 2006 and 2008.

•The frequency distribution curve for grain protein content for both years approximate more or less the normal distribution and allows to identify genotypes with protein content over the mean values.

•The correlation coefficients indicate significant and complex relationships between the analysed characters. First of all can be noted the well known negativ correlation between protein content and yield components.

•Attempt to break this negativ correlation by use such parameters as NUE proved to be useful, so in this way the correlation between NUE and grain protein content becomes positive and significant (r=0.26).

•Regression analyses between harvest index and protein content shows that the negative relation given by regression coefficient is not so strong, so coefficients of determination (r^2) indicate the fact that only 14% of the total variation of protein content can be attributed to variation of harvest index, existing quite enough exceptions of genotypes which combines high harvest index with high protein content.

•Regression between NUE and grain protein content is illustrated by the positive slope of regression line, this way by use of NUE can be easily identify genotypes which combines in the same time high protein content and good yielding ability.

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