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GENETIC VARIATION OF DRY MATTER AND NITROGEN ACCUMMULATION OF DOUBLE HAPLOID WHEAT LINES

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Summary

The study considers the genotype peculiarities in the dynamics of dry matter and nitrogen accumulation in plant parts during the different stages of 10 DH wheat lines characterised as initial breeding material of high quality. These were obtained from 2 crosses - 7- P_2 - 11 x H-81/32-4 and 7- P_2 - 11 x H-81/32-24. Considerable genotype variations were established both between the lines and the parental forms, and in comparison to the standard quality variety Slavyanka-196. Lines 41-191 and 41-344 are of special interest because of their high grain yield and high intensity of biomass accumulation (kg/dka/day) and high intensity of nitrogen uptake (g/dka/day) mainly in the second half of the grain filling period. These lines stand out among the new DH lines with their high protein yields. In line 41-181 the ratio NHI/GHI changes positively with a high degree of certainty in both phases of grain maturity. This line is characterised with the highest value of nitrogen (mg) in vegetation mass per unit mature grain. A positive correlation was established between the NHI/GHI ratio and protein content in grain. Line 41-344 is the most economic one with regard to nitrogen formation per 100 kg grain with the lowest expense for formation of the respective quantity of straw.

1. Introduction

In order to more fully realise the genetic potential of the different wheat varieties, it is necessary both to provide well plants with nutrition elements and to thoroughly know the physiological and biochemical processes in the plant organism which determine yield and its quality. In this connection, it is especially important to understand the peculiarities of nitrogen exchange in plants because nitrogen is the nutrient element which, to a higher degree in comparison to the others, determines yield, content and quality of protein in cereal crops (Kondratyev and Kostyukovitch, 1981).

The breeders have achieved remarkable results with regard to grain yield increase, but increasing its protein content through breeding has turned out a difficult task. According to Pavlov (1982) nitrogen (mg) in vegetation mass per unit mature grain is a very efficient index for characterising the peculiarities of nitrogen metabolism at the genotype level. It depends on the GHI values and nitrogen content in vegetation mass. The author concluded that using genotypes in breeding, the increased values for this index of which are at the expense of a decreased GHI, is not promising. The reasons for the difficulties in quality breeding are clear, because many internal factors, physiological and other aspects determine the capability of wheat genotypes to form grain with increased or decreased protein content. Furthermore, the significance of the factors is not the same for the different genotypes.

Cox et al. (1985) have pointed out that the simultaneous increase of grain yield and protein content in it can be achieved through breeding.

All this comes to demonstrate that in order to increase the breeding efficiency in the direction of increasing protein content in grain, it is necessary to use initial genetic material that has already been characterised with regard to nitrogen metabolism and rate of protein accumulation in grain.

The aim of this study is to provide information for the dynamics of dry matter accumulation and nitrogen uptake in plant parts and according to the phases of the development of the DH wheat lines which have high quality indices. The study aims at obtaining knowledge on the dynamics of the changes in GHI and the NHI/GHI ratio according to the phases of grain maturity, protein yield and expenses for formation of the end product.

2. Materials and methods

The study includes DH wheat lines obtained from the crosses 7-P_2-11 x H-81/32-4 (41-519; 41-181 and 41-191) and 7-P_2-11 x H-81/32-24 (41'-306; 41'-344; 41'-355, 41'-470; 41'426; 41'-413 and 41'234) which are characterised with high quality indices. The method of obtaining the crosses is described in detail elsewhere (Nankova et al., 1998). The variety Slavyanka-196 was used as a standard of quality in this research.

The DH wheat lines were tested under field and vegetation conditions. The vegetation trial was carried out in plastic pots filled with the same type of soil, at dressing levels $N_0P_{200}K_{200}$, $N_{200}P_{200}K_{200}$ and $N_{400}P_{200}K_{200}$ mg/1000 g soil. The dynamics of dry matter accumulation and the chemical composition of in plant parts and according to the stages of development was established. Total nitrogen content was determined by the method of Keldal.

3. Results and discussion

In studying the dynamics of biomass accumulation, considerable differences were established between the new DH wheat lines and the initial parental forms (Table 1). In the first cross, at the stages heading and grain-filling, line 41-181 formed a maximal amount of biomass, mainly at the expense of leaves and stems. In full maturity this line exceeds only the mother form - 7-P_2-11 - by yield from biomass, considerably falling behind all genotypes from the cross by grain yield. From this cross, line 41-191 exceeds significantly both the initial forms and the standard variety Slavyanka-196 by its highest grain yield.

In the second cross a considerably higher differentiation was registered between the new DH lines regarding their biomass yield and the individual plant parts. During heading, line 41'-355 exceeds all other lines, including the standard, but falls behind the father form. It is characterised with a very high spike yield during this stage. During grain-filling this line forms the highest biomass yield, but concedes to the father form and to cv. Slavyanka-196 by grain yield. At full maturity line 41'-344 exceeds all other genotypes from the cross and equals cv. Slavyanka-196 by its grain yield.

The registered genotypic differences become even greater with regard to nitrogen uptake in the total biomass and in the parts (Table 2). In the first cross, the DH lines considerably exceed the parental forms by the amount of nitrogen uptake. In the second cross line 41'-355 and the father form demonstrate the highest nitrogen uptake in the

Table 1. Dynamics of dry matter accumulation in the plant parts of DH wheat lines at the different stages of development.

Plant parts	Heading				Grain filling				Full ma		
	MS_v	Ms_e	F	df	MS_v	Ms_e	F	df	MS_v	Ms_e	F
Stems	38747.2	12.2	3188.1	13	131356.9	0.62	213455	13	48352.5	0.54	89797.4
Leaves	3737.3	2.3	1661.0	13	6004.0	1.58	3807.4	13	6607.2	0.18	36165.5
Spikes	5764.7	0.33	17633.3	13	-	-	-	-	-	-	-
Grain	-	-	-	-	33529.6	0.04	871769	13	118469.7	0.15	770053.0
Chaff	-	-	-	-	11810.3	0.74	15951.6		11377.9	0.08	147913.0
Non-production biomass	417.6	0.06	7054.5	13	489.9	2.04	240.8	8	7295.3	0.14	53360.0
Total	114947.4	9.39	12248.5	13	443228.3	13.5	32738.5	13	439250.5	2.46	178445.5
GHI	8.2	0.06	139.9	13	42.9	0.38	112.3	13	34.3	0.05	695.9

trial. This line, however, slightly exceeds the father form by nitrogen uptake in leaves and spikes.

During grain filling the lines from the first cross differ slightly both between themselves and from the parental forms by the total amount of nitrogen uptake, but they considerably exceed the standard. More significant differences between them were established with regard to nitrogen uptake in spikes and mainly in the filling grain. In the second cross the amount of nitrogen uptake is under the level of the father form. However, line 41'-355 is closest to the father form by the amount and rate of nitrogen uptake in stems and even exceeds it. At the final stage line 41-191, characterised with the highest grain yield among all lines in the cross, stands out with the highest amounts of nitrogen uptake in the parts, but considerably concedes to the father form by this index. This line has the highest NHI among the genotypes of this cross (Nankova et al., 1998).

Table 2. Dynamics of total nitrogen uptake in the parts at the different stages in DH wheat lines

Plant parts	Heading				Grain filling				Full maturity			
	MS_v	Ms_e	F	df	MS_v	Ms_e	F	df	MS_v	MS_e	F	df
Stems	3.75	0.0008	4722.2	13	10.10	0.0046	2187.2	13	0.77	0.004	195.6	13
Leaves	6.65	0.0017	3977.3	13	3.47	0.0030	1153.0	13	0.47	0.004	126.6	13
Spikes	2.69	0.0022	1245.8	13	-	-	-	-	-	-	-	-
Grain	-	-	-	-	14.50	0.0036	3999.5	13	54.77	0.021	2632.2	13
Chaff	-	-	-	-	1.80	0.0036	495.29	13	0.59	0.001	569.8	13
Non-production biomass	0.036	0.001	36.43	13	0.39	0.0003	1183.85	8	3.39	0.003	1008.3	13
Total	37.34	0.0024	15532.1	13	92.71	0.0044	20916.93	13	84.88	0.002	51360.3	13
GHI	7.07	0.0006	11758.5	13	87.53	0.0006	145648.50	13	30.46	0.040	768.1	13

In the second cross it is worth mentioning lines 41'-344 and 41'-355, which stand out with the highest amounts of nitrogen uptake in parts and as a total. By their index values, they exceed the father form that they have been conceding to up to now, but as a whole they have less nitrogen uptake in comparison to cv. Slavyanka-196.

The harvest index of grain varies considerably according to both the degree of grain maturity and the genotype (Table 3). In some lines, the harvest index increases nearly two times from grain filling to full maturity. Line 41-191 has the maximal value of this index in the trial. It has the lowest NHI/GHI ratio which actually reveals the proportion of nitrogen translocation to the other components of grain. It is known from the literature that in *Triticum aestivum* L. there is a positive correlation of NHI/GHI and nitrogen content in grain (Cox et al., 1986). The authors have established that the coefficient correlation between this ratio and protein content in grain varies from $r = 0.39$ to 0.45, $P < 0.01$. In our trial the value of this correlation is $r = 0.324$.

In the second cross line 41'-344 has the highest GHI value which is equal to that of the father form and exceeds that of the standard variety. In this line, as in line 41'-355, the differences in the two stages of grain maturity in the NHI/GHI ratio were not proved in comparison to cv. Slavyanka-196. In line 41-181 the variation of this ratio in a positive direction is proved to a highest degree of significance; it will be demonstrated below that this line possess a great potential for the highest nitrogen uptake in grain under vegetation conditions. The established differences in the amount of formed biomass and the amount of nitrogen uptake in the parts at the individual stages reveal a rich variety in

Table 3. Dynamics of increase in GHI and the NHI/GHI ratio

Genotypes	GHI- grain filling	GHI- full maturity	NHI/GHI - grain filling	NHI/GHI - full maturity
1. 7-P_2-11	26.57	42.61	1.53	1.67
2. H 81/32-4	26.53	40.70	1.52	1.75
3. 41-519	32.19	45.23	1.46	1.71
4. 41-181	17.78	31.81	1.91	2.17
5. 41-191	26.96	49.22	1.78	1.61
6. H-81/32-24	25.96	46.57	1.49	1.64
7. 41'-306	19.43	43.48	1.68	1.72
8. 41'-344	21.42	46.46	1.75	1.76
9. 41'-355	19.92	43.86	1.76	1.80
10. 41'-470	18.64	41.50	1.72	1.88
11. 41'-426	24.59	45.81	1.66	1.67
12. 41'-413	24.83	42.12	1.67	1.72
13. 41'-234	26.28	41.31	1.75	1.76
14. Slavyanka -196	31.37	45.57	1.78	1.78
GD 5 %	1.34	0.48	0.0567	0.0650
1 %	1.86	0.67	0.0790	0.0906
0.1 %	2.61	0.94	0.1107	0.1270

the genotypes with regard to the dynamics of dry matter accumulation and the intensity of nitrogen uptake in spikes (Table 4).

Table 4. Dynamics in the changes of biomass amount (1) and nitrogen uptake intensity (2) in the spikes during the stages of maturity.

Genotypes	Heading - Grain filling		Grain filling - Full maturity	
	1	2	1	2
1. 7-P_2-11	19.71	291.30	10.39	270.83
2. H 81/32-4	18.66	326.96	38.04	971.67
3. 41-519	23.83	312.61	22.87	473.75
4. 41-181	19.54	280.44	15.37	335.83
5. 41-191	21.53	350.44	39.24	755.00
6. H-81/32-24	31.88	541.30	4.58	136.67
7. 41'-306	3.51	29.57	38.43	751.25
8. 41'-344	23.80	375.22	38.80	670.83
9. 41'-355	24.39	384.78	26.33	51.00
10. 41'-470	12.86	183.91	24.46	573.75
11. 41'-426	18.56	291.74	12.48	330.42
12. 41'-413	34.98	257.83	6.54	514.17
13. 41'-234	22.98	363.91	25.61	475.83
14. Slavyanka -196	25.42	334.78	38.39	789.58

Key: 1. kg/dka/day , 2. N g/dka/day

These indices characterise very well the efficiency of the nutrition process. In the period from heading to grain filling line 41'-413 forms the maximal spike yield per day per unit area among the tested genotypes, but it does not have a high intensity of nitrogen uptake. This index is highest in the father form H-81632-24, and in the new lines 41'-234 and 41-191, respectively. In the second half of the process of grain maturation, most of the tested genotypes are characterised with a higher intensity of biomass accumulation and nitrogen uptake in spikes, which is most clearly expressed in line 41-191.

Protein content in grain also varies according to the genotype (Table 5). The mother form does not differ by this index from the standard variety, but the two father forms (especially in the first cross) exceed the standard to a maximal degree of significance. Lines 41-181, 41'-470 and 41'-426 exceed the standard to the same degree of significance. Only the father form from the first cross and line 41-191 exceed to a maximal degree of significance cv. Slavyanka by protein yield. In the other genotypes a high degree of significance of the differences was also registered, but it is a negative one. However, line 41'-344 from the second cross exhibits the highest protein yield, only a little conceding to cv. Slavyanka. The two lines from the two crosses pointed out in another study of ours have demonstrated the highest intensity of biomass accumulation and nitrogen uptake in grain during grain filling (Nankova et al., 1998). May be this fact is the reason for the highest protein yields obtained among all DH lines, although they do not possess high protein content in grain.

Table 5. Protein content and protein yield

Genotypes	Field trail		Vegetation trial - protein in %		
	Protein - %	Yield - kg/ha	N_0	N_{200}	N_{400}
1. 7-P_2-11	12.48	876.1	11.57	14.42	16.87
2. H 81/32-4	15.73	1831.0	10.66	12.60	16.93
3. 41-519	12.26	1286.1	11.97	13.17	17.67
4. 41-181	13.79	930.8	12.14	15.45	20.01
5. 41-191	12.26	1671.0	10.94	12.20	17.44
6. H-81/32-24	12.94	1164.6	10.94	14.14	18.13
7. 41'-306	12.54	1152.4	11.34	15.68	18.24
8. 41'-344	11.57	1536.5	13.05	13.79	18.13
9. 41'-355	12.48	1437.3	12.08	14.65	17.78
10. 41'-470	14.14	1122.7	13.22	14.65	17.73
11. 41'-426	13.45	918.6	12.31	15.16	18.01
12. 41'-413	12.71	1117.9	11.23	13.85	16.93
13. 41'-234	12.03	1250.6	10.94	12.08	15.05
14. Slavyanka -196	11.74	1559.0	11.06	13.28	17.27
GD 5 %	0.660	17.88	Genotyres 0.161	Dressing	0.074
1 %	0.920	24.91	0.215		0.010
0.1 %	1.290	34.93	0.283		0.131

The obtained data for protein content in the grain of the genotypes tested under vegetation conditions allow to follow their reaction at different rates of nitrogen dressing. Under conditions without nitrogen fertilization, lines 41'-344 and 41'-470 are worth paying special attention. Nitrogen dressing, whatever the norm, leads to considerable increase of protein in grain. At an optimal level of nitrogen dressing, the index values vary from 12.08 to 15.68 %, and at a high level of nitrogen fertilization - from 15.05 to 20.01 %. The latter value concerns line 41-181. It considerably exceeds both the initial forms and the standard variety by this protein content.

Characterising the genotypes with regard to nitrogen expense for formation of end product, line 41'- 344 from the second cross can be considered the most economical one. It has the lowest expense of additional product for formation of 100 kg grain. The index of this line for nitrogen (mg) in vegetation mass per mature grain unit is lowest for the entire trial. Similar is the case with lines 41-519 and 41-191 from the first cross. According to Pavlov (1982), the highly productive varieties are characterised with decreased values of this index due to the higher GHI. This is the main reason for the reverse relation between the value of yield and the protein content in it. In this case the indicated DH lines are characterised with a high grain yield and GHI.

Line 41-181 stands out with its highest total expense for formation of 100 kg grain, but also with the highest nitrogen (mg) in vegetation mass per mature grain unit among the studied DH wheat lines.

Table 6. Nitrogen expense for formation of production

Genotypes	Nitrogen expense in kg for 100 kg grain			N mg / 1 kg mature grain
	grain	straw	total	
1. 7-P_2-11	2.19	0.66	2.85	30.73
2. H 81/32-4	2.76	0.77	3.53	38.79
3. 41-519	2.15	0.53	2.68	27.89
4. 41-181	2.42	0.50	2.92	35.00
5. 41-191	2.15	0.55	2.70	27.12
6. H-81/32-24	2.27	0.61	2.88	29.67
7. 41'-306	2.20	0.63	2.83	30.20
8. 41'-344	2.03	0.39	2.42	24.82
9. 41'-355	2.19	0.46	2.65	27.72
10. 41'-470	2.48	0.50	2.98	31.82
11. 41'-426	2.36	0.62	2.98	30.91
12. 41'-413	2.23	0.62	2.85	30.83
13. 41'-234	2.11	0.59	2.70	29.50
14. Slavyanka-196	2.06	0.47	2.53	26.25

4. References

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