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Influence of Flag Leaf area on Wheat Adaptation on Stress Condition

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Abstract: The leaf area plays main importance for photosynthesis and for obtaining high grain yield. The leaf area duration (LAD) and leaf area index (LAI), directly affect dry matter synthesis and grain yield and consequently tolerance to stress conditions. In diallel crosses (4 x 4) without reciprocals of divergent wheat cultivars (Jugoslavia, Zitnica, NS Rana 2, Osijecanka) in F_1 and F_2 hybrids significant differences were found for the examined characters. The flag leaf area in F_1 and F_2 generation was inherited intermediately, partially dominantly or dominantly depending on the combination. The analysis of variance for both general (GCA) and specific (SCA) combining ability showed that flag lef area controled by genes with additive and non-additive effect. The highest positive value of GCA in both F_1 and F_2 hybrids was shown Zitnica cultivar. The best F_1 hybrid combination were, Zitnica x NS Rana 2 and NS Rana 2 x Osijecanka and F_2 generation the best combination was Jugoslavija x NS Rana 2.

Key words: wheat, flag leaf, photosynthesis, stress tolerance gene effect, combining ability, inheritance,

Introduction

In the past a few decades the extensive studies were conducted to improve knowledge about plant system, their genetic base and specificity of interaction with environment. The investigation in biochemestry, genetics and molecular biology were contributed to the progress in plat breeding. Genetic manipulation for an optimum combination of components which have high efficiency in improving adaptability have played a very important role in plant improvement. The genotype's adaptability can refer to response to predictable and unpredictable environmental influence. The point of breeding is to select genotypes with high and stable yield genetic potential, high quality, resistant to desease and stress conditions. For selection of such genotypes, very important is to pay more attention on inheritance and gene composition for morpho-physiological trait like flag leaf area. The flag leaf area contributes about 42% of total grain yield in wheat (Mackey, 1982). The source of carbon for grain filling is assimilation by the lightintercepting viable green surfaces. This source is normally diminishing due to natural senescence and the effect of various stresses (Blum, 1996). During the photosynthesis, about 95% of dry matter of carbochydrates were synthesised in green organs of plants (Nichiporowich, 1956).

Delayed leaf senescence has long been considered to be a desirable trait in cereal breeding (Borojevic et al., 1980; Thomas and Smart, 1993). The longer leaf area duration (LAD) can contribute to grain filling and yield. Drought condition during grain filling often involve heat stress which reduced the duration grain filling. The genetic information about nature of gene action in expresion of flag leaf area can contribute in breeding of more resistant wheat genotypes to drought.

The flag leaf area in four wheat cultivars, six hybrids of F_1 and F_2 generations derived from diallel crosses were presented in this study. The posibility of selection and predicting genotypes with higher efficiency of green area for photosynthetic activity and increasing of tolerance to drought were investigated.

Materials and methods

The experimental material comprised four wheat cultivars, Yugoslavia, Zitnica, Novosadska Rana 2 and Osijecanka which were taken on the basis of their genetic diversity. These cultivars were crossed according to scheme of diallel without reciprocals. The parent cultivars all the cross combination of F_1 and F_2 were shown in a complete block design with three replications at the experimental field of the Center for Small Grains in Kragujevac.

Plant material was shown in 1 m long rows with 0.20 m spaces between rows and 0.05 m distance between each plant in the row. The flag leaf area were studied at 30 plants (10 plants per replication) for parents and F_1 and at 120 plant (40 plants per replications) in F_2 .

The surface of leaf was analyzed by using proposed method (Aleksenko, 1956). The combining ability were analyzed according to Griffing (1956) method 2, model 1.

Results

The obtained results indicating variability of flag leaf area in wheat cultivars and F_1 and F_2 hybrids. The highest value of flag leaf area had Zitnica cultivar while lowest NS Rana cultivar. The value of flag leaf area showed variations in F_1 hybrids. The highest flag leaf area was found in the hybrid Zitnica x Osijecanka and significantly differed from flag leaf area of other hybrids of F_1 generation. The lowest value of flag leaf area was found in the hybrid Jugoslavija x NS Rana 2. Flag leaf area of other hybrids varied between these two values. The analysis of F_2 hybrids showed variations of flag leafa area. The highest flag leaf area had hybrids Zitnica x Osijecanka, while the lowest flag leaf area in F_2 generation was found in the combination Jugoslavija x Osijecanka (Table 1).

Tab. 1. Average values of flag leaf area (cm^2) and mode of inheritance (P, F_1 and F_2)*

Cultivar	Jugoslavija	Zitnica	NS Rana 2	Osijecanka
Jugoslavija	**33.42**	43.29^{h}	39.45^{h}	43.78^{h}
Zitnica	34.41^{-pd}	**42.24**	48.11^{h}	48.78^{h}
NS Rana 2	36.81^{h}	37.53^{+pd}	**29.18**	47.19^{h}
Osijecanka	34.27^{-pd}	38.64^{-pd}	34.33^{+pd}	**37.89**

* The values below diagonal are for F_2 generation

In all F_1 hybrids heterosis were occured for flag leaf area. In F_2 hybrids the values of leaf area, approximately, were same to one or second parents indicating partial dominance as a mode of inheritance. However, in cross combination Jugoslavija x Zitnica, heterosis was occured (Table 1). The values of leaf surface varied from 29 to 49 cm^2 what is in agreement with obtained in investigation of Jost and Milohnic (1972).

The grain yield analysis showed value variations in F_1 hybrids. The highest grain yield was obtained in the hybrid Zitnica x NS Rana 2 and significantly differed from grain yield of other hybrids of F_1 generation. The lowest grain yield was obtained in the hybrid Jugoslavija x Zitnica. Grain yield of other hybrids ranged between these two values (Table 2).

Tab. 2. Average values of dry matter in plant in grain (g/primary tiller) and mode of inheritance (P, F_1 and F_2)*

Cultivar	Jugoslavija	Zitnica	NS Rana 2	Osijecanka	LSD	
Jugoslavija	2.95	2.44^{-h}	2.58^{-h}	2.51^{-h}	0.05	0.01
Zitnica	2.49^{-h}	3.10	2.98^{-pd}	2.51^{-h}	0.32	0.42
NS Rana 2	2.40^{-h}	3.03^{-pd}	3.25	2.29^{-h}		
Osijecanka	2.58^{-h}	2.70^{-h}	2.31^{-h}	3.02		

* The values below diagonal are for F_2 generation

The obtained results regarding grain yield indicate that differences between hybrids of F_1 generation an parental cultivars. Majority combinations of F_1 generation had considerably lower grain yield than parents. Only grain yield of the F_1 Zitnica x NS Rana 2 was at the level of parental grain yield but a bit lower. The analysis of F_2 hybrids showed variations of grain yield. The highest grain yield was found at the hybrids Zitnica x NS Rana 2, while the lowest grain yield in F_2 generation was found in the combination NS Rana x Osijecanka (Table 2).

The information about gene effects gave analysis of variance of combining abilities (Table 3). The impact of additive and non-additive gene was equal in F_1 hybrids for flag leaf area, while additive gene effect are prevail in inheritance of flag leaf area in F_2 hybrids. This resulats are in agreement with sdudies of Borojevic and Cupina, (1969), Kraljevic-Balalic (1974).

Tab. 3. GCA values for flag leaf area in wheat (parents, F_1 and F_2)

Cultivar	F_1			F_2		
	GCA	Rank	SE	GCA	Rank	SE
Jugoslavija	-2.217	3		- 1.177	3.15	
Zitnica	2.999*	1	1.095	2.616*	3.15	1.12
NS Rana 2	-2.259	4		- 2.055	3.15	
Osijecanka	1.475	2		0.61	3.15	
LSD 0.05		2.30			2.35	
0.01		3.15			3.22	

In F_1 and F_2 generation, the highest values of general combining ability (GCA) were found for Zitnica cultivar which was high significant different from GCA values of other analyzed cultivars (Table, 3). The best combiner for flag leaf area in both generation was Zitnica cultivar, which had highest GCA value, indicating highest number of genes with additive action. The fixing of additive gene effect is possible in late generations after hybridization.

The best cross combination in F_1 was Novosadska Rana 2 x Osijecanka, Zitnica x Novosadska Rana, while in F_2 was Jugoslavija x Novosadska Rana 2 (Table 7 and 8).

General discussion

The photosynthetically active radiation (PAR) during the growth stages can increase set of spikelets and fertile florets through the direct effect of the large photosynthetic area and the indirect effect of formation of a large root mass. There is association between grain yield and vegetative growt rate in cereals (oat) (Takeda and Frey, 1977; Bregitzer et al., 1987; in Peltonen-Sainio, 1996). The HI is one of the three yield correlated factors which varies depends from genotypes.

In the case of reaching the optimum leaf area index (LAI) rapidly, and maintaining it, is essentian for high yield. The relationship between leaf are duration (LAD) and grain yield are associate. The cereal breeders need to produce cultivars with a low proportion of sterile tillers has resulted in assimilate savings, that are likely to be invested in set of florets and spikelets in addition grain-fill (Evans, 1994).

The high-yielding have better growth rates and dry-matter accumulation during post-anthesis. This superiority requires increasing post-anthesis photosynthate production or an increasing ability to build up (stem) reserves.

The importance of the flag leaf as in assimilate source for grain filling is evident, not least due to the free capture of PAR and the short distance between the source and sink tissues. In the experiment of Bregitzer et al. (1987) (in Peltonen-Sainio, 1996) grain yield of oat lines was not related to the photosynthetic area above the uppermost leaf sheath, whereas in northen European growing conditions, plant breeding has increased flag leaf area by up to 40% during the last 60 years, and concomitantly grain yield has increased by 20-30% (Peltonen-Sainio, 1994).

Crop management has had a great impact on realization of yield potential. For example, use of plant growth regulators decreased flag leaf area, which may indicate reduced ability of this leaf, closest to the panicle, to support grain growth, whereas nitrogen is likely to have the oposite effect on green leaf area.

Genetic studies have focused on the selection of plant genotypes that are less subject to environmental stress factors to increase yield and yeild stability. The genetic variability plays an important role in determining positive adaptation to environmental stresses and, hance, in supporting the spread of various genotypes to extreme climatic conditions. The adaptation of the plants to drought environments has been studied for a long time. Newertheless, very few traits are considered to be important in breeding today, and we still need to understand the drought-resistance mechanism to develop new genotypes for drought areas.

The number of modifications of gene expression specific for cold or for drought response have also been observed. When barley plants are under reduction in water availability, the typical molecular response leads to the accumulation of dehydration related proteins called dehydrins. These polyptides are comprise 15 amino acid domine rich in lysine. In many dehydrins domain rich in serine. In barley 10 dehydrin genes have been idnetified. Genes *dhn1* and *dhn2* are located at the chromosome 7, while *dhn3*, *dhn4* and *dhn5* at the chromosome 6 (Huen et al., 1991) and *dhn6* at the chromosome 4 (Zee et al., 1995; in : Peltonen-Sainio, 1995). Recently van Zee et al. (1995) found that only *dhn5* among dehydrin gene family, besides the induction by ABA or drought, is also expressed under low temperatures. In barley a large number of ABA - regulated and drought-induced genes are known; however, several non-ABA-regulated genes have also been identified in response to desiccation or drought sterss. It is arguable whether all these genes are really expressed by cerel plants during their life cycle when a drought stress event occurs. The expression of dehydrin genes under field conditions requires a more severe water deficit or a greater rise in the ABA content than that produced by drought condition able to reduce plant yield of about 25% (Lacerenza et al., 1995; in: Peltonen-Sainio, 1995).

Cereals are affected by a range of economically important deseases that may reduce both yield and quality. Pests and deseases of cereals are as old as agriculture itself. Leaf deseases are considered to be a limiting factor in wheat production. This is more important in high-input agriculture in concrete environments. Efforts to improve disease resistance in breeding programs has often been a second priority compared to yield. For the most crop plant cultivars a main attention is being given to improvement and stability of yield through the incomporation of desease resistance genes. Currently, DNA - based markers for genes imparting resistance to stem, leaf and stripe rusts, powdery mildew, scald, net blotch, BYDV have been identified. Markers assisted selection in improvements for resistance disease. Especially greatest impact of marker assisted selection will be for the effective utilization of resistant genes from wild relatives. With recent advances in molecular biology it will be easy to overlook the potential influence of the other factors on plant diseases.

The more we need study diversity and activity of microorganisms living in soil, the better our chances to exploit these organisms for our own use. For example, farmers have long used rhizobium inoculants to reduce nitrogen fertilizer inputs. They accomplish this by exploiting the nitrogen fixation potential of the legume rhizobium symbiosis. Rhizobia inoculants are produced commercially and successfuly marketed because we understand how this plant microbe system works, and we can identify and explain the factors responsible when it does not work. However, we do not fully understand how all plant growth promoting rhizobacteria (PGPR) as biofertilizers work and why they are not always effective. Additional research will resolve these issues. Furthemore, because producers and the industry seek alternatives to chemical imputs, commercial production and marketing of various microbial inoculants as "biofertilizers" is now recognized as a growing agbiotech industry.

Root storage is important in some legumes and other species and other species, there is no evidence that roots or leaves are as important as stems for reserve storage in the small grains. There are a lot of reports of stem reserves in the small grains, stems also include the leaf sheats, which in themselves contains reserves (Dubois et al., 1990). Under dryland field conditions only half the amount of water soluble carbohydrates was avaulable for remobilization during grain filling, as compared with irrigated conditions. When ambient CO_2 concentration was raised to increase assimilation, more carbon was stored in the stems (Winzeler et al., 1989). On the other hand, some studies with wheat did not find a strong negative relationship between yield potential and reserve utilization for grain filling (Blum et al., 1994; Davidson and Chevalier, 1992).

Conclusions

Flag leaf area were studied in diallel crosses (4x4) without reciprocals of wheat genotypes (Jugoslavija, Zitnica, NS Rana 2 and Osijecanka).

The cultivars and F_1 and F_2 hybrids expressed significant differences in flag leaf area.

The mode of inheritance of flag leaf area in F_1 was overdominance. In F_2 mainly partial dominance were established.

The analysis of combining ability showed that both additive and non-additive gene actions were present in the inheritance of flag leaf area in F_1 and F_2

The best general combiner for flag leaf area was Zitnica cultivar.

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UTICAJ POVRŠINE LISTA NA ADAPTIVNOST PŠENICE NA STRESNE USLOVE

-originalni naučni rad-

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Rezime

Površina lista ima važnu ulogu u procesu fotosinteze i ostvarivanja visokog prinosa zrna. Fotosintetska površina svojom aktivnošću može direktno uticati na povećanje prinosa preko broja klasaka i broja fertilnih cvetova ili indirektno preko povećanja mase korena. Utvrdjeni podaci u ranijim istraživanjima su pokazali da dužina trajanja fotosintetski aktivne površine lista i indeks površine lista imaju pozitivnu vezu sa sintezom suve materije i prinosa, a samim tim i sa tolerancijom na uslove stresa. Ovim istraživanjima su obuhvaćene 4 genetički divergentne sorte pšenice, koje su uključene u ukrštanja po principu dialela i F_1 i F_2 hibridi nastali u ovim ukrštanjima. U izučavanjima je fokusirana genotipska varijabilnost za površinu lista zastavičara, kao determinante za odabiranje genotipova sa većom adaptivnošću na stresne uslove. Osim toga izučavane su kombinacione sposobnosti za ovu osobinu, pri čemu su analize F_1 i F_2 hibrida pokazale da sorta Žitnica ima najveću pozitivnu vrednost a time i najbolju opštu kombinacionu sposobnost. Ustanovljeno je da su za oplemenjivanje pšenice na ovo svojstvo perspektivni F_1 hibridi Žitnica x NS Rana 2 i NS Rana 2 x Osiječanka, kao i F_2 hibridi nastali u kombinaciji Jugoslavija x NS Rana 2.

Na osnovu dosadašnjih znanja može se reći da u procesu oplemenjivanja i odabiranja genotipova treba posvetiti posebnu pažnju nasledjivanju morfofizioloških osobina, kao što je površina lista zastavičara. Takodje treba nastaviti genetička izučavanja o prirodi aktivnosti gena u ekspresiji površine lista zastavičara, koji ima važnu ulogu u procesu nalivanja zrna i formiranju prinosa, a koji može doprineti većoj adaptivnosti na uslove stresa vazdušne i zemljišne suše, saliniteta i drugih stresnih faktora spoljašnje sredine.