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Regulation of carbon metabolism under the damage of sink-source relations in wheat genoteypes

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Introduction

Much attention is paid today to the study and decoding of mechanisms regulating photosynthesis and photosynthetic carbon metabolism in order to optimize productive processes and to form high yields. However, it is clear drawing any correlation between photosynthesis and productivity depends on a more complete understanding of carbon partitioning within the leaf and of the subsequent translocation of assimilates via the phloem to sink (Geiger and Servaites, 1994; Grodzinski et al., 1998). Yet, the data available on the effect of assimilates export variation on the intensity of photosynthesis and photosynthetic carbon metabolism has an extremely contradictory character. In this connection we have made a comprehensive study of the activity of the key enzymes of photosynthesis, i.e. carbonic anhydrase, RBPCO, PEP-carboxylase, as well as that of assimilates export are changed artificially by way of excising the bottom leaves or half the ear.

Materials and methods

Various wheat genotypes grown at the experimental station of the Azerbaijan Institute of Agriculture have been used in the experiments. The contrast genotypes of winter wheat such as *Garagylchyg-2*, a low-stature variety of the intensive type with good architectonics and a potential yield of 60-70 centers of hector, and *Gyrmyzy bugda*, a high-stature variety of the extensive type with a potential yield of 30-35 centers per hector have been selected for the study.

The activity of carbonic anhydrase has been determined by the electrometric method (Wilbur and Anderson 1948), the activity of RBP-carboxylase and that of PEP-carboxylase - by the spectrophotometric method, the activity of RBP-oxygenase - by the amperometric method (Romanova 1980), and the photosynthetic carbon metabolism, transport and assimilate distribution - by the radiometric one.

Results and Discussion

The results obtained have shown that the disturbance of source-sink relations in various wheat genotypes brought about by the excision of part of the ear or bottom leaves results in the variation of both the enzyme activity and the rate of label inclusion into the products of photosynthesis and utilization. A day after the excision of bottom leaves in the *Gyrmyzy bugda* - low productive genotype considerable decrease in the activities of RBP-carboxylase (**Fig.1**, I), RBP-oxygenase (**Fig.1**, II) and PEP-carboxylase of the flag leaf as compared with the control plant could be observed. The activity of those enzymes is gradually increasing for the days following the excision and exceeds the activity of the enzymes of the control plants.

As it has been seen in **Fig.1**, the activity of the said enzymes in the high-productive genotypes increased for the first days after removing bottom leaves and decreased later and did not differ notably from the control plants.

The observed change in the rate of ^{14}C-inclusion into sucrose and glycine+serine after excision bottom leaves has an opposite character both in the high productive genotypes and in the low productive one. The excision of ear parts in the *Gyrmyzy bugda* low productive genotype results in decrease of activity of all the enzymes studied, while in the high-productive genotypes it brings about decrease only in the activity of RBP-carboxylase and that of PEP-carboxylase. In the experimental plants the activity of carbonic anhydrase and that of RBP-oxygenase did not decrease, on the contrary increased to some extent. The data obtained indicate that every genotype is likely to be characterized by a definite value of the RBP-carboxylase/oxygenase relation and the variation in this relation brought about by the effect of various factors has a temporal character.

The study of the transport of assimilates from flag leaves and their distribution to various wheat parts under variation of source-sink relations has shown that irrespective of the version of experiment the low-productive genotype exports its assimilates from the flag leaf practically in the same manner (up to 70-80%). Though there are some data available in literature that are indicative of the intensification or inhibition of the assimilates outflow from the rest of the leaves after the excision of part of the leaf surface or that of the ear respectively (Habeshaw, 1973; Hofstra and Nelson, 1969). The excision of part of the ear resulted in a considerable decrease in the quantity of assimilates coming to the ear, with the content of assimilates in the stem being about twice as large as that in the control plants. This indicates that the stem in the *Gyrmyzy bugda* low-productive genotype becomes a chief consumer of assimilates after the excision of part of the ear or that of bottom leaves. It should be noted that the excision of bottom leaves from low-productive genotypes results in influx of assimilates to the ear from the flag leaves (Table 1)

Table 1. Transport and distribution of assimilates of various parts of wheat genotypes (after 24 hours since excision of bottom leaves or half ear)

Genotypes	**Gyrmyzy bugda**			**Garagylchyg-2**		
Experiment options	Control	Bottom leaves excised	Half ear excised	Control	Bottom leaves excised	Half ear excised
Parts of plant	%	%	%	%	%	%
Ear	32.7–1.3	14.34–0.6	10.27–0.4	47.44–1.9	51.78–2.0	20.38–1.1
Stem	41.52–1.2	51.88–1.6	1	31.56–0.9	31.15–1.3	42.57–1.2
Flag leaf	5	28.06–1.4	61.43–1.2	17.9–0.9	14.7–0.6	30.2–1.1
The other leaves	22.64–0.7	-	3	0.16–0.1	-	0.71–0.04
Root	0.64–0.03	5.72–0.28	23.97–0.8	2.94–0.1	2.37–0.1	6.14–0.4
	2.5–0.1		0.85–0.04			
			3.48–0.1			

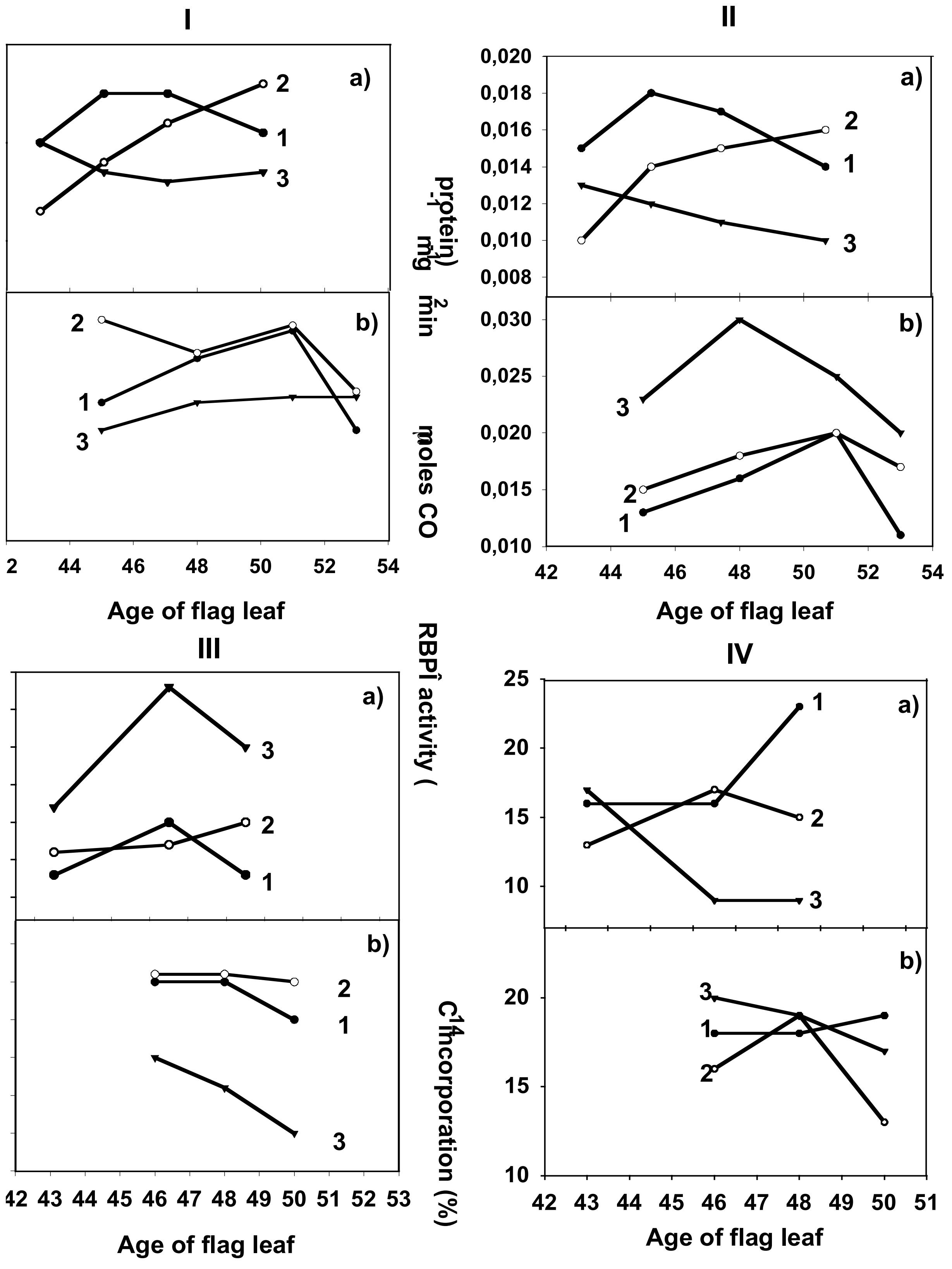

Figure 1. Variations in activities of RBP-carboxylase (1), RBP-oxygenase (II), incorporation of 14C into sucrose (III), into glycine+serine (IV) in flag leaf at grain maturation stage with disturbance of source-sink relations in wheat genotypes: a) *Gyrmyzy bugda*, b) *Garagylchyg-2* 1) control; 2) excision of bottom leaves; 3) excision of half ear.

The results show that the rate of assimilate export from flag leaves in the high-productive genotype *Garagylchyg-2* differs from that of the low-productive genotype *Gyrmyzy bugda*. The excision of the ear part in Garagylchyg-2 considerably decreased the export of assimilates to the ear from the flag leaves. That was accompanied by a simultaneous increase in the influx of assimilates to the other parts. The excision of bottom leaves in the said genotype practically did not affect the intensity of assimilate export from the flag leaf, even the influx of assimilates to the ear increases to a certain extent. This once again points to the dominant role of the flag leaf in the formation high production of intensive varieties. The high attractive ability of the ear in the said genotypes seems to be great significance. The results obtained prove that the reduction of leaf surface in the wheat genotypes studied practically does not affect the intensification of the outflow of assimilates from the flag leaf. The inclusion of ^{14}C into the products of glycolate cycle at an artificial in the shift of source-sink relations accords with the change in the activity of the RBP-oxygenase enzyme. Thus, the data illustrated prove that the enzymes studied participate in adaptation processes in plants under various environmental conditions. In the low-productive genotype as well as in high-productive one the process of adaptation to new environmental conditions has both common and distinctive features brought about by their genotypical peculiarities.

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