Short Communication

Post-anthesis changes in internodes dry matter, stem mobilization, and their relation to the grain yield of barley (*Hordeum vulgare* L.)

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Abstract

Making an increase in the yield of agricultural plants including barely is considered as the main challenge for researchers in agriculture related sciences. Water-soluble carbohydrates transport and source–sink relations have a significant effect on the grain yield. This study was carried out in order to examine genotypic variation of storage and remobilization ability of carbohydrates in eighteen developed and two commercial varieties of barley. The study was arranged in a complete randomized block design with three replications. Samples were collected at anthesis and 14, 21, and 28 days after anthesis. Dry matter and length of peduncle and penultimate, and other physiologic and morphologic characters including leaf area index and SPAD number were examined in different stages after anthesis. At the maturity, grain yield and its components were measured. A positively significant correlation was observed between the dry matter of the last two internodes during grain filling and the rate of stem remobilization and grain yield. According to the findings, a high level of variability rate of stem remobilization was observed in different barley genotypes which can be used in barley breeding program.

Keywords: barley; grain yield; stem remobilization; source–sink relations

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Introduction

The green plants' ability to produce photosynthetic materials and transfer them to the filling grains is considered as an effective factor in economic function of most agricultural plants including barely (Wardlaw, 1990). Since an increase in leaf age and falling and other photosynthesis limiting factors decreases the level of stored materials, carbon can be supplied through other resources including stored carbohydrates in stem. Two last internodes

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(peduncle and penultimate) play more important role in remobilization of stored carbohydrate (Ehdaie, 1996). Cereals stem storages mostly consist of water-soluble carbohydrates (WSC). WSC are the main source of transportation, particularly when drought stresses constrain photosynthesis (Foulkes, 2007; Plaut, 2004; Takai, 2006). During vegetative and reproductive growth stages of cereals, carbon fixed in the leaf sheath and stem is stored as carbohydrates which mostly can transfer to the seed through remobilization process. This kind of remobilization has a main contribution in the final grain yield in wheat and barley (Blum, 1998; Housley, 2000). This study examines and analyses the post-anthesis changes in internode dry matter, stem mobilization variation and their relation to the grain yield of Barley.

Materials and Methods

A field trail was performed at *Seed and Plant Improvement institute of Iran* – Karaj (SPII). The study was carried out in a complete randomized block design with three replications on 20 varieties of barely including eighteen advanced lines and two cultivars. At initiation of anthesis (pollination 0%) and 14, 21, and 28 days after anthesis (DAA), five main tillers were harvested and divided into spike and stem; then leaf sheaths were removed from the stem. Each stem was divided into three segments, namely, peduncle (first internode below the spike including the distal node), penultimate (next-to-last internode), and the lower internodes. The dry matter and length of peduncle and penultimate were examined. The rate of mobilization in each internode segment was estimated as the difference between post-anthesis maximum and minimum dry matter (Ehdaie, 2006; Bonnet 1993). Leaf area index (LAI) (using AccuPAR model LP-80, Decagon Devices Inc.) and flag leaf SPAD number (Minolta, Japan) were measured 14 and 28 days after anthesis.

Table 1
Analysis of variance for morphological and physiological traits of twenty genotypes of barely in a field trail.

	df	Leaf Area Index	SPAD No.	Peduncle		penultimate	
				Length	Dry matter	Length	Dry matter
Replication	2	0.29	31.54	3.77	0.002	10.83	0.0005
Genotype	19	2.23**	56.14**	55.19**	0.007**	27.56**	0.007**
Error	38	0. 79	20.86	10.32	0.001	3.99	0.001
Time	1	205.5**	4673.4**	6691.3**	0.36**	357.8**	0.22**
Time*Genotype	19	2.38**	37.21	10.15**	0.001**	4.009**	0.001*
Time*Replication	2	6.54**	14.91	4.90	0.0007	0.77	0.0005
Error	38	0.83	24.01	5.96	0.0008	1.52	0.0008
CV%		14.92	11.16	9.69	19.77	6.65	15.6

** and * significant at (P≤0.01) and (P≤0.05) respectively

Results

Based on variance analysis, there was a significant difference (P≤0.01) in physiological traits between various genotypes in each stage (Table 1). Weight and length changes of the last two internodes in different stages of sampling were determined and a significant difference was observed in these parameters (P≤0.05) (Table1). The last two internodes indicated a decrease in dry matter following an increase of weight. Accordingly, for both internodes, maximum weight was achieved in the 21 day after anthesis (Figure I). It was found that remobilization

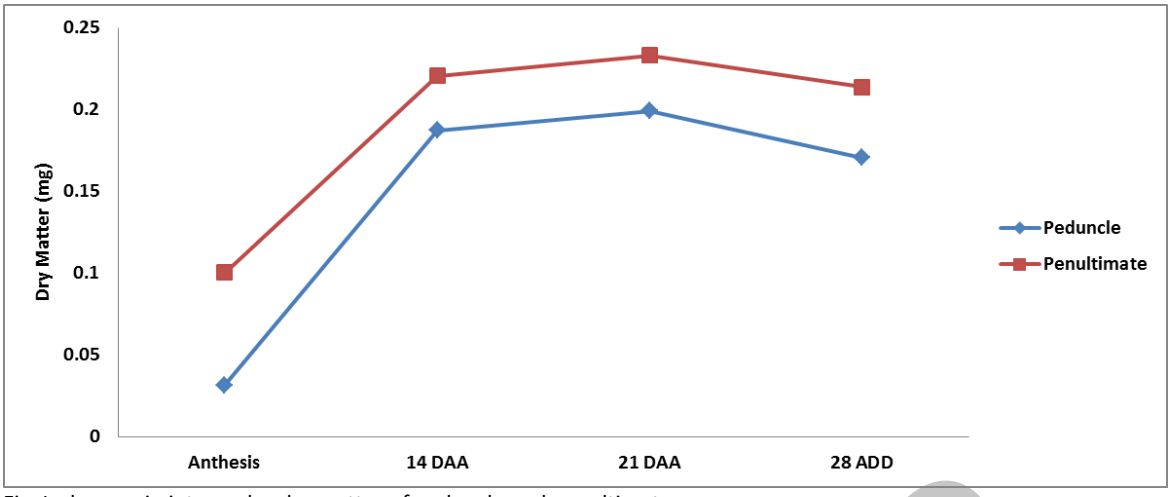

Fig. I. changes in internodes dry matter of peduncle and penultimate.

followed a determined model in internodes and this confirmed the findings of a previously reported study (Croz-Aguado et al., 2000).

Examination of post-anthesis remobilization in peduncle showed a wide variation among genotypes, so that, the maximum remobilization was observed in genotype 17 and the minimum in genotypes 11 and 12. Such variation was also observed in penultimate where genotypes 6 and 10 showed the maximum and genotypes 3, 12, and 14 the minimum remobilization (Fig. II). The relation between remobilization and grain yield and other characters was examined through the Pierson's correlation index and presented in Table 2.

According to present results, there were positively significant relations between grain yield and remobilization rates in the last internodes two (P≤0.05). In addition, there were positively significant relations between remobilization in peduncle and penultimate (P≤0.01). Finally, there were negatively significant relations (P≤0.05) between grain yield and the weight and length of peduncle and penultimate (Table 2).

Table 2
The Pierson's correlation index among different yield and remobilization and others traits of 20 genotypes of barely in a field trail.

Traits	Leaf Area Index	SPAD number	Grain yield	Peduncle length	Peduncle dry matter	Penultimate length	Penultimate dry matter	Remobilization of peduncle	Remobilization of penultimate
Leaf Area Index	1								
SPAD number	0.157	1							
Grain yield	0.070	0.186	1						
Peduncle length	0.058	-0.069	-0.284**	1					
Peduncle dry matter	0.116	-0.204	-0.249*	0.512**	1				
Penultimate length	-0.029	0.114	-0.173	0.536**	0.124	1			
Penultimate dry matter	0.119	-0.146	-0.077*	0.407**	0.795**	0.384**	1		
Remobilization of peduncle	-0.139	-0.281*	0.303*	-0.193	0.145	-0.242	0.037	1	
Remobilization of penultimate	-0.025	-0.076	0.448**	-0.105	0.011	-0.214	-0.128	0.508**	1

** and * significant at (P≤0.01) and (P≤0.05) respectively.

Discussion

Increase in grain yield of crop plants including barely in enviornmental stress is considered as a main challenge for the researchers in agriculture-related sciences. Water soluble carbohydrates stem storage, their transportation and the source – sink relations are effective factors in grain yield.

In present study, we observed a considerable variation among genotypes in post-anthesis remobilization contribution of two last stem internodes (peduncle and penultimate). An experiments on 11 varieties of wheats in two stress and watery enviornment showed a wide varitation for the rate of remobilization of genotypes (Ehdaie, 2006). Other studies reported the same results (Ehdaie, 1996; Xue, 2009). In 21th day after anthesis, the weight of both internodes reached to the maximum level (Figure I). It was found that remobilization followed a determined model in internodes and this confirmed the findings of a previously reported study (Croz-Aguado et al., 2000). It is noteworthy that in most of the studies there was no simple relation between storage and remobilization. This is due to the different factors and characters involved in the storage and remobilization process and the change of these factors in various species and environments (Ruuska, 2006). In fact, high level of storage does not necessarily lead to high level of remobilization. A close relation between source power, storage power and environmental conditions on one hand and remobilization and storage on the other justifies this relation. The current study on 2 lines and genotypes of barely in irrigated condition showed a wide genetic variety for storage and remobilization among barely genotypes. This means, it is possible to improve and breed genetic characters of different genotypes. This study is an introduction to research on

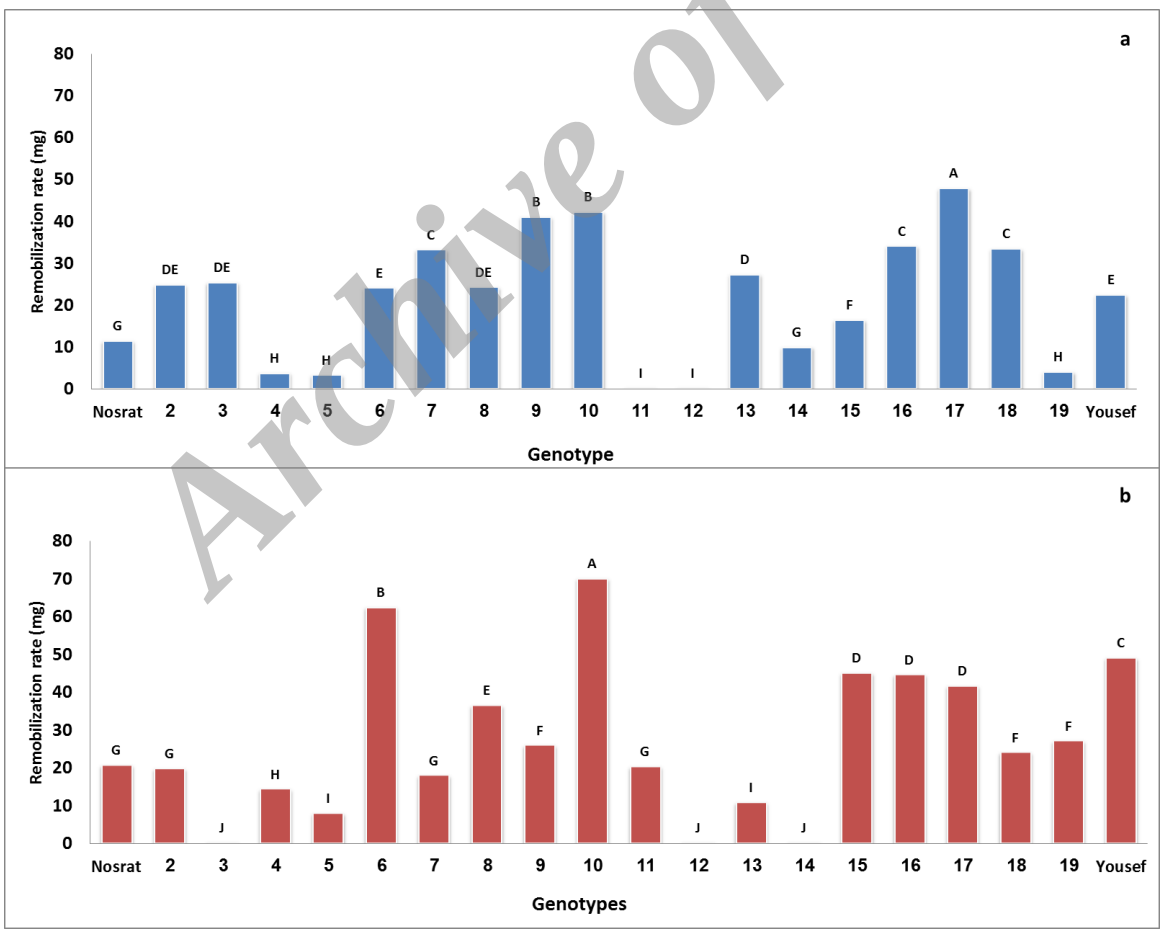

Fig. II. Comparing average rate of remobilization in peduncle (a) and penultimate (b) of 20 barely genotypes. The genotypes with similar letter(s) are not significantly different at 1% probability level, using Duncan's Multiple Range test.

remobilization and the effect of stem storage on grain yield of barely.

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