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Short Report

Quantification of vascular tissues in the peduncle of durum wheat cultivars improved during the twentieth century

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ABSTRACT The grain yield of wheat has augmented in the last century due mainly to the use of cultivars with increased higher yield capacity. This work analyzes if this genetic gains in yield has been accompanied by similar increases in the size of the vascular system in the stem. Significant differences were obtained for cultivars and dates of genetic improvement both in the area of the peduncle; area of the vascular tissues; and phloem and metaxylem areas. In spite of the large variations encountered for these characteristics between cultivars, no clear association was encountered between the genetic improvement and the magnitude of the vascular system in the peduncle of the spike, indicating that the amount of phloem in the modern varieties seems to be sufficient to sustain the maximum rate of grain growth. Nevertheless, the existence of a great genotypic variation in the vascular tissues of the peduncle found in this study could permit to improve the phloem transport capacity in durum wheat in the future.

Introduction

In the last century, the grain yield of wheat has increased by about 150% as a result of better crop management and the use of cultivars with higher yield potential. The main physiological changes associated with this increase in grain yield has been related with a bigger level of saturating light for photosynthesis, a lesser sensitivity to photoperiod, a longer duration of photosynthesis, a decrease in plant height and a higher harvest index, i.e., a better partitioning between grain and vegetative biomass (Austin *et al.,* 1980; Calderini *et al.,* 1999). Frequently, the capacity of the vascular system for mobilizing the assimilates to the growing grains have been pointed out as one of the causes that could limit the yield in cereals, specially under conditions that promote the development of a high photosynthetic capacity (Evans, 1993). However, little information is available about the modification in the capacity of the vascular system responsible for the translocation of assimilates from the leaves until the grains. The objective of this work has been to study the variation in the size of the vascular tissue of wheat cultivars released at different times since 1900, in order to ascertain if the genetic gain in wheat yield has been accompanied by a comparable increase in the ability for mobilizing the assimilates in the vascular system.

Materials and Methods

For this study, 24 cultivars of durum wheat (Triticum durum Desf.) obtained by genetic improvement since1900 until the present time have been used. These cultivars were grown under field conditions during the year 2000 according to an experimental design of randomized blocks with three replications.

To quantify the size of the vascular system, three stems by cultivar and replication were taken at the beginning of the linear phase of grain growth. Later in the laboratory, on each stem and by using a vibratome Polaron Watford, 5 serial cuts of about 25 micrometers of thickness were obtained in the peduncle at 2 mm below the spike. For each peduncle, three of these cuts were digitized with an Olympus-SZ11 binocular microscope equipped with a video camera JVC TK-C621. The transverse area of the peduncle, and the area of the vascular system, the area of phloem and the area of metaxylem in each cut were measured with the aid of the image analysis program Visilog v.4 (Noesis Visión Inc.). The data were studied by means of analysis of variance to verify the existence of significant differences between cultivars or genotypic improvement date.

Results and Conclusions

The analysis of variance revealed significant differences between the 24 cultivars for all of the parameters studied. Thus, the area of peduncle varied in about 48% between the minimum and maximum values obtained in the group of cultivars analyzed (Table 1). The range of variation in the cross-sectional area of the vascular bundles was of similar magnitude, being of 46, 53 and 60% for the vascular tissues, phloem and metaxylem areas, respectively (Table 1).

Significant differences between the dates of genetic improvement were also obtained in the analysis of variance. Nevertheless, the range of variation for the area of peduncle (38%) and for the area of phloem tissue (33%) encountered between dates, was of lesser extent than the observed for cultivars (Table 1). The percent

TABLE 1

RANGE OF VARIATION IN THE MEAN VALUES OF THE PARAMETER STUDIES OBTAINED FOR CULTIVARS AND FOR THE DATE OF RELEASING OF EACH CULTIVAR

	Area μm^2 ($x10^3$)			
	Peduncle	**Vascular tissues**	**Phloem**	**Metaxylem**
Cultivar	1223 – 2384	150.3 – 279.5	55.9 – 121.1	19.5 – 48.9
Date of releasing	1421 – 2298	169.6 – 320.5	61.5 – 91.9	21.9 – 48.9

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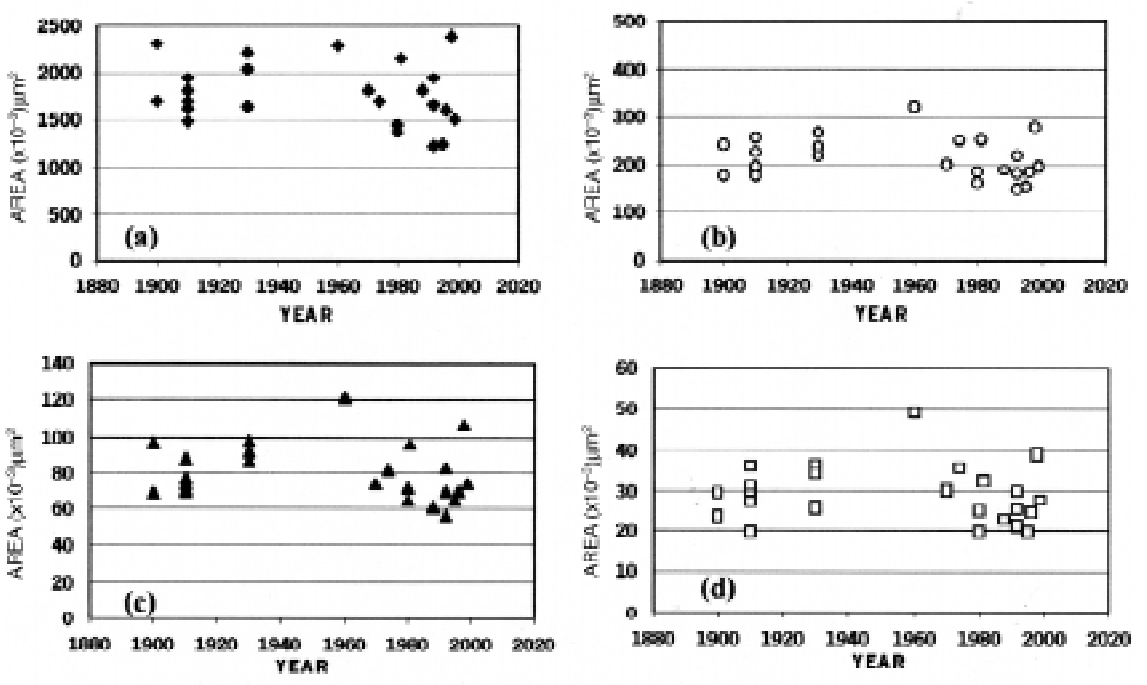

Fig. 1. Chronological evolution of vascular characteristic in durum wheat. (a) *Area of the peduncle;* **(b)** *Area of vascular tissues;* **(c)** *Phloem area;* **(d)** *Metaxylem area.*

of variation found in the area of vascular tissue (47%) and area of metaxylem (55%) was, however, very similar to that observed between cultivars (Table 1).

In spite of the large variations encountered in this study for all of the vascular parameters, a clear association has not appeared between the timing of genetic improvement of the cultivar and the magnitude of its vascular system. Figure 1 shows the chronological evolution of the four vascular characteristics studied. In all of the cases could be seen that the new cultivars have similar values in the area of both phloem and metaxylem that the oldest cultivars.

These results indicate that during the last century, the genetic improvement in grain yield of durum wheat has not modified the size of the vascular system for the mobilization of assimilates to the grains. This could probably has been due to the fact that in the ancient process of domestication of wheat from wild to cultivated forms, the cross-sectional area of phloem was already increased by over a 16-fold range (Evans *et al.,* 1970). This amount of phloem, therefore, seems to have been sufficient to sustain the maximum rate of grain growth in the actual cultivars. Nevertheless, the existence of a great genotypic variation in the vascular tissues of the peduncle, as reveal in this study, could permit the use of these characteristics to improve the phloem transport capacity in durum wheat in the future, if necessary.

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