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INITIAL VIGOR IN WHEAT GERMOPLASM (*TRITICUM* SPP)

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Abstract: The scarcity of water and the low profitability of wheat cultivation will force in the short term to use conservation tillage systems that include the retention of residues on the surface to promote optimal establishment and greater leaf development of the seedlings that increase competitive aptitude. against weeds and increase water use efficiency by avoiding losses through evaporation. Given this new panorama, the use of wheat genotypes (Triticum spp.) with characteristics of greater initial vigor that are more competitive when planted in soils with residues on the surface will help the adoption of this system. The objective of the present study was to determine the characteristics of initial vigor and its association with plant height in wheat genotypes. For this purpose, the length of the coleoptile and the leaf area of the first three leaves of 414 wheat genotypes were measured. The length of the coleoptile of the genotypes fluctuated between 3.9 and 11.3 cm, the most frequent class was between 7.1 and 9 cm in length with 206 genotypes. Durum wheats had longer coleoptiles than bread wheats. Plant height and average leaf area of the first three leaves were positively associated with coleoptile length.
Keywords: Coleoptile, leaf area, conservation agriculture, irrigation, height.

INTRODUCTION

Under conservation tillage sowing systems, genotypes with greater initial vigor (long coleoptiles and high specific leaf area) have competitive advantages by promoting optimal establishment and greater leaf development of the seedlings. Richards (1992) points out that the

The shorter height of current semi-dwarf wheats is due to the use of height-reducing genes insensitive to gibberellic acid. These genes reduce the height of the plant but also the size of the cells of leaves and stems, as well as the length of the coleoptile and the leaf area of the seedlings (Hoogendoorn et al., 1990). Poor initial vigor causes poor emergence and reduction of leaf area, reducing competitiveness with weeds, which causes considerable water losses through soil evaporation, which can reduce yield. Lemerle et al. (1996) reports differences between wheat varieties and their competitive ability with grasses, which is associated with plant height, leaf shape and size, and leaf area index. In the case of cereals, it has been observed that varieties with high soil cover (prostrate growth habit) reduce weed emergence (Andrew et al., 2015). On the other hand, it has been shown that modern semi-dwarf wheat cultivars are much less competitive against weeds than traditional cultivars (Wicks et al., 1994). However, subsequent studies indicate that the height of the plant alone is not the most important characteristic, if it does not create a dense and homogeneous canopy, which prevents as much as possible the passage of light to the lower strata through the herbs, since There may be the case of a short variety that produces abundant foliage and therefore competes better than a tall variety (Cosser et al. 1997).

Conservation tillage or direct sowing without prior land preparation or mechanized work during the crop cycle, leaving at least 30% of the soil surface covered with crop residues, allows reducing water and wind erosion of the soil (Tiscareño et al. 1999), gradually increases the organic matter content of the arable layer and provides nutrients to the soil (Moldenhauer et al., 1994). Additionally, no-till increases water infiltration and reduces evaporation (Unger and Weise, 1979). In Mexico, the adoption of CA has been limited, and until the 2008-2009 cycle it covered approximately 1% of the agricultural surface, which is equivalent to around 22,800 ha (Valerio et al., 2016). The trend is towards increase since this system improves the planting opportunity and makes grain production more profitable by reducing investment costs.

Given this new panorama, the use of wheat genotypes (Triticum spp.) with characteristics of greater initial vigor that are more competitive when planted in soils with residues on the surface will help the adoption of this system. The initial vigor of seedlings is crucial for their establishment and subsequent production of biomass and grain (Steege et al., 2005). Greater initial vigor can increase water use efficiency by up to 25% (Siddique et al., 1990). This trait can be selected to improve performance under water stress (Richards et al. 2002). Initial vigor traits that reduce soil evaporation and that can increase light interception and competitiveness of the wheat crop during early development are: seedling leaf width, coleoptile lengths, leaf area, and tillers. long coleoptile (Stummer et al., 2023). These characters are associated with increasing early leaf development (increased vigor) so that the crop canopy develops as quickly as possible and the soil surface is shaded, avoiding losses through evaporation, allowing more water to its use in perspiration (Mullan and Barcelo Garcia, 2012).

Current semi-dwarf wheats owe their lower height to the reducing genes Rht1, Rht2 and Rht3 that are insensitive to gibberellic acid (Khalid et al., 2023). These genes reduce plant height but also decrease leaf and stem cell size, coleoptile length, and seedling leaf area (Hoogendoorn et al., 1990). The short coleoptiles of current semi-dwarf wheat varieties do not adversely affect yield in humid or irrigated environments. However, short coleoptiles can reduce yield through poor establishment in dry or rainfed environments (Du et al., 2018). A reduction in coleoptile length leads to poor emergence when seed is sown deep, when soil moisture near the surface is insufficient for germination or when planting equipment is not properly adjusted (Richards et al. 2002). Shorter coleoptiles also make emergence more difficult in the no-till, surface residue conservation tillage system (Chastain et al., 1995). Poor initial vigor causes poor emergence and reduction of leaf area, reducing the competitiveness of the crop with weeds and yield (Amram et al., 2015).

Since the 1960s, some competitive characteristics of tall varieties of wheat (traditional varieties) have been lost, given that current agriculture promotes the planting of homogeneous semi-dwarf varieties, which are managed with high densities and doses of fertilizers, irrigation and chemical weed control. Although homogeneous crops are appropriate for technical agriculture, they have disadvantages in environments where tillage systems with residue retention are practiced, where it is important to maximize the development of the leaf area of the seedlings to reduce soil water losses through evaporation and to reduce competition with weeds. The use of genotypes with greater initial vigor will contribute to the adoption of conservation tillage systems. For this reason, small grain cereal improvement programs must consider among their goals the improvement of initial vigor characteristics, to release as commercial varieties the genotypes that are more competitive when planted in soils with residues on the surface. In Mexico, the information available on the characters, coleoptile length and leaf area of wheat seedlings in the country is scarce, so this work aims to evaluate the initial vigor characteristics (coleoptile and leaf area) of wheat seedlings. bread and durum wheat for irrigation and determine its association with plant height with a three-watering schedule.

MATERIALS AND METHODS

The results of this work were obtained from three experiments carried out at the INIFAP Bajío Experimental Field located in Celaya, Guanajuato (20° 32' N; 100° 48' W; 1752 masl; with average annual precipitation and temperature of 578 mm and 19.8°C, respectively) (Ledesma et al., 2023). In the first experiment, 414 genotypes, 39 crystalline and 375 flour, were planted in the autumn-winter cycle with a three-watering schedule (0-45-75 days after sowing). The experimental plot was made up of 2 double-row furrows 3 m long and 0.75 m apart. The sowing density was 120 kg ha-1 and it was fertilized with the 240-60-00 formula, half of the nitrogen and all of the phosphorus at sowing and the rest of the nitrogen in the first aid irrigation. The 414 genotypes were evaluated in experiments with different numbers of treatments using randomized block designs with three repetitions. Plant height was taken in cm (AP), measured from the soil surface to the terminal spikelet without considering edges.

In the second experiment, the length of the coleoptile, the length and breadth of the first three leaves and the average leaf area of 414 wheat genotypes that have the major genes for height reduction Rht1 and Rht2 were evaluated. Germination and coleoptilar development of wheat genotypes were promoted in the following way: two towels (30 x 25 cm sheets of paper for germination) were spread on a flat surface, a line was drawn on them with a pencil and on From this, a little glue was applied (non-toxic latex rubber), 15 seeds per genotype were placed, subsequently, they were rolled into a "taco" shape and moistened in a solution with Metacaptan at a dose of 1 g L-1. The "tacos" were placed vertically in plastic bags and the bags in trays, which were placed in the incubation chamber for nine days at a temperature of 22 °C, in order to allow maximum development of the coleoptiles. Nine days after sowing, measurements were made of the coleoptiles of ten seedlings per block.

In the third experiment, the 414 genotypes were sown in 200-cavity germinating boxes in a shade house. The broad and long of the first three leaves and the average leaf area were evaluated. 10 plants per genotype per repetition were planted, using a completely randomized design with four repetitions. To fill the germination boxes, the Sushine R substrate mix 3 was used. It was watered daily up to two times according to the needs of the plants. When the plants were in the stage of two expanded leaves (11 of the code of Zadoks, et al. 1974), the foliar fertilizer Nutriplan Plus R was applied, at a dose of 1 L in 200 L of water, to promote the vigorous development of the seedlings. At the stage of three ray leaves (14 of the code of Zadoks et al. 1974), the maximum length and broadness of each of the leaves was measured; Leaf area was estimated from the product of length times broad of all leaves correcting for leaf shape with the correction factor of 0.8 (Rebetzke and Richards, 1999).

The genotypes were classified according to coleoptile length into five classes: < 5, 5 to 7, 7.1 to 9, 9.1 to 11 and > 11 cm. Phenotypic correlations were obtained between these five classes of length of the coleoptile with the characters, average leaf area of the first three leaves and plant height.

The average leaf area of the three leaves was correlated with the long and broad characteristics of each of the leaves and with the average length and broad of the three leaves. In addition, these characters were correlated with coleoptile length and plant height. Graphs were made between the characters that had higher correlations.

With the plant height information, five groups of genotypes <80, 81-85, 86-90, 90-95 and >95 cm were made.

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Phenotypic correlations were run with the data to determine the association between these variables.

RESULTS AND DISCUSSION

COLEOPTILE LENGTH

Figure 1 shows the frequency histogram where it was classified into five classes < 5; 5.1 to 7; 7.1 to 9; 9.1 to 11 and > 11 cm, the length of the coleoptile of the wheat genotypes evaluated. The most frequent class was the coleoptiles of 7.1 to 9 cm in length, followed by the class of 9.1 to 11cm, these two classes comprised 87.4% of the total genotypes. The least frequent class was coleoptiles longer than 11.1 cm, with only two genotypes; The line with the longest coleoptile recorded 11.3 cm and the one with the shortest 3.9 cm. Richards et al. (2002) obtained coleoptiles in wheat with a range of 6.0 to 14 cm in length; although, in semi-dwarf wheats with the Rht1 and Rht2 genes the variation observed was only 6.0 to 9.0 cm in length. The highest values were observed in wheat with dwarfing genes Rht8, Rht9 sensitive to gibberellic acid. In this research, 30 genotypes were found with coleoptiles greater than 9 cm in length, including two of them greater than 11 cm; The observed variation indicates that it is feasible to increase coleoptile length by selection in wheat populations with height genes insensitive to gibberellic acid, as suggested by Beharev et al. (1998).

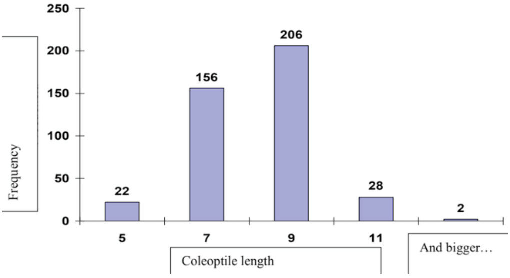

Figure 1. Classification of coleoptile length into five classes: < 5; 5.1 to 7; 7.1 to 9; 9.1 a11 and > 11cm of 414 wheat genotypes.

The length of the coleoptile correlated ($p \leq 0.05$) positively with the plant height groups, which indicates that the taller genotypes have longer coleoptiles. When running a regression analysis (Figure 2), a greater fit was observed with the quadratic model (R2 = 0.9602) than with the linear model (R2 = 0.8041). The model indicates that for every cm that the genotypes are taller they will have 0.3123 cm longer coleoptiles, in the range of 80 to 95 cm in height, after this height there will be a decrease of 0.0016 cm in the coleoptile for each cm that is increased. the plant height. Lemerle et al. (1996) reports differences between wheat varieties and their competitive ability with grasses, which is associated with plant height, leaf shape and size, and leaf area index. In the case of cereals, it has been observed that varieties with high soil cover (prostrate growth habit) reduce weed emergence (Bruce et al., 2022). On the other hand, it has been shown that modern semi-dwarf wheat cultivars are much less competitive against weeds than traditional cultivars (Wicks et al., 1994). However, subsequent studies indicate that the height of the plant alone is not the most important characteristic, if it does not create a dense and homogeneous canopy, which prevents as much as possible the passage of light to the lower strata through the herbs, since It may be the case that a short variety produces abundant foliage and therefore competes better than a tall variety (Cosser et al. 1997).

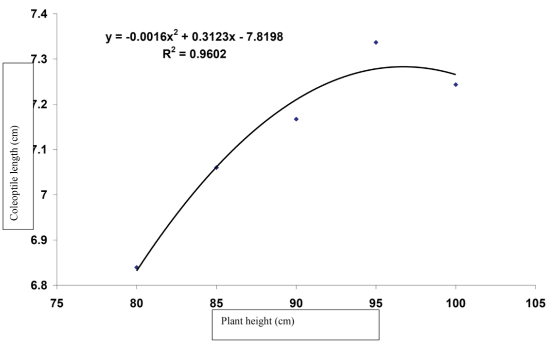

Figure 2. Association between plant height and coleoptile length in 414 genotypes of bread and durum wheat.

Table 1 shows the comparison of means between durum and bread wheat. Durum wheats recorded longer coleoptiles than flour wheats ($p \leq 0.05$), which agrees with the results obtained by Trethowan et al. (2001). This association is due to the positive relationship that exists between the weight of a thousand grains with the length of the coleoptile since durum wheats generally have heavier grains than flour wheats.

Wheat type	Coleoptile length (cm)
Crystalline	8.5 a
Flour miller	7.1 b
DSH	0.4

Table 1. Comparison of coleoptile length means of bread and durum wheat genotypes.

LEAF AREA

Rapid ground cover by the canopy is a desirable trait in the early stages of growth in low rainfall areas. Rapid canopy growth reduces evaporation from the soil surface, increasing crop water use efficiency (Richards et al., 2002). Under more favorable conditions, rapid canopy growth increases the competitiveness of the crop with weeds due to light interception (Lemerle et al., 1996). Furthermore, Zhao et al. (2019) showed that rapid leaf area growth in wheat is positively correlated with biomass area and grain yield.

Table 2 shows the average length, breadth and leaf area of the first three leaves of 38 durum wheat genotypes. The length of the first leaf varied from 7 to 9.1 cm, that of the second from 9.5 to 12.3 and that of the third from 12 to 15.8 cm. The average broadness of the three leaves fluctuated between 0.4 and 0.5 cm. The average leaf area of the first three leaves was in the range of 2.7 to 5.8 cm2.

Character	Averages	Standard deviation	Minimum	Maximum
Long H1 (cm)	8.1	0.6	7	9.1
Broad H1 (cm)	0.4	0.0	0.3	0.4
AF H1 (cm2)	2.7	0.3	2.1	3.3
Long H2 (cm)	10.7	0.7	9.5	12.3
Broad H2 (cm)	0.4	0.0	0.3	0.5
AF H2 (cm2)	3.8	0.4	3	4.6
Long H3 (cm)	14.1	1.1	12	15.8
Broad H3 (cm)	0.5	0.0	0.4	0.6
AF H3 (cm2)	5.8	0.7	4.6	7.2

Table 2 Means of seedling vigor characteristics in 38 durum wheat genotypes.

H1=sheet1; H2=sheet2; H3=sheet3; AF= leaf area

Table 3 shows the means of seedling leaf characteristics of 376 bread wheat genotypes; The length of the first leaf varied from 5.3 to 11.7, that of the second from 7.5 to 16.7 and that of the third from 9.7 to 19 cm. The average width of the three leaves was similar to that of durum wheats between 0.4 and 0.5 cm. The leaf area fluctuated between 2.6 cm2 for the first leaf and 6.6 cm2 for the third leaf.

Character	Averages	Standard deviation	Minimum	Maximum
Long H1 (cm)	7.8	0.8	5.3	11.6
Broad H1 (cm)	0.4	0	0.3	0.6
AF H1 (cm2)	2.6	0.4	1.2	4
Long H2 (cm)	11.1	1.1	7.5	16.7
Broad H2 (cm)	0.4	0	0.3	0.5
AF H2 (cm2)	4.1	0.6	2.2	6.1
Long H3 (cm)	14.6	1.4	9.7	19
Broad H3 (cm)	0.5	0	0.4	0.6
AF H3 (cm2)	6.2	1	3.3	9.4

Table 3. Means of seedling vigor characteristics, in 376 bread wheat genotypes.

H1=sheet1; H2=sheet2; H3=sheet3; AF= leaf area.

The rapid development of leaf area and above-ground biomass, denoted as initial vigor, contributes to high production due to shading of the soil surface that reduces evaporation and leaves more water available for the crop. Greater initial vigor can increase seasonal crop water use efficiency by about 25% (Siddique et al., 1990), and is recognized as a selection alternative to improve production under water stress (Richards et al., 2002). In more favorable environments, initial vigor can be beneficial because it increases the plant's competitiveness against weeds, resulting in less need for herbicide use (Lemerle et al., 1996). The initial vigor of wheat is lower than that of other cereals such as barley (Zhao et al., 2019). However, no studies have been done between the characteristics of initial vigor between bread and durum wheat. When comparing the leaf area of these two species, no significant differences were obtained in this character (Table 4).

Wheat type	Leaf area: cm^2
Crystalline	3.7 a
Flour miller	4.0 a
DSH	0.45

Table 4. Comparison of leaf area means of bread and durum wheat genotypes.

The average leaf area of the three leaves in bread wheat had a significant correlation with the length of the coleoptile; This association means that in bread wheat the long coleoptiles genotypes have greater leaf area.

Figure 5 shows that for bread wheat, for every centimeter that the coleoptile increases, the average leaf area of the three leaves increases by 0.0908 cm^2.

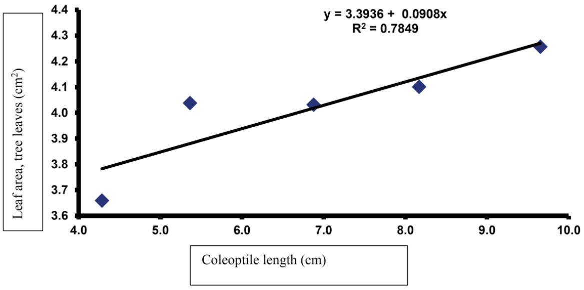

Figure 5. Relationship between the average leaf area of the three leaves with the length of the coleoptile in bread wheat.

The average leaf area of the three leaves of durum wheat had a non-significant correlation with yield; but it presented a significant positive correlation with the length of the coleoptile; This association means that in durum wheat the long coleoptile genotypes have greater leaf area.

Figure 6 shows that for durum wheat, for every centimeter that the coleoptile increases, the average leaf area of the first three leaves increases by 0.1953 cm^2

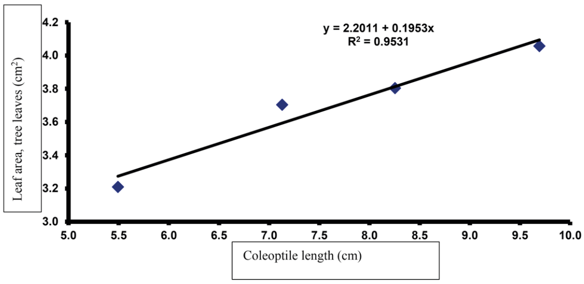

Figure 6. Association between the length of the coleoptile and the average leaf area of the first three leaves in durum wheat.

CONCLUSIONS

In the coleoptile length character, the most frequent range of the 414 genotypes evaluated was 7.1 to 9 cm. This trait correlated significantly and positively with leaf area and plant height. Durum wheats have longer coleoptiles than flour wheats.

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