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# The Comparison of Root Development and Some Agricultural Characteristics of Wheat Breeding Cultivars and Landraces

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**Abstract:** This research was conducted to compare root development and some agricultural characteristics of wheat breeding cultivars and wheat landraces in Diyarbakir ecological conditions in Application Research Farm, Faculty of Agriculture, University of Dicle, Turkey, during 2003-2004 and 2004-2005 growing seasons as randomized complete block design with 3 replications. Study materials consisted of Pehlivan, Svevo, Zenit, Firat-93 and Ege-88 durum wheat breeding cultivars, which are widely cultivated in the Southeastern Anatolia Region and Asure, Hevidi, Bagacak, Sorgul, Beyaziye and Mersiniye wheat landraces, which are cultivated in limited area of the same Region. Average values were calculated in wheat landraces and breeding cultivars for germination percentage (92.39 and 93.37%), primary root length (189.28 and 144.11 mm), the number of secondary roots (7.76 and 7.41), fresh root weight (2.55 and 1.99 g), dry root weight (0.229 and 0.198 g), the number of tillers at the beginning of winter (4.67 and 2.30), grain yield per plant (1.551 and 3.812 g plant$^{-1}$) and 1000 grain weight (39.82 and 44.07 g), respectively. At the end of the study, primary root length, the number of secondary root, fresh root weight, dry root weight, the number of tiller of the landraces were found to have higher values than those of breeding cultivars, but germination percentage, grain yield per plant and 1000 grain weight of the landraces were shown to be lower than those of breeding cultivars. According to experimental results, deeper and faster root development and over tillering can be often mentioned as characteristic features of landraces. Landraces gave the better performance in respect of rooting and tillering in the first stages of development than breeding cultivars, but they could not reflect these advantages to grain yield in latter stages of development. The first development traits of landraces should be evaluated in wheat breeding programs.

**Key words:** Wheat landrace, wheat breeding cultivar, primary root, secondary root, fresh and dry root weight, grain yield

## INTRODUCTION

Modern cultivars of wheat as well as of many other crops are often quite uniform, with relatively narrow genetic constitution. Therefore, the need of new sources of diversity for breeding is frequently discussed (Devkota and Shah, 1998; Moghaddam *et al*., 1997). Landraces that were created through a combination of natural selection and selection by farmers (Belay *et al*., 1995) have some valuable characters that can be utilised for improvement of new cultivars and broadening of their diversity (Tesemma *et al*., 1998; Keller *et al*., 1991). Landraces and obsolete cultivars usually comprise much broader intra-specific genetic diversity than modern cultivars; therefore, they are considered as a valuable part of gene pool (Zou and Yang, 1995; Vojdani and Meybodi, 1993). The diversity of landraces is a result of different soil and climatic conditions in various regions and is also strongly influenced by local practices and specific demands for product quality and other characters (Van Hintum and Elings, 1991). Tolerance to stresses (Xingpu *et al*., 1997) and yield stability are often mentioned as characteristic features of landraces (Tesemma *et al*., 1998).

Ehdaie and Waines (1989) reported significant genetic variability in spike productivity and tillering in wheat landraces. Xingpu *et al*. (1997) found wheat landraces resistant to stresses (frost, drought, salinity); Obari (1990) confirmed earliness and good adaptability of landraces to high temperatures. Good grain quality characters were also reported in some wheat landraces and obsolete cultivars and much broader diversity of quality characters can be expected in them than in the presently grown cultivars. Keller *et al*. (1991), Wang and Guo (1992), Rodriguez-Quijano *et al*. (1994) and Yang and Liang (1995) found a very high protein content in kernels of some landraces of common wheat.

Landraces are well adapted to environmental conditions since they are exposed to many years of selection in a specific area and can easily survive the harsh climatic conditions of extreme years. Landraces are generally cultivated in areas with high elevation and environmental stress, where dry farming is performed. Thanks to their resistance to extreme environmental conditions and some quality characteristics such as kernel color and vitreousness, high protein percentage, such landraces are cultivated by farmers for household consumption only in marginal areas.

Cereals such as wheat have two types of roots: seminal roots and crown or nodal roots. Seminal roots are produced from the base of the main stem at the seed shortly after germination. Upon germination of the grain, the primary root takes the lead, but very soon, two other roots appear on opposite sides of the first. To this whorl of three, still others may be added and together they constitute the primary root system. Later, the crown roots grow from the base of the crown beginning about the 4 leaf stage when tillers begin to form. Early in the development of the plant, roots of the secondary root system grow from nodes above the primary one. The number of roots increases somewhat in proportion to the number of tillers (Wechsung *et al*., 1995).

Robinson *et al*. (1994) observed that dry root weight and total root length of wheat during days 42-49 increased from 0.37-0.41 g plant$^{-1}$ and from 53.4-78.7 m plant$^{-1}$ in not Nitrogen fertilizer (N0) treatment; from 0.17-0.21 g plant$^{-1}$ and from 32.5-44.3 m plant$^{-1}$ in the N fertilizer (N+) treatment, respectively.

The relationship between the number of secondary roots and tillering rate cannot be ignored. Tillering and root development are closely related to temperature, moisture and soil characteristics. An important part of the wheat root system can develop at 12-16°C temperatures. At higher temperatures, surface organs are known to develop faster.

Early root development increases winter resistance of the plant and decreases the damage sustained by drought and speeds stemming and fertilization in such a way as to encourage early development. Resistance to winter and cold are believed to depend on the amounts of the chemical components in root, including dry materials (particularly sucrose and glucose). Thus, winter resistance of the plant depends on the dry material amount of the root rather than the leaves. In addition, water-stress affects development of under-soil and surface organs of plant (Yilmaz and Konak, 2000). Sade *et al*. (2003) suggested that lack of sufficient nutritional elements in the soil has negative impacts on root development and improvement. However, such negative impacts are not so pronounced as the damage to surface organs.

Koc (1993) stated that as the light intensity increases, the flag leaf photosynthesis speed of landraces increases more than that of breeding cultivars and that Beyaziye, Menceki and Bagacak perform best in terms of photosynthesis speed.

Genc *et al*. (1993) reported that although, the index of sensitivity to tension under various drought levels is higher for landraces when compared to breeding cultivars, the kernel number, 1000 grain weights and biological yield of the landraces were found to be higher than breeding cultivars under terminal water-stress conditions and the harvest index and unit area grain yield of the landraces were shown to be lower than those of breeding cultivars. At the end of the study, in which they imposed water stress during different development phases of the wheat, Ozturk and Aydin (2004) suggested that water-stress during early phases resulted in a 40% decrease and that water stress during late phases resulted in a 24% decrease in the yield; late-phase water-stress increased grain protein content by 8.3% and decreased 1000 grains weight.

By defining the traits of landraces, this study aimed to identify the characteristics that will contribute to obtaining plant materials and lines, which will serve as a basis for high-yielding variety of breeding attempts to enable a classification of the studied varieties on the basis of their different characteristics; in turn to provide a limited number of grouped materials-rather than a high number of materials-for the breeder to work with.

Wheat, the basic agricultural product of Turkey, is mainly cultivated in arid and semi-arid areas in Central Anatolia, Southeastern Anatolia and transition areas. Development of the root (the part providing the water needed by the plant) and surface organs (the parts consuming the water) is of great importance for breeding purposes. Crop varieties, whose roots grow well, particularly in the early development phases, are more resistant to negative conditions and such characteristics have positive impacts on the grain yield of the race per unit area.

## MATERIALS AND METHODS

**Plant materials:** The experiment was conducted at the Application Research Farm, Faculty of Agriculture, University of Dicle, in Diyarbakir, Turkey during 2003-2004 and 2004-2005 growing seasons. Diyarbakir is located in 37°55'N and 40°12'E of Turkey.

Table 1: Precipitation, average temperature and relative humidity data belong to long term, 2003-2004 and 2004-2005 growing seasons of Diyarbakir Province

| | Long term | | | 2003-2004 | | | 2004-2005 | | |
|---|---|---|---|---|---|---|---|---|---|
| Months | Precip. (mm) | Temp. (°C) | Humid. (%) | Precip. (mm) | Temp. (°C) | Humid. (%) | Precip. (mm) | Temp. (°C) | Humid. (%) |
| September | 3.4 | 24.9 | 31 | 0.3 | 25.0 | 21 | 0.0 | 25.0 | 19 |
| October | 28.3 | 17.2 | 48 | 33.3 | 19.0 | 40 | 1.3 | 18.2 | 41 |
| November | 53.5 | 9.9 | 68 | 62.5 | 8.8 | 68 | 123.1 | 8.2 | 69 |
| December | 74.6 | 4.2 | 77 | 87.9 | 4.0 | 76 | 4.7 | 1.4 | 60 |
| January | 76.9 | 1.5 | 77 | 85.1 | 3.3 | 82 | 58.7 | 2.3 | 66 |
| February | 66.7 | 3.6 | 73 | 93.4 | 2.7 | 80 | 46.8 | 3.0 | 62 |
| March | 64.8 | 8.3 | 66 | 1.5 | 9.6 | 54 | 58.4 | 8.4 | 53 |
| April | 74.0 | 13.8 | 63 | 54.9 | 12.8 | 50 | 36.8 | 14.1 | 52 |
| May | 45.8 | 19.4 | 56 | 97.5 | 18.0 | 54 | 26.5 | 19.6 | 44 |
| June | 6.9 | 26.0 | 34 | 16.0 | 26.4 | 23 | 33.1 | 25.8 | 25 |
| July | 1.5 | 31.0 | 26 | 0.0 | 31.1 | 12 | 0.0 | 32.4 | 11 |
| August | 11.0 | 30.4 | 26 | 0.0 | 30.0 | 14 | 0.0 | 31.8 | 20 |
| Total | 507.4 | | | 532.4 | | | 389.4 | | |

Table 2: Some chemical and physical properties of the experimental soils

| Depth (cm) | Texture | pH | Total salt (%) | Lime (%) | Organic matter (%) | Potassium (ppm) | Phosphorus (ppm) |
|---|---|---|---|---|---|---|---|
| 0-40 | Killi-Tin loamy clay | 7.63 | - | 7.81 | 1.86 | 87 | 4.547 |

In this research, bread wheat (winter type; Pehlivan), durum wheat (spring types; Firat-93 and Ege-88, Alternative types; Svevo and Zenit) cultivars having different biological characters and widely grown in the Southeastern Anatolia region, Turkey and wheat landraces (Spring types; Beyaziye and Mersiniye, alternative types; Bagacak, Sorgul, Asure and Hevidi) cultivated in a limited area were used as material. Seeds of wheat landraces were collected during May 1998 from central district and villages of the Southeastern Anatolia Region. The region, where wheat landraces collected has an altitude between 600 and 1500 m.

**Climate and soil conditions:** According to data obtained from the records of Diyarbakir Regional Directorate of Meteorology Affairs, rain in Diyarbakir falls mainly during the winter and spring seasons. The highest rainfall was recorded in May, 2004 (97.5 mm), followed by February, 2004 (93.4 mm) and December, 2003 (87.9 mm) during the 2003-2004 growth season; besides, in November, 2004 (123.1) and January, 2005 (58.7 mm) during second growth season. Total rainfall during the October 2003-July 2004 and October 2004-July 2005 seasons, when the study was carried out, was recorded as 498.8 and 389.4 mm, respectively (Table 1). During the study period, the number of snowy days in the study area was 12 and 2. The lowest temperature in second growing seasons was recorded in February, 2004 (-14.1°C) and December, 2004 (-12.0°C). The soils of the research area are in the red-brown soil group; they have a low organic material content (1.86%) and are comprised of 7.81% lime at a depth of 0-40 cm. The pH of the soil was found as 7.63 (Table 2). The soil temperature were measured in 5, 10 and 20 cm soil depth during 22 days after the emergence at two growing seasons (Table 3).

Table 3: The soil temperature (°C) during 22 days after emergence

| | 2003 Soil depths (cm) | | | 2004 Soil depths (cm) | | |
|---|---|---|---|---|---|---|
| Days | 5 | 10 | 20 | 5 | 10 | 20 |
| 7 | 11.60 | 12.90 | 14.40 | 14.60 | 15.00 | 15.50 |
| 8 | 11.70 | 12.70 | 14.20 | 16.40 | 15.70 | 15.90 |
| 9 | 10.90 | 12.10 | 13.80 | 15.20 | 16.00 | 16.30 |
| 10 | 10.60 | 11.60 | 13.40 | 15.20 | 15.60 | 16.00 |
| 11 | 9.30 | 10.80 | 12.90 | 14.30 | 15.10 | 16.00 |
| 12 | 9.10 | 10.60 | 12.40 | 12.90 | 14.10 | 15.50 |
| 13 | 8.50 | 10.10 | 12.10 | 14.20 | 13.50 | 15.10 |
| 14 | 8.70 | 9.90 | 11.70 | 11.40 | 12.70 | 14.70 |
| 15 | 8.50 | 9.60 | 11.40 | 14.90 | 14.70 | 13.90 |
| 16 | 8.80 | 10.10 | 11.40 | 12.70 | 12.80 | 14.20 |
| 17 | 8.30 | 9.40 | 11.40 | 11.80 | 12.60 | 13.80 |
| 18 | 8.00 | 9.20 | 11.00 | 11.50 | 12.00 | 13.20 |
| 19 | 10.40 | 11.10 | 11.60 | 10.00 | 10.70 | 11.80 |
| 20 | 10.30 | 11.10 | 12.00 | 9.40 | 10.20 | 11.40 |
| 21 | 9.70 | 10.70 | 12.20 | 10.30 | 10.60 | 11.90 |
| 22 | 8.00 | 8.70 | 11.20 | 9.70 | 10.30 | 11.60 |
| 23 | 5.20 | 6.80 | 10.00 | 5.40 | 7.40 | 9.90 |
| 24 | 4.00 | 5.60 | 8.80 | 3.50 | 5.50 | 8.30 |
| 25 | 4.80 | 5.90 | 8.40 | 4.00 | 5.70 | 7.60 |
| 26 | 6.10 | 7.20 | 8.90 | 3.60 | 5.00 | 7.00 |
| 27 | 7.10 | 8.10 | 9.30 | 2.70 | 4.00 | 6.10 |
| 28 | 7.20 | 7.70 | 9.50 | 2.40 | 3.40 | 4.90 |
| Averages | 8.49 | 9.63 | 11.45 | 10.28 | 11.03 | 12.30 |

**Field experiments:** In this study, the experiment was laid out in randomized complete block design with three replications. Soil preparation included ploughing, disk harrowing and cultivation. Wheat seeds were sown to plots in the first week of November of both growing seasons and matured toward the second or third week of June. All plots were sown as 6 rows of 150 seeds (10 cm apart) per genotype with sowing machine. The row spacing was 40 cm. Plot size was 2×15 m. $P_2O_5$ at 60 kg $ha^{-1}$ and nitrogen at 60 kg $ha^{-1}$ were applied as diammonium phosphate (20-20-0) into the soil together with sowing; 60 kg $ha^{-1}$ nitrogen that remained was applied at tillering period. The plots were irrigated just

Table 4: Sources of variation, degrees of freedom, mean squares and variation coefficient obtained from the analysis of variance belong to characters investigated in durum wheat cultivars and landraces

| Source of variation | df | Germination (%) | Primary root length | No. secondary roots | Fresh root weights | Dry root weights | No. tiller per plant | Grain yield | 1000 kernel weights |
|---|---|---|---|---|---|---|---|---|---|
| Years | 1 | 260.015** | 107.4190 | 3.274 | 0.419 | 0.0110 | 1.121 | 0.214 | 0.044 |
| Error | 4 | 6.424 | 1666.9710 | 2.019 | 0.197 | 0.0020 | 8.433 | 2.810 | 2.540 |
| Genotypes | 10 | 82.633** | 10887.3080** | 2.590** | 3.187** | 0.0070** | 15.142** | 9.140** | 52.127** |
| Year × genotype | 10 | 22.882 | 1235.0190** | 1.894** | 0.410 | 0.0030** | 1.887 | 0.034 | 4.651 |
| Error | 40 | 15.508 | 342.9170 | 0.591 | 0.256 | 0.0010 | 1.843 | 0.104 | 4.032 |
| General | 65 | 30.172 | 2180.2350 | 1.228 | 0.729 | 0.0020 | 4.290 | 1.651 | 11.373 |
| CV (%) | - | 5.920 | 27.6700 | 14.580 | 37.220 | 22.5900 | 57.630 | 49.840 | 8.080 |

*, **: Significant at 0.01 levels of probability

after sowing to ensure germination and emergence. Growth conditions were very favorable during both years of the experiment and the crop developed normally.

**Observations:** Characteristics related to the first wheat growth and development morphology were observed following the sowing process. Firstly, germinated seeds were counted on the 5th and 7th days after sowing to determine the germination percentage of each genotype. A rectangular-shaped soil part of 20 cm depth containing a plant was excavated from the middle row of each plot on the 22nd day after the emergence of the seedlings. From each plot 10 seedlings were uprooted together with soil in the same way. A shovel was used in such way as not to damage the plant roots. The soil was soaked in water. When, roots were exposed, they were washed several times. After separating the seedling, roots were dried between papers and the average values of primary root length and the number of secondary roots were determined. Roots of 10 seedlings removed on the 22nd day were weighed and their fresh root weights were determined. These roots were dried at 105°C for 48 h until the weight stabilized and dry root weight was determined. Ten plants removed from each plots on the 22nd day were counted to determine the average number of tiller. All traits except germination percentage, grain yield per plant and 1000 grain weight were measured on the basis of 10 plants of each plot and their average was considered as a replication of each genotype.

Plants that reached harvest maturity indicated by yellowing of the uppermost internode, as suggested by Copeland and Crookston (1985), of about 50% of the plants, were cut at soil level. Taking into consideration the border effect of the plots, grain yield per plant (g $plant^{-1}$) was calculated by weighing the grains obtained from a plant with tiller after the harvest. By weighing 400 grains, 1000-grain weight was determined for all genotypes.

The statistical analysis of measurements were performed by using TARIST package program for Windows and the differences among the means were compared with LSD (Least Significant Differences) at a 5% significant level. The Coefficient Variation (CV%) for each character was calculated (Table 4).

## RESULTS AND DISCUSSION

The results of variance analysis belonging to traits of wheat breeding cultivars and landraces under field conditions are presented in Table 4. When, the data are evaluated, it can be concluded that there is statistically significant differences between years and genotypes of wheat cultivars and landraces at 0.01 levels of probability in germination percentage. Hevidi landrace (96.17%) has the highest germination percentage among the landraces, while Pehlivan (95.00%) has the highest germination percentage among the breeding cultivars. However, there are no significant differences between wheat cultivars (93.37%) and landraces (92.39%) when the averages are compared (Table 5).

Seedp germination is one of major problems of wheat production. It is influenced by many environmental factors, but the availability of soil moisture has a major effect on germination and subsequent emergence (Azam and Allan, 1976). Rauf *et al.* (2007) reported that there was decrease in germination percentage and seedling growth with increase in moisture stress. They observed the maximum values for germination percentage (98%), root length (9.92 cm), coleoptile length (4.37 cm), fresh root weight (0.323 g) and dry root weight (0.12 g) in control (distilled water) and minimum values of germination percentage (86.7%), root length (6.90 cm), coleoptile length (1.75 cm), fresh root weight (0.175 g) and dry root weight (0.059 g) in moisture stress by using 25% Polyethylene Glycol (PEG) concentration.

In this research, soil temperature in germination and early development stages of the 2nd year was higher according to the first year. Because of increasing of soil temperature at 2nd year, germination percentage, primary root length and fresh root weight values were found to have higher values than first year values in both landraces and breeding cultivars. The main reason behind any possible decrease in number of plants per unit area can be listed as negative climatic conditions, but soil temperature and other environmental conditions are also factors in such a decrease. Tosun *et al.* (1975) suggested that a soil temperature of 12°C is a determinant factor for

Table 5: The data belong to germination percentage and primary root length of wheat landraces and breeding cultivars for 2003-04, 2004-05 growing seasons and average

| | Germination (%) | | | Primary root length (mm) | | |
|---|---|---|---|---|---|---|
| Genotypes | 2003-04 | 2004-05 | Means | 2003-04 | 2004-05 | Means |
| **Landraces** | | | | | | |
| Asure | 93.33a | 97.67a | 95.50ab | 228.67ab | 201.67ab | 215.17a |
| Hevidi | 94.33a | 98.00a | 96.17a | 253.00a | 184.33b | 218.67a |
| Bagacak | 90.00a | 95.00ab | 92.50ab | 188.00c | 188.67ab | 188.33b |
| Sorgul | 93.67a | 96.67a | 95.17ab | 238.00a | 214.00ab | 226.00a |
| Beyaziye | 92.33a | 92.33ab | 92.33ab | 147.00d | 152.33c | 149.67c |
| Mersiniye | 75.33b | 90.00b | 82.67c | 132.00de | 143.67c | 137.83cd |
| Means of landraces | 89.83 | 94.95 | 92.39 | 197.78 | 180.78 | 189.28 |
| **Breeding cultivars** | | | | | | |
| Pehlivan | 94.33a | 95.67ab | 95.00ab | 203.60bc | 215.53a | 209.57ab |
| Svevo | 93.67a | 94.67ab | 94.17ab | 137.00de | 127.67c | 132.33cd |
| Zenit | 91.33a | 93.33ab | 92.33ab | 113.33e | 126.33c | 119.83d |
| Firat-93 | 89.33a | 93.33ab | 91.33b | 117.67de | 150.00c | 133.83cd |
| Ege-88 | 91.67a | 96.33ab | 94.00ab | 112.00e | 138.00c | 125.00d |
| Means of breeding cultivars | 92.07B | 94.67A | 93.370 | 136.720 | 151.510 | 144.110 |
| LSD | 8.548 | 4.125 | 4.599 | 30.393 | 32.687 | 21.626 |

germination and root development of cereals and that any temperature above 12°C has a negative impact on the development of coleoptile and root. It is known that landraces have a higher level of adaptation to regional conditions in terms of winter resistance, when compared to breeding cultivars.

As well as soil temperature, seed zone water content is also vital for germination and emergence. In some arid regions, by reason of insufficient moisture for germination in seed zone, farmers have to sow seeds to dry soil (at a depth of 2-3 cm) or wait for rainfall. This situation delays sowing and emergence and may result in decreased yields (Donaldson *et al*., 2001). Baser *et al*. (2005) found significant and positive relations between germination and emergence percentage of durum wheat and their characteristics such as the number of leaves, seedling weight, root weight, root length and seedling length.

It is seen that there is statistically significant differences between genotypes and year-genotype interactions of wheat cultivars and landraces at 0.01 levels of probability in primary root length when Table 4 is evaluated. Sorgul (226.00 mm), Hevidi (218.67 mm) and Asure (215.17 mm) landraces were found to have the longest primary root length among landraces and overall. Among breeding cultivars, while Pehlivan winter bread wheat cultivar (209.57 mm) has the longest root length, Zenit (119.83 mm) and Ege-88 (125.00 mm) durum wheat cultivars were found to have the shortest root lengths. The average primary root length was measured as 189.28 mm for landraces and as 144.11 mm for breeding cultivars (Table 5).

As time passed, the root length of all varieties increased. Root development was quite fast in landraces in the early development stages and then slowed in later phases. In breeding cultivars, on the other hand, root development was initially quite slow but accelerated in the following phases. Camargo *et al*. (2004) suggested that primary root lengths of different wheat genotypes, measured on the 7th day after emergence, tended to decrease under different temperature and pH environments. Gecit *et al*. (1987) and Schliephake and Garz (1986) suggest that root length increases with new development stages and those by Kuz'min and Shumeiko (1987) suggest that root development is higher in early developing varieties and that there is a high correlation between the number of primary roots and yield in mid-early and late developing varieties is compatible with the findings obtained in the study.

While, primary root lengths are similar amongst different wheat varieties, there are differences between varieties in terms of secondary root lengths. Development of primary roots is also related to the size of the seed (Kun, 1996).

It was determined that there were statistically significant differences between genotypes and year genotype interactions of wheat cultivars and landraces in secondary root number at 0.01 levels of probability when Table 4 is evaluated. Considering the secondary root number values of the landraces, calculated at the beginning of the tillering stage, Pehlivan (8.70), Firat-93 (8.03) breeding cultivars and Beyaziye (8.03), Bagacak (8.03) landraces were found to have the highest number of secondary roots. Average secondary root number per plant was 7.76 for landraces and 7.41 for breeding cultivars (Table 6).

Barraclough and Leigh (1984) suggested that sowing time and sowing methods are also known to affect rooting and tillering. The relationship between the initial root development and winter resistance of the varieties should not be sought within wheat genus but between the species of the genus (bread-durum) and even between cultivars. In addition, high yield levels of bread wheat results from its highly developed root system.

Table 6: The data belong to number of secondary root and fresh root weights of wheat landraces and breeding cultivars for 2003-04, 2004-05 growing seasons and means

| | The number of secondary roots | | | Fresh root weights (g) | | |
|---|---|---|---|---|---|---|
| Genotypes | 2003-04 | 2004-05 | Means | 2003-04 | 2004-05 | Means |
| **Landraces** | | | | | | |
| Asure | 7.27de | 7.00cde | 7.13c-f | 2.03b | 2.13c-f | 2.08cd |
| Hevidi | 8.47a-d | 6.67de | 7.57b-e | 3.00a | 1.93def | 2.46bc |
| Bagacak | 7.07e | 9.00a | 8.03ab | 3.40a | 3.59a | 3.50a |
| Sorgul | 7.67a-e | 8.33ab | 8.00abc | 3.10a | 2.87abc | 2.98ab |
| Beyaziye | 8.73a | 7.33bcd | 8.03ab | 2.00b | 2.63bcd | 2.32cd |
| Mersiniye | 8.60ab | 7.00cde | 7.80bcd | 1.70b | 2.20c-f | 1.95cde |
| Means of landraces | 7.97 | 7.56 | 7.76 | 2.54 | 2.56 | 2.55 |
| **Breeding cultivars** | | | | | | |
| Pehlivan | 8.57abc | 8.83a | 8.70a | 3.50a | 3.33ab | 3.42a |
| Svevo | 6.93e | 6.33de | 6.63f | 1.37b | 1.43f | 1.40e |
| Zenit | 7.40b-e | 6.00e | 6.70ef | 1.27b | 1.63ef | 1.45e |
| Firat-93 | 8.07a-e | 8.00abc | 8.03ab | 1.57b | 2.30cde | 1.93cde |
| Ege-88 | 7.30cde | 6.67de | 6.98def | 1.43b | 2.07c-f | 1.75de |
| Means of breeding cultivars | 7.65 | 7.17 | 7.41 | 1.83 | 2.15 | 1.99 |
| LSD | 1.189 | 1.423 | 0.898 | 0.943 | 0.773 | 0.591 |

Table 7: The data belong to dry root weights and the number of tiller of wheat landraces and breeding cultivars for 2003-04, 2004-05 growing seasons and means

| | Dry root weights (g) | | | The number of tillers per plant | | |
|---|---|---|---|---|---|---|
| Genotypes | 2003-04 | 2004-05 | Means | 2003-04 | 2004-05 | Means |
| **Landraces** | | | | | | |
| Asure | 0.210ab | 0.230cde | 0.220bc | 2.63c-f | 4.77ab | 3.70cde |
| Hevidi | 0.227ab | 0.213c-f | 0.220bc | 2.73c-f | 3.20bc | 2.97def |
| Bagacak | 0.247ab | 0.283ab | 0.265a | 4.63bc | 5.73a | 5.18abc |
| Sorgul | 0.213ab | 0.303a | 0.258a | 7.20a | 5.50a | 6.35a |
| Beyaziye | 0.207bc | 0.193def | 0.200c | 6.03ab | 5.13ab | 5.58ab |
| Mersiniye | 0.237ab | 0.183f | 0.210c | 3.93bcd | 4.53ab | 4.23bcd |
| Means of landraces | 0.223 | 0.234 | 0.229 | 4.53 | 4.81 | 4.67 |
| **Breeding cultivars** | | | | | | |
| Pehlivan | 0.253a | 0.243bc | 0.248ab | 1.17f | 2.27c | 1.72f |
| Svevo | 0.133d | 0.187ef | 0.160d | 2.60c-f | 1.90c | 2.25ef |
| Zenit | 0.130d | 0.190ef | 0.160d | 1.50ef | 1.80c | 1.65f |
| Firat-93 | 0.203bc | 0.237cd | 0.220bc | 1.97def | 3.03bc | 2.50ef |
| Ege-88 | 0.163cd | 0.240bc | 0.202c | 3.70cde | 3.10bc | 3.40de |
| Means of breeding cultivars | 0.176B | 0.219A | 0.198 | 2.19 | 2.42 | 2.30 |
| LSD | 0.046 | 0.050 | 0.033 | 2.991 | 1.327 | 1.586 |

When, Table 4 is evaluated it is observed that there are only statistically significant differences between genotypes of wheat cultivars and landraces in fresh root weight at 0.01 levels of probability. The average fresh root weight of wheat landraces and cultivars was calculated as 2.55 and 1.99 g, respectively. The highest fresh root weight values belonged to Bagacak (3.50 g) among landraces and to Pehlivan (3.42 g) among breeding cultivars (Table 6).

It is possible to mention a positive relationship between the weight of root and surface organs in all plant development phases: root lengths increase with the increase in temperature; early root development triggers early blooming.

It can be concluded that root development is greater in early developing varieties. Moreover, a lack of nutritional elements in the soil has negative impacts on the development and improvement of the root. In their study, Budakli *et al.* (2003) suggested that the highest fresh root weight (17.07 g plant$^{-1}$) was obtained in complete nutrition solution while, the lowest values were recorded in environments lacking nitrogen (1.57 g plant$^{-1}$) and phosphor (2.08 g plant$^{-1}$).

It is possible to mention that there is statistically significant difference between genotypes and year genotype interactions (at 0.01 levels) of wheat breeding cultivars and landraces in dry root weight when Table 4 is evaluated. The average dry root weight of wheat landraces and cultivars were calculated as 0.229 and 0.198 g, respectively. Among landraces, Bagacak (0.265 g) and Sorgul (0.258 g) had the highest root dry weight values. Among breeding cultivars, Pehlivan (0.248) had the highest values (Table 7).

The better developed root system, especially in terms of rooting intensity, landraces may allow for greater soil water uptake in deep and shallow soil layers. In addition, faster early growth of this germplasm reported by Annicchiarico and Pecetti (2003) in comparison with control cultivar may contribute to higher Water Use Efficiency (WUE) via earlier ground cover.

Table 8: The data belong to grain yields and 1000 kernel weights of wheat landraces and breeding cultivars for 2003-04, 2004-05 growing seasons and means

| | Grain yields (g plant$^{-1}$) | | | 1000 kernel weights (g) | | |
|---|---|---|---|---|---|---|
| Genotypes | 2003-04 | 2004-05 | Means | 2003-04 | 2004-05 | Means |
| **Landraces** | | | | | | |
| Asure | 1.245e | 1.465de | 1.355f | 38.70de | 37.37ef | 38.03ef |
| Hevidi | 1.312e | 1.391e | 1.352f | 39.27d | 40.43cde | 39.85de |
| Bagacak | 1.704de | 1.821de | 1.763de | 44.13ab | 41.53bcd | 42.83bc |
| Sorgul | 1.452de | 1.564de | 1.508ef | 41.17bcd | 39.77def | 40.47d |
| Beyaziye | 1.321e | 1.410e | 1.366f | 35.40e | 36.67f | 36.03f |
| Mersiniye | 1.936d | 1.987d | 1.961d | 41.40bcd | 42.00bcd | 41.70cd |
| Means of landraces | 1.495 | 1.606 | 1.551 | 40.01 | 39.63 | 39.82 |
| **Breeding cultivars** | | | | | | |
| Pehlivan | 3.200c | 3.096c | 3.148c | 44.97a | 44.37ab | 44.67ab |
| Svevo | 3.707bc | 3.856b | 3.782b | 43.53abc | 43.70abc | 43.62abc |
| Zenit | 3.614bc | 3.773b | 3.694b | 43.67abc | 45.93a | 44.80ab |
| Firat-93 | 3.953ab | 3.872b | 3.913b | 46.53a | 44.07ab | 45.30a |
| Ege-88 | 4.289a | 4.753a | 4.521a | 40.80cd | 43.17abc | 41.98cd |
| Means of breeding cultivars | 3.753 | 3.870 | 3.812 | 43.90 | 44.25 | 44.07 |
| LSD | 0.448 | 0.633 | 0.376 | 3.166 | 3.661 | 2.345 |

It is determined that there is statistically significant difference between only genotypes of wheat breeding cultivars and landraces at 0.01 levels of probability in the number of tiller when Table 4 is evaluated. The average number of tiller in the landraces and breeding cultivars examined was 4.67 and 2.30, respectively. Sorgul (6.35) and Beyaziye (5.58) among landraces and Ege-88 (3.40) among breeding cultivars have the highest values (Table 7).

All cereals are capable of producing >1 stem for one plant. Tillering level changes on the basis of genotype, soil and climatic factors and the time and frequency of planting. Due to its relationship to root development, the immediate start of tillering before the winter starts is important for the plant to develop a strong root system before the winter comes. The findings of Sadhu and Bhaduri (1983), which suggest that early root development triggers early fertilization and increases surface and root weights, support the interpretations in the present study. A high level of tillering before winter can be regarded as an indicator of winter resistance. However, development of these tillers until the late development stages is not a desired outcome for the harvest index. In the present study, it was observed that landraces developed more tillers than breeding cultivars and that these tillers continued their development until late development phases. It was observed that the number of tillers with no spikes was higher for the landraces and the harvest index of these plants was low.

By looking at the grain yield values presented in Table 4, we can observe statistically significant differences between genotypes (at 0.01 levels of probability) of wheat landraces and breeding cultivars. The average grain yield of landraces was calculated as 1.551 g plant$^{-1}$ while, it was found to be 3.812 g plant$^{-1}$ for breeding cultivars. Among landraces, Mersiniye (1.961 g plant$^{-1}$) and Bagacak (1.763 g plant$^{-1}$) had the highest grain yield. Among breeding cultivars, Ege-88 (4.521 g plant$^{-1}$) and Firat-93 (3.913 g plant$^{-1}$) had the highest values (Table 8).

It is determined that there is statistically significant differences between only genotypes of wheat landraces and breeding cultivars at 0.01 levels of probability in 1000 kernel weight when Table 4 is evaluated. The average 1000 kernel weight in the landraces and breeding cultivars examined was (39.82 g) and (44.07 g), respectively. Bagacak (42.83 g) and Mersiniye (41.70 g) among landraces and Firat-93 (45.30 g), Zenit (44.80 g) and Pehlivan (44.67 g) among breeding cultivars have the highest values (Table 8).

It is noteworthy that landraces and breeding cultivars that produced high values in terms of the number of kernels per spike also present high values in terms of the number of tillers, root length and dry and fresh root weights. The number of kernels per spike is related with root development as well as fertilization and environmental conditions. As the root develops, the resistance of the plant to negative environmental conditions also increases.

## CONCLUSION

Careful monitoring and examination of the development phases of wheat plants is of great importance for making yield estimations during the early phases. Rather than using a single model to monitor the changes observed in plant development throughout time, development phases were examined one by one to see if this method could define development in a better way. It was concluded that examination of plant development phase by phase produced better results.

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