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RESEARCH ON THE RELATION MANAGEMENT BETWEEN ROOTS AND SOIL UNDER CLIMATIC STRESS CONDITIONS IN PREMIUM WHEAT CROP

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Abstract

The present study was conducted in order to highlight a big problem that breeders are facing with nowadays, namely the relations which are formed between the plants root system and the soil, that constitutes their living and development environment. There were identified three main ways through which the breeding of the roots-soil system can be achieved for its optimization: the factors related to soil, the soil technologies and, finally, the breeding, genetics and molecular genetics path. Taking into account all the principles mentioned above, were evaluated the yields obtained at Premium wheat in two agricultural years, years that were totally different from climatic point of view (2011-2012 and 2012-2013). The importance of the connection between plant roots and soil was especially visible in 2011-2012, when were registered extreme drought conditions. The phenomenon was also extended to neighboring plains (The Pannonian Plain in Austria, Hungary, examples being conclusive in this sense). Data obtained from our own experimental lots, where have been taken into account elements like soil amelioration, farm management, seed quality and varieties used in culture, are indicating significantly positive differences compared to those plots that were planted randomly, without taking into account all these aspects. In the same time, this paper presents the correlations between the wheat root system development and the yields level. Researches were performed in several areas of the country, making the relevance of the study and of its results even greater, while its utility for farmers increases directly proportional to the demonstrated importance.

***Key words*:** *abiotic factors, breeding, Premium wheat, root system, yield*

INTRODUCTION

The studies on the relationships between roots of the cultivated plants and soil are, generally, less known and almost all the manuals is resumed to the fixing and supplying function with water and mineral elements [8].
Even today most of the specialists are judging a plant by its appearance from the soil surface, forgetting that, in its entirety, the plant also has a root, often more developed than the outside part and with multiple features, delicate and mostly unknown [2] [3] [4].
On wheat roots are extremely numerous and long. According to Schweiger et al. (2009) [7] the total length of roots may reach 100-180 cm/plant. The experiment included two varieties (Capo and Saturnus) and there were no differences between them. Method used was the one with PVC tubes.
More complex researches were performed in 1995-1996 and published in 1999 by Schmid et al. [6]. These were carried out on different soils from the Munich area and with various crop systems. Results indicated a high sensitivity of root development depending on the precipitation regime and fertilization level.
Behaviour of roots depending on soil stress has been studied and presented by Merotto Jr. and Mundstock [5] in 1999. They demonstrated that a normal or good growth is conditioned by the hardness of the soil and they agree that roots don't increase at all at more than 3.5 MPa (35 kgf/cm^2).
In Romania, Berca M. (2011) [1] shows that on Burnas Plateau the hardpan layer located at 30-40 cm completely blocks the formation and penetration of roots into the soil. Therefore, the biological activity of the soil and the plant development are badly affected

and so is the wheat yield. For these reasons, in the mentioned area was conducted a whole program of soil ecology, reaching today to obtain in autumn wheat plant with small foliage, but strongly developed roots.
The autumn of 2007 was extremely dry and allowed wheat emergence of only later. Because of the organic soil, roots were formed much better than stems, so that 2008 has led to high and good quality yields. As can be seen (Fig. 1) the depth of the roots exceeded 20 cm. It is what is necessary for the agronomists to wish for their crops.

Fig. 1. Barley plants sprouted in November 2007, whose roots are extremely developed at 3.12.2007 (original)

MATERIALS AND METHODS

Aim of this paper was to follow the development of roots, but especially their effect on plant and yield components development on 15 wheat varieties in the Calarasi, Alexandria, Dobrogea areas. Due to the lack of equipment it wasn't pursued the measuring of biomass amount formed in the wheat plants root system, but were rather used techniques like visual tracing and photographing of roots in autumn and spring, until the end of tillering.
The work was performed in years and areas with different amounts of rainfall and it was observed the effect caused by the water stress on the formation of roots, tillers and some production components at 15 wheat varieties, mostly premium type. For this purpose soil monoliths were collected from the experimental fields, which initially were cleaned of the surplus of earth, then the roots and the plants were washed and measured. There have been also numbered the tillers for 150 plants and at harvest the ears were measured and weighed and it was calculated the grain weight per ear.
The work was carried out in 2 precipitation regimes, namely:

- for the period from September to June:
  - 530 mm precipitation;
  - 370 mm precipitation;
- for the period from April to June:
  - 281 mm precipitation;
  - 141 mm precipitation.

For the results interpretation was used the calculation of variance analysis, of correlations and functions.

RESULTS AND DISCUSSIONS

In Fig. 2, at Josef variety it is seen, on the left, the water stress effect in Modelu conditions on 23.04.2012, while on the right it is shown a plant that received the needed water accordint to the consumption curve.

Fig. 2. Josef variety wheat plants in water stress (left) and without stress (right) – original, 23.04.2012, Modelu

In Fig. 3, both left and right side, plants come from plots experienced water stress. Similarly stress condition is presented in Fig. 4, the photo being made to a later date.

Fig. 3. Balaton wheat plants grown under conditions of water stress in Alexandria – 25.03.2013 (original)

Our estimation shows that the root system under water stress was around 40-50 % lower than in the conditions of plants without stress. It will be noticed that between reducing root system and other parameters there are positive correlations, more or less significant.
From Fig. 4 it is seen that the number of tillers in the version without water stress is almost double than in the case with stress.

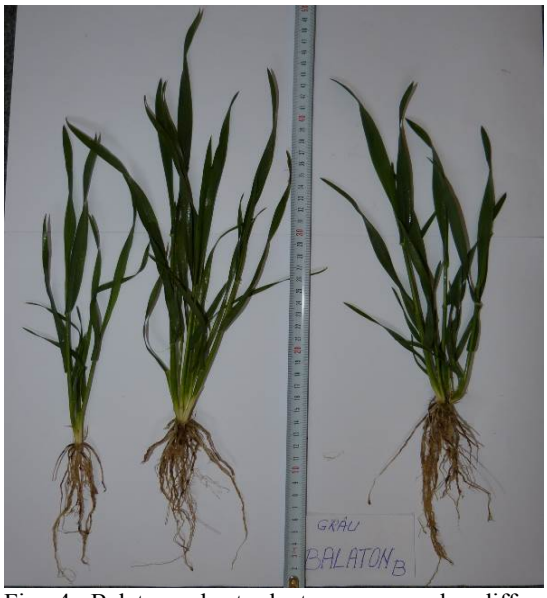

Fig. 4. Balaton wheat plants grown under different conditions of stress in Alexandria – 24.04.2012 (original)

The tillering analysis depending on varieties and moisture regime (Fig. 5) gives back the variability of the average tillers number, but generated by the studied varieties behavior.

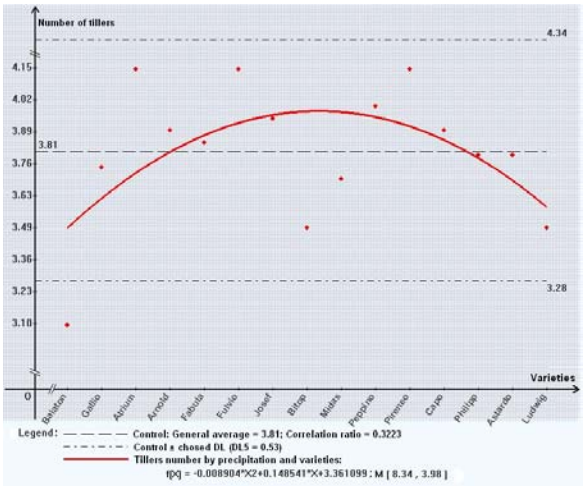

Fig. 5. Variability of the tillers number in relation to the variety (original)

As the evolution of the curve for the risk of 5% is inside the confidence interval, we can say, on average, that the variation of tillers formation in relation to the variety is insignificant.
On the contrary, judging only the calculations generated by the precipitation factor, it follows that an extra amount of rainfall during the wheat growing season brings a difference of 14% from the average and 26% among active variants. The quantity of additionally rainfall is of 530 – 370 = 160 mm.

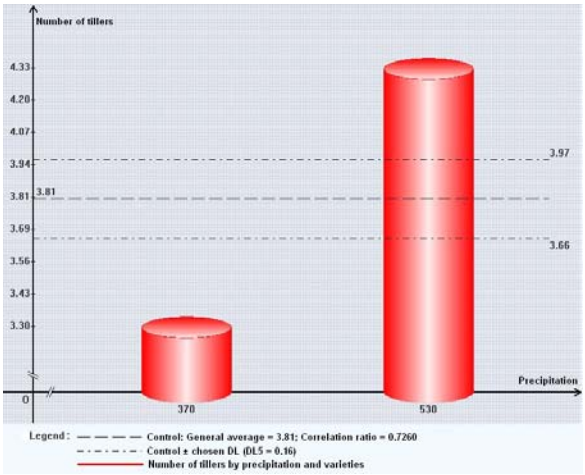

Fig. 6. Water stress effect on the formation of wheat tillers – Modelu 2012-2013

Appearance of a larger number of tillers in the version without or with low stress is primarily due to the formation of a vigorous root system, to the water conservation in the ecologized soil and to its optimal use, especially in spring, at the completion of twinning (also see Fig. 6).

The bifactorial effect, water stress and varieties, on tillers' number variation it's shown in Fig. 7, so we deduce that, taking the average as control, both curves move within the confidence interval, the differences being insignificant both horizontally and vertically in each curve, but frequently to very significant if taking into account differences between them.

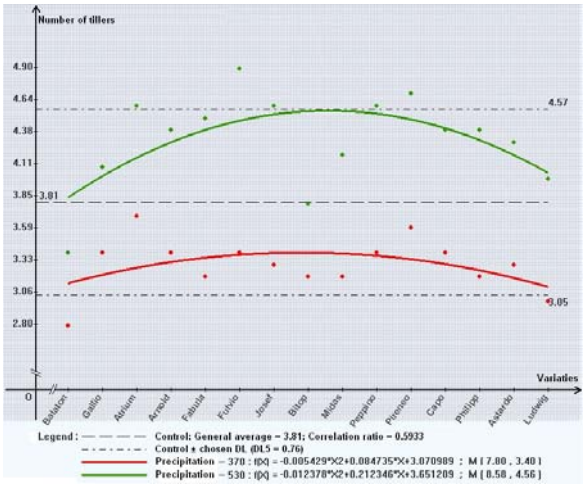

Fig. 7. Influence of rainfall and wheat varieties on the tillers' number variation on plants - Modelu 2012-2013

Variation of the data is greater in the stress-free variant than in the one with stress, in the last the varieties manifesting the tendency of tillers production standardization.

Analysis of the ears weight in relation to varieties and precipitation

The root system is the multifunctional component of the plant, its representative in the soil intimacy. It equally takes over the plant reaction in relation with the evironment. If the environemnt enter into water stress, the root system is the first that feels and transmits defense commands to the aeria part, although there are also sensors that record and transmit the phenomenon gravity to the roots.

The root system has the task to solve the problem, if possible. If not, it send to the aerial part the effort necessity to reduce production by reducing the production components.

In wheat the crop is achieved in the ear and it's correlated with their weight (Fig. 8). Excluding the first two varieties, where the weight of ears fits, on average, in the significantly negative field, there are also four varieties (Midas, Philipp, Astardo and Pedro) which have ears whose weight positively significantly exceeds the confidence interval for the risk of 5%. The other varieties are within the limits of the interval $\overline{m} \pm DL5\%$.

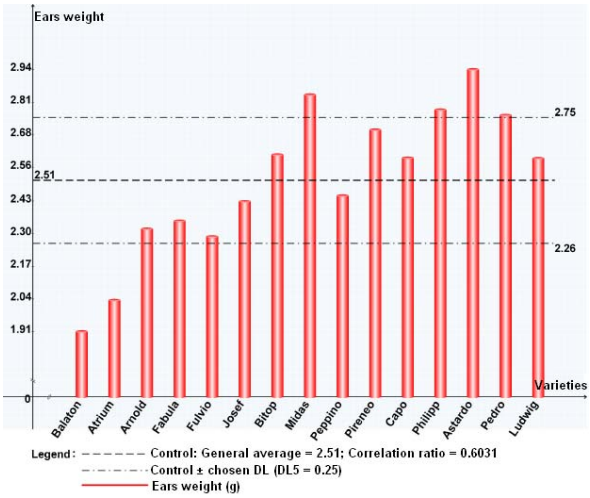

Fig. 8. Changes in the weight of a ear in relation to the cultivated varieties

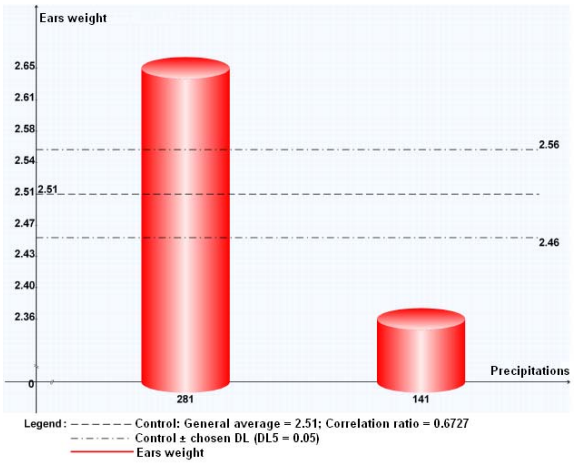

Fig. 9. Ear weight average decrease for 15 varieties by reducing to half the amount of water from April to July

The stress effect caused by the water scarcity brutal attack ear weight (Fig. 9), reducing it from 2.65 g to 2.36 g, ie with 11%, a very significant reduction taking into account the fact that are 500-600 spice/m^2. This implies a

reduction of at least 0.29 x 550 = 159.5 g/m^2, which is equivalent to about 1000 kg grain/ha. Bifactorial analysis (Fig. 10) reveals that varieties gave to ears' a weight extremely variable both between themselves, as well as in ratio with the volume of precipitation. There are some varieties, such as Atrium, Peppino, Capo, which are more resistant to water stress wide variations, a reason for the breeders to focus the breeding on their genoplasma.

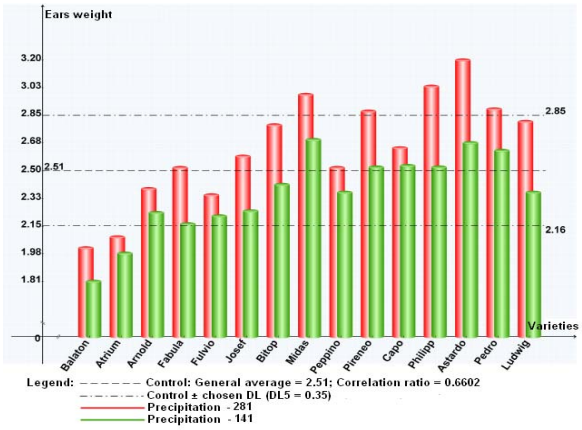

Fig. 10. Influence of April-June rainfall volume on ear weight variation in 15 premium wheat varieties – Modelu, 2011-2013

Grain weight per ear is one of the most important production components. There are, on average, varieties with a low grain weight in the ear, below the security threshold, such as Fulvio and Peppino, but also varieties with heavy grains, such as Bitop, Astardo, Ludwig (Fig. 11).

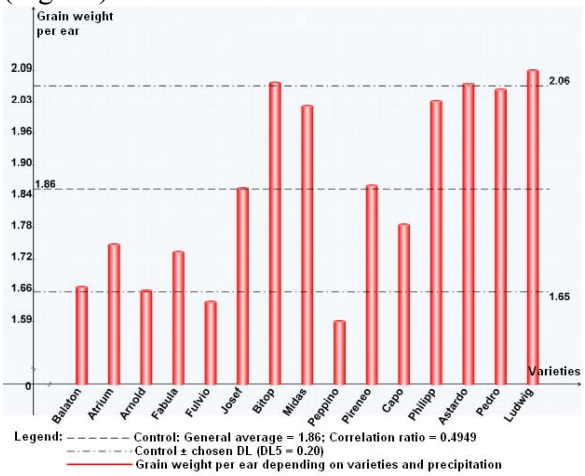

Fig. 11. Variation of the grain average weight per ear depending on variety – Modelu, 2011-2013

The variations of the remaining varieties are within the safety threshold.

Considering only the water stress factor (Fig. 12), for the varieties average it's noticed an average reduction of the grain weight in the ear from 2.07 g to 1.41 g, i.e. 42%, that explains the yield difference between the two systems, whose density correction remains in the ears density (or in the one of crop).

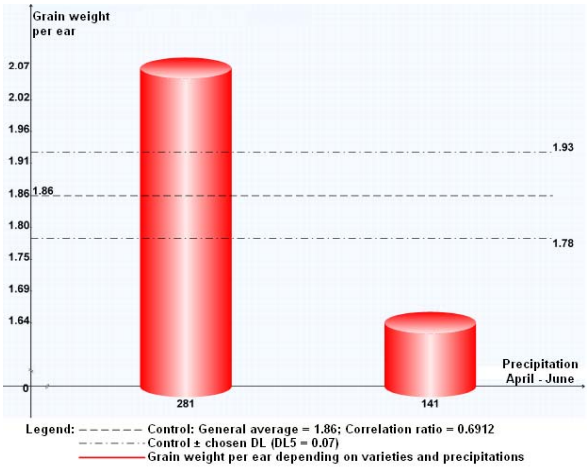

Fig. 12. Grain weight per ear depending on the soil supply level with rainfall water – Modelu, 2011-2013

Bifactorial analysis, varieties x water (Fig. 13), also highlights a large variation of varieties.

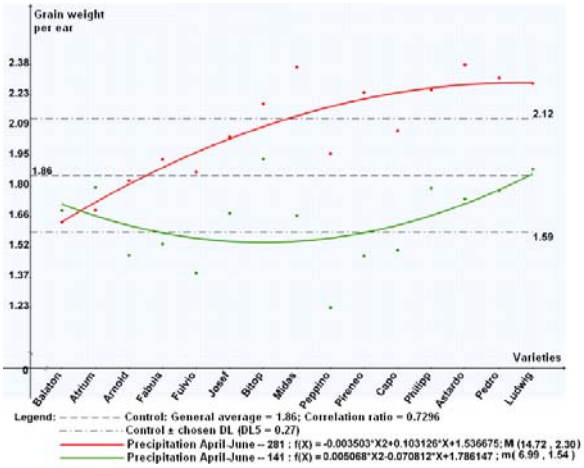

Fig. 13. Influence of water level received by the soil and of varieties on grain weight per ear (average) – Modelu, 2011-2013

Except for Balaton variety, which has reverse reactions, but insignificant, maybe also due to its property of being earlier, all other varieties respond positively in avoiding water stress, at least 6 varieties (Midas, Pireneo, Bitop, Philipp, Astardo and Ludwig) standing out

significantly positive by the confidence interval ($\overline{m} \pm$ DL5%).

From the above it follows that, given the lack of water stress, the root system is developing normally, the plants are forming a larger number of tillers, a greater weight of ear and of grain in the ear, a premise for a higher wheat yield and of a higher quality.

Correlations. Were tried two types of correlations, both based on the idea that a more developed root system, which allows the formation of a higher number of tillers, also helps on making higher weigh of grain in the ear (Fig. 14) . In the curve evolution, in the left side the lower number of tillers is generated by the water stress, while on the right side of the figure the lack of stress increases the number of tillers, but after normal logarithmic regularities.

The correlation coefficient r = $\sqrt{r^2}$ = $\sqrt{0{,}5268}$ = 0,72 is significantly distinct, so that the function can't be mathematically neglected.

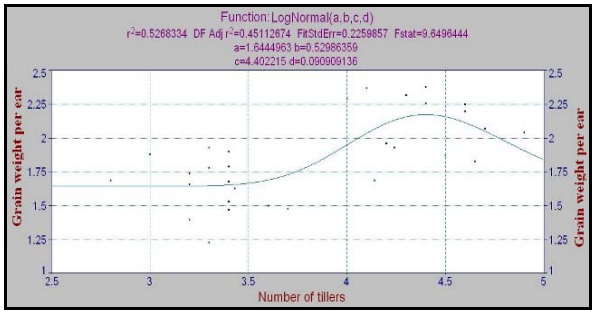

Fig. 14. Correlation between tillers number and grain weight per ear – Modelu, 2012-2013

Logically, the function and the correlation are indirect creations of root system development based on hydrological regime, that due to lack of indicators can't be directly placed into the mathematical relation. We found out, however, that the number of tillers, as a direct response of water regime and of varieties, became indirect indicators, which allow us, in the name of the direct ones, to calculate the grain weight in ear and the yield (with the help of density).

The above statement can be proved by the three-dimensional function shown in Fig. 15.

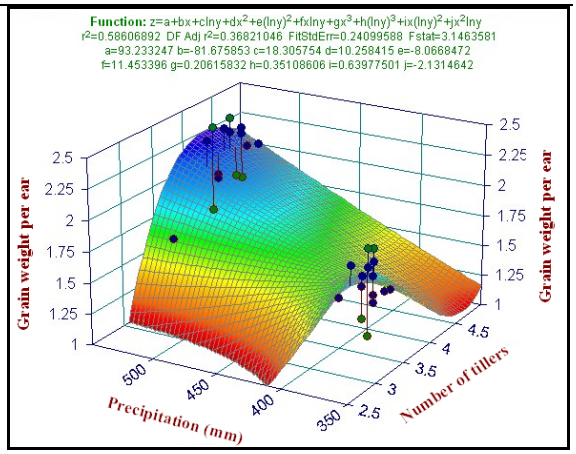

Fig. 15. Correlation between tillers, precipitation grain weight per ear – Modelu, 2012-2013

Introducing of rainfall factor changes neither the ratio or the correlation coefficient (r = $\sqrt{r^2}$ = $\sqrt{0{,}586}$ = 0,76) than insignificantly, the number of tillers remaining the basic indirect indicator of grains weight calculation.

We note, however, that to low rainfall can't be more than 2.5-3 tillers, while on sufficient rainfall we reach 4-5 brothers and a yield of 2.25 g grains/ear. On the other hand, sufficient rainfall offer a higher number of tillers in order to achieve a crop density of 500-600 spice/m^2.

CONCLUSIONS

Wheat root system development is critical to plant growth both in the initial time, until the end of tillering, as well as it is until maturity.

In the experimental fields, reduced root system caused by water stress was of about 40%.

Climatic stress leads to the formation of a less developed root system, which in its turn forms:

- ➔ less tillers (in average with 22% for 15 varieties);
- ➔ a lower ears' weight (in average with 11%);
- ➔ a lower grain weight in the ear (in average with 21%).

There is an indirect correlation between the tillers number and grain weight per ear in the range 2.5 - 4.5 tillers/plant.

With minor exceptions, the variation of the calculated indicators generated by varieties

exist, and it also exist the possibility of selecting some varieties for capturing genoplasm in order to breed grains for a better water stress resistance.

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