МОДЕЛ НА ПШЕНИЧНОТО РАСТЕНИЕ ЗА СУХИ УСЛОВИЯ НА КЛИМАТА ПО ЕЛЕМЕНТИ НА ДОБИВА И НЯКОИ МОРФОФИЗИОЛОГИЧНИ ПОКАЗАТЕЛИ
WHEAT PLANT MODEL FOR DRY CLIMATE CONDITIONS ACCORDING TO THE YIELD COMPONENTS AND SOME MORPHOPHYSIOLOGICAL INDICES

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Резюме

През 2006-2008 г. са изследвани 26 сорта пшеница, създадени в ИРГР – Садово в периода 1948-2006 г., и сортът Безостая 1. Направени са биометрични измервания по елементи на продуктивност - брой на продуктивни братя, жътвен индекс, височина на растението, надземна суха маса, вегетационен период, брой зърна в клас, маса на зърното в клас, тегло на зърното от 1 m^2 площ, брой класоносни стъбла на 1 m^2 площ, и някои морфофизиологични параметри - ширина на флагов лист, маса на 1 лист, загуба на листна маса на 1 растение, загуба на листна площ на 1 растение, измерени в две фази от развитието на пшениченото растение. Подробна агрометеорологична справка за годините на изследване е посочена в наша предишна публикация.

Данните от измерванията са обработени математически чрез компютърна програма SPSS 9.0 for Windows. Изведено е регресионно уравнение, отразяващо количественото изменение на добива от зърно от единица площ при „единица" промяна на всеки от проучваните признаци.

Получено е уравнение на теоретичния регресионен модел, както следва:

$Y=955,79+117,10*x_1+443,70*x_2-1,49*x_3-4,69*x_4+0,0064*x_5+2,27*x_6+93,91*x_7+181,05*x_8-+0,20*x_9+49,52*x_{10}-2883,52*x_{11}-8,55*x_{12}+5,39*x_{13}$

В резултат на проведените изследвания е създаден модел на пшеничено растение, подходящо за сухите условия на климата в Садово, характеризиращо се с висок добив от зърно.

Abstract

In 2006-2008 26 wheat varieties were tested, created at IPGR Sadovo during the period 1948-2006 as well as the *Bezostaya1* variety. Biometric measurements were made on some elements of productivity – number of productive tillers, harvest index, plant height, above-ground dry mass, vegetation period, number of grains in wheat ear, mass of grain in wheat ear, weight of grain per 1m^2 area, number of stem wheat-ears per 1 m^2 area, some morpho-physiological indices – flag leaf width, mass of 1 leaf, loss of leaf mass per 1 plant, loss of leaf area per 1 plant, measured in two phases of the wheat plant development. Detailed agro-meteorological statistics about the years of study is shown in our previous publication.

The data of the measurements were mathematically processed by a computer program *SPSS 9.0* for *Windows*. A regression equation was derived, explaining the quantitative modification of the grain yield per unit area in a "unit" change of any of the studied indices.

The obtained equation of the theoretical regression model is as follows:

$Y=955,79+117,10*x_1+443,70*x_2-1,49*x_3-4,69*x_4+0,0064*x_5+2,27*x_6+93,91*x_7+181,05*x_8-0,20*x_9+49,52*x_{10}-2883,52*x_{11}-8,55*x_{12}+5,39*x_{13}$

As a result of the study a model of a wheat plant was created suitable for the dry climate conditions in Sadovo, characterized by high grain yield.

Ключови думи: обикновена зимна пшеница, добив, сухи условия, модел на растение.
Key words: common winter wheat, yield, dry conditions, plant model.

INTRODUCTION

The changes in the climate conditions related to the sudden drought during the vegetation period of wheat; especially at the critical stages in yield formation requires the searching of a wheat plant model suitable for the changes. At least 60 million ha in the world are grown in dry climate conditions. The average yield under these conditions in a worldwide scale is from 0,8 to 1,5 t/dà what is approximately from 10 to 50 % of the direct potential in irrigated conditions (Morris et al.,1991). The wheat yield is formed by complex morphological and physiological parameters. The highest increase in productivity is achieved by stem shortening. (Bingham,1983). There is a proven influence on yield in weight and number of the grains in an ear (Boyadjieva,1987), number of grains per unit area (Calderini et al.,1995; Sayre et al.,1997). Some other positive changes are connected with the number of productive tillers and early maturity. (Khalil et al.,1995; Tsenov et al.,2005).

According to W.Kronstad (1998), one of the purposes in each selective program is to establish the limiting factors. In this sense the attention of the scientists is focused on the investigation of the physiological ground for yield improving and its stability in the presence of stress factors. (Harris, 1989; Salsac, Monneveux, 1989; Ortiz-Ferrara et al, 1989; Sarrafi et al,1992), as well as the methods for study of physiological indeces connected with productivity. (Whan et al., 1989; Araus et al., 1989).

Plant model tolerated in drought by improving and optimizing of specific physiological indeces is reported by Reynolds et al. (2000). With the creation of this model, the authors refer to indeces with potentially the highest amount of influence on yield in dry environmental conditions.

The purpose of this study is to establish a wheat plant model with high yield in drought conditions typical for the region of Sadovo and other areas with similar climate conditions and to determine how and in what direction the change of these indeces will contribute to the improvement of grain yield per unit area.

MATERIALS AND METHODS

In 2006-2008 there were examined 26 wheat varieties, created in IPGR Sadovo for the period 1948 to 2006 year as well as the variety Bezostaya1. The studied varieties and detailed agro-meteorological statistics about the years of study are given in our previous publication. (Andonov and Boyadjieva, 2009).

Biometric measurements were made on the following elements of productivity: $\mathbf{X_1}$ – number of productive tillers; $\mathbf{X_2}$ – harvest index; $\mathbf{X_3}$ – plant height (cm); $\mathbf{X_4}$ – above-ground dry mass (g/10plants); $\mathbf{X_5}$ – vegetation period (number of days from 01.01 to ear formation) $\mathbf{X_6}$ – number of grains in wheat ears; $\mathbf{X_7}$ – mass of grain in wheat ear (g); $\mathbf{X_8}$ – weight of grain per 1m^2 area (kg/m^2); $\mathbf{X_9}$ – number of wheat ears per 1 m^2 area and some morpho-physiological parameters $\mathbf{X_{10}}$ – flag leaf width (cm); $\mathbf{X_{11}}$ –mass of 1 leaf (g); $\mathbf{X_{12}}$ – loss of leaf area per 1 plant (%), $\mathbf{X_{13}}$ – loss of leaf mass per 1 plant (%) – measured in two phases of plant development (Boyadjieva and Andonov, 2010).

The measurements are done on 30 randomized plant variants for reading the productive indeces and 15 plants in the phase of florescence and 10 days later for reading some morpho-physiological indeces.

The data of the measurements are mathematically processed by a computer program SPSS 9.0 for Windows. Regression equation is derived, explaining the influence of each single index according to the grain yield per unit area that shows the model of wheat plant. (Stamatov and Deshev, 2010).

RESULTS

The result of the analysis of the studied indeces and their impact on yield makes clear the effectiveness of wheat breeding in IPGR Sadovo during the years. On the basis of the data processed by the computer program for statistic analyses SPSS 9.0 for Windows is created a theoretical model of wheat plant in the dry condition climate changes in Sadovo. The obtained equation of the theoretical regression model is as follows:

$$Y=955,79+117,10*x_1+443,70*x_2-1,49*x_3-4,69*x_4+0,0064*x_5+2,27*x_6+93,91*x_7+181,05*x_8-0,20*x_9+49,52*x_{10}-2883,52*x_{11}-8,55*x_{12}+5,39*x_{13}$$

With the coefficient of multiple regression **R=0,967**

Where: Y – grain yield, kg/da

The visualization of the dependence is shown from fig. 1 to 13.

Figures 1 and 2 shows the dependence on yield from the indeces number of productive tillers and harvest index. The highest grain yield of the studied varieties is reported by values of number of productive tillers in the range of 1,9 to 2,1 tillers on wheat plant. The deviation from the desired number leads to a proven decrease in the yield, reflected in the regression model.

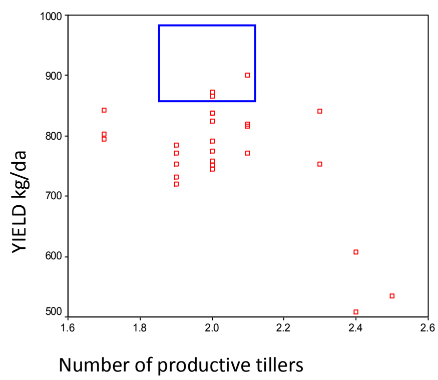

Fig. 1. *Yield dependence on number of productive tillers*

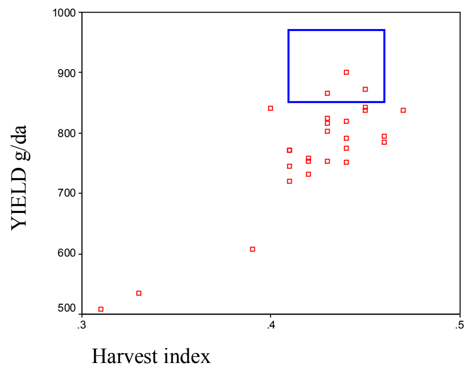

Fig. 2. *Yield dependence on harvest index*

The increase in the value of the harvest index has a positive influence on the change of grain yield per decare shown in the resulting regression model and proven by Đ=0,05%. The optimal levels of the harvest index in our study are from 0,43 to 0,47 (on the newly created varieties - Mima, Nova Zvezda) which are with high values and tested compared to the initial variety № 301, 0,31 (Andonov and Boyadjieva, 2009).

Another index with proven influence on yield improvement is the height of the wheat plant (fig. 3). The optimal height for realization of higher yields is from 105-113 cm; as the deviation from higher or lower than these values leads to a negative influence on grain yield kg/da. Changing the parameters of the index in the equation, outside the optimum set shown in the figure, lowers the yield level.

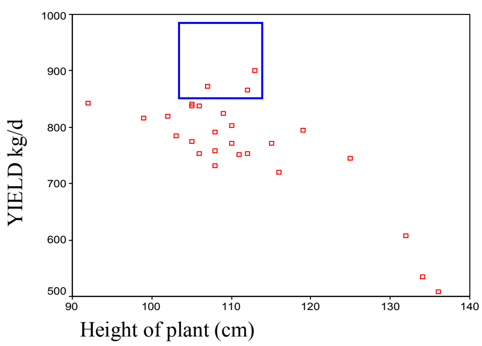

Fig. 3. *Yield dependence on height of plant*

In figure 4 the model of wheat plant is shown the index of above-ground dry mass. The optimal value in it having positive influence on the yield varies from 65 g to 73 of 10 plants. The index is characterized by a relatively narrow range of positive influence on yield, especially indicated in the later created varieties Lucil, Mima and Nova Zvezda (Andonov and Boyadjieva, 2009). The average value of the studied varieties is 72 g/10 plants and it is within the range of the optimum of the resulting model.

In the following fig. 5 it is shown the influence of index length of the vegetation period on the yield in the

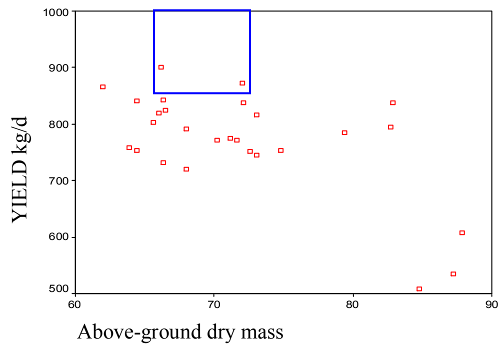

Fig. 4. *Yield dependence on dry above - ground mass*

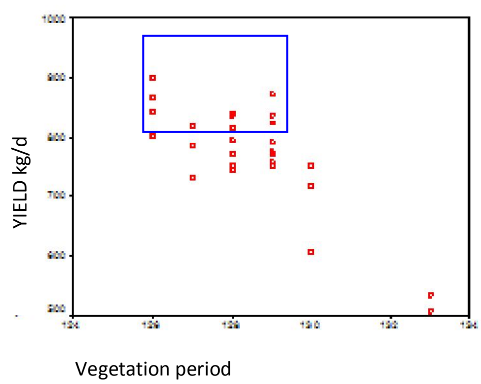

Fig. 5. *Yield dependence on vegetation period*

resulting regression model. Its graphic confirms the contemporary trends of wheat breeding in our country and in a worldwide range to create earlier mature varieties, especially for the drier areas in the area of wheat growing. The length of vegetation period on the adopted methodology CIMMYT concerning the days from 1 January to ear formation should vary in the optimal range of 126 to 129 days to obtain highest yields in the dry climate conditions in Sadovo.

In fig. 6 is shown another index that has a significant influence on the grain yield kg/da. This is the mass of grain received per one square meter area. The most positive influence on yield has the index that is in the range 1,0-1,2 kg grain from square meter ground area. All deviations from these values lead to the reduction in grain yield per decare. In the varieties that fall in the range of the optimum but do not have high enough yield are probably affected by other reasons that have negative influence on the discussed parameters. This is due to the complicated actions and interactions of the complex of indicators and factors affecting the yield.

The number of ear stems per one square meter area and their yield significance is shown in fig. 7. The favorable influence of this parameter on the yield is in the range from 726 to 816 ear bearing stems. Yield rapidly decreases with the increasing of ear stems per unit area out of the optimum in the varieties № 301, Jubileina 3. This tendency, however,

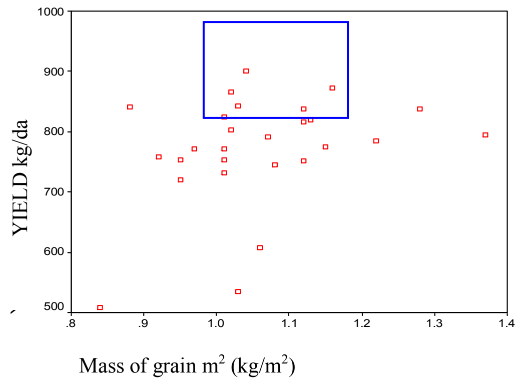

Fig. 6. *Yield dependence on mass of grain per m² area*

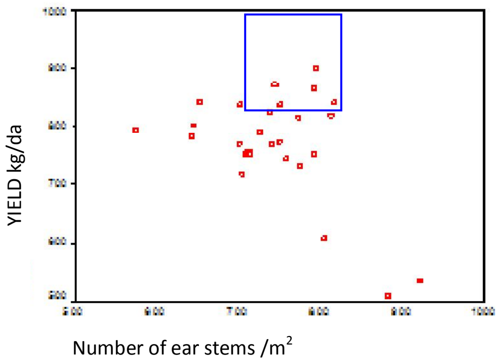

Fig. 7. *Yield dependence on the number of ear stems*

is not observed in their reduction under the optimal number in the varieties Perlom and Sadovo 772 (Andonov and Boyadjieva, 2009). The example is significant for the complex interactions and other indeces affecting the yield.

In figures 8 and 9 is shown the influence on yield of the two indeces of the ear of the wheat plant. These are the indeces number of grains in ear and mass of grain in ear (g), reported by biometrical analysis of the studied wheat varieties.

The proven influence of the first mentioned above parameters for the model of wheat plant (fig. 8) is in the optimal value from 35 to 42 grains in one ear. Within these limits is achieved higher grain yield kg/da for some varieties of the study (Katya, Murgavets, Sadovo 772, Prelom, Pobeda, Zdravko, Junak, Guiness, Geya 1, Lucil, Mima and Nova Zvezda). The presence of more or less kernels in the ear leads to decreasing of yield.

The optimal values of the index mass of grains in ear related to the yield in the studied varieties is in the range of 1,3 to 1,8 g. Besides the optimum in the change in both directions of decreasing and increasing, the yield decreases like it decreases in the lowering of the index. Deviation from this trend is observed only in the variety Petya, where despite of the lower mass of grains in ear the yield is high. This is due to the influence of other indeces (productive tillers, number of ear bearing stems).

The highest grain yield is realized on mass of 1 leaf from 0,08 to 0,12 g (fig. 10). In the given range of the studied index there are varieties with lower yield values. Probably this is due to the complex interaction of the analyzed indeces. The figure shows that there is no rapid decrease in yield in the increase of mass of 1 leaf (Prelom, Sadovo 772 and Murgavets).

The index width of flag leaf is proven to have a positive influence on yield. (fig. 11). The analysis of the results in the studied varieties shows that the highest yield is realized in the range of 1,8 to 2,1 cm width of flag leaf. The deviations from these limits in some varieties as Katya,

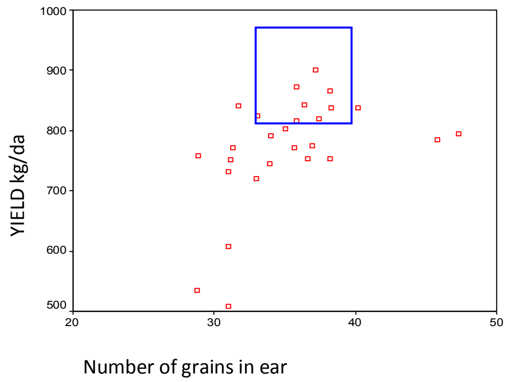

Fig. 8. *Yield dependence on number of grains in ear*

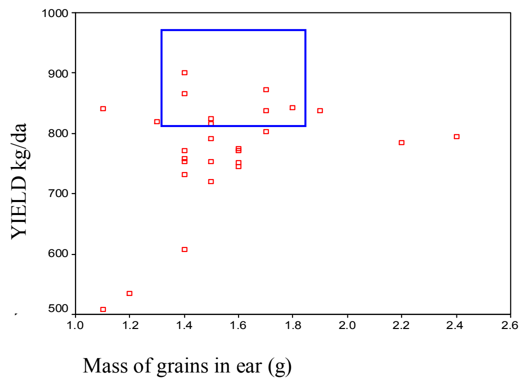

Fig. 9. *Yield dependence on mass of grains in ear*

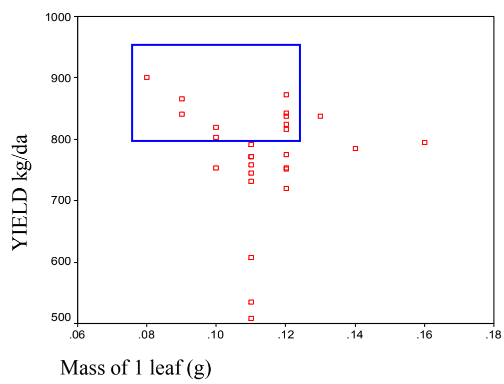

Fig. 10. *Yield dependence on mass of 1 leaf*

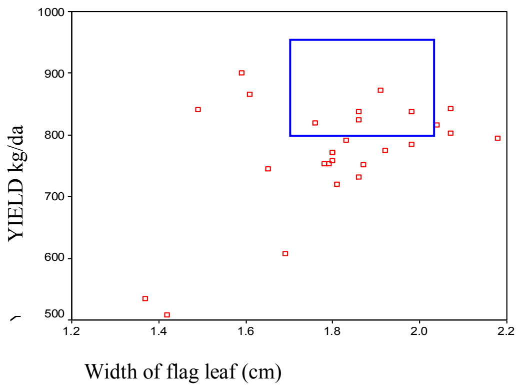

Fig. 11. *Yield dependence on width of flag leaf*

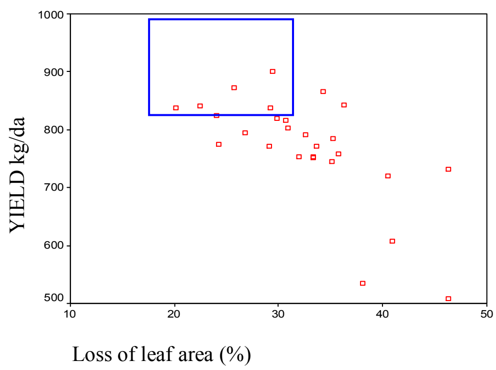

Fig. 12. *Yield dependence on loss of leaf area*

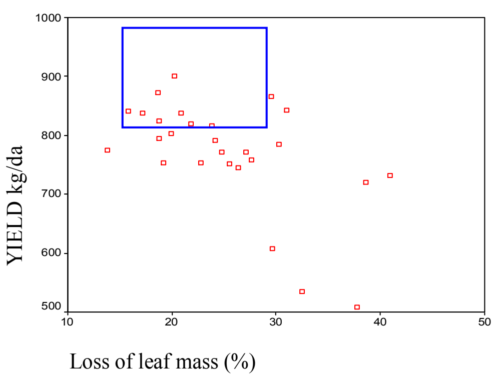

Fig. 13. *Yield dependence on loss of leaf mass*

Guiness lead to the yield change in a positive direction (Boyadjieva and Andonov, 2010). Probably it is because of the influence of the combination of other favorable characteristics and conditions of the genotype environment.

The width of flag leaf may serve as a direct index in the breeding work with wheat but after thoroughly and more detailed study.

In fig. 12 is shown the regression model with the index loss of leaf area per one plant in relation to yield. The given data indicate that the varieties realize higher yield in loss of leaf area maximum to 33% in the period of formation and filling of the grain. In the varieties Nova Zvezda, Petya, Lucil and Mima that are of the new selection of IPGR Sadovo is reported lower reduction of the index loss of leaf area per one plant (20,1%, 22,5%, 24,2% è 25,7%), that is not observed in the source variety ¹301 and variety Okerman (Boyadjieva and Andonov 2010).

The optimal values for the index loss of leaf mass per one plant (%) related to the yield in the studied varieties are in the range of 5 to 30% (figure 13). With proven lower value of the parameter is the variety Lucil 13.5%. The varieties that are in the range from 5 to 30% and in the average value of all varieties in the studied (25,10%), but do not have enough grain kg/da are affected by the influence of other indeces. In the analysis of the resulting regression model of the index loss of leaf mass per one plant is noticed a tendency towards decreasing the value of the index and at the same time preserving and even increasing the grain yield kg/da in the newly created wheat varieties Petya, Junak, Lucil, Mima and Nova Zvezda (Boyadjieva and Andonov, 2010).

CONCLUSION

Referring the results of the analysis for the conditions in IPGR Sadovo and the general climate conditions as a whole in South Bulgaria, higher grain yield could be obtained at certain combination of the studied indeces.

* The model of the wheat plant characterized with high grain yield should have the following parameters: (fig.14):

- X_1 – number of productive tillers – 1,9 – 2,1;
- X_2 – harvest index – 0,43 – 0,47 and higher;
- X_3 – height of the plant – from 105 to 113 cm;
- X_4 – above- ground dry mass – from 65 to 73g/10 plants;
- X_5 – vegetation period – from 126 to 129 days from 01. 01 to ear formation;
- X_6 – number of grains in ear – from 35 to 42 pieces;
- X_7 – mass of grain in ear – from 1,3 to 1,8 g in one ear;
- X_8 – weight of grain per m^2 area– from 1,0 to 1,2 kg/m^2;
- X_9 – number of stem wheat- ears per 1 m^2 area - from 726 to 816 pieces;
- X_{10} – width of flag leaf – from 1,8 to 2,1 cm;
- X_{11} – mass of one leaf – from 0,08 to 0,12 g;
- X_{12} – loss of leaf area per 1 plant – to 33%;
- X_{13} – loss of leaf area per 1 plant – from 5 to 30%;

- The given ideal model of wheat plant would hardly come to realization in the selection process. The purpose of every breeding program is to approach the analyzed indeces to the indicated values. The full expression of the high productive potential depends on the knowledge of the complex connections between the separate elements and

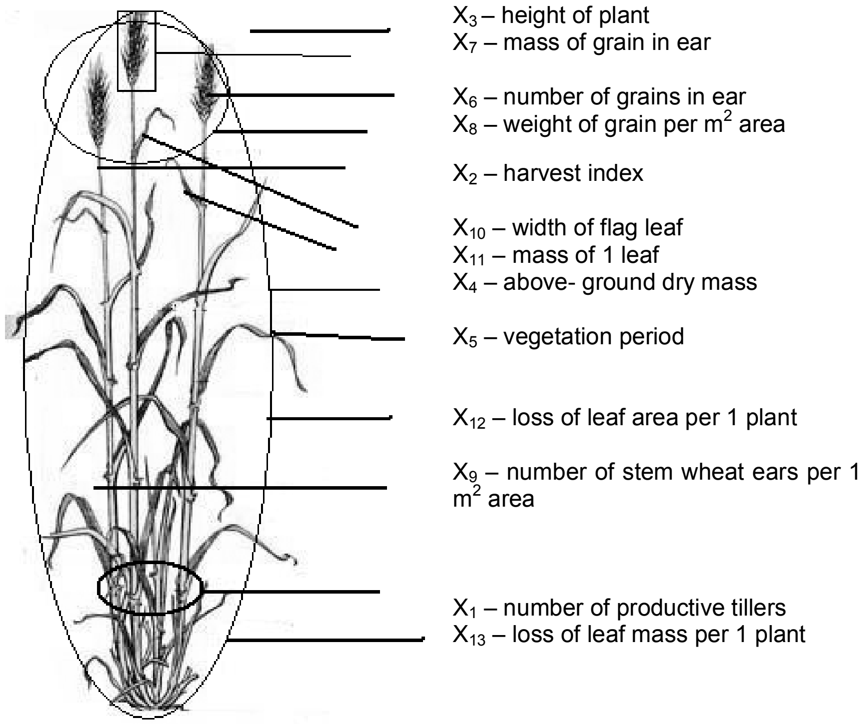

Fig. 14. *Model of wheat plant*

their combination in the plant in particular soil and climate conditions.

REFERENCES

Andonov, B. and Boyadjieva, D., 2009. Genetic progress of grain yield and parameters forming it into *Tr. aestivum* L., under the conditions of the Institute for Plant Genetic Resources, Sadovo, for the period 1948-2006 – Report of National Conference IG "D. Kostov" to BAS , in press. – J. Genetics and Plant Physiology.

Boyadjieva, D. and B. Andonov, 2010. "Selection efficiency of morphological and physiological parameters of *T. aestivum* L. in dry climate conditions". – Bulg. J. Agric. Sci., 16: 539-546.

Boyadjieva, D., 1987. Nasledyavane harakteristikite na klasa v hibridi na T. aestivum L. – Genetika i selektsiya, 5.

Araus, J. L., L. Alegre, T. Alidib, M. Benlaribi, Ph. Monneveux, 1989. Epidermal and stomatal conductance in seedlings of durum wheat landraces and varieties.Physiology-Breeding of Winter Cereals for Stresed Mediterranean Environments.Montpeiiier (France), INRA, ICARDA, July 3,6 1989, 225-243.

Bingham, J., 1983. Genetic constraints on progress in wheat breeding. The Yield of Cereals.AN International seminar on the technology of cereals production yields and productivity. June 29-July 5th 1983, Cambridge, England /report/.

Calderini, D. F., M. F. Dreccerand, G. A. Slafer, 1995. Genetic improvements in wheat yield and associated traits. A re-examination a previous results and latest trends. – Plant Breed, 114:108-112.

Harris, H., 1989. The relative impact of water and temperature constraints on wheat productivity in lowland areas of West Asia and North Africa. Montpellier (France), July 3.6.1989, 15-23.

Khalil, I. H., B. F. Carver and E. I. Smith, 1995. Genetic gains in two selection phases of a wheat-breeding program. – Plant Breed, 114:117-120.

Kronstad, W. E., 1998. Agricultural development and Wheat breeding in th 20th Century. H. J. Braun et al. (E.ds.) Wheat: Prospects for Global Improvement, 1-10 1998, Kluwer Academic Publishers, Printed in the Netherlands.

Morris, M. L., A. Belaid, and D. Byerlee, 1991. Wheat and barley production in rainfed marginal environments of the developing world. Part 1 of 1990-91 CIMMYT World Wheat Factors and Trends: Wheat and Barley Production in Rainfed Marginal Environments of the Developing World. CIMMYT, Mexico, D.F.

Ortiz-Ferrara, G., S. K. Yau, M. Assad Mousa, 1989. Physiology-Breeding of Winter Cereals for Stressed Mediterranean Environments, Montpellier /France/, July 3.6,1989.

Reynolds, M., Skovmand, B., Trethowan, R. and W. Pfeiffer, 2000. Evaluating a conceptual model for drought tolerance. – *In:* Ribaut, J.-M. and Poland, D. eds.

Molecular approaches for the genetic improvement of cereals for stable production in water-limited environments: a strategic planning workshop held at CIMMYT, El Batan, Mexico, 21-25 June 1999. CIMMYT, Mexico, 49-53.

Sayre, K. D., S. Rajaram and R. A. Fisher, 1997. Yield potential progress in short bread wheats in Northwest Mexico. – Crop Sci. 37:36-42.

Salsac, L., P. Monneveux, 1989. Relations entre nutrition minérale e la tolérance au déficit hydrique. Physiology-Breeding of Winter Cereals for Stresed Mediterranean Environments. Montpellier (France), INRA, ICARDA, July 3,6 1989, 49-66.

Sarrafi, A., A. Mentewab, P. Monneveux, 1992. Tolerance a la secheresse des cereales en zone mediterraneenne. Montpellier (France), 15-17, Decembre 1992.

Stamatov, S., M. Deshev, 2010. Model of breeding for high yields in non-shattering sesame (Sesamum indicum L.) suitable for mechanized harvesting. – Rastenievadni nauki, 2, 99-101.

Tsenov, N, E. Tsenova, M. Atanasova, 2005. Breeding for earliness of winter wheat, Balkan scientific conference - Breeding and cultural practices of the crops, Karnobat, Bulgaria, June 2 2005.

Whan, B. R., W. K. Anderson, R. F. Gilmour, K. L. Regan, N. C. Turner, 1989. Physiology-Breeding of Winter Cereals for Stressed Mediterranean Environments, Montpellier /France/, July 3.6.1989.

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