Bulgarian Journal of Agricultural Science, 27 (No 3) 2021, 531–535

Chickpea plant model for the climatic conditions of the Sadovo region according to the yield components

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Abstract

Petrova, S. (2021). Chickpea plant model for the climatic conditions of the Sadovo region according to the yield components. *Bulg. J. Agric. Sci., 27 (3)*, 531–535

During the studyed period on the experimental field of Institute of plant genetic resources – Sadovo are studied 95 chickpea accessions with different origin from the genebank. Biometric measurements are made on some elements of productivity – plant height, height to the first pod, number of main branches; number of pods per plant; number of grains per plant and mass of 100 grains.

The data of the measurements are mathematically processed by a computer program SPSS 13.0 for Windows. A regression equation is derived which expresses influences of each individual trait against grain yield from unit area. This gives an opportunity to statistically represent how and in what direction the change of these traits, contributing for the improvement of grain yield.

The resulting equation of the statistical regression model is as follows:

$Y = 47.010 + 1.297 * x_1 + 0.170 * x_2 + 0.888 * x_3 + 2.151 * x_4 – 0.831 * x_5 – 0.837 * x_6$

As a result of the study a model of a chickpea plant is created suitable for climate conditions in the Sadovo region, characterized by high grain yield.

Keywords: chickpea; grain yield; dry conditions; plant model

Introduction

Chickpea (*Cicer arietinum* L.) is the third most important grain legume crop in the world after bean and pea and the first in South and West Asia. It has a strategic position as a protein crop in the structure of world agricultural production in regions with warm, temperate, semi-arid and dry climates (Anbessa et al., 2006). According to statistics, 92% of the area and 75.4% of the grain production are concentrated in areas with moisture deficiency (FAOSTAT, 2008).

For Bulgaria the chickpea is an old traditional crop used mainly for human consumption and lesser extent for feed. In the recent decades, there are an increased interest in chickpea and its role in healthy diet. The grains are a food of great biological value for humans as they are rich in protein, carbohydrates, fats, minerals and vitamins (Petrova, 2015).

As yield is the resultant product of various morphological, physiological and biological components (Bandi et al., 2018). Decreases of genetic variation within cultivars as result of conventional breeding practices affect the success for productivity and adaptability improvement of crops (Desheva & Kyosev, 2015). Chickpea breeding activity is mainly aimed at improving productive potential (Mehandzhiev et al., 2002). To achieve an increase in the biological potential of yield the criteria for selection of source material with reference to morphological traits – hight of the plant and number of main branches per plant; a phenological trait – short vegetation period; resistance to abiotic and biotic stress – drought resistance, cold resistance, disease tolerance, ascochitosis, fusarium, viral diseases. Recently the development of cultivars which are adapted to different environmental conditions is ultimate aim of a plant breeder in the crop improvement programs (Singh, 1990; Muhammad et al., 2003; Mulusew et al., 2009; Pratap & Kumar, 2011).

The most common abiotic factors affecting chickpea production are drought, heat and cold. The drought together with heat causes 3.3 million tonnes loss of production per year (Croser et al., 2003; Singh et al., 1994).

Although chickpea are considered to be a drought sensitive species, the selection of genotypes and varieties is aimed to those of them that may be grown under water deficit as a more effective method of reducing the effects of drought. The studies of Krouma (2010) confirm the importance of the need for chickpea to avoid a drought.

Plant breeding is a lengthy process dependent on a number of biotic, abiotic and economic factors. The enormous losses that agriculture regularly incurs from drought, cold, disease, challenges breeding to create varieties resistant to stress factors affecting of productive potential in chickpea (Mihov et al., 2005; Georgieva & Kosev, 2018). Yield is a major consideration for any breeding program and is made up of several sub traits, each under separate genetic control (Afreen et al., 2017).

The purpose of this study is to establish a chickpea plant model with high grain yield in dry conditions typical for the Sadovo region and to determine how and in what direction the change of these traits will contribute to improvement of grain yield from unit area.

Material and Methods

The experiments are carried out on the experimental field of Institute of plant genetic resources – Sadovo during the period 2009-2015. The studied varieties and detailed agro-meteorological statistics about the years of study are given in the PhD thesis of Petrova (2015). In the assortment have been studied 95 accessions with different origin from the genebank. Agricultural technology is used for growing chickpea after precursor wheat.

The main productivity elements are defined of 10 premarked plants typical for each accession of the collection in the full maturation phase; X_1 – plant height (cm); X_2 – height to the first pod (cm); X_3 – number of main branches; X_4 – number of pods per plant; X_5 – number of grains per plant; X_6 – mass of 100 grains (g).

Based on the correlation dependencies and the regression equation, a linear model of the plant with high grain yield potential is derived (Draper & Smith, 1973). The model plant with high grain yield potential is built using the statistical program SPSS 13.0 for Windows.

Regression equation is derived, explaining the influence of each single trait according to the grain yield that shows the model of breeding of a highly productive plant (Stamatov & Deshev, 2010; Andonov, 2012; Kalapchieva, 2013). The data of the measurements are mathematically processed by a computer program SPSS 13.0 for Windows.

Results and Discussion

Togay et al. (2008) recommended using – correlation coefficients, multiple regression, Path-analysis in choosing genotypes at a breeding process of the relevant culture in order to increase efficiency. In genetic-selection investigations for analyzing causation in systems with correlating values are used these analyses.

The results of carried out analysis showed that the linear component in the regression of grain productiveness from 1 m^2 area in respect of the investigated traits is reliable and significant (Table 1).

Based on biometric analyzes of the studied chickpea collection are created a theoretical model of chickpea plant in soil and dry climatic conditions of the Sadovo region. A regression equation is derived which expresses influences of each individual trait against grain yield per unit area. This gives an opportunity to statistically represent how and in what direction the change of these traits, contributing for the improvement of grain yield per unit area.

Table 1. Regression analysis (ANOVA) of the grain productivity from 1 m^2 area in regard to the yield components

Despersion	df	Mean Square	F	Sig.
Regression	6	4282.240	3.447	0.004
Residual	89	1242.363		
Total	95			

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

$$Y = 47.010 + 1.297 * x_1 + 0.170 * x_2 + 0.888 * x_3 + \\ + 2.151 * x_4 - 0.831 * x_5 - 0.837 * x_6$$

with the coefficient of multiple regression R = 0.434,
where: Y – grain yield from1 m^2 area, g.

The applied analysis showed that for formation of the grain yield from1 m^2 are a highest influence have number of pods per plant (2.151) and plant height (1.297), followed by number of main branches (0.888). Weaker influence has the indicator height to the first pod (0.170).

The plant height and height to the first pod in chickpea are in relationship with the mechanized agriculture; therefore varieties with average high stem and higher betting on the first pod are for preference.

The traits: number of grains per plant (-0.831) and mass of 100 grains (-0.837) have negative coefficient of regression (Table 2). Above determinate parameters too great number of grains per plant and the mass of 100 grains have negative influence on the grain productiveness – the plant cannot feed the grains and prolong time for ripening, which make difficult the gathering of the harvest. Toker and Cagrirgan (2004) estimated that the grain yield is positively and significantly correlated with biological yield, harvest index plant height, branches and pods per plant while it is negatively correlated with grain weight. Selection of parents or genotypes based on such traits is adopted for improvement in chickpea. This result is in agreement with the findings of Deshmukh & Patil (1995), Muhammad et al. (2004) and Talebi et al. (2007). According to Parhe at al. (2014) the significant positive correlation has between seed yield per plant with number of secondary branches per plant, number of pods per plant and 100 seed weight.

The graphical representation of the relationships between grain yield from 1 m² area and the studied yield components allows with sufficient approximation to obtain statistical results and to see the basic regularity between the studied traits (Figures 1- 6).

Figures 1 and 2 shown the dependence of grain yield from 1 m² area to the traits – plant height and height to the first pod. The highest grain yield from 1 m² area from the studied accessions is obtained at a plant height from 38 cm to 43 cm. The deviation from the optimum plant height results in a proven decrease in grain yield from 1 m² area, shown in the resulting regression model. The increase in values height to the first pod has a positive effect on the change in grain yield from 1 m², shown in the resulting regression model. The optimum borders for the values of the height to the first pod in our study are from 25 cm to 29 cm. This trait is characterized by relatively narrow borders of positive impact on grain yield from 1 m² area, especially strongly expressed in 36.5% from the studied accessions.

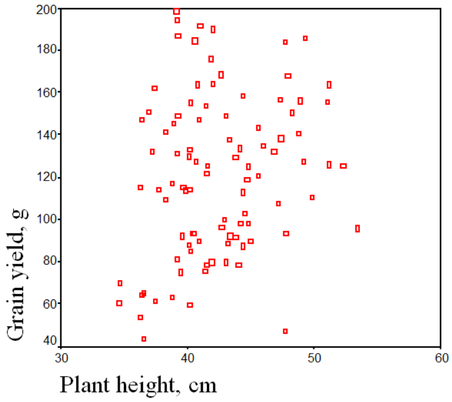

Fig. 1. Dependence between the grain yield and plant height

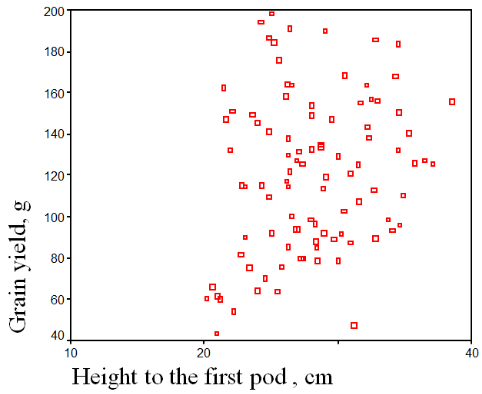

Fig. 2. Dependence between the grain yield and height to the first pod

The favorable influence of the trait the number of main branches on the grain yield of 1 m² area is in the range from 5 to 6 numbers (Figure 3). The grain yield from 1 m² area strongly decreases as the number of the main branches is re-

Table 2. Regression coefficients of the grain productivity from1 m² area in regard to the yield components

Trait	Coefficients	St. Error	t Stat	Lower 0.950	Upper 0.950
Plant hight (cm)	1.297	2.177	0.596	-3.028	5.622
Hight to the first pod (cm)	0.170	2.150	0.079	-4.102	4.442
Number of main branches	0.888	2.986	0.297	-5.045	6.822
Number of pods per plant	2.151	1.288	1.670	-0.408	4.711
Number of grains per plant	-0.831	1.115	-0.745	-3.047	1.386
Mass of 100 grains (g)	-0.837	0.738	-1.134	-2.302	0.629

duced beyond the optimum. However the same trend is not observed when the increasing of main branches is above the optimum number. Another trait with a proven impact on improving of the grain yield from 1 m^2 area is the number of pods per plant (Figure 4). The optimum number of pods for higher grain yield is from 25 to 45 pods, as deviations in higher or lower than these values having a negative effect on grain yield from 1 m^2 area. The changing of the parameters of the trait in the equation outside the range of optimums, which are indicated in the figure, reduces the level of grain yield. The trait is characterized by relatively wide borders of positive impact on grain yield, expressed in most of the studied accessions.

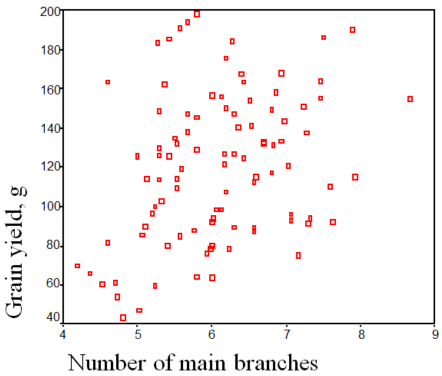

Fig. 3. Dependence between the grain yield and number of main branches

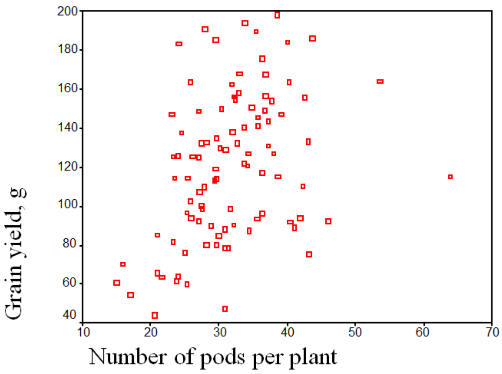

Fig. 4. Dependence between the grain yield and number of pods per plant

In Figure 5 from the chickpea plant model is shown the influence of the trait – number of grains per plant on the grain yield in the resulting regression model. The optimal values for it, having a favorable effect on grain yield from 1 m^2 area, range from 25 to 45 grains per plant. This trait is characterized by relatively wide borders, especially strongly expressed in 69.1% from the accessions.

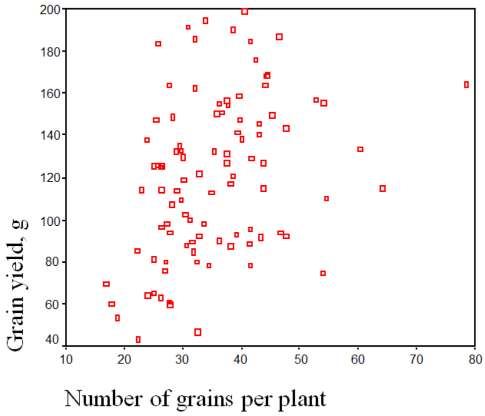

Fig. 5. Dependence between the grain yield and number of grains per plant

In the following Figure 6 is shown the influence of index mass of 100 grains on the grain yield in the resulting regression model. The beneficial effect of this trait on grain yield from 1 m^2 area is in the range from 28 g to 45 g. The grain yield from 1 m^2 area is strongly reduced at reduction the mass of 100 grains out of the optimum, as well as in the increased of the mass of 100 grains over the optimum. Most of the studied accessions have a mass of 100 grains from 28 g to 45 g.

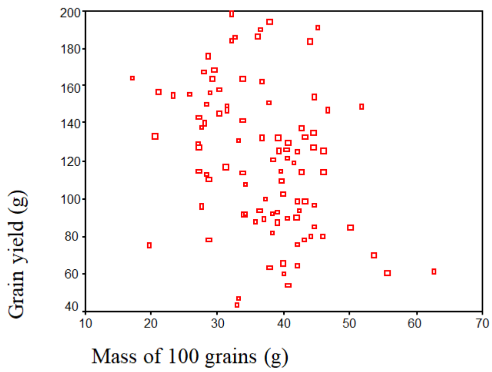

Fig. 6. Dependence between the grain yield and mass of 100 grains

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 chickpeat plant characterized with high grain yield should have the following parameters: plant height – from 38 to 43 cm; height to the first pod – from 25 to 29 cm; number of main branches – from 5 to 6 and above 6 numbers; number of pods per plant – from 25 to 45 numbers; number of grains per plant – from 25 to 45 numers; mass of 100 grains – from 28 to 45 g.

The given ideal model of chickpea plant would be difficult to implement in the breeding process. The task of some breeding program is to reach these optimal values. The full expression of high productive potential also depends on the knowledge of the complex relationships between the separate elements of yield and their combination in the plant.

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Received: January, 29, 2020; *Accepted:* August, 6, 2020; *Published:* June, 2021