Evaluation of plant characteristics related to grain yield of FAO410 and FAO340 hybrids using regression models

Seyed Mohammad Nasir Mousavi1 · János Nagy1

Received: 7 April 2020 / Accepted: 2 September 2020 / Published online: 15 September 2020 © The Author(s) 2020

Abstract

In breeding programs, estimation of increase in yield based on changes in effective plant traits is of great importance, which can be identified using regression modeling. The regression model refers to the prediction of the value of a dependent variable from the values of one or more independent variables. This study evaluated morphological traits of maize (FAO410) on six treatments of fertilizer in 2 years in Debrecen University by the regression model. This experiment was RCBD with four replications in the Látókép zone. Treatments were included in different levels of fertilizer: nitrogen, phosphor, and potassium. The regression model was significant at one percent that showed morphological traits have a straight effect on the yield of maize in FAO410 and FAO340. Grain yield had a positive correlation with plant height, outer ear diameter, the weight of ear, weight of cob, number of leaves, weight of all seeds in each ear, the weight of one thousand seeds on FAO410, and grain yield had a positive correlation with plant height, stem diameter, outer ear diameter, the weight of ear, weight of cob, number of seeds in each column, weight of all seeds in each ear, weight of the fresh plant in a hectare, the weight of one thousand seeds on FAO340 too. Cluster analysis showed the traits classification on two groups on hybrids. Reach maximum grain yield require the evaluation of yield components and their effect.

Keywords Regression model · Cluster analysis · Grain yield · Correlation

Introduction

Cereals are the most important food crop on the planet, supply 70% of the people’s food, and provide 75% of the total energy and more than half of the protein needed by humans (Emam 2007). Corn is high on grain and dry matter yield, having a varied nutritional value in the supply of carbohydrates, and edible oils in the agricultural economy of different countries are of particular importance (Nagy 2006). Maize (Zea Mays L.) as a staple food and forage crop has grown under a wide range of climates worldwide (Wang et al. 2008) and throughout much of the New World (Mexico, Central America, and South America) is an important plant. It is also the third-largest crop after wheat and rice in terms of area under cultivation and production (Kumar 2014).

Conventional farming practices in today’s world have not led to an acceptable success in resource management because of over-reliance on artificial inputs and injections of auxiliary energy such as fertilizers and pesticides; it has created unstable crop ecosystems (Cociu and Alionte 2017; Roberts 2008). Access to quantities and types of fertilizer can absorb more elements from the soil and transfer it to the seed, which is essential to optimize fertilizer consumption and improve product quality (Anjum et al. 2007). Climatic factors and nutrients play an important role in accelerating this genetic potential (Eichelberger et al. 1989; Asghari and Hanson 1984).

Nitrogen is one of the most important nutrients that has a major impact on maize grain yield (Borjian and Emam 2000). Inadequate nitrogen management is one of the important factors that reduce corn yield. Choosing the best method of nitrogen fertilizer is important for maximum yield and reduction of negative environmental impacts (Izadi and Emam 2010). Researchers have reported an increase in maize grain yield by increasing the amount of NPK chemical
Fertilizers due to the plant’s greater access to nutrients; also, it has shown that mineralization of soil organic matter alone cannot fully meet plant nutrition needs (Karimi et al. 2011). Other researchers have reported increasing quantitative and qualitative characteristics of maize under the influence of NPK chemical fertilizers (Akbari et al. 2005; Kogbe and Adediran 2003; Mostafavi et al. 2013; Hejazi et al. 2013; Bramdeo et al. 2019; Mousavi et al. 2013, 2019a, b).

Some researchers also reported that the effect of different levels of fertilizer application on fertilizer use efficiency in maize was significant. Therefore, the amount of fertilizer was increased from zero to 120%; this is the recommended amount in NPK fertilizer combination, which can decrease the amount of fertilizer use efficiency. The results showed that using treatment 80% of recommended fertilizer with an average of 21 kg/kg and 120% recommended fertilizer with an average of 11 kg/kg had the highest and lowest fertilizer use efficiency, respectively (Karimi et al. 2007).

Considering the importance of achieving sustainable agricultural goals to reduce the use of chemical fertilizers and to achieve more efficient use of resources through optimal input management, it is necessary to evaluate the effect of chemical fertilizers on these factors. Therefore, this experiment is conducted to estimate the effect of NPK chemical fertilizers on the quantitative and qualitative yield and trace element productivity in maize. Simple correlation, multiple regression and path analysis are used to analyze the components of yield and grain yield (Fraser 1983). Various methods exist for analyzing the yield components; the selection of the appropriate method is purely for research. One of these methods is the stepwise regression analysis. Identification of appropriate traits can be the basis of selection in breeding programs, and it can be useful to maximize grain yield (Pirzadeh Moghaddam et al. 2014).

**Materials and methods**

The study was carried out at the Debrecen Agricultural Research Station, 121 m above sea level in 2018 and 2019. The experiment was conducted in a randomized complete block design with four replications with maize hybrids (FAO340, FAO410). Treatments include NPK1 (N:0, P2O5:0, K2O:0), NPK2 (N:30, P2O5:23, K2O:27), NPK3 (N:60, P2O5:46, K2O:54), NPK4 (N:90, P2O5:69, K2O:81), NPK5 (N:120, P2O5:92, K2O:108), NPK6 (N:150, P2O5:115, K2O:135) in this experiment. The total rainfall from May until October was 291 mm in 2018 and 279 mm in 2019. April had a favorable effect on the partly dry and warm, but there was not fit value of precipitation until May (93.9 mm) due to the condition of the dried seedbed (Fig. 1).

Sowing was performed on April 24, 2018, and April 25, 2019, in a long-term experiment. Plant density was 72,000 plants per hectare.

The traits include green seeker (GR), chlorophyll meter (SP), plant height (HP), stem diameter (SD), outer ear diameter (OD), number of nodes (NN), the weight of ear (WE), the weight of cob (WC), number of seeds in each row (NSR), number of seeds in each column (NSC), number of leaves (LN), length of the ear (LE), weight of all seeds in each ear (WSE), number of seed in each ear (NSE), the weight of the fresh plant in hectare (WFP), weight of one thousand seeds (1S), grain yield (GY). The regression analysis and correlation analysis were performed with Genstat and Minitab software.

Regression refers to the prediction of the value of a dependent variable from the values of one or more independent variables. In general, the purposes of regression analysis are calculating the behavior of variable Y based on variable X; that is, by changing the X scores in the subjects, what behavior does the variable Y represent?

![Fig. 1] Monthly mean temperature and precipitation in 2018 and 2019
This behavior may be linear or curved. Data-based prediction for future samples is the data mining through statistical methods. The relative importance of each of the independent variables is estimated in predicting the dependent variable. Multivariate regression can investigate the unique effect of one or more predictor variables after controlling for one or more covariates.

Stepwise Method: In the step-by-step approach, it enters the variables one by one into the model. That is, the variable that has the highest correlation coefficient with the dependent variable is the first that entered into the analysis. In this method, the researcher does not enter the order of the variables.

In multivariate statistical analysis, there are different computational methods to measure the dependence or relationship between two random variables. The correlation between two variables is the ability to predict the value of one according to the other. One way of showing the relationship between the two variables is to calculate the “covariance” and “correlation coefficient” between them.

Regression and correlation are closely related. Also, regression is called the return to mean. The amount of correlation between the two variables determines the magnitude of the regression coefficient. Regression to the mean occurs when the correlation between the two variables is not complete. The accuracy of the prediction depends on the strength of the correlation. The higher the correlation between variables, the more accurate the prediction.

Tryon used the term cluster analysis in 1939 for methods of grouping objects that were similar. Cluster analysis is a data analysis shortcut tool that aims to arrange different objects into groups whose degree of correlation between two objects if they belong to a group is maximum and otherwise minimal. In other words, cluster analysis shows the structure of the data without explaining what exists (Rezaei 2007).

The objective of this study was to reach information about yield components by the regression model and find the best condition for the maximum yield on FAO410 and FAO340 hybrids.

**Results**

**Regression model**

The results of the regression analysis of variance for FAO410 and FAO340 hybrids showed that the regression model for trait hybrids was significant at one percent level. This means that the regression model, the slope of the line and the regression line equation can be investigated for effective traits on maize grain yield in hybrids. Also, the coefficient of determination was on FAO410 hybrid 89.05% and FAO340 hybrid 90.08% (Table 1).

Stepwise regression analysis of variance in FOA410 hybrid shows that in the first treatment (control) the traits length of ear and weight of ear, in the second treatment, traits weight of one thousand seeds and weight of cob, in the third treatment stem diameter and number of leaves, in the fourth treatment number of nodes and weight of ear, in the fifth treatment weight of ear and stem diameter and in the sixth treatment stem diameter and weight of ear had the maximum effect on maize grain yield. Reach to maximum grain yield must be paying attention to traits in treatments. For example, the weight of the ear and stem diameter had the highest effect on grain yield in the fourth and fifth treatments. When using this treatment, more attention is paying to the trait of the weight of ear and stem diameter for maximum grain yield. Also, these results in the FAO340 hybrid show that maximum grain yield on traits of first treatment (control) effect on plant height and the number of seed in each ear, the second treatment effect on stem diameter and weight of all seeds in each ear, the third treatment effect on the number of seeds in each column and number of leaves, the fourth treatment effect on the number of seeds in each row and weight of one thousand seeds, the fifth treatment effect on the number of leaves and outer ear diameter and the sixth treatment effect on the number of leaves and number of nodes. These traits had the most far-reaching effect on FAO340 maize grain yield. In this case, for the fifth treatment, traits including the number of leaves and outer ear diameter will have the most comprehensive effect on maize grain yield in FAO340 (Table 2).

**Correlation analysis**

In this research, the correlation analysis showed in FAO410 hybrid that chlorophyll meter with number of leaves, green seeker with number of seed in each ear, plant height with number of leaves, stem diameter, weight of ear, number of nodes, weight of cob, number of seeds in each column, length of ear, weight of all seeds in each ear, number of seed in each ear and grain yield, number of leaves with stem diameter, number of nodes, weight of ear, weight of cob, weight of all seeds in each ear and grain yield, stem diameter

| Hybrids | Model | df | F-Value | \( R^2 \) (%) |
|---------|-------|----|---------|----------------|
| FOA 410 | Regression model | 17 | 23.49** | 89.05 |
| Error | 30 | 62.22 |
| Total | 47 | 277.83 |
| FOA340 | Regression model | 17 | 15.49** | 90.08 |
| Error | 30 | 75.86 |
| Total | 47 | 222.55 |

Significant one percent (**), significant five percent (*)
Table 2 Stepwise regression analysis of treatments in hybrids

| Hybrids | Treatments | Regression equation | Parameters |
|---------|------------|---------------------|------------|
| FAO410  | NPK1 (N: 0, P2O5:0, K2O:0) | Y = 7.27 – 0.103 X1 – 0.115 X2 | X1: weight of ear, X2: length of ear |
| FAO410  | NPK2 (N:30,P2O5:23,K2O:27) | Y = 6.381 + 0.610 X1 + 0.459 X2 | X1: weight of one thousand seeds, X2: weight of cob |
| FAO410  | NPK3 (N:60,P2O5:46,K2O:54) | Y = 9.76 – 0.61 X1 + 0.284X2 | X1: leaves number, X2: stem diameter |
| FAO410  | NPK4 (N:90,P2O5:69,K2O:81) | Y = 5.782 + 0.532 X1 + 0.454 X2 | X1: number of nodes (pcs), X2: weight of ear |
| FAO410  | NPK5(N:120,P2O5:92,K2O:108) | Y = −4.64 + 0.712 X1 + 0.568 X2 | X1: weight of ear, X2: stem diameter |
| FAO410  | NPK6(N:150,P2O5:115,K2O:135) | Y = 128.5 – 15.60 X1 – 17.69 X2 | X1: weight of ear, X2: stem diameter |
| FAO340  | NPK1 (N: 0, P2O5:0, K2O:0) | Y = 6.194 + 0.3288 X1 – 0.0708 X2 | X1: number of seed in each ear, X2: plant height |
| FAO340  | NPK2 (N:30,P2O5:23,K2O:27) | Y = 3.617 + 0.380 X1 + 0.416 X2 | X1: weight of all seeds in each ear, X2: stem diameter |
| FAO340  | NPK3 (N:60,P2O5:46,K2O:54) | Y = 10.088 – 1.385 X1 – 0.921 X2 | X1: number of seeds in each column, X2: leaves number |
| FAO340  | NPK4 (N:90,P2O5:69,K2O:81) | Y = 2.84 + 4.62 X1 – 0.404 X2 | X1: number of seeds in each row, X2: weight of 1000 grain |
| FAO340  | NPK5(N:120,P2O5:92,K2O:108) | Y = 6.916 – 0.6756 X1 – 0.4184 X2 | X1: leaves number, X2: outer ear diameter (cm) |
| FAO340  | NPK6(N:150,P2O5:115,K2O:135) | Y = 1.344 – 0.9484 X1 + 2.314 X2 | X1: number of nodes (pcs), X2: leaves number |

Cluster analysis

Cluster analysis is a statistical method for grouping data or observations, according to their similarity or degree of proximity. Through cluster analysis, the data or observations are divided into homogenous and distinct categories. Two groups exist in grouping affect traits of grain yield by cluster analysis in this research. In FAO410, the first group includes chlorophyll meter, number of leaves, number of nodes, green seeker, number of seeds in each column, number of seed in each ear, plant height, length of ear, stem diameter, the weight of the fresh plant in hectare and number of seeds in each row that have effect on growth process in plant and grain formation. The second group includes outer ear diameter, the weight of the fresh plant in hectare and number of seeds in each row that have effect on growth process in plant and grain formation. The second group includes outer ear diameter, the weight of the fresh plant in hectare and number of seeds in each row that have effect on growth process in plant and grain formation.
### Table 3  Correlation analysis of FAO410

|       | GR    | HP    | LN     | SD     | OD     | NN     | WE     | WC     | NSR    | NSC    | LE     | WSE    | NSE    | WFP    | IS     | GY     |
|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| SP    | 0.194 | 0.312 | 0.392  | 0.314  | 0.108  | 0.329  | 0.229  | 0.357  | -0.066 | 0.304  | 0.205  | 0.242  | 0.135  | 0.036  | 0.120  | 0.261  |
| GR    | 0.275 | 0.321 | 0.081  | 0.112  | 0.345  | 0.143  | 0.143  | 0.143  | 0.143  | 0.062  | 0.148  | 0.141  | 0.424  | 0.024  | 0.007  | 0.98   |
| HP    | 0.617 | 0.546 | 0.242  | 0.560  | 0.406  | 0.510  | 0.183  | 0.550  | 0.385  | 0.466  | 0.361  | -0.018 | 0.371  |        |        |        |
| LN    | 0.443 | 0.315 | 0.901  | 0.445  | 0.389  | 0.078  | 0.367  | 0.249  | 0.409  | 0.313  | 0.179  | 0.219  | 0.452  |        |        |        |
| SD    | 0.103 | 0.488 | 0.002  | 0.295  | -0.126 | 0.402  | 0.532  | -0.029 | 0.262  | 0.809  | -0.370 | 0.046  |        |        |        |        |
| OD    | 0.290 | 0.578 | 0.234  | 0.316  | 0.228  | 0.223  | 0.564  | 0.404  | -0.101 | 0.438  | 0.378  |        |        |        |        |        |
| NN    | 0.292 | 0.307 | 0.057  | 0.341  | 0.240  | 0.248  | 0.277  | 0.252  | 0.143  | 0.256  |        |        |        |        |        |        |
| WE    | 0.606 | 0.164 | 0.321  | 0.082  | 0.978  | 0.327  | -0.144 | 0.553  | 0.867  |        |        |        |        |        |        |        |
| WC    | 0.002 | 0.581 | 0.262  | 0.587  | 0.528  | 0.221  | -0.043 | 0.508  |        |        |        |        |        |        |        |        |
| NSR   | -0.064| -0.156| 0.144  | 0.259  | -0.212 | 0.116  | 0.003  |        |        |        |        |        |        |        |        |        |
| NSC   | 0.396 | 0.299 | 0.858  | 0.412  | -0.072 | 0.313  |        |        |        |        |        |        |        |        |        |        |
| LE    | 0.072 | 0.310 | 0.431  | -0.139 | 0.009  |        |        |        |        |        |        |        |        |        |        |        |
| WSE   | 0.309 | -0.183| 0.547  | 0.860  |        |        |        |        |        |        |        |        |        |        |        |        |
| NSE   | 0.259 | -0.111| 0.235  |        |        |        |        |        |        |        |        |        |        |        |        |        |
| WFP   | -0.553| -0.152|        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| IS    | 0.551 |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |

Green seeker (GR), chlorophyll meter (SP), plant height (HP), number of leaves (LN), length of ear (LE), stem diameter (SD), outer ear diameter (OD), number of nodes (NN), the weight of ear (WE), the weight of cob (WC), number of seeds in each row (NSR), number of seeds in each column (NSC), length of the ear (LE), weight of all seeds in each ear (WSE), number of seed in each ear (NSE), the weight of the fresh plant in hectare (WFP) weight of one thousand seeds (IS), grain yield (GY). Significant one percent (**), significant five percent (*)
|   | GR   | HP   | LN   | SD   | OD   | NN   | WE   | WC   | NSR  | NSC  | LE   | WSE  | NSE  | WFP  | 1S   | GY   |
|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| SP | -0.062 | -0.052 | -0.059 | -0.005 | 0.299* | -0.046 | -0.002 | 0.005 | -0.079 | 0.298* | 0.090 | 0.003 | 0.170 | 0.283 | 0.098 | 0.254 |
| GR | 0.160 | 0.164 | 0.262 | 0.216 | 0.256 | 0.191 | 0.209 | -0.002 | 0.278 | 0.083 | 0.179 | 0.242 | 0.029 | 0.229 | 0.086 |
| HP | 0.503** | 0.653** | 0.244 | 0.451** | 0.401** | 0.503** | 0.020 | 0.247 | 0.108 | 0.371** | 0.220 | 0.191 | 0.152 | 0.475** |
| LN | 0.630** | 0.353* | 0.860** | 0.197 | 0.367* | -0.272 | 0.171 | 0.294* | 0.154 | 0.049 | 0.147 | 0.326* | 0.325* |
| SD | 0.454** | 0.691** | 0.401** | 0.666** | -0.144 | 0.332* | 0.503** | 0.342* | 0.321* | 0.372** | 0.239 | 0.520** |
| OD | 0.376** | 0.418** | 0.543** | 0.049 | 0.375** | 0.506** | 0.379** | 0.437** | 0.575** | 0.370** | 0.487** |
| NN | 0.313* | 0.516** | -0.398** | 0.159 | 0.420** | 0.261 | 0.004 | 0.217 | 0.261 | 0.004 | 0.276 |
| WE | 0.825** | -0.066 | 0.364* | 0.194 | 0.994** | 0.464** | 0.437** | 0.702** | 0.669** |
| WC | -0.111 | 0.249 | 0.441** | 0.764** | 0.307* | 0.350* | 0.472** | 0.546** |
| NSR | -0.309* | -0.293* | -0.058 | 0.167 | 0.070 | -0.099 | -0.006 |
| NSC | 0.231 | 0.376** | 0.637** | 0.408** | 0.379** | 0.475** |
| LE | 0.147 | 0.387** | 0.313* | 0.017 | 0.124 |
| WSE | 0.475** | 0.437** | 0.722** | 0.671** |
| NSE | 0.518** | 0.251 | 0.521** |
| WFP | -0.384** | 0.693** |
| 1S | 0.595** |

Green seeker (GR), chlorophyll meter (SP), plant height (HP), number of leaves (LN), length of ear (LE), stem diameter (SD), outer ear diameter (OD), number of nodes (NN), the weight of ear (WE), the weight of cob (WC), number of seeds in each row (NSR), number of seeds in each column (NSC), length of the ear (LE), weight of all seeds in each ear (WSE), number of seed in each ear (NSE), the weight of the fresh plant in hectare (WFP), weight of one thousand seeds (1S), grain yield (GY). Significant one percent (**), significant five percent (*)
seeker and number of seeds in each row that affect ear and grain of ear. The second group involves plant height, stem diameter, number of leaves, number of nodes, the weight of ear, weight of all seeds in each ear, the weight of cob and weight of one thousand seeds; these traits have impression on vegetative stage and grain production (Fig. 3).

Discussion

Regression analysis showed that the weight of ear is an effective trait for grain yield on FAO410 and the number of leaves is an effective trait for grain yield on FAO340. Accordingly, to reach maximum grain yield on different treatments, the charge of this trait could get an acceptable yield on hybrids. Researchers using stepwise regression in maize hybrid cultivars investigated grain yield as a dependent variable against
other traits as the independent variable. (Zinali et al. 2004). In the final model of multiple regression analysis, one thousand grain weight, number of seeds per ear, number of leaves and plant height were important traits of research (Mostafavi 2013). Based on correlation analysis, effective traits on grain yield in FAO410 hybrid include plant height, outer ear diameter, the weight of ear, weight of cob, number of leaves, weight of all seeds in each ear, weight of one thousand seeds. On the other hand, if you want to get maximum grain yield on this hybrid, we can control growth of these traits. Also, effective traits on FAO340 hybrid include plant height, stem diameter, outer ear diameter, the weight of ear, the weight of cob, number of seeds in each column, weight of all seeds in each ear, the weight of the fresh plant in a hectare, the weight of one thousand seeds. Extensive studies have been conducted to determine the correlation and analysis of genetic parameters of grain yield through the components of yield. Grain yield is a complex trait controlled by various morphological and physiological traits (Crosbie and Mock 1981). Thus, genetic control of yield is indirectly influenced by traits that are correlated with yield and increasing yield and improving its genetic characteristics is a function of various morphological and physiological traits. Understanding the correlation between yield and its components and finding the type of relationship between them can increase grain yield (Kalla et al. 2001). Another study also reported that grain yield had a positive and significant correlation with plant height, ear height and number of ear rows per ear (Sadek et al. 2006). In correlation analysis, some traits do not have a significant relationship with yield, and in regression analysis, some variables do not have a significant effect on the function (Farshadfar 1998). The results of stepwise regression analysis of maize showed that weight of one thousand grain yield and cob weight with negative coefficients, and the depth of planting and plant height with positive coefficients, justified 52% of total changes in grain yield and have been identified as effective traits in increasing grain yield (Amiri et al. 2009). In another study, it was reported that grain yield had a positive and significant correlation with plant height, ear height and number of rows in the ear (Sadek et al. 2006). Cluster analysis showed that breeding seeds and plant or reach the highest yield must be which part of the plant is significant, or have the maximum effect of the other parts. Morphological traits of maize by cluster analysis showed that area of the flag leaf, grain rows, peduncle length out of flag leaf and ear conicalness index were important traits of 25 traits on this experience (Choukan et al. 2005). The purpose of this study was to investigate the grain yield differences between FAO410 and FAO340 hybrids in Hungary. As we know, the yield is controlled by multigens. So to increase yield, attention needs to be paid to more traits. Therefore, it will be difficult to control multigens or traits of work. This study tries to facilitate the study of yield by clustering traits and classification of the traits. Therefore, the effective traits of yield are classified into two groups. In correlation and regression analyses, the interaction effects of traits with each other as well as the slope of the regression line have identified the traits that had the greatest effect on grain yield. Through studying (reducing or increasing) traits, maximum grain yield can be achieved in two hybrids and different levels of fertilizer to gain optimal stability yield. Breeders can also use the result of the research to study the effects on yield as well as plant breeding. Overall, to test the viability of these hybrids, it will require 3 years of testing, which will be reported soon.

Acknowledgement “The research was financed by the Higher Education Institutional Excellence Programme (NKFIH-1150-6/2019) of the Ministry of Innovation and Technology in Hungary, within the framework of the 4th thematic programme of the University of Debrecen.”

Funding Open access funding provided by University of Debrecen.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Akbari G, Mazaheri D, Mokhtasi Bid Goli A (2005) Effects of plant densities, different levels of nitrogen and potash on grain yield and yield components of maize (zea mays l.). J Agric Sci Nat Resources 12(5):46–54
Amiri S, Nour MS, Jafari AA, Chukan R (2009) Correlation, regression and path analysis for grain yield and yield components on early maturing hybrids of grain corn. J Plant Prod 16(20):99–112
Anjum MA, Sajjad MR, Akhtar N, Qureshi MA, Iqbal A, Rehman A (2007) Response of cotton to plant growth promoting rhizobacteria (PGPR) inoculation under different levels of nitrogen. J Agric Res (Pakistan) 45:135–143
Asghari M, Hanson RG (1984) Nitrogen, climate, and previous crop effect on corn yield and grain N. Agron J 76(4):536–542. https://doi.org/10.2134/agronj1984.00021960007600040007x
Borjian A, Emami Y (2000) The effect of urea solution spraying before flowering on the yield and protein of grain of wheat. Iran J Crop Sci 2:23–25
Bramdeo K, Mousavi SMN, Mohammed S, Nagy J (2019) Studying the relationships of various agronomic traits in maize using
correlation analysis. 18th Alps-Adria Sci Workshop. https://doi.org/10.34116/NTI.2019.AA.49

Choukan R, Hosseinzadeh A, Ghanadha MR, Taleei A, Mohammadi SA (2005) Classification of maize inbred lines based on morphological traits. Seed Plant 21:139–157

Cociu AI, Alionte E (2017) The effect of different tillage systems on grain yield and its quality of winter wheat, maize and soybean under different weather conditions. Romanian Agric Res 34:59–67

Crosbie TM, Mock JJ (1981) Changes in physiological traits associated with grain yield improvement in three maize breeding programs 1. Crop Sci 21(2):255–259. https://doi.org/10.2135/cropsci1981.001183X002100002013x

Eichelberger KD, Lambert RJ, Below FE, Hageman RH (1989) Divergent phenotypic recurrent selection for nitrate reductase activity in maize. II. Efficient use of fertilizer nitrogen. Crop Sci 29(6):1398–1402. https://doi.org/10.2135/cropsci1989.0011183X002900060013x

Emam Y (2007) Cereal production, vol 190, 3rd edn. Shiraz University Press, Shiraz

Farshadfar E (1998) Application of biometrical genetics in plant breeding, vol 1. Press Bostan, Boston, p 498

Fraser J (1983) Applications of yield component analysis to crop research (No. REP-3081. CIMMYT.)

Hejazi P, Mousavi SM, Mostafavi K, Ghomshei MS, Hejazi S, Mousavi SM (2013) Study on hybrids maize response for drought tolerance index. Adv Environ Biol 7(2):333–338

Izadi MH, Emam Y (2010) Effect of planting pattern, plant density and nitrogen levels on grain yield and yield components of maize cv. SC704. Iran J Crop Sci 12(3):239–251

Kalla V, Kumar R, Basandrai AK (2001) Combining ability analysis and gene action estimates of yield and yield contributing characters in maize (Zea mays L.). Crop Res-HISAR- 22(1):102–106

Karimi A, Mazardalan M, Homaee M, Liaghat AM, Raissi F (2007) Fertilizer use efficiency for sunflower with fertigation system. JWSS-Isfahan Univ Technol 11(40):65–77

Karimi H, Mazaheri D, Peyghambari SA, Mirabzadeh Ardakani M (2011) Effect of organic and chemical fertilizers application on grain yield and yield components of maize (Zea mays L.) SC704. Iran J Crop Sci 13(4):611–626

Kogbe JO, Adediran JA (2003) Influence of nitrogen, phosphorus and potassium application on the yield of maize in the savanna zone of Nigeria. African J Biotechnol. 2(10):345–349. https://doi.org/10.5897/ABJ2003.000-1071

Kumar S, Langyan S, Chaudhary DP (eds) (2014) Maize: nutrition dynamics and novel uses. Springer

Mostafavi K, Firoozi M, Mousavi SMN (2013) Effect of drought stress on yield and yield components of maize hybrids. Sci Res Essays 8(24):1145–1149

Mousavi SM, Hejazi P, Mostafavi K, Fotovat F (2013) investigation of drought stress on morphological traits in some bread wheat cultivars. Adv Environ Biol 1:131–136

Mousavi SM, Bodnár KB, Nagy J (2019a) Studying the effects of traits in the genotype of three maize hybrids in Hungary, Acta Agraria Debrecenensis. https://doi.org/10.34101/actaagrar/1/2378

Mousavi SM, Kith K, Nagy J (2019b) Effect of interaction between traits of different genotype maize in six fertilizer level by GGE biplot analysis in Hungary. Progress Agric Eng Sci 15(1):23–35. https://doi.org/10.1556/446.15.2019.1.2

Nagy J (2006) Maize production. Akadémiai Kiadó, Hungary

Pirzadeh Moghaddam M, Bagheri A, Malekzadeh-Shafaroudi S, Ganjeali A (2014) Multivariate statistical analysis in chickpea (Cicer arietinum L.) under limited irrigation. Iran J Pulses Res 5(2):99–110

Rezaei AM (2007) Concepts of statistics and probability. Mashhad Publication, Mashhad, p 431

Roberts TL (2008) Improving nutrient use efficiency. Turk J Agric Forestry. 32:177–182

Sadek SE, Ahmed MA, Abd El-Ghaney HM (2006) Correlation and path coefficient analysis in five parents inbred lines and their six white maize (Zea mays L.) single crosses developed and grown in Egypt. J App Sci Res 2(3):159–167

Wang C, Yang A, Yin H, Zhang J (2008) Influence of water stress on endogenous hormone contents and cell damage of maize seedlings. J Integr Plant Biol 50(4):427–434. https://doi.org/10.1111/j.1774-7909.2008.00638.x

Zinali H, Naser-Abadi E, Hossein-zadeh H, Chugan R, Sabokdast M (2004) Factor analysis on hybrid of cultivar grain maize. Iranian J Agric Sci 36(4):895–902