Analysis of the pre-registration maize breeding trials and the germplasm developed in Altınova breeding station from 2015 to 2018

ABSTRACT

Main goal of the most breeding programs is to develop highly adaptive hybrids in various environments, and the most important limitation are complex interactions between genotype, environment and management. Every hybrid breeding program follows certain strategy for new hybrid development. One possible strategy is to develop hybrids with lower adaptability, achieving best performance in "high input" environments (breeding for “race-horses”). However, another approach is to breed for hybrids with higher adaptability and stable performance across a wide range of environments (breeding for “work-horses”). High stability needs to be accompanied by high yield performance to insure profits, so stability should be monitored along with performance in breeding trials. Aim of this research was to analyze the new germplasm developments and their performances in the pre-registration trials in Turkey by the means of BLUP and GGE models. Heritability estimates for grain yield ranged from 0.58 to 0.85, and relative stability of all hybrids and checks is detected across all years. Cause of the high estimates of G×L interaction were crossovers of genotype performances across locations. The location Altinova was the least stable location across years. One hybrid was selected as a future check based on stability parameters across environments. As G×E interaction remains the greatest challenge in modern maize breeding, more research is needed in this field. Therefore mixed-model based approach is a valuable tool for analysis of genotype performances in maize breeding trials.

Keywords: breeding, G×E interaction, germplasm, maize

Analiza predkomisijskih pokusa kukuruza i germplazme razvijene u oplemenjivačkoj stanici u Altınovi od 2015. do 2018. godine

SAŽETAK

Glavni cilj komercijalnih oplemenjivačkih programa na kukuruzu je razviti hibride visoke prilagodljivosti u raznim okolinama, pri čemu glavno ograničenje predstavljaju kompleksne interakcije između genotipa, okoline i upravljanja. Svaki oplemenjivački program slijedi određenu strategiju za stvaranje hibrida. Jedna od strategija je stvaranje hibrida koji nemaju vrhunsku adaptabilnost, ali mogu postići najviše prinose u visokoprinosnim okolinama ("trkači konji"), dok...
je druga strategija stvaranje hibrida visoke adaptabilnosti u raznim okolinama („radni konji”). Visoka stabilnost mora biti popraćena visokim prinosima kako bi se osigurao profit, stoga bi se u oplemenjivačkim pokusima stabilnost trebala pratiti zajedno s prinosom. Cilj ovoga istraživanja je analiza nove germplazme (inbred linija i hibrida) kroz predkomisijske pokuse na raznim lokacijama u Turskoj, korišćenjem BLUP i GGE metode za predviđanje, odnosno stabilnost prinosa. Heritabilnost za prinos zrna iznosila je od 0.58 do 0.85, a relativna stabilnost svih hibrida i standarda je zabilježena u svim godinama. Uzrok visokih vrijednosti G×L interakcije su različite vrijednosti genotipova kroz lokacije. Lokacija Altınova bila je najmanje stabilna kroz sve četiri godine. Jedan hybrid je izabran kao budući standard na osnovu stabilnosti u svim okolinama. Kako G×E interakcija i dalje predstavlja najveći izazov u modernom oplemenjivanju kukuruza, potrebno je još istraživanja u tome području, a korišćenje mješovitih modela predstavlja vrijedan alat za analizu genotipova u oplemenjivačkim pokusima.

Ključne riječi: oplemenjivanje, G×E interakcija, germplazma, kukuruz

**INTRODUCTION**

Hybrid maize breeding requires considerable efforts and funds due to the highly developed markets worldwide and state-of-the-art technological applications in breeding programs. Main goal of most of the breeding programs is grain yield, which shows positive linear relationship to the year of hybrid development (Duvick, 2005). Main limits to the development of the highly adaptive hybrids are the genotype × environment (G×E) and more complex genotype × environment × management (G×E×M) interactions (Tollenaar and Lee, 2002). G×E and G×E×M interactions appear to be the number one factor in keeping maize breeder's jobs secure (Bernardo, 2016) and prediction of hybrid performances uncertain. One of the objectives of maize breeding is to maximize genetic gain per unit of time and cost and one of the main strategies in efficient utilization of available resources by bridging the G×E and G×E×M interactions is defining the target population of environments (TPE) representative of the area and management targeted for hybrid production (Messina et al., 2011). Once the TPE has been defined, the careful characterization of the agro-meteorological scenarios needs to be performed (Bustos-Korts et al., 2018; Tardieu et al., 2018) to allow the dissection of interactions. Efficiency of breeding is limited by several factors, one of the main being trait heritability. Modelling of the trait variance to estimate heritability is conveniently done by the restricted maximum likelihood (REML) based mixed modelling approach, allowing to estimate the unbiased variance components (Piepho et al., 2008; Van Eeuwijk et al., 2016), comprising the simplest form of best linear unbiased predictions of genotypic variance (BLUP). Every hybrid breeding program follows certain strategy of new hybrid development. One possible strategy is to develop the hybrids with low adaptability, achieving best performance in “high input” environments, while breeding for performance in “low input” environments is neglected (breeding for “race-horses”). However, another approach is to breed for hybrids with high adaptability and stable performance across a wide range of environments (breeding for “work-horses”; Tollenaar and Lee, 2002). High stability needs to be accompanied by high yield performance to insure profits, so stability should be monitored along with performance in breeding trials (Piepho et al., 2008). Aim of this research was to analyze the new germplasm developments and their performances in the pre-registration trials by the means of BLUP and GGE models.

**MATERIALS AND METHODS**

Trials were set with 15 to 16 experimental hybrids at four locations in Turkey from 2015 to 2018. These hybrids were selected based on the two year results of hybrid performance testing (first year of screening trials, and second year of testing on several locations). Trial locations were Altınova, Manisa and Adana in all four years while location Mersin was discarded in 2017 and 2018 due to the severe weather conditions that affected the trial quality. Five to six best performing commercial checks were chosen each year according to the sales data obtained from the Tarım Kredi Kooperatifleri database.
RESULTS AND DISCUSSION

Heritability estimates were 0.58 in 2015, 0.65 in 2016, 0.85 in 2017 and 0.82 in 2018. Considerably lower heritabilities were detected in years 2015 and 2016 compared to 2017 and 2018. Cause of the lower obtained heritabilities were the high estimates of G×L interaction (not shown). Cause of the high estimates of G×L interaction were crossovers of genotype performances across locations. The location Altinova was the least stable location across years. The instability of this experimental location is visible in BLUP estimates of the environmental effects (Figure 1) and high loading values in separate directions from other locations (except Manisa in 2015) in 2015 and 2016 in the GGE models (Figure 2A and B).
average yield to ensure profits. Inspection of the BLUP values of hybrids revealed the hybrid OS227×OS7798/2 in 2015 (G9 in Figure 2A). Hybrid was selected to enter pre-registration trials based on performance in 2014 in small pre-commission trial set on two locations. Next season the hybrid entered the official registration process, and was registered in 2017 under the name Albayrak. High stability throughout years 2016-2018 (Figure 2B–D, G9 in 2016, G19 in 2017 and 2018) accompanied with high yield performance (Figure 3) show that this is a true high yielding “work-horse” type of hybrid. Commercial checks were G17-G22 in 2015 and G16-G20 from 2016 to 2018. In 2017 and 2018, hybrid Albayrak was treated as internal performance check (genotype 19). As G×E interaction remains the greatest challenge in modern maize breeding, van Eeuwijk et al. (2016) presented statistical framework for dealing with it which includes the mixed-model based approach.
CONCLUSIONS

Relatively stable performances of all experimental hybrids and checks were detected across all years. Hybrid Albayrak was selected as a commercial check based on both yield and stability performances. Stability analysis and mixed model based approach are recommended for dealing with high yielding environments. As G×E interaction remains the greatest challenge in maize breeding, more research is needed to further explain these complex patterns.

REFERENCES


