Public Popcorn Breeding Studies of Turkey

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ABSTRACT

Popcorn (*Zea mays everta*) is one of the oldest forms of field maize and it was developed for higher popping volume from flint maize. Popcorn is a very popular appetizer in Turkey and its cultivation and consumption is increasing. It is widely cultivated in Aegean, Mediterranean, Southeast Anatolia and Marmara region of Turkey. Popcorn seed was supplied mainly by the public sector's varieties in the past. Currently both public and private sector's hybrids are produced by the growers. The primary concern in popcorn production is lack of enough high yielding and quality local popcorn varieties. According to the Variety Registration and Seed Certification Center of Turkey sources, there are only a few local popcorn hybrids in the production. Therefore, popcorn growers are often having difficulty finding sufficient seeds. A national big scale popcorn breeding project was initiated by Public, Private Sector and University partnership in order to develop and release high yielding popcorn hybrids in 2015. With the Project, it was targeted to develop local popcorn hybrids and inbreeds to meet high yield and quality variety need and increase national production. In order to develop new inbreds, genotypes derived from populations and pedigree breeding procedures was applied. During the studies, both field and greenhouses were used for generations. General combining ability tests have been done by topcrossing method and the trails were carried out in different 4 locations representing different regions of Turkey. On the other hand, to develop local new varieties in a near future, promising inbreds of public and private sector were crossed to each other in the light of genetic distances and breeding performances. Experimental hybrids will be evaluated in 4 locations in the 2nd and 3rd years of the Project. In the present paper, information on popcorn genetic resources such as developed populations, collections and inbred lines in Turkey are given, current and future studies of the breeding projects that carried out by the public sector are evaluated.

Keywords: genetic resources, population, inbred, hybrid, yield, quality

1. Popcorn Genetic Resources

Popcorn is a maize type that puffs up when heated. In order to maximize popping expansion selections were done in flint type maize in the past. Although yield is a very important trait in selecting popcorn germplasm, quality futures such as popping volume, flavor, mouth feel and also disease and insect resistance are very important selection criteria (Alexander, 1988).

In order to develop popcorn varieties for Turkey, different popcorn genetic resources beginning from

1980's to to date were used. Populations developed by Public National Research Institutes of Turkey are main sources for popcorn hybrid development projects.

Turkey has carried out intensive breeding studies on popcorn in the late 1990s. During that time, new popcorn breeding populations were developed. Ant-Pop-C6 popcorn source population was developed by Bati Akdeniz Agricultural Research Institute (BATEM) using half-sib recurrent selection in between 1996-2002. Ant-pop-C6 population consists of 256 family. The popping volume of the initial pop-

ulation, Ant-Pop-C3, was 21.6 cc/100g, while it was 27 cc/100g in the Ant-Pop-C6 population. Genetic progress has been made with the selections for popping volume (Koc *et al*., 2005).

On the other hand, ADAPOP-8 and ADAPOP-10 populations were developed by Maize Research Institute in 2008. Pop corn germplasm that has both white and yellow kernel around Turkey was collected and mass selection was applied to the collection in order to form ADAPOP-8 population. Recurrent Selection Method (S_1) was applied to the genetic material starting from 1992. The first cycle of the population was completed in 1996 and the studies started again in 1997 to obtain second cycle. Out of initial populations three populations (S_1C_1, S_1C_2, and S_1C_3) that were developed by S_1 recurrent selection method and one population (S_1C_3FS) which was developed by full-sib recurrent selection method were tested in Antalya (west Mediterranean) and Adapazari (Maramara region) ecological conditions (Figure 1). The study was carried out according to randomized complete block design using four replications. According to the results, the grain yield of the populations were changed between 5810 kg/ha and 7890 kg/ha in Adapazari location. The highest yield was obtained from S_1C_3 population in that location. Antalya site yields were lower than Adapazari location. The yields varied between 2770 kg/ha and 6330 kg/ha. The very similar yield trend in populations in both location was observed. It can be seen from the Figure1 that there were significant genetic improvement in the cycle three (C_3) in terms of grain yield (Figure 1). Also yield of full-sib population of C_3 was lower than S_1recurrent population. This situation showed that S_1recurrent selection method was more successful than full-sib recurrent selection method in the population improvement studies in popcorn. A similar approach for population improvement regarding to full-sib recurrent selection method was reported by Pandey and Gardner (1992) and Banziger *et al*., (2000). The researchers highlighted that full-sib method may be ineffective for the population improvement in terms of grain yield in maize. In addition. Hallauerand Miranda (1981) stated that the S_1recurrent selection method should be used between 2 and 4 cycles, after which the genetic structure of the population narrowed. Most probably, the current constriction is due to additive gene effects.

Another important popcorn source germplasm is ADAPOP-10. This population is composed of maize individuals with yellow grain kernel and mid-late maturity group. To date several popcorn inbred lines have been derived from the ADAPOP-10 source germplasm.

Public inbredlines from United States and Europe were used in the variety development projects. Generally the public inbredlines were crossed to adapted popcorn germplasm and lines derived from the F_2 populations. Especially, P206, P208, HP301, HP68-07, HP72-11 and P608 U.S public inbredlines were used in the pollinations.

Local popcorn populations or land races are valuable popcorn source germplasm for breeding popcorn in Turkey. Farmers used their own popcorn seed in the past since they could not find hybrid seed. This helped also to develop their own seed by selecting best germplasm for using in the future. Currently this germplasm were collected around the Turkey and characterized either by molecular markers or morphological data. Studies showed that there is a wide genetic distance between the popcorn germplasm (Figure 2) of Turkey (Ilarslan *et al*., 2001; Ozturk *et al*., 2017)

2. Popcorn Hybrid Breeding

Pedigree breeding approach was applied to the source germplasm to develop high yielding and quality popcorn single crosses. According to the method, inbred lines were derived from populations and general combining ability of the candidate lines were determined by using top crossing method in between S_2-S_5 selfing generations. Lines that have good combining ability were selected for further evaluations. During selections, yield, popping volume, popping rate and tenderness traits were the selection criteria. Candidate hybrids were assessed in different locations to select best hybrids. In a study Erdal *et al*., (2012) investigated the yield performances of 14 popcorn hybrids across four different regions of Turkey by using additive main effects and multiplicative interactions analysis (AMMI). The study showed that genotype by environment interaction is very important in these lection promising popcorn hybrids. After many studies on popcorn, the first improved local public popcorn hybrid (Ant Cin-98) was developed in Turkey in 1998. The hybrid was used by farmers for a long time and later NerminCin and KocCin were registered in 2002 and 2005, respectively (Anonymous, 2014). Information about these mentioned public popcorn hybrids are summarized in table 1.

3. Current Popcorn Breeding Studies

Popcorn production in Turkey is increasing. The most important problems encountered in the production of popcorn are lack of number of sufficient high quality and efficient popcorn varieties. According to the Variety Registration and Seed certification Center of Turkey sources. there are only a few pop-

corn hybrids including public varieties in the production (Anonymous 2014). In order to support popcorn growers, a public, private sector and university partnership was established in 2015. With the partnership, a national big scale popcorn breeding was initiated to develop and release high yielding popcorn hybrids.

The Project studies were illustrated in the Figure 3. Project works were planned in two main work packages. These are developing elite/advanced stage popcorn inbredlines and superior local popcorn hybrids. In the work package of developing elite/advanced popcornlines, 103 populations were used as starting material. 56 of these popcorn source germplasm belonged to BATEM and Maize Research Institute, 5 populations from gene banks around the World and 42 populations were provided from Turkey Eagean Agricultural Research Gene Bank. Selfing studies were done according to the Russel and Eberhart (1975) method. During the studies field and greenhouse have been used for generations. It was seen that green houses or shelters can be used very effectively for obtaining generations (Figure 4, 5, 6, 7). To date 314 S_4-S_5 level popcorn advanced inbred lines were developed and subjected to topcrossing method for general combining ability. After topcross yield tests across four locations in 2017 best lines will be selected for diallel crosses. The lines will be defined by morphological traits and thus will be ready for developing new hybrids.

On the other hand, to develop local new popcorn varieties in a near future, 66 promising popcorn inbred lines were used to generate hybrids in 2015 and 2016. These lines belonged to BATEM (34 lines), Black Sea Agricultural Research Institute (22 lines) and POLTAR (10 lines) which is a private sector seed company in Turkey. Hybrid parents were selected based on genetic distances that obtained by molecular markers and pedigree information given by breeders.

Experiments were conducted in four different geographical region of Turkey in 2016 and summer season of 2017 was used for final evaluations of the candidate hybrids. 59 candidate hybrids and 5 commercial checks (Antcin 98, NerminCin, SH9201, Baharcin and Elacin) including public varieties were tested in 2016. Hybrids were subjected to quality analysis after harvest.

4. Conclusions

With the efforts of National Turkish public research institutes, popcorn populations were developed and several inbred lines derived from the improved populations. Several inbred lines characterized by molecular and morphological markers. Public popcorn hybrids were developed and released for use in popcorn production. However, a strong relationship was needed to develop lines and hybrids of popcorn and therefore a national cooperation was established. The studies related popcorn hybrid breeding is going on and final results will be obtained in 2019. With the current public popcorn breeding studies popcorn genetic resources have been used effectively and it is believed that the study has the potential to provide a contribution to Turkish popcorn production.

Table 1. Information about registrated public popcorn hybrids in Turkey.

Hybrid	Registration year	FAO Maturity Group	Plant Height (cm)	1000 GrainWeight (g)	Earlength (cm)	Popping Volume (cc g⁻¹)	Yield (t/ha)
Ant Cin98	1998	550-600	210	135-150	18	26-28	5.5
NerminCin	2002	600	195	165	18	27	6
KocCin	2005	600	200	100	18	27	5- 6.5

Figure 1. Genetic improvement in the developed popcorn populations.
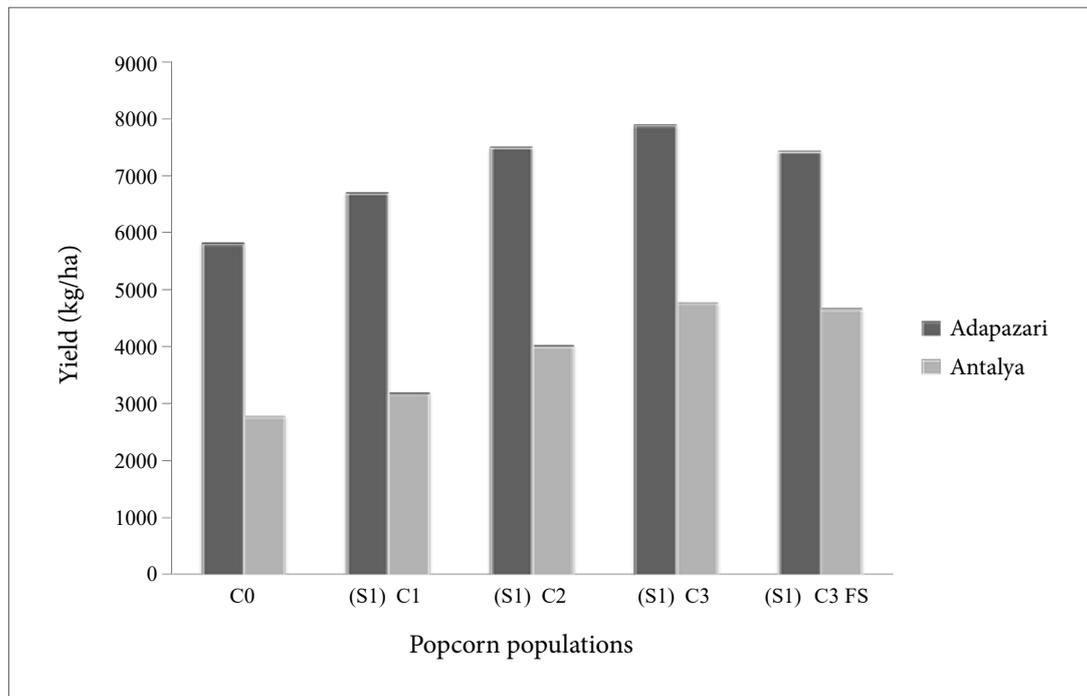
Figure 2. Different popcorn genetic resources of Turkey.

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Figure 3. The figure shows the current popcorn breeding studies that carried out by public and private sector in Turkey.
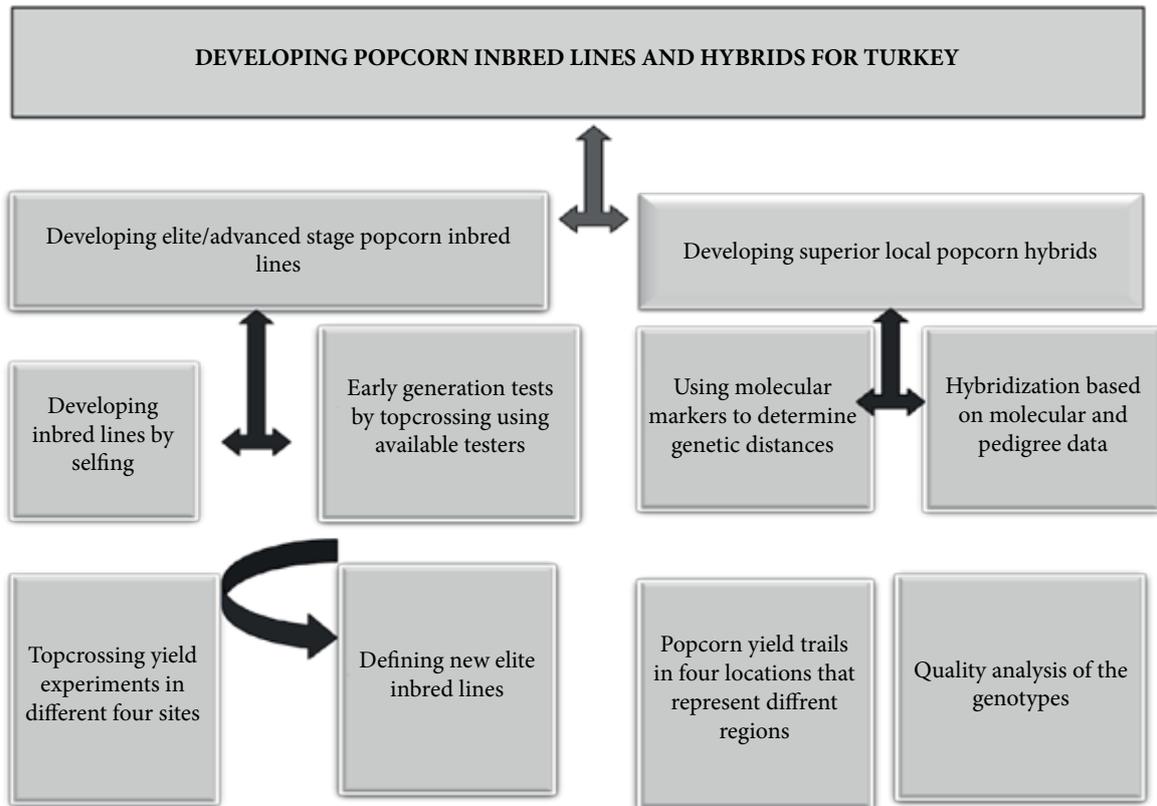
Figure 4. Popcorn seedlings during winter season.

Figure 5. Popcorn seedlings are ready for planting in greenhouse.

Figure 6. Popcorn plants during vegetation period in the greenhouse.

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Figure 7. Selfing studies in popcorn in the greenhouse.

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