An Investigation on Improvement of Yield Potential of TMP-2 Composite Maize Gene Pool

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Abstract: This study was conducted at the Black Sea Agricultural Research Institute in Samsun-Turkey in 2005 and 2006. The aim of this research was to improve the yield potential of the TMP-2 corn gene pool. A composite corn cultivar with high adaptation potential called 'Karadeniz Yildizi' in Turkish was enhanced using genetic source material (TMP-2). Nineteen maize source materials with high yield potential and similar agronomic traits to TMP-2 corn gene pool were obtained from Sakarya Agricultural Research Institute. These materials were then crossed with TMP-2 corn gene pool as female parents in 2005. Obtained hybrids were tested and experiment was conducted by randomized block design with three replications. Data was recorded for grain yield and yield components. In the experiment, the seeds of high yielding hybrids were mixed with seeds of TMP-2 gene pool at the rate of 5 % and used as male parents for next generation crossing.

Introduction

Maize is the world's third most important crop after rice and wheat. Recently, its production and yield has increased significantly. Maize is generally used as a food product and for animal feed. Maizecobs are also used as a biomass fuel source. Recent developments in quantitative genetics and experimental data in the last century have helped in the development of alternative approaches to the conventional hybrid methodology. Composite varieties have given yield levels which closely approach those of commercial hybrids (Singh, 1987). Composite varieties are important for countries where the hybrid seed industry has not been organized and regular hybrid seed replacement programs are not convenient. Composite cultivars are also important for regions where the climate is not very adequate for corn growing. The major advantages in the use of composites are; a) The seed of composite varieties is cheap and simple, b) Farmers can use their own seed for growing the next crops, c) Composites can be further improved for important characters, d) Because of wider genetic base composites are more stable to major biotic stresses and negative climatic conditions, and e) Elite composites can serve as base population for inbred lines (Singh, 1987).

The genetic variability of breeding materials is very important for maize breeders. Germplasm complexes and composites were developed and used as a genetic resource for the improvement of grain yield and other desirable characteristics. Different breeding methods and approaches were used for composite corn cultivars. Sprague and Eberhart (1977) showed that response to selection for yield improvement was similar for the different intra and inter-population recurrent selection schemes. S_1 family selection seems to provide better opportunity to screen out the poorest progenies and thus, make more rapid progress (Hallauer and Miranda, 1987). Recurrent selection methods have been widely used by maize breeders for population improvement. Maize breeders used recurrent selection methods for improvement of population mean performance and maintenance of genetic variation for continued selection (Weyhrich et al., 1998). Increasing grain yield potential of maize is due to the successive development of better adapted varieties. Estimates of increased productivity due to genetic gain in U.S. maize production are about 77 kg ha^{-1} (Duvick et al., 2004).

The aim of this research is to improve the yield potential of the TMP-2 composite maize gene pool by using high yielding source materials obtained from Sakarya Agricultural Research Institute.

Materials and Method

Nineteen maize source materials were obtained from Sakarya Agricultural Research Institute to use in this study (Table 1). These materials had high yield potential and similar agronomic traits to TMP-2 composite maize gene pool. Hybrids were produced by crossing each nineteen source material with the materials from TMP-2 composite maize gene pool. The materials obtained from Sakarya were used as female parents in 2005. From this crossing effort, nineteen hybrids were developed. The composite cultivar "Karadeniz Yıldızı" was used as the control in the trial. Experiment was conducted in Samsun (Lat. 36°20'E, long. 41°17'N, 4 m above sea level) in the 2006 growing season. The experimental design was a Completely Randomized Block Design with three replications. Each experimental plot included four five-meter long rows spaced 0.70 m apart, with 25 single-plant hills spaced 0.20 m apart. TMP-2 composite maize gene pool has a high plant height and the seed structure likes yellow flint. Composite cv. Karadeniz Yildizi, developed from TMP-2 composite maize gene pool is grown for silage and grain.

Data was recorded for grain yield and yield components. According to the experiment results, the high yielding hybrids were selected. Stock seeds of selected source materials were mixed with seeds of TMP-2 composite maize gene pool at the rate of 5 % and used as male parents for next generation crossing. Data were taken on tasselling time (days from planting to 50 % of plants tasselling), grain yield (kg da-1). Plant height (cm), ear height (cm), grain moisture (%), yield/ear ratio (%), plant and ear appearance were estimated from a sample of 10 plants from each plot. All the data were analyzed with analysis of variance (ANOVA) procedures using the Statistical Software Package. The comparison of the treatment means was made by using the Least Significant Difference (LSD) test.

1- KDEB.PN55	6- KDEB.PN155	11- KDEB.PN275	16- KDEB.PN632
2- KDEB.PN6	7- KDEB.PN165	12- KDEB.PN350	17- KDEB.PN643
3- KDEB.PN48	8- KDEB.PN176	13- KDEB.PN488	18- KDEB.PN644
4- KDEB.PN84	9- KDEB.PN187	14- KDEB.PN587	19- KDEB.PN648
5- KDEB.PN140	10- KDEB.PN261	15- KDEB.PN603	20- Karadeniz Yıldızı

Table 1. Maize source materials

Findings and Discussion

Grain yield, some yield related and morphological traits were investigated in this study. The results and statistical analysis were given in Table 1 and 2.

Grain Yield

The differences of grain yield of the hybrids were statistically significant (Table 1). The grain yields of hybrids ranged from 775 to 1155 kg/da, and averaged 984 kg/da. The highest grain yield was obtained from KDEB.PN187 x TMP-2 hybrid, and KDEB.PN643 x TMP-2 and KDEB.PN350 x TMP-2 hybrids followed it. Karadeniz Yildizi improved from TMP-2 composite maize gene pool yielded 1004 kg/da. Grain yield is the most important trait for selection of genetic source material. The aim of this study was to improve the grain yield potential of TMP-2 composite maize gene pool, and high yielding genotypes were determined for this aim. It is expected that cultivars coming from different genetic background might have different yield potentials, however the yields of cultivars correlated with their adaptation ability to different environment (Emeklier, 1987). Some researchers reported that hybrids between inbred lines with high yield potential might have high yield potential (Lonnquist and Lindsey, 1964; Lamkey and Hallauer, 1986).

Tasseling Time

Tasseling time is an important trait in this study, because tasseling time of selected source materials should be same or very close to tasseling time of TMP-2 composite maize gene pool. The tasseling time of source materials ranged from 64.3 days to 76.3 days, and difference of genotypes for tasseling time was statistically significant ($p<0.01$, Table 1). While some source material flowered earlier than Karadeniz Yildizi, some materials flowered later than it. The materials with high yield and similar tasseling time to TMP-2 composite maize gene pool were selected. Tasseling time can change according as genotype and climate. Martin et al. (1976) reported that ideal temperature for growing in corn was 21-27 ^{0}C for daylight and 13 ^{0}C for night. Corn is generally grown in hot climate, the temperature over 27 ^{0}C can decrease grain yield. Altinbas and Tosun (1998) found that late flowering cultivars generally had higher grain yield.

Genotypes	Grain yield (kg/da)	Tasseling time (day)	Plant height (cm)	Ear height (cm)
1- KDEB.PN55 x TMP-2	1015 ae**	67.7 ij**	282 cf**	115 bd**
2- KDEB.PN6 x TMP-2	877 df	66.0 jk	270 eg	103 ce
3- KDEB.PN48 x TMP-2	983 be	69.3 gi	292 be	103 ce
4- KDEB.PN84 x TMP-2	1080 ab	69.7 fh	305 ab	112 bd
5- KDEB.PN140 x TMP-2	916 cf	74.0 b	307 ab	132 ab
6- KDEB.PN155 x TMP-2	870 ef	69.3 gi	277 df	108 bd
7- KDEB.PN165 x TMP-2	991 be	69.0 gi	280 df	118 bc
8- KDEB.PN176 x TMP-2	1000 be	71.3 df	293 bd	105 cd
9- KDEB.PN187 x TMP-2	1155 a	72.0 ce	282 cf	108 bd
10- KDEB.PN261 x TMP-2	1068 ab	71.7 de	278 df	92 df
11- KDEB.PN275 x TMP-2	775 f	70.3 eg	273 df	92 df
12- KDEB.PN350 x TMP-2	1100 ab	72.0 ce	293 bd	120 bc
13- KDEB.PN488 x TMP-2	978 be	73.0 bd	292 be	110 bd
14- KDEB.PN587 x TMP-2	1023 ad	76.3 a	320 a	153 a
15- KDEB.PN603 x TMP-2	1081 ab	74.7 ab	288 be	107 cd
16- KDEB.PN632 x TMP-2	803 f	64.3 k	247 h	73 f
17- KDEB.PN643 x TMP-2	1104 ab	73.7 bc	310 ab	117 bc
18- KDEB.PN644 x TMP-2	818 f	64.3 k	250 gh	80 ef
19- KDEB.PN648 x TMP-2	1044 ac	68.0 hi	260 fh	107 cd
20- Karadeniz Yıldızı	1004 be	68.7 gi	303 ac	112 bd
Mean	984	72.3	285	108
CV (%)	9.0	1.61	4.71	13.8

**, Means within a column followed by the same letter are not significantly different at 1% level.

Table 2. Tasseling time, plant height, ear height and grain yield of genotypes.

Plant Height

The differences between plant height of genotypes were statistically significant ($p<0.01$) (Table 1). Plant height changed from 247 to 320 cm, and average plant height was found as 285 cm in the trial. The highest plant height was obtained from hybrid KDEB.PN587 x TMP-2. Plant height and ear height are important agronomic traits for cultivars and there is a close correlation between them. Plant height was a crucial trait to select for this source material. Selected material should have plant height close to the plant height of TMP-2 composite maize gene pool, because 'Karadeniz Yildizi' is grown for both grain and silage.

Ear Height

Significant differences among genotypes were observed for ear height. Obtained data for ear height ranged from 73 cm to 153 cm. Average ear height was 108 cm in the study. Hybrid KDEB.PN587 x TMP-2 had the highest ear height such as plant height. Genotypic factor are known to influence ear and plant height more than environmental factor (Hallauer and Miranda, 1987). Attention was also given to select source material with similar ear and plant height to TMP-2 composite maize gene pool to obtain morphologic similarity. Hallauer and Sears (1972) reported that mass selection for early silking concluded with an average decrease of 15 cm per cycle of selection for ear height. They also found that there was a simple correlation between early silking and lower ear height ($r = 0.89$).

Grain Moisture

Grain moisture of genotypes changed from 20.3% to 31.3% in the harvest (Table3). Significant variation was found among genotypes for grain moisture ($p<0.01$). Grain moisture is an important trait for location conducted the trial. The lowest grain moisture was recorded for hybrid KDEB.PN6 x TMP-2, while the highest for hybrid KDEB.PN587 x TMP-2. Karadeniz Yildizi had 24.3% grain moisture and mean grain moisture was 24.3% in the trial. We selected the source material with close or lower grain moisture content to TMP-2 composite maize gene pool.

Yield/Ear Ratio

Yield/ear ratio were recorded as 76.1% to 83.9% and averaged 79.3% (Table 3). Differences of yield/ear ratio among genotypes were significant ($p<0.01$). The hybrid KDEB.PN187 x TMP-2 with highest grain yield had the highest yield/ear ratio. Yield/ear ratio is a crucial trait for corn breeders and high yield/ear ratio is desired to develop high yielding hybrids.

Plant and Ear Appearance

Data for plant and ear appearances were not statistically analyzed (Table 3). Plant and ear appearance is an important criterion to selection for breeders. The genetic source materials having value 1 and close to 1 for plant and ear appearance were selected.

Genotypes	Grain moisture (%)	Yield/ear ratio (%)	Plant appearance (1-5)	Ear appearance (1-5)
1- KDEB.PN55 x TMP-2	26,3 cd**	76,2 k**	1,33	1,67
2- KDEB.PN6 x TMP-2	20,3 k	76,1 k	1,67	1,83
3- KDEB.PN48 x TMP-2	24,9 gh	79,5 gh	1,83	1,67
4- KDEB.PN84 x TMP-2	23,5 i	82,4 ce	1,17	1,67
5- KDEB.PN140 x TMP-2	24,5 gh	76,4 k	1,17	1,83
6- KDEB.PN155 x TMP-2	22,3 j	79,4 gh	1,83	2,00
7- KDEB.PN165 x TMP-2	24,1 hi	82,5 ac	1,83	2,00
8- KDEB.PN176 x TMP-2	26,9 c	78,4 hi	1,00	1,83
9- KDEB.PN187 x TMP-2	26,3 cd	83,9 a	1,50	1,33
10- KDEB.PN261 x TMP-2	25,9 de	81,1 df	1,17	1,50
11- KDEB.PN275 x TMP-2	25,2 ef	80,7 eg	2,17	2,17
12- KDEB.PN350 x TMP-2	26,9 c	76,5 k	1,00	1,50
13- KDEB.PN488 x TMP-2	27,9 b	77,3 ik	1,00	1,50
14- KDEB.PN587 x TMP-2	31,3 a	76,8 jk	1,17	1,50
15- KDEB.PN603 x TMP-2	26,9 c	76,5 k	1,33	1,67
16- KDEB.PN632 x TMP-2	23,9 hi	79,6 fh	2,50	2,00

17- KDEB.PN643 x TMP-2	25,8 de	81.0 df	1,33	1,83
18- KDEB.PN644 x TMP-2	21,9 j	78,2 hj	2,00	2,50
19- KDEB.PN648 x TMP-2	23,9 hi	83,3 ab	1.67	1,50
20- Karadeniz Yıldızı	24,3 gh	81,4 ce	2.00	1,67
Mean	25.1	79.3	1.53	17.6
CV (%)	1.76	1.13		

**, Means within a column followed by the same letter are not significantly different at 1% level.

Table 3. Grain moisture, yield/ear ratio, plant appearance and ear appearance of source materials hybrids.

Conclusion

The genetic materials of KDEB.PN187, KDEB.PN644, KDEB.PN350, KDEB.PN261, KDEB.PN84, KDEB.PN648 and KDEB.PN55 were selected to use for improving of yield potential of TMP-2 composite maize gene pool. The seeds of selected source materials at the rate of 5% could be mixed to the seeds of TMP-2 gene pool, and could be used as male parents. The hybrids of KDEB.PN603 x TMP-2 and KDEB.PN587 x TMP-2 with high grain yield were not selected because of their late tasseling time. The hybrid of KDEB.PN6 x TMP-2 had the lowest grain moisture, however it had lower grain yield.

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