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Estimating the Breeding Potential of Purple Sweet Corn Lines with Topcross Mating Design

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Abstract

The estimation of breeding potential of early generation lines is a prerequisite in corn breeding. Breeders could use a methodology called topcross for this purpose. The present study aimed (i) to investigate the breeding potential of purple sweet corn lines with topcross design, and (ii) to determine correlation between fresh ear yield and yield traits in topcross hybrids (TH). Hundred and eighteen S2 generation purple sweet corn lines were crossed with the tester, the Ant-224-E-1 yellow sweet corn inbred lines in isolated cross block (ICB), in Antalya in 2020. Hundred and twenty-one hybrids (118 topcross hybrids and 3 commercial hybrid controls) were obtained and analyzed with an 11 × 11 triple lattice design in 2021. It was determined that the number of days to anthesis (DtoA), plant height (PH), ear height (EA), general plant appearance (PA) and fresh ear yield (FEY) were statistically significant at $p < 0.001$ across the hybrids. The DtoA, PH, EH, PA and FEY varied between 90.7-103.0 days, 105.6-217.9 cm, 38.2-77.9 cm, 1.7-3.7 scores, and 4970.2-13472.9 kg ha^{-1}, respectively. Sixty-three topcross hybrids exhibited higher FEY when compared to the trial average. While 16 PSC lines exhibited statistically significant positive general combining ability (GCA) for FEY, 20 PSC lines exhibited negative GCA for FEY. Eighteen PSC lines were selected based on 15% selection intensity and yield trait criteria. It was determined that these lines had a significant PSC hybrid potential as parents in future PSC breeding programs.

1. Introduction

Corn is significant crop with various specialty varieties such as sweet corn (*Zea mays* saccrata Sturt.) (Hallauer, 2001). Although most cultivated sweet corn kernels are yellow, sweet corn breeding programs to achieve corn in different colors, especially purple, were initiated globally due to their rich phytochemical content. The breeding potential of the lines should be analyzed in corn breeding programs. The topcross mating design serves this purpose (Çeçen et al., 1998; Özkaynak and Samancı, 2003; Paterniani et al., 2006; Aydın et al., 2007; Aguiar et al., 2008; Nelson and Goodman, 2008; Erdal et al., 2010; Marcondes et al., 2015). Prediction of the combining ability of new inbred lines is important and topcross-mating design is one of the commonly preferred designs (Rahimi and Sadeghi, 2017). It was reported that the General Combination Ability (GCA) of the parental line could be determined based on the performance of the topcross hybrids with the same parental line (Zystro et al., 2021). Hallauer and Miranda (1981) reported that the topcross combining ability could lead to differences in F_1 hybrid performance and trial mean. It was suggested that the general combining abilities of the lines could be determined with an accepted tester (Davis, 1927; Jenkins and Brunson, 1932). It was also reported that homozygous lines with different genetic properties could be employed as testers to determine the line GCA (Russell and Eberhart, 1975; Hoegemeyer and Hallauer, 1976).

The present study aimed (i) to investigate the breeding potential of the S_2 generation PSC lines with topcross, and (ii) to determine their agronomical performances for the analyzed traits.

2. Material and Methods

2.1. Plant material

The purple sweet corn (PSC) breeding program was initiated in Turkey in 2017, similar to the global trends. One hundred eighteen inbred S_2 generation PSC lines were developed between 2017 and 2020. To obtain topcross hybrids, 118 PSC lines were used as female parents, and also the Ant-224-E-1 yellow sweet corn inbred line was used as both male parents and the tester. Three commercial hybrids were used as controls in topcross hybrid (TCH) analysis. The PSC lines were the crosses of the combination of purple waxy corn genotype procured from Thailand and standard BATEM yellow sweet corn lines. The sweet corn lines used in the current study were "su" type sweet corn.

2.2. Experimental design

2.2.1. Obtaining the hybrids

The study was conducted in 2020 and 2021 at Batı Akdeniz Agricultural Research Institute (BATEM) fields in Antalya, Türkiye (36º52'N, 30º45'E). The climate in Antalya is classic Mediterranean climate, and the climate data for the study period are presented in Figure 1. In the first year of the research, 118 PSC lines were crossed with the tester to obtain 118 isolated topcross hybrids. The topcross hybrids (TCH) were planted as 4 rows of female and 2 rows of male plants at 5 m distance. The female parents were detasseled by hand to produce topcross hybrids. The male parent (tester) was planted in 5-day interval to obtain maximum grain count with best pollination. The ears of the 118 TCH hybrids included both purple and yellow seeds, and these seeds were individually selected by hand. The yellow seeds were removed and purple seeds were selected for field analysis in the subsequent year.

2.2.2. Hybrid analysis

In 2021, the field experiments were conducted with 121 genotypes (118 PSC TCH and 3 commercial controls) to analyze the TCH with a 11×11 triple lattice design in three replicates in Antalya. The hybrids were planted on March 09, 2021. The plots included two 5 m long rows with a space of 0.7 m and 0.5 m between the rows and the plants, respectively. 80 kg ha^{-1} nitrogen, phosphorus and potassium were applied before sowing based on the soil tests, and nitrogen (170 kg ha^{-1}) was applied 4 times. Weed control was conducted with herbicides with an active ingredient of tembotrione and isoxadifen-ethyl. The topcross hybrids were harvested by hand in the 75 milk-line stage, about 24 to 26 days after the silks emerged (Olsen et al., 1990; Öktem, 2008) between July 5 and 15 in 2021. The traits were analyzed to estimate breeding potential of the PSC lines, including the number of days to anthesis (DtoA), plant height (PH, cm), ear height (EH, cm), plant appearance (PA, 1-5 points), ear length (EL, cm),

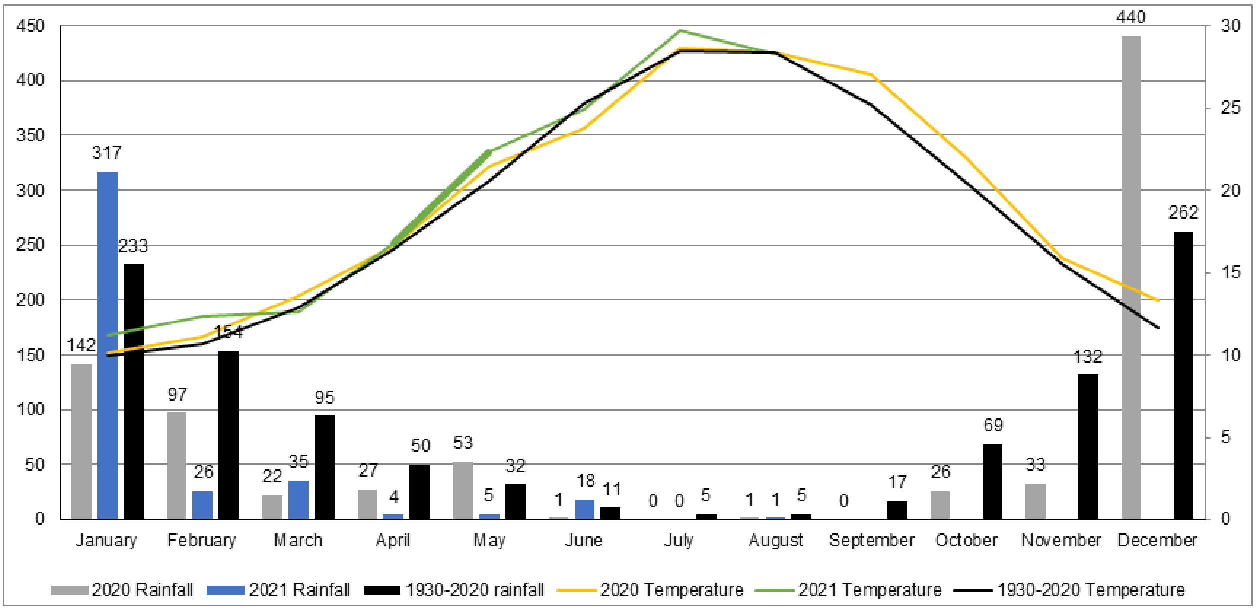

Figure 1. Climatic data for 2020 and 2021 in Aksu, Antalya (Rainfall: mm, Temperature: °C).

ear diameter (ED, cm), and fresh ear yield (FEY, kg ha^{-1}). The DtoA was calculated when 50% of plant anthers appeared in each plot. The PH, EH, PA, EL, ED were measured in ten random plants in each plot. PH and EH were determined by calculating the distance between ground and the top of the tassel and the first ear, respectively. PA was scored between 1 (best) and 5 (worst) during the milk stage. The ear length and ear dimater, which are important yield related traits, were measured from 10 plants presented each plot and mean of these data was recorded as ear length and ear diameter for each plot. EL was measured as the distance between the base and tip of the ear. ED was measured on the central section of the ear. FEY was determined by scaling all ear except the husk in each plot, and then the finding was converted to fresh ear yield per hectare (kg ha^{-1}).

2.3. Data analyses

The statistical data analysis was conducted with the SAS 9.0 Statistics Software. Analysis of Variance (ANOVA) was conducted on triple lattice experimental design criteria with the Fisher's least significant difference post hoc test. General Combining Ability was also estimated with the formula given below (Ferreira et al., 2009).

$$gi = ci - c$$

where; gi: the impact of the general combining ability of the lines, ci: mean of each hybrid, and c: overall mean of topcross hybrids.

3. Results and Discussion

3.1. Topcrosses

One hundred and twenty one genotypes (118 TH and 3 control varieties) were scrutinized to determine GCA of the PSC lines in Antalya in 2021. The trait data for the THs and controls are presented in Table1. DtoA, PH, EH, PA and FEY were significant in the studied genotypes at P<0.01, while EL and ED were insignificant.

The DtoA of TH varied between 90.7 and 103.1 days (average 98.3 days). All TH were in the same DtoA category. Thus, it could be suggested that it could be beneficial to conduct future breeding programs with these PSC lines as parents. It could be also noted that the earliest Jubilee and Adapare commercial control DtoAs were 90.7 and 92.1 days, respectively. TCH-29 had the longest flowering time (103.1 days; Table 1). Although the DtoA data were similar to those reported by Pecina-Martínez et al. (2013) and Mendoza et al. (2019), it was longer than those reported in certain studies (Turgut and Balcı 2002; Kara and Akman, 2002; Ji et al., 2010; Özata 2013; Tuan et al., 2016; Aboyousef et al., 2018; Ibrahim and Ghada, 2019; Ismail et al., 2020; Dermail et al., 2020; Reis et al., 2020; Tuan et al., 2021). The longer DtoA observed in the present study could be early plantation of the genotypes (on March 9) to avoid drought stress during the flowering period. The climate data demonstrated that the air temperature in March and April in 2021, when the experiments were conducted, were well lower than optimum temperature requirements of corn. Furthermore, sweet corn is more succeptible to abiotic stress factors such as low temperatures when compared to dent corn. It took a long time for the PSC lines to reach total temperature demand; and thus, DtoAs were extended. However, the DtoA of the purple sweet corn lines varied between 60 and 65 days between 2017 and 2021 (data not presented and unpublished).

There were statistically significant differences between the PH figures in the current study (P<0.01). The mean PH was measured at 188.5 cm. While the TCH-54 exhibited the shortest plant height (150.6 cm), TCH-08 had the highest plant height (217.9 cm) (Table 1). Furthermore, twenty-seven topcross hybrids (TCH-6, TCH-10, TCH-12, TCH-21, TCH-22, TCH-28, TCH-35, TCH-36, TCH-41, TCH-46, TCH-47, TCH-48, TCH-49, TCH-50, TCH-51, TCH-65, TCH-70, TCH-71, TCH-74, TCH-75, TCH-90, TCH-93, TCH-102, TCH-106, TCH-110, TCH-112 and TCH-117) were classified as the most significant group (above 199.19 cm). The plant height data were higher when compared to certain studies (Turgut and Balci, 2002; Bozolkalfa et al., 2004; İdikut et al., 2005; Mahato et al., 2018). However, TH plant height was similar to those reported in the literature (Ji et al., 2010; Özata, 2013; Ibrahim and Ghada, 2019; Mendoza et al., 2019; Islam et al., 2020; Arsyad and Basunanda, 2020; Gavriç and Omerbegoviç, 2021; Tuan et al., 2021).

There were statistically significant differences between thegenotypes based on first ear height (P<0.01) (Table 1). The ear height varied between 38.2 and 77.9 cm (average 60.0 cm). While TCH-94 had the lowest ear height (38.2 cm), TCH-6 ear height was the highest (77.9 cm). Certain studies reported similar first ear height figures (Turgut and Balcı, 2002; Bozolkalfa et al., 2004; Idikut et al., 2005; Ji et al., 2010; Özata, 2013; Tuan et al., 2016; Mahato et al., 2018; Ibrahim and Ghada, 2019; Mendoza et al., 2019; Dermail et al., 2020; Arsyad and Basunanda, 2020; Tuan et al., 2021).

There were statistically significant differences between the topcross hybrids employed in the current study based on the plant appearance (PA) variable (P<0.01) (Table 1). The mean genotype PA score was 2.9. While TCH-71 exhibited the best PA (1.7), TCH-53 scored the worst in PA (3.7). The scores of the TCH-121, 120, 94, 108, 119 and 54 were below the mean trial FEY score. The TCH-36, TCH-70 and TCH-75, which exhibited the best PA scores, were in the highest FEY group statistically. Nevertheless, ten out of 14 TCHs (TCH-8, TCH-10, TCH-32, TCH-36, TCH-46, TCH-50, TCH-70, TCH-

Table 1. Average data of topcross hybrids and checks for yield and yield related traits.

Hybrids number	Number of days to anthesis (day)	Plant height (cm)	Ear heigth (cm)	Plant appearance (1-5)	Ear length (cm)	Ear diameter (cm)	Fresh ear yield (kg ha^{-1})
TCH1	97.8	187.5	70.2	2.6	16.46	3.64	8905.0
TCH2	102.0	167.0	52.8	3.5	16.58	4.14	9319.5
TCH3	97.7	170.4	70.8	3.4	19.24	4.04	9150.2
TCH4	99.3	183.5	61.4	3.4	18.08	4.22	9049.6
TCH5	101.3	185.3	65.6	3.2	17.70	3.89	8229.9
TCH6	99.5	199.7	77.9	3.0	17.51	3.99	7758.4
TCH7	97.8	193.7	55.7	2.9	17.52	4.22	12054.7
TCH8	99.7	217.9	71.8	2.3	19.00	4.10	10735.6
TCH9	101.1	196.7	75.1	3.1	20.29	3.94	8925.5
TCH10	98.4	214.8	61.3	2.4	17.78	4.12	9790.8
TCH11	98.3	190.8	67.2	3.2	17.50	3.65	8155.7
TCH12	97.0	201.6	58.9	2.7	19.38	4.27	9689.3
TCH13	98.4	195.1	59.0	2.6	18.20	4.17	8855.7
TCH14	98.7	182.4	52.5	3.1	16.58	4.36	9384.5
TCH15	97.2	192.4	57.3	3.0	18.27	3.89	9530.6
TCH16	97.2	188.4	55.4	2.8	18.73	3.78	10561.7
TCH17	94.8	161.3	53.2	3.0	16.70	3.89	7132.8
TCH18	100.9	163.1	49.9	3.0	16.83	3.61	9194.2
TCH19	98.5	182.6	60.1	3.1	18.14	4.40	10742.2
TCH20	101.0	182.2	45.5	2.3	16.27	3.91	5530.4
TCH21	96.4	210.8	68.3	2.8	19.14	4.35	7340.2
TCH22	96.9	200.4	63.1	2.5	18.20	4.27	9613.1
TCH23	97.0	181.0	65.1	2.9	15.34	4.08	8484.6
TCH24	100.8	191.3	73.3	3.0	17.40	4.12	9919.8
TCH25	99.9	198.1	64.0	3.1	17.16	3.97	8493.1
TCH26	98.1	187.1	65.9	2.9	17.44	4.29	13057.3
TCH27	98.5	196.1	60.2	2.7	17.10	4.11	11348.0
TCH28	97.2	201.4	66.9	3.0	17.41	4.04	10074.5
TCH29	103.1	191.7	65.7	3.0	17.04	3.59	7108.8
TCH30	102.8	194.2	53.2	2.8	17.11	3.88	9476.9
TCH31	98.6	185.7	57.7	2.7	18.90	4.23	12486.8
TCH32	97.2	198.4	64.2	2.1	16.84	4.01	9880.5
TCH33	98.5	193.5	64.1	3.0	17.17	3.69	9883.9
TCH34	97.6	197.4	60.9	2.9	16.92	3.78	10358.1
TCH35	100.1	202.3	57.7	2.7	15.54	3.82	10606.4
TCH36	98.0	199.2	66.4	2.0	16.54	4.21	12728.7
TCH37	95.6	183.8	52.5	2.9	17.05	4.03	10415.5
TCH38	94.4	155.6	46.9	3.5	14.78	4.20	10406.9
TCH39	95.9	190.7	64.8	3.1	16.37	3.66	9741.4
TCH40	99.1	190.1	65.9	2.8	16.49	4.30	9059.6
TCH41	101.6	199.3	63.3	2.2	15.32	3.48	8886.1
TCH42	98.2	172.1	50.6	3.3	17.58	3.59	10375.0
TCH43	95.2	196.8	62.9	3.4	18.11	3.88	10882.9
TCH44	96.5	196.0	64.8	2.8	16.42	4.33	9157.7
TCH45	96.1	178.9	63.4	3.2	17.17	3.81	8617.8
TCH46	102.5	201.0	73.6	1.9	18.05	3.67	10192.4
TCH47	94.1	199.2	65.9	2.6	18.21	4.19	10600.5
TCH48	97.8	202.2	65.1	3.0	17.80	3.95	7415.5
TCH49	98.4	213.0	67.0	2.7	18.83	4.18	11045.3
TCH50	97.0	212.6	71.7	2.5	20.61	4.39	9717.2
TCH51	96.6	203.4	70.6	2.5	20.72	4.06	8712.8
TCH52	98.5	180.1	60.8	3.3	19.92	4.01	7323.7
TCH53	99.2	181.4	56.4	3.7	17.86	4.22	9453.4
TCH54	98.6	150.6	51.0	3.5	15.39	3.93	8827.7
TCH55	98.7	178.5	57.0	3.3	18.69	3.89	9305.5
TCH56	97.8	185.3	53.9	3.0	17.62	4.43	9777.1
TCH57	100.9	181.4	49.5	3.2	17.08	3.90	6294.5
TCH58	97.4	196.9	66.8	2.7	16.84	4.11	9890.1
TCH59	99.5	184.5	61.3	2.9	16.52	3.60	5968.1
TCH60	97.8	183.8	62.9	3.1	19.36	3.77	8114.5
TCH61	102.5	190.6	58.5	3.2	17.47	3.65	6022.1
TCH62	99.6	192.6	64.1	2.5	17.41	3.74	8216.9
TCH63	98.5	187.3	57.2	3.3	18.12	3.97	9626.8
TCH64	98.3	189.4	61.7	3.0	16.77	4.01	7808.4

Table 1. Average data of topcross hybrids and checks for yield and yield related traits (conti.).

Hybrids number	Number of days to anthesis (day)	Plant height (cm)	Ear height (cm)	Plant appearance (1-5)	Ear length (cm)	Ear diameter (cm)	Fresh ear yield (kg ha^{-1})
TCH65	98.8	202.1	55.1	2.9	17.39	3.56	8125.1
TCH66	99.0	184.5	56.7	3.0	18.52	4.17	8234.7
TCH67	100.5	182.0	69.6	2.7	17.06	3.93	7386.4
TCH68	101.0	188.5	57.7	3.0	19.12	3.84	8771.0
TCH69	97.1	179.7	52.1	3.1	16.88	3.95	6819.8
TCH70	99.1	202.9	68.3	2.5	18.10	3.73	11509.5
TCH71	101.5	201.7	71.8	1.7	16.56	3.70	10330.3
TCH72	100.6	192.0	58.8	3.0	16.79	3.68	7893.9
TCH73	99.1	189.6	53.6	3.3	18.45	4.37	7156.5
TCH74	100.1	200.6	61.8	3.0	15.80	3.86	9670.4
TCH75	94.7	207.3	65.8	2.4	18.02	3.88	13472.9
TCH76	97.2	187.5	56.4	3.2	13.67	4.23	10027.5
TCH77	98.2	196.7	66.9	3.2	14.90	4.08	10040.2
TCH78	99.2	171.9	63.2	3.1	19.11	3.96	9426.4
TCH79	95.5	187.9	55.1	3.0	16.09	4.23	10379.6
TCH80	97.8	174.4	56.9	2.8	16.29	4.28	10831.4
TCH81	98.1	178.3	58.5	3.0	16.71	4.57	9823.4
TCH82	97.0	164.4	55.5	3.1	14.08	3.99	8769.6
TCH83	96.9	186.0	51.0	3.2	16.75	3.94	7072.6
TCH84	95.5	170.4	52.3	2.9	15.67	4.03	7122.7
TCH85	97.9	178.6	46.3	2.7	16.71	4.35	8285.6
TCH86	98.5	186.5	53.7	2.9	15.17	4.16	7399.5
TCH87	97.2	193.0	62.2	2.5	17.53	3.76	9378.0
TCH88	95.5	194.7	63.2	3.0	17.39	4.07	8108.1
TCH89	99.1	188.8	54.7	3.0	17.40	3.59	9293.6
TCH90	96.5	211.6	73.8	2.7	17.74	4.40	10960.4
TCH91	95.2	181.0	49.6	3.1	19.97	4.04	8168.6
TCH92	98.6	180.2	53.6	3.0	21.02	3.97	5930.3
TCH93	101.9	207.0	60.9	3.0	18.15	4.16	7670.0
TCH94	102.2	164.2	38.2	3.6	17.87	3.63	5565.0
TCH95	98.6	186.5	46.4	2.8	15.30	4.25	9375.3
TCH96	98.4	178.2	46.8	3.0	15.02	4.02	10045.1
TCH97	97.8	175.0	55.1	3.0	18.65	3.96	7817.5
TCH98	96.9	194.4	67.0	3.0	17.51	3.81	8358.0
TCH99	98.0	189.1	54.2	2.9	15.81	3.91	9165.7
TCH100	97.9	182.3	48.5	3.0	18.56	3.60	6506.9
TCH101	98.3	187.7	49.8	3.0	17.30	4.16	10242.6
TCH102	98.1	203.8	72.8	2.6	18.02	4.31	11858.6
TCH103	100.0	184.3	59.0	3.2	17.23	3.82	8768.9
TCH104	98.7	188.1	62.1	2.9	17.13	3.53	10295.1
TCH105	97.1	169.3	49.8	3.3	16.13	3.87	6326.7
TCH106	97.3	217.2	74.7	1.7	17.12	4.15	7908.7
TCH107	99.9	185.1	62.0	3.3	17.99	3.57	10334.1
TCH108	98.4	177.1	50.1	3.4	17.76	3.62	6909.9
TCH109	96.5	190.5	64.5	3.2	17.66	3.80	9599.5
TCH110	99.4	203.0	66.8	3.0	16.93	3.46	8530.4
TCH111	97.0	188.0	72.6	2.9	18.43	4.09	8806.5
TCH112	96.8	201.7	63.0	2.6	16.53	4.16	11958.3
TCH113	99.0	187.0	58.2	3.1	15.52	3.97	9813.1
TCH114	98.3	191.0	60.0	3.1	17.15	4.15	9962.2
TCH115	99.2	179.3	52.0	3.1	17.85	4.35	9504.0
TCH116	99.6	187.5	62.1	2.9	16.20	4.17	6846.9
TCH117	97.8	199.5	69.0	2.8	16.81	4.18	7600.8
TCH118	99.0	176.3	61.4	3.1	19.35	4.00	7634.6
Batem Tatlı	97.2	174.5	51.4	3.5	18.64	3.81	12348.0
Adapare	92.1	161.3	47.3	3.5	17.11	3.50	8185.1
Jübile	90.7	159.5	43.7	3.6	14.44	3.18	4970.2
Mean	98.2	188.5	60.0	2.9	17.37	3.98	9080.23
LSD	2.97**	19.46**	15.41**	0.80**	ns	ns	213.9**
CV%	1.7	6.12	15.27	16.30	11.55	9.78	14.01

** and ns, significant at p≤0.01 and not significant, respectively.

71, TCH-75 and TCH-87) in the best PA group, exhibited higher FEY when compared to the trail mean score.

There were no statistically significant differences between the topcrosses based on ear length and diameter (Table 1). The mean TCH ear length was 17.4 cm and TCH varied between 13.7 cm (TCH-76) and 21.0 cm (TCH-92). The current study EL data were similar to those reported by previous studies (Turgut and Balcı, 2002; Bozokalfa et al., 2004; Ji et al., 2010; Özata, 2013; Tuan et al., 2016; Mahato et al., 2018; Ibrahim and Ghada, 2019; Mendoza et al., 2019; Dermail et al., 2020; Mollah et al., 2020; Islam et al., 2020; Arsyad and Basunanda, 2020; Gavric and Omerbegovic, 2021; Tuan et al., 2021).

The mean TCH ear diameter was 3.98 cm and varied between 3.18 cm (Jubile F1) and 4.57 cm (TCH-81). The current study ED findings were consistent with previous study findings (Turgut and Balcı, 2002; Bozokalfa et al., 2004; Ji et al., 2010; Özata, 2013; Tuan et al., 2016; Mahato et al., 2018; Ibrahim and Ghada, 2019; Mendoza et al., 2019; Dermail et al., 2020; Mollah et al., 2020; Tuan et al., 2021).

There were statistically significant differences between TCH fresh ear yield (FEY) (P<0.01). It was observed that the mean of FEY was 9080.2 kg ha^{-1} (Table 1). There were also significant differences between the genotype FEY figures in the present study. While Jubilee exhibited the lowest FEY (4970.2 kg ha^{-1}), the highest FEY was measured in TCH-75 (13472.9 kg ha^{-1}). Ten TCHs (TCH-75, TCH-26, TCH-36, TCH-31, TCH-119, TCH-7, TCH-112, TCH-102, TCH-70 and TCH-27) were in the same group with the best FEY statistically. The comparison of these findings with the previous studies conducted with sweet or purple corn revealed that FEY figures were higher in the current study when compared to certain studies (Tuan et al., 2016; Mendoza et al., 2019; Mollah et al., 2020). The plant materials in these studies were either population or open pollinated genotypes, which led to lower mean data when compared to the current study findings determined with hybrids.

3.2. Determination of the combining ability of topcross hybrids

The tester with a broad genetic base was crossed with the PSC lines to estimate the impact of the general combining ability. The GCA of the PSC lines for FEY varied between -3564 kg ha^{-1} (TCH-20) and 4377 kg ha^{-1} (TCH-75). The GCA estimates for PSC lines are presented in Table 2 and Figure 2. The analysis of the GCA findings revealed that 63 out of 118 THs exhibited higher FEY when compared to the trial mean (Table 2). The top 19 TH with the highest FEY were selected for GCA in the trial. Similarly, Sezer and Sürmeli (2003) also selected 19 lines in their study where 124 inbred lines were analyzed for topcross combining abilities. Finally, it was determined that 16 TCHs (TCH-75, TCH-26, TCH-36, TCH-31, TCH-7, TCH-112, TCH-102, TCH-70, TCH-27, TCH-49, TCH-90, TCH-43, TCH-80, TCH-19, TCH-47 and TCH-37) among the selected 19 TCHs had statistically positive and significant effects (Table 2). It was estimated that the hybrids of the lines with high GCA for FEY would have high FEY potential, similar to previous study findings (Rawlings and Thompson, 1962; Hallauer and Miranda, 1988; Aydın et al., 2007; Erdal et al., 2010).

The lines with a negative GCA should not be excluded from breeding programs (Rahimi ve and Sadeghi, 2017). Clovis et al. (2015) suggested that the selection of the lines with a negative GCA during flowering as male and female parents provided a significant earliness advantage. Lonnquist and Lindsey (1964) reported that hybrids obtained with high x low yield lines provided higher yields when compared to hybrids of high × high and low × low lines. Thus, lines with a statistically negative significant GCA for FEY (TCH-20, TCH-94, TCH-92, TCH-59, TCH-61, TCH-57, TCH-105, TCH-100, TCH-116, TCH-83, TCH-29, TCH-17, TCH-73, TCH-52, TCH-67, TCH-118, TCH-6, TCH-106 and TCH-62) were considered to have breeding potential in the present study.

To estimate of breeding potential of PSC lines, not only the GCA data but also all selection criteria presented Table 1 were considered. Thus, eighteen TCHs were selected based on all findings and 15% selection criteria in the trial (Table 3).

4. Conclusion

In the current study, the breeding potential of 118 S_2 purple sweet corn topcross lines was estimated in Antalya conditions. The PSC lines exhibited good general combining ability for FEY. Lines with high GCA were selected for testing in future breeding studies and included in diallel crosses for the determination of special combining abilities. The PSC lines also exhibited excellent variance for FEY and yield traits. Eighteen lines were selected noy only based on positive or negative statistical significance in fresh ear yield but also other analyzed observation criteria such as plant height, ear height, plant appearance, ear length, and ear diameter. The seeds of the promising PSC lines should be reproduced, and these lines should be employed as purple sweet corn hybrid parents in future PSC breeding programs.

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Table 2. Estimates of general combining ability of purple sweet corn inbred lines for fresh ear yield (kg ha^{-1}).

Topcross hybrids number	GCA value	Topcross hybrids number	GCA value	Topcross hybrids number	GCA value
TCH1	-190.0 ns	TCH41	-208.9 ns	TCH80	1736.4 *
TCH2	224.5 ns	TCH42	1280.0 ns	TCH81	728.4 ns
TCH3	55.2 ns	TCH43	1787.9 **	TCH82	-325.4 ns
TCH4	-45.4 ns	TCH44	62.7 ns	TCH83	-2022.4 *
TCH5	-865.1 ns	TCH45	-477.2 ns	TCH84	-1972.3 ns
TCH6	-1336.6 *	TCH46	1097.4 ns	TCH85	-809.4 ns
TCH7	2959.7**	TCH47	1505.5 *	TCH86	-1695.5 ns
TCH8	1640.6 ns	TCH48	-1679.5 ns	TCH87	283.0 ns
TCH9	-169.5 ns	TCH49	1950.3 **	TCH88	-986.9 ns
TCH10	695.8 ns	TCH50	622.2 ns	TCH89	198.6 ns
TCH11	-939.3 ns	TCH51	-382.2 ns	TCH90	1865.4 *
TCH12	594.3 ns	TCH52	-1771.3 **	TCH91	-926.4 ns
TCH13	-239.3 ns	TCH53	358.4 ns	TCH92	-3164.7 **
TCH14	289.5 ns	TCH54	-267.3 ns	TCH93	-1425.0 ns
TCH15	435.6 ns	TCH55	210.5 ns	TCH94	-3530.0 **
TCH16	1466.7 ns	TCH56	682.1 ns	TCH95	280.3 ns
TCH17	-1962.2 *	TCH57	-2800.5 **	TCH96	950.1 ns
TCH18	99.2 ns	TCH58	795.1 ns	TCH97	-1277.5 ns
TCH19	1647.2 *	TCH59	-3126.9 **	TCH98	-737.0 ns
TCH20	-3564.6 **	TCH60	-980.5 ns	TCH99	70.7 ns
TCH21	-1754.8 ns	TCH61	-3072.9 **	TCH100	-2588.1 *
TCH22	518.1 ns	TCH62	-878.1*	TCH101	1147.6 ns
TCH23	-610.4 ns	TCH63	531.8 ns	TCH102	2763.6 **
TCH24	824.8 ns	TCH64	-1286.6 ns	TCH103	-326.1 ns
TCH25	-601.9 ns	TCH65	-969.9 ns	TCH104	1200.1 ns
TCH26	3962.3 **	TCH66	-860.3 ns	TCH105	-2768.3 **
TCH27	2253.0 **	TCH67	-1708.6 *	TCH106	-1186.3 *
TCH28	979.5 ns	TCH68	-324.0 ns	TCH107	1239.1 ns
TCH29	-1986.2 **	TCH69	-2275.2 ns	TCH108	-2185.1 ns
TCH30	381.9 ns	TCH70	2414.5 **	TCH109	504.5 ns
TCH31	3391.8 **	TCH71	1235.3 ns	TCH110	-564.6 ns
TCH32	785.5 ns	TCH72	-1201.1 ns	TCH111	-288.5 ns
TCH33	788.9 ns	TCH73	-1938.5 *	TCH112	2863.3 **
TCH34	1263.1 ns	TCH74	575.4 ns	TCH113	718.1 ns
TCH35	1511.4 ns	TCH75	4377.9 **	TCH114	867.2 ns
TCH36	3633.7 **	TCH76	932.5 ns	TCH115	409 ns
TCH37	1320.5 *	TCH77	945.2 ns	TCH116	-2248.1 **
TCH38	1311.9 ns	TCH78	331.4 ns	TCH117	-1494.2 ns
TCH39	646.4 ns	TCH79	1284.6 ns	TCH118	-1460.4 *
TCH40	-35.4 ns				

**, * and ns, significant at p≤0.01, p≤0.05, and not significant, respectively.

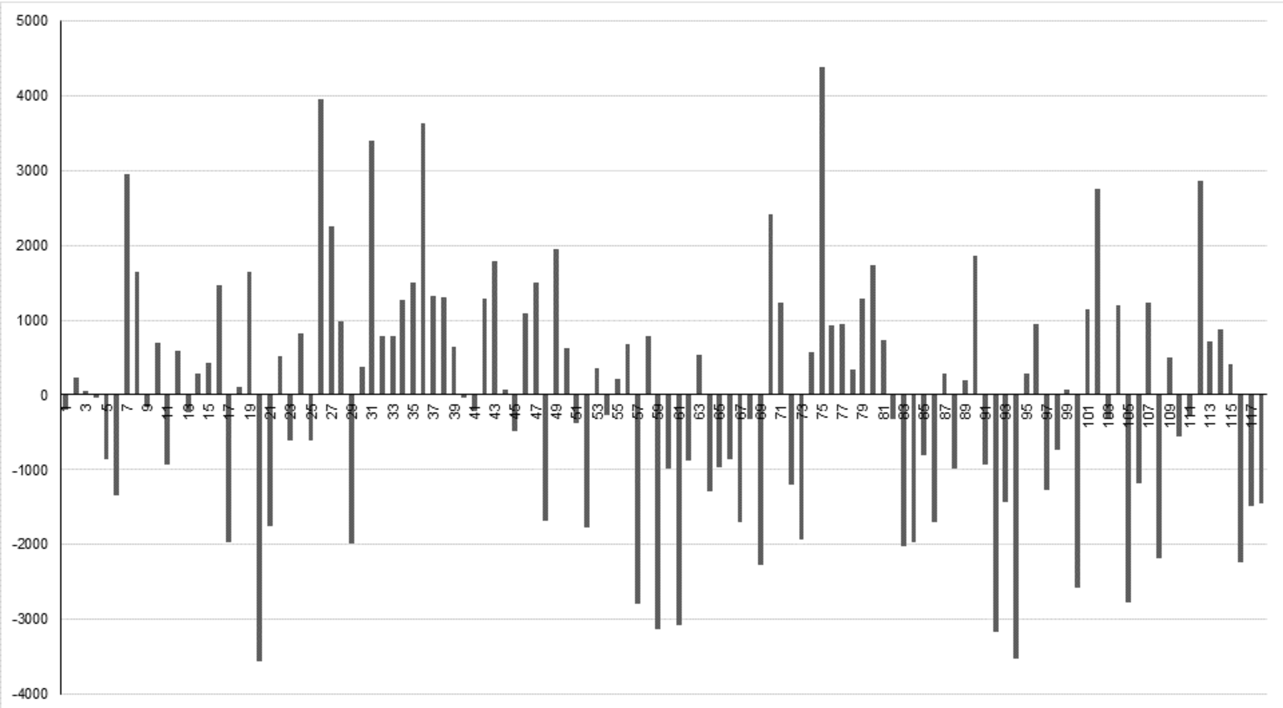

Figure 2. Showing of general combining ability value of purple sweet corn inbred lines for fresh ear yield.

Table 3. The number and traits of selected hybrids based on general combining ability and yield related traits as selection criteria.

No	Hybrids number	Number of days to anthesis (day)	Plant height (cm)	Ear heigth (cm)	Plant appearance (1-5)	Ear length (cm)	Ear diameter (cm)	Fresh ear yield (kg ha-1)
1	TCH19	98.5	182.6	60.1	3.1	18.14	4.40	10742*
2	TCH26	98.1	187.1	65.9	2.9	17.44	4.29	13057*
3	TCH31	98.6	185.7	57.7	2.7	18.90	4.23	12486*
4	TCH36	98.0	199.2	66.4	2.0	16.54	4.21	12728*
5	TCH43	95.2	196.8	62.9	3.4	18.11	3.88	10882*
6	TCH47	94.1	199.2	65.9	2.6	18.21	4.19	10600*
7	TCH49	98.4	213.0	67.0	2.7	18.83	4.18	11045*
8	TCH52	98.5	180.1	60.8	3.3	19.92	4.01	7323**
9	TCH62	99.6	192.6	64.1	2.5	17.41	3.74	8216**
10	TCH67	100.5	182.0	69.6	2.7	17.06	3.93	7386**
11	TCH70	99.1	202.9	68.3	2.5	18.10	3.73	11509*
12	TCH75	94.7	207.3	65.8	2.4	18.02	3.88	13473*
13	TCH90	96.5	211.6	73.8	2.7	17.74	4.40	10960*
14	TCH97	97.8	175.0	55.1	3.0	18.65	3.96	7817**
15	TCH102	98.1	203.8	72.8	2.6	18.02	4.31	11858*
16	TCH106	97.3	217.2	74.7	1.7	17.12	4.15	7908**
17	TCH112	96.8	201.7	63.0	2.6	16.53	4.16	11958*
18	TCH118	99.0	176.3	61.4	3.1	19.35	4.00	7634**

*, ** represent positive and negative general combining ability, respectively.

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