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RESEARCH ARTICLE

Determining the Performance of Some Soybean Genotypes in Middle Black Sea Transitional Zone

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Abstract: This research was carried out in 2017 and 2018 to determine the agronomic and chemical quality characteristics of 18 soybean genotypes including seven advanced lines and eleven cultivars under Tokat-Kazova conditions. The feasibility of soybean production in the region has been determined to create a database that may contribute to the oilseed deficit in the future. The phenological (germination, first flowering and physiological maturity) and morphological characteristics (plant height, number of side branches, first pod height, number of pods per plant, number of grains per pod, 1000-seed weight, seed yield, oil ratio, oil yield, protein ratio and yield) were examined in the study. All properties except number of grains per pod were significantly ($p<0.01$ and $p<0.05$) different between genotypes. The seed yield varied between 1.82 and 3.00 t ha^{-1}, oil ratio was between 19.73 and 25.20% and protein ratio was between 30.39 and 43.44%. The results of the study revealed that genotypes of 1, 2, 3 and 9 for the seed yield, 1, 7 and 8 for the oil yield and 1, 2 and 9 for the protein yield can be promising under Tokat-Kazova conditions. However, more efficient cultivars are needed due to the insufficient performances of the genotypes investigated.
Keywords: *Glycine max*.(L) Merrill, Oil Yield, Protein Yield, Seed Yield

1. INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is an important oilseed crop in the world. Soybean is rich in nutritional value due to high protein and oil content, in addition to the functional composition such as isoflavones (Singh et al., 2010). Soybean ranks the first (352 million tons) in world oilseed production. Oilseed production in Turkey is approximately 3 million tons, only 4.6% comes from soybean. These values indicate that soybean production in Turkey is not sufficient. Turkey, that is a net soybean importer, imported about 2.3 million tons of soybeans in 2017 and paid 948 million dollars for soybean (FAO, 2017). The amount of soybean import will increase every year with the growth of livestock sector. The import of soybean can only be reduced by the increase in soybean production. Introducing the genotypes suitable for different ecological regions of Turkey is necessary to increase the soybean production (Ilker et al., 2018).

Soybean can be grown in Turkey as the main crop and the second crop. However, the majority of soybean is produced in Adana and Samsun provinces, which meets only 11% of the soybean demand (FAO, 2017). Therefore, the expansion of soybean cultivation is necessary to meet the soybean demand of Turkey.

Adaptation studies on soybean cultivation have been conducted in different provinces of Turkey and are still continuing. The highest seed yield in a study carried out using 14 soybean varieties in Aksaray province as the main crop was obtained in Ataem 7 (4.98 t ha^{-1}) cultivar and the lowest yield was obtained in Nova (2.81 t ha^{-1}) cultivar (Mert & Ilker, 2016). Another study Yildirim & Ilker (2018) was carried out in the Aegean Region under the second crop conditions using 10 advanced level (F9) lines and 4 control varieties breed by the research institutes of the General Directorate of Agricultural Research and Policies. The results indicated that Kana (3.99 t ha^{-1}), Batem 317 (3.89 t ha^{-1}) and Kama (3.67 t ha^{-1}) cultivars were promising candidates with high yield, and Bravo (103.7 days), Ataem-7 (104.7 days), Arisoy (106.25 days) and Kasm 03 (106.5 days) lines had potential for earliness as the second crop in the Aegean Region. In another study conducted in Sanlıurfa province using 20 soybean varieties, the plant height varied between 61.23 and 103.10 cm, The first pod height was ranged from 1.80 to 9.03 cm, the number of branches per plant was between 2.00 and 5.07, the number of pods per plant was between 78.37 and 215.8, the number of seeds per pod was between 2.3 and 3.1, yield was between 2.18 and 4.13 t ha^{-1}, 100-seed weight ranged between 12.77 and 17.69 g, protein ratio was betweem 37.7 and 40.4%, oil ratio was between 14.87 and 19.1% and oil yield was between 0.39 0.73 t ha^{-1}. Aforementioned grain yield values from different regions of Turkey indicated the genotypes with higher yield values than the average world soybean yield (2.85 t ha^{-1}). The results also revealed that these genotypes have good adaptation to the regions in which the experiments conducted.

The aim of this study was to determine the performances of some soybean genotypes in Tokat-Kazova ecological conditions. The findings on feasibility of soybean production in the region will contribute to decrease in oilseed deficit of the country.

2. MATERIAL AND METHODS

The research was carried out in Agricultural Research Center of Tokat Gaziosmanpasa University in 2017 and 2018. Experimental lay out was randomized block design with three replications. Total of 18 soybean genotypes, including seven lines (TRE-S07-03-531210T, TRE-S07-03-542120T, TRE-SO7-05-111110T, TRE-S07-07-622110T, TRE-S07-08-421210T, TRE-S07-08-633210T and TRE-S08-03-111110T) and eleven cultivars (Traksoy, Türksoy, Yesilsoy, Nazlican, Adasoy, Cinsoy, Cetinbey, Atakisi, Arisoy, Umut-2002 and Mersoy) were used as the main crop.

Average temperature values during the experiment were similar to the long- term averages, however, the temperatures in July, August and September were higher compared to the long-term values. Total precipitation in 2018 was similar to the long-term averages, while precipitation in 2017 was higher than the long-term average precipitation. High temperatures caused a decrease in the average humidity during the experiment (Turkish State Meteorological Service, 2019).

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Soil samples of the experimental field were collected from three different points at 30 cm depth (Table 2), and some of physical and chemical characteristics were determined. Soil in experimental field was clayey loam, strongly alkaline, poor in organic matter content, very calcareous, low in plant available phosphorus and high in potassium concentrations (Kacar, 2012).

The seeds were inoculated with the bacteria (Rhizobium japonicum) during the preparation stage of the sowing. Inoculated seeds were sown to 5 cm depth by hand on April 28, 2017 and April 26, 2018, at 60 cm inter row and 5 cm intra row spacing. The length of rows was 5 m and each plot had 3 rows. The whole experimental field was sown without leaving any space between the plots, considering the first and last rows of the blocks as side effect. Fertilizers were applied before the planting and application rate of fertilizer was 40 kg N ha^{-1} and 88 kg P ha^{-1}. Since the formation of nodules was insufficient in the first flowering period, top fertilizers were applied in two (90 kg N ha^{-1}) different times. The plots were irrigated using drip irrigation system, considering the critical periods of soybean. Weed and pest controls were performed by mechanically and chemically. The plants were harvested at full maturity period by hand and blended. Necessary observations were conducted on 10 plants randomly selected from each plot in the harvest maturity period (Cevik, 2006; Günes, 2006; Unal, 2007).

The data obtained in the study were analyzed according to the experimental design by analysis of variance (ANOVA) using the MSTAT-C software. The means were grouped using Duncan's multiple range test ($P<0.05$) in case ANOVA denoted significant differences (Wang et al., 2013). Since the variations were homogeneous, years were assessed in together. Principal component analysis of the agronomic properties was carried out with Minitab® v17 (Minitab Inc., State College, PA, USA) software.

3. RESULTS AND DISCUSSION

The genotypes germinated within 12 to 17 days and the average germination period was 14 days. The change in the maturity group did not have a significant effect on the germination period. Flowering was completed in 61 to 76 days (mean 69 days), physiological maturation was between 118 and 174 days (mean 137 days). The earliest maturing genotypes were the advanced level lines. Türksoy, Yesilsoy, Nazlican and Adasoy cultivars showed late maturing characteristics, while Cinsoy was moderately late maturing.

Morphological characteristics of a soybean variety may change depending on growing conditions, cultivar, sowing time and sowing density (Onat et al 2017; Gaweda et al 2017). The plant height varied between 86.25 (TRE-S07-08-633210T) and 133.35 cm (Adasoy) (Table 4). The most branching genotypes were Umut-2002 (3.64) and Cinsoy (3.66) while the least branching genotypes were TRE-S07-07-622110T and TRE-S07-08-421210T. The lowest first pod height which is important for the harvest (Gizlenci et al., 2005; Bakal et al 2016) was obtained in TRE-S07-03-542120T, (9.71 cm), TRE-SO7-05-111110T, (9.61 cm) and TRE-S08-03-111110T (9.61cm) genotypes, while the highest value was recorded in Nazlican (17.75 cm) cultivar.

The number of seeds per pod (2.68-3.42) which affect the seed yield differed among the genotypes and lines, however the difference was not statistically significant. The highest number of pods per plant was obtained in Yesilsoy genotype while the least number of pods per plant was obtained in TRE-S07-07-622110T (36.69) genotype. One thousand seeds weight, which is another important trait that contributing to the yield ranged from 182.46 g (TRE-S07-08-633210T) to 132.80 g (Atakisi). The highest seed yield, with the influence of the number of pods and thousand seeds weight, was recorded in Mersoy (2.87 t ha^{-1}) genotype and three advanced level lines (TRE-S07-03-531210T, 2.96 t ha^{-1}; TRE-S07-03-542120T, 3.00 t ha^{-1} and TRE-SO7-05-111110T, 2.85 t ha^{-1}). Yesilsoy and Adasoy genotypes had the lowest seed yield values in the region. The yield values decreased with the decrease in the one thousand seeds weight because Yesilsoy and Adasoy genotypes were in the late maturing class and could not fill their seeds completely (Liu et al., 2017).

Soybean is an important food and feed source due to its high protein content and thus the most produced oilseed type of the world (Liu et al 2017; Tsindi et al 2019). The genotypes with the highest oil ratio were TRE-S07-03-531210T, TRE-S08-03-111110T and Traksoy. The same genotypes were also included in the highest seed yield statistical group, thus had the highest oil yields (0.72 t ha^{-1}, 0.68 t ha^{-1} and 0.70 t ha^{-1}, respectively). Although protein content of Adasoy (43.44%) and Yesilsoy (39.23%) varieties were high, the protein yields of TRE-S07-03-531210T, TRE-S07-03-542120T and Mersoy genotypes were the highest. The protein ratios of these genotypes were ranked statistically in the middle, however, their high seed yields per hectare caused the high protein yields per hectare (Tsindi et al., 2019).

The first four PCs with Eigen value higher than 1.0 explained 83% of the variation among 11 properties examined. The effect of seed yield, oil yield and protein yield which are important parameters of the first PC, was 46% (Abebe et al., 2010). The effect of the second PC explained 16% of the total variation. The contributions of number of seeds and oil ratio were positive while thousand seeds weight and protein ratio negatively contributed to the PC2. The third PC explained 11% of the total variation and plant height and number of branches were the main contributors of the PC3. The number of branches, number of pods per plant, oil ratio and number of seeds per pod were the important traits of PC4 which explained the 11% of the total variation in data set (Table 6). The results indicated that approximately half of the variation was originated from the first PC. Seed yield, oil yield and protein yield were the most contributing morphological traits of the PC1 to the total variation (Figure 1).

The examining the effects of morphological properties indicated that plant height, the first pod height and the number of branches per plant had a relationship with each other. Similarly, seed yield, oil yield and protein yield had a close relationship with each other (Figure 1).

Eighteen different genotypes comprised of I. II. III. and IV. maturity group. Comparison of genotypes for 11 traits revealed that the genotypes 1, 2, 6, 8, 11, 13 and 17 were highly sensitive to different environments (Yüksel & Akcura, 2012). Genotypes 1, 7 and 8 were determined superior in terms of oil content, and genotypes 11 and 13 in terms of protein ratio (Figure 2).

4. CONCLUSIONS

The main reasons of growing soybean are to produce oil and protein. The consumer prefers to use soybean and their products rich in oil and protein (Nonoy et al., 2017). However, the farmers want to grow the genotype that yields higher in per unit area. Considering the aforementioned expectations, the results of current study revealed that TRE-S07-03-531210T, TRE-S07-03-542120T, TRE-SO7-05-111110T and Mersoy genotypes can be grown in the region to obtain sufficient seed, oil and protein yields. Since sunflower and corn can be grown in the same fields where soybean can be grown, 3.00 t ha^{-1} of seed yield for soybean decreases the competing chance of soybean with other crops. Average corn yield is between 10 and 12 t ha^{-1} and sunflower yield is between 3 and 3.5 t ha^{-1}. Market value of soybean is 2300 TL per ton corn is 1100 TL and sunflower is 2500 TL (TSI, 2019). Production costs of all three crops are close to each

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other, therefore the income to be obtained can easily be compared. The income of corn is between 11000 and 14400 TL ha^{-1}, sunflower is between 7500 and 8750 TL ha^{-1}, and soybean is 6900 TL ha^{-1}. Therefore, the probability of expanding the soybean cultivation in the region seems low under these circumstances. New cultivars at least with 4 t ha^{-1} seed yield and adopted to the region need to be breed.

AUTHOR CONTRIBUTIONS

Study activities were supervised by AK, field and laboratory works have been conducted by all researchers. Manuscript has been prepared by equal contribution of all authors

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Table 1. Climate data of the study area for long-term (1960-2016) and during the experiment

Parameters	Year	Months						
		April	May	June	July	August	September	October
Total precipitation (mm)	1960-2016	54.3	58.9	39.0	12.1	6.7	18.6	38.7
	2017	48.2	80.6	76.5	5.4	4.2	29.6	31.9
	2018	45.5	59.1	41.5	7.2	3.9	14.2	39.6
Mean temperature (C^0)	1960-2016	12.4	16.2	19.5	22.0	22.2	18.7	13.6
	2017	12.3	16.5	20.7	25.1	25.5	22.9	13.7
	2018	14.8	18.5	22.0	24.2	23.7	20.4	15.7
Mean humidity (%)	1960-2016	59.0	61.3	59.7	57.4	57.7	59.5	65.3
	2017	51.6	64.8	64.6	49.8	51.6	43.7	57.4
	2018	46.4	60.9	54.9	52.7	55.8	60.1	69.3

Turkish State Meteorological Service

Table 2. Some of physical and chemical characteristics of experimental field

Property	2017	2018
Texture	Clayey loam	Clayey loam
pH	8.1- strongly alkali	7.99- strongly alkaline
Organic matter (%)	1.00-poor	1.13- poor
Lime (%)	20.6- very calcareous	18.25- very calcareous
Phosphorus (P_2O_5, kg da^{-1})	5.68-poor	5.13-poor
Potassium (K_2O, kg da^{-1})	157.7-high	169.8-high
Electrical conductivity (EC, dS m^{-1})	0.22-non saline	0.25- non saline

Table 3. Soybean genotypes germination, flowering and physiological maturity days

No	Genotypes	Germination (day)	Flowering (day)	Physiological maturity (day)
1	TRE-S07-03-531210T	12	61	118
2	TRE-S07-03-542120T	12	61	118
3	TRE-SO7-05-111110T	12	61	118
4	TRE-S07-07-622110T	17	61	118
5	TRE-S07-08-421210T	14	61	118
6	TRE-S07-08-633210T	17	61	118
7	TRE-S08-03-111110T	12	61	118
8	Traksoy	12	71	134
9	Mersoy	12	76	151
10	Turksoy	17	76	163
11	Yesilsoy	17	76	163
12	Nazlican	12	76	163
13	Adasoy	17	76	174
14	Cinsoy	12	76	137
15	Umut-2002	12	76	151
16	Cetinbey	12	71	129
17	Atakisi	14	73	134
18	Arisoy	17	73	134
Mean		14	69	137

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Table 4. Plant height, number of branches, the first pod height, number of pods per plant, number of seeds per pod and 1000-seed weight of soybean genotypes

No	Genotypes	Plant height**	Number of branches**	First pod height*	Number of pods per plant**	Number of seeds per pod^{ns}	1000-seed weight**
1	TRE-S07-03-531210T	107.95cd	2.40b-e	11.79abc	47.75e	2.78	149.80cde
2	TRE-S07-03-542120T	87.49f	1.98de	9.71c	45.41ef	2.75	163.14b
3	TRE-SO7-05-111110T	86.82f	2.03cde	9.61c	47.90e	2.87	159.69bc
4	TRE-S07-07-622110T	114.93bc	1.80e	14.00abc	36.69g	2.80	164.79b
5	TRE-S07-08-421210T	111.14bcd	1.75e	15.20abc	39.55fg	3.12	133.29f
6	TRE-S07-08-633210T	86.65f	2.43b-e	10.22bc	40.49fg	2.82	182.46a
7	TRE-S08-03-111110T	103.63cde	2.11cde	9.61c	58.00bc	2.88	139.85ef
8	Traksoy	116.30bc	2.61a-e	11.84abc	51.96cde	2.97	141.09ef
9	Mersoy	110.40bcd	2.61a-e	11.37abc	50.06de	2.92	145.48de
10	Turksoy	130.53a	2.00cde	18.20a	45.58ef	2.68	147.87de
11	Yesilsoy	129.57a	2.76a-e	14.92abc	66.69a	2.77	138.94ef
12	Nazlican	113.15bc	3.41ab	17.77a	56.13bcd	2.82	154.77bcd
13	Adasoy	133.35a	2.37b-e	13.89abc	60.01ab	2.68	140.51ef
14	Cinsoy	98.25def	3.66a	17.36ab	61.18ab	2.85	138.63ef
15	Umut-2002	123.18ab	3.64a	14.18abc	50.48de	2.83	155.95bcd
16	Cetinbey	93.88ef	2.97a-d	13.18abc	50.01de	2.90	161.10b
17	Atakisi	112.65bc	3.18ab	15.38abc	48.38e	3.42	132.80f
18	Arisoy	113.03bc	3.05abc	14.13abc	51.88cde	2.95	138.76ef
Mean		109.61	2.60	13.46	50.01	2.88	149.11

*, ** Different letters in a column indicate significant differences among genotypes and lines at p<0.01 and p<0.05 level, respectively, ns: non-significant

Table 5. Seed yield, oil ratio, oil yield, protein ratio and protein yield of soybean genotypes

No	Genotypes	Seed yield (t/ha)**	Oil ratio (%)**	Oil yield (t/ha)**	Protein ratio (%)**	Protein yield (t/ha)**
1	TRE-S07-03-531210T	2.96ab	24.35ab	0.72a	33.98def	1.01ab
2	TRE-S07-03-542120T	3.00a	21.21d-g	0.64a-d	35.16c-f	1.07a
3	TRE-SO7-05-111110T	2.85abc	21.44d-g	0.62a-e	32.93f	0.94a-d
4	TRE-S07-07-622110T	2.68a-d	21.40d-g	0.58a-f	35.56cde	0.96abc
5	TRE-S07-08-421210T	2.57a-e	20.30f-g	0.53def	33.30ef	0.86b-f
6	TRE-S07-08-633210T	2.64a-e	19.73g	0.53def	35.44cde	0.93a-e
7	TRE-S08-03-111110T	2.78a-d	24.30ab	0.68abc	32.94f	0.92a-e
8	Traksoy	2.76a-d	25.20a	0.70ab	34.00def	0.94a-d
9	Mersoy	2.87abc	20.66efg	0.59a-f	35.41cde	1.03ab
10	Turksoy	2.53a-f	22.87bcd	0.58a-f	33.76def	0.85b-f
11	Yesilsoy	1.82h	19.73g	0.36g	39.23b	0.71f-g
12	Nazlican	2.03fgh	21.22d-g	0.44f-g	37.32bc	0.76c-g
13	Adasoy	1.89gh	19.57g	0.37g	43.44a	0.60g
14	Cinsoy	2.34c-g	20.21fg	0.48efg	35.64cde	0.83b-f
15	Umut-2002	2.44b-f	22.74bcd	0.56b-f	35.67cde	0.84b-f
16	Cetinbey	2.30d-h	23.55abc	0.54c-f	30.39g	0.73efg
17	Atakisi	2.14e-h	21.81c-f	0.47efg	35.15c-f	0.74d-g
18	Arisoy	2.57a-e	22.43b-e	0.58a-f	35.94cd	0.92a-e
Mean		2.51	21.82	0.55	35.29	0.87

** Different letters in a column indicate significant differences among genotypes and lines at **p<0.01

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Table 6. Eigenvectors and eigenvalues of the first four principal components (PC) of 9 quantitative traits of 18 soybean genotypes

Traits	Eigenvectors			
	PC1	PC2	PC3	PC4
Plant height	-0.28	0.17	-0.63	-0.03
Number of branch	-0.22	0.25	0.44	0.45
First pod height	-0.31	0.22	-0.09	-0.12
Number of pod per plant	-0.31	0.00	0.10	0.49
Number of grain per pod	0.00	0.52	0.39	-0.49
Thousand seed weight	0.18	-0.50	0.27	0.18
Seed yield	0.43	0.00	-0.11	-0.02
Oil ratio	0.22	0.46	-0.22	0.47
Oil yield	0.41	0.20	-0.19	0.20
Protein content	-0.32	-0.32	-0.26	-0.02
Protein yield	0.39	-0.05	-0.09	-0.02
Eigenvalues	5.07	1.79	1.21	1.03
% of total variance explained	46.10	16.30	11.00	9.40
% cumulative variance explained	46.10	62.30	73.30	82.70

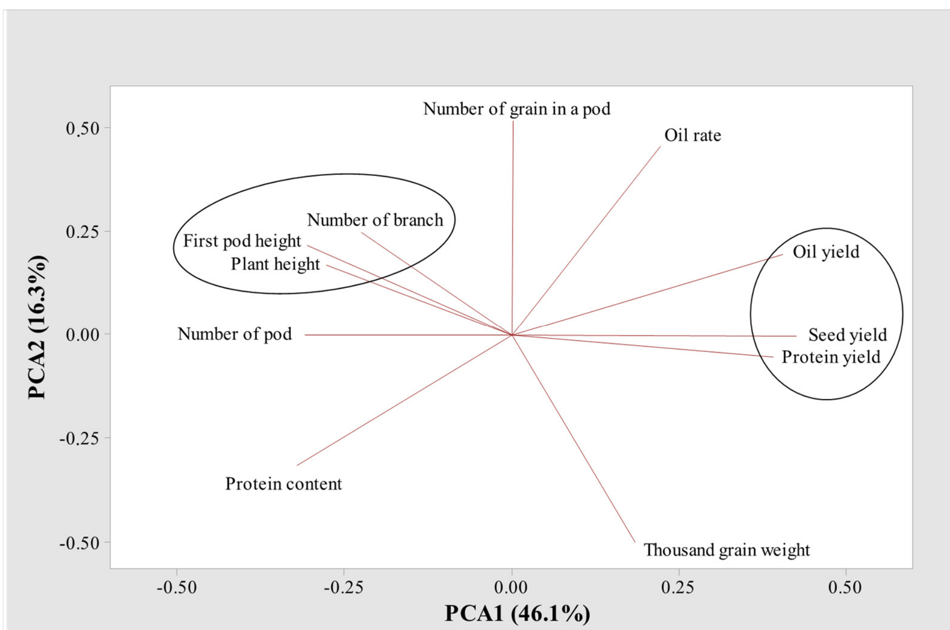

Figure 1. Biplot graph with dispersion of the 18 soybean genotypes for the traits

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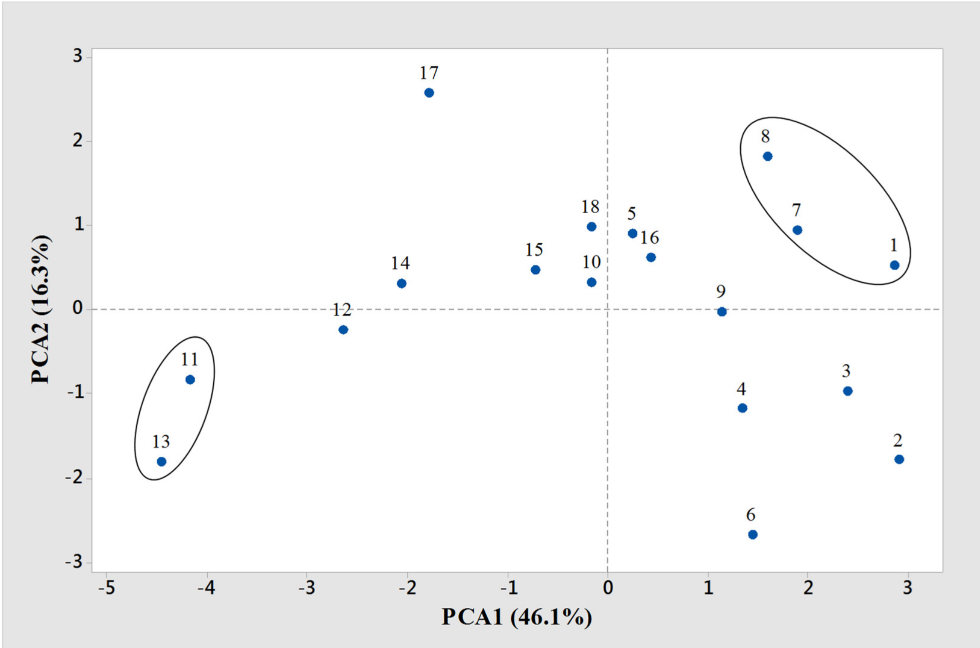

Figure 2. Biplot of PCA1 and PCA2 scores obtained from yield and yield components data of 18 genotypes

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CONFLICTS OF INTEREST

"The authors declare no conflict of interest".