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DETERMINATION OF YIELD AND YIELD COMPONENTS OF SOME NEW SWEET CORN (*Zea mays saccharata* Sturt.) TYPES IN DIFFERENT LOCATIONS IN TURKEY†

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ABSTRACT

This study was conducted to investigate the yield and yield components of sweet corn genotypes with different endosperm types (*su*, *se* and *sh*$_2$) at Tokat-Kazova, Hatay and Samsun locations in 2009 and 2010 growing seasons. Thirteen F_1 sweet corn varieties with different kernel colors and sugar contents and a composite variety were experimented in randomized blocks design with 3 replications. The following yield, yield components, morphological and agronomic traits were studied: tasseling period, silking period, fresh kernel ripening period, plant height, ear length and diameter, number of rows per ear, percent of barren tip, number of kernels per ear, single ear weight, fresh kernel weight per ear, number of ears per plant, number of marketable ears per decare, fresh ear yield per decare, fresh kernel yield per decare and fodder yield. Present findings revealed that Tokat, Hatay and Samsun ecologies were appropriate for production of high yield and quality sweet corn varieties. Among the sweet corn genotypes, early-ripening Bodacious and Fantastic varieties and the varieties of Lumina, Fantastic and Sunshine with well ear characteristics, the varieties of Sunshine and Vega with the greatest number of ears per decare, the varieties of Sunshine, Vega, Fantastic and Silver Queen with the first places in fresh ear yield per decare, fresh kernel yield and fodder yield were identified as prominent varieties. The varieties of Vega, Fantastic, Bodacious and Lumina with desired values of investigated parameters were identified as stable varieties for fresh ear and kernel yield per decare and such a stability indicated that these varieties could successfully be used in different locations. The first principle component included barren tip and explained 47.1% of the total variation, thus it was seen that assessment of barren tips will be sufficient to put forth the differences of genotypes.

KEYWORDS: Sweet corn, location, variety, yield, yield components, quality, genotype x environment interaction

1. INTRODUCTION

With regard to area of cultivation and annual productions, maize is among the primary crops of the world. Just as the other cereals, maize plays a significant role in daily diets of humans. Sweet corn is directly used as human foodstuff. About 74% of annual sweet corn production is consumed freshly in cardboard cups and 26% is processed into different foodstuffs (1).

When harvested at the end of milk stage, sweet corn has quite greater sugar content and nutritional value than the other maize species. Total sugar content of the other maize species is about 1-3% and such a value may vary between 4-12% in sweet corn depending on type. Total sugar of sweet corn is composed of sucrose (60-70%), glucose (10-15%), fructose (10-15%) and maltose (5%). Among the maize species, sweet corn has the largest embryo and the greatest oil and protein content (2,3). Ears are directly consumed as boiled or roasted or fried. Kernels are used in food industry as canned or frozen foodstuff. In sweet corn cultivation, growers generally prefer the non-tillering, homogeneously ripened and high-yield cultivars with large ears, yellow kernels with high sugar content and resistant to pests and diseases.

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Taste and flavor have become significant parameters in sweet corn and new sweet corn varieties with different kernel color and sugar content have been developed. Genetically, there are three types of sweet corn and these are called as *su* (sugary - normal sugar), *se* (sugar enhanced – increased sugar) and *sh2* (shrunken – super sweet). In Turkey, generally *su*-type sweet corn varieties are used, but their quality attributes are quite lower than the *se* and *sh2*-type varieties.

Sweet corn is produced in Turkey over quite limited and confined spaces. It is either produced as a family business or contracted farming. Considering the consumptions of sweet corn as boiled or roasted ear or boiled kernels, Turkey has a high consumption and production potential. Yield level is a significant economic criterion, thus ear yield and kernel yield have become prominent issues in sweet corn cultivation. High ear yield is desired for fresh consumptions and high kernel yield is desired by food industry. Hybrid varieties should widespread to increase sweet corn production of Turkey (4). As compared to open-pollinating composite varieties, hybrid varieties are more sensitive to ecological and environmental conditions. Yield and quality of hybrid varieties significantly decrease with limitations induced by soil factors, drought, pests and diseases and the other environmental factors (5).

The varieties able to tolerate environmental limitations should be identified at different locations. To do so, variations resulted from plant structure and environmental factors should be taken into consideration (6, 7). Kleinhenz (8) conducted a study on 10 sweet corn varieties with different endosperm types (*se, sh2)* and reported that variety x location and variety x year interactions were significant for marketable yield and genetic structure was prominent in performance of varieties at different locations, therefore recommended further researches to be done with greater number of varieties at greater number of locations. Williams et al. (9) conducted a study with three sweet corn varieties and indicated that differences in canopy structure (leaf area index) was closely related to variations in yields of the varieties. Syafi'i et al. (10) conducted a research with 16 sweet corn varieties at 4 locations to identify stable genotypes prominent in each location and reported that genotype x environment interaction was significant for kernel yield.

Previous researchers mostly focused on fresh ear yields of sweet corn varieties grown either as the main crop or the second crop at different locations of Turkey and reported significant variations in fresh ear yields of the locations and the years (11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21). However, researches on fresh kernel yield per unit area have recently become prominent. Boiled sweet corn kernels in cardboard cups are getting more popular in each day. Kernels are also used as canned food in food industry. Therefore, it is quite significant to know fresh kernel yields of the varieties.

Consumptive quality of sweet corn is largely designated by structure, taste and aroma of the kernels. Consumers also take ear length, diameter, number of kernels, number of kernel rows and ear weight into consideration. Rather than genetics, environment and growing techniques are more effective on these quality attributes. Bozkalfa and Eşiyok (22) indicated that the first principle component (PC) explained 41% of variations in ear characteristics of 17 sweet corn genotypes and identified the parameters with the greatest contribution to such a variation as ear length, ear diameter, ear volume, single ear yield and 1000-kernel weight. Multivariate analysis methods are useful tools to asses stability of the genotypes at different environments (23) and can be used to identify the groups with desirable traits for breeding.

There is a need for studies about the performance of new sweet corn varieties with different kernel colors and sugar contents at different locations of Turkey and how-well they will satisfy the consumer preferences. Therefore, this study was conducted to investigate the variations in yield and yield components of sweet corn at Tokat, Hatay and Samsun locations and to identify the appropriate varieties for each region.

2. MATERIALS AND METHODS

Experimental locations

The research was conducted in Tokat/Kazova, Hatay and Samsun locations in 2009 and 2010 growing seasons. Descriptions and agronomic details of the experimental locations are provided in Table 1. The average monthly temperatures in the first and second trial years were 18.3 °C and 20.7 °C in Tokat, 24.6 °C and 25.2 °C in Hatay,

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Table 1. Description of experimental locations and agronomic details

Location	Tokat-Kazova		Hatay		Samsun	
Coordinates Altitude (m)	40°13' N 36°1' E 608		36°12' N 36°10' E 80		41°17' N 36°20' E 40	
	2009	2010	2009	2010	2009	2010
Soil characteristics						
Available P (as P_2O_5, $kg.da^{-1}$)	7.6	2.1	1.8	2.8	1.6	2.5
Exchangeable K (as K_2O, $kg.da^{-1}$)	4.6	99.3	14.1	140.3	4.6	58.6
$CaCO_3$ (%)	13.6	9.4	21.4	21.8	7.4	6.5
Organic matter (%)	1.8	0.2	1.3	0.9	1.7	1.2
pH	7.9	7.8	7.9	7.8	7.9	7.8
Total salt (%)	0.02	0.03	0.04	0.04	0.03	0.02
Texture	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam	Clay-loam
Climate factors						
Average temperatures from sowing to ripening (°C)	18.3	20.7	24.6	25.2	18.5	20.3
Total rainfall from sowing to ripening (mm)	200.0	179.5	66.6	57.2	246.4	222.9
Average relative humidity (%)	56.5	60.1	58.5	58.8	76.1	80.2
Agronomic practices						
Fertilizers (kg ha^{-1})						
N (seed bed + knee-high stage)	70 + 70	70 + 70	70 + 70	70 + 70	70 + 70	90 + 90
P	30	50	60	80	60	80
Sowing date	11 May	28 April	4 May	4 May	14 May	12 May
Harvest date	29 July-14 August	20 July-10 August	27 July-7 August	19 July-29 July	10 August-20 August	28 July-03 August

18.5 °C and 20.3 °C in Samsun, respectively. Total rainfalls throughout the growing season were 200.0 mm and 179.5 mm in Tokat, 66.6 mm and 57.2 mm in Hatay, 246.4 mm and 222.9 mm in Samsun. The average relative humidity was 56.5% and 60.1% in Tokat, 58.5% and 58.8% in Hatay, 76.1% and 80.2% in Samsun. In Tokat location, soils were clay-loam in texture, unsaline and slightly alkaline, medium in calcium carbonate (9.4-13.6%) and poor in organic matter (1.84-0.16%) in both years. The available phosphorus was sufficient in the first year but insufficient in the second year, whereas the soils were poor in potassium in the first year but rich in the second year. In Hatay location, soils were clay-loam in texture, unsaline and slightly alkaline, rich in calcium carbonate, poor in available phosphorus in both years, the soils were poor in potassium in the first year but rich in the second year, organic matter was sufficient in the first year and poor in the second year. In Samsun locations, soils were clay-loam in texture, unsaline and slightly alkaline, medium in calcium carbonate, poor in available phosphorous and organic matter in both years, the soils were poor in potassium in the first year but sufficient in the second year (24).

Plant growth, cultural practices and harvest

A composite variety and thirteen F1 sweet corn varieties with different sugar contents and kernel colors were included in the research (Table 2). Experiments were conducted in randomized complete blocks design with three replications. Each plot consisted of eight rows, 5.0 m long with 70 cm row spacing. On-row plant spacing was 20 cm. Two rows of sorghum were planted at the edge of each plot to avoid cross-pollination of varieties. The seeds were sown on May 11 in 2009 and April 28 in 2010 in Tokat, on May 4 in 2009 and 2010 in Hatay, on May 14 in 2009 and May 12 in 2010 in Samsun. In both years of the trials, hoeing was done twice or three times with the help of a hand-hoe or machine. Tillers were removed in knee-high stage and hilling was applied in Tokat. Three and four irrigations were carried out at the stages of knee-high, tasseling and grain-filling in

Table 2. Sweet corn genotypes included in the study and their certain properties

Genotype	*Hybrid level*	*Endosperm type*	*Ripening period (day)*	*Kernel color*	*Seed source*
IOChief	F_1	su[1]	88	Yellow	Levan Seed Inc., USA
Bodacious	F_1	se[2]	75	Yellow	"
Envy	F_1	sh2[3]	81	Yellow	"
Silver Queen	F_1	su	92	White	"
Cellestial	F_1	se	87	White	"
Extra Tender	F_1	sh2	82	White	"
Peaches&Cream	F_1	su	85	Bicolor	"
Ambrosia	F_1	se	75	Bicolor	"
Fantastic	F_1	sh2	74	Bicolor	"
Lumina	F_1	su	83	Yellow	Anadolu Seed, Turkey
Merit	F_1	su	80	Yellow	May Seed, Turkey
Vega	F_1	super sweet	Early	Yellow	May Seed, Turkey
Sunshine	F_1	sweet	Early	Yellow	May Seed, Turkey
Sakarya	Composite				Sakarya Agr. Res. Inst.,Turkey

[1]*Sugary,* [2]*Sugar-enhanced,* [3]*Shrunken (super-sweet)*

both years through a drip irrigation system in Tokat, furrow and sprinkler irrigation systems in Hatay and sprinkler irrigation system in Samsun (25). A full dose of phosphate (3 kg in Tokat, 6 kg in Hatay and Samsun locations in the first year and 5 kg in Tokat, 8 kg in Hatay and Samsun locations in the second year as P_2O_5 / da) along with half dose of nitrogen (14 kg/da in the first year in Tokat and Hatay, 14 kg/da in the first year and 18 kg in the second year in Samsun) were applied at sowing. The remaining half of the nitrogen was applied when the plants were plants reached to a height of 40-50 cm. In each experiment, weeds were controlled with harrowing and chemical control practices. Harvest was performed between July 29 and August 14 in the first year and between July 20 and August 02 in the second year in Tokat, between July 27 and August 7 in the first year and between July 19 and August 29 in the second year in Hatay, August 10 and August 20 in the first year and between July 28 and August 03 in the second year in Samsun. Harvest was carried out around 21 days after the appearance of the silks, i.e., at the end of milky stage (26).

Statistical analysis

Collected data were subjected to the analysis of variance (ANOVA) using MSTAT-C software (27). The means were compared using the Duncan's multiple comparison test (27). Relative magnitude of the years, locations, genotypes and their interactions were calculated as percentage (28). Stability analysis were performed whenever the genotype x environment interactions for fresh ear yield and fresh kernel yields were significant ($P < 0.01$). The regression coefficient (*bi*) (29) and mean square of deviation from the regression (S^2_d) (30) values were used as the stability parameters. Sweet corn genotypes demonstrating a higher value than the overall mean with a *bi* value of 1 or close to 1 and an S^2d value of 0 or close to 0 in fresh ear and fresh kernel yield were judged as a stable genotype. Additionally, graphical adaptation classifications, developed by Finlay and Wilkinson (29) using the overall mean and *bi* value, were employed for the assessment of stability parameters for fresh ear yield and fresh kernel yield of sweet corn genotypes. Overall mean and confidence intervals for the regression line (b = 1) were calculated by the following formula: Confidence interval = $\bar{X} \pm t.S\bar{X}$. ($\bar{X}$: overall mean, t: t-test, $S\bar{X}$: standard error). Principle component analysis (PCA) was performed (Canoco for windows software) in order to figure out the grouping of genotypes according to yield and yield components.

3. RESULTS AND DISCUSSION

Results of variance analysis for tasseling period, silking period, ripening period, plant height, ear length, ear diameter, number of kernel rows per ear, number of kernels per ear, single ear yield, fresh kernel yield per ear, number of ears per plant, number of marketable ears per decare, fresh ear yield per decare, fresh kernel yield per decare and fodder yield are provided in Table 3 and 4. Locations and years had significant effects on investigated yield components (P<0.05 or P<0.01).

According to combined variance analyses over the years and locations, all genotype x environment interactions were not found to be significant for number kernel rows per ear, genotype x year x location interactions were not found to be significant for ear length and single ear yield, genotype x environment interactions were found

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Table 3. Variance analysis table for yield and yield components of 14 sweet corn genotypes grown at three locations in two growing seasons

Source of Variation	df	Mean square	F value	Variation (%)†	Mean square	F value	Variation (%)	Mean square	F value	Variation (%)
		Tasseling period (day)			**Silking period (gün)**			**Ripening period (day)**		
Year (Y)	1	421.7	383.2**	5.9	403.8	382.4**	6.7	3052.1	3629.3**	24.5
Location (L)	2	2281.4	2073.2**	64.1	1668.1	1579.9**	55.0	2504.7	2978.3**	40.2
Y x L	2	282.0	256.3**	7.9	134.5	127.4**	4.4	771.1	916.9**	12.4
Replication (Lx Y)	12	3.1	2.9**	0.5	2.5	2.4**	0.5	1.3	1.5 ns	0.1
Genotype (G)	13	77.5	70.4**	14.1	109.1	103.3**	23.4	135.8	161.5**	14.2
G x Y	13	5.8	5.3**	1.1	6.2	5.9**	1.3	15.5	18.4**	1.6
G x L	26	7.9	7.1**	2.9	11.4	10.8**	4.9	18.0	21.4**	3.8
G x Y x L	26	2.8	2.6**	1.0	2.5	2.3**	1.1	10.1	12.0**	2.1
Error	156	1.1		2.4	1.1		2.7	0.8		1.1
Variation source		**Plant height (cm)**			**Ear length (cm)**			**Ear diameter (mm)**		
Year (Y)	1	6381.3	43.5**	2.0	2.9	2.7 ns	0.5	1622.9	801.3**	14.0
Location (L)	2	70447.1	480.8**	43.3	21.6	20.5**	8.1	1200.7	592.8**	20.8
Y x L	2	13624.9	93.0**	8.4	4.9	4.7*	1.9	2991.5	1477.0**	51.7
Replication (Lx Y)	12	469.5	3.2**	1.7	1.1	1.1 ns	2.5	9.9	4.9**	1.0
Genotype (G)	13	7680.7	52.4**	30.7	10.3	9.8**	25.3	40.6	20.1**	4.6
G x Y	13	490.5	3.3**	2.0	2.1	2.0*	5.2	7.7	3.8**	0.9
G x L	26	355.6	2.4**	2.8	4.2	4.0**	20.7	14.5	7.1**	3.3
G x Y x L	26	259.4	1.8*	2.1	1.0	0.9 ns	4.8	4.6	2.3**	1.0
Error	156	146.5		7.0	1.1		31.0	2.0		2.7
Variation source		**Number of kernel rows per ear**			**Barren tip size (cm)**			**Number of kernels per ear**		
Year (Y)	1	0.2	0.3 ns	0.0	22.6	66.9**	7.6	33943.9	17.3**	1.9
Location (L)	2	0.4	0.6 ns	0.1	2.9	8.5**	2.0	134065.0	68.4**	14.6
Y x L	2	1.0	1.4 ns	0.3	10.0	29.5**	6.7	2615.8	1.3 ns	0.3
Replication (Lx Y)	12	0.7	1.1 ns	1.4	0.4	1.2 ns	1.6	3788.0	1.9*	2.5
Genotype (G)	13	35.8	51.2**	71.6	8.7	25.9**	38.3	59231.5	30.2**	42.0
G x Y	13	1.0	1.4 ns	2.0	1.0	3.0**	4.5	7623.9	3.9**	5.4
G x L	26	1.0	1.5 ns	4.2	1.3	3.8**	11.2	8295.8	4.2**	11.8
G x Y x L	26	0.9	1.3 ns	3.6	1.2	3.5**	10.4	3459.7	1.8*	4.9
Error	156	0.7		16.8	0.3		17.7	1960.6		16.7

***P<0.01, *P<0.05, ns: not significant, †: variation due to the total sum of squares of all treatment effects*

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Table 4. Variance analysis table for yield and yield characteristics of 14 sweet corn genotypes grown at three locations in two growing seasons.

Variation source	df	Mean square	F value	Variation (%)†	Mean square	F value	Variation (%)	Mean square	F value	Variation (%)
		Single ear weight (g)			**Fresh kernel weight per ear (g)**			**Number of ears per plant**		
Year (Y)	1	12151.4	27.1**	2.5	88.1	0.3 ns	0.0	0.06	3.9 ns	0.7
Location (L)	2	76692.9	171.0**	31.9	7025.9	26.7**	7.0	0.63	40.2**	14.6
Y x L	2	37873.8	84.5**	15.8	17066.5	64.9**	17.0	0.52	33.1**	12.1
Replication (Lx Y)	12	1607.9	3.6**	4.0	1082.9	4.1**	6.5	0.02	1.1 ns	2.4
Genotype (G)	13	6492.2	14.5**	17.6	2386.7	9.1**	15.5	0.06	4.0**	9.4
G x Y	13	972.6	2.2*	2.6	980.3	3.7**	6.4	0.08	5.2**	12.4
G x L	26	1398.1	3.1**	7.6	1241.3	4.7**	16.1	0.04	2.2**	10.4
G x Y x L	26	624.8	1.4 ns	3.4	850.1	3.2**	11.0	0.03	2.0**	9.6
Error	156	448.4		14.6	263.0		20.5	0.02		28.4
Variation source		**Number of marketable ears per decare**			**Fresh ear yield per decare (kg/da)**			**Fresh kernel yield per decare (kg/da)**		
Year (Y)	1	74498862.5	147.1**	19.6	370698.7	17.0**	1.9	129885.8	10.4**	1.4
Location (L)	2	10325099.8	20.4**	5.4	857538.1	39.4**	8.7	67238.8	5.4**	1.5
Y x L	2	5286044.9	10.4**	2.8	575279.9	26.4**	5.8	475836.6	38.2**	10.4
Replication (Lx Y)	12	1262651.6	2.5**	4.0	103470.6	4.7**	6.3	50342.0	4.0**	6.6
Genotype (G)	13	5296885.2	10.5**	18.1	468302.1	21.5**	30.9	154226.0	12.4**	22.0
G x Y	13	2153886.2	4.3**	7.4	57959.1	2.7**	3.8	43615.1	3.5**	6.2
G x L	26	2092767.3	4.1**	14.3	151970.5	7.0**	20.1	78009.4	6.3**	22.2
G x Y x L	26	1122017.4	2.2**	7.7	38730.2	1.8*	5.1	29389.6	2.4**	8.4
Error	156	506295.3		20.8	21783.9		17.3	12469.5		21.3
Variation source		**Fodder yield (kg/da)**								
Year (Y)	1	1174923.9	10.5**	1.2						
Location (L)	2	2016635.1	18.0**	4.0						
Y x L	2	4803846.5	42.8**	9.5						
Replication (Lx Y)	12	216165.2	1.9*	2.6						
Genotype (G)	13	2934480.2	26.1**	37.6						
G x Y	13	731260.5	6.5**	9.4						
G x L	26	426775.4	3.8**	10.9						
G x Y x L	26	296262.6	2.6**	7.6						
Error	156	112341.8		17.3						

***P<0.01, *P<0.05, ns: not significant, †: variation due to the total sum of squares of all treatment effects* to be highly significant for the other traits (Table 3 and 4). With regard to contributions of the years, genotypes, environments and locations to variations in investigated traits, it was observed that years had greater contributions to variations in barren tip ratio (7.6%) and number of marketable ears per decare (19.6%) than the locations, to variations in ripening period (24.5%), ear diameter (14.0%) and number of marketable ears per decare than the genotypes (Table 3 and 4). The traits over which locations had greater contributions in variations than the genotypes were identified as tasseling period (64.1%), silking period (55.0%), ripening period (40.2%), plant height (43.3%), ear diameter (20.8%), single ear yield (31.9%) and number of ears per plant (14.6%) (Table 3 and 4).Rather than environmental factors, genetics had greater contributions to variations in ear length (25.3%), barren tip ratio (38.3%), number of kernel rows per ear (71.6%), fresh kernel yield per ear (15.5%), fresh ear yield per decare (30.9%), fresh kernel yield per decare (22.0%) and fodder yield (37.6%) (Table 3 and 4).

Variations in yield and yield components of the genotypes at different locations in 2009 and 2010 growing seasons are provided in Table 5 and 6. Except for ear length, number of kernel rows per ear, fresh kernel yield per ear and number of ears per plant, significant differences were observed in the other traits of the genotypes with the years (Table 3, 4, 5 and 6). Asghar and Mehdi (31) and Asghar and Mehdi (32) investigated various traits of sweet corn and reported the greatest degree of heredity (h^2= 0.84) for number of kernel rows per ear and indicated less effects of environment on number of kernel rows per ear. Eşiyok et al. (18) reported significant effects of environment on number of kernel rows per ear. In the second year with lower rainfall, high temperature and relative humidity (Table 1), decreases were observed in tasseling period, silking period, ripening period, ear diameter and barren tip ratio (Table 5). Flowering duration is prolonged under humid and cool conditions and shortened in hot weathers (33). Ripening period of sweet corn genotypes may prolong about 6-19 days depending on environmental conditions (7). Average ear diameter of the first year (46 mm) significantly decreased in the second year (41 mm) (Table 5). Ear barren tip length was 1.4 cm in the first year and 0.8 cm in the second year (Table 5). Besides the variety characteristics, environmental factors, especially high or low humidity levels, influence kernel fill of tip kernels (34).

Average plant height of the genotypes increased significantly in the second year (from 162.1 cm to 172.2 cm) (Table 5). Keskin et al. (35) also reported differences in plant heights of the years. Number of kernels per ear and single ear yields of the first year were lower than the second year (Table 6). Aldric et al. (36) indicated that loss of moisture may exert a stress on plant, kernel-fill may negatively be influenced by increased respirations at high night temperatures and ultimately ear weights may decrease. Number of marketable ears per decare was 4420.1 in the first year and the value increased significantly in the second year and reached to 5366.4 (Table 6). Years had greater effects on number of marketable ears per decare than the locations (Table 4). In the second year, fresh ear yield per decare increased to 1238.2 kg, fresh kernel yield per decare increased to 768 kg and fodder yield increased to 2213.3 kg (Table 6). It was reported in previous studies conducted at different locations of Turkey with the main or second crop sweet corn varieties that fresh ear yields varied with the environments (12, 13, 15, 17, 18, 19, 20).

Except for number of kernel rows per ear, significant differences were observed in investigated traits of the experimental locations (Table 3, 4, 5 and 6). The greatest tasseling period, silking period, ripening period, plant height and single ear yield values were observed in Samsun location with greater temperatures and rainfalls than the other locations and the lowest values were observed in Hatay location (Table 5 and 6). Locations had greater effects on above-mentioned traits than the years and genotypes (Table 3 and 4). Asghar and Mehdi (31) reported the lowest level of heredity (h^2= 0.38) in maize for kernel yield per plant. Similarly, Eşiyok et al. (2004) reported that single ear yields of sweet corn varieties at different locations significantly varied with the environments.

Genotypes had similar ear lengths, barren tip sizes and number of kernels per ear at Samsun and Tokat locations, thus they were placed in the same statistical groups. Average values were lower in Hatay location. Eşiyok et al. (18) conducted a study with sweet corn varieties at different locations and reported that ear lengths significantly varied with the environments. In this study, locations had greater effects (14.6%) on number of kernels per ear than the years (Table 4). Besides variety characteristics, number of kernels are negatively

Table 5. Average values of yield and yield components of 14 sweet corn genotypes grown at three locations in two growing seasons.

Number	Genotypes	**Tasseling period (day)**		**Silking period (day)**		**Ripening period (day)**		**Plant height (cm)**		**Ear length (cm)**		**Ear diameter (mm)**		**Number of kernel rows per ear**		**Barren tip size (cm)**	
1	*IOChief*	53.4	bc**	57.7	b**	80.8	c**	173.7	d**	19.8	cde**	44	bc**	15.4	cde**	1.7	bc**
2	*Lumina*	51.6	efg	55.5	cd	79.5	fg	180.0	cd	21.5	a	43	cd	19.1	a	2.0	ab
3	*Peaches &Cream*	51.9	ef	55.4	cd	79.7	ef	157.8	e	19.7	c-f	41	e	17.3	b	0.6	efg
4	*Merit*	53.9	b	57.3	b	80.4	cde	194.7	ab	19.5	def	45	ab	17.3	b	0.9	ef
5	*Silver Queen*	55.7	a	60.4	a	83.4	a	200.7	a	19.7	c-f	41	e	14.0	f	0.7	efg
6	*Sunshine*	51.9	ef	55.3	cd	79.8	def	185.2	bc	20.6	abc	45	ab	17.3	b	2.3	a
7	*Sakarya*	52.2	de	55.6	cd	78.5	h	189.9	abc	19.1	ef	42	de	15.0	e	1.4	cd
8	*Bodacious*	47.7	ı	50.9	f	74.2	j	146.8	efg	18.7	f	43	cd	15.6	cde	1.4	cd
9	*Cellestial*	51.2	fg	54.7	d	78.7	gh	172.1	d	20.8	ab	43	d	15.2	de	0.9	de
10	*Ambrosia*	49.4	h	52.3	e	75.3	ı	142.7	fg	19.7	c-f	44	bc	15.5	cde	1.9	abc
11	*Envy*	53.1	bcd	57.1	b	82.1	b	151.4	ef	20.3	bcd	43	d	16.0	c	0.6	efg
12	*Vega*	50.9	g	54.8	d	77.9	h	158.2	e	20.6	abc	44	bc	15.8	cd	0.3	g
13	*Extra Tender*	52.6	cde	56.0	c	80.6	cd	139.1	g	19.0	ef	45	ab	17.7	b	0.3	efg
14	*Fantastic*	48.9	h	52.0	e	74.3	j	148.0	efg	19.8	cde	46	a	18.1	b	0.3	fg
General mean		51.8		55.4		79.0		167.2		19.9		44		16.4		1.1	
Locations																	
Tokat-Kazova		53.0	*b***	56.4	*b***	79.1	b**	163.2	b**	20.0	a**	46	*a***	16.3		1.3	*a***
Hatay		46.0	*c*	50.5	*c*	73.4	c	140.4	c	19.4	b	46	*a*	16.4		0.9	*b*
Samsun		56.3	*a*	59.2	*a*	84.3	a	197.9	a	20.4	a	39	*b*	16.5		1.1	*a*
Years																	
2009		53.0	*a***	56.6	*a***	82.4	a**	162.1	b**	19.8		46	*a***	16.4		1.4	*a***
2010		50.5	*b*	54.1	*b*	75.5	b	172.2	a	20.0		41	*b*	16.4		0.8	*b*

*Different letters in the same column indicate significant difference (**P<0.01, *P<0.05)*

Table 6. Average values of yield and yield components of 14 sweet corn genotypes grown at three locations in two growing seasons.

Number	Genotypes	**Number of kernels per ear**		**Single ear weight (g)**		**Fresh kernel weight per ear (g)**		**Number of ears per plant**		**Number of marketable ears per decare**		**Fresh ear yield per decare (kg/da)**		**Fresh kernel yield per decare (kg/da)**		**Fodder yield (kg/da)**	
1	*IOChief*	565.6	ıj**	234.1	bcd**	151.9	abc**	0.93	d**	3828	d**	967	g	621	ef	2419	b**
2	*Lumina*	735.5	a	243.8	b	153.0	abc	0.97	cd	5261	abc	1278	bc	795	bcd	2316	bc
3	*Peaches &Cream*	683.4	bc	211.4	e	141.9	cde	1.04	a-d	4876	bc	1120	ef	748	bcd	2228	bcd
4	*Merit*	669.3	cd	238.3	bc	154.9	abc	0.94	d	4699	c	1152	cde	723	cde	2543	b
5	*Silver Queen*	547.4	j	212.8	e	132.3	e	1.00	a-d	4690	c	1158	cde	710	cde	3034	a
6	*Sunshine*	646.1	cde	265.0	a	155.5	abc	0.98	bcd	5748	a	1584	a	933	a	2390	b
7	*Sakarya*	562.0	ıj	212.8	e	142.5	cde	0.96	cd	4805	bc	1063	efg	691	de	2327	bc
8	*Bodacious*	596.9	ghı	211.1	e	131.9	e	0.98	bcd	4774	c	1135	def	699	cde	1618	fg
9	*Cellestial*	640.8	def	243.4	b	159.4	ab	1.10	ab	4678	c	1276	bc	804	bc	1962	de
10	*Ambrosia*	601.5	f-ı	236.8	bc	148.9	bcd	1.03	a-d	5286	abc	1263	bcd	786	bcd	1506	g
11	*Envy*	587.2	hıj	221.4	cde	130.4	e	1.11	a	3791	d	997	fg	579	f	1900	ef
12	*Vega*	632.4	d-g	248.1	ab	155.6	abc	0.96	cd	5477	ab	1336	b	831	b	2042	cde
13	*Extra Tender*	618.5	e-h	216.7	de	134.0	de	1.03	a-d	4701	c	1121	ef	687	de	1988	de
14	*Fantastic*	716.2	ab	264.7	a	166.1	a	1.07	abc	4905	bc	1346	b	833	b	1757	efg
General mean		628.8		232.9		147.0		1.00		4823		1200		746		2145	
Locations																	
Tokat-Kazova		658.1	*a***	235.8	b**	144.8	b**	1.10	*a***	5060.7	*a***	1229	a**	715	b**	2266	a**
Hatay		583.3	*b*	201.3	c	139.2	b	1.00	*b*	4987.2	*a*	1088	b	752	ab	2198	a
Samsun		645.0	*a*	261.5	a	157.1	a	0.92	*c*	4420.1	*b*	1283	a	770	a	1971	b
Years																	
2009		617.2	*b***	225.9	*b***	146.4		1.02		4279.0	*b***	1162	b**	723	b**	2077	b**
2010		640.4	*a*	239.8	*a*	147.6		0.99		5366.4	*a*	1238	a	768	a	2213	a

*Different letters in the same column indicate significant difference (**P<0.01, *P<0.05).*

influenced also by drought and nutrient stress-like environmental factors (18, 34, 36), excessive nitrogenous fertilization and growing techniques (34).

As compared to Samsun, greater ear diameters were obtained at Tokat and Hatay locations (Table 5). Favorable environmental conditions of Tokat and Hatay locations during the grain filling period (Table 1) positively influenced ear diameters (15, 36). Contrary to ear length, environmental factors had greater effects on ear diameter than the genotypes. In a previous study, lower heredity levels were reported for ear diameters (37). Fresh kernel yield of a single ear was greater in Samsun location than in Tokat and Hatay locations (Table 6). The greatest number of ears per plant was observed in Tokat and the lowest value was observed in Samsun location (Table 6). In a previous study, differences in number of ears per plant of the locations were not found to be significant (18). In present study, locations had greater contributions to variations in number of ears per plant than the years and genotypes (Table 4). The greatest number of marketable ears per decare was obtained from Tokat and Hatay locations (Table 6).

Tokat and Samsun locations with better values for yield and yield components also had greater fresh ear yield per decare than Hatay location (Table 6). Locations had greater contributions to variations in fresh ear yield than the years (Table 4). The greatest fresh kernel yield per decare was obtained from Samsun location and it was respectively followed by Hatay and Tokat locations (Table 6). Considering the yield and yield components of Samsun location with higher precipitations and relative humidity, it can be stated the location was more suitable for sweet corn cultivation. On the other hand, greater fodder yields were obtained from Tokat and Hatay locations than from Samsun location (Table 6).

Significant differences were observed in investigated traits of the genotypes (Table 3, 4, 5 and 6). Tasseling periods of the genotypes varied between 48-56 days, silking periods varied between 51-60 days and ripening periods varied between 74-83 days. The varieties of Bodacious and Fantastic (with ripening periods of 74.2 and 74.3 days) were identified as the earliest varieties and the varieties of Silver Queen (83.4 days) and Envy (82.1 days) were identified as the latest varieties (Table 5). Based on present findings, genotypes were placed in medium-ripening group (70-84 days) (2). Genotypes had lower contributions to variations in ripening periods than the years and locations (Table 3). However, variety characteristics were indicated as the primary factor designating ripening periods (2). Serving present early varieties into markets will of sure increase grower incomes.

Plant heights of the genotypes varied between 139-201 cm with the greatest value from the latest variety of Silver Queen (Table 5) and the variety had also high fodder yields (Table 6). Previous researchers also reported taller plant heights for late varieties than for the early ones (38). Taller plants may have advantages in cases where fodder material remained after the harvest was used in animal feeding. Saleh et al. (37) reported the greatest level of heredity (h^2= 0.97) for plant height of sweet corn varieties. In this study, locations had greater effects on plant height than the genotypes (Table 3).

For fresh consumptions of sweet corn, generally large ears without a barren tip are desired. Ear lengths of the genotypes varied between 18.7-21.5 cm with the longest ear in Lumina variety and the ear diameters varied between 41 - 46 mm with the largest ear in Fantastic variety (Table 5). Motes et al. (39) indicated that early varieties had smaller ears and lower fresh consumption quality than the late-ripening ones. Genotypes were indicated among the parameters with the greatest contribution to variations in ear lengths (22). In another study, low heredity levels were reported for ear diameters (37). Thus, in present study, genotypes had quite low contribution (4.6%) to variations in ear diameters (Table 3). Number of kernel rows per ear of the genotypes varied between 14 – 19 and the greatest number of rows was observed in Lumina variety with the greatest ear lengths (Table 5). Albayrak (40) reported significant differences in number of kernel rows per ear of sweet corn varieties. Genotypes had 71.6% contribution to variations in number of rows per ear (Table 3). Asghar and Mehdi (31) and Asghar and Mehdi (32) investigated eight plant characteristics and reported the greatest level of heredity (h^2= 0.84) for number of kernel rows per ear.

Barren tip size of the genotypes varied between 0.3 - 2.3 cm and number of kernels per ear varied between 547.4 - 735.5. Despite greater barren tip size, Lumina variety with longer ears had the greatest number of kernels per ear (Table 5 and 6). With regard to ear characteristics, the composite variety Sakarya left behind the hybrid varieties. In a previous study, insignificant differences were reported for barren tips of sweet corn varieties (40). Genotypes had greater effects on barren tips and number of kernels per ear than the years and locations (Table

3). Single ear yields with significant effects on unit-area yield of the growers varied between 211.1-264.7 g and single ear fresh kernel yields of the genotypes varied between 130.4 - 166.1 g. The varieties of Sunshine and Fantastic had the first place in both parameters (Table 6). It was reported in previous studies that single ear yields varied with the varieties (18, 21, 40, 41). Genotypes had greater contributions to variations in single ear fresh kernel yields than the years and locations (Table 4). The varieties of Sunshine, Fantastic, Vega and Lumina with a high single ear yield had also high ear yield per decare (Table 6). Bozkalfa et al. (22) also reported a positive correlation between single ear yield and ear yield per decare.

Since sweet corn is generally sold as fresh ears, number of ears per unit area is a significant parameter. Number of ears per plant of the genotypes varied between 0.94-1.11 with the greatest value in Envy variety (Table 6). Eşiyok et al. (18) reported insignificant differences in number of ears per plant of sweet corn varieties. Number of ears per decare of the genotypes varied between 3791-5748 (Table 6). The varieties of Sunshine and Vega with the greatest number of ears per decare are recommended for greater incomes from sweet corn cultivation.

Fresh ear yield per decare of the genotypes varied between 967-1584 kg with the greatest yields in Sunshine, Fantastic and Vega varieties (Table 6). Yields per decare of the varieties with the same endosperm type were also different. The high-yield genotypes were placed into different ripening groups (Table 4) and they had high single ear yields (Table 5) (38). Kleinhenz (8) reported fresh ear yields of *se*-type varieties as between 880 - 1240 kg/da and fresh ear yield of *sh2*-type varieties as between 950 - 1230 kg/da. For fresh ear yield per decare, the b_i (29) and S^2_d (30) stability parameters are provided in Table 7. Regression coefficients varied between -0.19 and 2.00. Adaptation classes of the genotypes as specified by Finlay and Wilkinson (29) are presented in Figure 1. Based on b_i values calculated for fresh ear yields of sweet corn genotypes (Table 7) and the graph for adaptation classes of these values (Figure 1), Vega and Fantastic varieties can be stated as stable. Based on S^2_d values, it can be stated that Bodacious variety was prominent as a stable genotype.

Fresh kernel yield per decare of the genotypes, which is a significant parameter for canned food industry and fresh consumption in cardboard cups, varied between 579 - 933 kg. The varieties of Sunshine, Fantastic and Vega with a high fresh ear yield per decare had also high fresh kernel yields (Table 6). It was indicated in previous studies that fresh kernel yields varied with the varieties (21, 40). Based on b_i values calculated for fresh previous studies that fresh kernel yields varied with the varieties (21, 40). Based on b_i values calculated for fresh kernel yield per decare and adaptation classes, it can be stated that Vega variety exhibited medium-compatibility

Table 7. Stability parameters and mean values for fresh ear yield per decare and fresh kernel yield per decare of sweetcorn genotypes grown in 3 different locations with 3 replications in 2 growing seasons.

Number	***Genotype***	**Fresh ear yield per decare (kg/da)**			**Fresh kernel yield per decare (kg/da)**		
		b_i	S^2_d	**Mean**	b_i	S^2_d	**Mean**
1	*IOChief*	0.21	43897.3	967	0.43	16479.6	621
2	*Lumina*	1.84	4243.2	1278	2.35	4859.8	795
3	*Peaches &Cream*	1.54	10704.7	1120	1.66	6869.5	748
4	*Merit*	1.64	5521.2	1152	1.27	8133.7	723
5	*Silver Queen*	1.37	22049.9	1158	1.48	15777.6	710
6	*Sunshine*	0.50	114375.7	1584	1.30	70193.5	933
7	*Sakarya*	2.00	21002.3	1063	1.08	29338.4	691
8	*Bodacious*	1.34	3787.9	1135	1.12	3596.7	699
9	*Cellestial*	1.74	21411.5	1276	0.21	18509.0	804
10	*Ambrosia*	0.13	12586.9	1263	0.65	18177.4	786
11	*Envy*	0.17	14652.6	997	0.08	9576.9	579
12	*Vega*	0.89	23559.7	1336	1.06	16665.0	831
13	*Extra Tender*	-0.19	17981.8	1121	0.59	13219.0	687
14	*Fantastic*	0.80	25143.5	1346	0.73	13552.5	833
Mean		1.00		1200	1.00		746
Confidence interval		1.00 ± 0.73		1200±161	1.00 ± 0.61		746± 92.5

in all environments and was prominent as a stable variety (Table 7 and Figure 2). Based on S^2_d values, Bodacious and Lumina varieties were also accepted as stable varieties (Table 7).

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Fodder yields of the genotypes varied between 1506 - 3034 kg/da (Table 6) and fodder yields were mostly influenced by genotypes (37.6%) (Table 4). The greatest fodder yield was obtained from Silver Queen variety and the lowest fodder yield was obtained from Ambrosia variety. In a previous study, significant variations were reported in fodder yields of the genotypes (42).

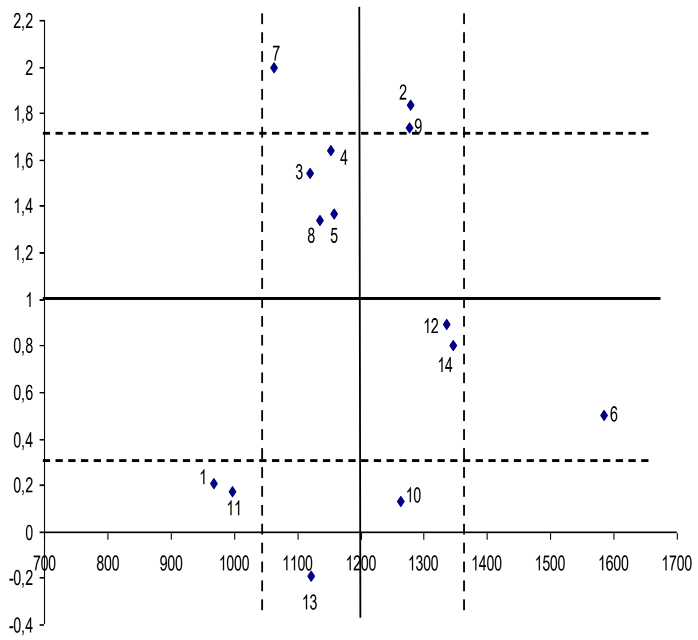

Figure 1. Adaptation classification of sweetcorn genotypes by fresh ear yield per decare

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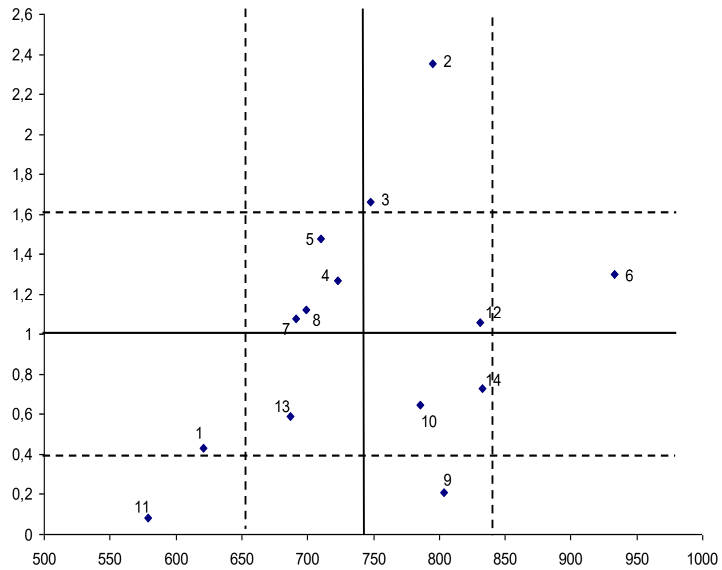

Figure 2. Adaptation classification of sweetcorn genotypes by fresh kernel yield per decare.

The first principle component included barren tips and explained 47.1% of total variation (Table 8). It was seen that assessment of barren tips will be sufficient to put forth the differences of genotypes. The second principle component included tasseling, silking, ripening period, fresh ear and kernel yield per decare and explained

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24.1% total variation. The third principle component, fodder yield, explained 18.7% of total variation. There was a negative correlation between plant height and number of ears per plant (Figure 3). Ear length, fresh ear and kernel yield and number of marketable ears per decare had positive effects, but tasseling, silking and ripening periods had negative effects on fresh ear and kernel yield per decare (Figure 3). As can be seen in Figure 3, Sunshine (6), Lumina (2) and Ambrosia (10) genotypes had high values for barren tip with contributions to variations in the first principle component (Table 5). Silver Queen (5) and Envy (11) genotypes had high values for tasseling, silking and ripening periods (Table 5).

Table 8. Principal component analysis for yield and yield components of 14 sweetcorn genotypes

Characteristics	PC1	PC2	PC3
Tasseling period (day)	-0.0590	**0.7824**	-0.4682
Silking period (day)	-0.0650	**0.8019**	-0.4607
Ripening period (day)	-0.0608	**0.7438**	-0.3887
Plant height (cm)	0.4401	0.5185	-0.6694
Ear length (cm)	0.2519	-0.2426	-0.4224
Ear diameter (mm)	-0.0369	-0.5275	-0.0131
Number of kernel rows per ear	-0.0140	-0.4692	-0.2090
Barren tip size (cm)	**0.9882**	0.0374	0.1467
Number of kernels per ear	-0.0357	-0.6277	-0.3585
Single ear weight (g)	0.2256	-0.6232	-0.4000
Fresh kernel weight per ear (g)	0.2072	-0.5316	-0.4323
Number of ears per plant	-0.4595	-0.2703	0.2626
Number of marketable ears per decare	0.2864	-0.6921	-0.4550
Fresh ear yield per decare (kg/da)	0.2560	**-0.7717**	-0.5161
Fresh kernel yield per decare (kg/da)	0.2644	**-0.7628**	-0.5546
Fodder yield (kg/da)	0.1444	0.6614	**-0.7275**
Proportion of total variance (%)	*47.1*	*24.1*	18.7
Cumulative variance (%)	*47.1*	*71.2*	89.8

4. CONCLUSION

Years had greater contributions to variations in barren tips than the locations; to variations in number of marketable ears per decare than the locations and genotypes; to variations in ripening period and ear diameter than the genotypes. Locations had greater contributions to variations in tasseling, silking and ripening periods, plant height, ear diameter, single ear yield and number of ears per plant than the years and genotypes. Rather than environmental factors, genetic structure played greater roles in ear length, barren tip, number of kernels per ear, number of kernel rows per ear, fresh kernel yield per ear, fresh ear and kernel yield per decare and fodder yield. Present findings revealed that Tokat, Hatay and Samsun ecologies were appropriate for production of high yield and quality sweet corn varieties. Among the sweet corn genotypes, early-ripening Bodacious and Fantastic varieties and the varieties of Lumina, Fantastic and Sunshine with well ear characteristics, the varieties of Sunshine and Vega with the greatest number of ears per decare, the varieties of Sunshine, Vega, Fantastic and Silver Queen with the first places in fresh ear yield per decare, fresh kernel yield and fodder yield were identified as prominent varieties. The varieties of Vega, Fantastic, Bodacious and Lumina with desired values of investigated parameters were identified as stable varieties for fresh ear and kernel yield per decare and such a stability indicated that these varieties could successfully be used in different locations. The first principle

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component included barren tip and explained 47.1% of the total variation, thus it was seen that assessment of barren tips will be sufficient to put forth the differences of genotypes.

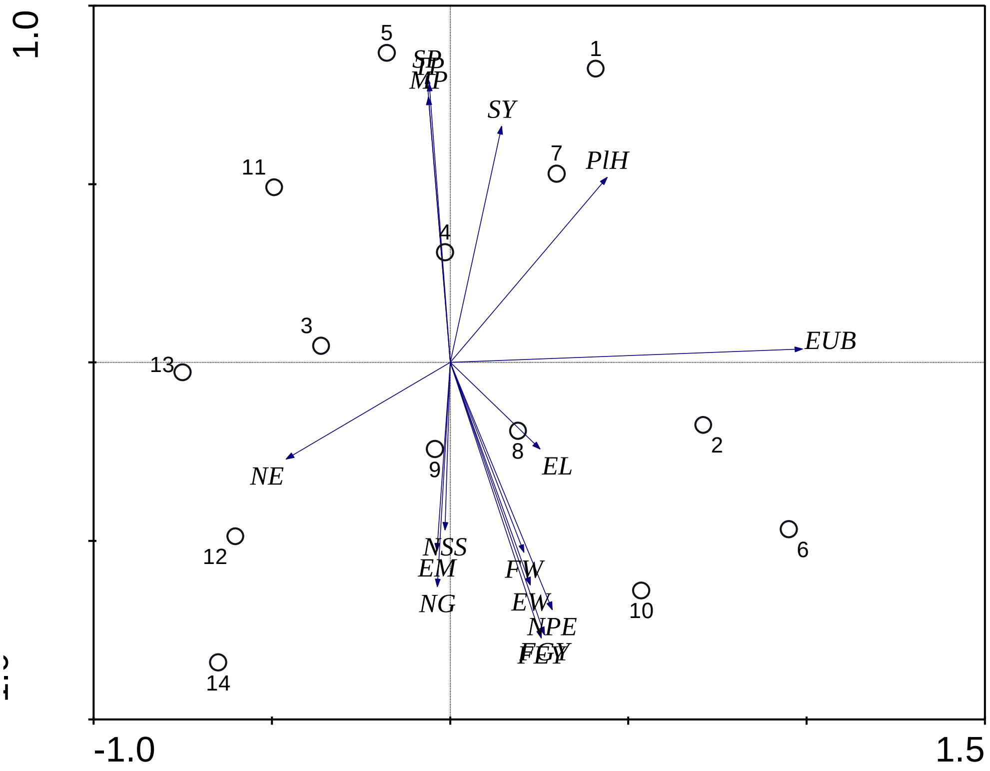

Figure 3. Varimax rotated principal component loadings in regard to yield components and fresh ear yield and fresh kernel yield per decare of 14 sweet corn genotypes (TP: tasseling period; SP: silking period; MP: fresh maturing period; PIH: plant height; EL: ear length; EM: ear diameter; NSS: number of rows per ear; EUB: Barren tip size; NG: number of kernels per ear; EW: single ear weight; FW: fresh kernel weight per ear; NE: number of ears per plant; NPE: number of marketable ears per decare; FEY: fresh ear yield per decare; FGY: fresh kernel yield per decare; SY: fodder yield)

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