Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2020, Vol. 4 (1), 21-32
https://doi.org/10.29329/ijiaar.2020.238.3

Original article

Genetic Variability, Heritability, and Genetic Advance for Ethanol Yield and Yield Components in Sweet Sorghum (*Sorghum Bicolor Var. Saccharatum* (L.)

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Abstract

Sweet sorghum is a strong candidate for a cheap and renewable source of energy and play a vital role for the uplift of socio-economic status of the farmers of Turkey through the development of high yielding varieties along with a reasonable amount of fodder and biofuel production. The objective of this research was to evaluate the potential of sweet sorghum as a source for fodder and biofuel production, also the magnitude of genetic variability, heritability and genetic advance for yield and contributing characters of forty-nine sweet sorghum genotypes. The experiment was carried out in a randomized complete block design with four replications in Turkey. Analysis of variance revealed that there are highly significant differences among the genotypes in all investigated traits indicating the presence of variability. The genotypes Smith and Batem-3 with high juice, sugar and ethanol yield can be used for breeding of biofuel production in the Mediterranean region of Turkey. High heritability accompanied with high genetic advance was observed for the flowering day, fresh biomass weight, stem fresh weight, juice volume, estimated sugar yield, and estimated ethanol yield. Therefore, these characters could be used for the development of high yielding sorghum varieties through selection in a breeding program.

Keywords: Phenotypic and genotypic coefficient of variation, Sorghum, Variability, Additive gene action.

Received: 07 October 2019 * **Accepted:** 23 November 2019 * **DOI:** https://doi.org/10.29329/ijiaar.2020.238.3

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INTRODUCTION

Sweet sorghum (*Sorghum bicolor var. saccharatum* (L.) Mohlenbr.) is an annual, seed-propagated C4 grass that derives its name from the high concentration of soluble sugars (a mixture of sucrose, glucose, and fructose) contained in its tall, juicy stalks (Smith et al., 1987; Murray et al., 2009). Historically, sweet sorghum is grown to support the production of syrup and molasses, but there is a growing interest in its use as a feedstock for renewable fuels and chemicals (Almodares and Hadi, 2009; Ou et al., 2016; Wang et al., 2015). Therefore, it can play a vital role for the uplift of socio-economic status of the farmers of Mediterranean region of Turkey through the development of high yielding varieties along with a reasonable amount of fodder and biofuel production.

Sweet sorghum varieties differ greatly in their qualities and adaptation to various soil and climatic conditions (Ratnavathi et al., 2010). Yield is a complex trait, depending on many attributes characters. Yield potential accompanied by a desirable combination of traits has always been the major objective of sorghum breeding program. To improve the yield of existing landraces, an understanding genetics of yield components is a necessity. The knowledge of genetic variability, heritability, and association among economic traits in existing local varieties is a pre-requisite for selection and development of a well-adapted variety (Falconer and Mackay, 1996; Jalata et al., 2011).

Therefore, the objectives of this study were to determine the amount of genetic variability, heritability, genetic advance and strength of association of yield-related traits among some selected sorghum genotypes in the Mediterranean region of Turkey.

Materials and Methods

The experimental material were 49 sweet sorghum genotypes grown in the experimental field of the Eastern Mediterranean Agricultural Research Institute, Adana-Turkey (35^{o} 18$^{'}$ E, 37^{o} 01' N; 23 m above the sea level) during 2015 second crop growing season (June-October).

Field experiment was carried out in a randomized complete block design with four replications. Each genotype was sown in a single row of 4 m length with a spacing of 70 × 25 cm. At planting time, each plot received an equivalent rate of 50 kg N/ha and 8 kg P/ha. Six weeks after planting, additional 50 kg N/ha was supplied.

The data were recorded on five random plants from each genotype in each replication for thirteen characters viz., plant height (PH: cm); stem diameter (SD: mm); fresh biomass weight (FBW, g/plant); leaf fresh weight (LFW: g/plant); panicle fresh weight (PFW: g/plant), stem fresh weight (SFW: g/plant); stem/leaf ratio (S/L Ratio). Flowering day (FD: day) was recorded as the number of days after sowing, 50 percent of plants in each plot flowered. Each genotype was harvested in the milk-dough stage. After harvesting, these five plants were crushed on an electrically operated three-roller cane crusher to estimated juice volume (JV: ml/plant); juice extractability (JR: %); brix (B: %); estimated sugar yield (ESY: g/plant) and estimated ethanol yield (EEY: ml/plant). The juice and juice ratio was computed by multiplying average juice weight from 5 plants. Soluble solids concentration (Brix %) was recorded with a portable refractometer (Comecta. A.S.Spain). Estimated ethanol yield was calculated using the formula given by Bunphan et al. (2015). Estimated ethanol yield = [(Total Soluble Solid/5.68) x 3.78]x 0.8.

Forty-nine sweet sorghum genotypes obtained from various sources were used as a material. List of material in the research was given in Table 1.

Table 1. Name and origin of evaluated sweet sorghum genotypes

No	Genotype name	No	Genotype name	No	Genotype name
1	Blue Ribben*	17	P1579753*	33	Waconia-L*
2	Brandes*	18	Ramada*	34	Williams*
3	Colman*	19	Rex*	35	Wray*
4	Corina*	20	Rio*	36	No 2 USDA-China**
5	Cowley*	21	Roma*	37	No 91 USDA-Taiwan**
6	Dale*	22	Rox Orange*	38	No 5 USDA-S. Africa**
7	Early Folger*	23	Simon*	39	No 20 USDA-Sudan**
8	Grassi*	24	Smith*	40	No 24 USDA -Uganda**
9	H. Sugarcane*	25	Snow Flakes*	41	No 30 USDA-Malawi**
10	Hasting*	26	Sugar Drip*	42	No 41 USDA-Zaire**
11	Honey*	27	Theis*	43	No 42 USDA Kenya**
12	M81-E*	24	Topper 76*	44	No 43 USDA Uganda**
13	Mennonita*	29	Tracy*	45	No 46 USDA-Turkey**
14	N98*	30	UNL-hybrid -3*	46	No 49 USDA-India**
15	Nebraska sugarcane*	31	UNL-hybrid -4*	47	Gulseker (Local control variety) ***
16	Norkan*	32	White Orn*	48	Rox(Local control variety) **
				49	No 453 (ICRISAT-S. Afrika) **

* These materials were obtained from Nebraska University, Prof. Dr. Ismail Dweikat, USA

**These materials were obtained from West Mediterranean Agriculture Research Institute, Turkey (Origin USDA Gen Bank and ICRISAT)

***These materials were obtained from Uludağ University, Bursa-Turkey

The data collected for each character was subjected to analysis of variance (ANOVA) using randomized complete block design to test the variations among genotypes. The analysis of variance was calculated using SPSS software. After testing the ANOVA assumption, treatment means were tested with Tukey HSD ($P \leq 0.01$) (IBM, 2013). The genetic parameters genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) were calculated as suggested by Singh and Chaudhary, (1985). Estimated Mean Squares are helpful to evaluate variance components calculated by the REML method as suggested by Jalata et al. (2011), and the broad sense heritability (H) and genetic advance (GA) of the traits were calculated (Hanson et al., 1956).

Results and Discussion

Mean squares obtained from analysis of variance revealed that the differences among the sorghum genotypes were significant for all measured traits (Table 2).

Table 2. Mean squares of traits in sweet sorghum genotypes

Traits	Genotypes	Replications	Error
Flowering day (day)	495.818***	3.034 NS	5.138
Plant height (cm)	14606.057***	5408.097 NS	2948.11
Stem diameter (mm)	66.513***	11.989 NS	16.512
Fresh biomass weight (g plant^{-1})	675343.042***	69777.025 NS	54837.951
Leaf fresh weight (g plant^{-1})	18144.980***	9906.351**	2149.744
Panicle fresh weight (g plant^{-1})	2697.665***	141.148 NS	504.578
Stem fresh weight (g plant^{-1})	520821.681***	33161.35 NS	34418.53
Stem/leaf ratio	4.978***	4.837***	0.61
Juice volume (mL plant^{-1})	97507.605***	22851.839**	7334.5
Juice extractability (%)	0.015***	0.007 NS	0.004
Brix (%)	0.001***	0 NS	0
Estimated sugar yield (g plant^{-1})	1432.412***	305.620*	118.56
Estimated ethanol yield (mL plant^{-1})	495.639***	106.187*	40.998

*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001; NS: Non-significant

The highest mean square value was estimated for fresh biomass weight followed by juice volume, stem fresh weight, leaf fresh weight and plant height. This fact suggested that selected genotypes were genetically variable and a considerable amount of variability existed among them. Similar findings were reported by Bhushan et al. (2013), Zou et al. (2011).

Data regarding traits of the 49 sorghum genotypes (Table 3) focused on the highly significant (P ≤ 0.01) variation among sorghum genotypes in all characters. These variations between genotypes may be due to genetic behavior combined with environmental factors that were more suitable for one genotype than another. These findings are in agreement with those obtained by Oyier et al. (2017) and El Naim et al. (2012).

According to Table 3, Rox-Orange took the least (58 d) to flowering day followed by Norkan (60 d) and Waconia-L (61 d). The maximum plant height was measured in genotype P 1579753 with 418.6 cm. Genotype UNL-hybrid -3 had the highest stem diameter and fresh biomass weight at 31.5 cm and 1950 g plant^{-1}, respectively. The highest leaf fresh weight was observed in Topper 76 at 356.6 g, followed by Corina at 337.5 g and UNL-hybrid -3 at 325g. Rox-Orange attained an overall panicle fresh weight of 161.5 g. The highest stem fresh weight was observed on UNL-hybrid -3 at 1982.5 g followed by Theis 1725 g. The maximum steam/leaf ratio was observed on Theis 8.75 followed by Gülşeker at 7.25. The highest juice volume was obtained from UNL-hybrid -3, while there were no significant differences between Theis and Batem-3. Honey gave the highest juice ratio. Brix is a good indicator for sugar and ethanol production. The highest rate of brix accumulation was seen in Rex at the rate of 17 percent. Furthermore, this was followed by ranked genotypes N 98, P1579753, Smith, Wray, Ramada, Nebraska sugar cane, Roma, Cowley, Blue Ribben, Bataem-1, Williams, Norkan, Mennonite, Snow Flakes, and Rox-Orange. In terms of estimated sugar and ethanol yield, Smith had the highest value, besides no significant differences were observed among Smith, Theis, UNL-hybrid -3 and Batem-3 sorghum genotypes (Table 3). Data regarding genetic parameters of sweet sorghum are shown in Table 4.

Table 3. Mean value of Sweet Sorghum genotypes for growth traits

Genotypes	FD	PH	SD	FBW	LFW	PFW	SFW	S/L Ratio	JV	JR	B	ESY	EEY
Blue Ribben	65.00	250.90	25.10	1146.65	129.65	80.00	940.00	7.28	373.35	0.40	0.15	47.34	27.85
Brandes	92.00	268.45	27.75	1465.00	260.00	35.50	1165.00	4.45	385.00	0.33	0.13	43.64	25.68
Colman	72.00	386.90	20.25	840.00	116.00	44.00	680.00	5.95	213.35	0.32	0.13	23.33	13.75
Corina	97.75	259.10	27.65	1721.25	337.50	73.88	1395.00	4.13	436.88	0.31	0.12	43.30	25.48
Cowley	74.00	354.50	23.16	1720.00	242.65	42.20	1433.35	5.98	536.65	0.38	0.15	68.44	40.25
Dale	83.00	321.90	27.00	1646.65	186.75	33.15	1413.30	7.60	533.30	0.38	0.14	61.70	36.30
Early Folger	68.50	300.15	21.95	970.00	147.00	59.10	765.00	5.20	305.00	0.40	0.13	34.54	20.35
Grassi	74.75	392.85	27.25	1795.00	227.00	43.80	1550.00	6.80	585.00	0.38	0.13	64.20	37.78
H. Sugarcane	64.50	210.90	19.80	831.25	119.18	64.00	642.08	5.85	294.18	0.46	0.10	25.15	14.80
Hasting	67.25	264.35	26.00	1299.00	222.00	77.00	988.00	4.78	390.00	0.40	0.13	42.36	24.93
Honey	65.50	302.25	19.60	800.00	130.00	38.00	632.00	5.15	325.00	0.52	0.10	26.60	15.68
M 81-E	93.50	369.75	26.60	1606.65	206.65	30.85	1380.00	6.73	633.25	0.46	0.14	74.68	43.95
Mennonita	63.25	215.15	53.25	1030.00	151.00	49.00	816.00	5.88	407.50	0.50	0.15	50.98	29.98
N 98	66.50	116.15	13.40	875.00	115.00	21.25	721.25	6.25	271.88	0.38	0.16	37.28	21.93
Nebraska sugarcane	72.50	317.25	27.35	1346.65	201.35	10.65	1160.00	5.78	463.35	0.40	0.16	60.91	35.83
Norkan	60.50	235.65	23.68	961.25	165.25	63.25	725.00	4.53	318.75	0.44	0.15	39.81	23.43
P1579753	89.00	418.60	26.80	1636.00	230.00	37.45	1395.00	6.13	370.00	0.27	0.16	51.15	30.10
Ramada	84.50	329.35	26.05	1533.30	260.00	35.35	1253.35	4.90	503.35	0.40	0.16	66.68	39.25
Rex	72.50	242.35	12.80	573.35	79.35	30.00	443.35	5.60	156.65	0.33	0.17	22.91	13.50
Rio	83.25	309.55	20.35	1001.68	139.00	23.38	831.68	6.03	347.50	0.42	0.13	38.55	22.70
Roma	83.75	325.85	91.45	1426.65	240.00	24.65	1160.00	4.83	396.65	0.34	0.15	50.90	29.93
Rox Orange	58.50	263.30	21.95	1657.50	220.33	161.50	1268.50	5.90	550.20	0.43	0.15	68.20	40.13

Simon	66.50	150.35	12.55	388.93	50.80	21.85	289.10	5.85	108.50	0.41	0.14	12.87	7.58
Smith	72.75	368.10	27.75	1910.00	275.00	37.60	1615.00	5.90	672.50	0.42	0.16	92.84	54.65
Snow Flakes	69.75	262.90	23.50	1195.00	218.00	41.75	940.00	4.40	369.50	0.39	0.15	45.77	26.95
Sugar Drip	73.75	279.00	26.15	1250.00	159.50	66.95	1020.00	6.45	427.50	0.42	0.14	50.99	30.00
Theis	94.00	386.50	28.45	1950.00	200.00	35.45	1725.00	8.75	712.50	0.41	0.14	84.72	49.83
Topper 76	105.25	321.00	31.00	1893.35	356.65	44.75	1535.50	4.43	606.65	0.40	0.12	62.92	37.03
Tracy	75.75	298.25	26.10	1377.50	173.75	37.00	1183.75	6.80	479.38	0.41	0.13	54.09	31.80
UNL-hybrid -3	72.50	368.90	31.35	2360.00	325.00	51.15	1982.50	6.10	807.50	0.41	0.12	81.32	47.85
UNL-hybrid -4	69.50	286.30	21.90	1310.00	280.00	49.50	990.00	3.55	330.00	0.33	0.11	32.13	18.90
White Orn	73.25	289.15	26.50	1710.00	265.00	65.75	1395.00	5.30	442.50	0.34	0.12	44.31	26.08
Waconia-L	61.75	193.85	19.90	675.00	102.00	30.60	545.00	5.38	220.00	0.41	0.14	25.46	14.98
Williams	69.00	262.85	24.10	1128.35	138.65	36.00	946.65	6.85	450.00	0.48	0.15	56.44	33.23
Wray	71.75	259.30	19.05	1085.00	158.68	23.90	898.33	5.75	285.75	0.32	0.16	40.26	23.68
No 2	65.50	299.45	22.55	1230.00	178.33	43.00	1001.68	5.90	415.75	0.41	0.15	53.00	31.18
No 91	102.00	332.75	102.90	1806.65	260.00	42.75	1493.35	5.73	616.65	0.41	0.14	75.30	44.30
No 5	73.75	281.55	25.85	1923.75	255.85	66.75	1607.50	6.33	687.50	0.43	0.13	76.67	45.10
No 20	94.50	265.25	24.30	1015.00	230.00	47.55	745.00	3.25	210.00	0.28	0.12	22.08	13.00
No 24	70.50	282.95	21.20	1020.00	142.00	49.30	850.00	6.20	369.00	0.42	0.12	35.69	21.00
No-30	67.00	317.90	22.85	1245.00	218.00	112.45	890.00	4.05	227.50	0.26	0.13	24.38	14.35
No 41	72.50	260.95	17.80	1442.25	258.00	102.40	1091.08	4.70	450.00	0.42	0.10	37.33	21.95
No 42	71.50	304.25	22.25	1213.35	182.65	68.00	966.65	5.33	356.65	0.37	0.11	33.31	19.60
No 43	69.25	297.00	21.55	1340.00	251.00	69.00	1020.00	4.15	377.50	0.37	0.12	37.59	22.13
No 46	72.75	237.90	23.65	937.50	175.50	43.25	727.50	4.13	210.00	0.29	0.11	19.71	11.60
No 49	72.25	305.10	24.85	1453.35	268.00	49.00	1140.00	4.28	346.65	0.30	0.12	36.03	21.20
Gülşeker (Control)	70.75	231.55	21.60	1643.35	180.75	76.00	1379.58	7.73	666.03	0.48	0.10	55.63	32.75

Rox (Control)	62.25	207.90	22.10	788.75	112.75	54.25	617.50	5.63	239.38	0.38	0.11	22.16	13.05
No 453	71.00	296.35	23.25	1133.35	148.00	54.65	926.65	6.28	470.00	0.50	0.12	47.82	28.15
CV (%)	15.01	26.59	22.85	34.73	39.84	63.21	36.80	23.59	41.54	20.54	16.02	44.87	44.85

FD: Flowering day (day); PH: Plant height (cm); SD: Stem diameter (mm); FBW: Fresh biomass weight (g/plant); LFW: Leaf fresh weight (g/plant); PFW: Panicle fresh weight (g/plant); SFW: Stem fresh weight (g/plant); S/L ratio: Stem/leaf ratio; JV: Juice volume (ml/plant); JR: Juice extractability (%); B: Brix (%); ESY: Estimated Sugar yield (g/plant); EEY: Estimated ethanol yield (ml/plant)

Table 4. Estimates of genetic parameter in sweet sorghum

Traits	Range	Min.	Max.	Mean	St. Dv.	SE	σ_G^2	σ_P^2	GCV	PCV	H	GA
Flowering Day	48	58	106	74.76	11.22	0.8	122.68	127.78	14.82	15.12	0.96	2.021
Plant height	741.8	84.2	826	287.81	76.52	5.47	2914.49	5912.8	18.76	26.72	0.493	1.448
Stem Diameter	35.4	2.2	37.6	23.46	5.36	0.38	12.52	28.94	53.37	123.36	0.43	1.357
Fresh biomass weight	2220	260	2480	1312.41	455.86	32.56	155126.7	210269.1	30.01	34.94	0.738	1.772
Leaf fresh weight	466.8	33.2	500	197.74	78.78	5.63	3998.81	6306.85	31.98	40.16	0.634	1.643
Panicle fresh Weight	196	8	204	50.99	32.23	2.3	550.13	1047.29	46	63.47	0.525	1.495
Stem fresh weight	1981	129	2110	1066.94	392.59	28.04	121607.2	156000.08	32.68	37.02	0.78	1.821
Stem/leaf Ratio	6.6	3.1	9.7	5.61	1.32	0.09	1.09	1.79	18.63	23.85	0.61	1.612
Juice volume	820	80	900	415.34	172.54	12.32	22543.27	30194.49	36.15	41.84	0.747	1.783
Juice extractability	0.5	0.1	0.7	0.39	0.08	0.01	0.003	0.006	14.04	19.86	0.5	1.375
Brix	0.1	0.1	0.2	0.13	0.02	0.002	0.003	0.004	41.21	47.58	0.75	1.547
Estimated Sugar yield	99.2	9.2	108.4	47.01	21.09	1.51	328.46	450.84	38.55	45.17	0.729	2.063
Estimated Ethanol yield	58.4	5.4	63.8	27.66	12.41	0.87	113.66	155.99	38.54	45.15	0.729	1.761

The highest genotypic (GV) and phenotypic (PV) variance were obtained from fresh biomass weight (155126.7 and 210269.1), followed by stem fresh weight (121607.2 and 156000.1), juice volume (22543.3 and 30194.5), leaf fresh weight (3998.809 and 6306.851) and plant height (2914.487 and 5912.801). Panicle fresh weight (550.1 and 1047.3), estimated sugar yield (328.5 and 450.8), flowering day (122 and 127), and estimated ethanol yield (113.7 and 156) had moderate GV and PV (Table 4). Lower GV and PV were observed from steam/leaf ratio (1.09 and 1.78), juice extractability (0.003 and 0.006) and brix (0.003 and 0.004). The phenotypic variance was greater than genotypic variance for all traits. These results showed that environmental influence was moderate for these traits as the experiment was managed under quite uniform input level to all the genotypes.

The genotypic coefficient of variation (GCV) ranged from 46.0 % to 14.8 %. The higher GCV were obtained in the panicle fresh weight (46. 0 %) followed by brix (41.21 %), estimated sugar yield (38.55 %), estimated ethanol yield (38.54 %), juice volume (36.15 %), stem fresh weight (32.68 %), leaf fresh weight (31.98 %), and fresh biomass weight (30.01 %) (Table 4). In the meantime, the GCV was low for flowering day (14.82 %), plant height (18.76 %), stem/leaf ratio (18.63 %), and juice ratio (14.04 %).The higher phenotypic coefficients of variation (PCV) were obtained from panicle fresh weight (63.47 %) followed by brix (47.58 %), estimated sugar yield (45.17 %), estimated ethanol yield (45.15 %), juice volume (41.84), stem fresh weight (37.02 %), leaf fresh weight(40.16 %) and fresh biomass weight (34.94 %), but low for flowering day (15.12 %), plant height (26.72 %), stem/leaf ratio (23.85 %), juice ratio (19.86 %).

Stem diameter, the weight of fresh biomass, leaf, panicle, stem, juice volume, brix, estimated sugar yield, and estimated ethanol yield showed high GCV and PCV values (Table 4). This indicated that there was greater scope for improvement in these traits either by direct selection among the genotypes or by involving chosen parents in hybridization. These results were in accordance with the study conducted by Bello et al. (2007), Yaqoob et al. (2015). As seen in Table 4, the flowering day, plant height, stem/leaf ratio, and juice extractability had lower GCV and PCV. These results indicated that improvement for such traits may be achieved only up to some extent, and these findings were similar to obtained Warkad et al. (2008) and Jain et al. 2010).

All traits in this research had higher PCV than GCV values (Table 4), which indicated the highest effect of environment and that variation for these traits remarkably contributed towards the total variability. Besides, it also showed that genotypes have a broad base genetic background, as well as good potential that may respond positively to selection.

These values alone are not helpful in determining the heritable portion of variation. The proportion of genetic variability which is transmitted from parents to all spring is reflected by heritability. Heritability in broad sense ranged from 0.96 to 0.49 and most of traits indicated higher estimates of broad sense heritability. Among these, flowering day recorded the highest estimates followed by fresh biomass weight, leaf, stem weight, steam/leaf ratio, juice volume, brix, estimated sugar yield, and estimated ethanol yield (Table 4). In our study, most characters that showed high broad sense heritability indicated a higher contribution of genotypic components and respond positively to selection. This is because of the likelihood of transferring heritable components from parents to offspring during breeding. High heritability obtained for most of the characters agreed with the findings of Bello et al. (2007) and Ranjith et al. (2017).

High heritability along with high genetic advance are important factors for predicting resultant effects of selecting best individuals. Johnson et al. (1955) suggested that without genetic advance heritability estimation will not render practical values, and they emphasized concurrent use of genetic advance along with heritability. Based on this consideration, flowering day, fresh biomass weight, stem fresh weight, juice volume, estimated sugar yield, and estimated ethanol yield indicated that genes governing these characters may have an additive effect. The phenotypic expression of these characters may be governed by the genes acting additively and thereby indicating the importance of these characters for selection. A simple selection model will be good enough to do what is necessary and no additional gain is achieved by using sophisticated models as reported by different scientists (Yaqoob et al., 2015; Ranjith et al., 2017). Registration of high heritability along with moderate genetic advance for leaf fresh weight, steam/leaf ratio, and brix indicated a predominance of additive and non-additive gene action in the expression of these traits; therefore, these traits can be improved by mass selection and other breeding methods.

It is concluded that Smith and Batem-3 genotypes showed the best performance by producing high juice volume, estimated sugar yield and ethanol yield. Therefore, these two genotypes may be used for breeding of biofuel production. Theis and Batem-3 genotypes also showed high estimated sugar and ethanol yield as well as high stem fresh weight, and steam/leaf ratio. Thus, both genotypes may be used for fodder and biofuel from a single sorghum crop. Stem diameter, fresh biomass weight (leaf, panicle, stem), juice volume, brix, sugar and ethanol yield would respond positively to selection because of their high GCV and PCV values. It can be mentioned here that flowering day, fresh biomass weight, stem weight, juice, sugar, and ethanol yield exhibited high heritability values along with high values of genetic advance. Therefore, these characters could be used for the development of high yielding sorghum varieties through selection in a breeding program.

Conclusions

Smith and Batem-3 genotypes showed the best performance by producing high juice, sugar and ethanol yield. Both genotypes can be used for biofuel production in the Mediterranean region of Turkey. Theis and Batem-3 Genotypes with high sugar and ethanol yield as well as high stem weight, and steam/leaf ratio may be used both for fodder and biofuel when breeding sorghum.

Besides, flowering day, fresh biomass weight, stem weight, juice, sugar, and ethanol yield exhibited high heritability values along with high values of genetic advance. Therefore, these characters could be used for the development of high yielding sorghum varieties through selection in a breeding program.

Acknowledgments

Authors are thankful to TUBITAK for providing financial support with 114 O 945 project number. This paper is a part of this project.

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