Genetic Variability and Flowering Intensity of Sugarcane Genotypes Affected by Agro-Climatic Conditions of Alexandria

Farrag F.B. Abu-Ellail [1] , El-Araby S.R. Salem[2] and Sheren E. El-Sherbiny[1]

ABSTRACT

In sugarcane breeding programs, flowering synchronization is most important for the success of the target hybridization. The study was undertaken with the objective of evaluating the flowering performance traits and synchronization of twenty-five sugarcane genotypes under agro-climatic conditions. The experiments were conducted at El-Sabahia Research Station (31o 12′ 54″ N 29o 58 ′ 23″ E), Alexandria, Egypt, during the 2020/2021 season (first plant cane crop) and the 2021/2022 season (second plant cane crop). The experimental design used was a randomized complete block design (RCBD) with three replications. As a result, the twenty-five assessed genotypes of sugarcane showed significant variation in how they responded to flowering throughout the two growth seasons. The total number and percentage of flowers, in addition to flowering dates, were indicators of flowering intensity. The majority of the investigated genotypes underwent natural flowering while the proportion of flowered genotypes varied depending on the first plant cane and the second plant crop. For every flowering trait in the current experiment, heritability estimates ranging from moderate to high were found. The results showed that flowering percentage contributes to a character with high phenotypic (PCV), genotypic (GCV) coefficient of variation, and heritability, together with an appropriate mean value. The results found that the genotypes named (CO.662, CP.31-294, BO 19, CP57-614, CO775, and CO1129) were flowered at close and synchronous dates and therefore can be used in breeding programs to produce new varieties.

Keywords: Sugarcane, flowering intensity, heritability, genetic variability

INTRODUCTION

The syncretization of early and late flowering in sugarcane varies with genotypes and agro-climatic conditions. For target hybridization in sugarcane breeding efforts, syncretism is particularly significant. Breeders of sugar cane believe that controlling the timing of flowering is essential. Breeders are drawn to the idea of inducing flowering since there is strong evidence to support the development of an extended breeding program that would provide improved varieties (Ghonema, 2017 and Abu-Ellail & McCord, 2019). Due to these genetic variations, sugarcane genotypes differ in flowering and other attributes. Sugarcane flowering naturally is essential for the development of new clones. According to Shanmugavadivu and Rao (2009), sugarcane flowering is a complicated physiological metric that involves multiple developmental stages, each with specific physiological and ecological requirements. Although it is commonly believed that sugarcane is a plant with short days, some genotypes will only tassel when the photoperiod falls within a very specific range (Berding *et al.*, 2007 and Abu-Ellail & Mohamed, 2020). Temperature and day length are the main factors controlling of the flowering process (Srivastava *et al.*, 2006). For all natural flowering studied, the average daily maximum temperatures during the vegetative, pre-initiation, and boot phases significantly influenced the tasseling percentage. The tasseling percentages for the flowering under investigation were significantly impacted by the average daily maximum temperatures during the vegetative, pre-initiation, and boot phases. The temperature differential between day and night is a significant element in facilitating the physiological transition of sugarcane from the vegetative to the reproductive phases (LaBorde *et al.*, 2014). Maximum temperatures are often correlated with clear skies, little precipitation, and low humidity, all of which can cause drought stress and water shortages, which are known to impede flowering (Moore and Berding, 2014). Knowing the above, the current study aims to quantify the variability, heritability, and correlation for flowering traits and to ascertain the impact of environmental factors on the growth and flowering traits of twenty-five genotypes from various origins under natural conditions to facilitate crossing between synchronized genotypes.

MATERIAL AND METHODS

In order to investigate the flowering performance of twenty five sugarcane genotypes under natural conditions, two field trials representing two plant crops were conducted in the 2020–2021 and 2021–2022 seasons at the Sugar Crops Division, El-Sabahia Research Station, Agricultural Research Center (31o 12 54″ N 29o 58 ٮ 23″ E), Alexandria, Egypt (Table 1). Three replications of randomized complete block design (RCBD) studies were conducted.

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[1] Breeding & Genetic Dept., Sugar Crops Research Institute. Agricultural Research Centre, Giza, Egypt.
[2.] Physiology and Chemistry Dept., Sugar Crops Research Institute. Agricultural Research Centre, Giza, Egypt.
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Table 1.Origin of tested sugarcane genotypes

Series	Genotype	Origin	Series	Genotype	Origin
1	CP72-35	USA (Florida, Canal Point)	14	CO475	India, Coimbatore
2	CO.662	India, Coimbatore	15	CP48-103	USA (Florida, Canal Point)
3	CP.31-294	USA (Florida, Canal Point)	16	CP44- 105	USA (Florida, Canal Point)
4	MEX2001- 80	Mexico	17	IK 76-79	Kalimantan, Indonesia
5	H86.37	USA, Hawaii	18	EH 26-2	Hawamdia, Egypt
6	L62-96	USA (Louisiana)	19	GT54-9	Giza, Egypt, Taiwan
7	BO 3	Bihar, Orissa, India	20	EH.16-1	Hawamdia, Egypt
8	SP59-56	Brazil, Sao Paulo	21	EH.5-1	Hawamdia, Egypt
9	CO.214	India, Coimbatore	22	EI.24-2	Hawamdia, Egypt
10	BO 19	Bihar, Orissa, India	23	NCO339	South Africa (Natal)
11	BO 22	Bihar, Orissa, India	24	CO775	India, Coimbatore
12	CP57-614	USA (Florida, Canal Point)	25	CO1129	India, Coimbatore
13	CP.63-46	USA (Florida, Canal Point)			

Three ridges were planted with fifteen 3-budded cane pieces in each row. Three rows per genotype in the middle of the March 2020 and 2021 seasons. Every ridge was 1 m apart and 5 m long; the plot size was, therefore, 15 m^2. In Sabahia Station, Alexandria, natural blossoming conditions and floral induction took place in mid-September, when the day length varies from 12:15 to 12.40 hours. Adequate humidity and temperature are also present, as seen in Figures 1 and 2. In order to raise the crop for normal growth and development throughout 2020 to 2022, all recommended cultural procedures were carried out. Information was gathered about characteristics of flowering. To encourage flowering, all suggested cultural procedures and fertilizer applications were followed. The following measurements were estimated for the first plant and the second plant crops:

Flowering Traits

- Pre-flag leaf stage was calculated as a number of days from the start of the planting date until stopping the formation of new leaves and beginning of the flag leaf formation.
- Flag leaf stage was calculated as a number of days from the beginning of flag leaf formation to the emergence of the inflorescence from the flag leaf sheath.
- The tip emergence stage was calculated as the number of days between the appearance of the flag leaf sheath and the start of inflorescence emergence.
- Full emergence stage: was calculated from the starting of the emergence of the inflorescence from the flag leaf until its full extension was completed.
- Percent of total flowering plants: number of flowering plants/number of plants per plot × 100.
- Pollen viability :Every morning, a paper cone was placed under the tassel to collect a pollen sample. Special care was taken to keep the sample over 20°C. A 1 % iodine (I2) solution was used to stain pollen. Slides were viewed with a microscope and the number of fertile (stained) and infertile (unstained) pollen grains counted. Pollen fertility per cent was calculated (Machado, 1987).

Genetic variability

- Estimation of phenotypic correlation coefficients was done based on the procedure of Dabholkar (1992)
- Phenotypic, genotypic variance, and coefficient of variation for all studied characters were estimated according to Chaudhary (2001).
- The broad sense heritability was estimated according to the method suggested by Johnson *et al.* (1955).

Statistical analysis

According to Snedecor and Cochran (1981), an aspirate analysis of variance was carried out for each season (two seasons for natural flowering). The days of pre-flag leaf stage, days of flag leaf stage, days of emergence stage, and the percentage values for total flowered stalks were converted to the matching angle values in degrees (Evwin *et al.* 1966). LSD was used to compare means at a 5% probability level, as stated by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Humidity and temperature on sugarcane flowering

Figs. (1 and 2) listed the number of days that first plant cane and second plant cane crops flowers under ideal temperature and humidity ranges (18–31 °C and 60–90%) during the course of five months (induction and initiation stage) from April to September. Results concluded that to better understand how temperature and relative humidity affect sugarcane flowering behavior and synchronize future genotype crossings, a deeper understanding of these factors is necessary. Because the percentage of daily humidity in the first plant cane crop was higher than in the second plant crop during the flowering phases, flowering for genotypes in the first plant cane crop was higher than in the second plant crop. In the plant cane initiation stage, the number of flowering days under the ideal temperature range of 18–31 °C was greater than in the second plant cane crop. The findings of Moore & Berding (2014); Pereira *et al.* (1983) and Clements & Awada (1964) all indicated that moisture had a greater impact on sugarcane flowering than did these data. Sufficient moisture is essential for seed set, induction, emergence of flowers, and initiation (Moore and Nuss, 1987). Sugarcane flowering is reduced by insufficient moisture during the beginning stage (Berding, 1995).

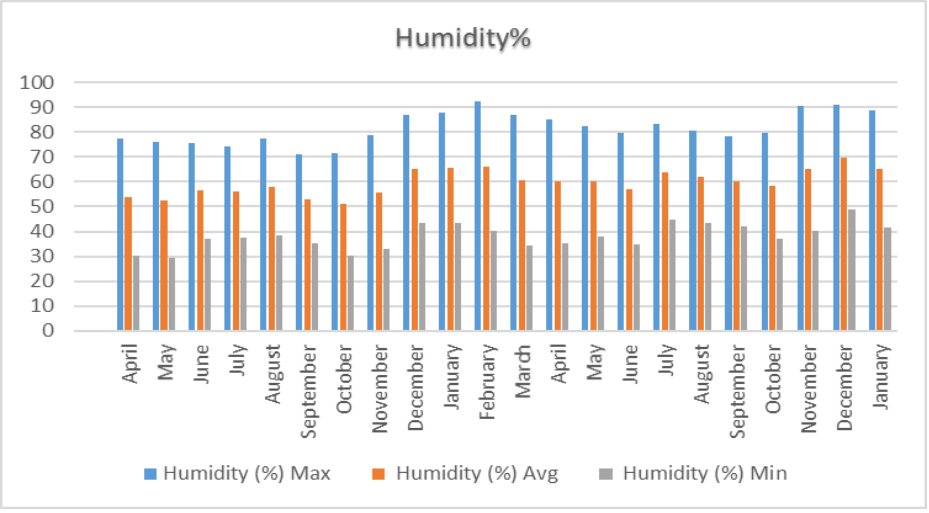

Fig. 1. Summary of humidity percentage meteorological data during 2020/2021 and2021/2022 seasons

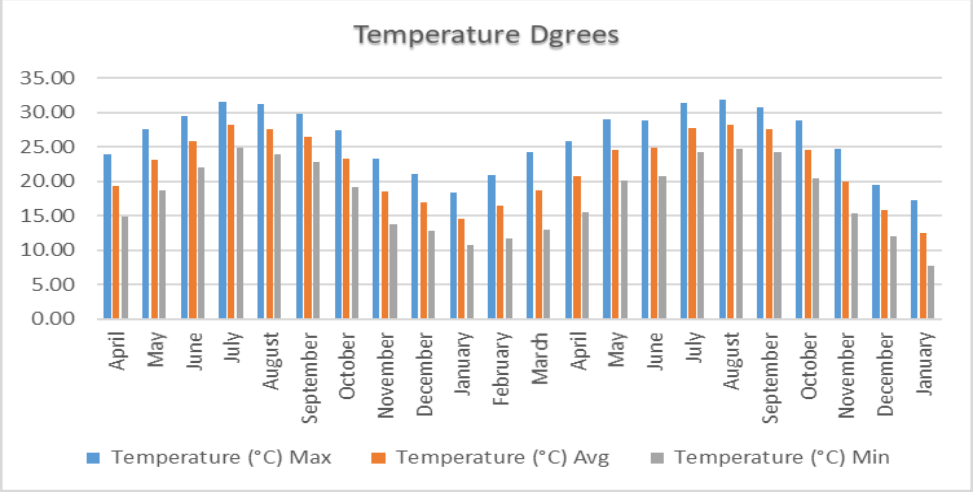

Fig.2 Summary of temprature degrees meteorological data during 2020/2021 and2021/2022 seasons

Flowering Traits

Preflag and falg leaf stages

In the present study, results presented in Table (2) show flowering traits (Per-flag and Flag leaf stages) of twenty-five sugar cane genotypes under natural flowering for first plant cane and second plant cane crops during 2020/2021 and 2021/2022 seasons. A significant difference could be observed between the mean values of the flag, tip, and full emergence. The period of pre-flag stage had the longest time when calculated from the beginning of photoperiod treatments. At the first season, pre-flag and flag leaf stages ranged from 221.33, 230.00 days, respectively, recorded by genotype (IK 76-79) to 273.78, 273.00 days recorded by genotypes (CP48-103 and CP.31-294, respectively). However, at the second season, the duration / days differed from 215.14, 250.78 days recorded by genotypes (CP57-614 and CO1129, respectively) to 297.59, 311.71 days recorded by genotypes (CP48-103 and CP.31-294, respectively). However, Table (2)'s data showed that the number of duration days for each per flag and flag leaf stage was expanded days by from the first plant cane to the second plant cane crops. These results are in harmony with those reported by Mohamed (1996) and Shanmugavadivu & Rao (2009). According to Abu-Ellail and McCord (2019), differences in flowering dates among cultivars that require nearly the same number of inductive cycles to complete the induction stage are caused by differences in time required for their pre-flag leaf stage under optimum flowering conditions.

Table 2. Flowering traits (per-flag and flag leaf stage) of twenty-five sugarcane genotypes under natural flowering for two plant cane crops during 2020/2021 and 2021/2022 seasons

Genotypes	Pre-flag leaf stage (day)		Mean	Flag leaf stage (day)		Mean
	1st season	2nd season		1st season	2nd season	
CP72-35	-	-	-	-	-	-
CO.662	233.67	267.48	250.58	251.35	278.78	265.07
CP.31-294	273	296.81	284.91	284.63	311.71	298.17
MEX2001-80	-	-	-	-	-	-
H86.37	-	-	-	-	-	-
L62-96	246.33	270.14	258.24	266.33	293.44	279.89
BO 3	234	257.81	245.91	259	286.11	272.56
SP59-56	-	-	-	-	-	-
CO.214	-	-	-	-	-	-
BO 19	237.67	261.48	249.58	249	276.11	262.56
BO 22	246.78	270.59	258.69	263.17	248.28	255.73
CP57-614	231.33	215.14	223.24	246.88	243.99	245.44
CP.63-46	-	-	-	-	-	-
CO475	-	-	-	-	-	-
CP48-103	273.78	297.59	285.69	284.22	311.33	297.78
CP44-105	230.56	251.37	240.97	237.11	264.22	250.67
IK 76-79	221.33	233.14	227.24	230	257.11	243.56
EH 26-2	234.33	248.14	241.24	246.06	261.17	253.62
GT54-9	-	-	-	-	-	-
EH.16-1	238.55	252.36	245.46	247.33	274.44	260.89
EH.5-1	234	295.81	264.91	277.6	304.71	291.16
EI.24-2	-	-	-	-	-	-
NCO339	271.22	-	-	279.75	-	-
CO775	257.6	281.41	269.51	265.6	292.71	279.16
CO1129	230.33	234.14	232.24	238.67	250.78	244.73
LSD at 05%						
Genotypes (G)	2 .10	2 .46		1.46	1.89	
G x Year			3.55			3.00

Tip emergance and full emergance stages

The phrase "tip and emergence stages" refers to the panicle's growth and elongation from the conclusion of the flag leaf stage until the moment it fully emerged from the flag leaf sheath. The data displayed in Table (3) demonstrated that, for the first season, the genotype IK 76-79 recorded the shortest tip and emergence stage duration (235.50 and 246.00 days, respectively), while the genotypes CP.31-294 and CP48-103 recorded the longest (291.50 and 301.78 days, respectively), with the remaining genotypes falling in between. This length varied from 258.27 to 269.55 days for genotype CP57-614 for tip and emergence stage, respectively, with regard to genotypes that bloomed in the second season. The genotype CP.31-294 recorded the longest tip and emergence stage durations (322.83 and 328.41 days, respectively), with the remaining genotypes falling in among. On the other hand, Table (3)'s data demonstrated that, from the first to the second year, the number of duration days for each tip and full emergence stage increased. These results are in line with Berding & Humey (2005) and Paliatseas (1974), who reported that the emergence of sugarcane inflorescence is controlled by environmental factors, such as low temperatures, that inhibit floral emergence. A low night temperature for six nights inhibited flower formation and total stalk flowering under field conditions. Allam (1999) mentioned that flowering represents a constraint for having a sustainable local breeding program. With the establishment of a successful, long-term breeding program to produce superior varieties, the development of novel sugarcane (*Saccharum spp*.) varieties through controlled crossing has been substantially expanded (Abu-Ellail and McCord, 2019).

Table 3. Flowering traits (tip and full emergence stage) of twenty-five sugarcane genotypes under natural flowering for two plant cane crops during 2020/2021 and 2021/2022 seasons

Genotypes	Tip stage (day)		Mean	Full emergence stage (day)		Mean
	1st season	2nd season		1st season	2nd season	
CP72-35	-	-	-	-	-	-
CO.662	265.44	284.77	275.11	277.22	290.33	283.78
CP.31-294	291.50	322.83	307.17	299.30	328.41	313.86
MEX2001-80	-	-	-	-	-	-
H86.37	-	-	-	-	-	-
L62-96	274.67	304.00	289.34	283.00	316.11	299.56
BO 3	266.67	296.00	281.34	273.00	308.11	290.56
SP59-56	-	-	-	-	-	-
CO.214	-	-	-	-	-	-
BO 19	262.00	291.33	276.67	267.00	300.11	283.56
BO 22	272.50	261.83	267.17	283.00	286.11	284.56
CP57-614	258.94	258.27	258.61	266.44	269.55	268.00
CP.63-46	-	-	-	-	-	-
CO475	-	-	-	-	-	-
CP48-103	293.50	309.87	301.68	301.78	319.89	310.84
CP44-105	246.50	271.83	259.17	257.00	294.11	275.56
IK 76-79	235.50	268.83	252.17	246.00	279.11	262.56
EH 26-2	253.33	269.66	261.50	261.45	285.56	273.51
GT54-9	-	-	-	-	-	-
EH.16-1	263.25	292.58	277.92	278.78	311.89	295.34
EH.5-1	-	-	-	-	-	-
EI.24-2	-	-	-	-	-	-
NCO339	-	-	-	-	-	-
CO775	275.00	304.33	289.67	291.60	324.71	308.16
CO1129	246.83	267.16	257.00	257.78	283.89	270.84
LSD at 05%						
Genotypes (G)	3.16	3.37		3.46	3.12	
G x Year			4.29			5.14

Flowering plant and pollen virability percentages

Table (4) displayed data indicating that the percentage of total flowered plants (%) and pollen vaiability percentage under first season ranged from 18.78% and 10.55 % for the genotypes L62-96 and EH 26-2, respectively.These percentages were significant. Conversely, for genotypes EH.16-1.The percentage of total flowered plants and pollen viability under the second year varied from 25.46% and 4.78 % for genotype EH.16-1 to 67.82% and 37.88 % for genotypes CO775 and CO.662, respectively. This is consistent with the findings of Miah and Paul (2008), who demonstrate a wide range of diversity in sugarcane flowering types. Certain kinds in the natural germplasm material flower early, while others flower in the middle, and yet others flower late (Junejo *et al.,* 2012 and Abu-Ellail & Mohamed 2020). Rao *et al.* (1973) found that while some cultivars produce blooms under the same climatic conditions, others do not. Depending on the variety to be induced, there are different numbers of induction rounds. According to the earlier findings, every genotype that responded had a unique characteristic about the length of the pre-flag leaf stage, the flag leaf stage, and the emergence stage. Additionally, there is a maximum number of inductive cycles required for each genotype to induce flowering. Conversely, Table (4) data showed that the total flowering % and pollen viability percentage decreased by approximately 1.34 and 4.46 days, respectively, from the first to the second year. These findings are consistent with those published by Berding (1995), who noted that male sterility and subsequent abortions might arise from nighttime temperatures below 20 °C before or during flowering. Furthermore, it has been reported by Nuss & Berding (1999) and Moore & Berding (2014) that pollen fertility declines below 18 °C.

Table 4. Flowering traits (flowering percentage and pollen viability %) of twenty-five sugar cane genotypes under natural flowering for two plant cane crops during 2020/2021 and 2021/2022 seasons

Genotypes	Flowering %		Mean	Pollen viability%		Mean
	1st season	2nd season		1st season	2nd season	
CP72-35	-	-	-	-	-	-
CO.662	33.12	31.56	32.34	49.45	37.88	43.67
CP.31-294	28.92	36.51	32.72	18.35	17.52	17.94
MEX2001-80	-	-	-	-	-	-
H86.37	-	-	-	-	-	-
L62-96	18.78	-	9.39	14.65	-	7.33
BO 3	46.52	41.25	43.89	35.65	31.44	33.55
SP59-56	-	-	-	-	-	-
CO.214	-	-	-	-	-	-
BO 19	51.45	46.87	49.16	45.55	37.81	41.68
BO 22	31.42	-	15.71	36.55	-	18.28
CP57-614	27.45	35.64	31.55	18.79	16.75	17.77
CP.63-46	-	-	-	-	-	-
CO475	-	-	-	-	-	-
CP48-103	66.45	61.54	64.00	47.32	28.77	38.05
CP44-105	64.12	58.78	61.45	35.64	21.54	28.59
IK 76-79	21.36	-	10.68	15.67	-	7.84
EH 26-2	38.41	31.54	34.98	10.55	8.66	9.61
GT54-9	-	-	-	-	-	-
EH.16-1	23.56	25.46	24.51	11.33	4.78	8.06
EH.5-1	-	-	-	-	-	-
EI.24-2	-	-	-	-	-	-
NCO339	-	-	-	-	-	-
CO775	75.56	67.82	71.69	51.41	27.54	39.48
CO1129	74.12	64.78	69.45	42.33	32.14	37.24
			LSD at 05%			
Genotypes (G)	3 .21	4.22		3.45	3.67	
G x Year			6.31			7.12

Distribution of flowering genotypes

Table (5) presents the flowering behavior of 25 genotypes of sugarcane when planted in the first and second seasons. The twenty-five sugarcane genotypes that were examined during the first and second seasons might be divided into four groups based on the results. Eleven genotypes (CP72-35, MEX2001-80, H86.37, SP59-56, CO.214, CP.63-46, CO475, GT54-9, EH.5-1, EI.24-2, and NCO339) that did not blossom or show any reaction were included in the first group. The genotypes that flowered only during the plant cane season made up the second group. CO.662, CP.31-294, L62-96, BO 19, CP57-614, CP48-103, CP44-105, EH 26-2, CO775, IK 76-79, and CO1129 were the eleven genotypes that made up this group. The third group consisted of ten genotypes (CO.662, CP.31-294, BO 3, BO 19, CP57-614, CP48-103, CP44-105, EH 26-2, CO775, CO1129) that bloomed solely under the first ratoon. In the fourth group, nine genotypes—CO.662, CP.31-294, BO 19, CP57-614, CP48-103, CP44-105, EH 26-2, CO775, CO1129—were flowered in both seasons. As a result, the twenty-five assessed genotypes of sugarcane showed significant variation in how they responded to flowering under first plant cane and second plant cane crops. Genotypes that are known to flower at the same time must be chosen in order for crossover to be effective. It is well known that sugarcane cultivars can be categorized as either late blooming or early to intermediate flowering. The cultivars differed in how late they flowered in the second week of March, to early blossoming in the second week of January, under Egyptian conditions (Rao *et al.*, 1973). Similar observations were reported by Junejo *et al.* (2012), who found that flowering occurred in most of the cane varieties in a natural environment, but the time, intensity, and percentage of flowered varieties differed widely between the years of the same environment.

Table 5. Distribution of sugarcane genotypes according to their flowering response under natural flowering for first plant cane, and second plant cane, during 2020/2021 and 2021/2022 seasons

No.	Genotypes Not Flowering	Genotypes response to flowering		
		First plant cane	Second plant cane	Both seasons
1	CP72-35	CO.662	CO.662	CO.662
2	MEX2001-80	CP.31-294	CP.31-294	CP.31-294
3	H86.37	L62-96	BO 3	BO 19
4	SP59-56	BO 19	BO 19	CP57-614
5	CO.214	CP57-614	CP57-614	CP48-103
6	CP.63-46	CP48-103	CP48-103	CP44-105
7	CO475	CP44-105	CP44-105	EH 26-2
8	GT54-9	EH 26-2	EH 26-2	CO775
9	EH.5-1	CO775	CO775	CO1129
10	EI.24-2	CO1129	CO1129	
11	NCO339	IK 76-79		
12				
13				
14				
Total	11	11	10	9
Flowering	44%	44%	40%	36%

Genetic variability

Heritability percentage

The genotypic coefficient of variation should be taken into consideration in conjunction with heritability estimations, as it is an inaccurate measure of the heritable variation that is present. All of the examined characters in the current experiment had moderate to high heritability estimates (Table 6), indicating that choosing these characters will be successful. Per flag and blooming percentage showed strong broad sense heritability, suggesting that these traits could be readily chosen for easy flowering. The highest heritability values for flowering traits in the first plant crop were determined to be the pollen viability percentage (73.37%), per flag (76.91%), and flag leaf stage (80.28%). Pollen viability percent (97.27%) indicated the highest heritability in the second plant cane crop, followed by flowering percent (92.29%) and per flag (81.33%). These findings imply that simple selection for these characteristics would be successful. Accordingly, traits including flowering percentage, per flag, and flag leaf were found to have strong heritability. Furthermore, state that high heredity for each flag was shown by heritability estimation. These results are in harmony with those reported by Mohamed (1996); Nuss & Berding (1999) and Abu-Ellail & McCord (2019).

Genotypic (GCV) and phenotypic (PCV) Coefficients of variation

Table (6) indicates that there was little variation between PCV and GCV for per flag, flag leaf, tip, full emergence, number of flowering plants, and pollen viability percentage. This suggests that the environment had less of an impact on the traits and that heritability was strong across all study seasons. According to phenotypic expression, these features would be a good indicator of genotypic potential, and high GCV and PCV indicated that selection might be effective based on these characters. In both first plant cane and second plant cane crops, the flowering attributes tip stage and flowering % exhibited low GCV and PCV values (Tables 6), suggesting that there is little genetic diversity for these aspects. Individual complete emergence showed a high genotypic and phenotypic coefficient of variance, according to Allam (1999). In addition to demonstrating high heritability across the study seasons, the narrow difference between PCV and GCV for per flag and full emergence suggests that the environment has less of an impact on the traits (Table 6). Therefore, as previous researchers Nair *et al.* (1980); Verma *et al.* (1988); Ghosh & Singh (1996) and Singh *et al.* (1996) noted, simple selection may result in higher improvement.

Phenotypic correlation coefficient

Correlation coefficients between all pairs of flowering traits are presented in Table (7). Per-flag stage showed positive and significant correlations with flag leaf stage (r = 0.44 **), tip stage (r = 0.33*), full emergence stage (r = 0.28 *), and flowering percentage (r = 0.37*), respectively. Results reported that flag leaf stage had a positive and highly significant correlation with all studied traits except pollen viability percentage (r = -0.14) respectively. A strong positive correlation between the tip stage and the full emergence stage was recorded.

Table 6. General mean, range, genotypic and phenotypic coefficient of variation, heritability percentage of flowering traits in first plant cane and second plant cane seasons (2020/2021 and 2021/2022)

Traits	First plant cane (2020/2021)					
	Range		General	Coefficient of Variation		
	Min.	Max.	mean	Genotypic	Phenotypic	Heritability (%)
Per Flag	230.33	273.78	243.41	15.27	18.54	76.91
Flag leaf stage	230	284.63	257.92	8.47	10.52	80.28
Tip stage	235.50	293.50	247.04	5.55	7.51	73.28
Full emergence	246.00	301.78	256.22	8.62	14.79	40.16
Flowering %	18.78	75.56	43.70	4.57	6.41	72.37
Pollen viability	10.55	51.41	29.52	6.69	8.84	73.37
	Second plant cane (2021/2022)					
Per Flag	215.14	296.81	262.23	15.48	18.28	81.33
Flag leaf stage	243.99	311.71	276.99	9.11	11.54	75.57
Tip stage	258.27	322.83	266.89	6.05	8.17	72.66
Full emergence	269.55	324.71	279.86	14.27	19.67	59.57
Flowering %	25.46	67.82	47.02	6.56	7.87	92.29
Pollen viability%	4.78	37.88	22.70	8.8	10.06	97.27

Table 7. Phenotypic traits association for sugarcane genotypes during a combined two-season period (2020/2021 and 2021/2022)

Combined two seasons (2020/2021 and 2021/2022)					
Traits	**Per flag**	**Flag leaf**	**Tip stage**	**Full emergence**	**Flowering%**
Per flag stage	1				
Flag leaf stage	0.44 **	1			
Tip stage	0.33*	0.45 **	1		
Full emergence stage	0.28 *	0.29 *	0.52**	1	
Flowering%	0.37*	0.34*	0.71 **	0.58 **	1
Pollen viability%	-0.12	-0.35	-0.026	-0.14	0.38**

The full emergence stage had a positive and highly significant correlation with flowering percentage, while it had a negative and non-significant correlation with pollen viability percentage (r = -0.14). Results reported that flag leaf stage had a positive and highly significant correlation with all studied traits except pollen viability percentage (r = -0.35). On the other hand, the full emergence stage showed a positive and significant correlation with flowering percentage (r = 0.38*) respectively. The results are in agreement with those mentioned by Abu-Ellail and McCord (2019).

CONCLUSION

In the flowering stages, there were discernible variations in temperature degrees and humidity percent. There were fewer flowering plants overall in the natural setting. The genotypes under examination differed significantly across all attributes, according to the data. The interaction of genotypes with years' interaction had a significant effect on most studied traits. In both seasons, the majority of the cane genotypes, including CO775 and CO.662, had higher flowering intensity and pollen viability percentages than the genotypes named, L62-96 and EH 26-2. According to the study, genotypes remain stable and synchronized during flowering and can be used in breeding programs.

Authors' contributions

All authors contributed to conceptualization, methodology, software, validation, formal analysis investigation, resources, data curtain, writing the original draft preparation, writing, review, editing, supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript

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الملخص العربي

التباين الوراثي وكثافة الإزهار لبعض التراكيب الوراثية من قصب السكر المتأثرة بالظروف المناخية الزراعية في الإسكندرية

فراج فرغل برعي أبو الليل، العربى سالم رمضان سالم وشيرين السيد الشربيني

في برامج تربية قصب السكر، يعد تزامن الإزهار هو الأكثر أهمية لنجاح التهجين المستهدف. أجريت الدراسة بهدف تقييم صفات سلوك الإزهار وتزامنه لخمسة وعشرين تركيباً وراثيًا من قصب السكر في ظل ظروف التزهير الطبيعية. أجريت التجارب في محطة بحوث الصبحية (31° 12′ 54″ N 29° 58′ 23″ E)، الإسكندرية، مصر، خلال موسم ٢٠٢٠/٢٠٢١ (محصول الغرس الأول) وموسم ٢٠٢١/٢٠٢٢ (محصول الغرس الثاني). كان التصميم التجريبي المستخدم هو تصميم القطاعات الكاملة العشوائية (RCBD)بثلاث مكررات. ونتيجة لذلك، أظهرت التراكيب الوراثية الخمسة والعشرون لقصب السكر التي تم تقييمها تباينًا كبيرًا في كيفية استجابتها للإزهار طوال موسمي النمو. كان العدد الإجمالي ونسبة الأزهار، بالإضافة إلى مواعيد الإزهار، مؤشرات على شدة الإزهار. وقد خضعت غالبية التراكيب الوراثية المدروسة للإزهار الطبيعي، في حين تباينت نسبة التراكيب الوراثية المزهرة تبعاً محصول الغرس الأول ومحصول الغرس الثاني. وقد تم التوصل إلى تقديرات لدرجة التوريث تتراوح من متوسطة إلى عالية لكل صفة إزهار في التجربة الحالية. وأظهرت النتائج أن نسبة الإزهار تساهم في صفة ذات قيمة للتبيان المظهري والتبيان الوراثي (GCVو PCV) ودرجة توريث عالية، إلى جانب قيمة المتوسط العام للصفة. ووجدت النتائج أن التراكيب الوراثية المسماة (CO.662، CP.31-294، BO 19، CP57-614، CO775، و CO1129) أزهرت في تواريخ قريبة ومتزامنة وبالتالي يمكن استخدامها في برامج التربية لإنتاج أصناف جديدة.

الكلمات المفتاحية: قصب السكر، كثافة التزهير، درجة التوريث، التباين الوراثي.