TEMPERATURE AND RELATIVE HUMIDITY EFFECTS ON SUGARCANE FLOWERING UNDER NATURAL CONDITIONS IN EGYPT

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ABSTRACT

This study consisted of two experiments that were carried out at El-Sabahia Research Station, Sugar Crops Research Institute, (ARC), Egypt, during 2013/2014/2015 (plant cane) and 2015/2016 (ratoon crop) seasons to investigate behavior of selected germplasm (40 genotypes from different origins) under natural flowering and make synchronization for crossing. Results of Individual and combined analysis of variance over two seasons, plant cane and first ratoon revealed significant differences among genotypes for duration of Pre flag leaf stage, duration of flag leaf stage, duration of emergence stage and percent of total flowered plants. The genotypes × inductive cycles interaction was significant for all studied characters. The forty sugar cane genotypes under study were classified into four groups. The first group included fourteen genotypes that flowered in plant cane and first ratoon seasons, and these genotypes ; EI 8-129, M35-157, PS 80-1424, K 81113, L 61-49, AN 56-79, SP 79-2233, G 2009-11, G 2009-10, G 2009-22, G 2009-86, G 2004-27, G 2008-64 and 88/5-27 .The second group consisted of ten genotypes that flowered only under plant cane. These ten genotypes are Koeng Java, SP 72-5181, G 84-68, G 84-47, G 74-96, G 2008-59, G 2006-3, G 2007-61, GT 54-9 and G 2008-20.The third group included two genotypes that flowered only under first ratoon and they are EI 242-16 and G 2006-36 . The fourth group included fourteen genotypes that did not show any response neither plant cane nor first ratoon, these genotypes are CO 775, G2003-47, US 59-161, ROC 10, EI 58-28, EI 8-10, F 161, L 62 -96, G 2000-5, G 99-80, SP 80-3250, SP 80-1842, G 2003-49 and Mex 2001-80. Therefore, the forty evaluated sugarcane genotypes varied considerably among themselves in their response to flowering under plant cane and first ratoon. Flowering for genotypes in plant cane was higher than first ratoon because percentage of daily humidity for plant cane (2014) were higher than first ratoon (2015) during flowering stages and the number of days for flowering under the optimum temperature (18-31 °C) during three month (induction and initiation stage) in plant cane was 63 days higher than first ratoon (33 days), all those factors was reasons of flowering in plant cant was higher than first ratoon, so a better understanding of temperature and relative humidity effects on sugarcane flowering is important to study behavior of genotypes flowering and make synchronization for crossing in future between these genotypes.

Key words: *Saccharum* spp, sugarcane, genotypes, plant cane, first ratoon, synchronization, flowering

INTRODUCTION

The development of new varieties of sugarcane from controlled crosses has been greatly extended and established a successful long term breeding program to induce improved varieties. Lack of flowering until 1970´S made it completely impossible to have any breeding program. Flowering by manipulation of nutritional and tissue moisture status of the plant was a success. Beside natural flowering panicle growth, also, is sensitive to temperature so that panicle emergence is delayed at temperatures below 21◦C (Clements & Awada 1965; Nuss & Brett 1977). Coleman (1968), he

reported day's minimum ≤ 18.3 °C and maximum ≥ 32 °C is important for the initiation period. Nuss (1980) reported the best night temperature for flowering to be around 23°C. Restrepo and Ranjel (1984) reported that low night temperatures were the only cause of failure to sugarcane flowering. Moisture is more effect on sugarcane flowering (Clement & Awada, 1964, Pereira *et al*, 1983). The enough moisture is very important and critical for induction flowering, flowering initiation, flower emergence (Moore and Nuss, 1987). Low moisture during the initiation period reduces tasseling (Berding, 1995). The photo period and temperature are major factors to control transition from vegetative to reproductive growth in grasses and legumes (Aamlid *et al*., 1999).

Managed initiation of flowering of sugarcane in a tropical environment has been advanced considerably by developing an understanding of the environmental variables affecting the flowering process and the management needs of the plants being initiated, and/also by developing an avoidance strategy to circumvent the high temperature events that impact on initiation efficacy under prevailing ambient conditions (Berding and Moore, 1996, 2001; Berding *et al*., 2004, 2007).

Shanmugavadivu and Gururaja Rao (2009) the reduction in flowering ability of clones in the traditional breeding plots could be due to high temperature prevailing prior to and during the floral initiation period and deficient rainfall. Both night and day time temperatures are important factors in promoting the physiological change from vegetative to reproductive phase in sugarcane (Chris La Borde, 2014). Average daily maximum temperatures during the vegetative, pre-initiation, and boot had a significant effect on tasseling percentage for the overall artificial photo period regimes examined. Critical temperatures identified in this study during the pre-initiation stage (>32.1 °C) and boot stage (>33.1 °C) have identified some weaknesses in the time frame of the artificial photo period regimes (LaBorde *et al*., 2014).

Maximum temperatures are frequently associated with cloudless skies, lack of rainfall, and low humidity, all of which might lead to water deficiency and drought stress, both of which are known to inhibit flowering (Moore and Berding, 2014). Sugarcane plants different in flowering from plant cane to first ratoon (Mohamed *et al*, 2016). The objectives of these experiments were to study behavior of selected germplasm, its results from sugarcane selection program in Mattana, Luxor, Egypt under natural flowering and make synchronization for crossing.

MATERIALS AND METHODS

Two experiments were conducted at El-Sabahia Research Station (31° 12 N), Alexandria, Egypt, during 2013/2014/2015 season (plant cane crop) and 2015/2016 season (first ratoon crop). The experimental procedures: Thirty-seven sugarcane genotypes from different origins and three checks commercial GT 54-9, G 84-47 and G 2003-47 were used in this study (Table 1). In the middle of August, 2013 three–budded/cuttings of each genotype were planted in 3 ridge plots. Each row was 5 m long and 1 m apart. Thus, the plot size was 15 m².

The experimental design used was Randomized Complete block with two replications. After flowering season, all plots of 2013 plant-cane were cut in June 14, 2015 and allowed to grow the ratoon in June 14, 2016. The following measurements were recorded three stages as (Mehareb, 2006). Duration of Pre flag leaf stage: This stage was calculated as a number of days from planting date until stopping formation of new leaves and beginning of the flag leaf formation and emergence. Duration of flag leaf stage: was calculated as a number of days from the beginning of flag leaf formation to as soon as the emergence of the inflorescence form flag leaf sheath occurred.

Duration of emergence stage: was calculated from the starting of emergence of the inflorescence from flag leaf until its full extension completed. Percent of total flowered plants: number of flowered plants/number of plants per plot × 100. The average daily humidity for five months from July to November for plant cane (2014 season) and first ratoon (2015 season). (figure 1) The number of days for flowering under the optimum temperature (18-31°C) during three month in 2014 and 2015 years. (table 2).

Statistical analysis:

An individual analysis of variance for each season as well as a combined analysis for both seasons were conducted according to Snedecor and Cochran (1967). The duration of pre flag leaf stage, duration of flag leaf stage, duration of emergence stage and the percentage values for total flowered stalks, were transformed to the corresponding angle values in degrees ARC-Sin according to Evwin *et al.* (1966). Means were compared using LSD at 5% level of probability according to Waller and Duncan (1969).

RESULTS AND DISCUSSION

Effect the humidity on sugarcane flowering:

The average daily humidity for five months from July to November for plant cane (2014 season) and first ratoon (2015 season) showed in figure 1. Figure 1, presented % of daily humidity for plant cane were higher than first ratoon in all five months, so sugarcane flowering in plant cane (2014/2015) was higher than sugarcane flowering in first ratoon (2015/2016) these results were in agreement with those obtained by (Clement & Awada, 1964, Pereira *et al*, 1983) and Moore & Berding 2014), they reported moisture is more effect on sugarcane flowering. Enough moisture is critical for induction, initiation, time of flowering emergence and seed set (Moore and Nuss 1987). Low moisture during the initiation period reduces sugarcane flowering (Berding 1995).

Effect the temperature on sugarcane flowering:

Table (2) presented the number of days for flowering under the optimum temperature (18-31 °C) during three month (induction and initiation stage) from July to September in plant cane and first ratoon, the number of these days in plant cane was 63 days higher than first ratoon (33 days), so flowering for genotypes in plant cane was higher than first ratoon, these results were agreement with those obtained by (Berding and Moore, 1996, 2001; Berding *et al.*, 2004, 2007, Moore and Berding 2014)., they showed high temperature effect on sugarcane flowering. Individual and combined analysis of variance (Tables 3 and 4) over the two seasons, plant cane and first ratoon revealed significant differences among genotypes for all measured characters. The difference between plant cant and first ratoon was significant for all characters. The genotype × year's interaction was significant for all studied characters.

Duration of pre flag leaf stage:

This stage was calculated as a number of days from the start of photo period treatments until stopping formation of new leaves and beginning of the flag leaf formation and emergence. Data presented in Table 5 indicated that within genotypes that flowered under plant cane and first ratoon, the duration of pre flag leaf stage varied from as minimum as 382 days for genotype G 2009-22 (Egypt) to as 496 days for genotype NA 56-79 intro used from Argentina. While the within genotypes that flowered under first ratoon the duration of pre flag leaf stage ranged between 239 days for G 2009-22 to 440 days for SP 79-223 (Brazil).

Duration of flag leaf stage:

This stage represents the developmental and elongation of the panicle from the end of pre flag leaf stage to the time of panicle emerges from the flag leaf sheath occurred. Data shown in Table 5 showed that plant cane, the lowest duration of this stage was recorded by the genotype M 35-157 from Mauritius (6.5 days), while

the highest duration was recorded by the genotype G 2008-20 (29.5 days) and the other genotypes fell in between. With respect to genotypes that flowered first ratoon this duration ranged from 7 days for four genotypes; PS 80-1424 (Sri Lanka), L61-49 (USA), EI 242-16 (Salvador) and G 2006-36 (Egypt) to 26.5 days for the genotype G 2009-86 (Egypt).

Duration of emergence stage

Emergence stage includes the full upward thrust off the inflorescence from the time it just emerges until the full extension of tassel is realized. Data presented in Table 6 presented that within the genotype group that flowered in plant cane this duration varied from 5 days for the genotype Koeng Java (Indonesia) to 18 days for the genotype G 2008-20 (Egypt), while within the genotype group that flowered under first ratoon, the duration of emergence stage fared from 7 days for three germplasm/s; SP 79-2233 (Brazil), G 2009-11 (Egypt) and EI 242 -16 (Salvador) to 19.5 days for promising variety G 2004-27 (Egypt).

Percentage of total flowered

Data in table 6 showed the percentage (%) of total flowered plants was significant under plant cane ranged from 12% for two germplasm/s; SP72-5181 (Brazil) and G2008-20 (Egypt) to 65% for G2009-22 (Egypt). While, % of total flowered plants was significant under first ratoon varied from 11.40% for promising variety G2004-27 (Egypt) to 61.5% for genotype NA 56-79 (Argentina). Within the genotype group that flowered under both plant cane and first ratoon, results indicated that, under plant cane and first ratoon the duration of pre flag leaf stage, the duration of flag leaf stage, Duration of emergence stage and Percentage of total flowered the for fourteen genotypes were, i.e., EI8-129, M35-157, PS80-1424, K81113, L61-49, NA56-79, SP79-2233, G2009-11, G2009-10, G2009-22, G2009-86, G2004-27, G2008-64 and 88/5-27.

Results indicated that, the duration of pre flag leaf stage is much longer than the other flowering stages since it included the time needed for the accumulation of stimulus to divert the meristem from leaf production to reproductive stage, following that, a fairly long period in which no structural change appears but during which the tip of inflorescence undertakes the change from the bilateral arrangement to a spiral arrangement. The breeding stock must be examined to define such response for better utilization of these materials in breeding programs. Flowering behavior of forty sugarcane genotypes when planted in plant cane and first ratoon is presented in Table (7). Results indicated that the forty sugarcane genotypes, tested under plant cane and first ratoon seasons could be classified into four groups. The first group included fourteen genotypes that flowered in plant cane and first ratoon seasons, and these genotypes were: EI8-129, M35-157, PS80-1424, K81113, L61-49, AN56-79, SP79-2233, G2009-11, G2009-10, G2009-22, G2009-86, G2004-27, G2008-64 and 88/5-27. The second group consisted of ten genotypes that flowered only under plant cane. These ten genotypes were: Koeng Java, SP72-5181, G84-68, G84-47, G74-96, G2008-59, G2006-3, G2007-61, GT54-9 and G2008-20.

The third group included two genotypes that flowered only under first ratoon and they were: EI 242-16 and G 2006-36. The fourth group included fourteen genotypes that did not show any response neither plant cane and/nor first ratoon, these genotypes were: CO 775, G2003-47, US 59-161, ROC 10, EI58-28, EI8-10, F 161, L62-96, G2000-5, G99-80, SP80-3250, SP80-1842, G2003-49 and Mex 2001-80. Therefore, the forty evaluated sugarcane geno-types varied considerably among themselves in their response to flowering under plant cane and first ratoon.

CONCLUSION

Flowering for genotypes in plant cane was higher than first ratoon because percentage of daily humidity for plant cane (2014) were higher than first ratoon (2015) during flowering stages and the number of days for flowering under the optimum

temperature (18-31 °C) during three month (induction and initiation stage) in plant cane was 63 days higher than first ratoon (33 days), all those factors was reasons of flowering in plant cant was higher than first ratoon, so a better understanding of temperature and relative humidity effects on sugarcane flowering is important to study behavior of genotypes flowering and make synchronization for crossing in future between these genotypes.

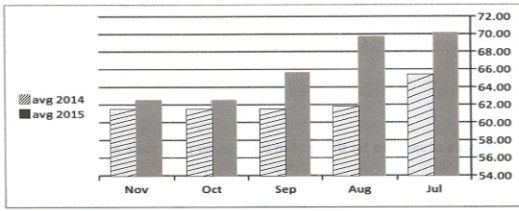

Fig. 1. The average daily humidity for five months from July to November for plant cane (2014 season) and first ratoon (2015 season).

Table-1 Source country of sugarcane genotypes studied

Sr. No.	Genotype	Source	Sr. No.	Genotype	Source
1	CO 775	India	21	SP 72-5181	Brazil
2	Koeng Java	Indonesia	22	G 84-68	Egypt
3	G2003-47	Egypt	23	G 84-47	Egypt
4	EI 8-129	Salvador	24	SP 79-2233	Brazil
5	US 59-161	South Florida	25	G 74-96	Egypt
6	M35-157	Mauritius	26	G 2003-49	Egypt
7	ROC 10	Taiwan	27	G 2009-11	Egypt
8	EI 58-28	Salvador	28	Mex 2001-80	Mexico
9	EI 8-10	Salvador	29	G 2009-10	Egypt
10	EI 242-16	Salvador	30	G 2009-22	Egypt
11	PS 80-1424	Sri Lanka	31	G 2009-86	Egypt
12	F 161	Taiwan	32	G 2006-36	Egypt
13	K 81113	Thailand	33	G 2008-59	Egypt
14	L 62-96	Lousiana	34	G 2006-3	Egypt
15	L 61-49	Lousiana	35	G 2004-27	Egypt
16	G 2000-5	Egypt	36	G 2007-61	Egypt
17	G 99-80	Egypt	37	GT 54-9	Egypt
18	SP 80-3250	Brazile	38	G 2008-20	Egypt
19	NA 56-79	Argentina	39	G 2008-64	Egypt
20	SP 80-1842	Brazile	40	88/5-27	Egypt

Table-2 The number of days for flowering under the optimum temperature (18-31°C) during three month in 2014 and 2015 years

No. of days		Month
2015	**2014**	
22	25	July
2	14	August
9	24	September
33	63	Total

Table-3 Analysis of variance for the studied traits under plant cane and first ratoon

Flag		Pre flag		df	S.O.V.
First ratoon	**Plant cane**	**First ratoon**	**Plant cane**		
0.8	68.45	49.613	644.11	1	Replication
103.441**	158.963**	57708.256**	99725.27**	39	Genotypes
2.005	3.117	8.151	17.34	39	Error
% Flowered plant		**Emergence**			
First ratoon	**Plant cane**	**First ratoon**	**Plant cane**		
29.258	112.813	11.25	16.2	1	Replication
794.385**	786.082**	58.358**	47.717**	39	Genotypes
1.604	3.838	0.788	0.995	39	Error

Table-4 Combined analysis of variance over two seasons (plant cane and first ratoon) for the studied traits

% Flowered plant	Emergence	Flag	Pre Flag	d.f	S.O.V.
666.75	40.00	483.03	729810.23	1	Year
71.04	13.73	34.63	346.86	2	Error
1442.81**	70.90**	164.58**	106742.43**	39	Genotypes
137.66**	35.18**	97.82**	50691.10**	39	Y x G
2.72	0.89	2.56	12.75	78	Error

Table-5 Duration of pre flag leaf stage and duration of flag leaf stage

Duration of flag leaf stage		Duration of pre flag leaf stage		Genotype
First ratoon	Plant cane	First ratoon	Plant cane	
15.00	15.00	240.00	400.00	EI 8-129
15.00	6.50	310.00	451.00	M35-157
7.00	29.00	302.00	422.00	PS 80-1424
12.00	10.50	363.00	493.00	K 81113
7.00	10.00	395.00	495.00	L 61-49
11.00	9.50	344.00	496.00	AN 56-79
9.00	27.50	440.00	414.50	SP 79-2233
21.00	16.00	349.50	435.00	G 2009-11
13.00	13.00	260.50	402.00	G 2009-10
13.00	13.00	239.00	382.00	G 2009-22
26.50	7.50	263.00	415.00	G 2009-86
8.50	12.00	336.00	430.00	G 2004-27
16.00	12.00	255.50	383.00	G 2008-64
16.00	10.00	384.00	464.00	88/5-27
-	10.00	-	490.00	SP 72-5181
-	27.50	-	422.00	G 84-68
-	20.00	-	465.00	G 84-47
-	12.00	-	480.00	G 74-96
-	10.00	-	435.00	G 2008-59
-	11.00	-	485.00	G 2006-3
-	13.00	-	460.00	G 2007-61
-	7.50	-	474.00	GT 54-9
-	29.50	-	424.00	G 2008-20
-	11.00	-	495.00	Koeng Java
7.00	-	433.00	-	EI 242-16
7.00	-	395.00	-	G 2006-36
-	-	-	-	G 2003-49
-	-	-	-	Mex 2001-80
-	-	-	-	CO 775
-	-	-	-	G2003-47
-	-	-	-	US 59-161
-	-	-	-	ROC 10
-	-	-	-	EI 58-28
-	-	-	-	EI 8-10
-	-	-	-	F 161
-	-	-	-	L 62-96
-	-	-	-	G 2000-5
-	-	-	-	G 99-80
-	-	-	-	SP 80-3250
-	-	-	-	SP 80-1842
0.640	0.790	1.291	1.880	LSD 0.05
		1.88	4.2	LSD 0.05 (G X Y)

Table-6 Duration of emergence stage and percentage of total flowered plants

% of total flowered plants		Duration of emergence stage		Genotype
First ratoon	Plant cane	First ratoon	Plant cane	
29.50	35.00	8.50	7.00	EI 8-129
56.25	60.00	14.00	8.00	M35-157
43.35	44.00	13.00	6.00	PS 80-1424
33.40	25.00	8.00	7.00	K 81113
20.00	19.00	10.00	6.50	L 61-49
61.50	45.00	8.00	6.00	AN 56-79
29.25	26.00	7.00	14.00	SP 79-2233
43.00	50.00	7.00	6.00	G 2009-11
35.64	41.00	10.00	7.50	G 2009-10
52.45	65.00	8.50	7.00	G 2009-22
38.25	40.00	7.50	15.00	G 2009-86
11.40	15.00	19.50	9.50	G 2004-27
47.40	49.50	11.00	7.50	G 2008-64
33.35	40.50	12.00	7.00	88/5-27
-	12.00	-	8.00	SP 72-5181
-	25.50	-	14.00	G 84-68
-	14.00	-	6.50	G 84-47
-	20.50	-	8.00	G 74-96
-	42.00	-	6.00	G 2008-59
-	23.00	-	6.50	G 2006-3
-	13.00	-	7.00	G 2007-61
-	13.00	-	8.00	GT 54-9
-	12.00	-	18.00	G 2008-20
-	12.50	-	5.00	Koeng Java
22.25	-	7.00	-	EI 242-16
22.20	-	10.00	-	G 2006-36
-	-	-	-	G 2003-49
-	-	-	-	Mex 2001-80
-	-	-	-	CO 775
-	-	-	-	G2003-47
-	-	-	-	US 59-161
-	-	-	-	ROC 10
-	-	-	-	EI 58-28
-	-	-	-	EI 8-10
-	-	-	-	F 161
-	-	-	-	L 62-96
-	-	-	-	G 2000-5
-	-	-	-	G 99-80
-	-	-	-	SP 80-3250
-	-	-	-	SP 80-1842
0.573	0.880	0.402	0.450	LSD 0.05
		1.94	1.11	LSD 0.05 (G X Y)

Table-7 Distribution of the tested genotypes according to their flowering response under plant cane and first ratoon

Sr. No.	Flowering in both season	Flowering in first ratoon	Flowering in Plant cane	No flowering
1	EI 8-129	EI 242-16	1-Koeng Java	CO 775
2	M35-157	G 2006-36	2-SP 72-5181	G2003-47
3	PS 80-1424		3-G 84-68	US 59-161
4	K 81113		4-G 84-47	ROC 10
5	L 61-49		5-G 74-96	EI 58-28
6	NA 56-79		6-G 2008-59	EI 8-10
7	SP 79-2233		7-G 2006-3	F 161
8	G 2009-11		8-G 2007-61	L 62-96
9	G 2009-10		9-GT 54-9	G 2000-5
10	G 2009-22		10-G 2008-20	G 99-80
11	G 2009-86			SP 80-3250
12	G 2004-27			SP 80-1842
13	G 2008-64			G 2003-49
14	88/5-27			Mex 2001-80

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