Journal of Sugarcane Research
https://doi.org/10.37580/JSR.2019.2.9.138-149

RESEARCH ARTICLE

EFFECT OF PHOTO INITIATION TREATMENTS ON FLOWERING, POLLEN VIABILITY AND SEED GERMINABILITY OF FOUR SUGARCANE CLONES

Farrag FB Abu-Ellail* and Bazeed D. Mohamed

Abstract

The research reported here, conducted during 2016 and 2017 at the breeding station of Sugar Crops Research Institute, Agriculture Research Center (ARC), Giza, Egypt (30° 0' N latitude, 31° 12' E longitude),to examine the response of three sugarcane clones (Co1129, IK76-99, and NCo339) and the commercial cultivar GT54-9, to four photo-initiation treatments of constant 12.5-h days of 15-, 21-, 30-, and 60-days length followed by a declination of 30 s/d to 11 h 30 min.. The four sugarcane clones varied considerably in their initiation response. None showed any flowering response to the 15-day treatment. However, they revealed differential responses regarding their flowering dates for the 21-, 30-, and 60-day photo-initiation treatments. Their flowering dates were delayed by increasing the number of initiation cycles. The cultivar GT54-9 responded only to the 21-day treatment. Co1129 responded best to the 30-day treatment with 50% flowering but produced no flowers in the 21-day treatment. IK76-99 and NCo339, with 50% flowering, responded best to the 30-day treatment. Increasing the length of the inductive cycle reduced pollen viability. This resulted in decreased seed germinability and germination speed. We suggest all germplasm be screened under different photo-initiation cycles to define and select parents for sugarcane breeding program so all cross combinations can be made among synchronized flowering parents.

Keywords : Sugarcane, artificial flowering, photo-initiation, pollen viability, seed germinability.

Introduction

The photo-initiation cycle is an important factor in sugarcane flowering, as initiation of sugarcane parents to flower is the cornerstone in any breeding program. Natural flowering of sugarcane clones at Alexandria, Egypt occurs in just 18 days because of the distance from the equator. Artificial initiation of flowering in sugarcane has been applied successfully at Giza and large numbers of crosses have been made with the flowers. The biggest challenge facing the Egyptian sugar industry is that only one cultivar (GT54-9) occupies over 96% of the cultivated area. As this cultivar is highly productive for cane yield and sugar content, and highly popular with farmers, use as a parent is desired. The cultivar is a recalcitrant flowerer, but several attempts to initiate its flowering have been unsuccessful. Stevenson (1965) indicated that with the manipulation of photoperiod under controlled conditions, initiation of flowering in nearly all sugarcane clones, and the making of desired crosses, is possible. Differences among clones for flowering propensity are genetically determined but interaction with environmental variables strongly determines actual flowering. Singh (1980) found a difference in inflorescence emergence among clones due to differences in time of initiation and the plants' age at the start of initiation. Coleman (1965) observed that 15 initiation cycles were necessary for maximum flowering, and no flowering occurred with fewer than 10 cycles. James and Miller (1971) reported that delaying flowering dates can be achieved by increasing the number of initiation cycles

Farrag FB Abu-Ellail and Bazeed D. Mohamed
Breeding & Genetics Dept., Sugar Crops Research Institute, Agricultural Research Center, 12619 Giza, Egypt.
*Corresponding author: farrag_abuellail@yahoo.com
Submitted: 20 December 2019; Accepted: 26 February 2020

beyond those required for completion of flower initiation. Nuss and Brett (1977) reported that 20-28 days of constant day length (12.5 hours) induced flowering, but flower emergence was delayed and pollen shed reduced. An effective photoperiod treatment for clones in Florida and Louisiana uses 30 to 45 days of 12.5 h day length, followed by days with a declination of 30 sec/ day. Mohamed (1996) subjected two cultivars of easy to medium flowering propensity to 30 or 37 days of constant 12.5 h and two cultivars of medium to hard propensity to 46 or 55 cycles, also of 12.5h, followed by declinations of 30 and 60 s/d. He found that each cultivar required an optimum number of inductive cycles for initiation. The flowering response was highly significantly affected by cultivars, inductive cycles, and their interaction. Paliatseas (1971) studied the minimum time required for flower initiation in nine cultivars under Louisiana conditions. He found that a minimum of 45 to 55 inductive days were required for initiation of easy-flowering clones, while 60 to 70 days were required for reluctant-flowering clones. Moore (1987) found that using more initiation cycles than the optimum of day length of 12 h 30 min, resulted in delayed flowering. Miller and Li (1995) studied clones under different photoperiod initiation treatments and found that timing of floral initiation and tassel emergence were affected. La Borde et al. (1997) stated that exposing cane to a constant day length of 12.5 h for 30 to 60 days, followed by a declination between 30 and 100 s/d resulted in flowering. Nuss and Berding (1999) showed that non-flowering clones required more initiating days than the flowering clones. Flowering was induced by gradually reducing day length between 12 h 45 min and 12 h 30 min by 30 to 60 s/d until the flowers emerge. Masri (2004) treated twenty sugarcane clones to different artificial initiating treatments, i.e. 45, 60, 75, and 105 constant day lengths of 12 h 30 min followed by a declination of 60 s/d down to 11.30 h. He observed that delaying flowering dates could be achieved by increasing the number of initiating cycles beyond that required to complete flower initiation. Non-optimum environmental factors during initiation can reduce the flowering intensity, or delay emergence, and negatively impact pollen viability (Gosnell 1973; Abu-Ellail and McCord, 2019). Flowering in sugarcane is a complex physiological process consisting of multiple stages of development, each stage having specific environmental and physiological requirements (Julien 1972). Sugarcane is an asexually propagated crop and gives very low sexual seed set even under ideal conditions. Sugarcane true seed loses its germinability quickly (Rao 1980). Hence it is very important to preserve or enhance the germination potential of the fluff, so that the requisite genetic variability for varietal development is maximized for any cross combination. The objectives of this study were to investigate the flowering response of four cultivars to four initiation treatments (15, 21, 30, and 60 days) and their effect on pollen viability and true seed germination.

Materials and Methods

This study was carried out during 2016 and 2017 at the sugarcane breeding facilities of Sugar Crops Research Institute, Agriculture Research Center (30° 0’ N latitude, 31° 12’ E longitude), Giza governorate, Egypt. The research work aimed to determine the effects of four initiation cycles on flowering, pollen viability, and seed germinability of four female parents pollinated by the same male parent. The clones, their source, and use as parents are listed in Table1. The planting procedures as described by Dunckelman and Legendre (1982) were followed. Six single-eye cuttings per cultivar were planted in 40 - L plastic pots on 11 September 2016. Thirty-two pots, eight per female cultivar, were filled with a mixture of clay soil, sand, and peat moss in the ratio 3:2:1. The plants

Journal of Sugarcane Research
https://doi.org/10.37580/JSR.2019.2.9.138-149

were maintained under greenhouse conditions until subjected to the initiation treatments.

Table 1. Source of the four sugarcane clones used in this study

Cultivar	Source	Used as
GT54-9	Egypt	Female
Co1129	India	Female
IK76-99	Indonesia	Female
NCo339	South Africa	Female
Bo22	India	Male

Plants were irrigated weekly and fertilizer applied weekly up to one month before initiation treatments started. All other recommended agronomic practices were implemented. Each plant was maintained as a single culm. The night temperature of the photoperiod facilities of the four chambers was maintained at 24°C. Supplementary lighting was provided by 12 incandescent lamps of 250 W in each room. A misting system delivering water operated outside of the four chambers from 12:00 pm to 17:00 pm daily. The 32 pots of the female parents were divided into four similar groups, and each group (8 pots) per treatment was arranged in randomized complete block design with two replicates. Each group received specific photo-inductive treatment. The pots were placed on carts and pushed in and out of the photoperiod rooms at specific times according to the planned schedule Table 2.

Plants showing signs of initiation were marcotted using a wet mixture of soil and peat moss. When a flower tip emerged, the culm was cut below the marcotted region and transferred into the hybridization house to allow the maturation of the tassel prior to crossing. The following observations described by Abu-Ellail and McCord (2019) were recorded:

1. Pre-initiation stage period (PISP): calculated as days from the start of initiation treatment to the beginning of flag leaf formation.
2. Flag stage period (FSP): calculated as days from the start of initiation treatment to the flag-leaf sheath emergence.
3. Tip of arrow emergence period (TAEP): calculated as days from the start of initiation treatment to the tip arrow emergence.
4. Full arrow emergence period (FAEP): calculated as days from the start of initiation treatment until full extension of the inflorescence.
5. Flowering percent was calculated as:

$$\frac{\text{No of Flowers}}{\text{No of Plants}} \times 100$$

Pollen test

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 one % iodine (I_2) solution was used to stain pollen. Slides

Table 2. Initiation treatments applied to four sugarcane clones.

Groups	Initiating treatments	Declination
Group 1 (8 pots)	60 days of 12 h 30 min constant day light from 1 July to 29 August 2017.	30 s/d to 11 h30 hours
Group 2 (8 pots)	30 days of 12 h 30 min constant day light from 1 to 30July 2017.	
Group 3 (8 pots)	21days of 12 h 30 min constant day light from 9 to 30 July 2017.	
Group 4 (8 pots)	15 days of 12 h 30 min constant day light from 15 st of July to 30 th of July 2017.	

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).

True seed germination

The fuzz (seeds) was stripped off the tassel, weighed, and three x 0.2-g samples per cross were taken for germination test. The fuzz was stored in sealed plastic bags at -20°C. The seed germination test was modified from (Abou-salama 1990; Brunkhorst et al. 2000). The seed-germination medium consisted of two parts of soil and one part of sand, heat sterilized, and after cooling, mixed with one part of peat. The mixture was placed in pottery germination trays. A 0.2-g fuzz sample was spread over each tray, covered with fine screened soil mixture and sprayed with water. The whole tray was then covered with a plastic sheet and kept warm at approximately 32.2°C for 7 days. The following data were recorded:

1. Seed (fuzz) weight per panicle (SFW/P)
2. The number of seedlings per 0.2 g of fuzz (NS/0.2g): counted on the seventh day. The mean of three samples per cross was recorded asseed germination.
3. Expected number of seedlings per cross = [weight of seed fuzz (g) per panicle] x [mean number of seedlings per 0.2g x 5].
4. Vigor Index (VI): Determined according to Rajendra Prasad and Balasundaram (2006) as [Seed germination x Dry matter production]/10.

Ten random plants per germination tray were dried and weighed to estimate the dry matter.

Statistical analysis

Combined analysis of variance of data from the four initiation treatments were conducted according to Snedecor and Cochran (1967).Comparison among means used a least significant difference test at *P* = 0.05 % (Waller and Duncan 1969).

Results and Discussion

Combined analysis of variance over the four initiation cycles revealed highly significant differences among clones for all traits except the tip of arrow emergence period (TAEP) full arrow emergence period (FAEP) number of viable pollen (NVP) and total pollen number (TPN; Table 3). The effect of initiation treatments was highly significant for all studied characters except tip of arrow emergence period (TAEP)**.** The main effects interaction (T x G) was high significant for all traits except, flag stage period (FSP), tip of arrow emergence period (TAEP), number of viable pollen (NVP), and, total pollen number. Partap and Singh (2003), found that varied significant variation among sugarcane clones in their flowering behavior in time and intensity.

Flowering ability

The four sugarcane clones under investigation varied considerably in their flowering response to each of the four initiation treatments Table 4. Under the 30-and 60-day of initiation treatment, IK76-99 was the first genotype to reach the pre-initiation stageat 114 and 121 days, respectively. While under 15- and 21-day treatments, the first genotype was NCo339 and GT54-9 at 75and 91 days, respectively, for the pre-initiation stage. In general, the number of days for the flag leaf development differed among plants within a genotype. However, plants of the genotype GT54-9 responded well to the 30- and 60-day treatments, having the minimum time to reach the flag leaf stage of 128 and 140 days, respectively. The cultivars NCo339 and Co1129 recorded the maximum days to reach the flag leaf stage of 158 and 151days, respectively under the 60-day treatment. James and Miller (1971) reported that for one day's delay in initiation of the inflorescence emergence was delayed by 1.4 days. Edwards and Paxton (1979) found the rate of leaf-sheath elongation was reduced when the declination was 30 s/d.

Journal of Sugarcane Research
https://doi.org/10.37580/JSR.2019.2.9.138-149

Table 3. Combined analysis of variance of data of 12 traits[1] recorded from four clones subjected to four initiation treatments.

S of V	df	PISP	FSP	TAEP	FAEP
Treatment (T)	3	4,801.19**	1,709.8**	18,264.2	39,786.3**
Error	6	12.67	18.42	6,636.4	521
Clone (G)	3	133.41 **	148.13**	3,095.1	836.2
T×G	9	150.43 **	46.84 NS	6,547.2	11,079.4**
Error	24	33.22	24.58	3,837.21	1273.31
S of V	df	NVP	NUVP	TPN	VP (%)
Treatment (T)	3	6,093.2**	7,100.7**	26,678.3**	9,143.5 **
Error	6	3.75	7.70	21.0	0.285
Clone (G)	3	18.91	247.9**	290.1	72.2**
T×G	9	9.47	91.56**	111.1	26.9**
Error	24	38.43	26.4	116.1	3.84
S of V	df	SFW/P	NS (0.2g)	NS/P	VI
Treatment (T)	3	25.99**	3,790.91**	747,010**	725.19**
Error	6	0.049	6.39	48,81.1	4.25
Clone (G)	3	0.84**	698.52**	175,333**	229.46**
T×G	9	0.33**	244.63**	70,102**	78.25**
Error	24	0.075	13.37	4,014.2	3.05

[1]PISP = Per-Initiation Stage Period; FSP = Flag Stage Period; TAEP = Tip of Arrow Emergence Period; FAEP = Full Arrow Emergence Period; NVP = Number of Viable Pollen; NUVP = Number of Unviable Pollen; TPN = Total Pollen Number; VP (%) = Viable Pollen Percentage; SFW/P = Seed Fuzz Weight/Panicle; NS (0.2g) = Number of Seedlings /0.2g fuzz; NS/P = Number of Seeds per Panicle; VI= Vigor Index.

The tip emergence stage did not occur for all the plants in each pot under 15 days of inductive photoperiod cycles Table 4. None of the plants reached the full arrow emergence stage under15-day treatment. Only GT54-9 reached the full emergence stage under 21-day treatment. However, under 30-day treatment, all plants of IK76-99 and NCo339 reached the tip and full emergence stages. In contrast, none of the plants of GT54-9 reached either of these stages under 60-day treatment, all plants of Co1129 reached the full arrow stage, GT54-9 again failed to reach this stage, while IK76-99 and NCo339 exhibited an intermediate response (Table 4.) Early-flowering clones took the minimum number of days while the late-flowering clones took the maximum number of days. Clements and Awada (1965) found fewer initiating days were required for early-flowering clones compared to the late-flowering clones, a finding which the present results corroborate. Our finding also agree with George (1961) who found variation in the time when clones initiated flowering. Early-flowering clones required comparatively fewer days than the mid- and late-flowering clone. Singh (1980) found variation in inflorescence emergence across clones due to differences in initiation time and time from cane maturity to flowering. In part, our findings support these results. Paliatseas (1971) reported that a minimum of 45-55 inductive days were required for initiation of profuse-flowering clones.

Total flowered plants percentage

Cultivars Co1129, IK76-99, and NCo339 did not respond to the 15- and 21-day initiation treatments

(Table 5). The cultivar GT54-9 had 16.7% of stalks reach the full emergence stage only under the 21-day treatment. For this cultivar, 50% of the plants completed the pre-initiation and flag stages under the 15-day treatment but none reached to the full emergence stage. Cultivars differed as to which treatment resulted in 50% flowering. This never occurred for GT54-6, Co1129 achieved this in the 60-day treatment and IK76-99 and NCo339 achieved this in the 30-day treatment. While cultivars Co1129, IK76-99, and NCo339 had 16.7 % stalks reach tip emergence stage under 15-day treatment, none progressed to full flowering (Table 5.) Only 16.7% of stalks of Co1129 in the 30-day treatment flowered, yet 83.3% of the plants completed the development stage. However, only with the longer 60-day treatment did 50% of plants reached the full emergence stage (Table 5.) Paliatseas (1974) found that time of flowering was delayed by either exposing the cane to more inductive day lengths or exposing the cane to long days just before the flower emergence, but flowering was reduced. Similar trend was reported by James and Miller (1971), reported that delaying flowering can be achieved by increasing the number of inductive cycles beyond those required for complete of flower initiation. Ellis et al. (1974) reported that flowering initiation under

Table 4. Data for four flowering traits[1] from three random stalks from each of four cultivars subjected to four initiation treatments together with the least significant differences from the analyses of variance.

Clone	Trait	Initiation treatment											
		15 days			21 days			30 days			60 days		
		Plants			Plants			Plants			Plants		
		1	2	3	1	2	3	1	2	3	1	2	3
GT54-9	PISP	88	91	90	95	100	92	130	129	132	121	130	119
	FSP	115	120	118	123	124	126	141	140	145	130	137	128
	TAEP	148	145	-	139	141	136	-	-	-	-	-	-
	FAEP	-	-	-	148	156	145	-	-	-	-	-	-
Co1129	PISP	81	100	92	98	96	102	125	132	136	136	145	142
	FSP	120	122	134	133	124	134	139	147	142	148	144	151
	TAEP	-	-	143	-	-	-	146	-	161	157	169	166
	FAEP	-	-	-	-	-	-	-	-	171	165	172	175
IK76-99	PISP	93	94	100	111	120	115	124	114	128	121	134	142
	FSP	118	121	132	128	131	137	133	137	142	145	145	159
	TAEP	124	-	-	-	142	149	142	138	151	-	151	-
	FAEP	-	-	-	-	-	-	156	165	168	-	155	-
NCo339	PISP	88	75	91	116	117	122	131	123	136	133	139	134
	FSP	115	108	117	135	123	139	150	137	148	147	158	149
	TAEP	-	-	130	-	-	-	157	150	158	160	-	-
	FAEP	-	-	-	-	-	-	163	154	170	167	-	-
LSD (0.05)	T		3.55			4.29			31.4			22.8	
	G		4.86			4.18			42.2			30.06	
	TxG		8.85			8.01			63.13			55.01	

[1]PISP = Pre-Initiation Stage Period; FSP = Flag Stage Period; TAEP = Tip of Arrow Emergence Period; FAEP = Full Arrow Emergence Period.

Journal of Sugarcane Research
https://doi.org/10.37580/JSR.2019.2.9.138-149

controlled conditions is a long process, which may take about four months for completion. However, flower initiation may take a period ranging from 15 to 60 days of photoperiod conditions prevailing after flower initiation.

Pollen viability

There was significance interaction between cultivars and initiation treatments for number of unviable pollen (NUVP) and pollen viability percentage (VP %) (Table 6.) Pollen viability percent decreased with increasing days of initiation treatment. Values ranged from 54.06% for NCo339 to 56.83% for Co1129 under 30-day treatment, while in the 60-day treatment values ranged from 45.32% for NCo339 to 48.11% for IK76-99. Flowers with abundant viable pollens are used as male parents in crosses, while flowers without pollen are used as seed-bearing parents (females) (Abu-Ellail and McCord 2019).There were insignificant differences among clone and among treatment for the number of viable pollen (NVP) and the total number of pollen (TPN). The genotype GT54-9 is highly sensitive to initiation treatment for all pollen traits, producing pollen only in the 21-day treatment. Genotype (IK76-99) was the most stable under the 30- and 60-day initiation treatments. These results are in agreement with those obtained by Abu-Ellail and McCord (2019) and Brett (1951) who found that pollen fertility was influenced by factors such as low temperature, photoperiod, and initiation treatment.

Table 5. Percent of 12 treated stalks of four cultivars subjected to four initiation treatments reaching each of the four flowering stages[1], together with mean results overall treatments.

Clone	Trait	Initiation treatment (days)				Mean
		15	21	30	60	
GT54-9	PISP	66.7	66.7	50.0	50.0	58.4
	FSP	50.0	50.0	50.0	16.7	41.7
	TAEP	50.0	50.0	-	-	25.0
	FAEP	-	16.7	-	-	12.5
Co1129	PISP	50.0	50.0	83.3	50.0	58.3
	FSP	50.0	50.0	50.0	83.3	58.3
	TAEP	16.7	-	50.0	66.7	33.3
	FAEP	-	-	16.7	50.0	16.7
IK76-99	PISP	50.0	50.0	66.7	66.7	58.4
	FSP	50.0	50.0	50.0	16.7	41.7
	TAEP	16.7	33.3	83.3	16.7	37.5
	FAEP	-	-	50.0	16.7	16.7
NCo339	PISP	50.0	50.0	83.3	83.3	66.7
	FSP	50.0	50.0	66.7	50.0	54.2
	TAEP	16.7	-	66.7	16.7	25.0
	FAEP	-	-	50.0	16.7	16.7
Total flowering (%)		28.1	25.0	58.3	43.8	38.8

[1] PISP = Per-Initiation Stage Period; FSP = Flag Stage Period; TAEP = Tip of Arrow Emergence Period; FAEP = Full Arrow Emergence Period.

Seed germination

None of the plants/cultivars under the 15-days

Table 6. Pollen viability and characterization traits[1] for four cultivars under four initiation treatments together with the least significant differences from the analyses of variance.

Clone	Initiation treatment (days)	NVP	NUVP	TPN	VP%
GT54-9	15	-	-	-	-
	21	43.0	55.3	98.3	43.9
	30	-	-	-	-
	60	-	-	-	-
Co1129	15	-	-	-	-
	21	-	-	-	-
	30	45.3	34.3	79.7	56.8
	60	38.3	45.0	83.3	45.9
IK76-99	15	-	-	-	-
	21	-	-	-	-
	30	37.7	30.7	68.3	55.1
	60	35.3	38.0	73.3	48.1
NCo339	15	-	-	-	-
	21	-	-	-	-
	30	45.3	38.0	83.3	54.1
	60	38.0	45.7	83.7	45.3
LSD (0.05)	T	1.9	2.8	4.6	0.5
	G	5.2	4.3	9.1	1.7
	T*G	9.2	7.8	16.2	2.9

[1]NVP = Number of Viable Pollen; NUVP = Number of Unviable Pollen; TPN = Total Pollen Number; VP (%) = Viable Pollen Percentage.

treatment produced seed. This contrasts with results from the 21-, 30-, and 60-day treatments Table 7. The fuzz weight per panicle ranged from 1.67 g for IK76-99under the 60-day treatment to 3.57 g for Co1129 under the 30-daytreatment. Excluding GT54-9, all cultivars showed a reduction in fuzz weight with increasing initiation treatment length. This may be explained by a more rapid development of the panicle resulting in decreased panicle size. Number of seedlings obtained decreased with increasing initiation treatment length. NCo339 had the highest mean number of seeds germinated, 52, under 30-days treatment, which was significantly higher than the lowest germination of 9 from GT54-9 in the 21-day treatment. Marginally lower pollen viability for the latter may explain this (Table 6) or impediments to fertilization may explain the lower seed set.Rajendra Prasad and Tripathi (1999) reported that the germination per 0.1 g of defuzzed seed ranged from 0-200 as counted from a replicated germination test in a seed germinator. Cabral (2007) found that seed germination of progenies tested was low, reaching a maximum value of 49%. He suggested sugarcane is a species which forms few seeds having low viability. Sugarcane is an asexually propagated crop and gives very low seed set, even under ideal conditions, with seed

Journal of Sugarcane Research
https://doi.org/10.37580/JSR.2019.2.9.138-149

losing germinability quickly (Rao 1980).

Under 30-day treatment, expected number of seedlings per panicle (NS/P) and the vigour index (VI) were the highest in NCo339 and Co1129 (808.6 and 25.49 respectively). The lowest values for NS/P and VI were recorded by GT-54-9 (140.40 and 1.85, respectively) under 21-day treatment. Clonal differences due to the initiation treatment were reflected in seed germination and vigour. The reason could be due to lower seed fertility and low dry weight of seedlings. All treatments showed significant differences for VI and NS/P for all cultivars. Often differences in the vigour are reflected in the rate, uniformity, and level of emergence, particularly in less than optimum conditions. So high vigour seeds emerge rapidly and uniformly, whereas low vigour seeds either tend to emerge slowly over a longer period or frequently fail to germinate (Rajendra Prasad and Balasundaram 2003).

Summary of flowering

Results in Fig.1 showed that plants of all cultivars did not flower under the 15-day treatment. In the 30-day treatment, flowering increased significantly (by 29.17%) as compared to 21-day treatment. About 50% of the plants initiated flowering in15-day treament, however the lowest initiation (37.50%) was observed in 30-day treatment. Plants that did not respond (remained

Table 7. Data for four seed traits[1] for crosses of four cultivars, subjected to four initiation treatments, with the male-fertile cultivar Bo22 together with the least significant differences from the analyses of variance.

Cross	Initiation treatment (day)	SFW/P	NS/0.2g	NS/P	VI
GT54-9 × Bo22	15	-	-	-	-
	21	3.12	9.00	140.40	1.85
	30	-	-	-	-
	60	-	-	-	-
Co1129 × Bo22	15	-	-	-	-
	21	-	-	-	-
	30	3.57	41.33	737.74	25.49
	60	2.57	33.67	432.66	20.35
IK76-99 × Bo22	15	-	-	-	-
	21	-	-	-	-
	30	1.98	35.67	353.13	14.50
	60	1.67	30.00	250.50	12.28
NCo339 × Bo22	15	-	-	-	-
	21	-	-	-	-
	30	3.11	52.00	808.60	20.59
	60	2.30	38.67	444.71	15.82
LSD (0.05)	T	0.220	2.53	69.79	2.06
	G	0.229	3.08	53.39	1.47
	T*G	0.434	5.69	108.69	3.06

SFW/P = Seed Fuzz Weight/Panicle; NS (0.2g) = Number of Seedlings /0.2g fuzz; NS/P = Number of Seeds per Panicle; VI = Vigor Index

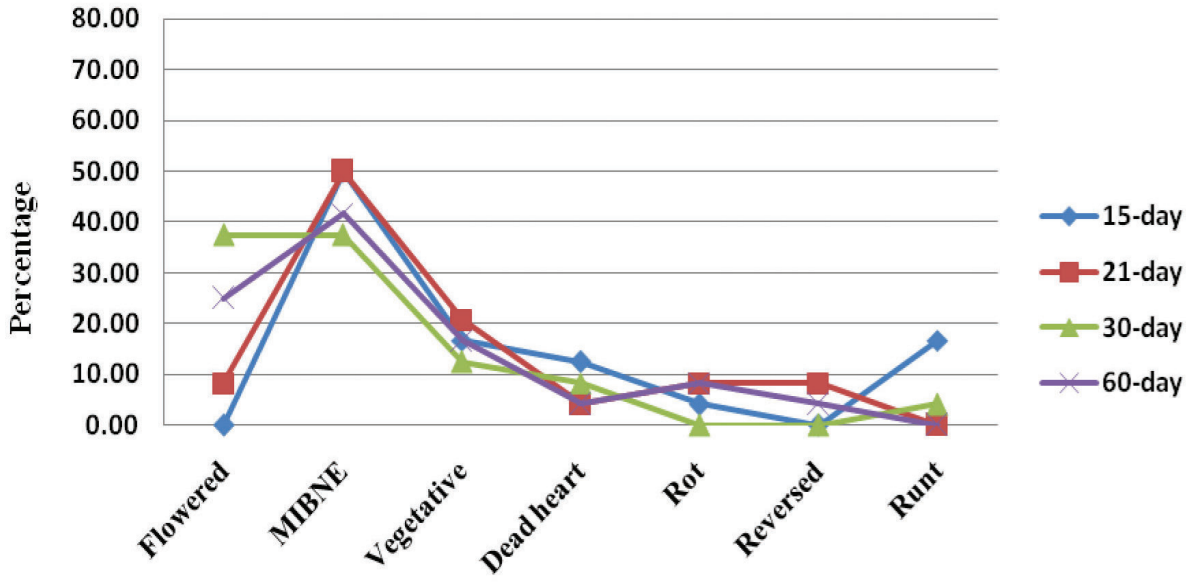

Fig. 1. Summary of flowering of four clones under four initiation treatments.
MIBNE = Meristem Initiated But Not Emerged. (According to Berding et al. 2010)

vegetative) ranged from 29.17% under 21-day to 2.50% under 30-day. The highest dead heart was 12.50% under 21-day, while the lowest 4.17% under 60-day. All clones under 30-day recorded zero plants rotand reversed, However those clone recorded the hightet perent for rot and reversed under 21-day. But under 15 day was recorded the highest rust (16.67%).

Conclusion

The study concluded that no cultivar flowered under the 15-day initiation treatment. The cultivars revealed a differential response regarding flowering dates to the 21, 30 and 60-day initiation treatments. Three different treatments were required to obtain a maximum response from the four cultivars treated. The pollen viability percent and seed germinability of sugarcane was affected by the increased days of photo initiation treatment.

Acknowledgements

The authors are thankful to Dr. Nils Berding principal researcher at Bureau of Sugar Experiment Stations (BSES) Limited, P.O. Box 122, Gordonvale 4865, Australia and to Dr. Rajendra Prasad, Principal Scientist at Sugarcane Breeding Institute (ICAR), Coimbatore-641 007, India for their suggestions.

References

Abu-Ellail FFB, McCord P H (2019) Temperature and relative humidity effects on sugarcane flowering ability and pollen viability under natural and semi-natural conditions. Sugar Tech., 21(1):83-92.

Abou-salama AM (1990) Sugarcane pollen viability and seed settingas affected by daylength declinerates and relative humidity. PhD. Thesis. Louisiana State University and Agricultural & Mechanical College.

Berding N, Pendrigh R S, Dunne V (2010) Pursuing higher efficacy for managed photoperiodic

Journal of Sugarcane Research
https://doi.org/10.37580/JSR.2019.2.9.138-149

initiation of sugarcane flowering the tropics. Proceedings of Australian Society Sugarcane Technologies, 32:234-250

Brett P G C (1951) Flowering and pollen fertility in relation to sugarcane breeding in Natal. Proceedings of International Society of Sugarcane Technologists, 7:43-56.

Brunkhorst M J, Coetzee N A, Nuss K J (2000) Efficiency of the germination test for predicting sugarcane seedling numbers at Mount Edgecombe. Proceedings of South African Sugar Technologists Association, 74:234-237.

Cabral FF (2007) Physiological quality, determination of water content and storage of sugarcane seeds from different crosses. 58f. Dissertation (Master in Plant Production) - Federal University of Alagoas, Rio Largo.

Clements H F, Awada M (1965) Experiments on the artificial induction of flowering in sugarcane. Proceedings of International Society of Sugar Cane Technologists, 12:795-812.

Coleman RE (1965) Effect of intercalated non-inductive nights on floral ignition in sugarcane. Phyton., 22:15-18.

Dunckelman P H, Legendre B L (1982) Guide to sugarcane breeding in the temperate zone. Agricultural Reviews and Manuals. USDA ARM-S-22/ January 1982.

Edwards E, Paxton J G (1979) Effects of photoperiod and temperature on the rate of elongation of sugarcane leaf sheaths. Proceedings of South African Sugar Technologists Associatio*n*, 53:163–164.

Ellis T O, Van-Breemen, J F, Arceneaux G (1974) Flowering of sugar cane in Louisiana as related to interspecific hybridization. Proceedings of International Society of Sugar Cane Technologists, 15:46-54.

George EF (1961) Cane breeding. Report Sugarcane Industry Research Institute, Mauritius, 1960, pp 35-37.

Gosnell JM (1973) Some factors affecting flowering in sugarcane. Proceedings of South African Sugar Technologists Association, 47:144–147.

James NI, Miller JD (1971a) Photoperiod control in the USDA sugarcane-crossing program. Proceedings of International Society of Sugar Cane Technologists, 14:341-347.

James N I, Miller J M (1971b) Shoot apex development in early, mid and late-season flowering sugarcane clones. Proceedings of International Society of Sugar Cane Technologists, 14:334-340.

Julien MR (1972) Physiology of flowering in Saccharum I. Day length control of floral initiation and development in *S. spontaneum* L. Journal of Experimental Botany, 24:549-557.

La Borde C M, Bischoff K P, Gravois K A, Milligan S B, Martin F A (1997) Photoperiod and crossing in the Louisiana "L" sugarcane variety development program. Sugarcane Research Annual Progress Report, LSU Agricultural Center .Louisiana Agriculture Experiment Station, Baton Rouge, LA, USA (Cited after Nuss and Berding, 1999).

Machado Jr GP (1987) Improvement of cane to acculturate. In Canada- to accultura: Cultivation and utilization, ed. S.B. Paranhos, 165-186. Campinas: Cargill.

Masri M I (2004) Flower induction and inheritance of some agronomic traits in sugarcane. Ph.D. Thesis, Fac. Agric., Cairo Univ.

Miller J D, Li QW (1995) Effect of photoperiod treatments on initiation, emergence and flowering date of elite and exotic sugarcane clones. Sugar Cane, 6:4-11.

Mohamed B D (1996) Sugarcane varietal response to photoperiod treatments.Ph.D. Thesis, Fac. of Agric., Assiut Univ.

Moore P H. (1987) Physiology and control of flowering. Copersucar International Sugarcane Breeding Workshop.Copersucar Technology Center, Sao Paulo, Brazil. pp 101-127.

Nuss K J, Brett P C G (1977) Artificial induction of flowering in a sugarcane breeding programme. Proceedings of South African Sugar Technologists Association, 6:54-64.

Nuss KJ, Berding N (1999) Planned recombination in sugarcane breeding: Artificial initiation of flowering in sugarcane in sub-tropical and tropical conditions. Proceedings of International Society of Sugar Cane Technologists, 23:504-507.

Paliatseas E D (1971) Flowering of sugarcane with reference to induction and inhibition. Proceedings of International Society of Sugar Cane Technologists., 14:354-364.

Paliatseas E D (1974) Flowering of sugarcane in Louisiana as related to interspecific hybridization. Proceedings of International Society of Sugar Cane Technologists, 15:46-54.

Pratap S. Archana, Singh S B (2003) Extent of flowering and pollen fertility in sugar cane with a view to crossing under the sub-tropical climate. Indian Journal Sugarcane Technologists. 8:93-95.

Rajendra Prasad N, Balasundaram N (2003) Invigoration treatment for improving germination of sugarcane true seed. Sugar Tech, 5(4):293-296.

Rajendra Prasad N, Balasundaram N (2006) Conservation of *Saccharum spontaneum* as defuzzed true seed. Sugar Tech, 8 (3):112-115.

Rajendra Prasad N, Tripathi B K (1999) Germination test for sugarcane true seed. Seed Research, 27(2):185-187.

Rao P S (1980) Fertility, seed storage and seed viability in sugarcane. Proceedings of International Society of Sugar Cane Technologists, 17:1236-1240.

Singh S (1980) Relative effectiveness of moisture stress and chemical spray treatments in sugarcane. Annual Report, Sugarcane Breeding Institute, Coimbatore, India, p 55.

Snedecor G V, Cochran W G (1967) Statistical methods .Sixth Ed. Iowa State Univ. Pross Ames Iowa, USA.

Stevenson G C. (1965) Genetics and Breeding of Sugarcane. Longmans, Green and Co. Ltd.

Waller R A, Duncan D B (1960) Abays' rule for the symmetric multiple comparison problems. American Statistical Association Journal Desegnation, *1458*-1503.