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Effect of Certain Climatic Factors on Flowering of Sugarcane at Gurabo, Puerto Rico

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Puerto Rico, lying within the Tropical Belt, shares with other tropical countries the advantage, as far as sugarcane breeding is concerned, of rather good flowering under prevailing natural conditions. In the 1967 season, however, a large number of varieties in our breeding plots had a very poor flowering record.

This paper presents results of the studies undertaken to determine the effect of certain climatic factors probably responsible for the poor flowering.

REVIEW OF LITERATURE

Baretto (*2*)[2] reported that flowering of sugarcane is accelerated in years of heavy rainfall. Sartoris and Belcher (*10*) noted an acceleration of the flowering of sugarcane during the fall of 1947, in Florida, as a result of a high temperature and flooding. Brett (*3*) concluded from an examination of the flowering records and possible factors affecting flowering in Natal, South Africa, that low night temperatures were probably responsible for poor flowering. He also observed that a winter drought occurring in the flowering season often seriously reduced flowering. Vijayasaradhy and Narasimhan (*11*) reported that frequent irrigation had an increasing effect on flowering. Paliatseas and Chilton (*9*) stated that the emergence of the sugarcane inflorescence was controlled by several environmental conditions of which temperature, light intensity, and light quality were the most important. Clements and Awada (*4*) reported that, in the areas in Hawaii where flowering is heavy, the minimum temperatures during the second half of August and the first half of September are characteristically around 70° F. In general, the range between maximum and minimum temperatures is narrowest where tasseling is heaviest (9–12 degrees). The same authors (*5*) reported on an experiment to determine whether or not there is a temperature minimum for flowering of sugarcane, that 54° F. is below the critical tempera-

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[2] Italic numbers in parentheses refer to Literature Cited, pp. 228–9.

ture for induction of flowering in varieties Na.Co. 310 and H. 37-1933, and that 58° F. is somewhat marginal. However, flowering under temperatures of 60° F. and 65° F. was completed, if the plant was exposed long enough to the proper night length. Ellis *et al.* (*7*) emphasized that average maximum temperature approximating 89° F. during the induction period was responsible for suppressing flowering under certain conditions. Arceneaux (*1*) reviewed the literature on sugarcane flowering and concluded that flowering of sugarcane, primarily a photoperiodic response, is conditioned by accessory factors the action of which, independently or collectively, can greatly reduce the extent of flowering and, in extreme cases, inhibit it entirely. Temperature and moisture conditions are especially important.

MATERIALS AND METHODS

The flowering records of 34 sugarcane varieties taken for the years 1965–67 were examined in this study. The varieties studied were a part of parental canes grown in the breeding plots at the Gurabo Agricultural Experiment Substation, which is located at 18° 16′ North Latitude. The breeding plots were established on the slope of a small hill at an elevation of around 250 to 300 feet above sea level. The flowering records were taken from the crops of plant cane and its first and second ratoon. All three crops were cultivated and managed in more or less the same way. Initiation of floral primodia was detected by dissection of stem apices, using microscopic examination when necessary.

RESULTS AND DISCUSSION

The flowering records of the 34 varieties taken for the years 1965–67 are shown in table 1.

From the records shown in table 1 it is quite evident that there were marked differences in both the time of emergence of the tassels and the intensity of tasseling between the 1967 flowering season and the 1965 and 1966 seasons for most of the varieties listed. In the latter part of December 1967, the tops of cane stalks of 10 varieties were dissected in order to determine which stage of flowering was seriously interrupted. The data are shown in table 2.

The results in table 2 clearly revealed that a large number of the tops of most varieties simply failed to produce flower primodia. This suggests that, during the flowering induction period of 1967, most cane stalks of the varieties listed were not able to accumulate enough flowering stimulus to divert the meristem from leaf production to floral initiation.

Furthermore, it was surprising to see so many tops of these varieties, specially Co. 650, Co. 658, and Co. 513, containing an abortive or deformed inflorescence mostly, 0.2–0.5-inch long, as shown in figure 1. The percentage

TABLE 1.—*Flowering records of 34 varieties growing at the Gurabo Agricultural Experiment Substation, 1965-67*

Variety	1965			1966			1967		
	Crop[1]	Time of maximum tassel emergence[2]	Intensity of tasseling	Crop[1]	Time of maximum tassel emergence[2]	Intensity of tasseling	Crop[1]	Time of maximum tassel emergence[2]	Intensity of tasseling
B. 35207	P	E	VH	1st R	E	VH	2d R	L	VL
B. 4145	do.	L	M	do.	L	M	do.	L	Few
B. 41227	do.	E	VH	do.	E	H	do.	L	do.
B. 42231	do.	M	M	do.	M	L	do.	0	0
B. 4362	do.	M	M	do.	M	L	do.	0	0
B. 47258	do.	L	M	do.	L	L	do.	0	0
B. 49198	do.	L	L	do.	L	L	do.	0	0
B. 50377	do.	L	L	do.	L	L	do.	VL	Few
C.B. 41-76	—	—	—	P	M	M	1st R	0	0
Co. 290	P	L	VH	1st R	L	VH	2d R	VL	Few
Co. 419	do.	M	H	do.	M	H	do.	0	0
Co. 421	do.	M	H	do.	M	H	do.	0	0
Co. 449	do.	E	VH	do.	E	VH	do.	L	Few
Co. 513	do.	M	H	do.	M	VH	do.	VL	do.
Co. 527	do.	E	VH	do.	E	VH	do.	L	do.
Co. 650	—	—	—	P	M	M	1st R	0	0
Co. 658	—	—	—	do.	L	M	do.	L	Few
C.P. 34-79	P	VL	M	1st R	VL	Few	2d R	0	0
Eros	do.	M	H	do.	M	M	do.	0	0
H. 32-8560	do.	L	M	do.	VL	Few	do.	0	0
H. 41-3340	do.	L	Few	do.	VL	do.	do.	0	0
H. 49-134	do.	L	do.	do.	do.	Few	do.	0	0
H. 49-3533	do.	VL	Few	do.	do.	do.	do.	0	0
H. 50-7209	do	0	0	do.	L	do.	do.	0	0
M. 336	do.	M	VH	do.	M	H	do	L	L
M. 134/32	do.	L	M	do.	VL	L	do.	0	0
Pindar	do.	L	M	do.	L	M	do.	0	0
P.R. 980	do.	M	M	do.	M	M	do.	L	VL
P.R. 1013	do.	M	M	do.	M	M	do.	L	L
P.R. 1117	do.	M	M	do.	M	M	do.	L	Few
P.T. 43-52	do.	L	H	do.	L	H	do.	0	0
Q. 50	do	M	H	do.	M	H	do.	0	0
Q. 58	—	—	—	P	E	M	1st R	0	0
Trojan	P	L	VL	1st R	L	VL	2d R	0	0

[1] P stands for plant cane; 1st R for first ratoon; and 2d R for second ratoon.

[2] E stands for early (Nov. 1-15); M for middle (Nov. 16-30); L for late (Dec. 1-15); VL for very late (after Dec. 16); 0 for no tasseling.

[3] The tassel intensity presented here is based on an estimate: VL stands for very light (below 5 percent); L for light (6 to 15 percent); M for moderate (16 to 40 percent); H for heavy (41 to 70 percent); VH for very heavy (71 percent and above); 0 for no tasseling.

TABLE 2.—*Detail records from dissected tops of 10 varieties*

Variety	Total tops examined	Vegetative tops		Tops with normal tassels		Tops with abortive tassels		Tops reverted	
	Number	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
B. 4145	185	159	85.9	4	2.2	21	11.4	1	0.5
B. 41227	121	95	78.5	6	5.0	8	6.6	12	9.9
C.B. 41-76	214	161	75.2	0	0	35	16.4	18	8.4
Co. 650	155	54	34.8	0	0	76	49.0	25	16.1
Co. 658	171	31	18.1	19	11.1	54	31.6	67	39.2
Co. 513	167	99	59.3	7	4.1	37	22.2	24	14.4
M. 336	98	68	69.4	14	14.3	12	12.2	4	4.1
P.R. 980	180	161	89.1	9	5.0	8	4.4	2	1.1
P.R. 1117	179	145	80.0	15	8.4	11	6.1	8	4.5
P.T. 43-52	245	187	76.3	4	1.6	44	17.9	10	4.1

FIG. 1.—Illustrating cessation of normal floral-part development of an embryonic sugarcane inflorescence (Co. 650).

of such tops for Co. 650, Co. 658, and Co. 513 were as high as 49.0, 31.6, and 22.2, respectively.

Another interesting point is that a high number of tops of these varieties had a cluster of twisted leaves within the spindle as shown in table 2, which

FIG. 2.—Illustrating reversion of an embryonic sugarcane inflorescence to vegetative growth (Co. 650).

apparently resulted from a reversion of an embryonic inflorescence (fig. 2) (*8,3,5*). This was later confirmed by the fact that many "bunch tops" (fig. 3, A and B) were found on these varieties. The abortive meristematic inflorescence and "bunch top" were also believed to have resulted from a weak flowering stimulus (*6*).

The known factors affecting flowering of sugarcane are length of day, temperature, soil moisture, altitude (often associated with temperature), light, nutrition state, soil quality, and maturity of cane. There is no doubt, however, that among the principal factors, length of day, temperature, and soil moisture are especially important. In this connection meteorological data for the months of August, September, and October, a period known to be critical for flowering induction and development of inflorescence, are given in table 3, for the years 1965–67.

As shown in table 3, the daily average maximum temperatures during the

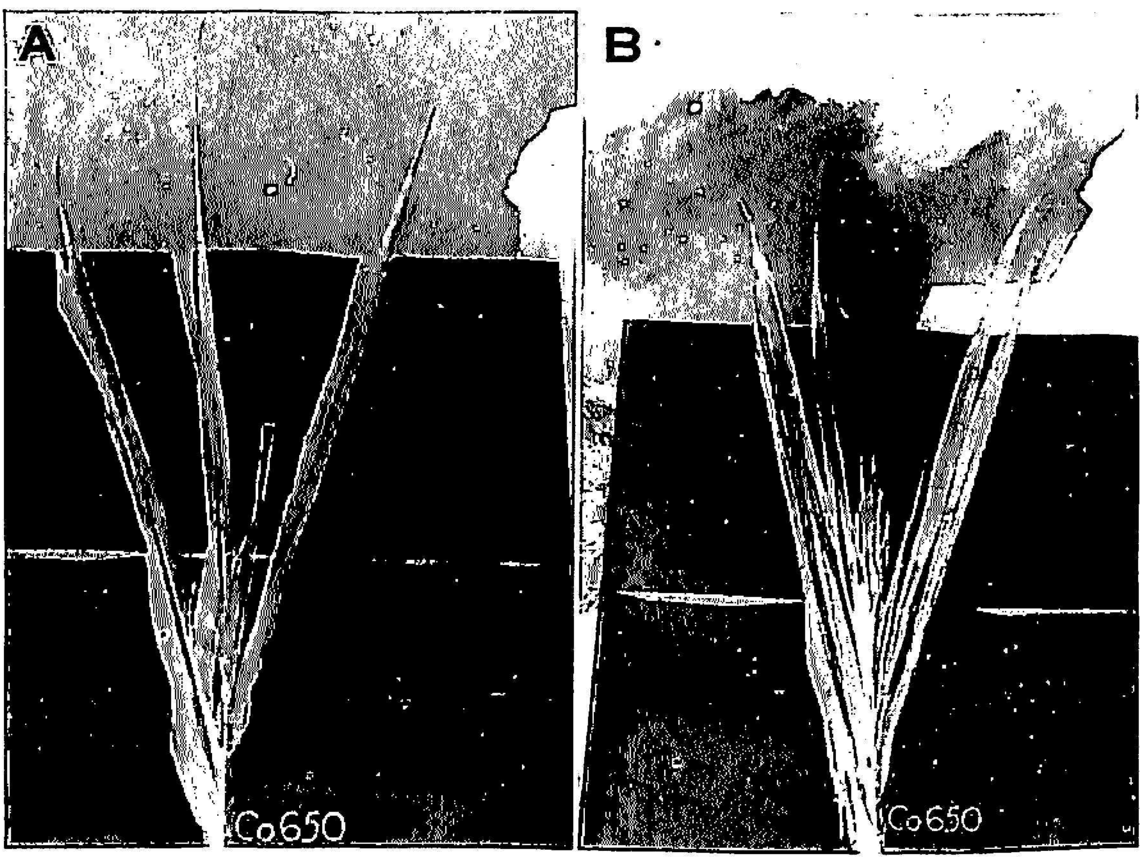

FIG. 3.—A and B.—Two stages in the development of "bunch-top".

flowering induction period of 1967 are somewhat uniformly higher than those of 1965 and 1966, while the daily average minimum temperatures are rather significantly lower. Consequently, the ranges between maximum and minimum temperature in 1967 became broader. A maximum temperature approximating 89° F. (*7*), a minimum temperature of around 67° F. (*3*), and a broad range of temperature (*4*) have been reported as having an unfavorable effect on flower initiation under certain natural conditions. According to these reports, any of the above three conditions—higher maximum and lower minimum temperature and a broader range—occurring during the 1967 induction period, or the three combined, probably were responsible for the poor flowering.

The rainfall data as shown in table 3 revealed that there were substantial differences in the amount of precipitation for the year 1965–67. The field received only 10.42 inches of rainfall during the period of August and October 1967, or about 41 percent of the 1965, and 56.9 percent of the 1966 rainfall. Low soil moisture has been reported to have an unfavorable effect upon flowering of sugarcane in three different ways: 1, By preventing the initiation of flowering under otherwise favorable conditions; 2, by destroying the rather susceptible embryonic inflorescence; or 3, by causing their reversion to vegetative growth (*8*).

TABLE 3.—*Meteorological data*[1] *at the Gurabo Agricultural Experiment Substation, for the years 1965–67*

Month	1965			1966			1967		
	Average maximum	Average minimum	Range	Average maximum	Average minimum	Range	Average maximum	Average minimum	Range
	Temperature in °F.								
August	88.6	68.9	19.7	88.2	70.5	17.7	89.6	67.5	22.1
September	89.0	68.0	21.0	88.1	68.2	19.9	89.3	67.7	21.6
October	84.9	71.6	13.3	87.8	67.3	20.5	89.6	66.7	22.9
Average	87.5	69.5	18.0	88.0	68.7	19.3	89.5	67.3	22.2
	Precipitation (inches)								
August	9.85			4.36			3.76		
September	9.63			6.82			3.09		
October	6.00			7.13			3.57		
Total	25.48			18.31			10.42		

[1] From the Report of the U.S. Weather Bureau.

On the basis of this report and of the reports obtained from other reviewed literature it seems that soil-moisture stress resulting from a shortage of precipitation during the flowering-induction period probably was the principal factor causing poor flowering in 1967.

As pointed out above, a large number of vegetative tops, abortive embryonic inflorescences, and "bunch tops" were found on many profusely tasseling varieties. The unfavorable effect on flowering was believed to have started at the first stage and lasted until the second stage of flowering.

SUMMARY

A large number of sugarcane varieties which are profuse or moderate tasselers under normal conditions at the Gurabo Agricultural Experiment

Substation, failed to flower, or flowered abnormally during the 1967 blooming season. Observations proved that a high percentage of the tops of many varieties had not accumulated enough flowering stimulus to shift the vegetative meristem to the initiation of flowering. Other varieties did have flower initiation, but failed to develop into normal tassels. Quite a number of reversions of meristem and "bunch tops" were also observed.

An examination of meteorological data indicated that the average maximum and minimum temperatures and their range during the flowering induction period of 1967, may have had some effect on the suppression of flowering. However, the principal factor responsible for the observed differences in flowering was probably the low soil moisture which resulted from the deficit in precipitation.

RESUMEN

Durante la estación de la florecida de 1967, un gran número de variedades de caña de azúcar que, bajo condiciones normales florecen profusa o moderadamente en la Subestación Experimental de Gurabo, no llegaron a florecer o, si lo hicieron, sus flores no alcanzaron un desarrollo normal. La investigación probó que un alto porcentaje de los ápices de muchas de las variedades no acumularon suficiente estímulo floral para que el meristemo pudiera cambiar del proceso vegetativo al de la formación de las flores. Aun cuando otras variedades iniciaron la floración, sus flores no llegaron a desarrollarse normalmente. Se observaron numerosos casos de regresión del meristemo y de la condición llamada en inglés *bunch top*.

El examen de los datos meteorológicos correspondientes al periodo de inducción floral de 1967 indicó que los promedios de las temperaturas máximas y mínimas, así como sus fluctuaciones, tuvieron un efecto adverso en la floración. Sin embargo, es probable que la poca humedad del suelo, como resultado de la escasez de lluvia durante ese año, haya sido la causa principal de las diferencias en la floración.

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