Influence of relative humidity on the type of flower in the 'Cavendish' banana.

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INFLUENCE DE L'HUMIDITE RELATIVE SUR LE TYPE DE FLEUR DE LA BANANE 'CAVENDISH'

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RESUME - Le nombre de fleurs persistantes (pas d'abscission) augmente lorsque de jeunes inflorescences du cv. 'Dwarf Cavendish' sont encloses sous gaine plastique, technique qui provoque l'apparition de telles fleurs persistantes dans le cv. 'Williams' où elles n'existent pas naturellement. Le traitement de fleurs avec un courant d'air sec ou humide montre que le facteur de l'environnement responsable du phénomène est une humidité relative élevée.

The perianth, style and staminodes of the female banana flower usually abscise a few days after flowering, leaving at the top of the ovary a calloused scar (7). Such a flower will be called 'ap' (abscising perianth) in this paper. It is mentioned in the literature that there are instances where the perianth does not abscise (1, 6, 8, 9). The publications did not include a detailed description of the phenomenon or its cause.

In Israel it was found that frequently no abscission layer develops in female flowers of cv. 'Dwarf Cavendish' (5), and the perianth, style and staminodes remain viable much longer and gradually dry up, but remain attached to the fruit. Fruits with a persistent perianth (referred to herein as 'pp') are less attractive in appearance and are more susceptible to finger tip diseases (2). Flowers with a persistent perianth occur in differing numbers throughout the growing season in cv. 'Dwarf Cavendish', but have not been found in cv. 'Williams'.

In this work we examined factors that influence the occurrence of 'pp' in banana.

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MATERIALS AND METHODS

Inflorescence Covering.

Inflorescences were enclosed in 70 x 125 cm sleeves on the shooting day, when the inflorescences were completely closed. The sleeves were tied to the floral axis above the inflorescence base, and were usually left open on the other side or, when necessary, were closed also on their lower side to produce a closed bag. Inflorescences were enclosed for about 2 weeks, then the cover was removed, and flowers were examined a week later. Each treatment was given to five inflorescences.

Temperature and relative humidity measurements.

Thermohygrographs were hung on the inflorescence under the cover to record data during the experiment period.

Removal of bracts.

Bracts were removed on the day of bunch emergence when the inflorescence was still closed. The removal was possible by splitting the bracts and pulling the halves to two sides of the closed inflorescence.

Treatment with dry and wet air.

Six inflorescences of 'Dwarf Cavendish' were enclosed in plastic sleeves. A 10-mm plastic tube in the upper part of the closed sleeves served as an air inlet, and a 20-mm short plastic tube at the bottom of the closed sleeves served as an air outlet. The treatments were : wet air, dry air, open (untreated) control, and closed control (inflorescences enclosed in an open plastic sleeve).

The desired humidity was achieved as follows : a compressor was placed in the orchard to serve as a source of compressed air. The stream of air was split : one half passed through metal columns containing dry silica gel to dray the air, and the other half was bubbled twice through water, to produce wet air. The air was administered to the bunches via flowmeters at a rate of 15 liters per minute per bunch. The entire air volume surrounding the bunch was replaced every 3 minutes. Temperature and humidity were determined in outgoing air with thermohygrographs. In addition, humidity was determined twice daily, at 06.00 and 14.00 hr, by a psychrometer.

Experiment design and statistics.

Each treatment was performed in five replicates in complete randomized design. The results were subjected to an analysis of variance and to a multiple range test ($P = 0.05$). For the results depicted in Table 7, we performed a separate analysis of variance for each date of experiment, where we had five replicates for each treatment and control ; then we analyzed the results by 't test'.

RESULTS

Effect of covering.

When emerging inflorescences of 'Dwarf Cavendish' were covered with sleeves of various materials, it was found (Table 1) that as the material was more impermeable to humidity, the incidence of 'pp' was much greater. Covering 'Williams' inflorescences with sleeves open at one end caused the appearance of only a few 'pp', but when the inflorescences were completely enclosed in a closed bag, almost all perianths became persistent (Table 2). The color of the polyethylene did not affect the results significantly (Table 2).

TABLE 1 - Effects of enclosing inflorescences of cv. 'Dwarf Cavendish' bananas in sleeves of different materials, on the incidence of flowers with a persistent perianth (pp). Numbers followed by different letters differ significantly at $P = 0.05$.

Material	% 'pp'
Control, open bunches	30 c
Craft paper	45 bc
Black paper	67 ab
Aluminium foil	93 a
Polyethylene	100 a

TABLE 2 - Effect of enclosing inflorescences of cv. 'Williams' bananas in sleeves and bags. Numbers followed by different letters differ significantly at $P = 0.05$.

Covering material	mode of enclosure	% 'pp'
control		0 c
craft paper	bag	0 c
blue polyethylene	sleeve	24 b
blue polyethylene	bag	90 a
silver polyethylene	bag	97 a
transparent polyethylene	bag	89 a

Duration of covering.

The influence of the covering treatment in 'Dwarf Cavendish' was very quick. After a period of 3 days, 88 % of the flowers were already of the 'pp' type ; when the treatment was longer, its influence was greater (Table 3).

The response of cv. 'Williams' was weaker also in this respect. Similar amounts of 'pp' (90 %) were obtained only after a longer time under cover (9 days *vs.* 3 in the 'Dwarf Cavendish'). The effect was obtained only if the flowers continued to be covered for about 3 days, after hand opening.

In further experiments where inflorescences were covered at more advanced stages after opening, it was found again that in order to obtain any response in cv. 'Williams', the inflorescence had to be covered for at least two days before hand opening, while in cv. 'Dwarf Cavendish' the effect was

TABLE 3 - Effect of duration of covering period on incidence of flowers with a persistent perianth ('pp') in cv. 'Dwarf Cavendish' bananas. Numbers followed by different letters differ significantly at P = 0.05.

Covering period (days)	N° of 'hands'	N° of open 'hands' at the end of treatment	N° of hands with 'pp'	% 'pp'
0	10.1	--	3.3	33 c
3	10.4	1.2	9.1	88 b
6	10.0	8.2	9.1	91 ab
9	10.2	10.2	10.2	100 a
12	10.6	10.6	10.6	100 a

TABLE 4 - Effects of duration of covering period of cv. 'Williams' banana inflorescences on incidence of flowers with a persistent perianth ('pp'). Numbers followed by different letters differ significantly at P = 0.05.

Covering period (days)	N° of 'hands'	N° of open 'hands' at the end of treatment	N° of hands with 'pp'	% 'pp'
0	9.3	-	0	0 c
3	9.2	2.6	0.4	4 c
6	9.4	9.4	5.7	61 b
9	9.2	9.2	8.3	90 a
12	9.1	9.1	9.1	100 a

obtained even when the bunch was covered on the day of hand opening.

Effect of dry and wet air.

Temperatures at the outlets of the dry and wet air streams were similar to those in the closed control and in the open air control, and therefore the effect of the treatments could not be attributable to temperature. The relative humidity in the wet air was a little lower than in the closed control, and in the dry air it was lower than in the open control (Table 5).

It was found (Table 6) that the wet air treatment induced the same amount of 'pp' as in the closed control. The relative humidities were similar in the two treatments. The increase over the open control was very clear. The dry air treatment also gave very clear results, the amount of 'pp' being less than in the control, as was the relative humidity.

During our work we observed that different treatments which influence the relative humidity surrounding the inflorescences influence also the incidence of flowers with persistent perianth. An attempt was made to determine the relationship between the two. We had to use relative parameters (ratio between a treatment and its specific control) in order to be able to compare the results of different experiments on a common basis. A strong (r = 0.912) direct correlation was found between the effect of a treatment on relative humidity, and the incidence of 'pp' flowers of 'Dwarf Cavendish' (figure 1).

TABLE 5 - Relative humidity (%) of microclimate around cv. 'Dwarf Cavendish' banana inflorescences

treatment	hour		average
	6.00	14.00	
Open control	82.00	55.8	68.8
closed control	97.0	97.6	97.3
dry air	60.8	68.0	64.4
wet air	94.7	92.7	93.7

TABLE 6 - Effect of microclimate humidity on incidence of flowers with persistent perianth ('pp') in cv. 'Dwarf Cavendish' bananas.

treatment	N° of flowers	% 'pp'
open control	459	31
closed control	325	88
dry air	310	9
wet air	312	87

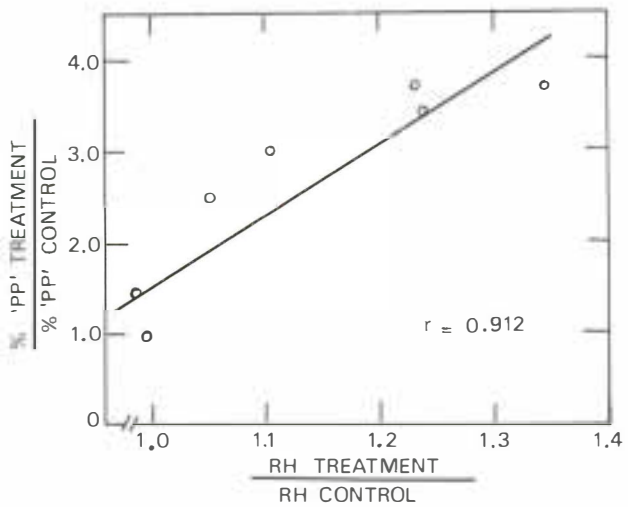

FIG. 1 • RELATIONSHIP BETWEEN RELATIVE HUMIDITY AND INCIDENCE OF FLOWERS WITH PERSISTANT PERIANTH (PP).

Effect of bract removal.

The relative humidity near the young flower is maintained high by the bract which covers each hand ; we therefore removed bracts while the inflorescence was still completely closed, in order to decrease humidity. Bract removal decreased consistently the incidence of 'pp'(Table 7), especially during the main flowering season (July-Sept.).

In order to find out if the effect of bract removal was due to reduction in relative humidity or due to some other factors, we removed bracts and enclosed inflorescences in plastic bags. The result was unequivocal : whereas no 'pp' occurred when bracts were removed, 92 % of the flowers were of the 'pp' type when bracts were removed and the bunches were enclosed in plastic bags.

DISCUSSION

The occurrence of persistent perianths in banana flowers of the 'Dwarf Cavendish' is mentioned in the literature (1, 2, 5, 6, 8, 9), generally in connection with finger-end diseases. We gave a detailed description of the occurrence throughout the season (3). However, the cause of this phenomenon is not known. We have observed that covering young female banana flowers increased the number of 'pp' in 'Dwarf Cavendish' (Tables 1, 3) and induce their occurrence in 'Williams' (Tables 2, 4) where they do not occur naturally in Israel. The effect was obtained after the emergence of the bunch, showing that the type of flower is determined close to the shooting day (Tables 3, 4, 6). These findings explain the effects of various treatments, but they do not show in what way the covering influences the type of flower. Several ways could be postulated : gas accumulation, temperature, relative humidity, etc.

We have shown (4) that ethylene in the 'ap' is a result, and not the cause, of the phenomenon. In the present work we studied effects of other environmental factors. In a crucial experiment in which a stream of air was passed around the bunches, we were able to exclude accumulation of gases and differences in temperatures (Table 5), and to prove (Table 6) a causal relationship between relative humidity and the incidence of 'pp' flowers. In a series of different types of experiments in which the relative humidity surrounding a banana inflorescence was changed by different treatments, we were able to show a close direct correlation between relative humidity and the incidence of 'pp', and to confirm our previous findings.

TABLE 7 - Effect of bract removal on incidence of flowers with a persistent periants ('pp') in cv. 'Dwarf Cavendish' bananas. (n.s. = not significant ; x = significant at P = 0.05) ; xx = significant at P = 0.01).

Date of treatment	% of 'pp'		
	bract removed	control	significance
24.IV	89.5	94.3	n.s.
6.V	16.7	37.0	n.s.
15.VI	30.6	35.9	n.s.
11.VII	0.0	15.6	n.s.
15.VII	0.8	10.6	x
20. VII	2.2	28.9	xx
2.VIII	5.5	41.4	x
3.VIII	0	27.0	xx
25.VIII	1.5	32.9	xx
5.IX	14.7	50.0	x
20.IX	4.9	46.0	xx

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