Age control of banana harvesting under Ecuadorean conditions.

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RECOLTE EN FONCTION DE L'AGE DES BANANES DANS LES CONDITIONS DE L'EQUATEUR.

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RESUME - Des régimes d'âges et de calibres connus étaient récoltés et les mains mises en cartons et à 13°C. Deux fois par semaine, la mesure de la dureté de doigts excisés permettait de détecter l'initiation du mûrissement. La couleur des fruits était observée. Toute main ayant présenté un fruit mûrissant est sortie de l'entrepôt et le nombre de jours avant ce mûrissement spontané est considéré comme la «vie verte» potentielle.

Dix récoltes sur la même parcelle expérimentale ont été observées et les corrélations entre «vie verte» potentielle, calibre et âge du fruit ont été calculées. Des coefficients de corrélation élevés ont été obtenus entre âge et calibre. Mais la vie potentielle «verte» a varié de 7 à 58 jours. Des mains qui auraient été considérées de maturité acceptable pour l'exportation ont eu une «vie verte» de 18 à 53 jours. On n'a identifié aucun critère objectif pour prévoir que des mains auraient plus de 25 jours de stade «vert», et on suggère de nouvelles recherches.

INTRODUCTION

Banana fruit are harvested in the green mature state for transport to distant markets, as such fruit resist the rigours of transport better than ripe fruit (MARRIOTT, 1980). The fruit are then artificially ripened by exposure to ethylene gas under controlled conditions of temperature and humidity, and reach the market at a predetermined stage of ripeness. Fruit which ripens «prematurely» during transport or storage before distribution will be over-ripe for retail sale. More importantly, banana fruit produce ethylene when ripening, so that the inclusion in several boxes of hands of fruit from a bunch liable to premature ripening will, through the action of ethylene evolved as they ripen, trigger the ripening of other hands in the box. PALMER (1971) has suggested that the inclusion of only 1 % of bunches liable to premature ripening may induce ripening in 3 % of boxes, and this is the maximum commercially acceptable incidence of prematurely ripe fruit.

It is important to determine when to harvest bananas in order to obtain a sufficiently long «green life» (preclimacteric period). Green life is shorter in older fruit (MARRIOTT, 1980) which are heavier. A compromise between yield and acceptable green life must therefore be found from experience. Three approaches have been used. The length of the green life of isolated fingers has been studied, and this shows that the ripening of isolated individual fingers from one hand is remarkably constant (MARRIOTT, 1980). Large scale trials under commercial conditions, using 500 or 1000 bunches in order to detect an incidence of premature ripening of 1 % have been carried out. A

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method in which separated hands are held in boxes in a single compartment has been described (MARRIOTT and NEW, 1975). The initiation of ripening is detected by removing fingers three times per week, and measuring the pulp rupture force, which is an early and sensitive indicator of ripening. The justification and application of this method of measuring the potential green life of bananas grown in Ecuador has been described by MARRIOTT and MONTOYA (1982). who presented some preliminary results. This paper reports further results for bananas harvested over two years from a single plot.

METHODS

Bananas were produced according to standard commercial practices in Ecuador from a single plot of 1/3 ha set aside for experimental harvests. The date of flower emergence (shooting) of each bunch was recorded, so that the physiological age of the bunch at harvest could be calculated. (The values reported here are higher than those usually specified in commercial systems using age control of harvesting because age is often recorded from the date of bagging). For the first five experiments, four bunches which had reached each of six standard caliper grades (42 to 52), measured using a standard caliper graduated in 1/32 inches, on the outer whorl of the second proximal hand of the bunch were harvested. For the next five experiments, five bunches of each of five ages between 14 and 18 weeks were selected for harvest. In each experiment grade and age were recorded for each bunch.

Four hands, numbers 1, 3, 5 and 7 from the proximal end, were treated with thiabendazole, and placed in boxes in a storage room at Boliche set at 13°C, 24 h after harvesting. The commencement of softening was detected by regular excision of two fingers from each hand, and pulp rupture force was measured on a transverse slice of each finger, using a force gauge with a penetrometer head and a motorised test stand (MARRIOTT and MONTOYA, 1982). To supplement the firmness measurements, which were scheduled according to grade or age, the hands were also observed visually three times per week, and any hands in which colouration had commenced or from which fingers with a lower pulp rupture force had been excised, were removed. In this manner it was possible to detect and record the commencement of ripening in individual hands, thus measuring the potential green life, and to remove any ripening hands soon after they began to produce ethylene.

Other parameters (mean finger weight, finger length, pulp density ; percentage pulp and percentage dry weight) were recorded from the other hands (2, 4, 6) not used in the measurement of potential green life, as were mean daily temperature, humidity and light intensity for the period from shooting to harvest. This data is not, however, presented, because as yet no useful correlations between any of these parameters and potential green life have been found.

RESULTS AND DISCUSSION

The potential green life of individual bunches ranged between 7 and 59 days. The means for up to 25 bunches from each harvest, together with the associated standard deviations shown in Table 1. As bunches of lower and of higher caliper grade or lower or higher age than would be commercially accepted were deliberately included in this experiment in order to demonstrate the differences, Table 1 also shows the mean potential green life (with associated standard deviation) for bunches of caliper grade 44 to 48. The observed green life of such bunches was between 18 and 53 days.

As may be inferred from the summary of the data in Table 1, some hands have an unacceptably short potential green life. Whilst some of this variation in mean green life is attributable to the inclusion of older bunches or bunches of grade 50 or 52 in the experiment which have a shorter green life, in some experiments, some or all the hands which might normally have been accepted for export on the basis of age or grade have a short green life. Some factor other than age or grade appears to influence green life. There is a marked variation between the April 1981 or September 1981 harvests and the February 1981 or September 1982 harvests.

The results from the individual experiments were analysed separately to determine the relationship between bunches harvested by caliper grade or by age. The conclusions are summarised in Table 2, which shows that the relationship between age and green life is consistently closer than that between grade and green life. Regression coefficients of 0.90 or more were normally observed in other studies in Jamaica (MARRIOTT, NEW, DIXON and MARTIN, 1979). In these experiments the green life of the proximal hands (1) and that of the distal hand (7) was always closely related, though that of the proximal hand was always closely related, though that of the proximal hand was sometimes shorter by up to 9 days. Figures 1 and 2 show the relationship between age and green life for two harvests of bananas with the longest and shortest green life. All correlation coefficients between age or grade and green life are highly significant ($p<0.001$) by the C-test. The poorest correlation coefficients were found for the February 1982 harvest and the best for the September 1982 harvest, both of which had relatively long periods of green life. Bananas harvested in September 1981 and January 1982 had a relatively short green life, but gave a relatively high and a relatively low correlation coefficient, respectively. The variation in green life and the differences between correlation coefficients suggests that some factor other than age influences green life. Whilst control of harvesting by bunch age is practised in Latin America, little has been published (RIPPON, 1975 ; MARRIOTT, 1980). The additional date recorded in these experiments was therefore examined to deek possible causes, in particular in an attempt to identify factors which could

TABLE 1 - Summary of potential green life of banana fruit.

Harvest date	Mean green life (all bananas)		Mean green life (grades 44-48 only)	
	mean	std. dev.	mean	std. dev.
23 Dec 80	40.6	9.2	43.3	8.6
11 Feb 81	44.3	12.9	42.7	10.3
1 April 81	22.2	4.1	21.4	1.9
18 Aug 81	31.5	9.9	32.1	7.1
30 Sept 81	25.9	7.4	28.7	6.0
11 Nov 81	32.6	5.9	33.5	3.7
21 Jan 82	25.9	6.0	33.0	1.9
12 May 82	32.3	4.4	35.6	3.2
15 June 82	28.7	7.4	31.8	5.5
9 Sept 82	42.5	8.3	42.4	6.5

TABLE 2 - Correlation between green life and either bunch age or caliper grade.

Harvest date	age/green life	caliper grade/green life
23 Dec 80	0.93	0.74
11 Feb 81	0.73	0.63
1 April 81	0.86	0.76
18 Aug 81	0.95	0.75
30 Sept 81	0.95	0.71
11 Nov 81	0.95	0.80
21 Jan 82	0.87	0.84
12 May 82	0.89	0.76
15 Jun 82	0.96	0.79
9 Sept 82	0.96	0.76

TABLE 3 - Possible correlation between green life and either initial pulp rupture force or dry matter content.

Harvest	Green life and pulp rupture force	significance level	Green life and dry matter content	significance level
23 Dec 80	0.49	0.05	0.84	0.001
11 Feb 81	0.58	0.01	0.17	NS
1 April 81	0.54	0.05	0.04	NS
18 Aug 81	0.86	0.001	0.58	0.001
30 Sept 81	0.84	0.001	0.61	0.001
11 Nov 81	0.21	NS	0.68	0.001
21 Jan 82	0.50	0.05	0.01	NS
12 May 82	0.31	NS	0.55	0.01
15 June 82	0.76	0.001	0.67	0.001
9 Sept 82	0.45	0.05	0.76	0.001

readily be observed or recorded on large numbers of plants, to predict which bunches of acceptable age or grade should be rejected for export to avoid losses due to premature ripening.

The expected correlation between age and grade was obtained, but attempts to construct indices of growth such as weight for age, weight for grade or weight for finger length failed to reveal any correlation with potential green life. In some experiments, a correlation between green life and either initial pulp rupture force or percentage dry matter content was found, but this was not consistent and thus of no predictive value. It is not unreasonable to consider a possible relationship between climate during growth and the metabolic state of the fruit. Climate records show that during the period of development and maturation

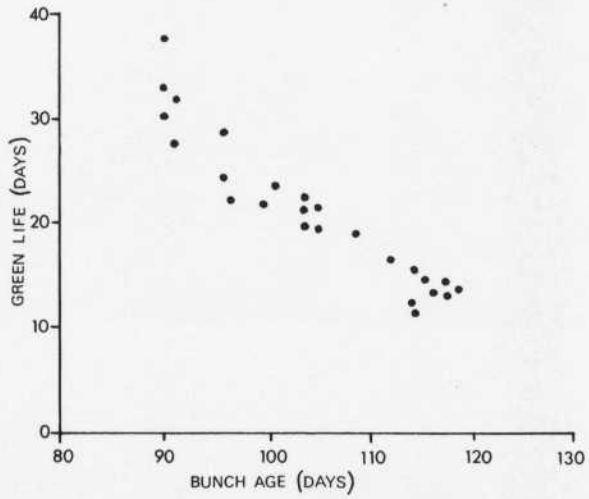

Figure 1 • GREEN LIFE AS A FUNCTION OF AGE FOR BANANAS HARVESTED 17 FEB 81.

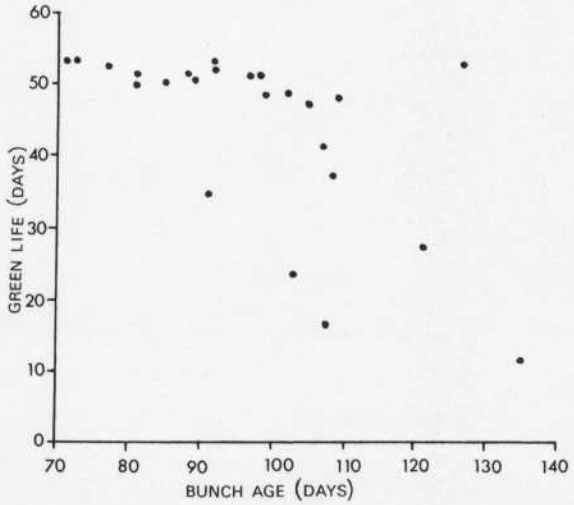

Figure 2 • GREEN LIFE AS A FUNCTION OF AGE FOR BANANAS HARVESTED 15 JUNE 82.

of the fruit (from shooting to harvest), the mean temperature and mean humidity at this locality were remarkably constant. Light intensity varied during the year, but there was no correlation between mean light intensity during growth and the subsequent green life of the harvested fruit. Such records of mean climatic variables do not, of course, rule out an effect at some critical period of fruit development, but they suggest that some other factor may be involved. No major disease outbreaks in the experimental plot or its surroundings were recorded : the plants received standard commercial care. One possible cause of variation in the post harvest behaviour of the fruit which requires investigation is plant nutrition, as it is possible that some mineral element or balance of elements is crucial to the development of fruit with an acceptably long shelf-life. Insufficient is known about the influence of plant hormones on the ripening mechanism in developing banana fruit to provide any theoretical explanation why some fruit have a shorter potential green life than other fruit of apparently similar age or caliper grade.

CONCLUSIONS

Data to support the practice of controlling banana harvesting primarily by controlling the age of fruit which are harvested is presented. However, this alone does not provide an adequate guarantee that the fruit will remain green at shipping temperatures sufficiently long to ensure that premature ripening will not occur. Bunches will continue to have to be rejected for export on the basis of experience. It is suggested that the nutrition of such fruit should be investigated in an attempt to reduce the incidence of fruit which have an unacceptably short life.

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