Influence of pre-harvest sprays of ethrel on ripening and abscission of coffee berries*

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COMPENDIO

Se aplicó ethrel (ácido fosfónico 2-cloroetano) como aspersión pre-cosecha a cerezas verdes maduras de Coffea canephora *'Robusta' and* Coffea arabica *cv 'Variegata' que crecía en un campo en la Estación Experimental de Gambari, Idi-Ayunre, Ibadán, en concentraciones que variaban de 50 a 500 ppm, con el fin de investigar el efecto del producto químico sobre la maduración y abscisión de las cerezas. Con las tasas de 100 ppm y más altas, el producto aceleró el comienzo de una maduración uniforme de las cerezas en ambas especies. En el caso de* C. arabica, *la mayor maduración ocurrió 6 a 13 días después de la aplicación en comparación con 9 a 17 días en el caso de* C. canephora.

Con 200 ppm y más altas dosis, el ethrel indujo grados variables de aflojamiento de frutos y a menudo, su caída. Las concentraciones más altas causaron caída de cerezas más temprana y rápida. Parece que las cerezas tienen que ser de cierta edad fisiológica antes de que puedan ser inducidas a madurar o caer. — La autora

Introduction

IN Nigeria the coffee plant normally flowers in two or three flushes and this results in berries of varied ages which ripen unevenly. Natural ripening of coffee berries usually occurs during the dry season and spreads over a period of about ten weeks beginning from October (9). Coffee harvesting therefore, is not a simple once-over procedure as the case in most other crops. As a result of this, many farmers pick berries at varied stages of ripening at harvest time. Some even deliberately pick green berries in order to harvest them before they are attacked by berry borers. On farms where more than one variety of coffee is grown there is the tendency of mixing berries together. Since all these factors contribute to the production of a poor quality coffee, it is considered that any growth regulator which can bring about uniform ripening of coffee berries may increase the efficiency of hand picking and thus improve the quality and subsequently, the price of coffee in the world market.

Existing reports have shown that the effect of ethrel (2 chloroethane phosphonic acid) on plants is similar to those produced by ethylene and this has been attributed to the liberation of ethylene gas in vivo by ethrel (3). In fact, the ability of ethrel to stimulate fruit ripening was first reported by Russo *et al.* (12) when they compared banana ripening of ethylene treated fruit with that of ethrel treated fruit. Garrison (7) also reported the stimulation of tomato ripening when ethrel was injected into the fruit and Robinson *et al.* (11) showed that field sprays of ethrel applied two weeks before harvest increased the proportion of ripe fruit. In a preliminary study by Oyebade in 1971 (10), it was discovered that aqueous sprays of ethrel on mature coffee berries four weeks before anticipated harvest induced uniform ripening in *C. canephora* 'Robusta'. Besides stimulating fruit ripening there are reports from other workers that other vital properties of ethrel include abscission promotion of fruits and other appendages (1, 2, 4, 5, 6, 8); and the effect of ethrel on fruit abscission could be of benefit in regulation of harvest dates of particular cultivars and for mechanical harvesting.

* Received for publication August 13, 1975

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The present study, therefore, was designed to investigate the abscission and fruit-ripening properties of ethrel on mature berries of *C. canephora* 'Robusta' and *C. arabica* cultivar 'Variegata' growing at the Gambari Experimental Station of the Cocoa Research Institute of Nigeria as there are a number of ways in which such an agent might find useful application in coffee cultivation. The Gambari Experimental Station is about 23 kilometres south west of Ibadan, Nigeria; and it is situated between the low land Rain Forest Zone of the Forest Region and the Southern Guinea Zone approximately 600 feet above sea level with an average annual rainfall of about 50 inches. The rainy season usually lasts from April to October with two rainfall maxima in May/June and September/October. There is approximately a four-month dry season of varying intensity lasting from November/December to February/March

Material and methods

During the last week of September 1974, when berries were still green but mature on both *C. canephora* 'Robusta' and *C. arabica*, ethrel at 0, 50, 100, 200, 250, 300 and 500 ppm was applied directly to the berries of some selected laterals until just before the point of run-off. The volume of solution applied usually amounted to between 20-25 ml depending on the number of berries borne by the selected lateral. Spraying was carried out with a 50 ml hand sprayer. A single dose of each of the treatments was applied, except the 50 ppm treatment which was applied on two occasions at intervals of 24 hours to give a double dose. This treatment is henceforth referred to as 50-2 in this paper. In all, there were eight treatments and the eight treatments were replicated five times for each of the two species of coffee used in this study. Relatively low concentrations of ethrel have been used in this study because preliminary investigations showed that ethrel at 1000 ppm and above is quite toxic to coffee plants in Nigeria.

The number of berries treated per replicate was not uniform but records were taken of the number at the time of ethrel application. After the application of the chemical, periodic observations were made on the berries so as to evaluate the effectiveness of the various concentrations in inducing ripening and abscission of the berries. The number of berries ready for processing were counted after day 6, 9, 13, 17, 24, 30, 43 and 50 of chemical application. All the data collected on ripening and fruit drop were subjected to analysis of variance and differences among means were tested for significance using the *t* - test method.

Results and discussion

A single dose of ethrel at 200 ppm and above showed a marked influence on ripening. Within the first six days after chemical application, ripening was visually noticeable in the case of *C. arabica* but this was delayed till about nine days in the case of *C. canephora*. In both species, the percentage ripe berries increased progressively with time as a result of the different treatments, but laterals treated with 300 and 500 ppm ethrel had the highest per cent ripe berries at all times during the experimental period and these were followed by those treated with ethrel at 250, 200, 100, 50-2 and 50 ppm in that order (Fig. 1). Thus ethrel applied at

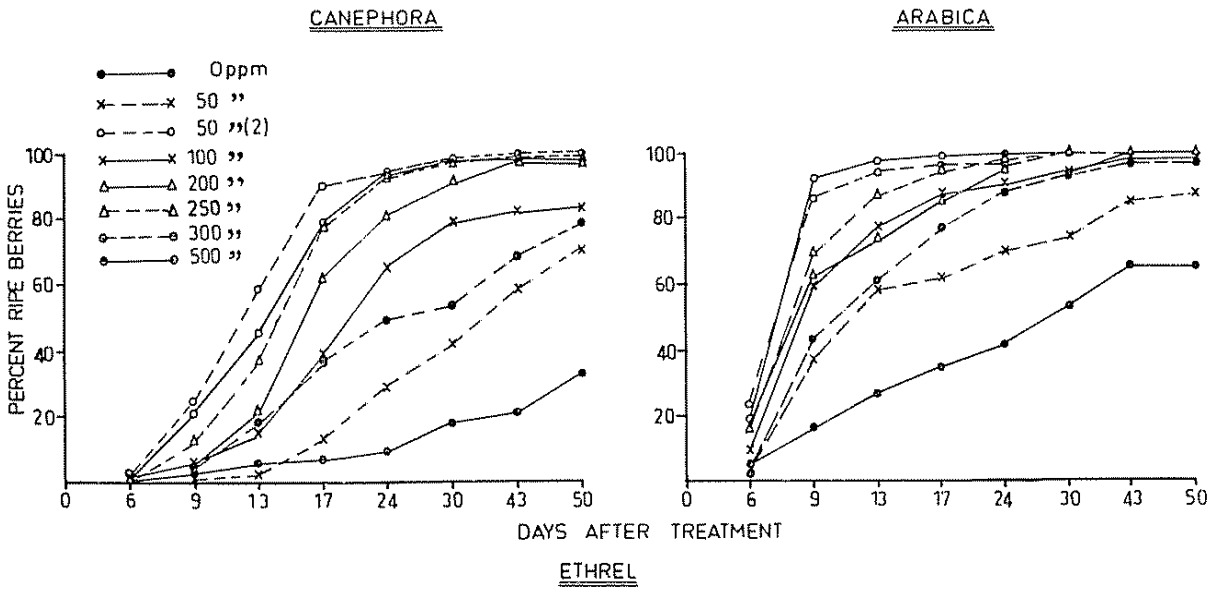

Fig. 1—*Effects of different concentrations of ethrel on percentage ripe berries*

300 and 500 ppm caused earlier ripening than ethrel applied at 250 ppm and below. Another way of explaining this phenomenon could be that the ability of ethrel to stimulate ripening decreases as the fruits became older, probably as a result of an increase of endogenously produced ethylene in the fruits themselves to a critical level.

Analysis of variance on log percentage ripe berries by the 13th day after spraying showed no significant difference between the control (0 ppm) and 50 ppm but both were, at this stage, significantly different from the other treatments at $P = 0.05$. Also, there was no significant difference between those sprayed with a double dose of 50 ppm and a single dose of 100 ppm, but both showed significant differences from berries sprayed with 300 and 500 ppm ($P = 0.05$). The same was also true for the data obtained 17 days after treatment.

It is evident from the results of this study that ethrel at 300 and 500 ppm was more effective in concentrating the ripening period of berries in both species. By the 17th day after treatment, for instance 99.4 per cent of the berries sprayed with 500 ppm ethrel had ripened in the arabica while at the same time, 77.2 per cent of those sprayed with the same ethrel concentration had ripened in the robusta. In the controls, on the other hand, 35.1 per cent ripe berries were recorded for arabica while only 7.6 per cent was recorded for the robusta. This shows clearly how the harvest time of both species had been shifted forward by about three weeks due to single sprays of ethrel at 300 ppm and above. By the time the experiment was terminated 50 days after treatment, 0 ppm was the only treatment significantly different from the others at $P = 0.05$. The percentages of ripe berries in the controls were then 65.3 and 32.7 respectively for arabica and robusta (Fig. 1).

Fruit drop after spraying was estimated at the same intervals as fruit ripening and expressed as per cent berry drop (Fig. 2). Ethrel, especially at the higher concentrations increased the fall of berries and this phenomenon became more pronounced with time. By the 13th day after treatment for instance, 9.6 per cent berry drop was induced by 500 ppm ethrel on arabica but this has increased to 50 per cent by the 24th day (Fig. 2A-C). In the case of the robusta sprayed with 500 ppm ethrel, percentage berry drop was 8.04, 13 days after treatment and this rose to 16.8 and 41.2 by the 24th and 30th day after treatment respectively (Fig. 2-A, C and D). It was apparent that ethrel increased berry drop partly by increasing their degree of ripeness because many of the berries which dropped were overripe with softer pericarp.

This experiment shows that besides the ability to stimulate the onset of fruit ripening ethrel is also an effective berry abscission agent. The speed of its response to both ripening and abscission may be associated with the high temperatures prevailing in the Western State of Nigeria at the time of this experiment. An agent such as ethrel, might find useful application in coffee cultivation. For instance, if it were possible to shorten the ripening period of coffee which normally spreads over about ten weeks (9), the cost of harvesting could

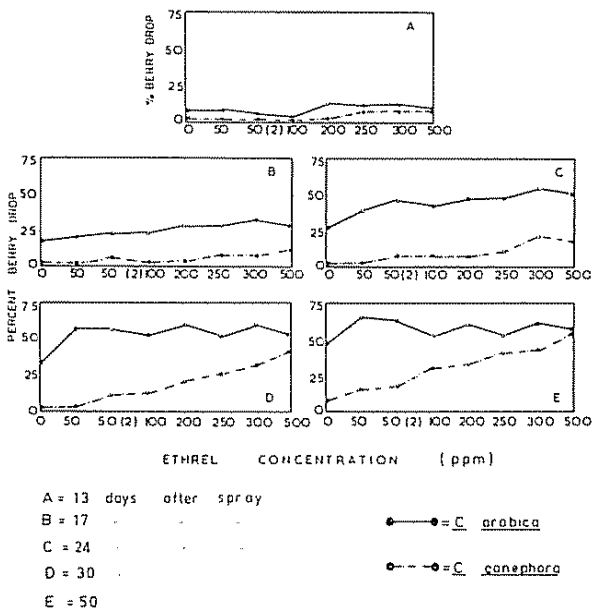

Fig. 2.—*Effects of eight concentrations of ethrel on the abscission of healthy coffee berries during five periods following treatment.*

be reduced because there would be fewer peak picking periods and more efficient use could be made of the available labour. Also in large coffee plantations, selective spraying of large blocks can be carried out so that harvest can be programmed to meet labour availability. Moreover, because ethrel is an abscission agent, it might be useful in controlling over-bearing, particularly in the first fruiting year of young trees. With a single fruiting season, the control of some pests and diseases would be easier and less expensive.

The abscission property of ethrel might also be very useful as an aid in the mechanical harvesting of coffee, but further research is still needed on whether the chemical can selectively remove ripe berries or not.

Summary

Ethrel (2-chloroethane phosphonic acid) was applied as a pre-harvest spray to mature green berries of *Coffea canephora* 'Robusta' and *Coffea arabica* L. cultivar 'Variegata' growing in the field at the Gambari Experimental Station, Idi-Ayunre, Ibadan, in concentrations varying from 50 to 500 ppm so as to investigate the effect of the chemical on berry ripening and abscission. At rates of 100 ppm and higher, the chemical accelerated the on-set of uniform on-the-tree ripening of berries in both species. In the case of *C. arabica*, greatest ripening occurred 6 to 13 days following application as against the 9 to 17 days in the case of *C. canephora*.

At 200 ppm and above, the chemical induced varying degrees of berry loosening and often, berry drop. The higher concentrations caused earlier and more rapid berry drop. It seems berries had to be of a certain physiological age before they could be induced to ripen or abscise.

Acknowledgement

I am thankful to F. Adesokan and S. Adeleke of Agronomy Division for taking pains to record the observations. The permission of the Director of Cocoa Research Institute of Nigeria, Ibadan to publish the findings is greatly acknowledged.

Literature cited

1. BROWNING, G. and CANNELL, M. G. R. Use of 2-chloroethane phosphonic acid to promote the abscission and ripening of fruit of Coffea arabica L. Journal of Horticultural Science 45(3):223-232. 1970.

2. BUKOVAC, M. J. *et al.* Chemical promotion of fruit abscission in cherries and plums with special reference to (2-chloroethyl) phosphonic acid. Journal of American Society for Horticultural Science 94:226-230. 1969.

3. COOKE, A. R. and RANDALL, D. I. Ethrel as ethylene releasing agent for the induction of flowering in pineapple. Nature 218:974-975. 1968.

4. CUMMINS, J. N. and FIORINO, P. Pre-harvest defoliation of apple nursery stock using ethrel. Horticultural Science 4:339-341. 1969.

5. DOZIER, W. A. Jr. and BARDEN, J. A. Influence of 2-chloroethyl phosphonic acid on growth and abscission of young apple tree leaves. Journal of American Society for Horticultural Science 98:239-243. 1973.

6. EDGERTON, L. J. and GREENHALGH, W. J. Regulation of growth, flowering and fruit abscission with 2-chloroethene phosphonic acid. Journal of American Society for Horticultural Science 94:11-13. 1969.

7. GARRISON, S. A. W. Stimulation of tomato ripening by Amchen 66-329. Horticultural Science 3(2):122 (Abstract). 1968.

8. LOONEY, N. E. and McMECHAN, A. D. The use of (2-chloroethyl) phosphonic acid and succinic acid 2, 2-dimethyl hydrazide to aid mechanical shaking of sour cherries. Journal of American Society for Horticultural Science 95:452-455. 1970.

9. OYEBADE, I. T. Studies on the pattern of growth and development of *Coffea canephora* (Pierre ex Froehner) fruit in Nigeria. In Press - Nigerian Journal of Science 7(2). 1973.

10. ———— Effect of pre-harvest sprays of ethrel (2-chloroethane phosphonic acid) on Robusta coffee (*Coffea canephora* Pierre) berries. Turrialba 21(4):442-444. 1971.

11. ROBINSON, R. W. *et al.* Chemical promotion of tomato fruit ripening. Proceedings of the American Society for Horticultural Science 93:823-830. 1968.

12. RUSSO, L., DOSTAL, H. C. and LEOPOLD, A. C. Chemical regulation of fruit ripening. Bioscience 18: 109. 1968.