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THE POTENTIAL FOR THE USE OF GIBBERELLIC ACID IN STORAGE OF YAMS, *DIOSCOREA ALATA*

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ABSTRACT

Gibberellic acid (GA_3) may be used to prolong dormancy in yams, *D. alata* and thus extend the shelf-life of treated tubers. The feasibility of using this treatment commercially, was assessed by comparing the break-even cost of treated tubers with the average retail price. Three GA_3 treatments: 50 ppm for 24 hours, 100 ppm for 21 hours and 500 ppm for 9 hours, and two treatment dates: January and April, were considered. The most economic and practical treatment was found to be 100 ppm GA_3 for 21 hours, applied in April. This treatment resulted in an extension of dormancy for 10 weeks, and the tubers were available until July.

RESUMEN

Estudios hechos en Trinidad han demostrado que el ácido gibberellico GA_3, prolonga el período de inactividad en tubérculos de D. alata por 10 a 17 semanas, dependiendo del tiempo del tratamiento y la concentración de GA_3 usada. Aquí se discute el resultado de tratar ñames en enero y abril. Un análisis breve del costo del tratamiento demuestra que sería económicamente factible tratar tubérculos con 100 ppm GA_3 para prolongar su disponibilidad por 10 semanas más.

Keywords: Yam; *Dioscorea alata;* Storage; Gibberillic Acid

Yam, *Dioscorea spp.*, is an important root crop in the Caribbean. The tubers are grown primarily for local consumption, although a number of the islands export to the United States and United Kingdom. Production of yams in the region was 305,000 metric tons in 1982/83, representing 15% of total root crop production (Ferguson, 1985).

Dioscorea alata is one of the most popular yam species and is widely grown in Antigua, Barbados, Montserrat, St. Kitts and Trinidad (Table 2). Tubers of *D. alata* experience a natural dormancy of 3–4 months after which sprouting, weight loss and loss in palatability occurs. Work done at the University of the West Indies by Wickham (1981) and subsequently by Jordan (1984) has shown that it is possible to prolong dormancy in tubers of *D. alata* by the application of gibberellic acid (GA_3).

The major advantage of using GA_3 to extend shelf-life is that there is no need for any specialised facilities or storage requirements, other than the usual precautions to prevent pest and disease damage. However before GA_3 can be recommended for use in commercial storage, it is necessary to estimate the cost of treatment. The current high cost of GA_3 (TT$4.25/gram) would seem to be a major constraint to its use on a large scale.

This paper examines the feasibility of using GA_3 in yam storage, by comparing the break even cost of treated tubers with the average retail price of yams.

Background

Jordan (1984) working with tubers of *D. alata* cv. 'White Lisbon' has shown that the extension of dormancy obtained by treatment with GA_3 is a function of concentration, and duration of exposure to the treatment solution. In addition, response to a given treatment varied depending on the date of application. Thus tubers treated in April (on breakage of dormancy) experienced an extension of domancy 1 week longer than tubers treated after harvest in January. Breakage of dormancy was defined as sprouting in 20% of tubers.

Tubers harvested in January experienced a natural dormancy of 13 weeks, and extension of dormancy was defined as the additional dormancy period measured from that time.

Table 1 shows the effect of three GA_3 treatments, applied in January and April, on extension in dormancy and availability of 'White Lisbon' yams. Jordan (1984) also reported that weight loss of dormant tubers was 0.5% per week on a fresh weight basis.

Methodology

The final break-even cost of treated tubers was calculated based on the cost of materials, labour and storage. The final cost was adjusted to take into account shrinkage due to weight loss during storage. All prices are quoted in TT dollars, and are prevailing prices in 1982/83.

Table 1. Effect of GA_3 on extension of dormancy and availability of *D. alata* cv. 'White Lisbon' tubers

GA_3 treatment	Date of treatment	Extension of dormancy	Minimum limit of availability
50 ppm/ 24 hrs	Jan	5.5	June
	Apr	6.5	
100 ppm/ 21 hrs	Jan	9.0	July
	Apr	10.0	
500 ppm/ 9 hrs	Jan	13.5	August
	Apr	14.5	

Source: Jordan (1984)

Cost of GA_3

The cost of GA_3 required to treat 1kg of yams was calculated as shown in Table 2. The cost varied between \$0.20 to \$2.00 depending on the concentration of GA_3 used. It was assumed that the GA_3 solution was used only once.

Table 2. Cost of GA_3 required to treat 1.0 kg of yam with a solution containing 50 ppm, 100 ppm or 500 ppm GA_3

*Volume of treatment solution 1/1.05	= 0.95 litres
Quantity of GA_3 required to prepare 0.95 l of 50 ppm solution	= 0.0475 g
Cost of GA_3	=\$4.25 per g
Cost of GA_3 required to treat 1 kg of yams with a solution of:	
50 ppm GA_3	$= 0.0475 \times 4.25$
	=\$0.20
100 ppm GA_3	=\$0.40
500 ppm GA_3	=\$2.00

*Calculated as volume of water displaced by 1 kg of yam of density 1.05 kg/l.

Initial cost of yams

It was assumed that the yams were purchased prior to treatment at the prevailing farm-gate price. Thus tubers treated in January cost \$1.66 per kg and the cost of tubers treated in April was \$0.93 per kg (Table 3).

Table 3. Average farm price per kilogram of 'White Lisbon' Yam in 1981

Month	Price per kg.
January	1.66
February	1.91
March	2.09
April	0.93
May	0.99
June	0.88

Source: Central Statistical Office, Index of Retail Prices, Quarterly Agricultural Report, 1977-1981.

Ministry of Agriculture, Planning Division, Republic of Trinidad and Tobago.

Labour

The cost of labour required to treat 1.0 kg of yams was \$0.18, calculated as shown in Table 4. The duration of the various procedures was estimated based on experience gained conducting experiments.

Table 4. Cost of labour required to treat one kilogram of yam with GA_3

[1] Time required to treat 225 kg[2] of yams

Operation	Duration (hrs)
Wash tubers	2
Mix chemical	1/2
Immerse tubers	1/2
Remove tubers	1
Pack	1
Unpack	1
TOTAL	6 hours

Time required to treat 1 kg $= \frac{6}{225}$ hours

[3] Cost of labour =\$6.77 per hr

Cost of labour per kg of yam treated $= \frac{6.77 \times 6}{225}$

=\$0.18

[1] Does not include time for which tubers are immersed in treatment solution

[2] Minimum weight of yam treated in experiments

[3] Hourly wage of male casual worker at the University Field Station, 1981.

Storage costs

The cost of warehouse storage was 0.2¢ per kg per week. Tubers treated in January had to be stored 13 weeks longer than tubers treated in April.

Shrinkage

Average weight loss during storage was 0.5% per week on a fresh weight basis. Tubers treated in January lost 6.5% more weight than tubers treated in April.

Break-even cost

The break-even cost of treated tubers was calculated as shown in Tables 5 and 6. The final cost shown here is the cost of tubers towards the end of the period of their availability. The break-even cost of tubers treated with 500 ppm was \$5.09 per kg and \$3.67 per kg for tubers treated in January and April respectively.

Tubers treated with 100 ppm GA_3 cost \$3.05 per kg and \$1.80 per kg, and those treated with 50 ppm GA_3 cost \$2.69 and \$1.49 per kg, for January and April – treated tubers respectively.

Discussion

The break-even cost of tubers treated with 500 ppm GA_3 was substantially greater than the cost of tubers treated with 50 or 100 ppm GA_3. The extension of shelf life achieved by treatment with 500 ppm GA_3 was 4 weeks longer than that obtained by the next best GA_3 treatment. However, the cost of that extra 4 weeks of storage increased the break-even cost by 67% and 104% in January- and April-treated tubers respectively. In both cases the break-even price exceeded the maximum price paid for yams during

Table 5. Estimated break-even cost of 1 kg of yam treated with GA_3 in the second week of January (at harvest)

	GA_3 treatment		
	50 ppm/ 24 hr	100 ppm/ 21 hr	500 ppm/ 9 hr
[1] Cost of yams	1.66	1.66	1.66
Cost of labour	0.18	0.18	0.18
Cost of GA_3	0.20	0.04	2.00
Minimum shelf-life (wks from date of treatment)	19.5	23	27.5
[2] Cost of storage (2¢ per week)	0.39	0.46	0.55
%weight loss during storage (0.5% per week)	9.75	11.5	13.75
Break-even cost at the end of the storage period	$2.69	$3.05	$5.09

[1] Farmgate price of 1.0kg 'White Lisbon' tubers in January 1981

[2] 1981 cost of warehouse dry storage

Table 6. Estimated break-even cost of 1 kg of yam treated with GA_3 in the last week of April (on breakage of dormancy)

	GA_3 treatment		
	50 ppm/ 24 hr	100 ppm/ 21 hr	500 ppm/ 9 hr
[1] Cost of yams	0.93	0.93	0.93
Cost of labour	0.18	0.18	0.18
Cost of GA_3	0.20	0.04	2.00
Minimum shelf-life (wks from date of treatment)	6.5	10	14.5
[2] Cost of storage (2¢ per week)	0.13	0.20	0.29
%weight loss during storage (0.5% per week)	3.25	5.0	7.25
Break-even cost at the end of the storage period	$1.49	$1.80	$3.67

[1] Farmgate price of 1kg 'White Lisbon' tubers in April 1981

[2] 1981 cost of warehouse dry storage

the year (Table 7). It is clear that the high cost of GA_3 makes treatment with 500 ppm GA_3 uneconomic, in spite of the extension in shelf life.

Treatment with 100 ppm GA_3 extended the shelf life of tubers for an additional 3.5 weeks, compared to the extension obtained by treatment with 50 ppm GA_3. The difference in the cost of the two treatment was $TT 0.36¢ and $TT 0.31¢ in the January- and April-treated tubers respectively. However, at both dates, the break-even cost of tubers in both treatments remained below the maximum price paid for yams during the year. A study of Table 7 shows that the additional cost of treatment with 100 ppm GA_3 would be offset by the increased price paid for yams stored for an extra 3.5 weeks.

Table 7. Average farm price per kg of 'White Lisbon' yam in 1981

Month	Price per kg
January	2.47
February	2.20
March	2.20
April	2.42
May	2.20
June	2.34
July	3.00
August	2.84
September	3.20
October	2.89
November	2.76
December	2.42

Source: Central Statistical Office, Index of Retail Prices, Quarterly Agricultural Report, 1977-1981.

Ministry of Agriculture, Planning Division, Republic of Trinidad and Tobago.

Treatment in April resulted in a lower break-even cost than treatment in January, and the availability of the tubers was extended for an additional week. The reduced cost of tubers treated in April was due primarily to the low farm price of yams at the time of treatment. In addition, the period of storage required, and the weight loss experienced were much less than that encountered by tubers treated in January.

It is possible that the break-even costs estimated here may be reduced by economies of scale, once the treatment is done commercially. By using the solution to treat several batches of tubers the cost of treatment would be further reduced. Jordan (1984) has shown that it is possible to use a given GA_3 solution for up to three times with no reduction of effectiveness.

Conclusions

Treatment with 100 ppm GA_3 would seem to be an economic and practical method of extending the period of availability of *D. alata* yams on the market. Such a treatment would guarantee that farmers would be able to market their yams at a reasonable price instead of being forced to dispose of the surplus rapidly and at a low price once dormancy is broken. In fact, production of *D. alata* could be increased in order to take advantage of the extended marketing period.

The potential for the treatment is assessed based on Trinidad prices in a Trinidad market. The analysis would have to be repreated in other countries in order to estimate the cost of treatment under different conditions.

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