Increased Quality and Prolonged Storage of Sweet Potatoes in Israel

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The predominant sweet potato [*Ipomoea batatas* (L.) Lam] variety grown in Israel, 'Georgia Jet', is hard to store for longer than 1 month because of its low dry matter content (16%). Curing processing is a common pre-storage treatment for sweet potatoes to prevent decay. Although an effective disease preventative in other varieties, it was not effective with Georgia Jet. In experiments conducted during 1995–97 it was proven possible to store var. Georgia Jet for 5 months by means of disinfecting the roots with iprodione in conjunction with the curing procedure. At the end of the storage period, 14% of the roots had decayed following this combined treatment (Exp. 1): 9% suffered soft decay and had to be discarded, and 5% had dry decay, which left them suitable for the local market. Compared with these figures, decay levels following single treatments were 61% with curing, 60% with iprodione and 100% in the control group. Three methods of iprodione application were also tested (Exp. 2): dipping, spraying, and 'Tabor' Atomizing System fogging which produces an extremely fine mist (droplet size $< 10\ \mu$). The fogging method proved to be the most effective, with 4% dry decay and 6% soft decay after 5 months of storage.
KEY WORDS: Sweet potato; *Ipomoea batatas*; storage; curing; iprodione.

INTRODUCTION

Sweet potato is a tropical crop which suffers from chilling injury at temperatures below 8°C, expressed by rapid deterioration of the tissue and decay of the roots caused, mainly, by the fungi *Rhizopus* spp. and *Fusarium* spp. (1,2). It is therefore not possible to keep it in the ground after December (in Israel), particularly during cold and rainy years. Demand for sweet potatoes, and therefore its economic value for growers, peaks during the months of February–April, but during that period it is not possible to meet the demand. Sweet potatoes, therefore, must be harvested before mid-December, and stored for several months.

Curing of sweet potatoes is a standard procedure prior to storage (3,4,6,12). In this procedure, wounds caused during harvest form layers of subarized and lignified cells, which protect the tubers against pathogen penetration (11). Iprodione is a common fungicide used for control of postharvest vegetable decay (5,8).

For historical reasons, the sweet potato variety grown in Israel is 'Georgia Jet'. This variety is attractive and tasty, and therefore in great demand for export. However, it is susceptible to pathogens during storage because of its low level (16%) of dry matter (10), compared with higher dry matter content in other varieties such as 'Jewel' and 'Beauregard'

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(7,9). These varieties, therefore, have greater resistance than Georgia Jet to decay during storage. Curing, which almost entirely prevents decay when these drier varieties are stored, proved ineffective with Georgia Jet. Replacing Georgia Jet with a different variety is likely to take a few years, due to difficulties in acquiring propagative material, problems of adaptability to growth conditions in Israel, and possible unsuitability for export markets.

This work examined new methods of lessening decay and prolonging the storage of var. Georgia Jet sweet potatoes. Prolonging its storage by 3–4 months could increase its value for growers, and thus lead to the expansion of growing areas and the concomitant possibility of new growers entering this branch.

MATERIALS AND METHODS

Plant material

Four-month-old sweet potato (var. Georgia Jet) roots harvested from Kibbutz Alumim in the northern Negev, Israel, were used for the experiments. The roots were washed in water to remove sand and then dried. They were held in ventilated plastic bins of 500 kg each. Dipping of the bins was done in appropriate containers.

Treatments (Exp. 1)

Treatments were applied as follows: (i) Dipping of sweet potato roots for 10 sec in water (control). (ii) Dipping the roots for 10 sec in 0.1% (w/v) suspension of iprodione (Rovral 50 WP, Rhône-Poulenc, France). In all experiments, the concentration of the disinfectant is presented as percent active ingredients. The suspension was maintained by continuous internal circulation. (iii) Dipping the roots for 10 sec in water plus curing procedure (the roots were held for 5 days at 30°C and 92% r.h.). (iv) Dipping the roots for 10 sec in 0.1% iprodione plus curing procedure.

Iprodione applications (Exp. 2)

Three methods of applying iprodione were tested: (i) Dipping the roots for 10 sec (see above) in 0.1% suspension of iprodione. (ii) Spraying with 0.1% iprodione until run-off. Spraying the sweet potatoes was done on a conveyor belt after harvesting. (iii) Fogging of 1% iprodione with the Tabor Atomizing System (Plassim Industry Ltd., Kibbutz Merhavya, Israel). This technique is based on compressed air and water which produces very small droplets (3–7 μ) which have almost no mass. Droplets of such tiny size behave as a weightless gas. Fogging was done for the first 8 h in the same room in which curing took place. In order to establish a common denominator among the treatments, concentrations and time periods were calculated on the basis of approximately 20 g of iprodione per ton of treated roots. Spraying with water until run-off, and 8 h of fogging with water with the Tabor Atomizing System were used as appropriate controls. As above, half of the roots were cured (see the curing procedure in exp. 1) and half were stored after the treatments.

Storage

The roots were stored in cold rooms ($8 \times 8 \times 6$ m^3) with air circulation. Ventilated plastic bins of roots were arranged in the rooms as follows: Rows of six bins were placed in stacks, four bins high. Spaces 10 cm wide were left between rows in the direction of the airflow. Roots which did not undergo the curing procedure were stored immediately following the treatments. After the treatments, the sweet potato roots were stored at 13°C and 90% r.h. for 5 months. Percent decay was evaluated monthly. Examination of cell layer formation following the curing procedure was done with an Olympus BH-2 light microscope (11,12).

Statistical analysis

All experiments were conducted in a completely randomized design with five replicates for each treatment. A replicate included 500 kg of roots which were stored in ventilated plastic bins (one bin = 500 kg). Experiments were conducted three times and similar results were obtained each time.

RESULTS

Testing different treatments for prolonging storage of sweet potatoes (Exp. 1)

A comparison of the treatments (all treatments in this experiment were done by dipping) established that the most effective was curing in conjunction with iprodione disinfection (Table 1). Microscopic examination showed that initial closing of wounds in cells of the periderm occurred within the first 24–36 h of the curing process. By the fourth day of curing, two or three additional layers of cells were formed. The general level of decay with this combined treatment, after 5 months of storage, was 14%: 9% with soft decay, which had to be discarded, and 5% with dry decay, which could still be marketed locally. The level of total decay in the iprodione and curing treatments, also after 5 months of storage, was 60% and 61%, respectively. In the non-treated control, the level of decay after this period of storage was 100%.

TABLE 1. Percent[z] decay of sweet potato roots (var. Georgia Jet) following different treatments, during 5 months of storage at 13°C and 90% r.h.

Treatment	Dry decay (%)					Soft decay (%)				
	Months in storage									
	1	2	3	4	5	1	2	3	4	5
Control	14	22	29	32	32	32	46	63	66	68
Curing	9	15	19	21	26	13	17	23	28	35
Iprodione	10	13	22	22	29	17	21	26	27	31
Curing + iprodione	3	4	4	5	5	2	3	5	5	9
$LSD_{0.05}$ (ANOVA)	2	2	3	2	4	3	4	4	3	5

[z]Data are means of five replicates. Each replicate included 500 kg of roots in a plastic bin.

The necessary length of storage for sweet potatoes in Israel for export purposes is approximately 3 months. General decay level at the end of this period, after the combined treatment, was 9% (Table 1). Isolates taken from decayed areas indicated that the decay was caused by *Rhizopus* spp. and *Fusarium* spp. *Fusarium* was isolated from dry decay and *Rhizopus* from areas of softer decay. Dry decay was defined as relatively light, dry decay, 1 mm in depth. The color of this decay is gray, and it covers 2–25% of the root. Often, roots with dry decay may be sold on the local market. Soft decay is defined as soft and wet, and dark in color; it covers most of the root and makes it unusable.

Testing different applications of the disinfectant iprodione (Exp. 2)

The goal of this experiment was to determine which if any of three methods tested (dipping, spraying, and fogging) would best prevent decay of stored sweet potatoes. The first experiment involved only dipping, and produced good results. However, dipping is a difficult and clumsy procedure, especially when dealing with large quantities of sweet potatoes. Spraying the sweet potatoes on a conveyor belt during the sorting and packing process is easier, but still awkward and involves the danger of exposing the packers to the spray. Disinfection by fogging is, by contrast, easy to implement and conducted in a closed room, thus eliminating danger to the workers.

In general, disinfection in conjunction with curing was more effective in preventing decay than disinfection alone. There were no great differences in effectiveness among the various methods of applying iprodione. After 3 months of storage, the decrease in levels of decay was 5% following a combined treatment of curing plus application of iprodione by fogging. Curing plus dipping in iprodione resulted in 8% decay, whereas curing plus spraying resulted in 6% decay (Table 2). The general level of decay after 3 months was 60–70% in the control (treatment with water) group without curing, and 28–36% with curing. The level of iprodione residues in the outer 1–2 mm of the roots was 2 ppm following dipping or spraying, as compared with 0.09 ppm following fogging.

TABLE 2. Percent[z] decay of sweet potato roots (var. Georgia Jet), cured and not cured, following different iprodione applications, during 5 months of storage at 13°C and 90% r.h.

Treatment	Dry decay (%)					Soft decay (%)				
	Months in storage									
	1	2	3	4	5	1	2	3	4	5
Without curing										
Dipping in water	17	18	2	26	29	25	32	47	59	70
Dipping in 0.1% iprodione	7	10	16	20	24	13	16	20	33	40
Spraying with water	15	20	25	28	33	28	36	44	63	67
Spraying with 0.1% iprodione	5	8	14	23	23	13	14	22	27	36
Fogging with water	13	16	21	26	30	23	30	41	56	70
Fogging with 1% iprodione	5	10	10	14	17	10	13	17	24	33
With curing										
Dipping in 0.1% iprodione	2	3	3	4	4	3	3	5	6	10
Spraying with water	8	13	14	23	26	12	17	22	28	33
Spraying with 0.1% iprodione	3	3	3	5	5	2	3	3	5	8
Fogging with water	7	10	12	17	21	9	12	16	26	30
Fogging with 1% iprodione	1	2	2	3	4	1	1	3	3	6
$LSD_{0.05}$ (ANOVA)	2	2	3	4	4	2	3	3	4	4

[z]Data are means of five replicates. Each replicate included 500 kg of roots in a plastic bin.

Storing var. Georgia Jet roots without washing after harvesting, treated or not treated with iprodione applied as described above, resulted in a higher level of decay as compared with washed roots (unpublished), probably because of the high susceptibility of this variety to soilborne pathogens.

DISCUSSION

This study indicated that it is possible to prolong storage of sweet potatoes var. Georgia Jet with minimal waste. The method is based on disinfection with iprodione combined with a curing treatment. Its success can be explained in the following manner: Disinfection with iprodione protects the roots during the first days of storage after gathering, before injuries have had a chance to form a protective layer of suberin (initial closing of wounds takes 24–36 h), whereas the curing process provides continued protection against pathogens causing decay (11). Curing alone is not sufficient for this variety, since during the first several days before periderm production takes place, pathogens, particularly *Rhizopus* spp., may penetrate through the wounds. Iprodione treatment prevents this, but alone is not sufficient, since it offers incomplete protection against *Fusarium* spp. The combined treatment protects the roots against both *Rhizopus* spp. and *Fusarium* spp. In fact, it is possible to store other sweet potato cultivars for half a year, and even longer, using curing alone (7).

The second experiment showed that it is possible to apply iprodione by dipping, spraying or fogging. However, the fogging method has particular benefits when utilizing the Tabor Atomizing System. The droplet size produced by this fogger is less than 10 μ with minimal mass, and leaves no condensation on the roots. This fogger produces a sort of 'dry cloud' containing disinfectant, which covers the roots without wetting them. This reduces the number of pathogens which could develop on wet roots. The other application methods (dipping and spraying) caused the roots to become wet during treatment.

The success of these experiments in prolonging sweet potato var. Georgia Jet storage by means of a combined treatment of curing plus iprodione disinfection, has led to the recommendation in Israel to follow this procedure for Georgia Jet roots intended for storage.

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