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Pesticides Increase True Seed Production of Sweet Potato[1]

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Abstract. **Application of systemic fungicides to sweet potato (*Ipomoea batatas* (L.) Lam.) increased the total number of healthy seed harvested 50% by increasing pod set, number of seed per pod and the proportion of healthy seed. Insecticides aldicarb and naled gave dramatic responses and increased the number of seedlings obtained per parent plant 2- to 5-fold. Insect damage appeared to be an important cause of low seed set and low seed quality in sweet potato.**

Historically, sweet potato breeding programs have been hampered by poor flowering and low true seed production (6). In our program, profuse flowering was achieved through intensive breeding (5), and sterility and incompatibility problems were largely circumvented through use of open-pollination (4). However, even in our recently developed mass selection populations that flower profusely, only about 0.3 seed of a maximum 4 is set per flower. In comparison to most other plant species, this is very low fecundity. In some years we have also experienced poor seed quality resulting in low germination (25-30%).

Research to identify specific pathogens involved in seed set problems of sweet potato has been limited (1, 2, 3). Jones (1) observed microcytes and other disruptions of the tetrad stage of pollen mother cells. Cultivar differences occurred, but the severity of expression was similar from one year to the next. *Fusarium moniliforme* Sheldon was repeatedly isolated from anthers in all stages of development. However, a plant free of the fungus was not obtained to test pollen mother cell development in the absence of the problem. In a later study (2), trellised plants with flowers held well above the ground had much lower frequencies of microcytes than non-trellised plants where flowers were close to the ground and in more dense foliage. An environmental effect was therefore apparent. In the trellised plants no correlation between microcytes and seed set was demonstrated. A later attempt to increase seed set by the application of protective fungicides failed (3). The most frequently isolated microorganism was *F. moniliforme,* although other fungi were isolated from floral parts.

Because of the severity of the seed production problem in our local environment, we have continued to study the efficacy of various pesticides for improving seed yield and quality. We report here the results from 3 experiments involving several commercially available pesticides.

Because *F. moniliforme* is systemic (3), we tested the effectiveness of 4 fungicides with systemic action on 2 breeding lines known to have high seed set (H/3-50 and W/3-100). The experimental design was a randomized complete block with 5 treatments and 3 replications consisting of 5 trellised plants of each breeding line per treatment. The test materials and application rates were: Thiophanate-methyl, dimethyl ((1,2-phenylene)bis(iminocarbonothioyl))=bis(carbamate), at 1000 ppm active ingredient (a.i.); a combination of benomyl, methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate), and thiram, bis(dimethyl-thiocarbamoyl) disulfide, at 1000 ppm a.i. of each; benomyl alone at 1200 ppm a.i.; thiabendazole, 2-(4-thiazolyl)=benzimidazole, at 2000 ppm a.i.; and water as the control. Treatments were applied to the plants to the point of run-off with a garden sprayer at weekly intervals for a period of 8 weeks during the summer when flowering was abundant. The percentage of pod set was determined by tagging flower buds and examining them 10 days later. Seed pods were harvested on 3 dates (Table 1). Seeds free of visible fungal growth were considered healthy.

Because responses to all treatments were essentially the same, they were averaged (Table 1). Seed production of H/3-50 showed a marked improvement from the fungicidal treatments. Total healthy seed set by H/3-50 more than doubled. The response in W/3-100 was positive but not as large as that in H/3-50, and total seed set was not significantly higher. In the control there was a clear trend for seed production to decrease with later harvest dates, and the treatments only partially offset that trend. When averaged over both cultivars the treatments improved all 4 measures of seed production and gave about a 50% increase in the number of healthy seed.

In 1973 we tested the effects of 2 pesticides on the polycross seed production of 30 breeding lines in 2 replications. Plants were set April 19 on 1 m spacing through black plastic mulch and were trellised. A 10% granular form of aldicarb, 2-methyl-2-(methylthio)-propionaldehyde *O*-(methylcarbamoyl)-oxime, was applied on July 11 at a rate of 4.473 kg/ha a.i. The material was divided and half was mixed with the soil to a depth of 15 cm at about 1 m on each side of the trellised plants. Naled, 1,2-dibromo-2,2-dichloroethyl dimethyl phosphate, at a rate of 1.121 kg/ha a.i. per application was applied as a foliar spray 8 times between July 13 and Sept. 12. Naled applications were made in the afternoons to minimize the destruction of insect pollinators. Seeds were harvested on August 15 and Oct. 25. After drying, the seeds were immersed in water containing a small amount of wetting agent; those that sank were considered healthy. The very low germination of samples of "floated" seeds confirmed that they were of low quality. Healthy seeds were scarified and seeded in greenhouse flats containing Jiffy mix, and emergence percentage and total seedlings were determined.

Both pesticides increased the total seedlings obtained from the polycross nursery (Table 2). Aldicarb was less effective in the late seed harvest, which

Table 1. Effect of systemic fungicides on true seed production of 2 sweet potato breeding lines in 1971.

Variable	Pod set (no.)		Healthy seed (no./pod)		Healthy seed (%)		Healthy seed (no.)	
	Treated[z]	Control	Treated[z]	Control	Treated[z]	Control	Treated[z]	Control
Breeding lines								
H/3-50	80b[y]	38c	0.66a	0.51bc	65a	50bc	59a	21b
W/3-100	134a	141a	0.56ab	0.42c	56ab	44c	68a	61a
Harvest dates[x]								
Sept. 24	123a	106ab	0.74a	0.59a	65ab	53bc	94a	65ab
Oct. 6	86ab	87ab	0.71a	0.41b	70a	49c	61ab	40bc
Nov. 19	112ab	76b	0.37b	0.38b	40cd	33d	36bc	18c
Year average	107a	90b	0.61A	0.47B	59A	46B	63A	41B

[z]Average of 4 systemic fungicidal treatments (see text).

[y]Mean separation within variable groups by Duncan's multiple range test 5% level (lower case), 1% level (upper case).

[x]Avg of both breeding lines at indicated dates.

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Table 2. Effects of aldicarb and naled treatments on sweet potato true seed production and seedling emergence, 1973.

Seed harvest dates	Healthy seed (%)			Healthy seed (no./parent plant)			Emergence (%)			Seedlings (no./parent plant)		
	Naled	Aldicarb	Control	Naled	Aldicarb	Control	Naled	Aldicarb	Control	Naled	Aldicarb	Control
August 15	42.9	48.5	38.2	16.6a	14.3ab	9.8abc	59.4ab	66.6a	60.8a	7.3a	7.0ab	4.6bc
Oct. 25	49.9	40.1	40.6	14.7ab	7.8bc	3.1c	65.9a	53.2bc	48.1c	7.7a	3.5cd	1.2d
Year total	46.4	44.3	39.4	31.3a	22.1ab	12.9b	62.6a	59.9ab	54.4b	15.0a	10.5b	5.8c

[z]Mean separation within variable groups within dates by Duncan's multiple range test, 5% level. (Lack of letters indicates no significance).

we attributed to a lack of sufficient residual activity by the single treatment early in the season. As noted in 1971 there was a trend for reduced no. of healthy seeds late in the season in the control plots. However, that trend was corrected by the naled treatments, which increased the no. of seedlings obtained from the late harvest about 6-fold and for the year about 2.5-fold. Apparently insect damage was a major cause of low seed production and quality.

In 1974 the pesticide test was repeated using the same formulations of aldicarb, naled and a combination fungicide made up on benomyl and thiram. Aldicarb was applied on July 2 and Sept. 10. Naled and the fungicide combination were applied 12 times at about weekly intervals between July 2 and Sept. 25. Thus, there were 5 treatments; naled, aldicarb, the fungicide combination, naled + fungicides, and the control. Two replications of plants were set on May 8, and seeds were harvested on August 12 and Nov. 19. Cultural practices were the same as those in previous tests. Methods of data collection were the same as those used in 1973 except that the proportions of healthy seeds were obtained from the late seed harvest only. Germination of 2760 floating seeds was only 0.6%, again confirming their low quality. Emergence data were obtained using samples of 100 healthy seeds composited from plants of each harvest date.

Both aldicarb and naled increased the proportions and total no. of healthy seeds produced (Table 3). Aldicarb appeared more effective in the early seed harvest; whereas, naled was more effective late in the season. No response from the fungicide treatment was demonstrated. Improvements in the no. of polycross seedlings obtained with aldicarb or naled was about 4- or 5-fold, probably due to the combined effect of higher set and better quality.

In this test the fungicide was not nearly as effective as the insecticides, but the difference may not be as great under other environmental conditions or where insects are less prevalent. Although the effectiveness of the fungicide was not statistically demonstrated in 1974, the 50% increase in seed production agrees closely with the 1971 test results and may be real. Certainly such an increase would be of real practical importance in a year of poor seed set. Results from 1971 (Table 1), when compared with the earlier 1968 test (3), suggest an advantage for fungicides with systemic action.

Polycross seed production in sweet potato is obviously influenced strongly by environment and the Charleston location may represent an extreme situation. Two replications of the 1974 polycross nursery were grown under better climatic conditions at Blackville, S. C., in cooperation with Dr. M. G. Hamilton of the South Carolina Agricultural Experiment Station. Seeds were harvested on Sept. 17 and Oct. 23. Total healthy seed production was 12 times that of the control plots at Charleston, and the proportion of healthy seeds was doubled. However, in the early harvest the number of healthy seeds was twice as much as that in the late harvest, and the proportion of healthy seeds was less (76 vs. 82%) in the late harvest than in the early. This pattern was similar to that observed at Charleston and may represent progressive seed production problems as pest populations increase during the season.

Based on the encouraging results from the previous tests, we applied aldicarb 4 times in 1975 to our mass selection seed increase nursery. The first treatment was pre-transplant and subsequent treatments followed at about monthly intervals and were applied as in 1974. In the previous 4 years healthy seed production per plant averaged 40. In 1975 plants averaged 203 healthy seeds each, for a 5-fold increase over the average of the previous 4 years.

We do not know what species of insects or other pests were affected, because no formal studies were conducted. On the basis of obvious differences in amounts of foliar injury, both of the treatments provided a high degree of control of the sweet potato flea beetle, *Chaetocnema confinus* Crotch, and leafhoppers, mostly *Empoasca* spp. However, neither of these are believed to be involved in seed damage. The most likely suspect is the southern green stinkbug *Nezara viridula* L. which was present in both adult and nymph stages in moderate numbers. Several species of Miridae were also present in low numbers and may have been responsible for some of the damage.

These preliminary tests were conducted to solve our local seed set and quality problems, but the results may be applicable to other localities. Although the precision of the 1973 and 1974 tests was not high, the close agreement of results from the 1974 test with those from the two earlier tests and the high seed set observed in 1975 increase our confidence that insects are an important cause of low seed set and low seed quality in sweet potato. A broad-spectrum insecticide increased polycross seedling production 5-fold under our environmental conditions.

Table 3. Effects of pesticide treatments on sweet potato true seed production and seedling emergence, 1974.

Trait and seed harvest dates	Treatment				
	Control	Fungicide	Aldicarb	Naled	Naled plus fungicide
Healthy seed (%)					
Nov. 19	32.8B[z]	30.7B	52.3A	49.5A	52.9A
Healthy seed (no./plant)					
August 12	14.7cd	7.5d	53.2b	19.6cd	23.7cd
Nov. 19	8.5cd	28.7cd	30.4c	68.6ab	76.3a
Year total	23.2B	36.2B	83.6A	88.2A	100.0A
Emergence (%)					
August 12	69.0b	69.5b	80.5ab	78.5ab	82.0ab
Nov. 19	76.0ab	72.0b	81.0ab	81.0ab	88.0a
Year total	72.5b	70.7b	80.7ab	79.7ab	85.0a
Seedlings (no./parent)					
August 12	8.6c	4.1c	34.2ab	12.4bc	16.2bc
Nov. 19	5.0c	16.4bc	19.7bc	46.2a	55.2a
Year total	6.8b	10.2b	26.9a	29.3a	35.7a

[z]Mean separation within rows by Duncan's multiple range test, 5% level (lower case), 1% level (upper case).

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Carotene Content of Sweet Potato (*Ipomoea batatas* Lam.) Roots as Affected by Various Nematicide Treatments[1]

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It has been reported (2, 3, 4) that the nematicides Nemagon and Telone C increased carotene content in carrots and sweet corn. Since the carotene content of sweet potatoes is important nutritionally, an attempt was made to extend the observations to this crop and to various nematicides.

The nematicides used and rates applied are presented in Table 1. All experimental plots were located at the Vegetable Research Farm near Salisbury, Maryland, on Norfolk sandy loam soil. The cultivar 'Centennial' was used in 1971; 'Centennial', 'Goldmar' and 'Nemagold' in 1972; 'Centennial' and 'Goldmar' in 1973 and 1975 and 'Centennial', 'Goldmar' and 'Jewel' in 1976. Treatments were replicated 7 times in 1971, 4 times in 1972, and 3 times in 1973, 1975 and 1976. All nematicides were applied 1–2 weeks before transplanting according to recommended procedures. All plots received fertilizer and irrigation according to recommended commercial practices and were harvested when judged to coincide with commercial harvests.

At harvest, a 10 root sample of No. 1 size roots was obtained from each plot and carotene estimated with a Hunter-Gardner color difference meter according to the procedure of Ahmed and Scott (1). Samples were prepared for measurement by two methods, either by cutting the root longitudinally and reading immediately or by blending 100 g of freshly peeled root with 100 ml of water to which 0.1 g of thiourea had been added.

None of the nematicides except Telone C in 1971 were effective in increasing carotene content (Table 1) according to an F test. Cultivar effects were significant at the 5% level in all years but there were no significant cultivar × treatment interactions. The increase in the Hunter "a" value resulting from the use of Telone C corresponds to approximately a 10% increase in carotene.

On the basis of these data it appears that only Telone C was effective in increasing carotene levels in sweet potatoes. It is unknown why Vorlex and DD which are closely related compounds were not effective.

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Table 1. Average Hunter "a" value of blended samples and half roots obtained from the several nematicide treatments.

Year	Nematicide[y]	Rate	Avg Hunter "a" value	
			Blend	Half root
1971	Telone C	73 l/ha	25.9*	27.5
	Telone C	104 l/ha	25.9*	26.8
	Control	--	24.4	26.4
1972	Nemacur 15G	6.8 kg a.i./ha	24.3	
	Mocap 10G	6.8 kg a.i./ha	23.1	
	Mocap 6EC	9 kg a.i./ha	23.2	
	Vorlex	65.5 l/ha	24.3	
	DD	187 l/ha	24.3	
	Control	--	24.3	
1973	DD	187 l/ha	30.8	34.1
	Mocap 10G	9 kg a.i./ha	29.1	33.7
	Mocap 6EC	9 kg a.i./ha	29.1	33.4
	Nemacur 3EC	6.8 kg a.i./ha	29.4	33.6
	Control	--	29.2	33.4
1975	Vorlex	65.5 l/ha	26.2	
	Mocap 6EC	9 kg a.i./ha	27.2	
	Mocap 10G	9 kg a.i./ha	28.2	
	Vydate 10G	6.8 kg a.i./ha	27.1	
	Nemacur 3EC	6.8 kg a.i./ha	27.7	
	K Azide 10G	22.4 kg a.i./ha	26.2	
	K Azide 10G	33.6 kg a.i./ha	28.4	
	Control	--	27.4	
1976	Vorlex	65.5 l/ha	26.0	
	NA 060	65.5 l/ha	28.2	
	NA 061	42 l/ha	26.9	
	NA 055	65.5 l/ha	27.0	
	Mocap 10G	6.8 kg a.i./ha	26.2	
	Telone II	112 l/ha	26.4	
	Furaden 109	6.8 kg a.i./ha	28.5	
	Nemacur 15G	4.8 kg a.i./ha	28.1	
	K Azide 10G	33.6 kg a.i./ha	26.5	
	Control	--	27.2	

[z]Chemical names and formulations are as follows: *Telone C* (1,3-Dichloropropene and related chlorinated hydrocarbons) 85%; chloropicrin (trichloronithromethane) 15%. *Nemacur* (Ethyl 3-methyl-4-(methylthio) phenyl (1-methyl-ethyl) phosphoramidate) formulated as 3EC. *Mocap* (0-Ethyl S, S, dipropyl phosphorodithioate) formulated as a 10% granular and 6EC. *Vorlex* (Methylisothiocynate), 20%; chlorinated C_3 hydrocarbons including dichloropropenes, dichloropropene, dichloropropane and related chlorinated hydrocarbons 80%. *DD* (1,3-Dichloropropene, 1-2, dichloropropane). *Vydate* (Methyl-N^1, N^1-dimethyl-N-[(methyl-carbamox)oxy]-1-thioxamimidate. *K Azide* (10% Potassium Azide). *Furadan* (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl-carbamate). *NA 055, NA 060* and *NA 061* are formulations of methylisothiocyanate produced by Nor-Am. *Telone II* (1,3-Dichloropropane and related chlorinated hydrocarbons) 92%.

*Significantly different from control (5%).

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