Effects of Incorporation Depth and Activated Carbon on Sweet Potato Response to Vernolate[1]

H. P. Wilson, B. Graves, and C. P. Savage, Jr.[2,3]
Virginia Truck and Ornamentals Research Station, Painter

Abstract. Incorporation of S-propyl dipropythiocarbamate (vernolate) to a depth of 5.0 cm in soil resulted in more vigor reduction of sweet potatoes [*Ipomoea batatas* (L.) Lam.] than incorporation to a depth of 10.0 to 12.5 cm. The initial plant response to vernolate by 'Nemagold' was greater than by either 'Julian' or 'Centennial'. Yields of all 3 cultivars were not affected by vernolate at the rate of 2.2 kg/ha, but yields were reduced at rates of 4.5 and 6.7 kg/ha. Activated carbon applied as a suspension in the transplant water protected sweet potatoes from vigor reductions at rates of vernolate up to 6.7 kg/ha. Dipping roots in a suspension of activated carbon prior to transplanting failed to protect sweet potatoes from vernolate injury.

Vernolate controls many annual broadleaf weeds, grasses, and nutsedge in sweet potatoes but researchers have reported crop tolerance varying from good to unacceptable (3, 5, 10, 11, 12, 14, 15). Injury has been manifested as growth inhibition, leaf darkening and necrosis, and stand reduction (3, 5, 10, 11, 15). Factors that have varied among these studies that might explain variable crop response to vernolate include soil characteristics, method and depth of incorporation into the soil, and cultivar.

Activated C root dips have protected various transplanted vegetable, fruit and ornamental plants from herbicide injury where the margin of safety was not adequate (1, 2, 4, 9, 13). Protection from 2-chloro-4,6-bis(ethylamino)-s-triazine (simazine) injury was obtained by dipping the roots of strawberry (*Frageria grandiflora* Ehrh.) plants in a slurry of activated C before transplanting (8); a suspension of activated C in the transplant water gave some protection against simazine injury but was less effective than the root dip. Arle (4) showed that an activated C root dip protected sweet potato sprouts from preemergence applications of (2,4-dichlorophenoxy)acetic acid (2,4-D). Koren et al. (6) showed that activated C had a high rate of adsorption of several thiocarbamate herbicides.

The purposes of this report were to elucidate the importance of cultivar and depth of vernolate incorporation in soil, on sweet potato tolerance to this herbicide and to determine if activated C would increase the margin of safety of vernolate on sweet potatoes.

Materials and Methods

Research was conducted at the Virginia Truck and Ornamentals Research Station, Painter, on a Sassafras sandy loam soil with an organic matter content of 1.2% and a pH of 5.5. Two experiments were conducted in 1969 and one in 1970.

Herbicides were applied to freshly tilled soil in late June at 500 L/ha and were incorporated immediately with a tractor-mounted power-driven rotary tiller. Sweet potato sprouts were planted in flat soil in rows 0.9 m apart. Plots were 2 rows wide by 6.1 m long. Soil moisture was adequate for good growth both years following transplanting. Weeds were removed by hoeing and cultivating to minimize effects on crop growth and yield. Ratings of treatment effects on crop vigor were made 4 or 5 weeks after transplanting using the scale 0 to 10 where 0 represents no effect and 10 represents complete kill. Roots were harvested in mid-October.

Effect of depth of vernolate incorporation on sweet potato cultivars. Vernolate was applied to the soil surface at rates of 0, 2.2, 4.5 and 6.7 kg/ha in each of 2 adjacent locations in the same field in 1969. Incorporation at 1 location was to a depth of 5 cm and at the other, to a depth of 10.0 to 12.5 cm. Following vernolate incorporation, 'Nemagold', 'Julian' and 'Centennial' sprouts were transplanted with a commercial transplanter. The experimental design consisted of a randomized complete block with 4 replications; treatment combinations were factorial with depths being handled as locations. Error mean squares in analyses of variance were homogeneous and permitted combining the data over locations and analyzing for effects of incorporation depth.

Activated C study. This study was conducted in both 1969 and 1970 using the cv. Nemagold. The experimental design used was a 4 replicate, randomized complete block with factorial treatment combinations. Four vernolate rates (0, 2.2, 4.5, and 6.7 kg/ha) were studied in all combinations with 3 activated C (Gro-Safe[4]) treatments. The C treatments were as follows: 1) no C, 2) roots and lower portion of stems dipped in a C suspension (0.45 kg of C in 7.6 L of water) prior to transplanting, and 3) sprouts watered with a C suspension (235 ml of 1.35 kg of C in 37.8 L of water) at time of transplanting.

Following incorporation of vernolate to a depth of 7.5 cm, the sprouts were transplanted by hand. All sprouts received either 235 ml of water or C suspension at transplanting.

Results and Discussion

Effect of depth of vernolate incorporation on sweet potato cultivars. Depth of vernolate incorporation affected sweet potato vigor with most injury resulting from shallow incorporation. Averaged over vernolate rates and sweet potato cultivars, vigor ratings were 2.7 for the 5.0 cm depth of incorporation and 1.9 for the 10.0 to 12.5 cm depth. With shallow incorporation, most sweet potato roots would have been below the zone of vernolate in the soil and the herbicide would have been concentrated around the lower portion of sweet potato stems. These results would agree with those for (S-ethyl dipropythiocarbamate) EPTC which show that shoot uptake is greater than root uptake (7).

Vernolate interacted with sweet potato cultivars in its effect on crop vigor (Table 1). Vigor was not affected by 2.4 kg/ha but was decreased by the 4.5 and 6.7 kg/ha rates of vernolate on all cultivars. Injury from 6.7 kg/ha vernolate was greater on 'Nemagold' than on 'Julian' or 'Centennial'.

Notwithstanding that depth of vernolate incorporation influenced initial crop response, yields were not affected by incorporation depth. Since all cultivars responded similarly to vernolate with reference to yields, data on yield presented in

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[2]Plant Physiologist, Horticulturist, and Agricultural Research Assistant, respectively.

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[4]ICI America, Incorporated, Atlas Chemicals Division, Wilmington, Del.

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Table 1. Effect of vernolate on vigor 4 weeks after transplanting and yields of 3 cultivars of sweet potatoes in 1969.

Vernolate rate	Sweet potato vigor[z,y]			Yield[w]
	'Nemagold'	'Julian'	'Centennial'	
kg/ha)				(1000 kg/ha)
0	0.8 a[x]	0.8 a	0.6 a	26.4 a
2.2	1.5 a	0.8 a	0.8 a	25.2 a
4.5	4.6 b	2.7 b	2.2 b	22.2 b
6.7	7.1 c	3.8 b	2.8 b	20.6 b

[z]Data are averaged over 2 depths of incorporation and 4 replications.

[y]Scale: 0, no effect to 10, complete kill.

[x]Mean separation, within columns, by Duncan's new multiple range test at the 5% level.

[w]Data are averaged over 2 depths of incorporation, 3 cultivars and 4 replications.

Table 1 are averages for the 3 cultivars and both incorporation depths. Yields were not affected by 2.2 kg/ha vernolate but were significantly reduced by vernolate at 4.5 and 6.7 kg/ha indicating that initial vigor reductions from high rates were not outgrown.

Table 2. Effect of vernolate on vigor of 'Nemagold' sweet potatoes 4 weeks after transplanting in activated C study in 1969.[z]

Vernolate rate	Vigor[y]	Yield
(kg/ha)		(1000 kg/ha)
0	1.5 a[x]	17.6 a
2.2	1.7 a	17.9 a
4.5	2.6 a	17.0 a
6.7	4.8 b	12.6 b

[z]Data are averaged over 3 C treatments and 4 replications.

[y]Scale: 0, no effect to 10, complete kill.

[x]Mean separation, within columns, by Duncan's new multiple range test at the 5% level.

Table 3. Effect of activated C on vigor 4 weeks after transplanting and yields of 'Nemagold' sweet potatoes treated with vernolate in 1969.[z]

C treatment	Vigor[y]	Yield
		(1000 kg/ha)
0	3.4 b[x]	14.5 b
Root dip	2.7 b	16.1 b
Transplant suspension	1.7 a	18.4 a

[z]Data are averaged over 4 vernolate rates and 4 replications.

[y]Scale: 0, no effect to 10, complete kill.

[x]Mean separation, within columns, by Duncan's new multiple range test at the 5% level.

Activated C study. Vernolate and activated C independently influenced vigor and yields of sweet potatoes in 1969. The high rate of vernolate caused a significant reduction in crop vigor and

Table 4. Relationship between vernolate and activated C on vigor of 'Nemagold' sweet potatoes 5 weeks after transplanting in 1970.[z]

	Vigor[y]			
	Vernolate rate (kg/ha)			
Activated C	0	2.2	4.5	6.7
None	0.2 a[x]	0.8 a	4.1 b	6.1 b
Root dip	0.2 a	0.8 a	4.2 b	5.8 b
Transplant suspension	0.0 a	0.4 a	0.4 a	0.6 a

[z]Data are averages of 4 replications.

[y]Scale: 0, no effect to 10, complete kill.

[x]Mean separation, within columns, by Duncan's new multiple range test at the 5% level.

Table 5. Relationship between vernolate and activated C on yields of 'Nemagold' sweet potatoes in 1970.[z]

	Yield			
	Vernolate rate (kg/ha)			
Activated C	0	2.2	4.5	6.7
	(1000 kg/ha)			
None	17.4 a[y]	16.3 a	7.4 b	4.9 b
Root dip	18.3 a	15.6 a	9.2 b	6.9 b
Transplant suspension	19.1 a	15.1 a	16.7 a	12.3 a

[z]Data are averages of 4 replications.

[y]Mean separation, within columns, by Duncan's new multiple range test at the 5% level.

a subsequent reduction in yield (Table 2). Carbon provided protection against vernolate injury when applied in the transplant water but failed to provide protection when roots were dipped in a suspension prior to transplanting (Table 3).

In 1970, vernolate and activated C interacted in their effects on sweet potato vigor and yields (Tables 4 and 5). Injury was not observed at 2.2 kg/ha vernolate and no differences existed between C treatments. At the higher rates of vernolate, C in the transplant water reduced herbicide injury and effected higher yields than the root dip which had no effect. The root dip had no effect in injury or yields.

Mature roots harvested from plots receiving C in the transplant water were covered with C. This C would likely be difficult to remove by commercial washing and grading equipment and could make roots unacceptable for market.

During both years of the study, it is probable that transplant water removed much of the C that was applied as a root dip so that little C remained on sprouts after transplanting. If this C could be retained on the root during transplanting, it is conceivable that sufficient C would be present to protect sweet potatoes from vernolate injury. This is especially likely since sweet potatoes possess at least a marginal amount of tolerance to vernolate.

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