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Effects of Sodium Azide Soil Treatments on Quality of Vegetable Root Crops[1]

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Abstract. **Sodium azide (NaN_3) applied at 134.4 kg/ha as a soil fumigant did not drastically alter the quality of vegetable root crops grown on treated soil. Azide soil treatment had no influence on quality of beets (*Beta vulgaris* L.) or potatoes (*Solanum tuberosum* L.). Differences were noted in quality of turnips (*Brassica rapa* L.) during 1976; however, no differences were found during the 1977 growing season at 2 locations. Azide soil treatments resulted in differences in quality of carrots (*Daucus carota* L.). Some differences that occurred were beneficial such as increased size and carotenoid content of carrots.**

Azides have been proven to be good broad spectrum soil fumigants for vegetable crops resulting in increased yields of most crops tested (3, 4). Both sodium azide (NaN_3) and potassium azide (KN_3) were shown to be good soil fungicides, herbicides, seedicides, and nematicides for use in vegetable crops (4) and in tobacco beds (2) when used at proper rates of application. Constantin and Hernandez (1) reported that sweet potatoes grown on azide-treated soil were similar in quality and yield as those grown on non-treated soil. Rates used in that study were lower than rates required for soil fumigation.

This study was initiated in 1975 to determine the effects of soil treatment with azides on quality of selected vegetable root crops.

Materials and Methods

Field procedures, Charleston, S.C. During the 1976 growing season turnips, carrots and beets were grown on azide-treated soil at the Clemson Univ. Truck Crops Research Station at Charleston, S.C. The soil type was a Nosbig fine sandy loam (ph 5.6). Control and 134.4 kg/ha treatments were replicated 4 times in a randomized block design. Plots were 3.05 m wide by 12.2 m long with each individual plot being isolated from the others by a continuous ditch 20 cm deep and 30 cm wide around the perimeter of the plot. After hand raking dry NaN_3 granules were applied on Nov. 15, 1975, with a 60 cm Gandy Turf Tender followed by soil incorporation 5-10 cm deep in order to bring the NaN_3 in contact with moist soil for extraction and hydrolysis to hydrazoic acid (HN_3). Treated plots were covered with 2 ml polyethylene tarps for one week.

The same experimental procedures were duplicated for the 1977 growing season, with the exception that the azide was applied earlier, on Oct. 12, 1976.

During 1976 'Detroit Dark Red' beets and 'Danvers' carrots were planted on Jan. 6 and harvested on May 18, 1976. 'Purple Top White Globe' turnips were planted on Feb. 12 and harvested May 4, 1976. During the 1977 growing season 'Chantenay Long Core' carrots were planted Jan. 25 and harvested on May 30, 1977. 'Purple Top White Globe' turnips were planted on March 15 and harvested May 31, 1977.

Pendleton, S.C. 'Kennebec' potatoes and 'Purple Top White Globe' turnips were planted at the Clemson Horticultural Research Farm on a Wickham sandy loam soil (ph 6.2). The same treatments were used in this study as in the Charleston study. Plot size was 3.05 m wide and 4.6 m long and were isolated with a ditch as described above. The azide was applied on Oct. 5, 1976, and sprinkled with water due to low soil moisture before being tarped. Turnips were planted on March 21 and harvested on June 3; whereas, the potatoes were planted March 10 and harvested on May 20, 1977.

Lubbock, Texas. During the 1975 season 'Norgold' potatoes were grown near Lubbock on plots treated with 11.2 and 16.8 kg NaN_3/ha (30.5 cm band application) and compared to control plots. Four field replications were combined for quality determinations.

Laboratory procedures. After harvest, crops were brought to the Dept. of Horticulture, Louisiana State Univ. for quality analyses. Dry matter content of carrots, beets, turnips, and potatoes was determined by drying 10-14 g duplicate samples of grated tissue for 24 hr at 80°C. After drying, the duplicate dry matter samples were combined and ground in a Wiley mill (40 mesh screen) and submitted to the LSU Feed and Fertilizer Laboratory for AOAC fiber and protein analyses. On some of the crops, average wt per root or tuber was determined in 1977.

Carotenoid content of canned carrots was determined by extraction of duplicate 0.1 g grated tissue in 10 ml hexane. Optical density of the filtrate was determined at 440 mμ using a Beckman DBG spectrophotometer. Concentration of carotenoid pigment was determined from a β-carotene standard curve. Optical density of beet pigment was determined by extraction of duplicate 0.1 g grated tissue with 10 ml methanol-HCl (1%) filtered and diluted 1:1 by volume at 525 mμ.

Beets, carrots, and turnips were processed using standard canning procedures of lye peeling (ca. 10% NaOH), washing, trimming, slicing or dicing, filling and covering with a 2% hot brine, exhausting (center can temp of 82°C), sealing and retorting at 116°C for the recommended time for each crop. After cooling, samples were stored for 1-2 months before evaluation.

Firmness of canned beets, turnips, and carrots was determined by use of an FTC shear press using 150 or 200 g samples, 4 measurements per replication. Color and flavor of the canned products were evaluated by a 3-6 member taste test panel. Color and flavor were rated on a scale of 1 (best) to 10 (poorest). Flavor was evaluated on freshly harvested beets and turnips after boiling using the same rating scale.

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Specific gravity of potatoes was obtained in 1975 and 1977 by using a hydrometer developed by the Potato Chip Institute International which used 3.63 kg of potatoes. Potatoes were also sliced into 0.8–1.0 mm slices, washed in warm water for 1 min, and fried 3 min in vegetable oil at 190°C. Chip color was determined by a 3-member panel using the Potato Chip Institute Color Reference Standard manufactured by B. L. Thomas & Assoc., Cincinnati, Ohio, and the Potato Chip Institute International. Ratings are on a scale of 1 (white) to 10 (dark brown). Potatoes were also cut into french fries and fried in vegetable oil at 190°C for 5½ min. Color of the fries was evaluated by the same panel using the USDA color standard for frozen french fries. Rating was on a scale of 0 (light) to 4 (dark brown). Four tubers from each plot were boiled for 1 hr, carefully peeled by hand and exposed to air for 2 hr to determine after cooking darkening (graying). Tuber color was rated by the same panel on a scale of 1 (free of "graying") to 5 (dark gray). During 1977 flavor of both chips and fries was evaluated by the same panel using a scale of 1 (good) to 10 (poor).

Results and Discussion

During 1976 season when beets were grown on azide-treated and non-treated soil, there were no significant effects of azide treatment on dry matter, protein, fiber and pigment contents, firmness, color and flavor of canned beets (Table 1). When fresh beets were boiled, those grown on azide-treated plots were rated better for flavor than those grown on non-treated soil.

Carrots grown on azide-treated soil in 1976 were lower in dry matter and higher in fiber content (dry wt basis) than those grown on the control plots (Table 2). Azide soil treatment had no influence on protein or fiber contents (fresh wt basis), firmness or color of canned, sliced carrots or color of the fresh carrots. Fresh boiled carrots from the control plots were rated better in flavor than the carrots from azide-treated plots. During the 1977 season there were no significant differences noted for dry matter, protein and fiber contents, firmness, color or flavor of the canned product due to azide soil treatment (Table 2). However, carrots grown on azide-treated soil were larger and had more carotenoid pigment than those grown on non-treated plots.

Turnips from non-treated plots in 1976 had higher dry matter, protein and fiber contents than turnips from azide plots during 1976 (Table 3). Azides had no influence on firmness of canned, diced turnips; however, the canned turnips from the azide plots were rated superior in flavor and color. During 1977 at Charleston and Pendleton, there were no differences in any of the quality variables evaluated on turnips (Table 3).

Irish potatoes grown on azide-treated soil during 1975 were similar in quality to those grown on control plots. Irish potatoes grown at Pendleton on treated and non-treated plots were similar in all quality variables studied (Table 4).

Some of the differences noted on turnips and carrots during 1976 could be possibly attributed to late azide application which requires warm temperatures for dissipation. Slight stand reduction of turnips and carrots did occur in the azide plots, probably resulting in less "in-row" competition. However, these differences were not large. During the 1977 season, thinning to a uniform stand was practiced. Small differences were noted on carrots for increased size and color due to azides. The data from this study suggest that azides could be used for soil fumigation without altering the quality of root crops grown on treated soil.

Table 1. Effects of NaN_3 soil treatment on quality of beets, Charleston, 1976.

Treatments	Dry matter (%)	Color (O.D.)	Protein (%)		Fiber (%)		Taste test[z]			Firmness	
							Fresh	Canned			
			Fresh wt	Dry wt	Fresh wt	Dry wt	Flavor	Color	Flavor	kg/cm^2	psi
Control	12.88	.25	1.22	9.4	.69	5.4	5.8	6.1	5.8	7.18	102.6
NaN_3 (134.4 kg/ha)	12.05	.27	1.48	12.3	.66	5.5	4.9	6.3	4.8	7.22	103.2
Significance level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	5%	N.S.	N.S.	N.S.	N.S.

[z]Scale of 1 (best) to 10 (poorest).

Table 2. Effects of NaN_3 soil treatment on quality of carrots, Charleston, 1976-77.

Year	Treatments	Avg wt/ root (g)	Dry matter (%)	Carotenoids (mg/100 g)	Protein (%)		Fiber (%)		Firmness		Taste test[z]	
					Fresh wt	Dry wt	Fresh wt	Dry wt	kg/cm^2	psi	Color	Flavor
1976	Control	–	12.50	7.5	1.06	8.2	1.18	9.4	3.39	48.4	2.8	3.1
	NaN_3 (134.4 kg/ha)	–	11.48	9.2	1.01	8.8	1.14	9.9	3.19	45.4	2.6	4.1
	Significance level	–	1%	N.S.	N.S.	N.S.	N.S.	5%	N.S.	N.S.	N.S.	5%
1977	Control	34.5	12.05	1.1	1.39	11.7	.59	4.9	2.09	29.8	5.5	6.4
	NaN_3 (134.4 kg/ha)	58.1	11.72	3.8	1.44	12.3	.58	5.0	1.92	27.5	6.1	5.6
	Significance level	5%	N.S.	1%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

[z]Scale of 1 (best) to 10 (poorest).

Table 3. Effects of NaN_3 soil treatment on quality of turnips, 1976-77.

Year	Treatments	Avg wt/ root (g)	Dry matter (%)	Protein (%)		Fiber (%)		Taste test[z]				Firmness	
								Fresh		Canned			
				Fresh wt	Dry wt	Fresh wt	Dry wt	Color	Flavor	Color	Flavor	kg/cm^2	psi
	Charleston												
1976	Control	104.2	8.41	.95	11.4	.78	9.2	–	–	5.7	6.3	2.85	40.7
	NaN_3 (134.4 kg/ha)	95.7	8.16	.53	6.5	.88	10.7	–	–	2.0	4.6	3.32	47.4
	Significance level	N.S.	5%	1%	1%	1%	1%	–	–	5%	5%	N.S.	N.S.
	Charleston												
1977	Control	189.3	8.78	1.02	11.7	.50	5.7	3.4	3.8	5.7	5.8	1.78	25.4
	NaN_3 (134.4 kg/ha)	173.2	8.03	.89	11.1	.47	5.9	4.0	4.2	5.8	5.6	2.00	28.6
	Significance level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	Pendelton												
1977	Control	192.8	9.04	1.03	11.4	.97	10.7	4.1	5.1	6.1	6.3	2.23	31.8
	NaN_3 (134.4 kg/ha)	193.8	9.17	.89	12.5	1.04	11.3	4.7	5.2	5.6	7.1	2.09	29.8
	Significance level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

[z]Scale of 1 (best) to 10 (poorest).

Table 4. Effects of NaN_3 soil treatments on quality of potatoes, 1975 & 1977, (no significant differences).

Year	Treatments	Avg wt/ tuber (g)	Dry matter (%)	Specific gravity	After cooking darkening[z]	Protein (%)		Fiber (%)		Chips[y]		French fries[x]	
						Fresh wt	Dry wt	Fresh wt	Dry wt	Color	Taste	Color	Taste
	Lubbock												
1975	Control	–	15.5	1.060	1.5	–	–	–	–	7.3	–	3.3	–
	NaN_3 (11.2 kg/ha)	–	16.4	1.064	1.5	–	–	–	–	7.3	–	3.3	–
	(16.8 kg/ha)	–	16.4	1.064	1.5	–	–	–	–	7.8	–	3.3	–
	Pendleton												
1977	Control	106.7	17.9	1.063	1.6	2.27	12.7	.43	2.4	2.6	3.57	1.13	4.31
	NaN_3 (134.4 kg/ha)	112.1	17.8	1.064	1.5	2.35	12.9	.42	2.4	3.0	4.07	0.44	3.63

[z]Scale of 1 (white) to 5 (dark gray).

[y]Scale of 1 (lightest) to 10 (darkest).

[x]Scale of 0 (lightest) to 4 (darkest).

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