with resistance to *Rhizoctonia solani* in *Phaseolus vulgaris. Phytopathology* 66:342-345.
13. Statler, G. D. 1970. Resistance of bean plants to *Fusarium solani F. phaseoli. Plant Dis. Rptr.* 54:698-699.
14. Wallace, D. H. and R. E. Wilkinson. 1965. Breeding for *Fusarium* root rot resistance in beans. *Phytopathology* 55:1227-1231.
15. ________ and ________. 1975. Breeding for resistance in dicotyledonous plants to root rot fungi. *In* G. W. Bruehl, (ed.) Biology and control of soil-borne plant pathogens. American Phytopathological Society. St. Paul, Minnesota.
16. Warner, J. N. 1952. A method for estimating heritability. *Agron. J.* 44:427-430.
17. York, D., M. H. Dickson, and G. A. Abawi. 1977. Inheritance of resistance to seed decay and pre-emergence damping-off caused by *Pythium ultimum* Trow. in snap beans. *Plant Dis. Rptr.* (in press).

J. Amer. Soc. Hort. Sci. 102(4):377–379. 1977.

Azide as a Broadspectrum Soil Treatment for Vegetable Crops[1]

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Additional index words. soil fumigation, weed control, nematode control, nutsedge, *Cyperus esculentus*

Abstract. **Azide as NaN_3 or KN_3 impregnated on clay granules gave excellent control of yellow nutsedge (*Cyperus esculentus* L.) compared to methyl isothiocyanate combined with chlorinated C_3 hydrocarbons (Vorlex) or a non-hand weeded control. Nematode control was obtained with all treatments. Significant yield responses from the use of azide were obtained with all crops.**

Salts of azide have been known for about 75 years. Azide has been investigated as a nitrogen source, an explosive, and a biologically active agent. In the ealy 1950's, Hill, Klingman, and Woltz (6) reported that azide was potentially useful as a nematicide, fungicide, and herbicide for tobacco plant beds.

In 1957 Bradbury et al. (3) obtained excellent control of late season infestations of nematodes with sodium azide (NaN_3) placed in the planting zone. They also observed that the nematicidal activity of azides increased progressively with decreasing pH. Adams et al. (1) conducted studies *in vitro* which demonstrated that hydrazoic acid (HN_3) is biologically active below pH 5.5 to 6.0 and inactive at values above 6.0 to 6.5 for reducing growth of *Sclerotinia sclerotiorum* and *Rhizoctonia solani.* When Adams adjusted pH in soil, pH had little or no effect on quantities of potassium azide (KN_3) required to obtain 50% reduction of *S. sclerotiorum* or *R. solani.*

Weaver (13) reported control of *Cylindrocladium floridanum* in artificially infested soils with KN_3. He suggested KN_3 is potentially useful for control of many soil borne pathogens.

Soil pH is one of the most important factors in determining the movement and biological activity of azide (2). Hydrolysis of azide salts to HN_3 (hydrazoic acid), the form of azide which volatilizes and moves within the soil as a vapor, occurs rapidly in an acid environment and is inhibited by alkaline conditions, thus giving greater biocidal activity and movement in acid soils. Likewise, soil moisture influences movement of azide vapors and consequently its biological activity. NaN_3 is water soluble to 40 g/100 ml in water; therefore, high soil moisture greatly restricts azide vapor movement, even in an acid environment, however, both HN_3 and NaN_3 are readily leached. Thus, the importance of thorough mixing of azide with soil for optimum biological activity is apparent (6, 8). Soil moisture content optimum for seed germination is also considered optimum for azide fumigation. Parochetti and Warren (8) showed that 30% of the azide was lost from air dry soil surfaces at pH 6.0 in 4 hr, whereas, only 5% was lost during the same period at pH 8.3. At field capacity losses from soil surface at pH 6.0 and 8.3 were 20 and 3% respectively. Additional studies by Ketchersid and Merkle (7) confirmed that dissipation from alkaline soil was much slower than from acid soil and that dissipation was reduced by higher moisture conditions.

In 1953, Hill et al. (6) reported that sodium azide killed bermudagrass (*Cynodon dactylon* (L.) Pers.) and many germinating weed seeds in tobacco plant beds. Danielson (5), working with soils having a pH of 6.2, controlled mugwort (*Artemisia vulgaris* L.) with potassium and sodium azide at 56 kg/ha rates of azide ion. He also showed that azide vapors released from the soil surface were toxic to exposed mugwort plants.

Parochetti and Warren (8) reported control of various weeds with KN_3 at rates of 112, 224 and 448 kg/ha when soil incorporated and covered with polyethylene film in a silt loam soil having a pH of 5.9. They reported a half life of 2 to 3 days for non-covered plots and 6 to 7 days in polyethylene covered plots. When soil pH was adjusted to 7.3, no diffusion of azide in the soil occurred, but diffusion was demonstrated at pH 5.4 and 6.0.

In 1969, Skroch and Monaco (9) reported control of some annual grasses, some broadleaves, and yellow nutsedge (*Cyperus esculentus* L.) with 84 kg/ha azide ion on the soil surface under plastic in a Norfolk sandy loam. Skroch et al. (10, 11) found that weed control with azide 84 kg/ha soil incorporated 5 cm (2 inches) and tarped under plastic was equivalent to that obtained from treatment with 269 kg/ha methyl bromide soil injected and tarped. Increases in tomato yield were associated with azide treatment.

This study was initiated to test the relative effectiveness of KN_3, NaN_3, and Vorlex (methyl isothiocyanate combined with chlorinated C_3 hydrocarbons) as preplant soil treatments to control weeds, nematodes, and soil-borne pathogens in long-season vegetable production.

[1]Received for publication October 30, 1976. Paper No. 5099 of the Journal Series of North Carolina Agricultural Experiment Station, Raleigh, North Carolina. The use of trade names in this publication does not imply endorsement by the North Carolina Experiment Station of the products named or criticism of similar ones not mentioned.

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Materials and Methods

This experiment was located on a sandy loam soil with 2.6% organic matter and pH 6.2. The site had been in vegetable crops for many years and was heavily infested with yellow nutsedge.

The experimental design was randomized split blocks with 4 replications. Azide rates were the whole plots while vegetable crops were the sub-plots. Prior to treatment, soil fertility was adjusted to 80 ppm of P and 150 ppm of K for the entire test area based on North Carolina soil extraction procedure. Plots 6.1 by 15.25 m were treated with 56 and 84 kg/ha of azide equivalent as NaN_3 or 84 kg/ha as KN_3 on Sept. 15. NaN_3 (8%) and KN_3 (10%) granules on attapulgite clay were broadcast on the soil surface and disked into a surface layer 15 cm deep. "Vorlex" was injected 15 cm deep at 468 liters/ha in the row using 2 chisels 30 cm apart. A bedding disk was used in all plots following treatment to form beds 30 cm high by 81 cm wide. Soil temp at 15 cm below bed surface was 22.5°C at time of treatment. Five 15.25 m rows were formed in each main plot. In March the following spring, a lettuce bioassay was used to determine if any Vorlex or azide residue was present in the soil (Charles M. Gates, Nor-Am, Agri. Products, Inc., personal communication). A few weeks later, on April 15, 2.5 cm of soil was scraped from the top of rows leaving a raised or ridged row as described by Turner et al. (12).

The center 7.5 m of each of the 5 raised rows in each plot were planted with either potato seed pieces (*Solanum tuberosum* L. cv. Sebago), tomato transplants (*Lycopersicon esculentum* Mill. cv. Manapal), pepper transplants (*Capsicum annuum* L. Var. *grossum* Bailey cv. Yolo Wonder), pole bean seed (*Phaseolus vulgaris* L. cv. Dade) or cucumber seed (*Cucumis sativa* L. cv. High Mark II). Potatoes were planted on April 15 while the remaining crops were planted on May 24. Tomatoes, pole beans, and cucumbers were trellised following planting and recommended cultural practices were followed for all crops including between row cultivation as needed.

Ten weeks after planting, on June 27 and 8 weeks later on August 16, weed control was evaluated by counting numbers and species of weeds in 5 randomly selected 30.5 sq cm samples in each plot. Counts were made for yellow nutsedge, hairy galinsoga (*Galinsoga ciliata* (Raf.) Blacke), common lambsquarter (*Chenopodium album* L.) and annual grasses composed primarily of yellow foxtail (*Setaria lutescens* (Weigel) Hubb), and barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.).

Soil samples from the tomato and pole snap bean plots were collected a year after treatment on Sept. 19 for plant parasitic nematode assay. Samples consisted of 10 randomly selected cores (2.54 × 20.3 cm) taken 15 cm from the row centers. Cores within each plot were pooled and then analyzed by the "sugar flotation-sieving technique" with current methods used by the North Carolina State Univ. Research Nematology Laboratory (4). Both the actual nematode numbers (x) and transformation to log (x + 1) were used in the analysis of variance tests. Pole bean plants were pulled from the 7th, 14th, and 21st hill of each plot on June 26 and inspected for the presence of bean root rot. Four potato roots and stems from each plot were pulled and evaluated for disease on July 19.

Potatoes were harvested in Sept. Peppers were harvested six times, pole beans 5 times, tomatoes 10 times, and cucumbers 19 times during the growing season. Harvests for each crop were combined for analysis of total yield.

Results and Discussion

Significant yield responses from the use of azide were obtained with all crops (Table 1). Each of the 3 azide treatments increased yields of pole beans over the weedy control and Vorlex treatment. There was also a significant yield increase from the 84 kg/ha rate of NaN_3 and KN_3 over the 56 kg rate of NaN_3 for beans. The 84 kg/ha rate of either azide increased production of pepper and potato when compared with either the weedy check or Vorlex. Potassium azide at 84 kg/ha resulted in greater pepper yield than sodium azide at 56 kg/ha. All azide treatments resulted in greater cucumber production than the weedy check while potassium azide at 84 kg/ha had greater cucumber yield than Vorlex. Yield differences in tomato were obtained only with sodium azide at 84 kg/ha. Only peppers responded to the Vorlex treatment. Greatest yield benefits among all crops resulted from the use of higher rate of azide from both sources.

Weed counts taken in June and August were similar; therefore, analysis of weed population data were based on the August weed counts only. Reductions in weed numbers resulted with certain soil treatments (Table 2). Yellow nutsedge numbers were reduced over the weedy check and Vorlex by each azide treatment, whereas Vorlex was ineffective in controlling this weed. Hairy galinsoga was reduced by Vorlex and by sodium azide at both the 56 and 84 kg/ha rates. Common lambsquarter was effectively controlled by Vorlex and by the high rate (84 kg/ha) of azides but not by sodium azide at the lower application rate. All soil fumigation treatments reduced the grass weed population.

Number of lesion (*Pratylenchus* sp.) and stunt (*Tylenchorhynchus* sp.) nematodes were reduced by soil treatment with

Table 1. Yield of several vegetable crops as influenced by soil fumigants.

Treatment	Yield (kg/ha) Pole beans	Peppers	Trellised tomatoes	Trellised cucumbers	Potatoes
Weedy control	84200	16800	52500	56800	8100
Vorlex (374 liters/ha)	94900	79500	68300	100000	8500
NaN_3 (56 kg/ha)	130500	26200	70600	107000	16700
NaN_3 (84 kg/ha)	175400	48300	81400	143500	22600
KN_3 (84 kg/ha)	169600	97600	75100	147800	20800
LSD 5%	30200	3700	23100	44400	10700

Table 2. August weed densities eleven months after soil fumigation treatments.

Treatment	Weed (no./30.5 sq. cm) Yellow nutsedge	Hairy galinsoga	Common lambsquarter	Grass[z]
Weedy control	46	.58	.20	17.8
Vorlex (374 liters/ha)	52	.08	.02	2.1
NaN_3 (56 kg/ha)	15	.17	.11	3.6
NaN_3 (84 kg/ha)	12	.14	.01	.04
KN_3 (84 kg/ha)	9	.20	.02	.05
LSD 5%	16	.41	.11	12.6

[z]Predominant grasses present were yellow foxtail and barnyardgrass.

Table 3. Soil nematode populations 12 months after soil fumigation treatments in pole beans and tomato plots.[z]

Treatment	Pole beans			Trellised tomatoes		
	Lesion	Stunt	Spiral	Lesion	Stunt	Spiral
Weedy control	325	1162	56	162	619	269
Vorlex (374 liters/ha)	31	62	0	25	12	0
NaN_3 (56 kg/ha)	6	94	0	19	94	19
NaN_3 (84 kg/ha)	0	6	0	0	12	0
KN_3 (84 kg/ha)	0	12	0	0	0	12
LSD 5%	119	606	NS[y]	38	493	197

[z]Results presented correspond to actual nematode numbers (x). Conclusions were not altered by analysis of transformed data to log (x + 1).

[x]Results insignificant because of variability among check plots which ranged from 0 to 175 spiral nematodes per 500 cc of soil.

Vorlex and by all azide treatments compared to the weedy control in pole beans and tomatoes 12 months after treatment (Table 3). In addition, the numbers of spiral (*Helicotylenchus* sp.) nematodes was reduced by Vorlex and the azide treatments in the tomato plants. The presence of root knot (*Moloidogyne* sp.), stubby root (*Trichodorus* sp.), and lance (*Hoplolamus* sp.) nematodes was also determined but insufficient numbers were found to draw any conclusions.

Differences in root rot among treatments were not observed for beans or potatoes. No root rots, wilts, or other soil-borne diseases were detected to account for the differences observed in yields (Table 1).

Results obtained in this study have demonstrated the efficacy of azide as a herbicide, seedicide and nematicide for vegetable crops. Azide, particularly sodium azide at 84 kg/ha was the best overall fumigant treatment with regard to weed control and crop production. Nematode control with all azide treatments was not significantly different to that achieved with Vorlex at 374 1/ha.

Literature Cited

1. Adams, P. B., H. L. Warren, and C. J. Tate. 1971. Potassium azide: Fungicidal activity as affected by pH. *Plant Dis. Rptr.* 55:1077-1081.
2. Birchfield, W., J. F. Parr, and S. Smith. 1969. Nematicidal and fungicidal activity of potassium azide in liquid anhydrous ammonia. *Plant Dis. Rptr.* 53:923-926.
3. Bradbury, F. R., A. Campbell, C. W. Suckler, H. R. Jameson, and F. C. Peacock. 1957. The nematicidal properties of azides. *Ann. Appl. Bio.* 45:241-250.
4. Byrd, D. W., Jr., C. J. Nusbaum, and K. R. Barker. 1966. A rapid flotation-sieving technique for extracting nematodes from soil. *Plant Dis. Rptr.* 50:954-957.
5. Danielson, L. L. 1965. Herbicidal effects of sodium and potassium azides on mugwort. *Weeds* 13:96-98.
6. Hill, G. D., G. C. Klingman, and W. G. Woltz. 1953. Chemical weed control in tobacco plant beds. North Carolina Agr. Expt. Sta. Bul. 382.
7. Ketchersid, M. L. and M. G. Merkle. 1976. Dissipation and phytotoxicity of sodium azide in soil. *Weed Sci.* 24:312-315.
8. Parochetti, J. V. and G. F. Warren. 1970. Behavior of potassium azide in soil. *Weed Sci.* 18:555-560.
9. Skroch, W. A. and T. J. Monaco. 1969. Herbicidal value of soil fumigants. *Proc. Southern Weed Sci. Soc.* 22:230.
10. ______ and ______. 1972. Azide as a broadspectrum fumigant. *HortScience* 7:337.
11. ______, ______, and T. R. Konsler. 1971. Evaluation of broadspectrum fumigants for trellis tomatoes. *Proc. Southern Weed Sci. Soc.* 24:196.
12. Turner, G. O., A. S. Greathead, and N. C. Welch. 1974. Control of annual weed seeds with soil fumigants containing 1,3-dichloropropenes. *Down to Earth* 29:25-28.
13. Weaver, D. J. 1971. Control of *Cylindrocladium floridanum* with potassium azide in soil. *Plant Dis. Rptr.* 55:1094-1096.

J. Amer. Soc. Hort. Sci. 102(4):379–380. 1977.

Yield of Young Muscadine Grapes as Affected by Cane Pruning[1]

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Additional index words. Vitis rotundifolia

Abstract. **Ten cultivars of muscadine grape, *Vitis rotundifolia*, Michx., were pruned to canes (25 cm) or conventional 3-bud spurs. During the first 5 years of production, significant differences in yield for the cane method were obtained with 'Cowart', 'Higgins' and 'Hunt'. The yield of other cultivars was significantly increased in some years by cane pruning. Increased yield with cane pruning was correlated with vine size increase.**

The short spur method of pruning muscadine grapes where 2- or 3-bud bearing units are retained has been practiced for many years. Several researchers (1, 6, 7) noted that retaining less 1-year-old wood had been practiced with a great deal of success in experiments at the Georgia Experiment Station. Armstrong et al. (1) recommended the short spur method but suggested leaving uncut the small lateral canes that were shorter than 45.7 cm. Murphy et al. (4) recommended that the practice be modified to leave all canes 45.7 to 50.8 cm long following a season of heavy growth, but there was no experimental evidence presented to substantiate improved yields.

An experimental planting was made in 1969 to study the long-range effects of cane pruning on muscadine grape yield.

Methods and Materials

Vines of 10 muscadine grape cultivars (Table 1) were planted 6.1 m apart in 3.7 m rows and trained to a single wire trellis. Training consisted of a single main stem raised to a wire 1.5 m in height with an arm extended 3.05 m in each direction from the main stem to form the permanent framework of the vine. Vines received a 227 g per vine application of 8N–3.4P–8.8K fertilizer in March of 1970 and 1971. Beginning in 1972, the rate was increased to 454 g/vine annually of 10N–4.3P–8.3K fertilizer. After the vines had reached the trellis, weed growth in a 0.9 m area in the row was prevented with simazine and paraquat treatments. The row middles were mowed.

Differential pruning was initiated in 1970. A split-plot design was used with half of the vines pruned annually to 3 bud spurs and the remaining half pruned leaving canes with 9 buds (about 25 cm). An attempt was made to balance the number of buds left on the spur- and the cane-pruned vines by thinning the latter so that remaining laterals were spaced about 20 cm apart. There were 4 single vine replications. Yields were determined during the first 5 years of production. Vine size was determined by weighing the amount of cane prunings at the end of the 5th growing season.

Results and Discussion

The t-test was used to compare the means within each cultivar and year when the F value indicated significance (P = 5%), Table 1. A significant correlation between pruning wt and mean yield (r = 0.652, P = 5%) indicates that increase in yield with cane pruning is associated with larger vine size (Table 2). The more vigorous cultivars, 'Cowart', 'Higgins' and 'Hunt' had significant yield increases with cane pruning each year. The 5-year mean increase for these 3 cultivars was 69, 64, and 67%

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