

NEMATICIDAL AND HERBICIDAL PROPERTIES OF CALCIUM AND HYDROGEN CYANAMIDES

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ABSTRACT

A comparative study on the nematicidal and herbicidal properties of calcium cyanamide [CaNCN] and cyanamide [H₂NCN] was conducted with 2 greenhouse experiments. In an experiment with soil infested with the reniform nematode [*Rotylenchulus reniformis*] the chemicals were applied at doses of: 100 - 300 mgs/Kg soil in 50 mgs increments and the soil was covered with polyethylene mulch for 1 week before sampling for nematode analyses. The soil was then planted with soybean [*Glycine max*] and after 2 months the plants were removed, growth parameters were recorded and soil and root nematode populations determined. Reniform nematode populations were reduced by cyanamide much more than by treatments with the calcium salt. Data from the final soil samples evidenced increased numbers of beneficial microbivorous nematodes in response to cyanamide applications but no obvious pattern of response to calcium cyanamide treatments. Root populations of the reniform nematode were reduced by the highest cyanamide rate but were either unaffected or were increased [100 mg rate] by all other doses. Calcium cyanamide applications resulted in a steady and lineal increase in reniform nematodes in the roots in response to increasing rates. The chemicals were applied at rates of 200 - 600 mgs/Kg soil in a second greenhouse experiment with a soil artificially infested with yellow nutsedge [*Cyperus esculentus*]. The soil was covered as for the first experiment and weekly counts of weed populations were performed for 1 month. Both compounds failed to control nutsedge and had a stimulatory effect on the weed in response to applications in the range 200 - 500 mgs/Kg soil. Calcium cyanamide did not prove acceptable as an alternative to methyl bromide. Cyanamide has significant nematicidal activity and may be an attractive choice for combination with herbicides to develop alternatives to methyl bromide.

Key Words: soil fumigation, soil disinfection, fumigants, pest control, beneficial nematodes, selector compounds, integrated pest management.

INTRODUCTION

Calcium and hydrogen cyanamides are among the oldest chemicals used in Agriculture. Ca cyanamide [CaNCN; N≡CN=Ca] has been used as a nitrogenous fertilizer since 1905 and as a defoliant, herbicide and general purpose soil disinfestant since the 1920's [Martin, 1961]. Recently, Bourbos et al., 1997, proposed its use in combination with solarization for control of Fusarium disease in greenhouse cucumber. Ca cyanamide is manufactured by the interaction of atmospheric N₂ on calcium carbide [Martin, 1961]. It hydrolyzes in the presence of moisture to give Ca(OH)₂ and an acid salt Ca(HCN₂)₂ from which, in soil the cyanamide is converted to urea [Martin, 1961]. Continuous carbonation of Ca cyanamide in water results in Ca(OH)₂ and

formation of hydrogen cyanamide [H₂NCN] referred to as cyanamide [Merck, 1989]. Presently, cyanamide is used mostly as a plant growth regulator in the breaking dormancy of flower buds in apples and other fruit trees [Meister, 2003]. It is available in 50% aqueous solution and in pure solid form. Because of the lack of comparative data on the relative pest control properties of Ca and H cyanamides a greenhouse study was conducted to determine the relation of application rate to soil and efficacy of the chemicals against nematodes and weeds.

MATERIALS AND METHODS

A greenhouse study was conducted to compare the nematicidal and herbicidal properties of calcium and hydrogen cyanamide.

Nematicidal Properties. Activity of the compounds against the reniform nematode [*Rotylenchulus reniformis*] was evaluated with a sandy loam soil [pH 6.2; org. matter < 1.0%; C.E.C. < 10 meq/100 gms soil] from a cotton field naturally infested with the nematode. The soil was sifted [1 mm] and mixed 1:1 [v:v] with washed fine [< 1mm] siliceous sand; the mixture will be referred henceforth as soil. The soil was apportioned in 1 Kg amounts in 4L polyethylene bags [chicken bags] The compounds were applied directly to the soil in the bags at doses of: 100 - 300 mgs/Kg soil in 50 mgs increments. Calcium cyanamide [Aldrich, Milwaukee, WI] was delivered in solid form and cyanamide in a 50% [w/w] solution obtained from the same supplier. After delivery of the requisite dose of chemical the soil in each bag was shaken vigorously to obtain thorough mixing; the mixture was transferred to 1L 10-cm diam. plastic pots with a bottom consisting of vinyl covered glass fiber screen [1 mm mesh] overlaid by a Whatman No. 1 filter paper. The pots with treated soil and control were covered with a polyethylene bag [1 mil] held tightly to the pots' wall with a rubber band and were placed on a greenhouse bench. There were in the experiment 5 doses per compound and a control for a total of 11 treatments. Each treatment was represented in the experiment by 8 replications [pots]. Pot covers were removed 2-wks after treatment and a soil sample [100 cm³] was removed from each pot for nematological analyses with the "salad bowl" incubation technique [Rodriguez-Kabana & Pope, 1981]. The soil was then planted [5 seed/pot] with 'Young' soybean [*Glycine max*]. After 2 months soybean plants were removed, soil samples for nematological analyses were taken and plant growth parameters were recorded after careful washing of the plants. Roots were incubated over water for 72 hrs to determine nematode root populations with the same technique used for soil samples.

Herbicidal Activity. The herbicidal properties of the two compounds were compared in a second greenhouse experiment with a soil of similar texture and properties as the one used for the nematode experiment. The soil which had the normal mix of annual and broadleaf weed species but no nematode problems, was mixed with sand and was treated and handled in the manner describe for the first experiment. Prior to application of the chemicals 5 tubercles of yellow nutsedge [*Cyperus esculentus*] were added to each bag with soil and dispersed by shaking of the bag's contents. The chemicals were applied at rates of 200 - 600 mgs/Kg soil in 100 mg increments. Pots with treated soil were covered as in the first experiment and were removed 1 week after. The number and species of weeds in the pots were counted for a month at weekly intervals with the first count when the covers were removed. The number of replications per treatment were as in the first experiment.

Statistical Design and Analyses. Data from the nematode experiment were recorded on nematode populations, shoot height, and fresh weights of shoots and roots. Data from the herbicide experiment consisted of weed counts. A randomized complete block design was used in both experiments and all data were analyzed according to standard procedures for analyses of variance. Unless otherwise stated all differences referred to in the text were significant at $p \leq 0.05$. When F values were significant [$p \leq 0.05$] Fisher's Least Significant differences were calculated and included in the graphs for ease of interpretation.

RESULTS

Nematicidal Properties. Data from the experiment on nematicidal activities are presented in Figs. 1-3. Reniform nematode numbers in soil were reduced by cyanamide applications much more so than by treatments with the calcium salt [Fig. 1 A & C]. This difference was most evident at the final samples where calcium cyanamide had practically no effect on the nematode at any dose. Results from preplant analyses revealed a negative lineal pattern of reduction in numbers of beneficial microbivorous nematodes in response to increasing rates of the chemicals [Fig. 1B]. However, data from the final soil samples evidenced increased numbers of microbivorous nematodes in response to cyanamide applications while no obvious pattern of response to calcium cyanamide was observed [Fig. 1D]. For each application rate at the final sampling date numbers of microbivorous nematodes in soils treated with cyanamide were several-fold higher than the numbers in soils treated with calcium cyanamide.

Reniform nematode root populations were reduced by the highest cyanamide rate but were either unaffected or were increased [100 mg] by all the other doses [Fig. 2A]; calcium cyanamide applications resulted in a steady and lineal increase in reniform nematode numbers in response to increasing rates. Numbers of microbivorous nematodes in the roots were increased by cyanamide application ≥ 200 mgs/Kg soil [Fig. 2B]; calcium cyanamide treatments had little or no effect on populations of these nematodes.

Soybean plants from soils treated with cyanamide were taller and had heavier shoots and roots than those grown in soils with calcium cyanamide [Fig. 3A-C]. Cyanamide applications improved the height and weight of shoots in proportion to dosage; this was also true for root weights except for the highest rate which resulted in a sharp drop in weight. Calcium cyanamide increased shoot weights in a similar manner as cyanamide; however, it had no effect on shoot height and improved root weights only with the 200 and the 250 rates.

Herbicidal Activity. The predominant weed species in the pots was yellow nutsedge with small numbers of other weeds. Data recorded for this experiment are illustrated in Fig. 4A-B, for the 2-week and the 1-month readings. Both compounds failed to control nutsedge and had a stimulatory effect when applied in the range 200-500 mgs/Kg soil; this was particularly evident at the 1-month reading [Fig. 4B].

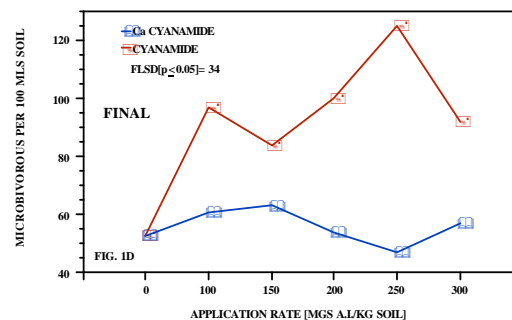
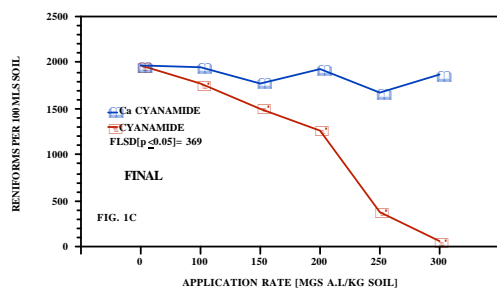
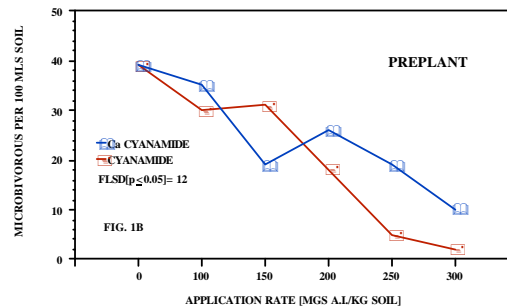
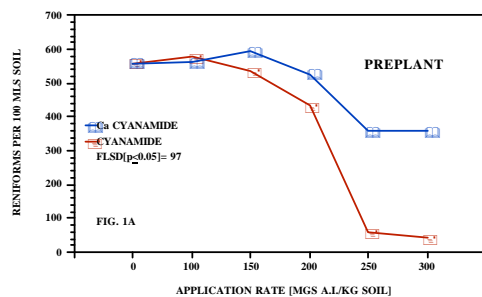
CONCLUSIONS

In contrast with calcium cyanamide, cyanamide demonstrated significant nematicidal activity against the reniform nematode. While both compounds initially decreased populations of beneficial microbivorous nematodes, numbers of these nematodes in cyanamide-treated soil were considerably higher than in control soils or in those with calcium cyanamide.

Calcium cyanamide did not prove to be an acceptable alternative to methyl bromide; it was neither a nematicide nor a herbicide. Failure of cyanamide to control yellow nutsedge, a major problem weed controlled by methyl bromide, suggests it should be used in combination with other chemicals to achieve broad-spectrum pest control. When it is considered that 1 mg/Kg soil is approximately equivalent to 2 Kgs/Ha and that current bulk price for cyanamide is \$1.00-2.00/lb, the compound is an attractive choice for combination with herbicides to develop alternatives to methyl bromide.

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Figures 1. Comparative activities of calcium cyanamide and cyanamide on soil nematode populations in a greenhouse experiment with soybean [*Glycine max*] in soil infested with the reniform nematode [*Rotylenchulus reniformis*]. A and B pre-plant nematode numbers; C and D numbers at the end of the experiment 2 months after planting.

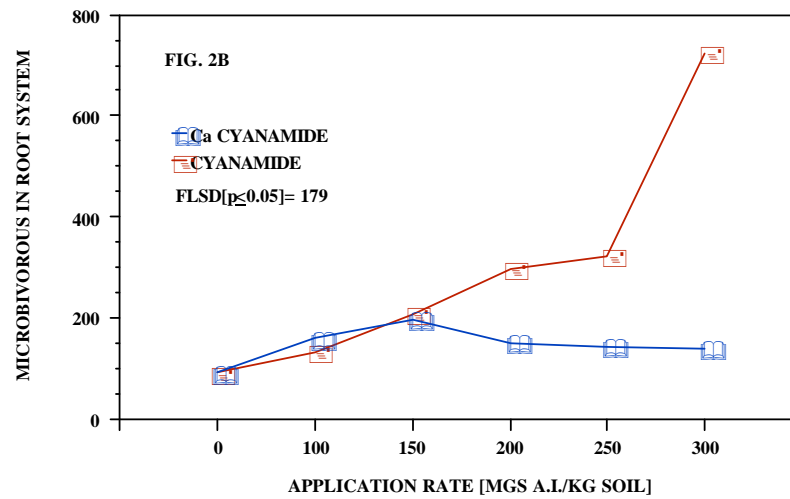
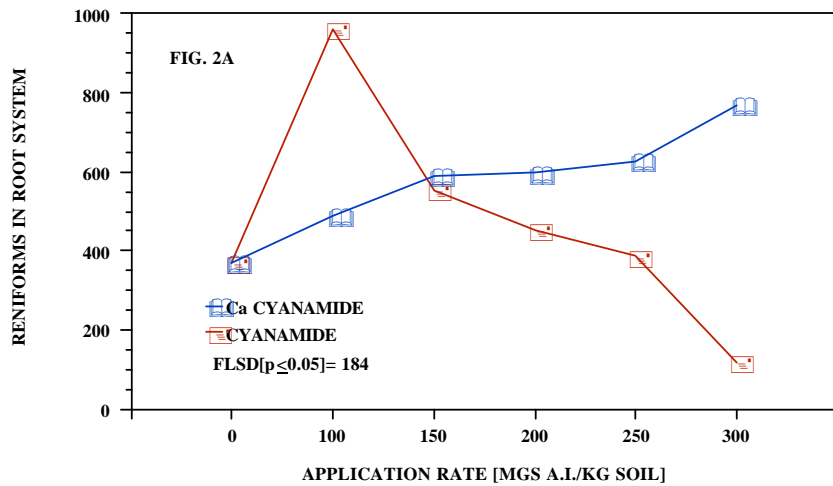


Figure 2. Numbers of nematodes extracted from soybean roots of 2-month old plants grown in soil infested with the reniform nematode and treated with increasing doses of calcium cyanamide and cyanamide.

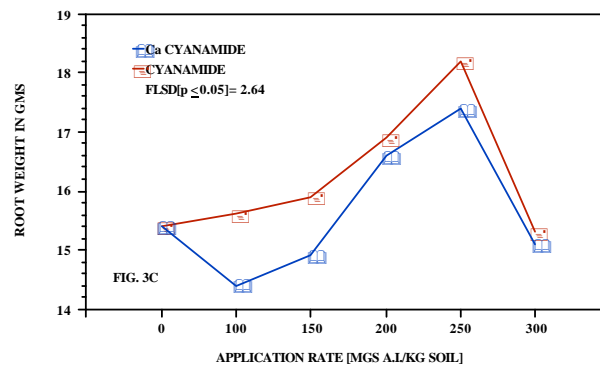
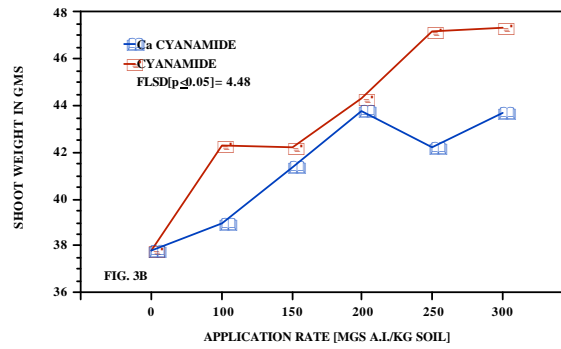
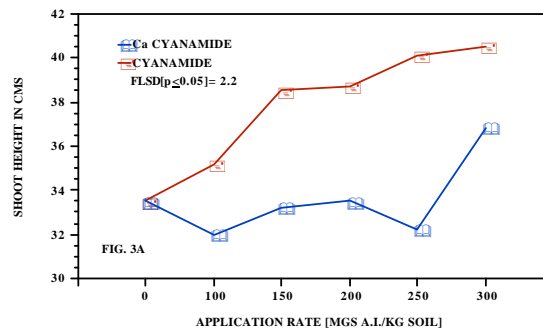


Figure 3. Growth response of soybean in a soil infested with the reniform nematode and treated with calcium cyanamide and cyanamide.

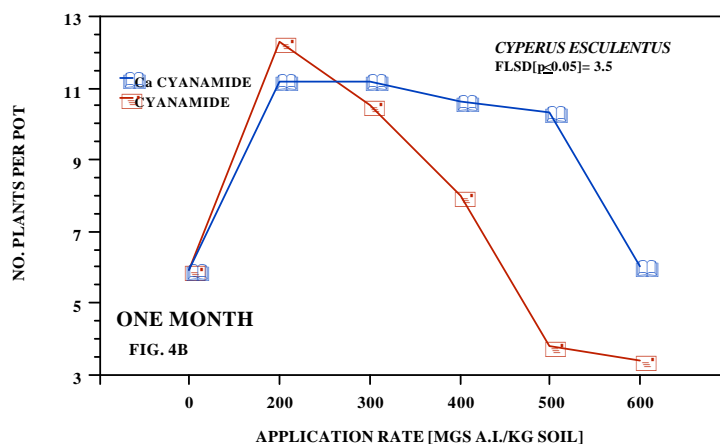
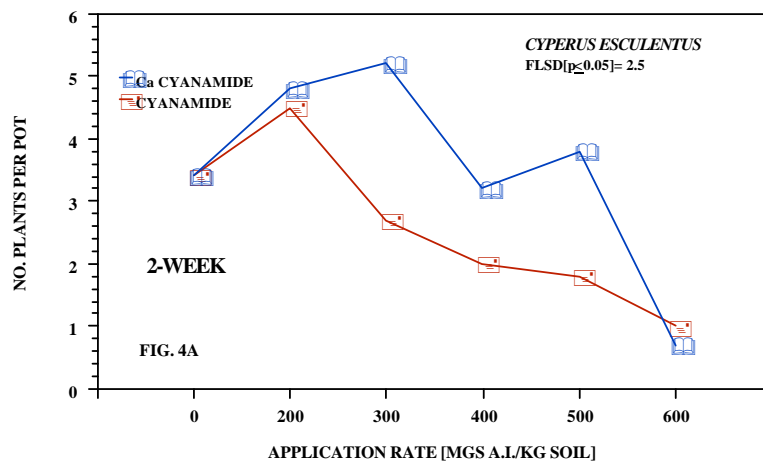


Figure 4. Relation between numbers of yellow nutsedge plants [*Cyperus esculentus*] and application rates of calcium cyanamide and cyanamide in a greenhouse study with a soil artificially infested with the weed. A. Counts taken two weeks after removal of plastic tarp; B. after one month.