CONTROL OF *MELOIDOGYNE ARENARIA* IN PEANUT WITH 1,3-D: RELATIVE EFFICACY AND APPLICATION DEPTH

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ABSTRACT

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A 2-year field study was conducted to compare the efficacy of preplant applications of 1,3-D (Telone® II) with that of ethylene dibromide (EDB) and aldicarb (Temik® 15G) for control of *Meloidogyne arenaria* and to increase yield of 'Florunner' peanut (*Arachis hypogaea*). 1,3-D was less effective than EDB for increasing yields; the advantage of EDB over 1,3-D was especially pronounced when both fumigants were applied at rates below 35 L/ha. In the first year of the study, at-plant applications of aldicarb at 1.1 and 2.2 kg a.i./ha were not as effective as treatments with 1,3-D at rates higher than 37.4 L/ha or those with EDB in the range of 8.4-33.7 L/ha for reducing *M. arenaria* populations in soil or increasing yields; however, control of *M. arenaria* and yield response in the second year (a dry season) was as good with aldicarb (2.2 kg a.i./ha) as with 1,3-D (18.7-93.5 L/ha) or with EDB (16.8 and 33.7 L/ha). The efficacy of 1,3-D for controlling *M. arenaria* and increasing yield was dependent on application depth; the optimal application depth for the chemical was ca. 23 cm.

Additional key words: chemical control, halogenated hydrocarbons, pest management, DD, methodology, carbamates, quantitative nematology, dosage response.

RESUMEN

Rodríguez-Kábana, R., y D. G. Robertson. 1987. Uso del 1,3-D para combatir *Meloidogyne arenaria* en maní: eficacia relativa y efecto de la profundidad de inyección. Nematrópica 17:17-29.

Se efectuó un estudio de dos años para comparar la eficacia de tratamientos de presiembra con 1,3-D (Telone® II) con otros con bibromuro de etileno (EDB) y con aldicarb (Temik® 15G) para combatir *Meloidogyne arenaria* y aumentar la produccion del maní 'Florunner' (*Arachis hypogaea*). Los tratamientos con EDB resultaron ser más eficaces que los efectuados con EDB para aumentar los rendimientos. La ventaja del EDB sobre el 1,3-D fué sobresaliente cuando se utilizaron estos fumigantes en dosis menores a 35 L/ha. En el primer año del estudio, el aldicarb a dosis de 1.1 y 2.2 kg a.i./ha no fué tan efectivo como los tratamientos con 1,3-D en dosis superiores a 37.4 L/ha o con EDB en dosis de 8.4-33.7 L/ha. En el segundo año (seco) el aldicarb (2.2 kg a.i./ha) fué tan efectivo como el 1,3-D (18.7-93.5 L/ha) o el EDB (16.8 y 33.7 L/ha). La eficacia del 1,3-D para combatir *M. arenaria* dependió de la profunidad de inyección en el suelo; la profundidad optima para una máxima eficacia del fumigante fué de ca. 23 cm.

Palabras claves adicionales: combate quimico, hidrocarburos halogenados, DD, metodología, carbamatos, nematología cuantitativa, dosimetría.

INTRODUCTION

The peanut (*Arachis hypogaea* L.) is a good host for a variety of nematodes (8,9). Root-knot nematodes (*Meloidogyne* spp.) are among the most important parasites of the crop (9). Damage caused by *Meloidogyne arenaria* (Neal) Chitwood is a limiting factor in the production of peanuts in the southeastern United States (2,7,9). In Alabama this nematode occurs in 43% of peanut fields (3), where it can cause severe losses in yield (17). Traditionally, the management of *M. arenaria* has been based on the use of nematicides in combination with effective rotations with crops that are not as good hosts for the nematode as peanut (8,10,14). This management system evolved from the fact that there are no commercially available peanut cultivars tolerant to *M. arenaria* and that there are no known sources of resistance to the nematode in *A. hypogaea* (5).

Applications of nematicides provided an effective means of controlling root-knot nematodes in peanut at reasonable costs (6,9,11). The most efficacious and economical nematicides were fumigants containing dibromochloropropane (DBCP) and ethylene dibromide (EDB) (6,12); however, the recent removal of these materials from use by producers has created a need for adequate substitutes. The use of 1,3-dichloropropene (1,3-D) for control of nematodes in peanut is not new; this material has been used in the crop since the late 1940's. More recently, workers in the southeastern United States have shown that applications of 1,3-D can be economical for control of root-knot nematodes in the crop (15). There is, however, a lack of information on the efficacy of 1,3-D relative to that of other nematicides. Also, there is little information available on some of the conditions necessary for its optimal use. This paper presents results from a 2-year study comparing the efficacy of 1,3-D with that of EDB and aldicarb for controlling *M. arenaria* and inncreasing yields in 'Florunner' peanuts. The paper also contains results from a study on the effect of application depth on the efficacy of 1,3-D.

MATERIALS AND METHODS

Experiments with 'Florunner' peanut were conductedd in 1985 and 1986 in an irrigated field at the Wiregrass Substation, near Headland, Alabama. The field was essentially level and had been in peanut for 8 previous years with hairy vetch (*Vicia villosa* Roth.) as a winter cover crop. The soil was a sandy loam (pH 6.2, org. matter <1.0%) infested with *M. arenaria.*

Efficacy studies. Two experiments were conducted to compare the relative efficacy of 1,3-D (Telone® II) treatments for control of *M. arenaria* with those of EDB and aldicarb (Temik® 15 G). In the first experiment in 1985, 1,3-D was applied at rates of 0, 9.3, 18.7, 28.0, 37.4, 46.7,

and 56.1 L/ha; the rates for EDB were: 8.4, 16.8, 25.2, and 33.7 L/ha. These fumigants were applied in the row to a depth of 30 cm one week before planting using 2 injectors per row set 25 cm apart with the seed furrow in the middle between the injectors. Aldicarb was applied at planting in a 12-cm band with shallow incorporation (3-4 cm) at rates of 1.1 and 2.2 kg a.i./ha; these rates are equivalent to 6.6 and 13.2 kg a.i./ha on a broadcast basis. Each treatment was represented by 8 replications (plots) in a randomized complete block design. Plots were 2 rows, each 0.8 m wide and 10 m long.

In the second efficacy experiment in 1986, 1,3-D was applied 2 weeks before planting at rates of 0, 18.7, 28.0, 37.4, 46.7, 56.1, 65.4, 74.8, 84.1, and 93.5 L/ha; EDB at 16.8 and 33.7 L/ha; and aldicarb at 2.2 kg a.i./ha. All other details of method and design for this test were identical to the 1985 experiment.

Application depth. The effect of depth of application on the relative efficacy of 1,3-D was studied with one experiment in 1985. The fumigant was applied one week prior to planting as described for the other

Table 1. Effect of treatments with 1,3-D, aldicarb, and EDB on 'Florunner' peanut yield and juvenile populations of of *Meloidogyne arenaria* in soil in a field experiment conducted at the Wiregrass Substation near Headland, Alabama in 1985.

Treatment	Rate (L/ha)	*M. arenaria* juveniles/100 cm^3 soil	Yield (kg/ha)
Control		157	2875
1,3-D	9.3	139	2815
1,3-D	18.7	116	3238
1,3-D	28.0	131	3290
1,3-D	37.4	37	3106
1,3-D	46.7	39	4003
1,3-D	56.1	11	4267
EDB	8.4	36	3946
EDB	16.8	6	3914
EDB	25.2	9	3865
EDB	33.7	12	4030
Aldicarb	2.2 kg a.i./ha	101	3214
Aldicarb	4.4 kg a.i./ha	149	3187
LSD (P=0.05)		79	553
Standard error		20	139

[z]Fumigants were applied pre-plant in the row; aldicarb treatments were at-plant in a 12-cm band.

experiments but at rates of 14.0. 28.0, and 56.0 L/ha. Each rate was delivered at depths of 7.8, 15.2, 25.4, and 35.6 cm; unfumigated controls were included. The number of replications per treatment, experimental design, and other details were as described for the efficacy experiments.

In all experiments cultural practices and control of foliar diseases, insects, and weeds were according to standard recommendations for the area (1).

Soil samples for nematode analysis were collected 2-3 weeks before harvest time to be within the period of time when *M. arenaria* juvenile populations in soil are at their maximum (16). Soil samples were collected from each plot and consisted of 16 to 20 2.5-cm-diam. cores taken with a standard soil probe. The cores in each plot were taken from the 2 rows at 0.4 to 0.6 m spacings by inserting the probe through the root system to a depth of 20-25 cm. The cores from each plot were composited and a 100-cm^3 subsample was then used to determine nematode numbers with the "salad bowl" incubation technique (13).

Yield data were obtained by harvesting the entire plot areas. All data were analyzed following standard procedures for analysis of variance (18). Regression analysis and curve fitting by the least squares method were also according to standard procedures (4,18). Fisher's least significant differences (L.S.D.) were calculated and are included in the tables of results. Unless otherwise stated, all differences referred to in the text were significant at the 5% or lower level of probability.

RESULTS AND DISCUSSION

Efficacy experiments. Data from the 1985 experiment are presented in Table 1. All EDB treatments reduced *M. arenaria* juvenile populations in soil and resulted in increased yields. There were no differences between EDB treatments with respect to yield response or to degree of *M. arenaria* control. The two aldicarb treatments did not reduce numbers of juveniles in soil or increase yields. 1,3-D applications at the two highest rates resulted in increased yields and reductions in *M. arenaria* juvenile populations equal to those obtained with EDB applications. A pattern of yield response to increasing rates was evidenced for 1,3-D. Fig. 1A presents the relation between the average yields (Y) in kg/ha and 1,3-D application rates (x) in L/ha. The relation was defined (R^2 = 0.81**) by the parabola:

$$Y = 2892.46-2.37x+0.48x^2 \quad (I)$$

A pattern of response to 1,3-D applications was also evidenced for *M. arenaria* juveniles. The equation (Fig. IB):

$$Ja = 158.46-1.65x-0.02x^2 \quad (II)$$

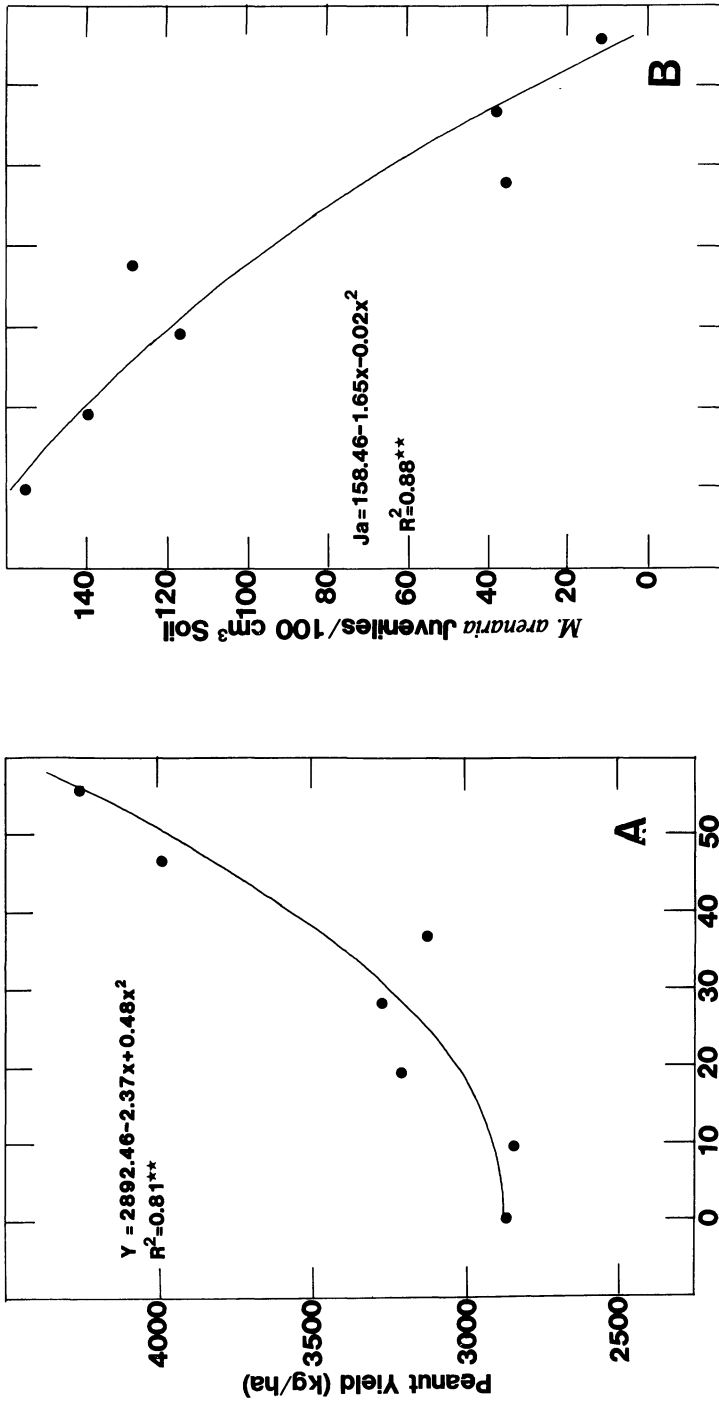

Fig. 1. Relation between 'Florunner' peanut yield or *M. arenaria* juvenile populations (Ja) in soil, and preplant application rates (x) of 1,3-D in a 1985 field experiment at the Wiregrass Substation, near Headland, Alabama.

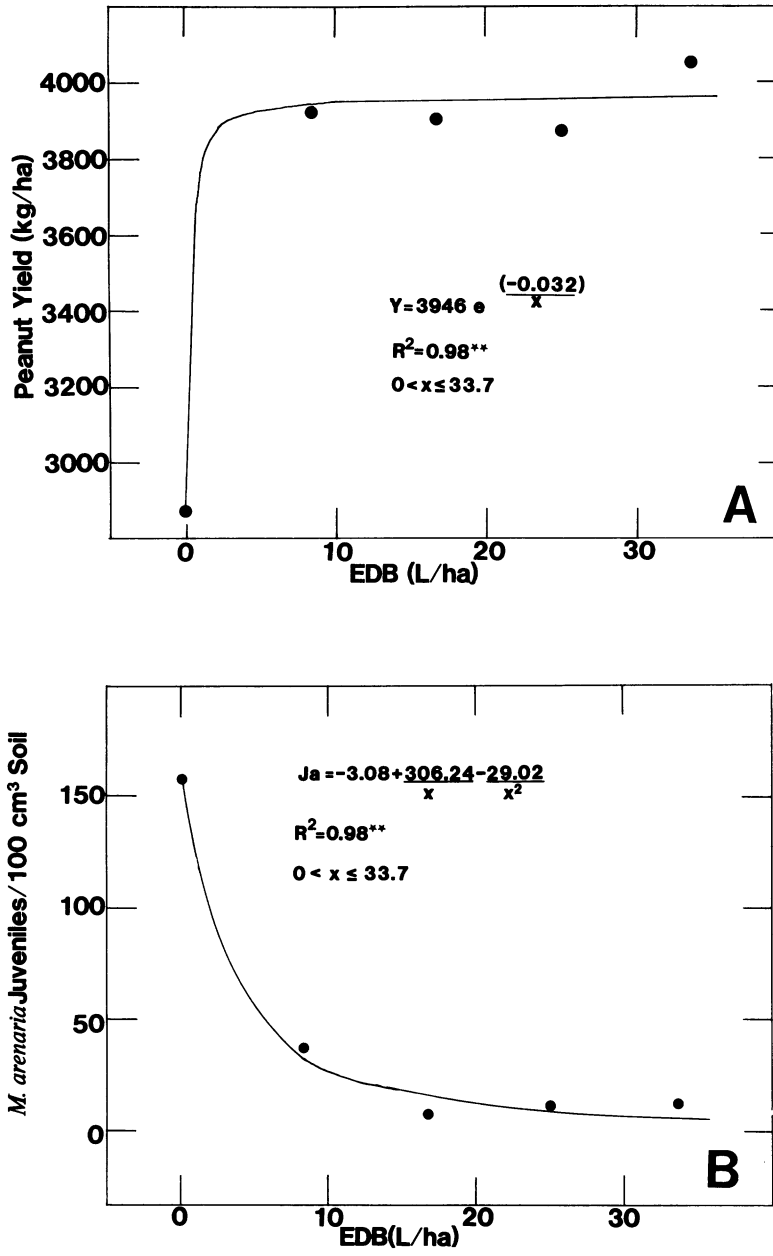

Fig. 2. Relation between 'Florunner' peanut yield or *M. arenaria* juvenile populations (Ja) in soil, and preplant application rates (x) of EDB in a 1985 field experiment at the Wiregrass Substation, near Headland, Alabama.

described (R^2 = 0.88**) the relation between the average numbers of *M. arenaria* juveniles in 100 cm^3 soil (Ja) and 1,3-D rates.

Yield responses to EDB treatments were related (R^2 = 0.88**) to rates of the fumigant by the equation (Fig. 2A):

$$Y = 3946/e^{(0.032/x)} \quad \text{(III)}$$

Average numbers of *M. arenaria* juveniles in soil were inversely related to EDB rates in a manner defined (R^2 = 0.98**) by the equation (Fig. 2B):

$$Ja = -3.08 + 306.24/x - 29.02/x^2 \quad \text{(IV)}$$

Equations III and IV describe types of response characterized by very sharp effects from low dosages with rapid declines in the rates of yield increase, dY/dx (or in the rate of juvenile population reduction, dJa/dx) in relation to EDB doses. In contrast, the rates of change in yield or juvenile numbers indicated by equations I and II are more progressive and responsive through high dosages of 1,3-D.

Data from the 1986 experiment are presented in Table 2. All nematicide treatments increased yields and reduced *M. arenaria* juvenile populations in soil. Yields and the size of *M. arenaria* juvenile populations for 1986 were considerably lower than those of the previous year; 1986 was a very dry year compared to 1985. The experimental fields were irrigated, but the severity of the drought in the June-August period was such that we were unable to maintain a level of moisture in the soil that we consider optimal for development of peanut and *M. arenaria*.

The relation between average yields and 1,3-D rates was defined (R^2 = 0.88**) by the parabola (Fig. 3):

$$Y = 2130 + 34.05x - 0.24x^2 \quad \text{(V)}$$

The rate of increase in yield in relation to 1,3-D dosage (dY/dx) declined with increasing rate following:

$$dY/dx = 34.05 - 0.48x \quad \text{(VI)}$$

Equation VI indicates that maximal yields would be attained with applications of 70.75 L/ha of 1,3-D. Equation V contrasts with equation I for which

$$dY/dx = -2.365 + 0.958x \quad \text{(VII)}$$

Equation VII indicates that dY/dx (within the range of 1,3-D dosages used in 1985) would increase at a constant rate. We interpret this apparent discrepancy as a result of the very different types of seasons the equations represent, i.e., 1985 a crop with normal rainfall, and 1986 one with abnormally low moisture. Previous work with peanut (15) has shown that yield responses to 1,3-D applications reach a definite limit

Table 2. Effect of nematicide treatments with 1,3-D, aldicarb, and EDB on 'Florunner' peanut yield and juvenile populations of *Meloidogyne arenaria* in soil in a field experiment conducted at the Wiregrass Substation near Headland, Alabama in 1986.

Treatment	Rate (L/ha)[z]	*M. arenaria* juveniles/100 cm^3 soil	Yield (kg/ha)
Control		98	2061
1,3-D	18.7	17	2794
1,3-D	28.0	7	2848
1,3-D	37.4	11	3282
1,3-D	46.7	4	2929
1,3-D	56.1	2	3390
1,3-D	65.4	10	3336
1,3-D	74.8	2	3200
1,3-D	84.1	5	3282
1,3-D	93.5	2	3282
EDB	16.8	2	3336
EDB	33.7	8	3282
Aldicarb	2.2 kg a.i./ha	5	3309
LSD (P=0.05)		58	399
Standard error		15	101

[z]Fumigants were applied pre-plant in the row and aldicarb treatments were at-plant in a 12-cm band.

as fumigant rate increases. We can expect that at rates higher than those used in 1985, the fumigant may not be able to dissipate from the soil within the 1-2 week waiting period used before planting. If so, residual 1,3-D in the soil could cause phytotoxicity and consequent yield loss.

Populations of *M. arenaria* juveniles in soil in 1986 were too low to establish any meaningful pattern of response to 1,3-D application rates.

Application Depth. Data from this experiment are presented in Table 3. Factorial analysis of the yield results revealed no significant interaction between depth of application and 1,3-D rates. Fig. 4A illustrates the effects of injection depth (d) on yield (Y) independently of rate of application; the relation was defined (R^2 = 0.98**) by the parabola:

$$Y = 2785 + 62.87d - 1.36d^2 \quad \text{(VIII)}$$

The model indicated that yields increased with increasing application depth, to a maximum of 23 cm but that deeper applications result in decreased yields from the maximum. Factorial analysis of the yield data also indicated that when the effects of 1,3-D rates were considered inde-

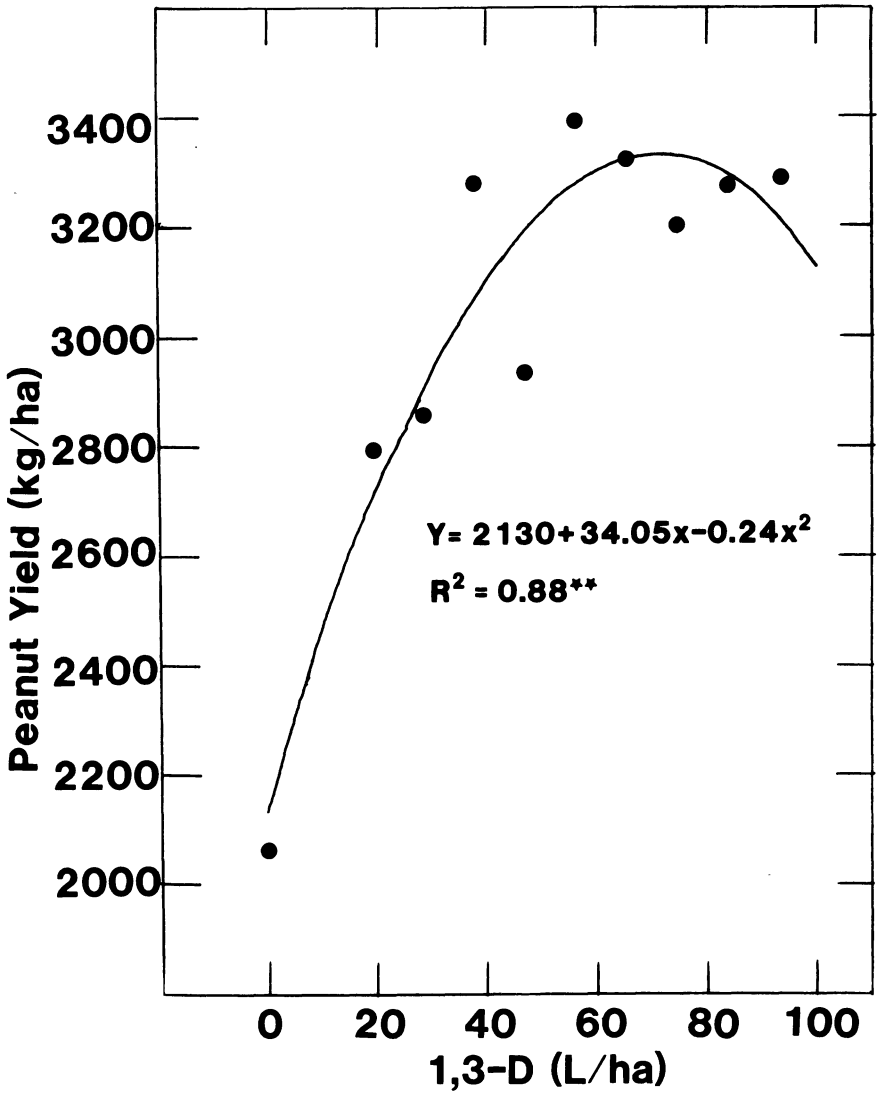

Fig. 3. Relation between 'Florunner' peanut yield (Y) and preplant application rates (x) of 1,3-D in a 1986 field experiment at the Winegrass Substation, near Headland, Alabama.

pendently of the effects of application depth, all 1,3-D applications increased yields; the relation between yields and application rates calculated from the average yields obtained from each treatment agreed well ($R^2 = 0.98^{**}$) with the model:

$$Y = 2788.34 + 21.75x - 0.11x^2 \quad \text{(IX)}$$

Table 3. Effect of application depth on the efficacy of 1,3-D treatments for control of *Meloidogyne arenaria* and increase of 'Florunner' peanut yield in a field experiment conducted at the Wiregrass Substation near Headland, Alabama in 1985.

Rate (L/ha)[z]	Application depth (cm)	*M. arenaria* juveniles/100 cm^3 soil	Yield (kg/ha)
0	—	111	2784
14	7.6	95	2910
28	7.6	119	3081
56	7.6	39	3534
14	15.2	73	2999
28	15.2	66	3499
56	15.2	21	3873
14	25.4	77	3228
28	25.4	54	3431
56	25.4	12	3767
14	35.6	98	3217
28	35.6	69	3187
56	35.6	27	3512
LSD (P=0.05)		56	424
Standard error		20	151

[z]The fumigant was applied pre-plant and in-the-row.

Analysis of the nematode data revealed no significant rate x depth interaction. When the effect of application depth on *M. arenaria* juvenile populations was considered independently of the effects of 1,3-D rates, the pattern of response depicted in Fig. 4B was revealed; the relation between average numbers of juveniles and application depth was defined (R^2 = 0.98**) by:

$$Ja = 113.66-5.53d+0.12d^2 \quad (X)$$

Equation X indicates that numbers of *M. arenaria* juveniles declined sharply in response to increasing application depth reaching a minimum at a depth of 23 cm; deeper placement of the fumigant actually resulted in increased numbers of juveniles above the minimum.

Results on application depth indicate that the popularly held view that "the deeper you place the fumigant the better" may not be true. Our soil was typical of the soils in the peanut-growing area of Alabama. The profiles of these soils consist of sandy loams or loamy sands in the top 25-30 cm, below which the texture becomes heavier and there is usually a clay horizon at depths below 35-40 cm. It is conceivable that

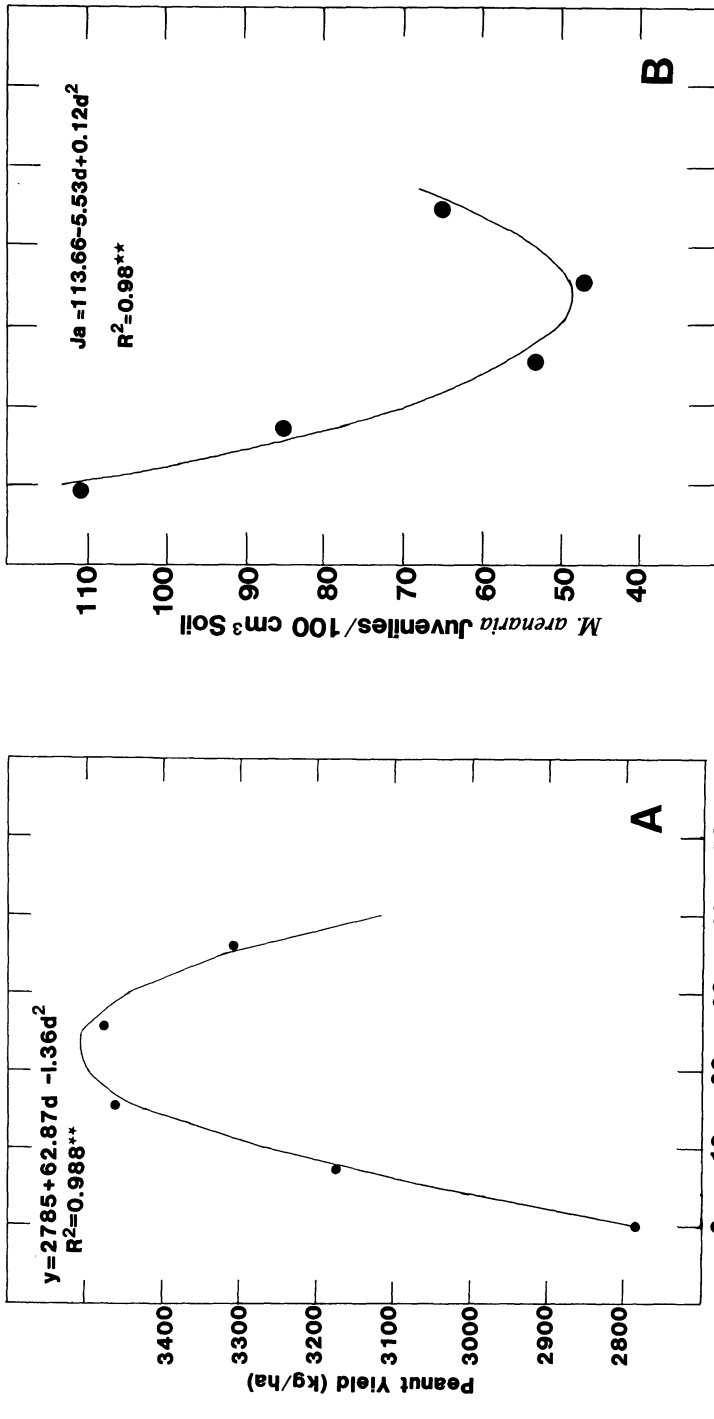

Fig. 4. Relation between 'Florunner' peanut yield or *M. arenaria* juvenile populations (Ja) in soil, and injection depth (d) for preplant applications of 1,3-D in a 1986 field experiment at the Wiregrass Substation, near Headland, Alabama.

the dissipation rate for 1,3-D could be affected by the type of soil surrounding the point of injection. Heavy clay soils in contrast to sands or loams have reduced pore space through which the fumigant can diffuse and dissipate upward. Thus, the placement of 1,3-D into a heavy textured soil horizon could result in prolonged residence time or "entrapment" of the fumigant in soil with consequent losses in nematicidal activity and in yields.

CONCLUSIONS

Our results indicate that EDB is more effective than 1,3-D for increasing 'Florunner' peanut yields in *M. arenaria*-infested soil.

There is an optimal depth for application of 1,3-D. In our soil, the greatest yield response and best control of *M. arenaria* were obtained when the fumigant was applied at depths ca. 23 cm.

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