Effects of Cultivars, Subsoiling, and Fumigation on Soybean Yields and *Meloidogyne incognita* Populations[1]

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Abstract: Application of 1,2-dibromo-3-chloropropane (DBCP) and subsoiling under the row in Tifton sandy loam heavily infested with *Meloidogyne incognita* increased yields of four soybean cultivars. These cultivars have levels of resistance to *M. incognita* as follows: 'Hutton', high; 'Essex', intermediate; and 'Davis' and 'Ransom', low. After growing these four cultivars, subsoiling, and applying DBCP for 2 years in the same plots, the residual effects of these practices on yield of Davis cultivar and populations of *M. incognita* were studied. Greatest yields of Davis were obtained on plots previously planted to Hutton and Essex and on plots previously treated with DBCP for 2 years. Residual effects of subsoiling on yield were not significant. Data on nematode populations indicated that some residual effects occurred because of cultivars and nematicides. However, root-knot was suppressed only where DBCP was applied the 2 previous years. Although beneficial residual effects occurred, they were not sufficient for maximum soybean production. *Key Words: Glycine max,* root-knot, DBCP (1,2-dibromo-3-chloropropane) nematicide, control.

Subsoiling and nematicide usage are increasing in soybean production. Minton and Parker (4) in Georgia reported that the average yield of four soybean cultivars was increased by 21.7% when they were grown in 1,2-dibromo-3-chloropropane (DBCP)-treated plots infested with *Meloidogyne incognita* without subsoiling. Subsoiling increased yields about the same amount. The combined treatment of DBCP and subsoiling increased yields 28.3% over the control treatment. Also, in compacted soils infested with *Hoplolaimus columbus,* soybean yields were 60% greater in soil that was subsoiled or treated with DBCP than in control treatments (5). Yields were increased by 88% when the soil was subsoiled and treated with DBCP. On the same farm, subsoiling and soil fumigation increased yields of cotton grown in soil infested with *H. columbus* (1). In South Carolina, researchers working on compacted soil infested with *H. columbus* found that combination treatments of subsoiling and the use of nematicides have been effective over a wide range of soil types (6).

In areas of Georgia where compacted soil is infested with nematodes, the normal practice is to subsoil and apply a nematicide. The question of obtaining favorable residual effects from this practice that might benefit the crop during the second season is often raised. In this paper we report the immediate effects (on four soybean cultivars and nematode populations) of 2 years' subsoiling and applying a soil fumigant and the residual effects of these soil treatments and cultivars on Davis soybean and nematode populations during the third year.

MATERIALS AND METHODS

The study was conducted during 1973-1975 at Tifton, Georgia on a Tifton sandy loam heavily infested with *Meloidogyne incognita* (Kofoid and White) Chitwood. In 1973-1974, treatments included four soybean [*Glycine max* (L.) Merr.] cultivars, subsoiling 41 cm deep beneath the row vs. no subsoiling, and nematicide vs. no nematicide. Cultivars, subsoiling, and nematicide treatments were whole plots, subplots, and sub-subplots, respectively. Sub-subplots were 6.1 m long with four rows each spaced 0.9 m apart. Each year the soil was turned 25 cm deep with a moldboard plow. The nematicide 1,2-dibromo-3-chloropropane (DBCP) 12.1EC was injected 20 cm deep with a single chisel in the row at a rate of 10 kg (a.i.)/ha. Four soybean cultivars representing four maturity classifications at Tifton were used: 'Essex' (V), very early; 'Davis' (VI), early; 'Ransom' (VII), medium; and 'Hutton' (VIII), late. Levels of resistance to *M. incognita* are: Hutton-highly resistant; Essex-moderately resistant;

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Ransom and Davis-highly susceptible. Each treatment was replicated 4 times.

In 1975, a single cultivar, Davis, was planted to all plots. The soil was not subsoiled or fumigated as in previous years.

Each year, lime and fertilizer were applied as recommended on the basis of soil tests for soybean production in Georgia. Weeds were controlled with trifluralin at 0.56 kg (a.i.)/ha applied before planting and cultivated as needed. Methomyl, methyl parathion, and carbaryl were applied as needed to control insects. Seeds were planted (33 seeds/m) 28 May 1973, 15 May 1974, and 9 May 1975.

The numbers of nematodes in the soil at 0-20, 20-33, and 33-46 cm depths were determined 1 July and 12 September 1973, 3 July and 20 August 1974, and 9 June and 26 August 1975. Soil samples were collected with a 7-cm diam x 16.5-cm depth bucket auger from the two outside rows of each sub-subplot. Five soil cores from each sub-subplot were placed in a pail, mixed well, and a 500-cm^3 subsample was withdrawn for assay. Each sample contained only soil from the depth zone indicated. Nematodes were extracted from 150 cm^3 of soil by the centrifugation-sugar flotation method (3). Roots of 10 plants from the two outside rows of each four-row sub-subplot were rated for galling 12, 16, and 17 weeks after planting in 1973, 1974, and 1975, respectively. Root-knot ratings were based on a 1-5 scale: 1 = no galling, 2 = 1-25%, 3 = 26-50%, 4 = 51-75%, and 5 = 76-100% of root systems galled. Soybean yields were obtained from the two center rows of each sub-subplot. Data were subjected to analysis of variance and Duncan's Multiple Range Test (7).

TABLE 1. Influence of preplant subsoiling and nematicide treatments on yield of four soybean cultivars, 1974.

Subsoiling and cultivar	Yield (kg/ha) No nematicide	DBCP	Avg mean
Not subsoiled[y]			
Essex	1,640c	2,009b	1,825c
Davis	2,103b	3,138a	2,621b
Ransom	2,486ab	3,306a	2,896ab
Hutton	2,816a	3,273a	3,045a
Avg mean	2,261	2,932	2,597[z]
Subsoiled[y]			
Essex	1,942b	2,325b	2,134b
Davis	2,574a	3,320a	2,947a
Ransom	2,533a	3,367a	2,950a
Hutton	2,984a	3,031a	3,008a
Avg mean	2,508	3,011	2,761[z]
Avg yield (cultivar and subsoiling combined)	2,385	2,972	

[y]Data underscored by the same line in rows or followed by the same letter in columns within a soil treatment are not different ($P = 0.05$) according to Duncan's Multiple Range Test.
[z]Significant response ($P = 0.05$) to subsoiling.

RESULTS

Yields in 1974 (Table 1) were similar to those of 1973 (4) with a few exceptions. Application of DBCP increased yields of all cultivars except Essex when the soil was not subsoiled in 1973, but in 1974 yields of Essex and Hutton were not increased. In 1973, on subsoiled plots, DBCP had no effect on yield, but in 1974 DBCP increased yields of Davis and Ransom.

Yield of Davis in 1975 (Table 2) was generally much lower than that of all cultivars in 1973 and 1974. Significant residual effects of cultivars and DBCP were reflected in the 1975 yields. On plots that were not subsoiled, yields from Davis and Hutton plots were greater on DBCP-treated than on nontreated plots. The DBCP-treated plots previously planted to Hutton produced greater yields than plots planted to Davis and Ransom. Residual effects of subsoiling on yield were not significant.

Yield of Davis in 1975 on the subsoiled plots previously planted to Essex was greater on the DBCP-treated than on the nontreated plots. The Davis yield from the Hutton no-nematicide plots was greater than that from Ransom plots. Also, on the DBCP-treated plots, yields from Hutton and Essex plots were greater than yields from Ransom plots.

The average yield of Davis in 1975 from all plots treated with DBCP in 1973-74 was greater than that from all nontreated plots. Yield was positively correlated with the nematicide treatment (r = 0.43). Average

TABLE 2. Yield of Davis soybean grown without subsoiling or nematicide treatments in 1975 (preceeded by four cultivars in the same plots that received subsoiling and nematicide treatments in 1973 and 1974).

Subsoiling and cultivar in 1973-1974	Yield (kg/ha) No nematicide	DBCP	Avg mean
Not subsoiled[y]			
Essex	1,243a	1,525ab	1,384a
Davis	726a	1,317b	1,021a
Ransom	1,149a	1,263b	1,206a
Hutton	1,035a	1,969a	1,502a
Avg mean	1,038	1,519	1,278[z]
Subsoiled[y]			
Essex	1,324ab	2,171a	1,748a
Davis	1,021ab	1,404bc	1,213ab
Ransom	961b	1,055c	1,008b
Hutton	1,546a	1,902ab	1,727a
Avg mean	1,213	1,633	1,424[z]
Avg yield (cultivar and subsoiling combined)	1,126	1,576	

[y]Data underscored by the same line in rows or followed by the same letter in columns within a soil treatment are not different ($P = 0.05$) according to Duncan's Multiple Range Test.
[z]Differences due to subsoiling are not significant ($P = 0.05$).

yield of Davis for plots treated with DBCP without subsoiling was 1,519 kg/ha or 481 kg greater than control. Differences due to DBCP were about the same in the subsoiled plots. The combined treatments of DBCP and subsoiling yielded 1,633 kg/ha or 595 kg/ha over the control treatment.

TABLE 3. Average root-knot index of four soybean cultivars growing in subsoiled and nematicide treated soil, 1974.[z]

Cultivar	No nematicide	DBCP
Essex	2.2 b	1.1 a
Davis	3.8 a	1.2 a
Ransom	3.8 a	1.4 a
Hutton	1.7 b	1.1 a
Avg	2.9	1.2

[z]Data are averages for subsoiled and not subsoiled treatments. Data underscored by the same line in rows or followed by the same letter in columns are not different ($P = 0.05$) according to Duncan's Multiple Range Test.

Root-knot indices of plants in 1974 (Table 3) were similar to those of 1973 (4). Nematode development was greatest on Davis and Ransom, intermediate on Essex, and least on Hutton in nonfumigated plots. DBCP suppressed the average root-knot development on all cultivars except Hutton. Subsoiling in plots not receiving DBCP also reduced the average root-knot index of all cultivars from 3.1 to 2.6 (data not included).

Galling in all plots in 1975 (Table 4) was more severe than in 1973 and 1974. Residual effects from cultivars and subsoiling were not significant. Root-knot indices on plots previously planted to Essex and treated with DBCP were lower than on nontreated plots. Also, the average root-knot index from all plots previously planted to the four cultivars and treated with DBCP was significantly lower than for nontreated plots.

Numbers of *M. incognita* larvae in the soil were greater in August or September than in June or July all years. However, the trends for the various treatments were similar during both periods. Hence, only the data collected during the fall will be discussed. Larval numbers were usually greatest for Davis and Ransom and smallest for Essex or Hutton in DBCP-treated and nontreated plots (Fig. 1, 2). DBCP reduced larval populations for all cultivars in 1973

TABLE 4. Average root-knot index of Davis soybean growth without subsoiling or nematicide treatments in 1975 (preceded by four cultivars in the same plots that received subsoiling and nematicide treatments in 1973 and 1974).[y]

Cultivar in 1973-1974	No nematicide[z]	DBCP[z]
Essex	4.4	3.4
Davis	4.3	3.9
Ransom	4.5	4.0
Hutton	4.2	4.0
Avg	4.4	3.8

[y]Data are averages for subsoiled and not-subsoiled treatments. Data underscored by the same line in rows are not different ($P = 0.05$) according to Duncan's Multiple Range Test.
[z]Differences among cultivars are not significant ($P = 0.05$).

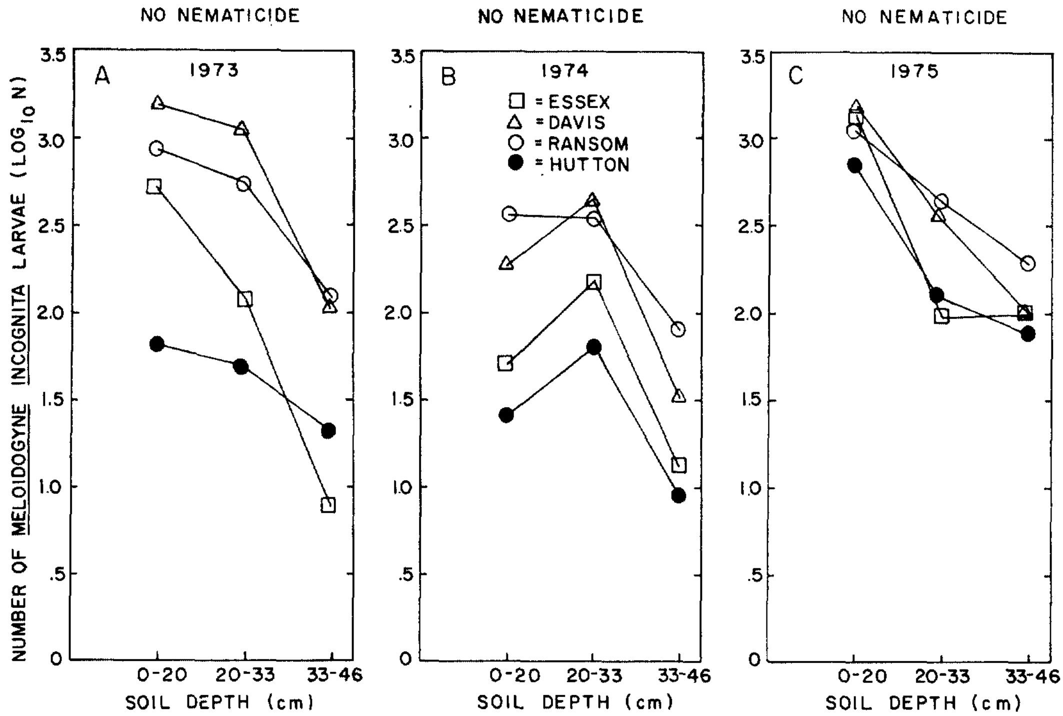

FIG. 1-(A-C). Avg mean nos. of *Meloidogyne incognita* larvae/150 cm^3 of soil at three depths as affected by four soybean cultivars grown in nonfumigated soil. *A-B)* Four cultivars planted in 1973 were repeated on the same plots in 1974. *C)* Davis cultivar was planted on all plots in 1975.

and 1974. The number of root-knot larvae in the soil was affected little or none by subsoiling throughout the experiment (data not included). Cultivars and DBCP had only slight residual effects on nematode populations in 1975. Numbers of larvae were greatest in the 0-20 cm depth, intermediate in the 20-33 cm depth, and smallest in the 33-46 cm depth for all cultivars in both the DBCP-treated and nontreated plots in 1973 and 1975. In 1974, the greatest numbers of larvae occurred at the 20-33 cm depth.

CONCLUSIONS

We earlier showed that soybean cultivars with different levels of resistance to *M. incognita* respond differently to subsoiling and DBCP (4). Yields were greater and root-knot indices lower in subsoiled and DBCP-treated plots, but only the nematicide reduced nematode population levels in the soil. Subsoiling did not affect the vertical distribution of *M. incognita* larvae as it reportedly did for *H. columbus* (5). The difference in methods of soil preparation may have affected nematode distribution. The soil in this experiment was turned to a depth of 25 cm with a moldboard plow before subsoiling, whereas the soil was disked twice to a depth of 10 cm in the *H. columbus* experiment. Turning the soil to a depth of 25 cm probably mixed the nematodes in the soil profile more thoroughly at a greater depth than did disking 10 cm deep.

Only limited beneficial residual effects to a soybean cultivar susceptible to *M. incognita* were obtained the first year after resistant cultivars and DBCP were used for the 2 previous years. Subsoiling provided very few or no beneficial residual effects. Any benefit that might have resulted from residual effects of subsoiling was probably masked by the severe nematode damage. In this experiment, we located the row over the subsoiled trench of the previous year; however, under usual farming practices it would be difficult to do this. Furthermore, a few trips over a field with cultivating equipment usually recreates the plow pan.

Neither practice nor combination of practices provided adequate residual effects

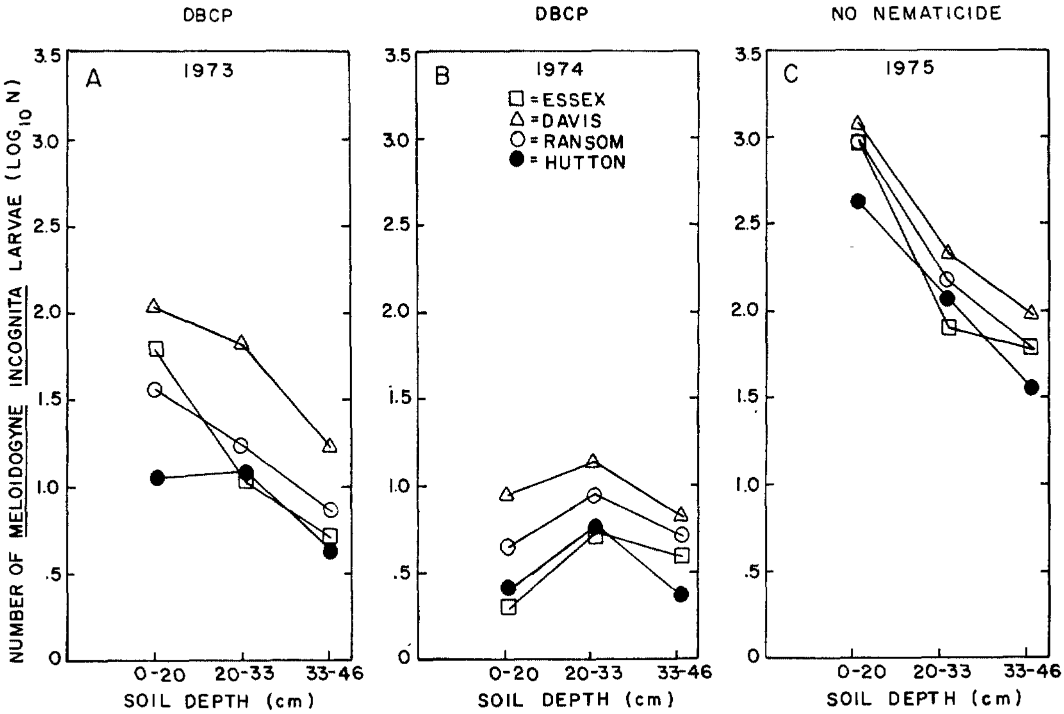

FIG. 2-(A-C). Avg mean nos. of *Meloidogyne incognita* larvae/150 cm^3 of soil at three depths as affected by four soybean cultivars and DBCP. *A-B)* Four cultivars planted in 1973 were repeated on the same plots in 1974. All plots were fumigated with DBCP both years. *C)* Davis cultivar was planted on all plots in 1975. None of the plots were fumigated.

for maximum soybean production in a monocropping system. *M. incognita* reproduced on resistant cultivars at a level high enough to maintain damaging populations even after soil fumigation. Although yields in 1975 were greater following certain treatments than others, yields in 1975 were less than in 1973 and 1974 when the treatments were applied. Seasonal variability may account for some of the lowering of the yield in 1975 below that of the previous 2 years, but we believe that most of the reduction was due to nematode damage. Therefore, to maintain high soybean yields in compacted soil infested with *M. incognita,* it is necessary to utilize practices each year that control the nematodes and promote good root growth.

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