1-1-1973

Programs for improving yields of strawberries in West Virginia

Robert E. Adams

Robert F. Keefer

Clinton E. Hickman

Programs for Improving Yields of Strawberries in West Virginia

Bulletin 618 February 1973

West Virginia University • Agricultural Experiment Station

Authors

Robert E. Adams is Plant Pathologist, Robert F. Keefer is Associate Agronomist, and Clinton E. Hickman is Assistant Horticulturist, West Virginia University Agricultural Experiment Station.

Agricultural Experiment Station
College of Agriculture and Forestry
R. S. Dunbar, Jr., Director

West Virginia University
Morgantown

Programs for Improving Yields of Strawberries in West Virginia

Robert E. Adams
Robert F. Keefer
and
Clinton E. Hickman

Summary

Strawberries of the cultivar Surecrop were grown on Vorlex-fumigated and nonfumigated soil to determine appropriate sources, amounts, times and methods of application of nitrogen fertilizers under West Virginia conditions. The fumigated plots averaged 3,962 quarts per acre and the nonfumigated plots averaged 3,279 quarts per acre. The increases in yield ranged from 204 to 1,139 quarts per acre. Granular urea applied to the soil before planting was as effective in increasing fruit yields as a split application put on before planting and in August of the first growing year. The source of N made little difference but yields increased as the amount of N applied was increased up to 170 lb N per acre. Among soil treatments with various dosages of Vorlex, maximum strawberry yields (cultivars Midway, 7,342 quarts per acre and Surecrop, 7,104 quarts per acre) were obtained following treatment at the rate of 35 gallons per acre. The 50-gallon rate depressed the yield and lower rates were less effective. Eight unregistered nematocides and foliar fungicides were tested alone and in all combinations. Some combinations interacted synergistically giving yield increases of U.S. No. 1 berries as great as 2,800 quarts per acre (8,827 quarts per acre Temik-Daconil treatment, 6,006 quarts per acre control) and a total yield increase of 3,503 quarts per acre. One fungicide (Bayer 47351) reduced yields below that of the unsprayed check (5,096 quarts per acre treated compared to 6,006 quarts per acre control). The most effective nematocide, determined by yield increases, was Temik (7,771 quarts per acre). [redacted]).

THE STRAWBERRY is a delectable fruit that is enjoyed by many people. It is seldom that supply meets the demand. Strawberry production on a commercial scale is an undertaking that should be reasonably well adapted to the mountainous terrain and climate of West Virginia. In home gardens throughout most of the State yields are sufficient to supply the needs of the household, but yields of commercial endeavors have been disappointing. Yields of 3,500 to 4,000 quarts of strawberries per acre in West Virginia are not economically competitive with yields obtained in other regions.

Low yields can be attributed to adverse weather (especially frost and/or drought), soils low in fertility, poor quality planting stock, weeds, nematodes, and diseases.

Frost damage and drought can both be counteracted by timely irrigation. Fertilizers can be applied to the soil. High quality virus-free and nematode-free planting stock is available from nurseries. Chemical and mechanical methods are available for weed control. Why then are we unable to consistently obtain high yields of strawberries? The key to this problem seems to lie in the area of disease control on both roots and leaves of the strawberry plant so that it can utilize fertilizers efficiently. Spray trials with conventional fungicidal chemicals (such as captan, zineb, and ferbam) on fumigated and unfumigated soil have never produced a significant increase in yield of fruit or a measurable decrease in the incidence of foliar disease. Studies with soil fumigants containing methyl bromide have shown that nematode control can increase the yield of strawberries by 2,000 or more quarts per acre. But the cost of the fumigant (approximately $500 per acre), the cost of the plastic tarpaulin (approximately $100 per acre), labor, and the expense of building the application machinery (cost unknown) make the use of this practice borderline in terms of economic returns to the grower.

Leaf spot, caused by the fungus *Mycosphaerella fragariae* (Tul.) Lindau, is generally severe (Figure 1). Because of the lack of effective spray materials, the amount of loss from this disease has not been measured. Field observations have led us to the conclusion that this disease must adversely influence yields, but we have not been able to obtain statistical verification.

We do not know the effects of nitrogen fertilization on strawberry production when grown in soils fumigated for the control of nematodes. However, the literature is replete with studies of the responses of strawberries to fertilization on nonfumigated soils. Most of these have shown that greatest yields are obtained when nitrogen is applied the year of planting and that yields are not improved by nitrogen applications made during the fruiting year (9, 13). The reason for this response is that flower bud initiation in the strawberry occurs between early September and mid-December (in Iowa). The exact timing varies with climate, soils, season and variety (10). Others (4, 7, 8, 11, 12) also have stressed the importance of applying nitrogen early in the fall to obtain greatest numbers of flowers and fruits the following year.

The form in which nitrogen is applied appears to make little difference in growth of plants provided the nitrogen is readily available to the plants (3, 5, 6, 12). In some cases (3) urea applied as a foliar spray appears to be more effective than other forms of nitrogen.

Recently, workers in California (2, 14, 15) have found that applications of up to 150-200 pounds of nitrogen per acre favor high yields of strawberries. But in Alabama, increasing the rate of nitrogen application from 96 lb/acre to 160 lb N/acre had very little effect.

This bulletin presents the results of a coordinated study designed to test cultural programs for improving strawberry yields in West Virginia.

FIGURE 1. Close-up view of Midway strawberry plants severely attacked by leaf spot.

Materials and Methods

These experiments were conducted at the Ohio Valley Experiment Farm of the West Virginia University Agricultural Experiment Station, Point Pleasant. The strawberry plants (cultivars Midway and Surecrop) used were produced in fumigated soil on the Eastern Shore of Maryland. Laboratory examination of root samples confirmed that they were free of plant parasitic nematodes. Representative soil samples were collected from the experimental plots with a soil probe before, and periodically after, soil treatment. The samples were taken to the laboratory in closed plastic bags and processed. The nematode populations in the samples were determined after extracting by a modified Baermann funnel technique (1).

The liquid soil fumigant Vorlex (a mixture of methyl isothiocyanate and dichloropropanes-dichloropropenes, Morton Chemical Co.) was chisel-injected 6-8 inches deep as described under the appropriate experiments. The soil to be treated was in good tilth and the soil moisture was adequate. A soil mulch seal was provided by pulling a drag behind the injector. One week after application, the Vorlex-treated areas were replowed to expose the soil-surface layers to high concentrations of the fumigant.

All the berries were picked by hand and graded. Results were recorded in quarts per acre. When the experimental design warranted, the results were subjected to statistical analysis.

Nitrogen Fertilization Experiment

An area 160 feet by 250 feet was divided into two 160 by 120-foot parts separated by a 10-foot wide sod strip. Vorlex at a rate of 50 gallons per acre was applied two weeks before planting to one of these, and the other was left untreated. Surecrop strawberry plants were set the first week of May, 1967. The plots were replanted June 30 because of low survival and unthrifty growth attributed to poor condition of the plants when set, coupled with very wet weather. Each area was subdivided into four blocks. Within each block the source of nitrogen—ammonium nitrate, soil applied granular urea, and foliar applications of urea—varied in the main plots. Rates and times of application varied in the sub-plots. Each sub-plot consisted of two rows of plants 40 feet long, four feet apart.

Vorlex Dosage Rate Study

Economic and other considerations made it desirable to determine the minimum dosage rate of Vorlex at which maximum yields of strawberries might be obtained under West Virginia conditions. As a consequence Vorlex was applied to 1/5-acre plots at rates of 15, 25, 35 and 50 gallons per acre on

October 24, 1967. Surecrop and Midway plants were set in the spring of 1968. Six 175-foot rows of each cultivar were planted in each plot. The large plots used in this experiment were selected in preference to replication of smaller plots to minimize reinfestation of the treated areas with soil-inhabiting pathogenic microorganisms. As a further precaution, whenever cultural practices such as weeding or cultivation were necessary, the plot that received the 50-gallon rate was worked first, followed in order by those that received 35, 25, and 15 gallons per acre, with the control plot being worked last.

Test of Unregistered Pesticides for Possible Use in the Future

Because of the failure of registered fungicides to provide acceptable control of foliage diseases and because only one effective nematocide that is practical under West Virginia conditions is available, four unregistered foliar fungicides and four unregistered nematocides were tested alone and in all possible combinations. This experiment was arranged in a randomized block design of 25 treatments in 4 replicates. Each plot was four rows wide and ten feet long and was separated from other plots by a buffer row of berries or by a 6-foot blank space in the row. The rows were planted four feet apart. Yield data were taken on the two middle rows in each plot. All the fruit harvested from these plots was destroyed.

Plants of the cultivar Midway were set June 16, 1967. The following granular nematocides were applied to the soil June 20, 1967 and incorporated into the soil with a rotary tiller: Temik, 10 lb actual per acre; Dasanit, 6 lb actual per acre; Zinophos, 10 lb actual per acre; and Disyston, 6 lb actual per acre. Two weeks after planting, the following fungicidal spray program was initiated: Daconil, 1 1/2 lb actual per acre; Bayer 47531, 1 lb actual per acre; Polyram, 4 lb actual per acre; and Difolatan, 2 lb actual per acre. Sprays were applied through cone-type nozzles at 200 psi at a rate of 200 gallons per acre with a tractor-mounted high pressure hydraulic sprayer. In 1967, seven sprays were applied at 14-day intervals through July, August, and September. In 1968, five sprays at 7-day intervals were applied between the last week of April and the beginning of harvest, the last week of May.

Results

The results of these studies are presented in Figures 5 through 10.

Figure 5 shows that yields of Surecrop strawberries increased as the amount of nitrogen applied was increased. This held true regardless of time of application or the form of nitrogen used. The relatively low yields in this experiment are attributed to the combined effects of the late planting date and frost damage. Approximately 25 per cent of the crop was destroyed by a late frost in the spring of 1968. The fumigated plots yielded an average of 3,962 quarts of U.S. No. 1 berries per acre, and the nonfumigated plots yielded an average of 3,279 quarts per acre. In this experiment, the maximum increase in yield from fumigation was 1,139 quarts per acre at 80 lb N as urea applied to the soil.

No evidence was obtained in this experiment that fertilization rates for fumigated soils should be different from those for untreated soils. Further, there was no indication of a deleterious effect of high rates of nitrogen fertilization on fruit quality.

The importance of time of application is shown in Figures 6 and 7. Greater yields resulted from applications of granular urea (120 lb N per acre) before planting, or when 80 lb N was supplied before planting and 40 lb N was supplied on August 1(Figure 6), than from the later application. Delaying the 40-lb N application until August 14 depressed yields. With ammonium nitrate applied at the same rate of nitrogen, the greatest yield was produced when 80 lb N was applied before planting and 40 lb N was applied August 1 (Figure 7). Lower yields occurred under the other two conditions. Similar yields were obtained when 50 lb N as ammonium nitrate was applied to the soil before planting followed by four foliar sprays of 15 lb N each as urea for a total of 110 lb N (Figure 8). Increasing the nitrogen to 170 lb by applying 100 lb N as ammonium nitrate before planting with the same four sprays gave no significant increase in yield over the 120 lb N rates (Figures 6 and 7). The greater expense of applying the foliar sprays of urea cannot be justified by these results.

Soil samples taken before fumigation revealed moderate to high populations (approximately 250 in 50 ml soil) of the American Dagger nematode and root lesion nematodes. Post fumigation soil samples showed that the nematode numbers had been reduced to 2-5 nematodes per 50 ml of soil and the population in the nonfumigated area remained stable. Populations in the fumigated area remained low throughout the two-year course of this experiment. Yield responses to the different nitrogen treatments were of similar magnitude on both fumigated and nonfumigated plots; however, fumigated plots yielded an average of 683 quarts more per acre of U.S. No. 1 berries than the nonfumigated plots. These increases ranged from 264 to 1,139 quarts per acre depending on the treatment. These results easily justified the cost of fumigation.

The results of the Vorlex dosage rate study are presented in Figure 9. Highest yield was obtained from plots receiving 35 gallons per acre; yield of the cultivar Midway was 1,877 quarts per acre greater, and that of Surecrop 1,167 quarts per acre greater than that of the nonfumigated plots of the same cultivars. Yields from plots receiving the 50- and 25-gallon rates were essentially identical, indicating phytotoxicity at the high rate and inadequate control at the lower rate.

Before fumigation, the plant parasitic nematode population was 3,850 in 500 ml of the surface 8 inches of soil. These were reduced to undetectable numbers at all fumigation rates three weeks after fumigation. Originally the population was made up of 80 per cent American Dagger nematodes, 15 per cent stunt nematodes, and 5 per cent root lesion nematodes. At the beginning of the third growing season, the plant parasites were essentially all Dagger nematodes with only a single specimen of root lesion and six specimens of stunt nematodes being found in the samples. By the beginning of the third growing season, the population of Dagger nematodes in the untreated plot had almost doubled. Populations of nematodes on the cultivar Midway in the plots receiving 15 and 25 gallons of Vorlex had reached the threshold of a potentially damaging size. The nature of the population build-up in the fumigated plots suggests that the cultivar Midway is a more favorable host for Dagger nematodes than is Surecrop.

It is probable that the productive life of the plantings on the 35- and 50-gallon treatments can be extended one or more years beyond the usual practice of cropping for one year and thus be an added economic benefit to strawberry growers (Figures 2, 3, and 4).

Representative results of the study on unregistered pesticides are presented in Figure 10. Yields in these plots were reduced approximately 25 per cent by frost. Projecting from the total yield from the best treatment (10,056) and adding to it the estimated frost kill (2,514), it is estimated that yields of 13,000 quarts of berries per acre are possible in West Virginia if foliage and root pathogens are controlled.

For the first time in our experience, statistically significant increases in yield of strawberries resulted from the application of foliar sprays.

Yield was greatest following fungicidal applications of Daconil, followed in order by Polyram and Difolatan. The numbered compound from Bayer (47531) reduced yields below that of the unsprayed control, but no foliage injury was observed.

Yield was greatest following nematocidal applications of Temik, followed in order by Zinophos, Dasanit, and Disyston. The fungicidal and nematocidal treatments interacted synergistically. This is supported by the highly significant F value (1 per cent level) obtained for the interaction. For example, Polyram foliar spray alone depressed yields below that of the untreated control, but when applied to plants growing in soil treated with Temik, Zinophos, Disyston, or Dasanit, significant increases in yield occurred. On the other hand, the application of Difolatan sprays in combination with Disyston soil treatment depressed yields, but when Difolatan was used in combination with Temik, Zinophos or Dasanit, yields were significantly higher. This suggests that there may be a problem of incompatibility when foliar sprays are applied to plants growing in treated soil that is analagous to the problem in the deciduous tree fruit industry when several chemicals are tank mixed to control insects and fungi.

Before treating the soil, the plant parasitic nematode population was 4,200 per 500 ml soil. The predominant form was the American Dagger nematode with a few root lesion nematodes. By the first week in August, 1967, plant parasitic nematodes could not be recovered from the plots treated with Temik, Zinophos, and Dasanit. A mean of ten specimens of the Dagger nematode was recovered per 500 ml soil from the Disyston treatments. The populations in the control plots had declined to a mean of 2,800 per 500 ml soil.

If and when the use of these materials is declared safe by agencies of the federal government, their use could benefit strawberry growers.

Conclusion

The results of these studies show that yields of strawberries can be improved. However, the use of foliar fungicides alone, high rates of fertilization alone, irrigation alone, the use of selective herbicides alone, or the use of nematocides alone, will not permit maximum production of strawberries in West Virginia. Only when all of these practices are successfully combined into a single practical production program will competitively high yields of strawberries be realized, and the longevity of plantings increased.

Caution

The legal uses and dosage rates of agricultural chemicals are subject to frequent and rapid change by agencies of the federal government as new information becomes available. Therefore, the compounds and their methods of application described in this Bulletin do not constitute a recommendation of the West Virginia University Agricultural Experiment Station for their use by strawberry growers.

Current recommendations of the best nematocidal materials that can be used and methods of application can be obtained from the office of the Plant Pathology-Entomology Extension Specialist, 401 Brooks Hall, West Virginia University, Morgantown, West Virginia 26506, Telephone 304-293-3912.

Similar information on fertilizers can be obtained from the office of the Agronomy Extension Specialist, 1074 Agricultural Sciences Building, West Virginia University College of Agriculture and Forestry, Morgantown, West Virginia 26506, Telephone 304-293-2219.

Literature Cited

1. Adams, R. E. 1965. Temperature and the quantitative recovery of nematodes with a modified Baermann funnel. Plant Disease Reptr. 49: 662-664.
2. Cannel, G. H., V. Voth, R. S. Bringhurst, and E. C. Proebsting. 1961. The influence of irrigation levels and application methods, polyethylene mulch, and nitrogen fertilization on strawberry production in southern California. Am. Soc. Hort. Sci. Proc. 78: 281-291.
3. Hagler, T. B., and R. L. Livingston. 1957. Rates and sources of nitrogen for strawberries. Assn. Southern Agr. Workers Proc. 54: 179-180.
4. Hartman, J. D., R. H. White-Stevens, and M. B. Hoffman. 1938. Phosphorus and nitrogen fertilization for strawberries on Long Island, New York. Am. Soc. Hort. Sci. Proc. 36: 473-476.
5. Jahn, O. L., and E. A. Crosby. 1957. Growth of the strawberry plant as affected by several nitrogen carriers. Am. Soc. Hort. Sci. Proc. 71: 207-215.
6. Kirsch, R. K. 1959. The importance of interaction effects in fertilizer and lime studies with strawberries. Am. Soc. Hort. Sci. Proc. 73: 181-188.
7. Long, J. H., and E. E. Murneek. 1937. Nitrogen and carbohydrate content of the strawberry plant. Seasonal changes and the effects of fertilizers. Missouri Agr. Expt. Sta. Res. Bull. 252: 1-52.
8. Long, J. H. 1939. The use of certain nutrient elements at the time of flower formation in the strawberry. Am. Soc. Hort. Sci. Proc. 37: 553-556.
9. Roach, F. A., and C. Bould. 1963. An experiment with strawberries on the effect and time of application of nitrogenous fertilizers. Exptl. Hort. 8: 62-70.
10. Ruef, J. U., and H. W. Richey. 1925. A study of flower bud formation in the Dunlap strawberry. Am. Soc. Hort. Sci. Proc. 23: 252-260.
11. Shoemaker, J. S. 1929. The strawberry in Ohio. Ohio Agr. Expt. Sta. Bull. 444. 50 pp.
12. Stadelbacher, I. J. 1963. Flower initiation and fruiting response of the strawberry as related to nitrogen nutrient levels. Dissertation Abstr. 24: 1780-1781.
13. Van Meter, R. A. 1935. Effects of late summer and fall applications of nitrogen on fruit production in the strawberry. Am. Soc. Hort. Sci. Proc. 33: 401-404.
14. Voth, V., E. L. Proebsting, Sr., and R. S. Bringhurst. 1961. Response of strawberries to nitrogen in southern California. Am. Hort. Sci. Proc. 78: 270-274.
15. Voth, V., K. Uriu, and R. S. Bringhurst. 1968. Effect of high nitrogen applications on yield, earliness, fruit quality, and leaf composition of California strawberries. Am. Soc. Hort. Sci. Proc. 91: 249-256.

FIGURE 2. Field of strawberries at the Ohio Valley Experiment Farm fumigated with Vorlex in the background and unfumigated in the foreground.

FIGURE 3. Close-up of strawberry plants growing in Vorlex fumigated soil 3 years after fumigation. Note the vigor and density of the plants.

FIGURE 4. Close-up of strawberry plants growing in unfumigated soil, the same age as the plants in Fig. 3. Note the lack of vigor and relative scarcity of plants compared to Figure 3.

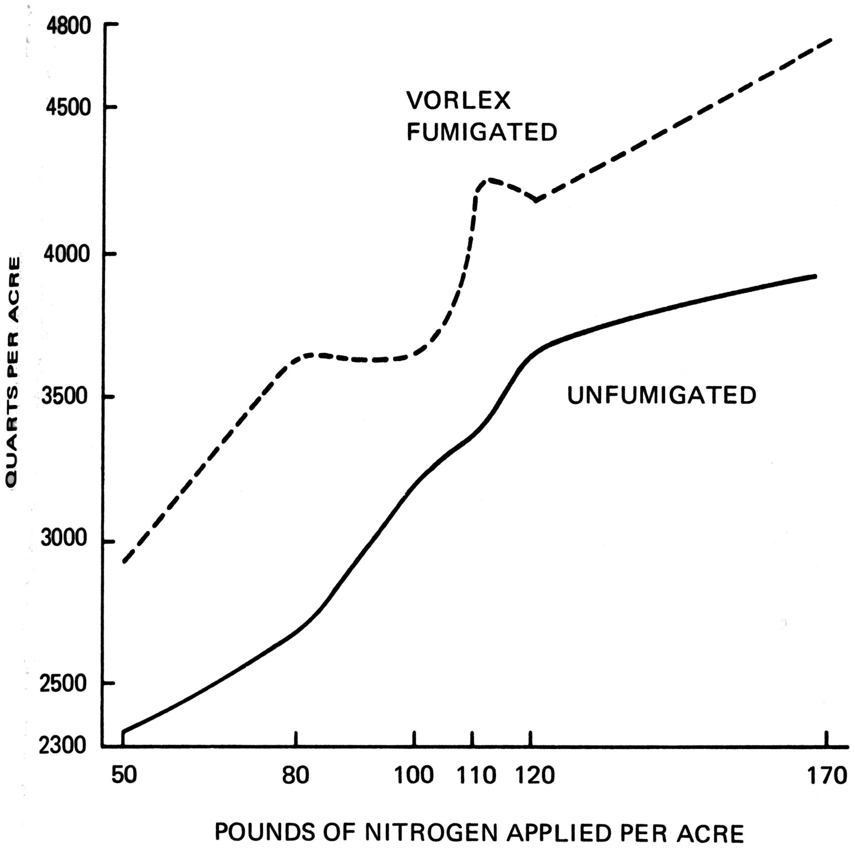


FIGURE 5. Influence of the Amount of Nitrogen Supplied on the Yield of U.S. Number 1 Surecrop Strawberries.

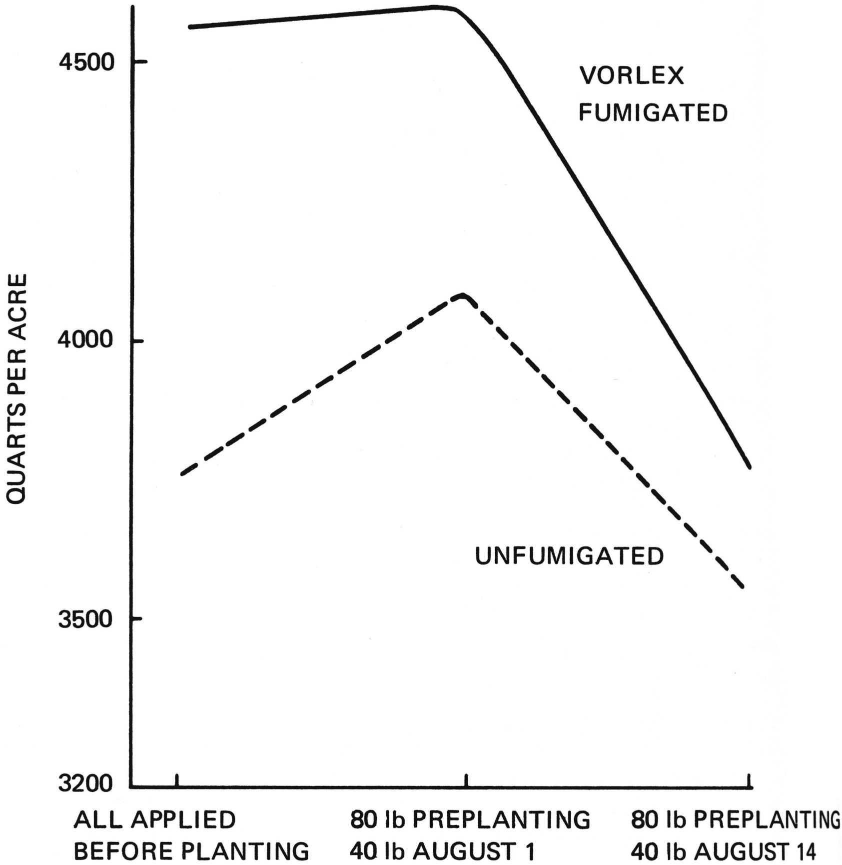


FIGURE 6. Influence of Time of Soil Application of 120 lb. Nitrogen as Urea on Yields of Surecrop Strawberries.

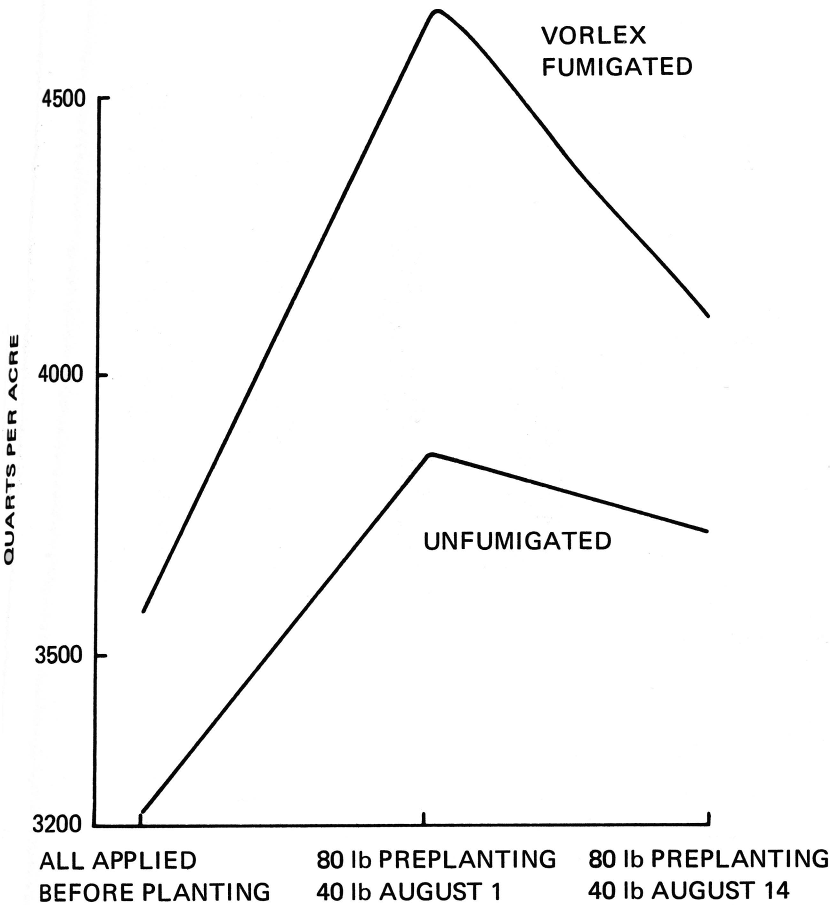
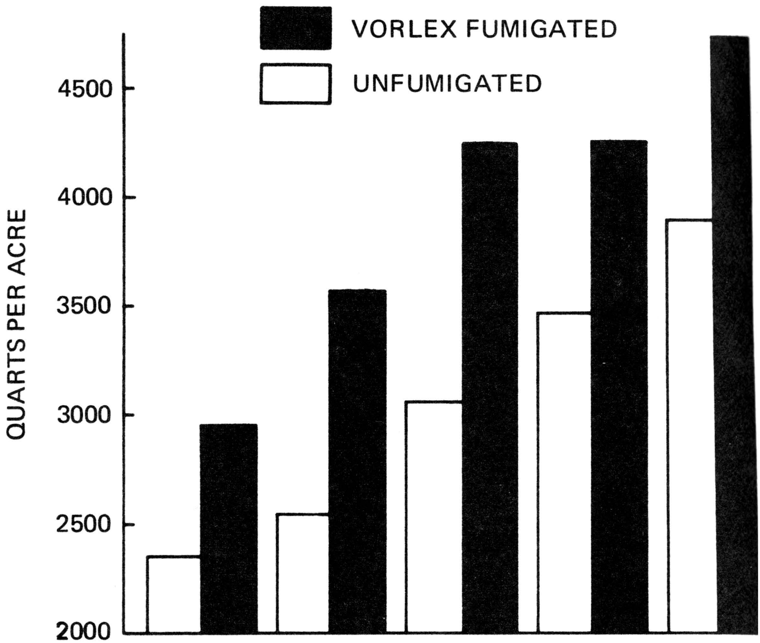


FIGURE 7. Influence of Time of Soil Application of 120 lb. Nitrogen as Ammonium Nitrate on the Yields of Surecrop Strawberries.



PRE PLANT AMMONIUM NITRATE	20 lb	20 lb	50 lb	50 lb	110 lb
UREA FOLIAR SPRAY	15 lb AUG OCT	15 lb JULY AUG SEPT OCT	15 lb AUG OCT	15 lb JULY AUG SEPT OCT	15 lb JULY AUG SEPT OCT
TOTAL NITROGEN APPLIED	50 lb	80 lb	80 lb	110 lb	170 lb

FIGURE 8. Influence of Urea Foliar Sprays in Conjunction with Soil Applications of Ammonium Nitrate on Yield of Surecrop Strawberries.

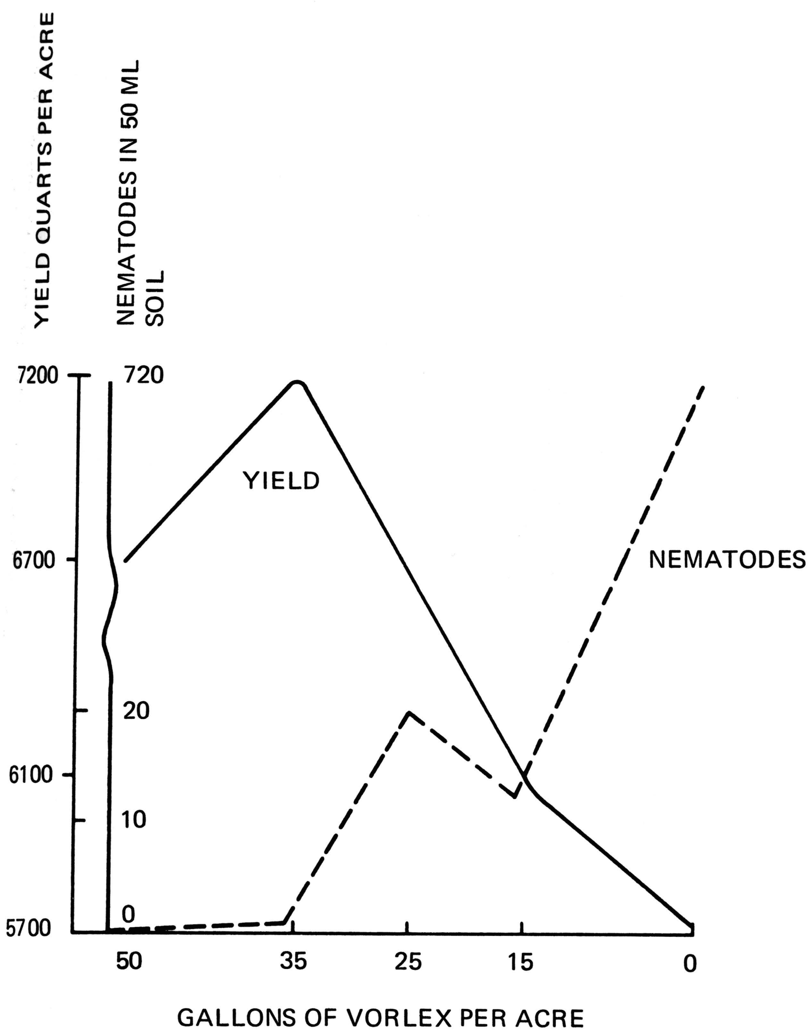


FIGURE 9. Average Strawberry Yields (Cultivars Midway and Surecrop) and Nematode Populations in Vorlex Dosage Study.

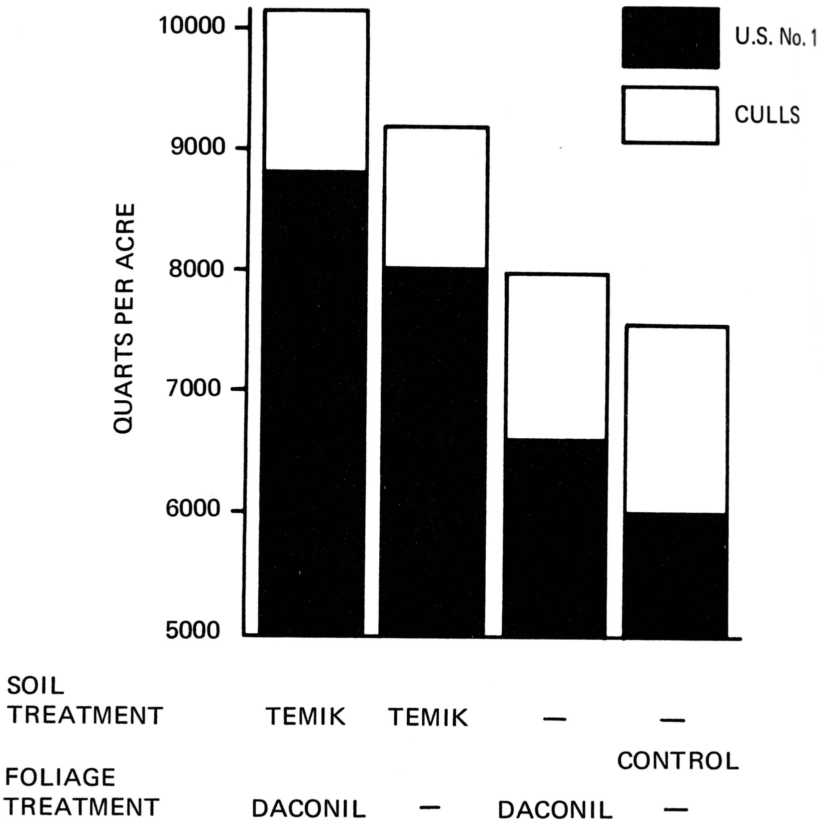


FIGURE 10. Yields of Midway Strawberries Treated with Unregistered Compounds to Control Nematodes and Foliage Diseases.

[Blank Page in Original Bulletin]