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# Effects of Applied Plant Nutrients on Sclerotinia Blight Incidence in Peanuts[1]

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## ABSTRACT

Field experiments were conducted in Southampton County, Virginia in 1978 and 1979 on Altavista loamy fine sand (Aquic Hapludult) to determine whether applied nutrients affect the severity of Sclerotinia blight in peanuts (*Arachis hypogaea* L.) caused by *Sclerotinia minor*. Soil or foliar applications of N, K, Ca, Mg, P, Mn, Zn, Fe, B, S, and Cl were evaluated alone and/or in various combinations and formulations. Multiple Zn or Cu sprays applied on the foliage suppressed Sclerotinia blight symptoms most during fruit development. Yields in plots sprayed with four 1.12-kg/ha applications of Zn were 1,965 kg/ha greater than in untreated plots in 1978. Four 2.24 kg/ha sprays of Zn increased yields 810 kg/ha in 1979. In 1978, $CuSO_4$ sprayed in a manner similar to $ZnSO_4$ was the second most effective treatment among the simple nutrient materials. Zinc and Cu (sulfates) applied in a multi-nutrient commercial material which also contains Mn, Ca, and P suppressed Sclerotinia blight symptoms nearly as effectively as $ZnSO_4$ sprays. Soil applied Zn or Cu (sulfates) at rates of 22.4 and 11.2 kg/ha, respectively, were relatively ineffective. Sequestrene Cu applied in four 0.56 kg/ha sprays of Cu suppressed Sclerotinia blight as effectively as four 2.24 kg/ha Zn sprays in 1979. Also, Sequestrene Zn and THIS Cu applied similarly to Sequestrene Cu decreased the disease symptoms in 1979.


Key Words: Groundnuts, *Sclerotinia minor*, Macronutrients, Micronutrients, Foliar Fertilization.

Sclerotinia blight, caused by *Sclerotinia minor* Jagger (9) is a major disease of peanuts (*Arachis hypogaea* L.) in Virginia. Although the first outbreak in Virginia was reported in 1971 (15), Sclerotinia blight has spread rapidly to all peanut-producing counties (17). Estimates made following the 1978 Virginia peanut crop placed the overall yield reduction from Sclerotinia blight at 7%; a gross loss to peanut producers of $4.6 million. These losses were nearly double that estimated from any other peanut disease.

Adquate controls for Sclerotinia blight are not available at the present time. Peanut cultivars adapted to Virginia conditions are not resistant to Sclerotinia blight (16), and fungicides available to producers provide only partial control (1).

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[4]Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by Va. Polytechnic Institute & State University or the U. S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

Relationships between plant nutrients and many diseases have been observed. Johnston and Beute (8) noted that exogenous nutrients enhanced pathogenicity of *Cylindrocladium crotalariae* in peanut hypocotyls, resulting in earlier than normal death of plants. Plant root exudates influence soil microorganism populations and their colonization of plant tissues (5, 18). Shay and Hale (19) found that sugar exudation by peanuts was reduced when the nutrient medium contained 50 vs. 10 mg/liter of Ca. Also, low levels of Ca increased root cell membrance permeability.

Relationships between the incidence of peanut pod breakdown disease and nutrients have been reported (4, 6). Field losses from this disease frequently were reduced by application of Ca, whereas K, particularly, and Mg sulfates increased losses. Moore and Wills (13), however, reported no relationship between applied Ca and the amount of pod breakdown in peanuts grown in artificial media.

Reports of research on the effects of nutrients on Sclerotinia blight in peanuts are few. *S. sclerotiorum* has no apparent preference for form of N (7). Bruehl (2) reported that *S. sclerotiorum* sclerotia with their rinds intact may be killed by chemicals. Maxwell and Lumsden (12) observed that the inclusion of potassium phosphate in the growth medium increased the production of oxalic acid by *S. sclerotiorum* possibly due to its buffering effects. Lumsden (10) noted that phosphatidase activity, a causative effect in pathogenesis, in cultures of *S. sclerotiorum* was near a maximum at pH 4, whereas it was nil at pH 7. Lumsden and Dow (11), however, reported that *S. sclerotiorum* penetrates host tissue mechanically, not by enzymatic dissolution, although the latter process may be active later. Vega and LeTourneau (20) reported that isolates of *S. sclerotiorum* produced less mycelia and no sclerotia in the absence of micronutirents. Sclerotia formed only in the presend of Zn alone or in combination with other micronutirents. Chet and Henis (3) also noted that the omission of Zn from a glucose-salts medium decreased the dry weight of *S. sclerotiorum* and prevented sclerotial production. Orellana et al. (14) observed that the virulence of *Whetzelinia sclerotiorum* was decreased when media contained high amounts of $CaCO_3$.

The objective of this research was to denote relationships between mineral nutrients or methods of application and the severity of Sclerotinia blight in peanuts. Results presented here include the effects of 12 nutrients applied alone and/or in various combinations and formulations on the incidence of Sclerotinia blight and on peanut productivity.

## Materials and Methods

This research was conducted in 1978 and 1979 on a private farm in Southampton County that had shown 50% or more damage from Sclerotinia blight. 'Va. 72R' peanuts were grown on Altavista loamy fine sand (Aquic Hapludult; fine, loamy, mixed, thermic). A rotation of corn and peanuts normally was followed. The general fertility level of the untreated surface soil was as follows: Soil pH was 5.4 both years. Dilute acid extractable P, K, Ca, and Mg contents were 70, 155, 325, and 30 in 1978, and 40, 150, 500 and 50 kg/ha, respectively, in 1979. Soil Mn and Zn contents were each 1.8 μg/g in 1978 and 2.4 and 1.1 μg/g, respectively, in 1979.

Thiram-treated seeds were machine-planted approximately 10 cm apart in the middle of beds 61 cm wide and ca 7 cm high in mid-May. Plots were 3.6 m (4 rows) wide and 5.9 m long. The following herbicides, insecticides, and fungicides were applied: [22.4 kg/ha of vernolate 10G (*S*-propyl dipropylthiocarbamate) + 56 kg/ha of benefin 2.5G (*N*-butyl-*N*-ethyl-α, α, α-trifluoro-2, 6-dinitro-*p*-toluidine) incorporated preplant; 4.7 liters/ha of alachlor 4 EC (2-chloro-2', 6'-diethyl -*N*-(methoxymethyl) acetanilide) + 3.5 liters/ha of dinoseb 3 EC (2-sec-Butyl-4, 6-dinitrophenol) sprayed at emergence; 4.5 kg/ha of diphenamid 50W (*N*, *N*-dimethyl-2, 2-diphenylacetamide) sprayed 8 weeks after planting; 1.2 liters/ha of butonate (dimethyl (2, 2, 2-trichloro-1-hydroxyethyl) phosphonate butyrate) sprayed 11 weeks after planting; 7.8 kg/ha of aldicarb 15G (2-methyl-2-(methythio) propionaldehyde *O*-(methyl carbamoyl) oxime) incorporated at planting; 4.7 liters/ha of methomyl (S-methyl *N*-[(methylcarbamoyl)oxy] thioacetimidate) sprayed during fruiting; and 5 biweekly applications each 4.7 liters/ha of chlorothalonil 500 (tetrachloroisophthalonitrile)] as sprays during fruiting. Treatments (Table 1) were arranged in a completely randomized block design replicated four times. The lime treatments which increased soil pH to 6.6 were broadcast just before planting and rototilled into the fruit zone. The other soil treatments were sidedressed or banded on the peanut rows and incorporated into the fruiting zone ca 2 weeks after emergence. The spray treatments were made with a $CO_2$ pressure-regulated backpack sprayer that delivered 140 or 280 liters at 2.8 kg/cm$^2$. The solutions were sprayed on the peanut foliage through a Tee-Jet 8004E flat-tip nozzle. All plots in 1979 received 896 kg/ha of pulverized landplaster during the early flowering stage.

All disease observations and plant productivity measurements were made on the two center rows of each plot. Estimates of the extent of infection of peanut vines by *S. minor* were made by averaging disease symtom scores from 10 random observations within each plot. Injury or infection was scored visually on a basis of 1 = no apparent injury to 10 = dead plants. Such estimates were made four times in 1978 and five times in 1979 during the peanut fruit maturation period. The peanuts were dug in early October, allowed to dry in the field for several days, then were harvested with a small-plot picker. The partially dried fruits were further dried artificially to ca 9% moisture content and later 500-g samples were graded.

After harvest, soil collected from each plot was assayed for sclerotia of *S. minor*. Soil, collected with a standard 2.5-cm diameter soil sampling tube to a depth of 10 cm (20 to 30 cores/plot), was air dried, screened to pass through a 10-mesh sieve and thoroughly mixed. Soil samples (100g) collected from plots soon after digging were wet-sieved for 5 min using a 40-mesh sieve. Material including soil particles, plant debris, and sclerotia of *S. minor* collected during sieving was placed in a counting chamber and the sclerotia of *S. minor* were counted using a stero-microscope (10X).

Foliar samples were taken in late September from the upper main stem branches of 10 to 12 plants per plot. Before wilting, the green foliage was washed several times in distilled and then in deionized water. The samples were dried and finely ground in a stainless steel mill. Dry

**Table 1. Treatments applied in 1978 and 1979.**

| Materials | Rate | How applied | Schedule |
|---|---|---|---|
| | kg/ha | | |
| | 1978 TREATMENTS | | |
| $ZnSO_4$ | 4.48-Zn | 4, 1.12-kg/ha sprays | 3§ |
| Nutra-Phos ZMC† | 44.8 | 4, 11.2-kg/ha sprays | 3 |
| $CuSO_4 \cdot 5H_2O$ | 4.48-Cu | 4, 1.12-kg/ha sprays | 3 |
| Nutra-Phos 3-15† | 30.24 | 4, 7.56-kg/ha sprays | 3 |
| KCl (50%) + | 1,120 | Sidedress and rototill | 2 |
| Landplaster | 1,120 | Band over row (61 cm) | 2 |
| Superphosphate (44%) | 1,120 | Sidedress and rototill | 2 |
| $FeSO_4 \cdot 7H_2O$ | 4.48-Fe | 4, 1.12-kg/ha sprays | 3 |
| $MgSO_4 \cdot H_2O$ + | 1,120 | Sidedress and rototill | 2 |
| Landplaster | 1,120 | Band over row (61 cm) | 2 |
| $ZnSO_4$ | 22.4 | Band over row (61 cm) | 2 |
| KCl (50%) | 1,120 | Sidedress and rototill | 2 |
| Sodium borate | 0.56-B | Spray | 2 |
| Urea + nitrapyrin† | 224-N, 0.56 | Sidedress and rototill | 2 |
| $CuSO_4 \cdot 5H_2O$ | 11.2-Cu | Band over row (61 cm) | 2 |
| Daminozide† | 1.12 | Spray | 2 |
| Urea | 224-N | Sidedress and rototill | 2 |
| Dolomitic lime | 2,240 | Broadcast and rototill | 1 |
| Landplaster (x) | 1,120 | Band over row (61 cm) | 2 |
| Landplaster (3x) | 3,360 | Band over row (61 cm) | 2 |
| $MnSO_4 \cdot 2H_2O$ | 4.48-Mn | 4, 1.12-kg/ha sprays | 3 |
| Flowable S | 20.2-S | 4, 5.05-kg/ha sprays | 3 |
| Zn ion - maneb complex† | 8.96ai | 4, 2.24-kg/ha sprays | 3 |
| $MnSO_4 \cdot 2H_2O$ | 33.6-Mn | Band over row (61 cm) | 2 |
| Check - untreated | -- | -- | - |
| $NH_4NO_3$ | 224-N | Sidedress and rototill | 2 |
| $K_2SO_4$ + | 1,120 | Sidedress and rototill | 2 |
| Landplaster | 1,120 | Band over row (61 cm) | 2 |
| $K_2SO_4$ | 1,120 | Sidedress and rototill | 2 |
| | 1979 TREATMENTS | | |
| $ZnSO_4$ (2x)‡ | 8.96-Zn | 4, 2.24-kg/ha sprays | 4 |
| Sequestrene Cu† | 2.24-Cu | 4, 0.56-kg/ha sprays | 4 |
| Sequestrene Zn† | 2.24-Zn | 4, 0.56-kg/ha sprays | 4 |
| THIS Cu with S† | 2.24-Cu | 4, 0.56-kg/ha sprays | 4 |
| $CuSO_4 \cdot 5H_2O$ + | 6.72-Cu | 4, 1.68-kg/ha sprays | 4 |
| $MnSO_4 \cdot 2H_2O$ | 2.24-Mn | 4, 0.56-kg/ha sprays | |
| $ZnSO_4$ (x) | 4.48-Zn | 4, 1.12-kg/ha sprays | 4 |
| $ZnSO_4$ + | 6.72-Zn | 4, 1.68-kg/ha sprays | 4 |
| $MnSO_4 \cdot 2H_2O$ | 2.24-Mn | 4, 0.56-kg/ha sprays | |
| Dolomitic lime | 4,480 | Broadcast and rototill | 1 |
| THIS Zn with S† | 2.24-Zn | 4, 0.56-kg/ha sprays | 4 |
| Check - untreated | -- | -- | - |

†/ Nitrapyrin is 2-chloro-6-(trichloromethyl)pyridine; Daminozide= succinic acid (2, 2-dimethyl hydrazide); Nutra-Phos (Reg. TM Leffingwell Chemical Co.) ZMC contains 10% Zn, 10% Mn, 6% Cu, 8% S, 9% Ca, and 4% $P_2O_5$; Nutra-Phos 3-15 contains 15% Zn, 15% Mn, 15% $P_2O_5$, 7.5% Ca, and 3% S; Zn ion-maneb complex contains 16% Mn, 2% Zn; THIS (Reg. TM Stoller Chemical Co.) Cu (phenolic acid chelate) contains 5% Cu, 4% S; THIS Zn (phenolic acid chelate) contains 7% Zn, 4% S; Sequestrene (Reg. TM Ciba-Geigy) Zn (EDTA chelate) contains 6% Zn; Sequestrene Cu (EDTA chelate) contains 13% Cu.

‡/ Applied in 280 liters/ha of solution; other spray treatments were in 140 liters/ha.

§/ Application schedules were as follows: 1) at planting; 2) 6/20; 3) 6/28, 7/18, 8/9, 9/16; 4) 7/5, 7/26, 8/13, 9/14.

(70 C) 1-g samples were ashed at 450 C for 2.5 to 3 hours and the nutrient constituents of the ash were dissolved in 25 ml of 0.5 N HCl. Calcium, Mn, Zn, and Cu were determined by atomic absorption spectroscopy.

# Results

### Weather

Air temperature and precipitation recorded during the 1978 and 1979 peanut-growing seasons by the U. S. Weather Service are given in Table 2. The precipitation in 1978 was above the long-time average in May, June, and for the 5-month growth period, but below normal in July and September. In 1979, it was excessive in May and September and subnormal (-9.5) in August. Average temperatures were relatively normal both years. In general, the weather conditions were favorable for peanut production.

Table 2. Average daily maximum and minimum temperatures and precipitation.

| | Temperature† | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum | | | Minimum | | | Precipitation† | | |
| | Normal | 1978 | 1979 | Normal | 1978 | 1979 | Normal | 1978 | 1979 |
| | C | | | | | | cm | | |
| May | 25.6 | 26.0 | 25.0 | 12.8 | 12.3 | 13.3 | 9.7 | 13.4 | 25.5 |
| June | 29.4 | 31.2 | 27.2 | 17.2 | 16.5 | 14.4 | 11.5 | 20.2 | 10.8 |
| July | 31.1 | 31.9 | 30.0 | 19.4 | 18.6 | 18.9 | 15.5 | 11.5 | 14.6 |
| August | 30.6 | 32.7 | 31.1 | 18.9 | 20.0 | 18.9 | 15.2 | 14.8 | 5.7 |
| September | 27.8 | 30.5 | 26.7 | 15.6 | 16.3 | 16.7 | 10.8 | 5.9 | 22.0 |
| Ave. or total | 28.9 | 30.5 | 28.0 | 16.8 | 16.7 | 16.4 | 62.6 | 65.8 | 78.6 |

†/ The 1978 data were recorded in Boykins and the 1979 data in Suffolk, Va. Normal or long-time averages are available only for Suffolk.

### Sclerotinia Blight Severity

The effects of 26 treatments (Table 1) on the incidence of visual symptoms of Sclerotinia blight were evaluated in 1978. However, the results of only those which appeared to suppress the disease and certain other treatments which have been of interest in the control of peanut diseases are given in Table 3. Among the single cations applied in 1978, disease symptoms were lowest in plots sprayed with $ZnSO_4$. A spray treatment of $CuSO_4$ also was very effective and gave the second highest degree of disease suppression among the simple nutrient materials. The multi-nutrient Nutra-Phos ZMC (ZMC), which contained Zn, Cu, Mn, S, P, and Ca, however, suppressed Sclerotinia blight development considerably, also. There were no significant differences among the above three treatments in the amount of foliar disease symptoms observed. Another multi-nutrient material, Nutra-Phos 3-15 (3-15), which contained equivalent contents of Zn, Mn, and P was fourth in degree of disease suppession as indicated by the visual estimates. Noticeable but statistically insignificant (5% level) suppression of disease symptoms occurred at various times throughout the 1978 season in several other treatments, particularly lime and S. The most severe symptoms of Sclerotinia blight occurred in plots treated with $K_2SO_4$ without landplaster, although the average score (7.8 at harvest) was not significantly (5% level) higher than that for the check plots.

Table 3. Effects of foliar and soil amendments on peanut foliar symptoms of Sclerotinia blight, number of sclerotia in the fruiting zone, yield and crop value.

| Treatment | Foliar symptom scores: During‡ season | Foliar symptom scores: At harvest | *S. minor* sclerotia | Crop yield | Crop value |
|---|---|---|---|---|---|
| | 1=healthy, 10=dead | | no./100g | kg/ha | $/ha |
| | | 1978 | | | |
| $ZnSO_4$-sprays† | 2.0a | 3.0a* | 4a | 3,550a | 1,536a |
| Nutra-Phos ZMC | 2.2a | 2.8a | 8a | 3,030ab | 1,149bc |
| $CuSO_4$-sprays | 2.8ab | 4.2ab | 9a | 2,555bc | 1,079bc |
| Nutra-Phos 3-15 | 3.2b | 4.2ab | 6a | 2,115cd | 719d |
| $ZnSO_4$-band | 4.0c | 6.2c | 9a | 1,625de | 625de |
| $CuSO_4$-band | 4.2c | 5.8bc | 8a | 1,800de | 635de |
| Lime | 4.4c | 5.0bc | 5a | 2,345bcd | 874cd |
| Landplaster (3x) | 4.5c | 6.8c | 7a | 2,565bc | 1,193b |
| Flowable S | 4.5c | 5.2bc | 8a | 2,230cde | 664de |
| Check | 4.8c | 6.8c | 10a | 1,585e | 568e |
| | | 1979 | | | |
| $ZnSO_4$ (2x)§ | 1.7a | 2.4ab | 2a | 3,225a | 1,549a |
| Sequestrene Cu | 1.7a | 2.2a | 3a | 2,895ab | 1,338abc |
| Sequestrene Zn | 2.1ab | 2.4ab | 4a | 2,850ab | 1,215abc |
| THIS Cu | 2.4ab | 3.4abc | 5a | 2,975ab | 1,395abc |
| $CuSO_4$ + $MnSO_4$ | 2.4ab | 3.9cd | 5a | 2,985ab | 1,403ab |
| $ZnSO_4$ (x) | 2.6ab | 3.4abc | 4a | 3,000ab | 1,302abc |
| $ZnSO_4$ + $MnSO_4$ | 2.7abc | 3.7bcd | 4a | 2,490ab | 1,119bc |
| Lime | 2.9bc | 3.5a-d | 3a | 2,665ab | 1,042bc |
| THIS Zn | 3.2bc | 4.3cd | 6a | 2,235b | 1,020bc |
| Check | 3.7c | 4.9d | 5a | 2,415ab | 993c |

†/ Complete treatments are described in Table 1.

‡/ Mean of observations taken on 8/21, 8/28, 9/15 and 9/28 in 1978 and on 8/15, 8/21, 9/10, 9/25 and 10/3 in 1979.

§/ Applied in 280 liters/ha of solution; other spray treatments were in 140 liters/ha.

*/ Means followed by all unlike letters are significantly different at the 5% level of probability. Compare statistical notations within years.

In 1979, the suppressive effect of Zn and Cu again occurred (Table 3); however, to a somewhat lesser extent than in 1978. Average Sclerotinia blight symptom scores were lowest in plots sprayed with a total of 8.96 kg/ha (2x rate) of Zn from $ZnSO_4$ or 2.24 kg/ha of Cu from Sequestrene Cu. Considerable suppression of the disease also occurred where 2.24 kg/ha of Zn or Cu from Sequestrene Zn or THIS Cu, respectively, or 4.48 kg/ha Zn from $ZnSO_4$ were applied. The addition of $MnSO_4$ with either $ZnSO_4$ or $CuSO_4$ appeared to reduce their effectiveness.

The concentrations of sclerotia of *S. minor* in the fruiting zone following digging were somewhat lower in the

$ZnSO_4$ (spray) and lime treatments than in other plots in 1978 (Table 3). In 1979, also, there was a trend toward lower sclerotia numbers in treatments where maximal disease suppression occurred, although the treatment effects did not differ significantly.

### Crop Productivity

Crop yields and values (Table 3) varied considerably among the treatments. In 1978, significantly higher yields occurred where $ZnSO_4$ was sprayed than with any other treatment except ZMC. The $ZnSO_4$ sprays increased yields by 1,965 kg/ha, whereas ZMC increased Yields 1,445 kg/ha. Yields significantly greater than the check also were obtained from several other treatments. There was a yield response to landplaster that did not appear disease related. Differential treatment effects on peanut yield in 1979 (Table 3) were not as large as in 1978, perhaps due to the uniform application of landplaster on all plots. Nevertheless, yields averaged from 435 to 810 kg/ha higher than the check where Zn or Cu was applied except for plots treated with THIS Zn or Zn + Mn sulfates. However, these differences were not statistically significant at the 5% level of probability.

Treatment effects on peanut crop values (Table 3) generally were similar to the effects on yields; however, the value of peanuts produced on plots sprayed with $ZnSO_4$ was significantly higher than that for any other treatment in 1978. Crop values significantly higher than that of the check also were obtained from plots treated with lime, LP(3x), $CuSO_4$ sprays of ZMC. In 1979, the crop values of plots treated with $ZnSO_4$(2x) or $CuSO_4$ + $MnSO_4$ were significantly higher than the check plot crop values.

### Foliar Nutrient Concentrations

The concentrations of Zn, Cu, Mn, and Ca in the main or central stem foliage near maturity are given in Table 4. Significant differences among treatments occurred in the concentrations of each nutrient both years. Treatment effects influenced the foliar levels of Cu most. Micronutrient concentrations varied greatly among treatments.

Many of the spray treatments were phytotoxic, particularly those containing appreciable Zn or Cu. No foliar injury was observed where the treatments ZMC, 3-15, or $MnSO_4$ sprays were applied in 1978. The ranges in concentrations of Zn in the foliage were increased from 45 and 65 ppm to 406 and 641 ppm, and Cu contents from 8 and 11 ppm to 169 and 382 ppm by the Zn or Cu sprays in 1978 and 1979, respectively. The spray applications of $ZnSO_4$, $CuSO_4$, or $MnSO_4$ increased foliar levels of Zn, Cu, or Mn, respectively, considerably more than the soil treatments in 1978. In 1978, concentrations of Ca were lowest in foliage sprayed with $ZnSO_4$ only and in 1979 where $ZnSO_4$ was sprayed at the 2x rate.

## Discussion

The results of these experiments indicate that, among the nutrients applied, Zn and Cu applied on the foliage had the greatest potential for suppression of Sclerotinia blight in peanuts. These nutrient sources, however,

Table 4. Effects of foliar and soil amendments on the concentrations of Zn, Cu, Mn, and Ca in central stem peanut foliage just prior to harvest in 1978 and 1979.

| Treatment | Zn | Cu | Mn | Ca |
|---|---|---|---|---|
| | ppm | | | |
| | 1978 | | | |
| $ZnSO_4$-sprays† | 406a* | 13d | 77f | 1.84d |
| Nutra-Phos ZMC | 232b | 100b | 181b | 2.02c |
| $CuSO_4$-sprays | 82d | 169a | 50g | 1.90cd |
| Nutra-Phos 3-15 | 97c | 10de | 205a | 2.27bc |
| $ZnSO_4$-band | 102c | 8e | 127c | 2.18c |
| $CuSO_4$-band | 68ef | 9de | 117c | 2.34b |
| Lime | 70e | 14d | 87ef | 2.25bc |
| Landplaster (3x) | 100c | 13d | 176b | 2.60a |
| Flowable S | 60f | 20c | 100d | 2.13c |
| Check | 45g | 12d | 95e | 2.20bc |
| | 1979 | | | |
| $ZnSO_4$ (2x)‡ | 641a | 11d | 68d | 1.79f |
| Sequestrene Cu | 74g | 108c | 64d | 2.10de |
| Sequestrene Zn | 181e | 13d | 68d | 2.27c |
| THIS Cu | 99f | 130b | 138b | 2.63a |
| $CuSO_4$ + $MnSO_4$ | 72g | 382a | 225a | 2.04e |
| $ZnSO_4$ (x) | 394c | 11d | 94c | 2.27c |
| $ZnSO_4$ + $MnSO_4$ | 536b | 18d | 233a | 2.12de |
| Lime | 78g | 15d | 83c | 2.22cd |
| THIS Zn | 218d | 11d | 90c | 2.48b |
| Check | 65g | 15d | 90c | 2.44b |

†/ Complete treatments are described in Table 1.

‡/ Applied in 280 liters/ha of solution; other spray treatments were in 140 liters/ha.

*/ Means followed by all unlike letters are significantly different at the 5% level of probability. Compare statistical notations within years.

caused phytotoxicity both years at the spray rates used. When Mn was included in the solutions with $ZnSO_4$ or both Zn and Cu in 1978, as in the 3-15 or ZMC treatments, no phytotoxicity was observed. Phytotoxicity did occur when concentrations of Zn or Cu were in excess of 232 or 100 ppm, respectively, although the foliar Zn level in the Sequestrene Zn treatment was only 181 ppm in 1979. Apparently phytotoxicity was precluded by competition among Mn, Cu, or Zn, or of P on Zn which reduced the uptake of each other in the 3-15 and ZMC treatments (Table 4). The Mn included with the Zn or Cu sulfates in the 1979 test, however, did not reduce phytotoxicity appreciably, and crop productivity probably was reduced. In 1978, the phytotoxicity did not limit crop productivity perceptibly, because yields and grades were somewhat higher for the $ZnSO_4$ spray treatment than for the ZMC treatment.

The possible effect of sulfate on the suppression of Sclerotinia blight is worthy of mention. Because the flowable S treatment became relatively more effective with time (10th out of the 26 treatments at the harvest observation), it is possible that the sulfate did give some control when applied on foliage.

Although it was only a trend, the most effective treatment on Sclerotinia blight, $ZnSO_4$ sprays, had the lowest average number of *S. minor* sclerotia in 1978 (Table 3). However, the 2nd and 3rd most effective treatments, ZMC and $CuSO_4$ sprays had twice as many sclerotia. This indicates that Zn may deter sclerotia production more than Cu. The sclerotia count was 6/100 g of soil for the Nutra-Phos 3-15 treatment, which contains Zn. Possibly Cu suppressed the effectiveness of Zn in the ZMC treatment somewhat. There was no significant differential treatment effect on numbers of sclerotia in 1979. The results obtained in this investigation appear to differ with those of Vega and LeTourneau (20) and Chet and Henis (3). These workers reported that Zn is needed for the formation of *S. sclerotiorum* sclerotia.

No definite explanation is apparent for the lesser disease control obtained from the soil than from foliar applications, unless soil fixation reduced uptake and/or the disease-suppressant activity of these nutrients. Rates of micronutrients in foliar sprays were considerably lower than when soil-applied, but plant uptake of the nutrients was much greater when they were applied on the foliage. The mode of activity of these nutrients was not investigated in these experiments. However, fungicidal properties of Zn, Cu, and S have been reported in a number of situations.

Soil pH in the lime plots increased from ca 5.4 to 6.6 during the growing period. Sclerotinia blight symptoms in lime-treated plots also decreased in most plots as the season progressed. Thus, the disease may have been suppressed slightly by the higher pH. These results support those reported by Lumsden (10) and Orellana et al. (14).

Many of the treatments in this experiment had highly significant differential agronomic effects in 1978. Application of Ca increased peanut productivity markedly. Productivity of many treatments probably was limited by Ca deficiency in the fruiting zone.

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