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EFFECTS OF PREPLANT INCORPORATED HERBICIDE-INSECTICIDE COMBINATIONS ON SOYBEAN (GLYCINE MAX (L.) MERRILL) GROWTH AND DEVELOPMENT

by

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INTRODUCTION

Todays agriculture demands the use of a number of pesticides to control weeds, insects, and diseases. Using two or more pesticides to control a number of pests is becoming a common practice on agronomic crops, horticultural crops, lawns, and ornamentals. Insecticide-fungicide combinations are used on many vegetable, fruit, and ornamental crops. Both herbicides and fungicides are being used on cotton, peanuts, vegetables, and other crops. Herbicide-insecticide combinations are used on lawns, and some agronomic and horticultural crops. It is not uncommon for all three of these pesticides to be used in one field.

Problems have been encountered with herbicide and insecticide mixtures used to control weeds and insects. In some cases, formulation has made the combining of herbicides and insecticides impossible. Also synergistic interactions have been reported on sorghum (*Sorghum bicolor* (l.) Moench) and cotton (*Gossypium hirsutum* L.), causing many growers to refrain from using combinations on these crops.

Herbicide-insecticide combinations on soybeans in the Midwest are rare, mainly because insect populations seldom reach economic threshold levels and insecticide applications are not necessary. If insecticides are used on soybeans they are usually applied alone during the growing season. An example is the use of carbaryl to control bean leaf beetles which feed on the foliage.

The purpose of this research is to investigate the effects of certain herbicide-insecticide combinations on soybeans (*Glycine max* (L.) Merrill).

REVIEW OF LITERATURE

Johnson (22, 23) reported that some pesticide combinations affected soybean growth. Some herbicide-insecticide combinations reduced plant stand and plant vigor, but did not affect plant height. A few herbicides reduced plant height. Herbicide-insecticide combinations did not affect date of maturity, lodging, seed yield, or quality of the soybeans. Also none of the herbicide-fungicide combinations affected soybean growth.

Mobil Chemical Company (31) released a report indicating that injury symptoms were noted at high rates of ethoprop plus alachlor on corn (Zea mays L.), and ethoporp plus metribuzin on soybeans. Greater injury occurred when overhead watering was increased from ¼ inch to ½ inch.

Soybeans escaped injury from metribuzin when trifluralin was used in combination with metribuzin. Ladlie, Meggitt, and Penner (28) noted that soybean injury at high soil pH values was reduced by applying metribuzin in combination with trifluralin. Trifluralin also protected soybeans from injury caused by low rates of atrazine. Trifluralin reduced root development and greatly reduced atrazine and metribuzin uptake and content within the soybean plant. Reduced root growth was probably the reason for the lower absorption of metribuzin and atrazine.

Arle (1) attributed the reduced injury from diuron on cotton to the retardation of branch root development by trifluralin, thus resulting in decreased diuron uptake.

Sun and Adams (38) observed that a nutrient-herbicide interaction can take place in soybeans. Inhibition of photosynthesis resulted from a phosphorus-manganese-atrazine interaction. Atrazine exerts its herbicidal action by making manganese unavailable for photosynthesis. Excess phosphorus further enchances the effect of atrazine by precipitating manganese in the tissue.

Soybean tolerance to metribuzin is greatly influenced by herbicide rate, soil organic matter, and rainfall after treatment. Coble and Schrader (10) observed that soybean tolerance increased with increasing soil organic matter to the point where no injury occurred. Under low soil organic matter content, injury to soybeans from metribuzin is likely to occur if there is rain within ten days after treatment. Injury to soybeans is likely to occur when metribuzin is applied at higher rates.

Differences in absorption, translocation, and metabolism of metribuzin contribute to differential susceptibility of soybean plants and weed species. Hargroder and Rogers (18) found that hemp sesbania (Sesbania exaltata) absorbed appreciably more herbicide than did soybean plants. In hemp sesbania metribuzin was rapidly translocated and accumulated in all parts of the plant. Only in the roots and lower leaves of soybean did metribuzin accumulate to any extent. A higher rate of metribuzin degradation occurred in soybeans than in hemp sesbania.

Chemagro (9) places certain restrictions and precautions on the use of metribuzin.

1. Soybean injury may occur if metribuzin is used on calcareous soils or a soil with a pH of 7.5 or higher.
2. Do not apply to light soils (sandy loam or loamy sand) containing

less than 2 per cent organic matter.

3. Crop injury may occur when preplant incorporated or preemerge applications of metribuzin are used in conjunction with soil-applied organophosphate insecticides.

Some insecticides inhibit the metabolism of herbicides in leaf tissue. Chang, Smith, and Stephenson (7) determined that certain organophosphate and carbamate insecticides inhibit herbicide metabolism in bean, wheat, lettuce, red beet, tomato and plantain.

Chang, Stephenson, and Smith (8) also reported that some herbicides inhibit the breakdown of certain insecticides in bean and tomato plants.

A herbicide-insecticide combination may interact synergistically to affect one crop but not another. Hamill and Penner (15) reported that carbofuran interacted synergistically with alachlor to reduce barley seedling growth but not corn germination and growth. The basis for the observed interaction in barley appeared to be greater alachlor uptake by plants which had received a carbofuran seed treatment. An increased accumulation of alachlor in barley roots indicated a reduced rate of alachlor metabolism.

In another study Hamill and Penner (17) observed that carbofuran combined with butylate reduced synergistically the root and shoot growth of barley but not that of corn. Barley plants treated with carbofuran had a greater accumulation of butylate in the roots than did corn. This accumulation indicates a lower metabolism of butylate by barley. Absorption of butylate by corn was reduced by carbofuran. Competition for uptake sites by the two carbamates in corn roots explains the lower absorption of butylate.

A single herbicide-insecticide combination may interact to affect two different crops. Hamill and Penner (16) determined that carbofuran interacted synergistically with chlorbromuron to reduce the root length of three day old barley and the leaf area and dry weight of seven day old corn grown in sand culture. Carbofuran reduced chlorbromuron metabolism, resulting in a higher chlorbromuron level in barley and corn.

Some herbicide combinations become synergistic or antagonistic depending on the plant species it is used on. Colby, Wajtaszek, and Warren (11) observed that paraquat plus solan was synergistic on crabgrass, but antagonistic on tomato plants. Velvetleaf is resistant to both DCPA and sesone alone, but is quite susceptible to the combination.

Colby and Feeny (13) observed that certain herbicide combinations are synergistic against different plant species. Potassium azide with calcium cyanamid caused synergistic interactions against several plant species including yellow nutsedge and crabgrass.

Cotton is another crop that has been studied for effects of herbicide-insecticide interactions. Swanson and Swanson (39) observed that monuron degradation was inhibited in cotton leaf tissue by certain carbamate insecticides.

Herbicide-insecticide interaction may cause favorable effects such as increased lateral root production and taller plants. Hassawy and Hamilton (19) noted that plants treated with trifluralin and the organophosphate insecticide phorate had more lateral roots than did the cotton plants with trifluralin alone. Also plants treated with trifluralin plus phorate were taller than plants treated with trifluralin alone. Plants grown in soil treated with phorate alone were taller than the plants grown with trifluralin treated soil. Trifluralin, phorate and their combination did not affect cotton germination.

Arle (2) also found that phorate or disulfoton with trifluralin resulted in increased cotton seedling growth as compared to trifluralin used alone. The combination of phorate and trifluralin showed an increase in secondary root development as compared to trifluralin alone. Phorate was more effective than disulfoton in overcoming the inhibitory effect of trifluralin on secondary root development.

Ivy and Pfrimmer showed no significant herbicide-insecticide interactions on seedling survival and yield of cotton. But some herbicide treatments had significantly higher yield and seedling survival than others. Also some insecticides were better than others as far as yield and seedling survival.

Helmer et al. (20) reported that trifluralin in combination with the insecticides disulfoton, phorate or temik caused no reduction in yield of cotton. Seed quality greatly influences plant stand, growth, and yield. Low quality seed usually resulted in a reduction in plnat stand, growth and yield. No interaction was found to exist between seed quality and the recommended rate of trifluralin.

Boling and Hacskaylo (4) reported only a slight interaction when the systemic insecticide UC-21149 and two of four herbicides were tested on cotton. Plants treated with the insecticide and either trifluralin or chloro-IPC were shorter than plants treated with either insecticide or herbicide alone. When properly used, any of the herbicides could be employed safely in combination with UC-21149.

Nash (33) indicated that synergistic phytoxicities resulted when diuron was combined with disulfoton or phorate on oats and corn. A tendency toward synergistic phytotoxicities resulted when these chemicals were applied to cotton. Corn and cotton were more tolerant than oats to diuron and diuron-insecticide combinations.

Lower rates of the herbicide-insecticide treatment may lessen or stop synergistic effects in some cases. Hacskaylo et al. (14) and Walker et al. (40) determined that combinations of monuron or diuron with phorate or Di-syston often caused a loss of plants or retardation of growth of cotton seedlings. A reduced rate of application tended to lessen or stop seedling damage.

Powell, Richards, and Whitworth (34) reported that the rate of application of trifluralin influenced the degree and persistence of stunting on cotton seedlings.

Fungicides normally give the seedling cotton plant an initial advantage, but this lasts only a few weeks. Kappelman and Buchanan (24) noted that soil fungicides increased emergence and early growth of cotton plants; however, this increase was not evident as the plants grew older. Lanstan-fluometuron treated plants were taller at two weeks than plants receiving other fungicide-herbicide treatments. It was also noted that plant height was affected by soil type for some fungicide-herbicide combinations.

In another study Kappelman, Buchanan, and Lund (25) reported that no interactions occurred with fungicide-herbicide combinations on cotton. However a reduction in total growth did occur between the herbicides trifluralin and prometryne.

Richardson (37) reported that the protective action of a fungicide can be enhanced by the addition of an insecticide. Pre emergence damping off was controlled better when an insecticide was added to a fungicide than if the fungicide was used alone. The insecticide-fungicide combination caused a greater lag period of the mycelium growth.

Ranney (36) reported that the fungicides hexachlorophene-captan mixed with Di-syston or phorate caused a lower emergence rate, higher incidence of seedling disease, and definite root abnormalities on cotton.

Arnold and Apple (3) observed that insecticides caused no inhibition of fungicides when mixtures were used on injured corn seed. Seed treated with the insecticide-fungicide combinations did not produce stands or yields significantly different from the stand and yield of fungicide treated corn seeds. Captan, dichlone, and thiram had no adverse effects upon the insecticidal action of dieldrin.

Pesticide combinations can give antagonistic, synergistic, additive, or independent effects. Nash (32) found that a combination of dalapon with Di-syston, phorate, or carbaryl in soil resulted in additive phytotoxic effects to oats. Diuron combined with Di-syston, phorate, or carbaryl produced synergistic phytotoxic effects. Captan combined with dalapon gave an independent effect, while choranil was antagonistic toward the herbicidal activity of diuron.

Chambers, Overton, and Andrews (6) also reported that herbicides, systemic insecticides and fungicides can give antagonistic, synergistic, additive or independent effects on cotton.

Microbial breakdown of a herbicide may be inhibited if other pesticides are combined with the herbicide. Kaufman (26) reported that the microbial degradation of dalapon was inhibited by the presence of amitrole.

Kaufman et al. (27) determined that methylcarbamate insecticides inhibit the herbicide phenylcarbamate (CIPC) in the soil by inhibiting the microbial activity. Methylcarbamates are competitive inhibitors of the phenylcarbamate hydrolyzing enzyme.

Some phosphate insecticides inhibit the hydrolysis of a herbicide in plant tissue. Matsunaka (29) reported that the hydrolysis of the herbicide propanil by rice plants was inhibited by insecticides. The inhibitory activity of an organophosphate is stronger than an organothiophosphate. Some carbamates also inhibit propanil hydrolysis in rice.

Prendeville et al. (35) reported that antagonistic responses can occur with combinations of carbamate and growth regulator herbicides on sorghum.

Cargill and Santelmann (5) observed no apparent herbicide-insecticide or herbicide-fungicide interactions when two pesticides were used on peanuts.

Menzer, Iqbal, and Boyd (30) reported that ethoprop was rapidly metabolized in plants, and that the metabolites were not likely to be considered toxic in any way. Uptake of ethoprop from treated soil was slow and the amounts of ethoprop likely to be present in the plant tissue at any time were low. There was no buildup of ethoprop metabolites in the plant.

Most of the research on herbicide-insecticide combinations has been done on crops other than soybeans. Cotton has had the most extensive research with herbicide-insecticide combinations. Results from researchers vary, so herbicide-insecticide interactions are not well defined. Rarely do insect pest populations reach economic threshold levels on soybeans and the use of insecticides on soybeans is uncommon and uneconomical. This is probably the main reason herbicide-insecticide interactions have not been studied more extensively.

METHODS AND MATERIALS

Effects of preplant incorporated herbicide-insecticide combinations on soybeans were determined in 1976 and 1977 in field experiments conducted at the Ashland Agronomy Farm near Manhattan, Kansas.

Field experiments were carried out at two locations. Location one was a Muir silt loam with an organic matter content of 2.5 per cent and a pH of 6.3 and location two, a Haynie very fine sandy loam with an organic matter content of 1.0 per cent and a pH of 7.7. Two dates of planting for each location were investigated.

The soybean cultivar "Williams", a semi-indeterminate with a group three maturity date and well adapted for eastern Kansas growing conditions, was used in both 1976 and 1977.

All soybean seeds were treated with Captan fungicide to prevent fungal infection prior to emergence. Soybeans were planted at a rate of 33 seeds per meter of row with a Buffalo No-Till planter.

A split-split plot design with three replicates was used for 1976 and 1977. Treatment effects were studied at two locations and two planting dates. The four row plots with rows 9.1 m long and 76.2 cm apart were kept weed free. The four row border that surrounded the plot area was treated with 0.56 kg/ha of metribuzin and 2.24 kg/ha of alachlor. Soybean yield, number of plants per meter of row, plant height, and weight per 100 beans were obtained from the center two rows and statistically analyzed.

1976. Location one was chiseled and disked after the 1975 wheat crop was removed. In the fall, the ground was furrowed and fertilized with 112 kg/ha of 18-46-0. Soybean residue was left on the surface of location two the winter of 1975 to prevent wind and water erosion. Prior to spring tillage, 112 kg/ha of 18-46-0 was applied to location two. In spring, both locations were clean-tilled using shallow tillage operations to keep the sites weed free until treatment applications.

The herbicide-insecticide treatments for the first date of planting were applied broadcast June 1 with a tractor-mounted spray boom 305 cm long with nozzles 48 cm from the ground. Tractor speed of application was 5.5 km/hr. Compressed air was used for herbicide-insecticide agitation and spray pressure. Tee-Jet 8004 stainless steel nozzles were operated with a spray pressure of 1.2 kg/cm^2. Herbicide-insecticide combinations were applied with water at the rate of 187 l/ha.

Each treatment for the first date of planting was incorporated immediately after application with a tandem disk at 5.5 km/hr. Plots were then time-tooth harrowed at right angle to direction of disking.

Plots for the first date of planting, were planted June 1.

Chemicals were applied broadcast and soybeans were planted on June 21 for the second date of planting. Incorporation was with a spring tooth harrow in the same direction as the plots lie and a tine-tooth harrow at right angles to the plots.

The twelve treatments and rates of applications are listed in Table 1.

1977. The chemical treatments for the first planting date were applied May 19. All chemicals were incorporated in the same direction with a Lely-Roterra at a tractor speed of 3.2 km/hr to a depth of 7.6 cm.

Table 1. Treatments and rates of application for 1976 and 1977.

Treatments	Rates (kg/ha)
1. Metribuzin	0.56
2. Metribuzin + Alachlor	0.56 + 2.24
3. Metribuzin + Trifluralin	0.56 + 1.12
4. Metribuzin + Ethoprop	0.56 + 6.72
5. Metribuzin + Carbofuran	0.56 + 6.72
6. Metribuzin + Alachlor + Ethoprop	0.56 + 2.24 + 6.72
7. Metribuzin + Alachlor + Carbofuran	0.56 + 2.24 + 6.72
8. Metribuzin + Trifluralin + Ethoprop	0.56 + 1.12 + 6.72
9. Metribuzin + Trifluralin + Carbofuran	0.56 + 1.12 + 6.72
10. Ethoprop	6.72
11. Carbofuran	6.72
12. No Treatment	------

The first date of planting for 1977 was June 3. Prior to soybean planting a shallow tillage with a spring tooth harrow was made in the same direction as previous incorporation with the Lely-Roterra. A final cultivation with a tine-tooth harrow was made at right angles to the previous operation at a tractor speed of 8 km/hr.

Treatments were applied for the second date of planting on June 16. All treatments were incorporated in the same direction with a Lely-Roterra at a tractor speed of 3.2 km/hr to a depth of 7.6 cm.

Soybeans were planted June 28 for the second date of planting. Prior to soybean planting the area was tilled with a spring tooth harrow in the same direction as the ground had been worked earlier. A final cultivation with a tine-tooth harrow was made at right angles to the previous operation.

RESULTS AND DISCUSSION

Herbicide-Insecticide Study 1976

In 1976 the Buffalo No-Till planter gave an excellent stand of soybeans for the first date of planting on location two. Due to less than desirable seedbed condition and soil mositure, plant stand on location one was only fair.

Ten days after planting, soybeans at location one showed slight injury wherever metribuzin was applied. Typical metribuzin injury of yellowing along the margins of the leaves was easily identified. Plots treated with metribuzin plus ethoprop were much more severly injured than the rest of the plots. Leaves were more yellow or brown. This injury seemed to be more severe on the smaller plants in the row.

At location two, soybeans showed injury ten days after planting wherever metribuzin was applied. Injury on these plants was much more pronounced than plants with the same treatment at location one. Five days later many of the plants were recovering from the metribuzin injury. Plots treated with metribuzin plus ethoprop resulted in a definite stand reduction.

At location two, a 50% stand reduction for the treatment metribuzin plus ethoprop was estimated. Plots with ethoprop alone showed no injury to the plants. Plots with metribuzin alone showed some injury. The metribuzin plus alachlor plus ethoprop and metribuzin plus trifluralin plus ethoprop treated plots showed slightly more injury than the plots with metribuzin alone.

Within seven days after the second date of planting 13 cm of rain fell, which resulted in standing water on some of the plots at location two. After the heavy rains, a crust formed on the soil surface which may have reduced soybean emergence. The rest of the summer was hot and dry which adversely affected soybean yield.

Plots treated with metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, and metribuzin plus trifluralin plus ethoprop significantly reduced the yield, plant stand and height of the soybeans. The phytotoxic effects that occurred from metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop were more pronounced than the effects from metribuzin plus trifluralin plus ethoprop. Carbofuran-herbicide combinations did not cause the severe phytotoxic effects that the ethoprop-herbicide combinations did. When the insecticides were used alone on soybeans no phytotoxic effects were produced. Slight to no injury to the soybeans occurred when the herbicides were used alone or in combinations. Phytotoxic effects were much more noticeable on the Haynie very fine sandy loam than on the Muir silt loam.

Soybeans planted at the first date of planting (date 1) had a significantly higher yield than soybeans planted at the second date of planting (date 2). Soybeans at the first date of planting were significantly taller than those plants at the second date of planting. There were significantly more plants in a meter of row at date 1 than at date 2. The difference between the weights per 100 beans at date 1 and date 2 was not statistically significant (Table 2). Environmental factors such as amount and timing of rainfall, and a longer growing season gave soybeans at date 1 an advantage over the soybeans at date 2 for yield

Table 2. Comparisons of mean between date 1 and date 2 for yield, number of plants in a meter of row, plant height, and weight per 100 beans for 1976.

Date	Yield (kg/ha)	Plants Per Meter (numbers)	Plant Height (cm)	Seed Weight (gm)
1	2188.8	13.8	83.1	15.3
2	1800.9	10.2	68.2	16.0
LSD(.05)	266.5	1.1	6.9	NS

and plant height. Crusting and dry soil conditions reduced soybean emergence and survival for date 2.

Including both locations and both dates of planting, the lowest yields were obtained from plots treated with metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop (Table 3). The yields for the treatment of metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop are significantly lower than the other treatments, which indicates a deleterious interaction. Seven other treatments have significantly lower yields than the no treatment (Table 3).

Combining the overall results for plant height at both locations and both dates of planting the shortest plants were found to be in the plots treated with metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, and metribuzin plus trifluralin plus ethoprop. All the plants in these treatments were significantly shorter than the plants in the no treatment plots. But the treatment combinations were not significantly different among themselves. Plots with carbofuran alone were significantly taller than all other treatments except ethoprop alone. This data suggests that carbofuran increases soybean plant growth. When metribuzin was added to carbofuran, plant height for that treatment was significantly shorter than the no treatment (Table 3).

The overall results for the number of plants per meter at both locations and both planting dates, indicated that four herbicide-insecticide combinations interacted significantly to give a reduced number of plants per meter when compared to the no treatment plots. Starting with the treatment that had the smallest number of plants in a meter of row were metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop,

Table 3. Overall effects of treatments on yield, number of plants in a meter of row, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gm)
Metribuzin	1893.9	12.9	76.1	15.5
Metribuzin + Alachlor	2161.2	14.0	77.4	16.0
Metribuzin + Trifluralin	2089.5	13.6	78.2	15.2
Metribuzin + Ethoprop	1545.4	8.4	66.4	15.7
Metribuzin + Carbofuran	2031.8	11.3	73.9	15.5
Metribuzin + Alachlor + Ethoprop	1602.7	9.1	68.1	15.2
Metribuzin + Alachlor + Carbofuran	1951.5	12.3	75.6	15.6
Metribuzin + Trifluralin + Ethoprop	1902.7	10.2	70.6	15.6
Metribuzin + Trifluralin + Carbofuran	2137.0	11.8	76.6	15.9
Ethoprop	2110.0	13.3	81.3	16.0
Carbofuran	2155.5	13.5	84.4	16.1
No Treatment	2356.8	13.5	79.2	15.9
LSD (.05)	216.4	1.7	4.7	0.48

metribuzin plus trifluralin plus ethoprop, and metribuzin plus carbofuran (Table 3).

Weight per 100 beans from both locations and dates of planting indicated that the treatments metribuzin plus alachlor plus ethoprop and metribuzin plus trifluralin were significantly lighter than the beans from the no treatment plots (Table 3).

It should be noted that the results from the overall treatment effects indicate an injurious interaction between some herbicide-insecticide combinations. For the variables yield, plant height, and plants per meter the treatments metribuzin plus ethoprop, and metribuzin plus alachlor plus ethoprop always produced the most damage. Metribuzin plus trifluralin plus ethoprop was also among the lowest treatment for the variables plant height and plants per meter. More injury was apparent on these three treatments than on any of the other nine treatments during the growing season.

At location one plots treated with metribuzin plus alachlor plus ethoprop, metribuzin plus ethoprop, and metribuzin plus trifluralin plus ethoprop all have significantly lower yields than the no treatment plots. Yield differences between these three treatments were not significant (Table 4).

At location two the lowest yields were obtained from plots treated with metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop (Table 5). Plots with herbicide-insecticide combinations were significantly lower in yield than the no treatment plots, but were not significantly different among themselves. Metribuzin plus trifluralin plus ethoprop also caused significantly lower yield than no treatment

Table 4. Effects of treatments at location one on yield, number of plants in a meter of row, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kh/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gm)
Metribuzin	2072.6	13.9	73.6	16.0
Metribuzin + Alachlor	2181.1	13.5	73.2	16.6
Metribuzin + Trifluralin	2181.1	13.8	76.3	15.7
Metribuzin + Ethoprop	1877.3	9.8	72.7	16.4
Metribuzin + Carbofuran	2240.8	11.6	73.4	16.2
Metribuzin + Alachlor + Ethoprop	1850.1	9.1	72.5	15.5
Metribuzin + Alachlor + Carbofuran	2213.7	12.1	75.1	16.3
Metribuzin + Trifluralin + Ethoprop	1920.7	9.8	71.2	15.9
Metribuzin + Trifluralin + Carbofuran	2143.1	11.6	74.8	16.7
Ethoprop	2040.0	11.2	73.7	16.4
Carbofuran	2197.4	12.1	74.3	16.9
No Treatment	2316.7	12.3	74.7	16.6
LSD (.05)	306.1	2.4	NS	.69

Table 5. Effects of treatments at location two on yield, number of plants in a meter of row, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gm)
Metribuzin	1715.1	11.9	78.7	15.0
Metribuzin + Alachlor	2141.3	14.6	81.7	15.4
Metribuzin + Trifluralin	1997.9	13.4	80.1	14.8
Metribuzin + Ethoprop	1213.5	7.1	60.0	15.0
Metribuzin + Carbofuran	1822.8	11.0	74.3	14.8
Metribuzin + Alachlor + Ethoprop	1355.2	9.1	63.8	14.9
Metribuzin + Alachlor + Carbofuran	1689.4	12.5	76.1	14.9
Metribuzin + Trifluralin + Ethoprop	1884.8	10.7	69.9	15.3
Metribuzin + Trifluralin + Carbofuran	2130.9	11.9	78.3	15.1
Ethoprop	2180.0	15.3	89.0	15.6
Carbofuran	2113.6	14.8	94.4	15.3
No Treatment	2396.8	14.6	83.7	15.1
LSD (.05)	306.1	2.4	6.7	NS

but was not among the lowest yielding.

Plant heights at location one showed no statistical difference among treatments (Table 4).

Most of the herbicide-insecticide combinations at location two resulted in a definite interaction. Plots with treatments metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, metribuzin plus trifluralin plus ethoprop, metribuzin plus carbofuran, and metribuzin plus alachlor plus carbofuran had soybean plants that were significantly shorter than the no treatment plants. The plants in the carbofuran treated plots at location two were significantly taller than all other treatments, except the ethoprop treated plots. When compared to the other treatments, ethoprop treated plots had plants that were significantly taller than all other treatments except the no treatment and carbofuran treated plots (Table 5).

Metribuzin plus alachlor plus ethoprop, metribuzin plus trifluralin plus ethoprop, and metribuzin plus ethoprop interacted significantly to reduce plant stand below that of the no treatment plots at location one (Table 4).

The three treatments that reduced plant stand the most at location one (Table 5). Metribuzin plus carbofuran, metribuzin alone, and metribuzin plus trifluralin plus carbofuran also reduced plant stant at location two.

Plots treated with metribuzin plus alachlor plus ethoprop, metribuzin plus trifluralin, and metribuzin plus trifluralin plus ethoprop had soybeans that were significantly lighter in weight than the soybeans from the no treatment plots at location one (Table 4).

At location two, there was no significant difference in weight per 100 beans when beans from the eleven treatments were compared to the weight of the no treatment soybeans (Table 5).

Comparisons of the same treatment at location one and two indicated that yield was not significantly different for the no treatment, metribuzin, metribuzin plus alachlor, metribuzin plus trifluralin, metribuzin plus carbofuran, metribuzin plus trifluralin plus carbofuran, ethoprop, and carbofuran treatments (Table 6). Areas treated with metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, and metribuzin plus alachlor plus carbofuran produced significantly higher yields at location one than at location two (Table 6).

Comparing different treatments at location one and two indicated that plots treated with metribuzin plus trifluralin plus ethoprop at location one, had significantly larger yields than plots treated with metribuzin plus alachlor plus ethoprop at location two (Table 6). Yield for the treatment metribuzin plus trifluralin plus ethoprop at location two, was not significantly different from the yield for the treatment metribuzin plus alachlor plus ethoprop at location one. No significant difference in yield occurred between the herbicide-insecticide combinations metribuzin plus trifluralin plus ethoprop at location two and metribuzin plus ethoprop at location one (Table 6).

The plots treated with metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop at location one produced plants that were significantly taller than plants at location two for the identical treatment (Table 6). The treatments carbofuran, ethoprop, metribuzin plus alachlor, and no treatment at location two produced plants that were

Table 6. Comparisons of the same treatment at location one and location two for yield, plant stand, plant height, and weight per 100 beans for 1976. Note: For each variable, the upper number is from location one, lower is from location two.

VARIABLES	Metribuzin	Metribuzin + Alachlor	Metribuzin + Trifluralin	Metribuzin + Ethoprop	Metribuzin + Carbofuran	Metribuzin + Alachlor + Ethoprop	Metribuzin + Alachlor + Carbofuran	Metribuzin + Trifluralin + Ethoprop	Metribuzin + Trifluralin + Carbofuran
Yield (kg/ha)	2072.6	2181.1	2181.1	1877.3	2240.8	1850.1	2213.7	1920.7	2143.1
	1715.1	2141.3	1997.9	1213.5	1822.8	1355.2	1689.4	1884.8	2130.9
Plants per Meter	13.9	13.5	13.8	9.8	11.6	9.1	12.1	9.8	11.6
	11.9	14.6	13.4	7.1	11.0	9.1	12.5	10.7	11.9
Plant Height (cm)	73.6	73.2	76.3	72.7	73.4	72.5	75.1	71.2	74.8
	78.7	8.17	80.1	60.0	74.3	63.8	76.1	69.9	78.3
Bean Weight (gms)	16.0	16.6	15.7	16.4	16.2	15.5	16.3	15.9	16.7
	150.0	15.4	14.8	15.0	14.8	14.9	14.9	15.3	15.1

Table 6 continued.

VARIABLES		Treatments			
		Ethoprop	Carbofuran	No Treatment	LSD (.05)
	Yield	2040.0	2197.4	2316.7	431.4
	(kg/ha)	2180.0	2113.6	2396.8	
	Plants per Meter	11.2	12.1	12.3	3.7
		15.3	14.8	14.6	
	Plant Height (cm)	73.7	74.3	74.7	8.3
		88.9	94.4	83.8	
	Bean Weight (gm)	16.4	16.9	16.6	1.2
		15.6	15.3	15.1	

significantly taller than plants at location one for the identical treatment (Table 6).

The only treatment that had significantly more plants per meter of row at one of the two locations was ethoprop. Ethoprop at location two had significantly more plants in a row than it did at location one (Table 6).

Identical treatments at both location one and location two showed statistical difference between locations when weight per 100 beans was measured. Plots with treatments metribuzin plus alachlor, metribuzin plus alachlor plus ethoprop, metribuzin plus carbofuran, metribuzin plus alachlor plus carbofuran, metribuzin plus trifluralin plus carbofuran, carbofuran, and the no treatment produced soybeans that were significantly heavier at location one than at location two (Table 6).

Compution of the correlation coefficient determined that there was a positive correlation between yield and plant height. There was also a strong positive correlation between number of plants in a row and plant height.

The statistical analysis of the 1976 data indicates that some herbicide-insecticide combinations interacted significantly to reduce yield, plant height, plant stand and soybean weight. Combinations of the herbicide metribuzin and the insecticide ethoprop seemed to cause the most destructive interactions. Metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop caused the most harmful effects on the soybean plant at both locations and dates. Treating the plots with metribuzin plus trifluralin plus ethoprop did reduce yield, plant height, plant stand and soybean weight. Metribuzin plus trifluralin plus ethoprop did not cause quite as strong of a phytotoxic effect as metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop. This may be due to a reduced absorption of the chemicals by the soybean plant. Root pruning from trifluralin may have caused lower absorption of the chemicals, thus lowering the phytotixicity of the metribuzin and ethoprop combination.

Carbofuran-herbicide combinations did not produce interactions that were as damaging to the soybean plant as ethoprop-herbicide combinations were. Only at location two did the treatments metribuzin plus carbofuran and metribuzin plus alachlor plus carbofuran significantly reduce yield, plant height, and plant stand. Statistical comparisons indicate that treatments metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop reduced yield, plant height, and plant stand significantly more than the treatments metribuzin plus carbofuran and metribuzin plus alachlor plus carbofuran at location two.

Carbofuran at location two seemed to act like a growth stimulant. Plots treated with carbofuran alone produced plants that were significantly taller than all other plants except the plants treated with ethoprop. Nematode populations in the soil were not large enough to cause a reduction in plant growth. Thus the greater plant height in the carbofuran treated plots can not be related to the control of nematodes in the soil, but possibly to a physiological reaction of the plant. Except for the increase in plant height from carbofuran the two insecticides when used alone did not have any significant effect on yield, plant height, plant stand, or soybean weight.

Degree of interaction from the herbicide-insecticide combinations depended on soil type. The Haynie very fine sandy loam at location two, which had a soil pH of 7.7 and a organic matter content of 1 per cent, had most of the chemical pesticides in the soil solution and a very small amount adsorbed on the soil particles. At location one, the Muir silt loam with a pH of 6.3 and a organic matter content of 2.5 per cent had much more of the chemical pesticides adsorbed to the soil particles and less was available in the soil solution. Organic matter ties up chemical pesticides in the soil. Thus the lower organic matter content of the soil at location two caused the treatment effects to be much more pronounced than at location one.

Metribuzin is not recommended for use on high pH soils. Alkaline conditions greatly accelerates metribuzin phytotoxicity. High soil pH and low organic matter at location two result in the effects of metribuzin and metribuzin plus insecticide combinations being more pronounced at location two than at location one.

The first date of planting gave significantly better yields, plant height, and plant stand than the second date of planting. This was probably due to more favorable environmental conditions at each stage of soybean development for the first date of planting. Soybeans planted at the first date of planting had a longer growing period than the second date of planting. Soybeans in the first date of planting were able to grow, develop, and mature before the first freeze.

Soybeans planted at the second date of planting experienced cooler temperatures late in the soybean's life cycle. The lower temperatures slowed the soybean development, thus having a detrimental effect on yield and plant height. Also soybeans planted the first date had better growing conditions than those at the second date of planting. Good soil moisture and warm atmospheric temperatures gave soybeans good germination and facilitated early growth at the first date of planting. At the second date of planting, heavy rains the first week after planting followed by soil cursting and hot, dry weather caused a lower percentage of soybean emergence and seedling survival.

The plants treated with metribuzin plus trifluralin plus ethoprop and metribuzin plus trifluralin at location one produced significantly smaller soybean seeds than the seeds from the no treatment plants. This may be due to lower nutrient and water absorption by soybean plants treated with trifluralin. Root pruning from trifluralin may have lowered the absorption of nutrients and water by the soybean plants during the bean filling stage, thus producing a smaller bean.

Late in the growth cycle, soybeans showed a great difference in the rate of maturing among treatments. This was most noticeable at location two. Some plots had soybean plants that were still green, while others were at physiological maturity and others were at harvest maturity. Delayed maturity was most evident in the treatments that showed the most injury earlier in the growing season. Plants in the metribuzin plus alachlor plus ethoprop treated plots were all very green. The insecticides alone and no treatment plots were at harvest maturity. The plants treated with the other pesticide combinations ranged in stage of maturity anywhere from slight yellowing of the leaves to 95 per cent leaf drop which seemed to depend on the degree of early crop injury. The more crop injury to the soybean plant, the more delayed the maturity.

Herbicide-Insecticide Study 1977

Originally the plan was to apply the chemical treatments and plant soybeans on the same day as in 1976. But this was not possible due to a heavy rain shower shortly after chemicals were applied. Instead chemicals were applied May 19 and soybeans were planted June 3, for the first date of planting. Within this fifteen day period the plot area received 21.3 cm of rain. At location two, water ran diagonally across the plot area and stood on the third set of replicated plots for a day. For the second date of planting, chemicals were applied June 16 and soybeans were planted June 28. Within this twelve day period 26 cm of rain fell. Again at location two, water flowed over the plot area, and stood in places for a short time.

It was noticed that plots at location one had better weed control from the herbicide treatments than the plots at location two. This observation suggests the possibility of a loss of herbicide in the soil from the heavy rains. Metribuzin is the herbicide that would be most likely leached because of its higher solubility than trifluralin or alachlor.

Phytotoxicity from metribuzin in 1977 was not apparent in the soybean plants as it was to the soybeans grown in 1976.

At location two, many of the soybean plants contained the fungi Phyllosticta, Phomopsis, Cephalosporium, Alternaria, Colletotrichum, and Rhizoctonia. These pathogins usually cause the following diseases: leaf spot, pod and stem blight, brown stemrot, leaf, stem and seed decay, and root rot. Pod and stem blight from Phomopsis was the disease that was most pronounced.

There was a significant difference between locations for yield and weight per 100 beans. Soybeans at location one produced higher yields than at location two. Weight per 100 beans was significantly higher at location one than the weight of the beans at location two (Table 7).

There was no significant difference between locations for plant height or plant stand.

Soybeans planted at the first date of planting produced significantly higher yields than the soybeans planted at the second date of planting. Soybean plants were significantly taller at date 1 than at date 2. The number of plants in a row was not significantly different between the two dates of planting (Table 8).

Soybeans were significantly heavier at date 2 than at date 1 (Table 8). Some of the beans from plots at the second date of planting were still green and not fully matured at harvest time, causing the increase in bean weight.

Comparisons of the two planting dates at the same location indicated there were significant yield differences. At location one, the first date of planting had significantly greater yield than the second date of planting. At location two, date 1 also had significantly greater yields than at date 2 (Table 8).

Soybean plants at location two were taller in the first date of planting plots than at the second date of planting plots. Height differences between the two dates of planting at location one were not significant (Table 9).

Plant stand was not statistically different between the two dates for either location one or location two.

Table 7. Comparing means between location one and location two for yield, plant stand, plant height, and bean weight for 1977.

Location	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight per 100
One	3658.6	27.5	99.7	21.7
Two	3208.8	27.0	100.1	20.5
LSD (.05)	69.8	NS	NS	0.28

Table 8. Comparing means between date 1 and date 2 for yield, plant stand, plant height, and bean weight for 1977.

Date	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight per 100
1	3943.9	27.4	105.4	20.8
2	2923.5	27.1	94.4	21.3
LSD (.05)	107.9	NS	5.8	0.40

Table 9. Comparing means of the dates at a location for yield, plant stand, plant height, and bean weight for 1977.

Location	Date	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight per 100
One	1	4245.5	27.9	101.7	21.8
One	2	3071.8	27.1	97.7	21.6
Two	1	3642.3	26.9	109.1	19.9
Two	2	2923.5	27.1	94.4	21.3
LSD (.05)		152.6	NS	8.2	0.57

At location two, bean weights at date 2 were significantly heavier than the weights were at date 1. No significant difference between dates for bean weight occurred at location one (Table 9).

Comparing the two locations at the same date of planting indicated significant differences for yield. For date 1, yields were significantly larger at location one than the yields at location two. Yields at location one, date 1 were greater than the yields at location two, date 2 (Table 10).

Soybean plants were taller at location two, date 1 than the plants at location one, date 1. The plants at location one and location two showed no difference in height at date 2. At location one, date one soybean plants were significantly taller than the plants at location two, date 2. Also plants at location two, date 1 were significantly taller than the plants at location one, date 2 (Table 10).

There was no significant difference in plant stand between two locations at the same or different dates of planting (Table 10).

Significant differences in bean weight resulted when two locations were compared at the same or different dates of planting. Location one, date 1 had beans that were heavier than the beans at location two, date 1. At location one, date 2 beans were heavier than the beans at location two, date 2. Weight per 100 beans was greater at location one, date 2 than at location two, date 1 (Table 10).

Calculation of the partial correlation coefficients resulted in a positive correlation between yield and weight per 100 beans. There was a negative correlation between the number of plants in a row and the weight per 100 beans.

Table 10. Comparing means between the two locations at the same or different date of planting for yield, plant stand, plant height, and bean weight for 1977.

Location	Date	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight per 100
One	1	4245.5	27.9	101.7	21.8
Two	1	3642.3	26.9	109.1	19.9
One	2	3071.8	27.1	97.7	21.6
Two	2	2775.2	27.1	91.1	21.0
One	1	4245.5	27.9	101.7	21.8
Two	2	2775.2	27.1	91.1	21.0
One	2	3071.8	27.1	97.7	21.6
Two	1	2642.3	26.9	109.1	19.9
LSD (.05)		128.5	NS	5.1	0.49

Unlike 1976, none of the treatments in the 1977 growing season resulted in significant differences for either location or date of planting. The time between chemical application and planting, along with heavy rainfall during this period seemed to prevent the herbicide-insecticide interactions from occurring as they had in 1976. This lag period between treatment application and planting was purely unintentional, but was dictated by the weather conditions.

Location one produced heavier beans than location two. This partly explains why yields are greater at location one. Also the differences in yield and bean weight between locations may have been influenced by disease. At location one there was no evidence of disease, but there was definite evidence at location two. Location one also had a solid windbreak around the south side of the plot area which protected the soybean plants from the hot dry south winds. Location two had no protection from the south winds.

The first date of planting resulted in greater yields and plant height. This is greatly influenced by favorable environmental factors and a longer growing season. Bean weights for the second date of planting were greater than the weights at the first date of planting. At the second date of planting, some of the beans at harvest time were still green and not fully matured causing a heavier bean.

It should also be noted that plant stand was not affected by any of the treatments, locations or dates of planting in 1977.

Comparisons of 1976 to 1977

Statistical analysis indicated significant differences between the 1976 and 1977 growing season for yield, plant stand, plant height, and bean weight. Comparisons of overall means between 1976 and 1977, indicated that soybeans grown in 1977 had significantly greater yields, more plants per meter, greater plant height, and weight per 100 beans than soybeans grown in 1976 (Table 11).

Including both years, location one produced significantly greater yields and bean weights than location two. The number of plants per meter and soybean height was not significant between the two locations (Table 12).

The analysis of dates of planting for the two years showed that the first date of planting produced greater yields, larger numbers of plants per meter and greater plant height than at the second date of planting. Bean weight was the greatest at the second date of planting (Table 13).

Comparisons of the two years at the same or different dates of planting resulted in better soybean stands and yields for the 1977 growing season. There was no significant difference between years at the same or different dates of planting for plant height and bean weight (Table 14).

Combining the two years data indicated that at location one, first date of planting soybeans were taller than the soybeans at the second date of planting. At location two, soybeans were also taller at date 1 than at date 2.

Table 11. Overall means for 1976 and 1977 for yield, number of plants per meter, plant height, and bean weight.

Year	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight (gm)
1976	1994.8	12.0	75.7	15.7
1977	3433.7	27.2	99.9	21.1
LSD (.05)	138	1.3	3.8	0.4

Table 12. Overall means from 1976 to 1977 at location one and location two for yield, number of plants per meter, plant height, and bean weight.

Location	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight (gm)
One	2880.8	19.6	86.7	19.0
Two	2547.8	19.6	88.8	17.8
LSD (.05)	138	NS	NS	0.4

Table 13. Overall means from 1976 and 1977 at date 1 and date 2 for yield, number of plants per meter, plant height, and bean weight.

Date	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight (gm)
1	3066.4	20.6	94.3	18.1
2	2362.2	18.6	81.3	18.7
LSD (.05)	119	0.6	3.8	0.5

Table 14. Comparisons of 1976 to 1977 at the same or different date of planting for yield, number of plants per meter, plant height, and bean weight.

Year	Date	Yield (kg/ha)	Plants per Meter	Plant Height (cm)	Bean Weight (gm)
1976	1	2188.8	13.8	83.1	15.3
1976	2	1800.9	10.2	68.2	16.0
1977	1	3943.9	27.4	105.4	20.8
1977	2	2923.5	27.1	94.4	21.3
LSD (.05)		258	2.0	NS	NS

Results from 1976 and 1977 indicated that at location one, date 1 had taller plants than at location two date 2. Location two date 1, had taller plants than location one date 2. At location two date 1, plants were taller than at location one date 1. Plant height was not significantly different when location one date 2 was compared to location two date 2.

Comparisons of the two years at the same location and the same or different dates of planting were made for the number of plants in a row and bean weight. It was noted that the number of plants in a row and bean weight was always greater in 1977.

Data from 1976 and 1977 indicated that the plots with metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, and metribuzin plus trifluralin plus ethoprop produced yields, number of plants in a row, and plant heights significantly lower than the no treatment (Table 15). The three treatments mentioned above gave the lowest yields. Metribuzin plus alachlor plus carbofuran, metribuzin plus trifluralin plus carbofuran, and metribuzin plus carbofuran also gave yields that were significantly lower than the no treatment. There was no treatment effect for bean weight when the two years were analyzed together.

The treatments in 1977 produced greater yield, more plants per meter, greater plant heights, and weights per 100 beans than the same or different treatment in 1976 (Table 16).

At location one, the treatments metribuzin plus alachlor plus ethoprop, metribuzin plus ethoprop, and metribuzin plus trifluralin plus ethoprop produced significantly lower yields than the no treatment. At location two, all of the herbicide-insecticide combinations gave yields

Table 15. Overall treatment means for yield, number of plants per meter, plant height, and bean weight.

Treatment	Yield (kg/ha)	Plants Per Meter	Plant Height (cm)	Bean Weight (gm)
Metribuzin	2737.4	19.9	88.4	18.3
Metribuzin + Alachlor	2799.1	21.0	87.7	18.4
Metribuzin + Trifluralin	2763.2	20.5	88.7	18.2
Metribuzin + Ethoprop	2457.3	17.8	82.4	18.4
Metribuzin + Carbofuran	2753.4	19.6	88.4	18.3
Metribuzin + Alachlor + Ethoprop	2484.6	17.4	82.9	18.2
Metribuzin + Alachlor + Carbofuran	2674.0	19.5	89.3	18.1
Metribuzin + Trifluralin + Ethoprop	2657.7	18.7	85.4	18.3
Metribuzin + Trifluralin + Carbofuran	2727.4	19.5	88.0	18.5
Ethoprop	2812.9	20.4	91.0	18.7
Carbofuran	2799.0	20.4	91.5	18.4
No Treatment	2905.1	20.5	89.5	18.5
LSD (.05)	128	1.0	2.9	NS

Table 16. Comparisons of 1976 to 1977 at the same or different treatment for yield, plants per meter, plant height, and bean weight.

Treatments	Year (kg/ha)	Yield (kg/ha)	Plants Per Meter	Plant Height (cm)	Bean Weight (gm)
Metribuzin	1976	1893.9	12.9	76.1	15.5
	1977	3580.9	27.0	100.8	21.1
Metribuzin + Alachlor	1976	2161.2	14.0	77.4	16.0
	1977	3437.1	27.9	98.0	20.9
Metribuzin + Trifluralin	1976	2089.5	13.6	78.2	15.2
	1977	3437.1	27.5	99.2	21.3
Metribuzin + Ethoprop	1976	1545.4	8.4	66.4	15.7
	1977	3369.3	27.2	98.4	21.0
Metribuzin + Carbofuran	1976	2031.8	11.3	73.9	15.5
	1977	3475.1	27.9	102.9	21.2
Metribuzin + Alachlor + Ethoprop	1976	1602.7	9.1	68.1	15.2
	1977	3366.5	25.8	97.6	21.2
Metribuzin + Alachlor + Carbofuran	1976	1951.6	12.3	75.6	15.6
	1977	3396.4	26.7	103.1	20.7
Metribuzin + Trifluralin + Ethoprop	1976	1902.7	10.2	70.6	15.6
	1977	3412.7	27.1	100.2	20.9
Metribuzin + Trifluralin + Carbofuran	1976	2137.0	11.8	76.6	15.9
	1977	3317.7	27.3	99.4	21.1
Ethoprop	1976	2110.9	13.3	81.3	16.0
	1977	3215.8	27.7	100.7	21.4
Carbofuran	1976	2155.5	13.5	84.4	16.1
	1977	3442.5	27.3	98.7	20.8
No Treatment	1976	2356.8	13.5	79.2	15.9
	1977	3453.4	27.5	99.8	21.4
LSD (.05)		510	4.8	10.6	1.5

that were significantly lower than the no treatment.

At location two, carbofuran alone produced taller plants than the rest of the treatments except ethoprop alone. Also when both year's data was combined, plots with metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, and metribuzin plus trifluralin plus ethoprop had plants that were significantly shorter than the no treatment, ethoprop, and carbofuran alone plots at location two.

The data from two years indicated that the treatment metribuzin plus alachlor plus carbofuran at location one gave larger yields than at location two. Plots treated with metribuzin plus ethoprop at location one gave larger yields than at location two.

Carbofuran treated plots at location two had plants that were significantly taller than all treatments at location one except for the metribuzin plus alachlor plus carbofuran, metribuzin alone, metribuzin plus trifluralin, and metribuzin plus carbofuran treated plots.

Comparisons of 1976 to 1977 at the same or different location and the same or different treatment indicated that yields from 1977 were always greater than the yields from 1976.

All treatments in 1977 at location one had taller plants than the same or different treatment in 1976 at location one. All treatments in 1977 at location two produced taller plants than the same or different treatment in 1976 at location one. In 1977 at location one, carbofuran treated plots produced plants that were significantly taller than all treatments except carbofuran, ethoprop, no treatment, and metribuzin plus alachlor at location two in 1976. At location two in 1977 none of the treatments produced plants that were significantly taller than the carbofuran treated plots in 1976 at location two. Also at location two in 1977, metribuzin plus alachlor plus ethoprop and metribuzin plus ethoprop treated plants were taller than all the treated plants in 1976 at location two except carbofuran, ethoprop, and the no treatment plants. The no treatment plots at location two in 1977 had plants that were taller than all treatments except carbofuran and ethoprop at location two in 1976.

Statistical analysis for 1976 and 1977 together resulted in positive correlations between yield and plant height, yield and bean weight, and number of plants per meter of row and plant height.

Visual observation throughout the growing seasons of 1976 and 1977 along with statistical analysis determined that effect of treatments were not similar for the two years. This difference in results for the two years was greatly influenced by environmental factors and time between applying chemicals and soybean planting. In 1976, chemicals were applied and soybeans were planted on the same day. Rainfall was small through out the 1976 growing season. In 1977, two weeks elapsed between chemical application and planting, during which 26 cm of rain fell.

SUMMARY

Some herbicide-insecticide combinations may cause harmful interactions to the soybean plant. The most noticeable interactions were produced from the metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop treatments. Metribuzin plus trifluralin plus ethoprop in some cases produced harmful interactions on soybeans. Interactions of this type reduce yield, stand, and height of soybean plants. In some cases metribuzin plus alachlor plus carbofuran, metribuzin plus trifluralin plus carbofuran, and metribuzin plus carbofuran may reduce yield, plant stand and plant height. Carbofuran-herbicide combinations were never as damaging to the growth of soybeans as ethoprop-herbicide combinations. When the insecticides were used alone, no phytotoxic effects occured. In some cases carbofuran caused an increase in plant height. Herbicides used alone or in combination with other herbicides caused little or no harmful effects on soybeans. Treatment effects were much more noticeable on the Haynie very fine sandy loam than on the Muir silt loam. The date of planting did not influence the treatment effects.

The herbicide-insecticide treatments that caused the phytotoxic interactions in 1976 had no effect on soybean growth and development in 1977. A two week period between chemical application and planting along with heavy rains, may have prevented treatment phytotoxicities from occurring in 1977.

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APPENDIX

Table 17. Effects of treatments at date 1 on yield, number of plants in a meter of row, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gms)
Metribuzin	1980.4	14.8	84.9	15.0
Metribuzin + Alachlor	2430.7	15.5	85.4	15.8
Metribuzin + Trifluralin	2235.4	15.5	84.2	14.8
Metribuzin + Ethoprop	1649.4	9.3	70.0	15.2
Metribuzin + Carbofuran	2159.4	13.1	80.4	15.1
Metribuzin + Alachlor + Ethoprop	1757.9	10.3	71.8	14.9
Metribuzin + Alachlor + Carbofuran	2110.6	14.1	83.2	15.1
Metribuzin + Trifluralin + Ethoprop	2181.1	12.1	77.2	15.4
Metribuzin + Trifluralin + Carbofuran	2457.8	13.7	84.4	15.7
Ethoprop	2376.4	15.8	92.3	15.9
Carbofuran	2333.0	16.0	93.2	15.4
No Treatment	2593.4	15.7	90.3	15.5
LSD (.05)	306.1	2.4	6.7	.69

Table 18. Effects of treatments at date 2 on yield, number of plants in a meter of row, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gms)
Metribuzin	1807.4	11.0	67.4	16.0
Metribuzin + Alachlor	1891.7	12.6	69.4	16.1
Metribuzin + Trifluralin	1943.6	11.6	72.3	15.7
Metribuzin + Ethoprop	1441.4	7.6	62.7	16.2
Metribuzin + Carbofuran	1904.2	9.6	67.3	15.8
Metribuzin + Alachlor + Ethoprop	1447.4	7.9	75.4	15.5
Metribuzin + Alachlor + Carbofuran	1792.5	10.6	68.0	16.0
Metribuzin + Trifluralin + Ethoprop	1624.4	8.4	63.9	15.7
Metribuzin + Trifluralin + Carbofuran	1816.2	9.8	68.8	16.1
Ethoprop	1843.5	10.7	70.3	16.1
Carbofuran	1978.0	11.0	75.6	16.7
No Treatment	2120.1	11.2	68.1	16.3
LSD (.05)	306.1	2.4	6.7	.69

Table 19. Effects of treatments at location one, date 1 on yield, plant stand, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gms)
Metribuzin	2061.8	14.6	79.5	15.4
Metribuzin + Alachlor	2354.7	14.1	80.2	16.2
Metribuzin + Trifluralin	2343.9	15.7	84.7	15.0
Metribuzin + Ethoprop	2040.0	11.2	76.8	15.5
Metribuzin + Carbofuran	2343.9	12.6	78.0	15.7
Metribuzin + Alachlor + Ethoprop	2148.6	10.7	78.2	15.1
Metribuzin + Alachlor + Carbofuran	2452.4	12.4	81.7	15.7
Metribuzin + Trifluralin + Ethoprop	2202.8	11.4	77.3	15.7
Metribuzin + Trifluralin + Carbofuran	2398.1	12.4	81.5	16.2
Ethoprop	2343.9	13.3	80.8	16.0
Carbofuran	2289.6	12.7	79.7	16.3
No Treatment	2409.0	12.2	82.3	15.9
LSD (.05)	Ns	3.4	NS	NS

Table 20. Effects of treatments at location one, date 2 on yield, plant stand, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gms)
Metribuzin	2083.4	13.1	67.7	16.5
Metribuzin + Alachlor	2007.5	12.8	66.2	16.9
Metribuzin + Trifluralin	2018.3	11.8	68.0	16.3
Metribuzin + Ethoprop	1714.5	8.4	68.5	17.2
Metribuzin + Carbofuran	2137.7	10.7	68.8	16.6
Metribuzin + Alachlor + Ethoprop	1551.7	7.6	66.8	15.9
Metribuzin + Alachlor + Carbofuran	1974.9	11.9	68.5	16.8
Metribuzin + Trifluralin + Ethoprop	1638.5	8.1	65.2	16.1
Metribuzin + Trifluralin + Carbofuran	1888.1	10.8	68.2	17.1
Ethoprop	1736.2	9.2	66.7	16.7
Carbofuran	2105.1	11.5	69.0	17.4
No Treatment	2224.5	12.3	67.0	17.4
LSD (.05)	432.8	3.4	NS	.97

Table 21. Effects of treatments at location two, date 1 one yield, plant stand, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Seed Weight (gms)
Metribuzin	1899.0	15.0	90.3	14.5
Metribuzin + Alachlor	2506.7	16.8	90.7	15.5
Metribuzin + Trifluralin	2126.9	15.3	83.7	14.5
Metribuzin + Ethoprop	1258.7	7.4	63.2	14.9
Metribuzin + Carbofuran	1974.9	13.6	82.8	14.6
Metribuzin + Alachlor + Ethoprop	1367.3	9.9	65.5	14.7
Metribuzin + Alachlor + Carbofuran	1768.7	15.8	84.7	14.5
Metribuzin + Trifluralin + Ethoprop	2159.4	12.7	77.2	15.2
Metribuzin + Trifluralin + Carbofuran	2517.5	15.0	87.3	15.1
Ethoprop	2409.0	18.3	103.8	15.8
Carbofuran	2376.5	19.3	106.7	14.5
No Treatment	2777.9	19.1	98.3	15.0
LSD (.05)	432.8	3.4	9.4	NS

Table 22. Effects of treatments at location two, date 2 on yield, plant stand, plant height, and weight per 100 beans for 1976.

Treatments	Yield (kg/ha)	Plants per Meter (numbers)	Plant Height (cm)	Bean Weight (gms)
Metribuzin	1531.3	8.8	67.0	15.5
Metribuzin + Alachlor	1776.0	12.4	72.7	15.2
Metribuzin + Trifluralin	1868.9	11.4	76.6	15.1
Metribuzin + Ethoprop	1168.2	6.7	56.9	15.1
Metribuzin + Carbofuran	1670.7	8.5	65.8	15.0
Metribuzin + Alachlor + Ethoprop	1343.1	8.2	62.0	15.1
Metribuzin + Alachlor + Carbofuran	1610.1	9.2	67.6	15.2
Metribuzin + Trifluralin + Ethoprop	1610.2	8.7	62.6	15.4
Metribuzin + Trifluralin + Carbofuran	1744.3	8.8	69.4	15.1
Ethoprop	1950.9	12.3	74.0	15.4
Carbofuran	1850.8	10.4	82.1	16.0
No Treatment	2015.6	10.2	69.2	15.1
LSD (.05)	432.8	3.4	9.4	NS

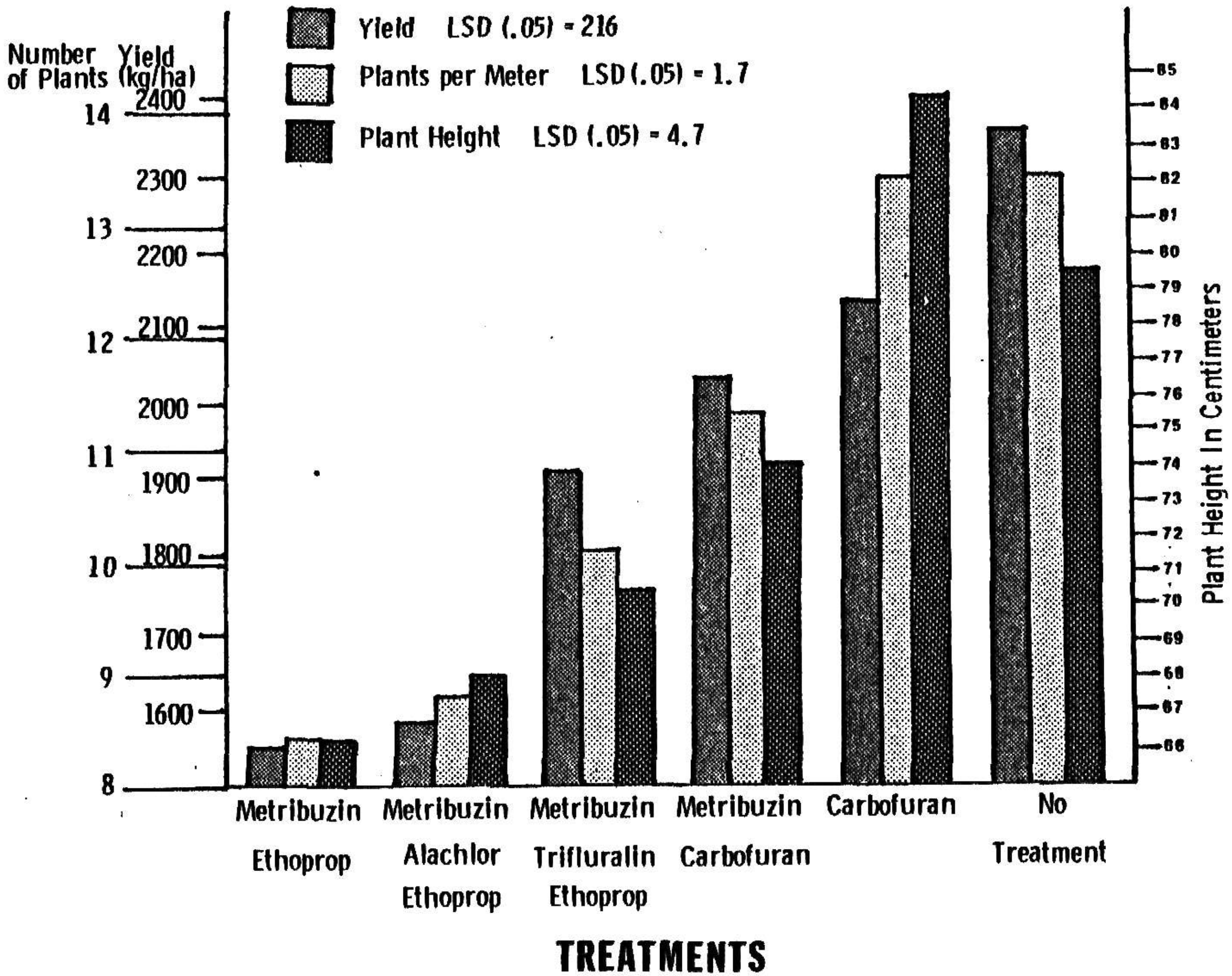

Fig. 1. Overall effects of treatments on yield, number of plants per meter, and plant height for 1976.

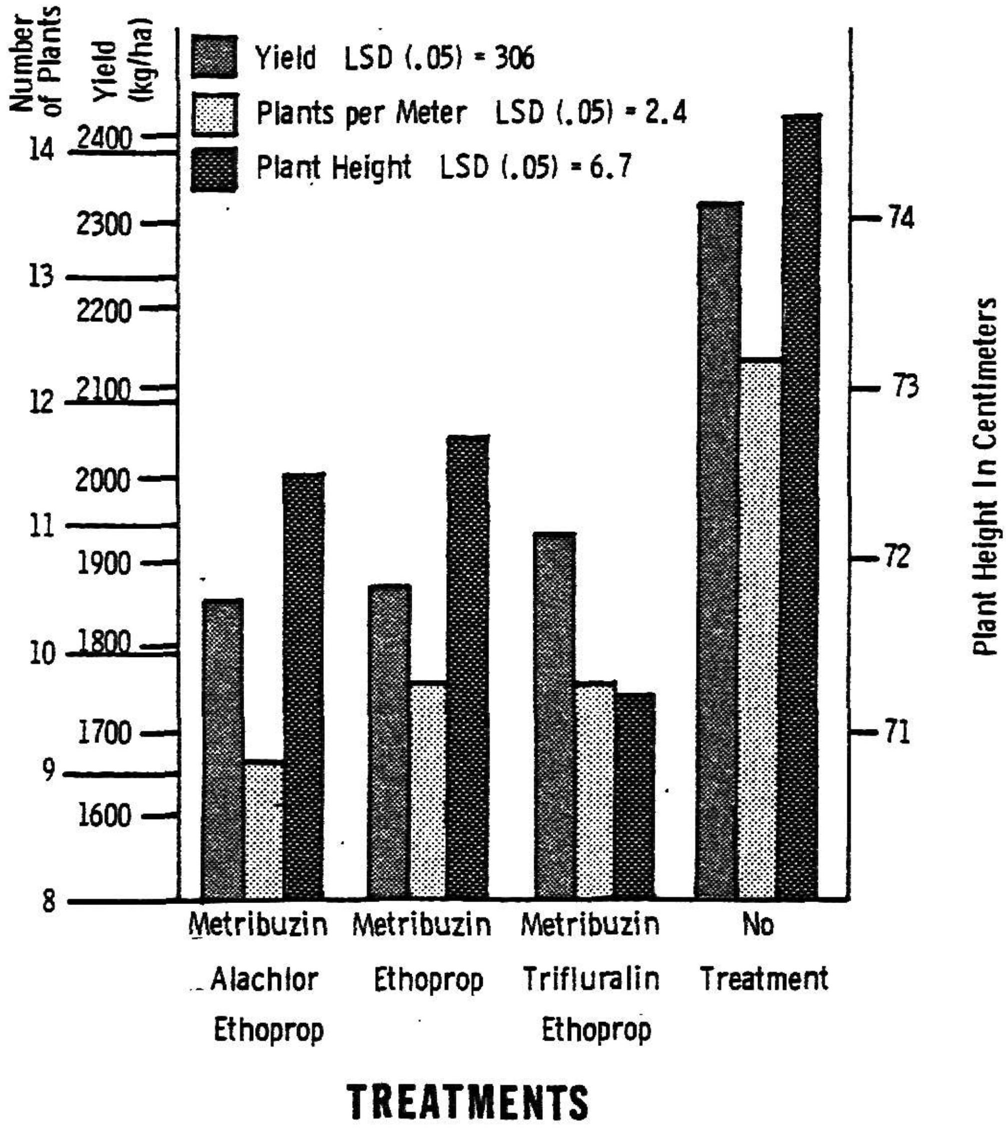

Fig. 2. Effects of four treatments at location one on yield, number of plants per meter, and height for 1976.

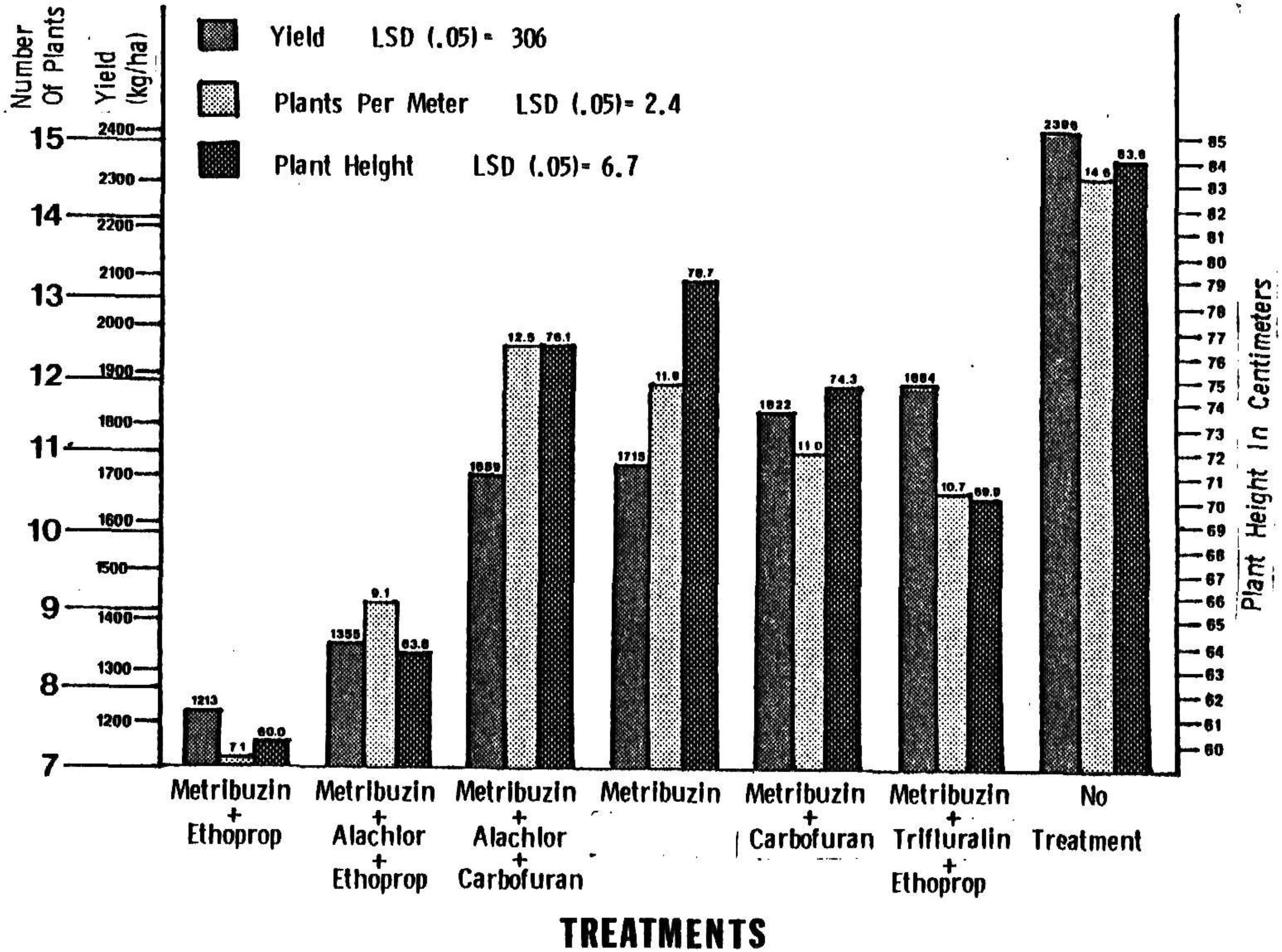

Fig. 3. Effects of seven treatments at location two on yield, number of plants per meter, and plant height in 1976.

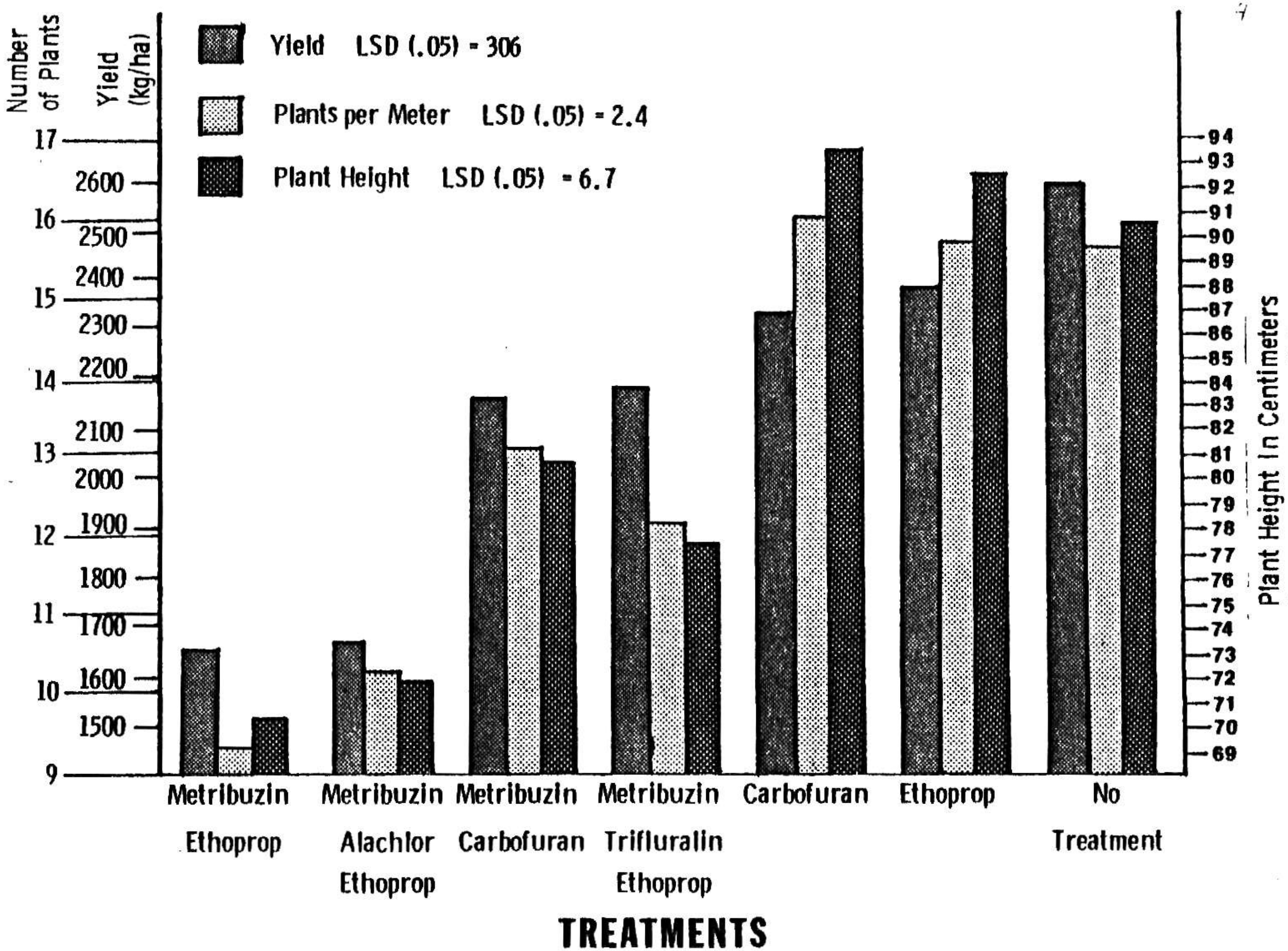

Fig. 4. Effects of seven treatments at date 1 on yield, number of plants per meter, and plant height for 1976.

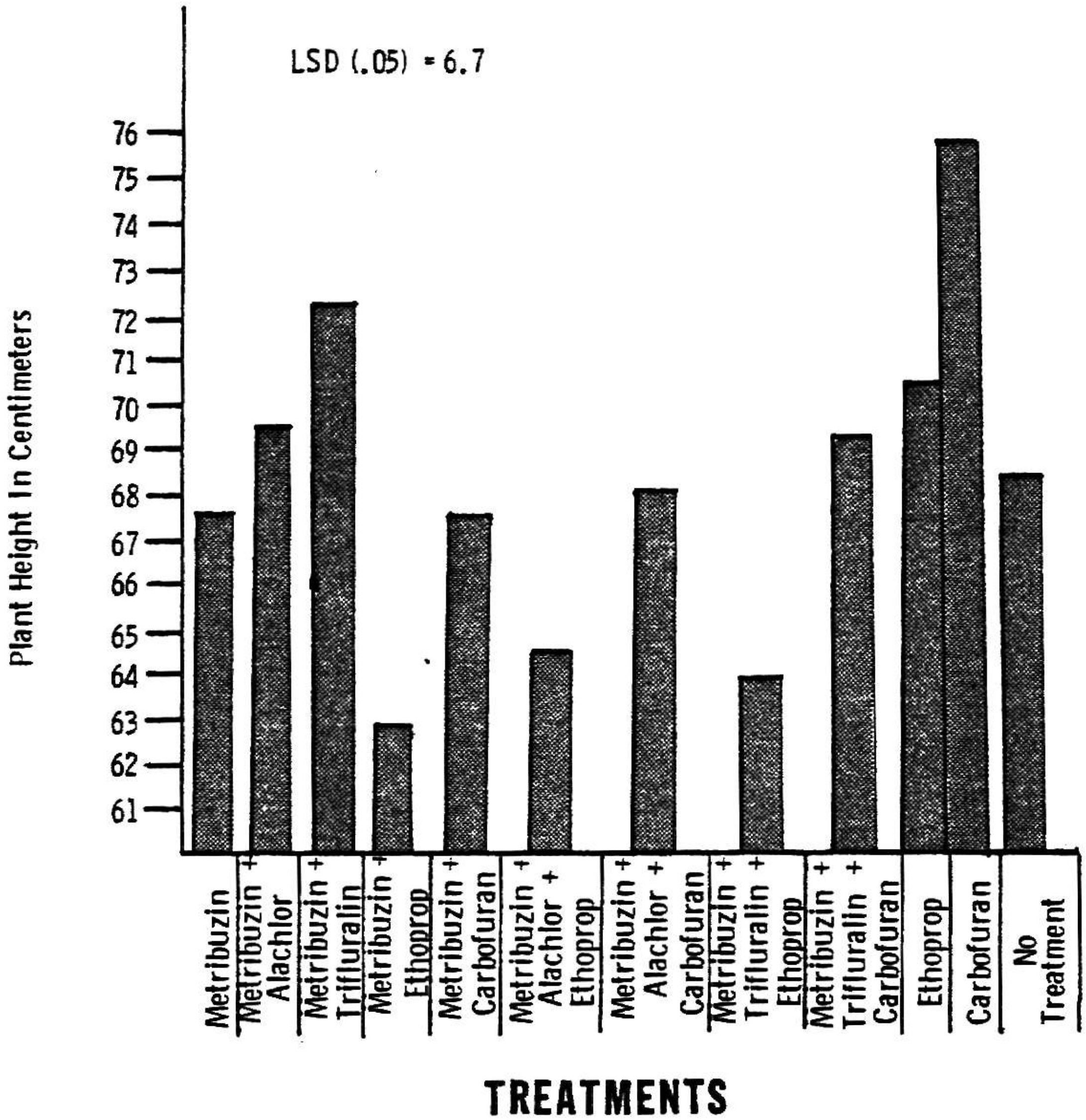

Fig. 5. Effects of treatments on plant height at date two for 1976.

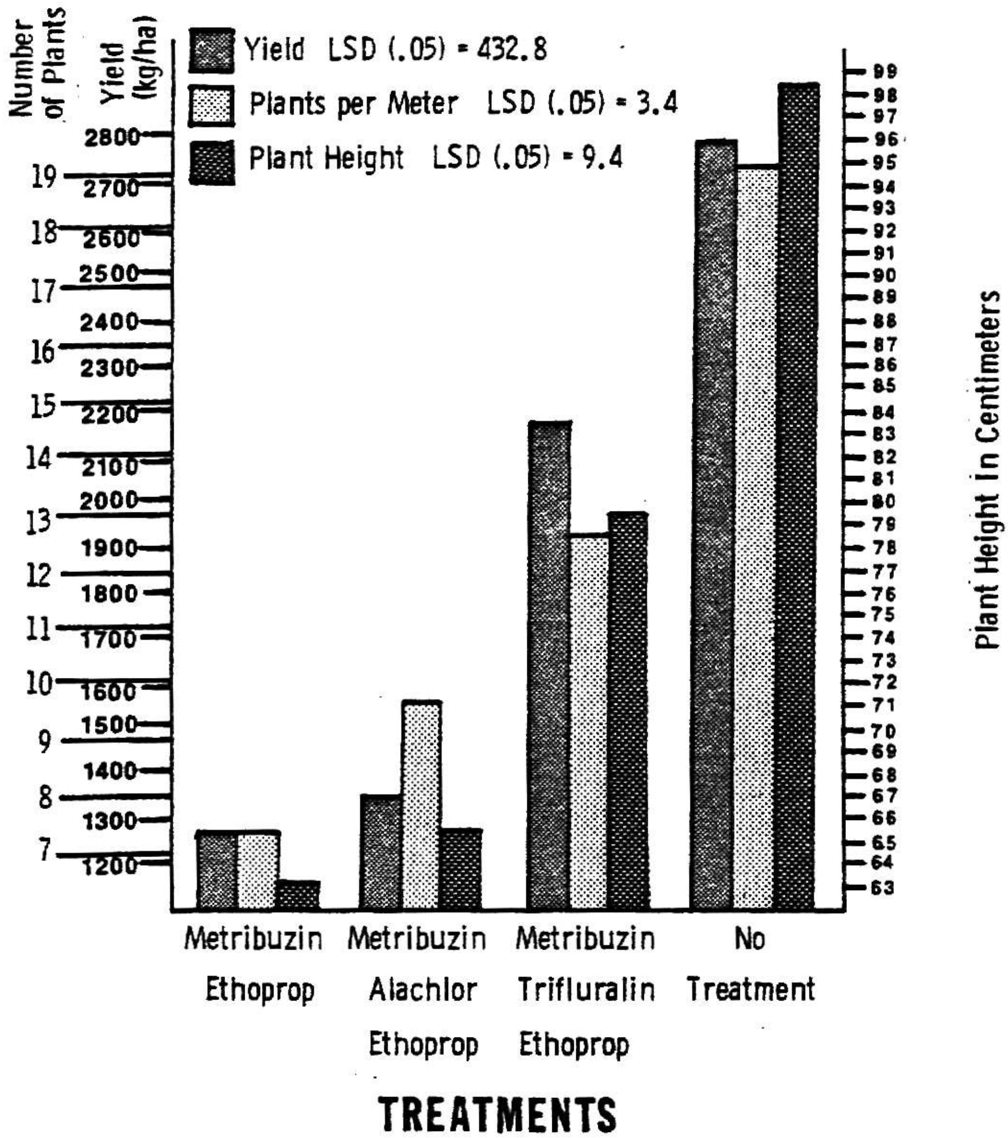

Fig. 6. Effects of four treatments at location two, date 1 on yield, plant stand, and plant height for 1976.

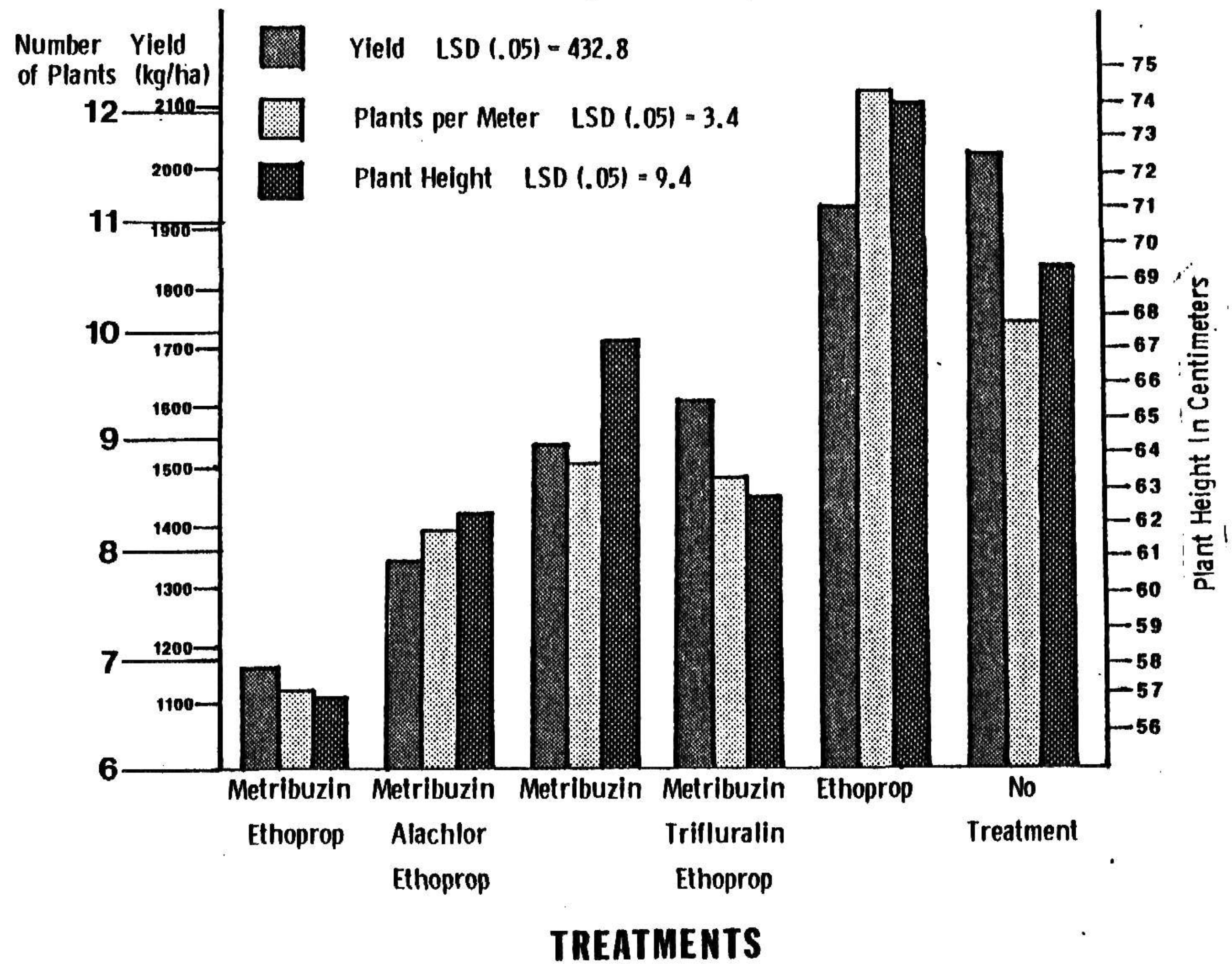

Fig. 7. Effects of six treatments at location two, date 2 on yield, plants per meter, and plant height for 1976.

EFFECTS OF PREPLANT INCORPORATED HERBICIDE-INSECTICIDE COMBINATIONS ON SOYBEAN (*GLYCINE MAX* (L.) MERRILL) GROWTH AND DEVELOPMENT

by

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Effects of preplant incorporated herbicide-insecticide combinations on soybean (Glycine max (L.) Merrill) growth and development were studied in 1976 and 1977. The herbicides 2-chloro-2', 6'-diethyl-N (methoxymethyl) acetanilide (alachlor), 4-amino-6-tert-butyl-3-(methythio) -as-triazin-5-(4H) one (metribuzin), and a,a,a-trifluoro-2,6-dinitro-N, N-dipropyl-p-toludine (trifluralin) and the insecticides 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methyl-carbamate (carbofuran) and O-ethyl S,S-dipropyl phosphorodithioate (ethoprop) were used in combination to form twelve treatments. The experiment was conducted on two soil types, a Muir silt loam and a Haynie very fine sandy loam and at two dates of planting.

In 1976 plots treated with metribuzin plus ethoprop, metribuzin plus alachlor plus ethoprop, and metribuzin plus trifluralin plus ethoprop significantly reduced the field, plant stand and height of the soybeans. The phytotoxic effects that occurred from metribuzin plus ethoprop and metribuzin plus alachlor plus ethoprop were more pronounced than the effects from metribuzin plus trifluralin plus ethoprop. Carbofuran-herbicide combinations did cause some damage, but the phytotoxic effects were not as severe as these of the ethoprop-herbicide combinations. When carbofuran or ethoprop were used alone on soybeans, no phytotoxic effects were produced. Slight to no injury to the soybeans occurred when the herbicides were used alone or in combinations. Phytotoxic effects were much more noticeable on te Haynie very fine sandy loam than on the Muir silt loam soil. Date of planting did not influence the treatment effects.

None of the treatments in 1977 significantly reduced the yields, plant stand, plant height, or weight of the soybeans.