

COMPETITION AND CONTROL OF FALL
PANICUM (*Panicum dichotomiflorum* Michx.)
IN SOYBEANS (*Glycine max* (L.) Merr.)

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ABSTRACT OF THE THESIS

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Fall panicum (*Panicum dichotomiflorum* Michx.) has become one of the most serious weed problems in row crops, particularly in corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.), in the Northeastern U.S. in recent years. Its resistance to 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine (atrazine) has led to extensive proliferation in corn.

The objectives of this study were to determine the competitive effects of various fall panicum densities in soybeans and to identify the critical period during which the crop can grow in association with the grass without yields being adversely affected. Chemical control of fall panicum and other broadleaf weed species was investigated.

A uniform stand of fall panicum was established in a soybean crop and allowed to grow in competition with the crop for predetermined intervals after the crop emergence. Weed-free bands of various widths were established in soybean rows. In another study, fall panicum plants were thinned in soybean plots to single rows alongside the soybeans at various equidistant spacings.

Post-emergence chemical control of fall panicum by various rates of 2[4-(4-trifluoromethyl-phenoxy)phenoxy]propanoate (HOE 29152) and sodium 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate

(acifluorfen-sodium) alone and in combinations were investigated in the greenhouse and under field conditions. Several surfactants were included in the study to determine their toxicity on the grass and/or soybeans.

It was found that fall panicum can grow with soybeans for the first three weeks after the crop emergence without adversely affecting the crop yield. Lesser weed densities resulted in higher soybean yields. Highest yields were recorded from 76.20-cm weed-free band, whereas, the 25.40-cm weed-free band treatment and the check were comparable regardless of the competitive period.

There was a slight yield increase with a decreasing number of fall panicum plants per meter of soybean row.

The number of soybean pods per plant and the weight of 500 soybeans from each treatment were found to be statistically significant, whereas, the height of soybean plants was not related to yield directly.

Total dry weights of fall panicum per plot showed negative linear correlation in both quantitative and qualitative competition studies. Coefficient of determination ($r^2 = -0.946$) indicated negative correlation between soybean yields and fall panicum dry weights. There was less percent total nitrogen in weed-free band treatments than in less densely grown fall panicum.

Post-emergence applications of a phenoxy-phenoxy derivative herbicide, HOE 29152, controlled fall panicum adequately in both greenhouse and under-field conditions at 0.57 kg/ha.

A diphenylether compound, acifluorfen-sodium, applied early post-emergence was found to have herbicidal activity on both broadleaf

weed species and some grasses. Fall panicum was sensitive to the compound especially at 1.13 to 2.36 kg/ha.

Combinations of HOE 29152 and acifluorfen-sodium applied post-emergence effected excellent broadspectrum weed control. Inclusion of nonionic surfactants enhanced activity of both the compounds investigated. There was no adverse effect on soybean stand or vigor from any of the chemical and/or chemical combinations investigated.

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I. INTRODUCTION

Fall panicum (*Panicum dichotomiflorum* Michx.) of the family *Gramineae* is an annual grass and a serious weed problem in row crops. The species is distributed world-wide and thrives well in areas with above-normal rainfall. Establishment of fall panicum is favored by high light intensity and minimum cultivation.

Increased fall panicum infestations were noticed in corn (*Zea mays* L.) under continuous use of 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine (atrazine) (Harvey and Doersch, 1974; Peters, 1975). Its resistance to atrazine has led to extensive proliferation in corn and soybeans [*Glycine max* (L.) Merr.].

Conventional methods for the control of fall panicum are not adequate although significant progress has been made in controlling this weed by use of herbicides. However, little is known about the nature and impact of fall panicum competition on soybeans.

Herbicide usage in any crop does not always render complete weed control. Need for research to understand fall panicum competition in soybeans is imperative. It is known that weeds compete with crops for nutrients, moisture, light, and space but the nature and extent of competition in causing significant yield reductions is not fully understood. Proper herbicide placement, row spacing, and timing of cultural practices are vital for improved crop yield. To achieve maximum soybean yields with minimum herbicide use, it is important to ascertain the competitive effects of fall panicum.

The objectives of this study were to determine competitive effects of various fall panicum densities in soybeans and the length

of time the crop can tolerate fall panicum interference without reducing soybean yields. Chemical control of the grass and other broadleaf weed species was also investigated.

II. REVIEW OF THE LITERATURE

Studies of competition in plant communities have been going on for many years. Systematic research and data collection were not recorded, however, until the early nineteenth century when Clements and his co-workers (1903) initiated an extensive investigation on the nature and extent of competition. It is a well-known fact that crop-weed competition is a physical process which affects water availability, competition for light, nutrients, and space. Both aerial and subterranean parts of plants play a role in competition.

Weeds vary in their competitive ability. Competition within the same species is less complex than among plants of different species since their requirements are very similar (Weaver et al., 1929).

Black et al. (1969) reported that competition among plants may depend on morphology, their capacity to extract nutrients and moisture from the soil, differential response to temperature and to a variety of other factors.

A. *Effects of annual grass competition on soybeans*

In his early studies on grass competition in soybeans, Staniforth (1957, 1958) found that yield reductions due to annual weed infestations depended heavily on water availability. He also reported that competition for soil nutrients, particularly nitrogen, was vital between corn and foxtail (*Setaria* spp.). Removal of foxtail weeds at various stages of crop development had varied impact on the yield of soybeans. After foxtail infestation had become well established in a soybean field, removal did not enable crop recovery after initial competition. It was further found that the presence of weeds delayed

maturity, decreased plant height and increased soybean lodging. Furthermore, soybean yields are decreased when severe lodging occurs prior to physiological maturity (Woods and Swearingin, 1977).

Weber and Fehr (1966) reported that yield loss due to lodging was 29 lbs/A. They further indicated that for every inch of elevation of a combine from ground-level it misses 38 lbs/A of soybeans.

According to Nave and Wax (1971) one giant foxtail (*Setaria faberii* Herrm.) plant per linear foot in 30-inch rows reduced yield by 13%. Stubble, lodging and stalk were more than doubled in foxtail plots when compared with weed-free plots.

Work done by Knake and Slife (1965) indicated that foxtail species which were grown together with soybeans throughout the growing season reduced yield by 27%. Any foxtails which were planted later than three weeks after crop emergence did not reduce yield.

Yield reductions from the heaviest stand of smooth pigweed (*Amaranthus hybridus* L.) averaged 39% in corn and 55% in soybeans (Moolani et al., 1964). They also reported that as the stand of smooth pigweed was increased, there was a decrease in soybean pods per plant.

Several comparison studies between foxtail and two dicotyledonous plants [smartweed (*Polygonum* spp.) and velvetleaf (*Abutilon theophrasti* Medic.)] have been conducted (Staniforth and Weber, 1950). They found that foxtail reduced yields more than either smartweed or velvetleaf. Early season competition was found to be more severe than late season competition. This severity was attributed to competition for soil moisture.

B. *Effects of fall panicum competition*

Peters (1975) reported that the first recorded observations of fall panicum in the northeastern U.S. were in 1914. In recent years, fall panicum has acquired the status of being a serious weed problem, particularly in the Northeast U.S.A.

Several researchers (Houghton and Slife, 1969; Brimhall, 1970; Houghton, 1974; Peters, 1975) have attributed fall panicum increases to its resistance to atrazine which provides good control of other weeds. The greatest changes in fall panicum populations have been noticed with conditions of continuous corn cultivation with annual application of atrazine. It is evident (Houghton and Slife, 1969) that fall panicum infestations are favored by above normal rainfall during the spring and summer. Early germination of this weed allows rapid establishment and, therefore, a potential for severe competition. It is not until after the onset of frost that competition is minimized.

Studies conducted in Massachusetts (Vengris and Damon, 1976) indicated that fall panicum emergence occurs as early as April 30th, although greatest emergence occurs during the warmest period of the growing season, June to August. The most severe competition, however, was effected by the plants emerging in May and June due to profuse tillering. The investigators further reported that the plants that had emerged in late June and early July produced the most vigorous, rapidly growing plants. Shading (63% ambient), however, decreased tillering and the number of panicles per fall panicum plant. Decreased light intensity delayed emergence, heading, and maturity.

A typical soybean farmer loses 10-20% of crop yield due to weeds (Buchanan, 1975). Soybean seed yield losses due to lodging and

combine harvesting are estimated to be 29 lbs/A (Weber and Fehr, 1966).

Working with peanuts (*Arachis hypogaea* L. 'Florigiant') in Raleigh, North Carolina, York and Coble (1977) reported that seed yield was reduced 25% by a fall panicum density of one weed per 4.9 meters (16.17 ft) of row. Their findings further indicated that greater weed densities resulted in greater yield losses. These same investigators (1975) reported that peanut reductions were inversely proportional to fall panicum dry matter. The lowest fall panicum density observed, one weed per five meters (16.4 ft) of linear row, contributed to a 30% yield loss.

Burnside and Colville (1964) positively correlated soybean yields with plant height at maturity, lodging, weight per 100 seeds, number of seed bearing nodes per plant, pod number, and the number of seeds per plant. All these yield components were negatively affected by fall panicum competition.

Burnside et al. (1973) and Weber and Fehr (1966) reported that in combine harvesting, there was a 16% decrease in yield due to weeds not being dessicated at the time of harvest.

C. *Competition for environmental factors*

Weeds, like crops, vary in their competitive ability (Muzik, 1970). During early development, they spread rapidly, exerting both aerial and subterranean competition for light, nutrients, water, and space. Other researchers have included carbon dioxide as another factor involved in plant competition. Of these factors, soil moisture is considered by some workers to be the most important since early plant development is very sensitive to moisture stress. However, other

factors appear to be equally important and the final results of all these spheres of competition are injury to crops.

Analyzing the biochemical basis for plant competition, Black et al. (1969) concluded that a major limitation to crop yield is water supply. Doss et al. (1974) conducted several experiments on conventional irrigation and rainfall distribution. Insufficient water during the flowering and pod-fill stages was found to be the most critical factor in causing yield reduction. More soybean production was obtained when water was applied after full bloom than with earlier applications.

Investigations conducted during 1977 presented additional information on water stress. Sionit and Kramer (1977) subjected plants to water stress during flower induction, flowering, pod formation, and pod filling. Water stress during early pod formation caused the greatest reduction in the number of pods and seeds harvested. Sojka et al. (1977) reported a similar effect caused by water stress on soybeans (reduction in number of pods).

Early season competition was reported to be more severe to soybean yield reduction than late season competition (Staniforth and Weber, 1950; Knake and Slife, 1965). The need for soil moisture at this stage of development for both crop and weeds is critical.

Staniforth (1957) in his early research reported that corn yield reductions were greatest where the highest mature foxtail infestations occurred. Competition for nitrogen was the main factor. The results indicated that due to mature foxtail competition, corn yield reductions averaged 14, 10, and 5 bu/A, respectively, with applications of 0, 70, and 140 lbs of nitrogen per acre.

In his nutrient study in India with wheat (*Triticum vulgare* L.), peas (*Pisum sativum* L.), potato (*Solanum tuberosum* L.), rice (*Oryza sativa* L.), corn (*Zea mays* L.), soybean, and sorghum (*Sorghum vulgare* Pers.) Mani (1975) reported that substantial amounts of nitrogen were assimilated within five to six weeks of sowing seeds. Similar conclusions have been reported by other investigators. Vengris et al. (1955) found that weeds require nutrients and moisture when growing in association with cultivated plants. They also reported that young weeds, at an early stage of growth are substantially higher in phosphorus content than older plants. Young weeds are more aggressive competitors for nutrients than mature weeds.

Wax and Slife (1967) reported the effect of soybean canopy on the emergence and growth of weeds. Soybean plots kept weed-free for one month after sowing produced comparable yields to plots kept weed-free throughout the season.

There is little recorded information on the effect of temperature on soybeans. Mann and Jaworski (1970) and others have reported that temperatures above 40°C (104°F) cause severe pod abscission. Shading (63% ambient) caused abscission of several pods per plant. Their studies indicated that soybean yields may be limited by high temperatures and low light intensities which cause pod shedding. They further observed that inadequate light retarded pod filling. Some investigators have shown that additional light can increase soybean yield. Schou et al. (1975) conducted a study using reflectors to direct sunlight onto soybean plots. With only two weeks of additional light, they were able to increase yields to 69 bu/A as compared to 47 bu/A in the controls.

D. *Factors affecting yield reduction*

In determining soybean yield Burnside and Colville (1964) considered several characteristics. Plant height at maturity, and the number of seed bearing nodes were found to be the most important yield components. Pandey and Torrie (1973) studied the direct and indirect effects of seed components on seed yield. They reported that pods per unit area and seeds per pod had the greatest effect on seed yield. An interesting observation was also reported. Soybeans were found to have the ability to compensate for differences in stand. Compensation was accomplished primarily through the number of pods per plant.

Moolani et al. (1964) reported that yield reductions associated with the heaviest stand of smooth pigweed in their experiment averaged 55% in soybeans. They further reported that the height of soybeans was decreased and the number of pods per plant was decreased from 38 to 28 per plant. Similar observations were reported by Chaundhary and Singh (1974) in India. They showed that the number of seeds per plant was positively correlated with the number of pods per plant, however, seed size was negatively correlated. The greatest yield was affected by the number of seeds per plant.

Relative humidity, as it influences plant yields, has been given little consideration in research. Woodward and Begg (1976) reported that soybean yield was affected by low humidity. They observed reduction in pod and bean number. Floret abortion rather than pod abortion effected low yield. Reduced quantities of photosynthates was reported to cause floret abortion.

Woods and Swearingin (1977) and several other investigators

have reported that soybean seed yields are decreased when severe lodging occurs before maturity.

E. *Cultural weed control*

In their work with soybeans, Lovely et al. (1958) concluded that the best cultural weed control was obtained when a rotary hoe together with herbicides was used. They further reported that early cultural practices were more beneficial than later cultivations.

Peters et al. (1961) stated that "Other benefits from cultivation, e.g., loosening the soil, aeration, increased penetration of rainfall, formation of soil mulch to reduce evaporation, and increased nitrification have in most cases, been shown to contribute practically nothing to increasing yields on many soils." The main factor which accounted for increased yield was the reduction of weeds which compete with the crop. One of the same authors (Peters, 1965), working with soybean row spacing and cultivation reported that narrow rows were more successful for producing a soybean canopy to cover the ground rapidly, and inhibit weed seed germination.

On evaluating the effects of six cultivation treatments on soybean yield, Russell et al. (1971) concluded that yield reduction was attributed to root disturbance during cultivation. Depth and closeness of cultivation were important considerations during soybean development.

F. *Chemical weed control*

The number of cultivations can be reduced or almost eliminated by appropriate use of herbicides (Muzik, 1970). Most herbicides used in soybeans today have been developed within the last few years.

Burnside and Lipke (1960) reported that 3-amino-2,5-dichlorobenzoic acid (chloramben) was an effective pre-emergence herbicide for control of fall panicum. Cialone and Lassiter (1968) reported that fall panicum could be controlled post-emergence with 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (linuron); 1,1'-dimethyl-4,4'-bipyridinium ion (paraquat); and 2,2-dichloropropionic acid (dalapon). The authors also indicated that the addition of surfactants further improved control.

The use of 3-[p-(p-chlorophenoxy)phenyl]-1,1-dimethylurea (chloroxuron) as a post-emergence herbicide for soybeans has been well documented (Anderson, 1971). However, it was shown to exhibit temporary initial injury from early post-emergence applications.

In the early 1970's Smith and Ilnicki (1972) conducted extensive field and greenhouse studies on the control of fall panicum. In their competition study, they reported that atrazine can encourage the growth of fall panicum because it removes competition from other weeds. The authors further reported that pre-emergence applications of 2-chloro-4,6-bis(ethylamino)-s-triazine (simazine) and atrazine provided good control of fall panicum. The inclusion of surfactants was found to further improve control.

In their comparison study of triazine herbicides for fall panicum control, Harvey and Doersh (1974) found that the order of effectiveness was: 2-[[4-chloro-6-(ethylamino)-s-triazin-2-yl]amino]-2-methylpropionitrile (cyanazine)=simazine>2-chloro-4-(cyclopropylamino)-6-(isopropylamino)-s-triazine (cyprazine)>atrazine. Kern and his co-workers (1975) demonstrated that good post-emergence fall panicum control was obtained by use of cyanazine at the rate of 3.0 lb/A. They

further showed that the use of adjuvants increased cyanazine activity.

Post-emergence use of 3-isopropyl-1H-2,1,3-benzothiadiazin-(4)-3H-one 2,2-dioxide (bentazon) has been fully documented by several weed scientists (Rogers, 1973). This herbicide controls broadleaf weeds in soybeans with complete safety. Timely applications of this compound is emphasized.

Dowler and Parker (1975) and several researchers have reported the use of α,α,α -trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), and 2-chloro-2'6'-diethyl-N-(methoxymethyl)acetanilide (alachlor) for broadspectrum weed control in soybeans.

It is important to mention the current compounds which show activity on fall panicum control in soybeans. From other studies conducted in New Jersey and elsewhere, 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide (metolachlor) provides good broadleaf control and has some activity on fall panicum. It also provides good control on nutsedge (Unpublished data, 1976, 1977). 2-[4-(2,4'-Dichlorophenoxy)phenoxy]propanoic acid (Diclofop) effects season-long fall panicum control. A currently registered compound for use in soybeans, N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine (Pendimethalin) exhibits broadspectrum weed control (Frye et al., 1977). It effects good fall panicum control in soybeans. Combinations of some of these compounds have been found to exhibit excellent broadspectrum weed control in soybeans.

An examination of the literature pertaining to the effects of fall panicum in soybeans reveals incomplete research on the actual nature and extent of the grass-crop competition. The studies have shown that fall panicum reduces soybean yields, however, the extent

and impact of competition is not fully understood. Cultural and chemical control at various physiological stages of grass development have not been fully explored.

III. METHODS AND MATERIALS

Location of experiments

Field experiments were conducted in 1976 and 1977 at the New Jersey State Agricultural Experiment Station, Adelphia, New Jersey. Soil was Freehold sandy loam of medium fertility and a pH of 6.2. Experimental sites were known to be heavily infested with fall panicum.

Soybeans (var. 'Williams') were planted June 3, 1976 and repeated on June 1, 1977. The field was sub-divided into plots 4 rows wide (2.29 meters) by 5.79 meters in a complete randomized block design with six replications in 1976 and four replications in 1977.

1976 experiments

No herbicide was used in 1976. Broadleaf weed species and other grasses were carefully pulled out by hand or cut at ground level with a razor blade (special attention was paid to avoid soil disturbance). A uniform stand of fall panicum was established in the soybean crop and allowed to grow in competition with the crop for predetermined intervals after crop emergence.

Two experiments were conducted in 1976. In the first experiment, weed-free bands of varying widths were established in soybean rows as follows:

- A = 25.4-cm band; i.e., 12.7 cm on each side of soybean row
- B = 50.8-cm band; i.e., 25.4 cm on each side of soybean row
- C = 76.2-cm band; i.e., 38.1 cm on each side of soybean row
- D = 0-cm band; i.e., check (control)

Time schedule for establishing the bands was:

- I = clean cultivation throughout the growing season
- II = one week with weeds, clean cultivation throughout the rest of the growing season
- III = two weeks with weeds, free thereafter, and,
- IV = three weeks with weeds, clean cultivation for the entire growing season.

All possible combinations of the above treatments were investigated, i.e., A-I, A-II, A-III, A-IV, B-I, B-II, B-III, B-IV, C-I, C-II, C-III, C-IV and 0 for a check or control. Time duration began when grass was in the 2 to 4 leaf stage approximately 20 cm tall.

In the second experiment, fall panicum was thinned in soybean plots to single rows alongside the soybeans at the following distances between panicum plants: 15.24 cm, 30.48 cm, 45.72 cm, and 60.96 cm apart corresponding to 4, 2, 1.3, and 1 plant(s) per 0.61 meters of row. The single row of fall panicum was approximately 10.16 cm to 15.24 cm away from soybean row. In all the treatments, the opposite side of the row was maintained weed-free.

Types of data collected, 1976

The following parameters were examined in both experiments: number of pods per soybean plant, number of branches per soybean plant, number of pods per branch, height of soybean plants, yield and weight of 500 soybean seeds. Where statistically feasible, analyses of variance were run.

Greenhouse study, 1976

The effect of post-emergence applications of various rates of 2[4-(4-trifluoromethyl-phenoxy)phenoxy]propanoate, hereafter referred to as HOE 29152, were investigated. Eighty pots were arranged in a complete randomized block design with four replications in a greenhouse maintained at 25°C. Fall panicum was sprayed with HOE 29152 at one of two stages of its development; either one to three leaf stage or the three to five leaf stage. The rates used were 0.28, 0.57, 1.13 and 2.26 kilograms per hectare for both stages.

An endless belt sprayer with one spray head equipped with a fan Teejet No. 8003E nozzle tip was utilized for herbicide application. Pressure of 2.1 kg/cm² or 2109.2 gm/cm² (30 psi) and a speed of 3.22 km/hr were maintained delivering 151.42 liters of spray per hectare. Periodic visual ratings were made throughout the course of investigation.

1977 experiments

Pre-emergence applications of 2-sec-butyl-4,6-dinitrophenol (dinoseb) at 1.36 kg/ha were made for broadleaf weed control in the studies in 1977. In the first experiment, treatment combinations were the same as those of the first experiment in 1976, i.e., A-I, A-II, A-III, A-IV; B-I, B-II, B-III, B-IV; C-I, C-II, C-III, C-IV and 0 for a check or control. The second experiment had the same equidistant intervals as 1976, however, two more treatments were included; 10.16 cm and 20.32 cm apart, i.e., 6 and 3 weeds per 0.61 meters, respectively, giving a total of six treatments, i.e., 10.16, 15.24, 20.32, 30.48, 45.72, and 60.96 cm apart which correspond to 6, 4, 3, 2, 1.3, and 1 plant(s) per 0.61 meters of row.

Following greenhouse observations of 1976, a field experiment was designed to evaluate the pre- and post-emergence control of fall panicum with HOE 29152 (Tables 1 through 7). The results were compared with those from the greenhouse experiment. Included in the same field study were sodium 5-[2-chloro-4-(trifluoromethyl)phenoxy]-2-nitrobenzoate (hereinafter referred to as acifluorfen-sodium), bentazon, and several surfactants. The surfactants investigated included: 11 E oil, a nonphytotoxic phytoblend paraffinic oil of medium viscosity (110 sec) containing 1% v/v of an alkyl aryl polyether alcohol surfactant; 2, 4, 7, 9 - tetramethyl -5- decyne - 4, 7- diol (Surfynol-104-ES-75); 2, 4, 7, 9 - tetramethyl -5- decyne- 4, 7- diol reacted with 65 moles of ethylene oxide (Surfynol 465); Blend C (40% Surfynol 465 and 40% 2, 4, 7, 9- tetramethyl -5- decyne- 4, 7- diol reacted with 40 moles of ethylene oxide and 20% TWEEN* emulsifier); and Blend E (15% 11 E oil and 85% Blend C).

Besides fall panicum, experimental site contained the following weeds: pigweed (*Amaranthus retroflexus* L.), lambsquarters (*Chenopodium album* L.), and velvetleaf. These were in the 3 to 4-leaf seedling stage approximately 15 cm tall at the time of spraying.

Field spraying equipment and methods of application

Applications were made using a hand operated back-pack sprayer equipped with a four-nozzle boom spaced at 50.8 cm intervals in an overlapping pattern. The nozzle contained a 50- mesh strainer with Teejet No. 730616 tips. CO₂ was used as a propellant with the sprayer pressurized at 2.1 kg/cm² or 2109.2 gm/cm² (30 psi). The ground speed

*TWEEN - trademark for a series of general purpose emulsifiers and surface active agents made of polyoxyethylene derivatives of fatty acids and esters of sorbitol anhydrides.

Table 1. Preplant Incorporated (PPI) and Preemergence (PRE) treatments in soybeans with HOE 29152 alone and in combination with dinoseb.

Herbicide	Rate (kg/ha), Active Ingredient
HOE 29152 (PPI)	0.28
HOE 29152 (PPI)	0.57
HOE 29152 (PPI) + dinoseb (PRE)	0.28 + 3.39
HOE 29152 (PPI) + dinoseb (PRE)	0.57 + 3.39
Dinoseb 3 EC/3 gal. (PRE)	3.39
HOE 29152 (PRE)	0.14
HOE 29152 (PRE)	0.28
HOE 29152 (PRE)	0.36
HOE 29152 (PRE)	0.57
HOE 29152 (PRE) + dinoseb (PRE)	0.14 + 3.39
HOE 29152 (PRE) + dinoseb (PRE)	0.28 + 3.39
HOE 29152 (PRE) + dinoseb (PRE)	0.36 + 3.39
Dinoseb (PRE)	3.39
Check (Control)	

Table 2. Postemergence treatments in soybeans with HOE 29152 applied alone and in combination with acifluorfen-sodium and bentazon when fall panicum was at the 1-3 leaf stage.

Herbicide	Rate (kg/ha), Active Ingredient
HOE 29152	0.14
HOE 29152	0.28
HOE 29152	0.57
HOE 29152 + bentazon	0.14 + 1.13
HOE 29152 + bentazon	0.28 + 1.13
HOE 29152 + bentazon	0.57 + 1.13
Bentazon	1.13
HOE 29152 + acifluorfen-sodium	0.14 + 0.57
HOE 29152 + acifluorfen-sodium	0.28 + 0.57
HOE 29152 + acifluorfen-sodium	0.57 + 0.57
Acifluorfen-sodium	0.57
Check (Control)	

Table 3. Postemergence treatments in soybeans with HOE 29152 applied alone and in combination with acifluorfen-sodium and bentazon when fall panicum was at the 3-5 leaf stage.

Herbicide	Rate (kg/ha), Active Ingredient
HOE 29152	0.14
HOE 29152	0.28
HOE 29152	0.36
HOE 29152 + bentazon	0.28 + 1.13
HOE 29152 + bentazon	0.57 + 1.13
HOE 29152 + acifluorfen-sodium	0.14 + 0.57
HOE 29152 + acifluorfen-sodium	0.28 + 0.57
Hoe 29152 + acifluorfen-sodium	0.36 + 0.57
HOE 29152 + acifluorfen-sodium	0.57 + 0.57
Check (Control)	

Table 4. Postemergence treatments in soybeans with acifluorfen-sodium applied alone and in combination with spray adjuvant.

Herbicide and Adjuvant	Rate (kg/ha), Active Ingredient
Acifluorfen-sodium 2 LC*	0.28
Acifluorfen-sodium 2 LC	0.57
Acifluorfen-sodium 2 LC	1.13
Acifluorfen-sodium + 11E oil 1/4 GPA	0.28
Acifluorfen-sodium + 11E oil 1/4 GPA	0.57
Acifluorfen-sodium + 11E oil 1/4 GPA	1.13
Acifluorfen-sodium + 11E oil 1/2 GPA	0.28
Acifluorfen-sodium + 11E oil 1/2 GPA	0.57
Acifluorfen-sodium + 11E oil 1/2 GPA	1.13
Acifluorfen-sodium + 11E oil 1 GPA	0.28
Acifluorfen-sodium + 11E oil 1 GPA	0.57
Acifluorfen-sodium + 11E oil 1 GPA	1.13
Check (Control)	

* Liquid concentrate without surfactant.

Table 5. Postemergence treatments of HOE 29152 applied alone and in combination with surfactants in soybeans.

Herbicide	Surfactant Concentration (v/v)	Rate (kg/ha), Active Ingredient
HOE 29152		0.14
HOE 29152		0.28
HOE 29152		0.57
HOE 29152 + S-104-ES-75	1/4%	0.14
HOE 29152 + S-104-ES-75	1/2%	0.14
HOE 29152 + Blend C	1/4%	0.14
HOE 29152 + Blend C	1/2%	0.14
HOE 29152 + Blend E	1/4%	0.14
HOE 29152 + Blend E	1/2%	0.14
HOE 29152 + Surfynol 465	1/4%	0.14
HOE 29152 + Surfynol 465	1/2%	0.14
HOE 29152 + S-104-ES-75	1/4%	0.28
HOE 29152 + S-104-ES-75	1/2%	0.28
HOE 29152 + Blend C	1/4%	0.28
HOE 29152 + Blend C	1/2%	0.28
HOE 29152 + Blend E	1/4%	0.28
HOE 29152 + Blend E	1/2%	0.28
HOE 29152 + Surfynol 465	1/4%	0.28
HOE 29152 + Surfynol 465	1/2%	0.28
Check (Control)		

Table 6. Postemergence treatments of bentazon applied alone and in combination with surfactants in soybeans.

Herbicide	Surfactant Concentration (v/v)	Rate (kg/ha), Active Ingredient
Bentazon		0.28
Bentazon		0.57
Bentazon		1.13
Bentazon + S-104-ES-75	1/4%	0.28
Bentazon + S-104-ES-75	1/2%	0.28
Bentazon + Blend C	1/4%	0.28
Bentazon + Blend C	1/2%	0.28
Bentazon + Blend E	1/4%	0.28
Bentazon + Blend E	1/2%	0.28
Bentazon + Surfynol 465	1/4%	0.28
Bentazon + Surfynol 465	1/2%	0.28
Bentazon + S-104-ES-75	1/4%	0.57
Bentazon + S-104-ES-75	1/2%	0.57
Bentazon + Blend C	1/4%	0.57
Bentazon + Blend C	1/2%	0.57
Bentazon + Blend E	1/4%	0.57
Bentazon + Blend E	1/2%	0.57
Bentazon + Surfynol 465	1/4%	0.57
Bentazon + Surfynol 465	1/2%	0.57
Check (Control)		

Table 7. Postemergence applications of HOE 29152 in combination with bentazon and surfactants in soybeans.

Herbicide	Rate (kg/ha), Active Ingredient	Surfactant - Conc.* (v/v)
HOE 29152 + bentazon	0.28 + 0.57	S-104-ES-75 1/4%
HOE 29152 + bentazon	0.28 + 0.57	S-104-ES-75 1/2%
HOE 29152 + bentazon	0.28 + 0.57	Blend C 1/4%
HOE 29152 + bentazon	0.28 + 0.57	Blend C 1/2%
HOE 29152 + bentazon	0.28 + 0.57	Blend E 1/4%
HOE 29152 + bentazon	0.28 + 0.57	Blend E 1/2%
HOE 29152 + bentazon	0.28 + 0.57	Surfynol 465 1/4%
HOE 29152 + bentazon	0.28 + 0.57	Surfynol 465 1/2%
Check (Control)		

* Concentration.

was 6.44 km/hr delivering 151.42 liters of solution per hectare. Water was used as the chemical carrier. Spray nozzles were held at 50.8 cm to 55.88 cm above the surface to be sprayed. All herbicide treatments were applied as overall sprays.

Types of data collected, 1977

The same type of data collected in 1976 was collected in 1977. In addition, fall panicum dry weights and nitrogen content were determined. Standard Kjeldahl digestion method was utilized for nitrogen analysis (Horowitz, 1965). All herbicide-treated plots (1977) were rated on August 23, approximately one month after post-emergence applications. Ratings were based on the scale of 0 to 10 where 0 = no control or no effect on the crop, 10 = complete control or complete elimination of stand.

Exceptionally wet conditions in 1977 made it impossible to harvest all soybeans on time. Additional soybean losses were due to pod shattering. Treatment lists pertaining to Tables 4, 5, 6, and 7 (1977) were not harvested, however, weed and crop response ratings were made throughout the growing season on all treatments. The analyses of variance of these ratings (Tables XXIII - XXXXVI) were performed using an arcsin transformation of the data. Additional statistical analyses are found in the appendix pages 88-105 (Tables I-XXXXVI).

IV. RESULTS

1976 experiments

The development and subsequent yield of soybeans were markedly affected by full season infestation of fall panicum in both experiments. The yield components showed varied responses to treatments. It is evident from the data (Fig. 1) that soybean yield in the weed-free bands increased with increasing widths.

There was a slight linear yield increase with decreasing number of panicum plants per 0.61 meters (Fig. 2). However, the magnitude of increase was not nearly as great in the weed-free band experiment.

Both early and late pod counts were found to be statistically significant in the fall panicum density experiment (Table 8) and only the early pod count was found to be significant in the equidistant fall panicum spacings (Table 9).

The weight of 500 soybean seeds was found to be significantly different at 5% level in the interval spacing experiment (Table 10) and not in the weed-free band study (Table 11). The height of soybeans was not related to yield in either experiment.

Greenhouse experiment, 1976

Fall panicum plants were sprayed in pots with HOE 29152. Best control (10) of fall panicum was obtained by 0.57, 1.13 and 2.26 kg/ha when the grass was at the one-to-three leaf stage (Fig. 3A,B). The lowest rate (0.28 kg/ha) provided poor control. Fall panicum response to the compound was noticed four to six days after herbicide

SOYBEAN
YIELD
kg/ha

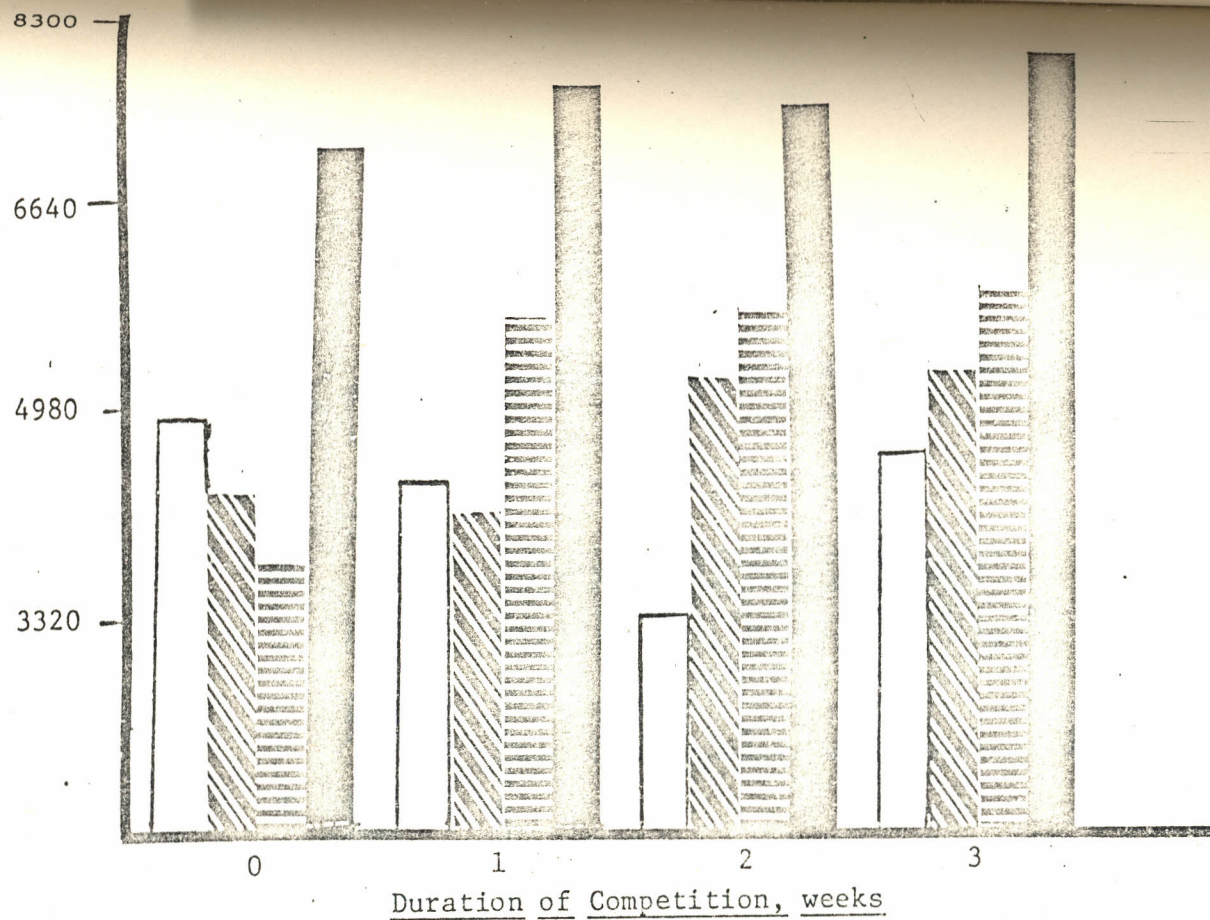


Figure 1. The effects of weed competition on soybean yield, 1976.

 CK  25.4  50.8  76.2 (Weed-free band, cm)

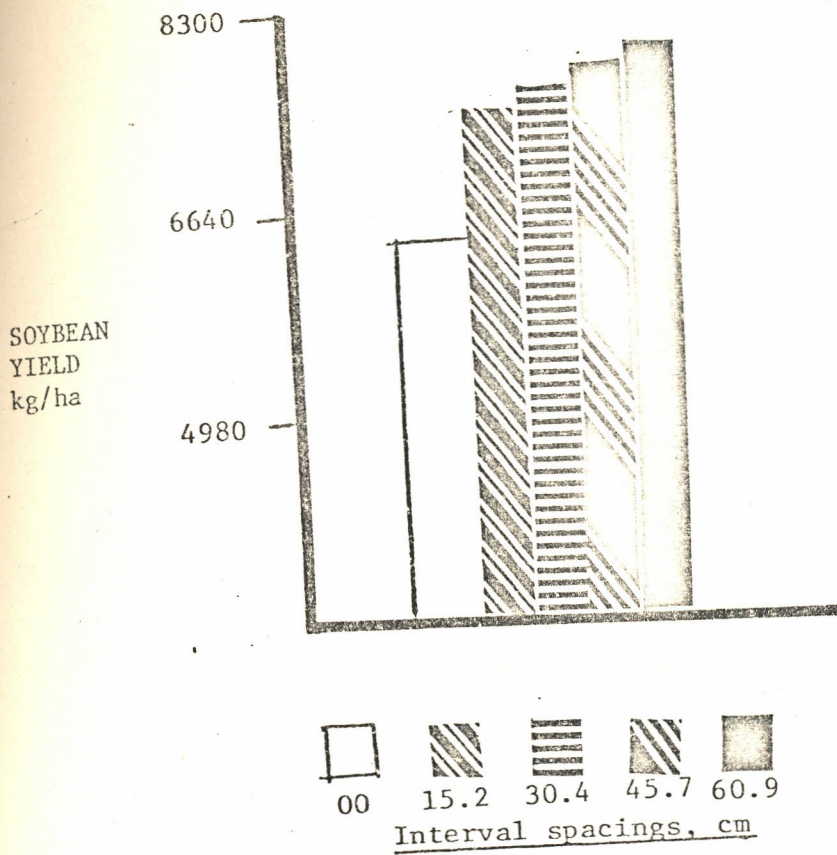


Figure 2. The effect of fall panicum spacings on soybean yield, 1976.

Table 8. Early and late season soybean pod counts harvested from fall panicum density and duration study, 1976.

Band-Widths (cm)	Duration (wks)	Counts	
		Early (8/15)	Late (9/22)
25	0	21.1	18.3
50	0	23.3	27.1
75	0	34.5	30.4
25	1	23.9	23.7
50	1	22.3	27.7
75	1	23.6	25.8
25	2	21.7	25.8
50	2	27.1	24.5
75	2	29.1	24.8
25	3	21.7	20.7
50	3	25.0	19.0
75	3	29.1	24.7
Check ¹		23.0	23.6
LSD (0.05)		5.0	6.6

¹ No fall panicum plants were removed from the check.

Table 9. Early and late pod counts in varied interval spacings of fall panicum plants, 1976.

Interval ¹	Early Count 8/15/76	Late Count 9/22/76
4 plants/0.61 m	35.8	34.2
2 plants/0.61 m	40.8	33.7
1.3 plants/0.61 m	37.8	33.2
1 plant/0.61 m	36.3	27.2
Check	32.7	28.7
LSD (0.05)	4.5	NS ²

¹ Distance between adjacent fall panicum plants.

² Non-significant.

Table 10. Effect of fall panicum interval spacings on the weight of 500 soybean seeds, 1976.

Interval	wt (kg)
4 plants/0.61 m	93.3
2 plants/0.61 m	92.9
1.3 plants/0.61 m	91.9
1 plant/0.61 m	92.3
Check	89.6
LSD (0.05)	3.1

Table 11. Effect of weed-free widths and duration on the weight of 500 soybeans, 1976.

Band-Width (cm)	Duration (wks)	Weight (kg)
25	0	96.5
50	0	93.6
75	0	95.0
25	1	96.2
50	1	93.3
75	1	94.0
25	2	97.3
50	2	93.2
75	2	95.8
25	3	95.3
50	3	91.8
75	3	96.5
Check		98.5



Figure 3A. The effect of HOE 29152 on fall panicum applied when the grass was at one-to-three leaf stage. From left to right (top) 0.28 kg/ha, check; (bottom) 0.57 kg/ha, check.



Figure 3B. The effect of HOE 29152 on fall panicum applied when the grass was at one-to-three leaf stage. From left to right (top) 1.13 kg/ha, check; (bottom) 2.36 kg/ha, check.

spraying.

Excellent results were obtained by the two highest rates investigated when the grass was at the three-to-five leaf stage (Fig. 4A,B). However, lower rates provided very good fall panicum control although response did not become evident until seven days after herbicide application.

1977 experiments

Fall panicum studies: In the banding experiment there were differences in yield at the 1% level of probability among various weed-free treatments at various durations (Table 12). Soybean yields increased linearly with increasing weed-free widths. From the data, it is evident that soybean yield decrease was not due to the duration of weed competition but rather the width of weed-free bands between the soybean rows. The interaction, however, between duration (weeks) and weed-free widths was significant at the 1% level (Table XI).

Soybean yields in different fall panicum spacings were significantly different from the check and not between treatments (Table 13). Differences in yield were found to be small regardless of the number of weeds per 0.61 m left to compete with the crop.

The relationship between soybean yields and fall panicum dry weights was determined. A plot of fall panicum weights as a function of soybean yields showed a negative linear correlation (Fig. 5 and 6). The coefficient of determination, $r^2 = -0.865$ for weed-free band widths and $r^2 = -0.946$ for different fall panicum equidistant spacings, indicate that the soybean yields could be predicated if fall panicum dry weights are known. The present data are

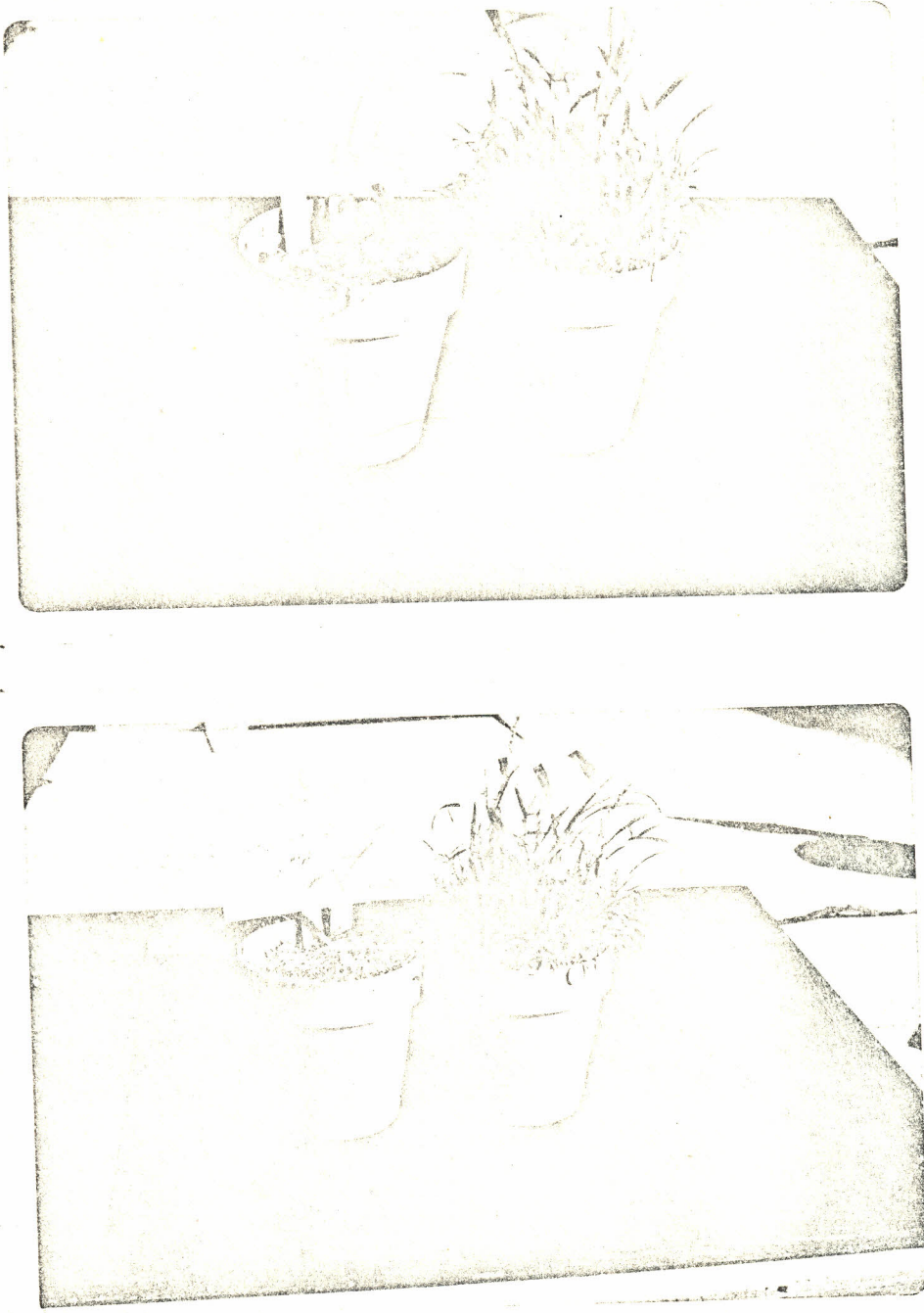


Figure 4A. The effect of HOE 29152 on fall panicum applied when the grass was at three-to-five leaf stage. From left to right (top) 0.28 kg/ha, check; (bottom) 0.57 kg/ha, check.



Figure 4B. The effect of HOE 29152 on fall panicum applied when the grass was at three-to-five leaf stage. From right to left (top) 1.13 kg/ha, check; (bottom) 2.36 kg/ha, check.

Table 12. Effect of weed-free band width and duration of grass competition on soybean yield, 1977.

Band-Width (cm)	Duration (wks)	Yield (kg/ha)
25	0	430.1
50	0	934.1
75	0	1727.0
25	1	463.8
50	1	490.6
75	1	1626.2
25	2	638.4
50	2	376.3
75	2	1720.3
25	3	490.6
50	3	631.7
75	3	1243.2
Check		302.4
LSD (0.01)		833.0

Table 13. Influence of fall panicum interval spacings on soybean yield, 1977.

Interval ¹ (cm)	Yield (kg/ha)
10.16	1229.8
15.24	1115.5
20.32	1236.5
30.48	1149.1
45.72	1102.1
60.96	1202.9
Check	329.3
LSD (0.01)	1297.0

¹ The distance between adjacent fall panicum plants.

inconclusive. It is evident that an increase in fall panicum dry weight effects a corresponding decrease in soybean yield.

There were significant differences in fall panicum dry matter production among treatments in both experiments (Tables 14 and 15).

Determination of percent total nitrogen (N) in different treatments were not found significantly different at 5% level of probability in either experiment (Tables 16 and 17). However, higher nitrogen contents were analyzed in the fall panicum spacing experiment.

The number of pods per plant (Tables 18 and 19) and soybean heights (Tables 20 and 21) was not found to be significantly different in either experiment.

Chemical control

Treatments of soil incorporated HOE 29152 did not provide adequate fall panicum control at any of the rates tested (Table 22). Pre-emergence applications, however, provided better fall panicum control at the highest rate indicated (0.57 kg/ha). There was no effect on soybean stand and vigor.

Weed control data from early post-emergence applications of HOE 29152 are summarized in Table 23. It is evident that with increasing the rate of the compound, there was a commensurate increase in the control of fall panicum.

Combinations of HOE 29152 plus bentazon (0.57 + 1.13 kg/ha) effected good fall panicum control. Lower rates of HOE 29152 combined with bentazon were not as effective as the highest rates used. Soybean vigor (not included in table) was not affected by HOE 29152 alone or in combination with bentazon; however, the vigor of the grass was tremendously reduced.

Figure 5. Relationship between soybean yield and fall panicum dry weight in weed-free band experiment, 1977.

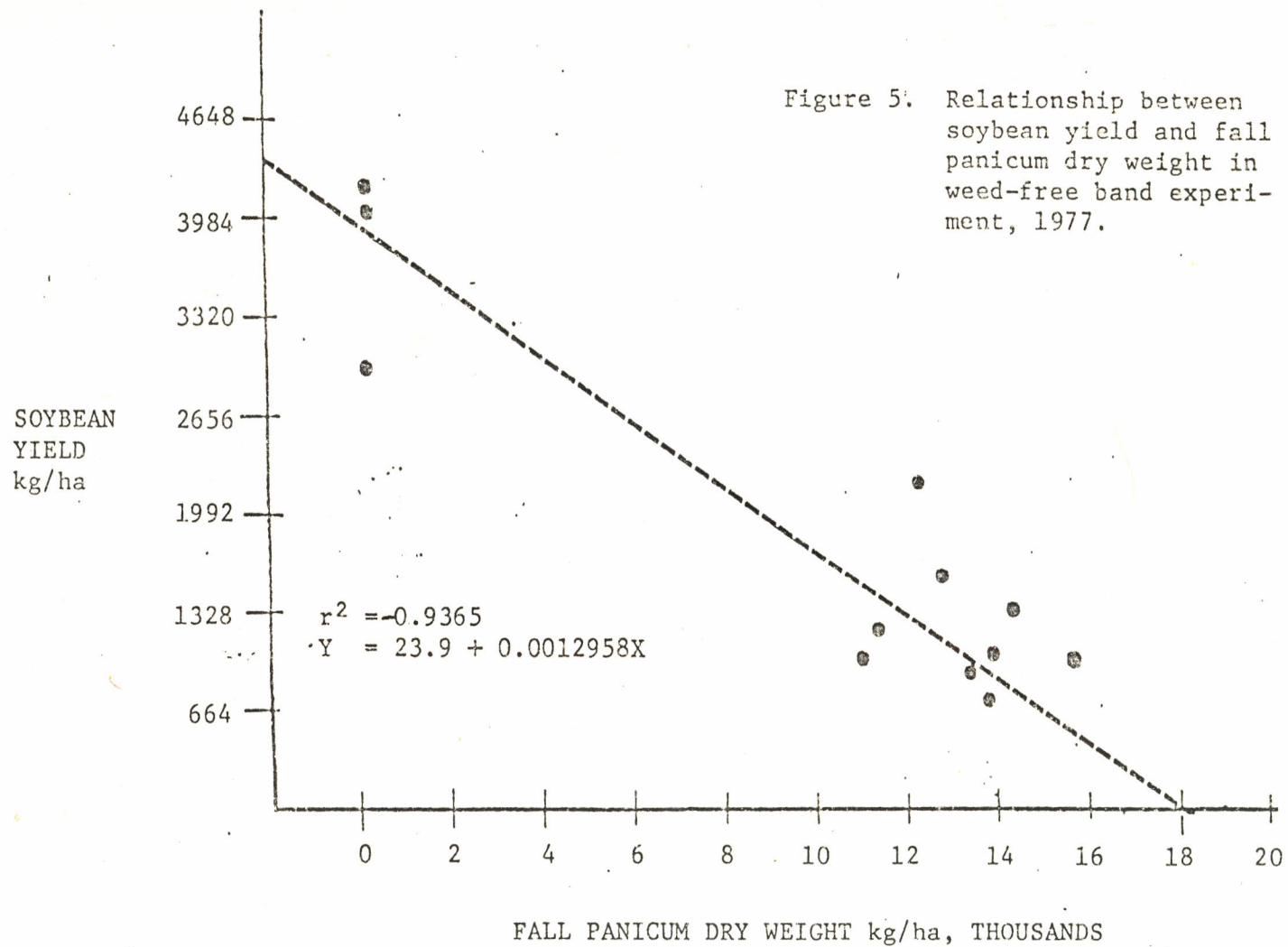


Figure 6. Relationship between soybean yield and fall panicum dry weight in different fall panicum interval spacings, 1977.

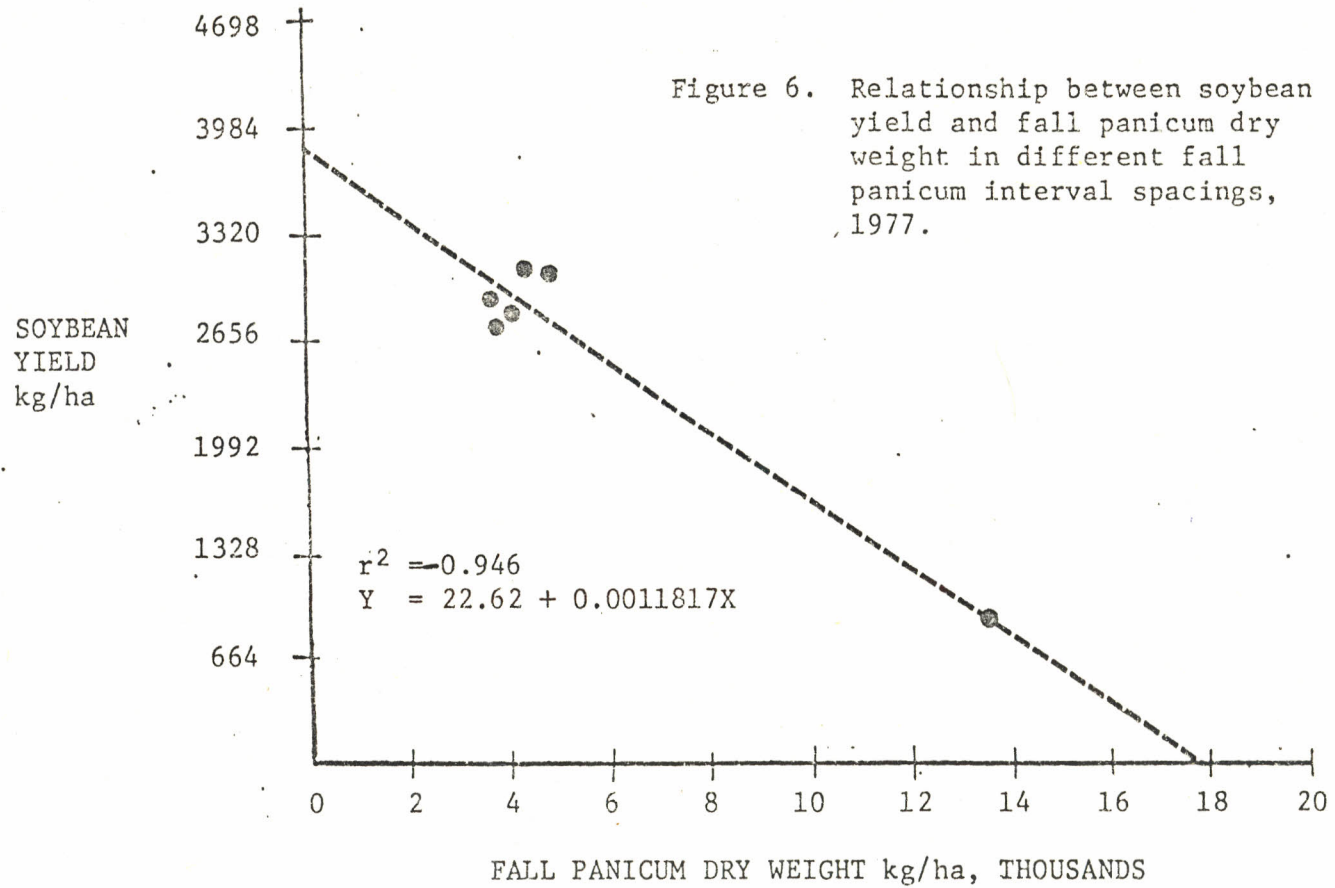


Table 14. Effect of band width and duration on the yield of the unremoved fall panicum, 1977.

Band Width (cm)	Duration (wks)	Yield (kg/ha)
25	0	13620
50	0	12153
25	1	15682
50	1	10759
25	2	14099
50	2	13329
25	3	11122
50	3	12327
Check		13503
LSD (0.05)		2818

Table 15. Relationship between plant interval and dry matter yield of fall panicum, 1977.

Interval ¹ (cm)	Yield (kg/ha)
10..16	4759
15..24	4091
20..32	4127
30..48	4102
45..72	3519
60..96	3365
Check	13511
LSD (0.01)	1506

¹ Distance between adjacent fall panicum plants.

Table 16. Effect of weed-free band width and duration on percent total nitrogen content of unremoved fall panicum, 1977.

Band-Width (cm)	Duration (wks)	N Content (%)
25	0	1.02
50	0	1.04
25	1	1.10
50	1	1.01
25	2	1.01
50	2	1.20
25	3	1.00
50	3	0.93
Check		1.01

4.

Table 17. Effect of interval spacings on percent total nitrogen content of fall panicum, 1977.

Interval (cm)	N Content (%)
10.16	1.43
15.24	1.23
20.32	1.27
30.48	1.71
45.72	1.52
60.96	1.50
Check	1.01

Table 18. Effect of weed-free band width and duration on soybean pod number, 1977.

Band-Width (cm)	Duration (wks)	Number of Pods Per Plant
25	0	21.5
50	0	17.6
75	0	23.3
25	1	23.4
50	1	18.0
75	1	27.3
25	2	15.6
50	2	25.6
75	2	21.2
25	3	21.0
50	3	24.3
75	3	23.3
Check		20.3

Table 19. Effect of fall panicum interval spacings on the number of soybean pods, 1977.

Interval (cm)	Number of Pods Per Plant
10.16	27.4
15.24	23.8
20.32	22.4
30.48	25.3
45.72	27.3
60.96	21.5
Check	20.3

Table 20. Effect of fall panicum weed-free band width and duration on soybean height, 1977.

Band-Width (cm)	Duration (wks)	Height (cm)
25	0	96.25
50	0	90.25
75	0	91.50
25	1	94.25
50	1	87.00
75	1	87.50
25	2	87.50
50	2	93.50
75	2	96.25
25	3	91.25
50	3	88.25
75	3	87.00
Check		84.25

Table 21. Effect of fall panicum interval spacings on soybean height, 1977.

Interval (cm)	Height (cm)
10.16	93.00
15.24	91.75
20.32	84.75
30.48	92.50
45.72	92.75
60.96	91.25
Check	84.25

Table 22. Preplant Incorporated (PPI) and Preemergence (PRE) fall panicum control with HOE 29152 alone and in combination with dinoseb.

Herbicide	Rate (kg/ha)	Fall Panicum Control ¹
HOE 29152 (PPI)	0.28	0.0
HOE 29152 (PPI)	0.57	2.5
HOE 29152 (PPI) + dinoseb (PRE)	0.28 + 3.39	1.5
HOE 29152 (PPI) + dinoseb (PRE)	0.57 + 3.39	1.8
HOE 29152 (PRE)	0.14	0.0
HOE 29152 (PRE)	0.28	3.3
HOE 29152 (PRE)	0.57	8.5
HOE 29152 (PRE) + dinoseb (PRE)	0.14 + 3.39	0.0
HOE 29152 (PRE) + dinoseb (PRE)	0.28 + 3.39	1.3
HOE 29152 (PRE) + dinoseb (PRE)	0.57 + 3.39	5.4
Dinoseb (PRE)	3.39	0.0
Check		0.0
LSD (0.01)		2.3

¹ Based on a scale of 0 to 10, where 0 = no stand reduction and 10 = complete stand reduction.

Table 23. Fall panicum control in soybeans with HOE 29152 applied early postemergence alone and in combination with bentazon and acifluorfen-sodium.

Herbicide	Rate (kg/ha)	Fall Panicum Control ¹
HOE 29152	0.14	0
HOE 29152	0.28	4.5
HOE 29152	0.57	6.0
Bentazon	1.13	1.0
HOE 29152 + bentazon	0.28 + 1.13	0.0
HOE 29152 + bentazon	0.57 + 1.13	9.5
Acifluorfen-sodium	0.57	0.0
HOE 29152 + acifluorfen-sodium	0.14 + 0.57	2.0
HOE 29152 + acifluorfen-sodium	0.28 + 0.57	2.5
HOE 29152 + acifluorfen-sodium	0.57 + 0.57	8.8
Check		0.0
LSD (0.01)		3.00

¹ Based on a scale of 0 to 10, where 0 = no stand reduction and 10 = complete stand reduction.

HOE 29152 plus acifluorfen-sodium provided good fall panicum control at the highest rates used. Lower rates of both combined compounds effected poor fall panicum control. Acifluorfen-sodium alone was ineffective in controlling the grass but the compound slightly reduced vigor (0.7).

Late post-emergence applications of HOE 29152 alone provided slightly better fall panicum control than early applications (Table 24). Greenhouse observations revealed similar responses. This kind of response is not consistent with chemical cultural practices because early weed control is more desirable than late control. Combining this compound with bentazon provided only fair control.

The following results include control of other weeds present on the experimental site besides fall panicum.

Pre-emergence applications of acifluorfen-sodium alone effected broadspectrum weed control (Table 25). This material was found to be equally effective on all weed species whether applied pre-emergence or post-emergence. Control of fall panicum was better from pre-emergence applications than from post-emergence applications.

Weed control data for acifluorfen-sodium applied post-emergence alone and in combination with a spray adjuvant are summarized in Table 26. It is evident from the data that with increasing rate of acifluorfen-sodium alone, there was a proportionate increase in the control of fall panicum and redroot pigweed although the control of the former species was poor. The effects on velvetleaf were inconclusive. As the volume of 11 E oil was increased, there were increases in the control of all weed species, but the greatest increases were for fall panicum and velvetleaf.

Table 24. Fall panicum control in soybeans with HOE 29152 applied late postemergence alone and in combination with bentazon and acifluorfen-sodium.

Herbicide	Rate (kg/ha)	Fall Panicum Control ¹
HOE 29152	0.14	0.0
HOE 29152	0.28	8.9
HOE 29152	0.57	9.9
Bentazon	1.13	0.0
HOE 29152 + bentazon	0.28 + 1.13	1.3
HOE 29152 + bentazon	0.57 + 1.13	5.3
Acifluorfen-sodium	0.57	1.8
HOE 29152 + acifluorfen-sodium	0.14 + 0.57	1.0
HOE 29152 + acifluorfen-sodium	0.28 + 0.57	3.5
HOE 29152 + acifluorfen-sodium	0.57 + 0.57	5.3
Check		0.0
LSD (0.01)		1.0

¹ Based on a scale of 0 to 10, where 0 = no stand reduction and 10 = complete stand reduction.

Table 25. Pre-emergence weed control in soybeans with acifluorfen-sodium, 1977.

Herbicide	Rate (kg/ha)	Weed Control ¹			
		Fall panicum	Lambs- quarters	Pigweed	Velvet- leaf
acifluorfen-sodium	0.57	3.7	9.5	8.1	7.0
acifluorfen-sodium	1.13	7.7	9.7	9.5	9.3
acifluorfen-sodium	2.36	8.2	10.0	10.0	9.4
check	-	0.0	0.0	0.0	0.0

Based on a scale of 0 to 10, where 0 = no control and 10 = complete control.

Table 26. Weed control in soybeans with acifluorfen-sodium applied postemergence alone and in combination with spray adjuvants.

Herbicide and Adjuvant Concentration (v/v)	Rate (kg/ha)	Weed Control ¹		
		Fall Panicum	Pig- weed	Velvet- leaf
Acifluorfen-sodium	0.28	1.3	7.5	7.7
	0.57	1.8	9.2	8.8
	1.13	4.2	9.7	4.8
+ 11E oil 1/4 GPA	0.28	3.8	9.7	7.3
	0.57	6.0	9.7	9.3
	1.13	7.7	9.8	9.3
+ 11E oil 1/2 GPA	0.28	5.2	9.8	7.0
	0.57	7.0	10.0	9.7
	1.13	7.4	9.7	9.5
+ 11E oil 1 GPA	0.28	7.0	9.9	9.9
	0.57	7.9	10.0	9.9
	1.13	8.8	10.0	9.9
Check		0.0	0.0	0.0
LSD (0.01)		1.2	0.2	0.8

¹ Based on a scale of 0 to 10 where 0 = no stand reduction and 10 = complete stand reduction.

Several surfactants in combination with herbicides were evaluated for post-emergence fall panicum, pigweed and velvetleaf control. Soybean response was also observed.

Applications of HOE 29152 alone provided adequate fall panicum and pigweed control (Table 27). The effects on velvetleaf are not definitive. The vigor of all the weed species was reduced with greatest reductions for fall panicum and velvetleaf.

The surfactants investigated showed definitive effects on all the weed species. Addition of S-104-ES-75 (1/4 and 1/2% v/v) to HOE 29152 effected good fall panicum control but was only fair on pigweed and velvetleaf. Vigor of the three weed species was equally reduced. There was no significant difference in weed control between the higher and lower rates of HOE 29152.

Combinations of Blend C and HOE 29152 gave better velvetleaf and fall panicum control and were only fair on pigweed. All rates and volumes of herbicides and surfactants, respectively, were comparable in weed control. However, soybean vigor was reduced as the volume of Blend C and the rate of HOE 29152 increased. All weed species were slightly reduced in vigor by a combination of Blend C and HOE 29152.

Additions of Blend E to HOE 29152 provided comparable fall panicum and pigweed control but poor velvetleaf control. There was negligible soybean vigor reduction with 1/2% v/v of Blend C. Appreciable vigor reduction of all the other weed species was noticed.

HOE 29152 plus Surfynol 465 was comparable in weed control to the herbicide plus Blend E. This was true for soybean vigor reduction. Both materials further exhibited similar weed vigor reduction.

Table 27. The effects of postemergence applications of HOE 29152 and surfactants on weeds.

Herbicide	Rate (kg/ha)	Surfactant - Concentration (v/v)	Weed Control ¹						
			Fall. Pan.		Pigweed		Velvetleaf		
			S	V	S	V	S	V	
HOE 29152	0.14		7.2	0.7	6.7	1.2	5.3	1.0	
	0.28		8.9	3.5	6.3	1.2	8.0	4.0	
	0.57		9.9	7.9	6.5	0.2	3.0	1.2	
HOE 29152	0.14 + S-104-ES-75	1/4%	9.9	7.3	6.9	0.5	3.7	0.9	
	"	"	1/2%	9.6	3.2	6.2	1.2	6.9	3.3
	0.14 + Blend C	1/4%	9.3	1.7	6.3	1.0	7.3	0.9	
	"	"	1/2%	9.8	2.0	3.7	0.9	8.7	0.9
	0.14 + Blend E	1/4%	9.9	7.0	5.7	0.9	4.3	0.2	
	"	"	1/2%	9.9	4.0	9.9	0.5	5.5	1.2
	0.14 + Surfynol 465	1/4%	6.8	4.3	7.3	0.9	6.9	0.9	
	"	"	1/2%	9.8	5.9	8.2	0.7	2.0	0.5
	0.28 + S-104-ES-75	1/4%	9.9	7.0	8.2	0.5	8.3	4.3	
	"	"	1/2%	9.7	6.9	6.5	1.3	6.3	0.7
	0.28 + Blend C	1/4%	9.9	7.7	7.2	0.5	5.7	0.3	
	"	"	1/2%	10.0	-	5.7	1.3	6.9	1.5
	0.28 + Blend E	1/4%	9.2	6.9	8.2	2.3	5.7	1.2	
	"	"	1/2%	9.9	6.9	8.3	0.5	2.3	0.7
	0.28 + Surfynol 465	1/4%	9.9	7.7	9.0	0.7	1.7	0.9	
"	"	1/2%	9.6	4.0	5.9	0.7	4.2	0.9	
Check (Control)			0.0	0.0	0.0	0.0	0.0	0.0	
LSD (0.01)			1.5	NS	2.2	0.55	2.7	NS	

¹ Based on a scale of 0 to 10, 0 = no control, 10 = complete control; S = stand, V = vigor.

It is important to note that HOE 29152 is not a broadleaf weed herbicide but a graminicide; however, the activity of the compound on broadleaf weed species was enhanced by the three surfactants studied.

Bentazon alone applied post-emergence provided poor fall panicum control at all rates investigated (Table 28). There was no improvement in the control of this species when surfactants were included. Appreciable control of pigweed and velvetleaf was effected with bentazon alone and in combinations with the three surfactants used. Increase in volume of any surfactant from 1/4 to 1/2% v/v was not advantageous in any weed species' control. There was one observation worthy of note. Bentazon alone, at all rates used, slightly reduced soybean vigor, however, inclusion of Blend C and Blend E somewhat counteracted soybean injury. Although fall panicum control was poor, vigor reduction was observed. The two volumes of S-104-ES-75 used combined with bentazon effected the highest stand reduction of velvetleaf. The same observations were true with Surfynol 465 plus bentazon. Additions of S-104-ES-75 or Surfynol 465 to bentazon effected temporary comparable injury to soybeans.

A summary of weed control data resulting from the applications of combinations of HOE 29152 and bentazon plus surfactants applied post-emergence is found in Table 29. This combination proved to be a successful weed control program on all the three weed species present. Control of velvetleaf with both the herbicide combination and all surfactant additions was excellent. Fall panicum and pigweed control were satisfactorily controlled by the chemicals studied. All the surfactants were found to be safe on soybeans, perhaps, with Blend C being the safest.

Table 28. The effects of postemergence applications of bentazon and surfactants on weeds in soybeans.

Herbicide	Rate (kg/ha)	Surfactant - Concentration (v/v)	Weed Control ¹								
			Fall.		Pan.		Pigweed		Velvetleaf		
			S	V	S	V	S	V	S	V	
Bentazon	0.28		2.7	0.3			9.0	2.7	9.3	3.7	
	0.57		3.3	0.3			9.6	2.5	9.9	7.0	
	1.13		3.5	0.7			9.8	3.9	10.0	-	
Bentazon	0.28	+ S-104-ES-75	1/4%	2.7	0.3			9.1	2.3	9.9	7.7
	"	"	1/2%	3.0	1.5			9.2	2.3	9.1	7.5
	0.28	+ Blend C	1/4%	0.0	0.0			9.0	1.3	10.0	-
	"	"	1/2%	2.5	0.7			8.3	1.9	10.0	-
	0.28	+ Blend E	1/4%	0.9	0.2			9.4	5.3	10.0	-
	"	"	1/2%	3.3	0.0			8.7	1.5	8.2	2.0
	0.28	+ Surfynol 465	1/4%	1.7	0.0			9.5	4.5	8.5	5.7
	"	"	1/2%	2.3	0.3			9.1	2.5	9.7	7.3
	0.57	+ S-104-ES-75	1/4%	4.0	0.3			8.2	2.3	10.0	-
	"	"	1/2%	2.2	0.5			8.0	4.9	10.0	-
	0.57	+ Blend C	1/4%	3.5	0.7			9.8	4.0	10.0	-
	"	"	1/2%	2.7	0.2			8.9	2.7	10.0	-
	0.57	+ Blend E	1/4%	3.7	0.3			9.1	3.3	10.0	-
	"	"	1/2%	2.5	0.3			9.4	1.3	10.0	-
	0.57	+ Surfynol 465	1/4%	2.0	0.2			8.7	2.2	10.0	-
"	"	1/2%	3.9	1.0			9.0	2.7	9.9	5.3	
Check (Control)			0.0	0.0			0.0	0.0	0.0	0.0	
LSD (0.01)			1.4	NS			0.11	NS	0.11	2.0	

1. 0 = no control, 10 = complete control; S = stand, V = vigor.

Table 29. Postemergence weed control in soybeans with HOE 29152 in combination with bentazon and surfactants.

Herbicide	Rate (kg/ha)	Surfactant - Concentration (v/v)	Weed Control ¹							
			Fall. Pan.		Pigweed		Velvetleaf			
			S	V	S	V	S	V		
HOE 29152 +	0.28 +									
Bentazon	0.57 +	S-104-ES-75	1/4%	8.9	2.0	9.3	4.0	10.0	-	
"	"	"	1/2%	9.6	7.6	8.4	3.9	10.0	-	
	0.28 +									
	0.57 +	Blend C	1/4%	8.5	2.0	9.1	4.3	9.7	8.3	
"	"	"	1/2%	9.0	3.2	8.9	2.2	10.0	-	
	0.28 +									
	0.57 +	Blend E	1/4%	9.1	2.0	7.0	3.0	9.8	7.3	
"	"	"	1/2%	9.3	5.9	7.2	2.0	10.0	-	
	0.28 +									
	0.57 +	Surfynol 465	1/4%	8.2	0.5	8.8	1.5	10.0	-	
"	"	"	1/2%	9.0	1.7	7.5	1.9	10.0	-	
Check (Control)				0.0	0.0	0.0	0.0	0.0	0.0	
LSD (0.01)				0.06	1.90	0.22	1.50	0.10	3.0	

¹ 0 = no control, 10 = complete control; S = stand, V = vigor.

V. DISCUSSION

The yield data indicate that complete cultural control of fall panicum early in the growing season effected good soybean yield. It is apparent that weed competition can occur up to three weeks after soybean emergence without causing great yield loss. Yields from plots that were weed-free throughout the growing season were not significantly different from those that had weeds for three weeks. This statement is not in complete agreement with results of some other investigators. It is generally agreed that soybeans are most vulnerable to weed competition during the first few weeks after emergence (Knake and Slife, 1965; Staniforth, 1957, 1958; Burnside, 1973). From this study, it is apparent that severe fall panicum competition occurs after the three-week period when plants are well established.

Fall panicum is a late-germinating annual grass. Competition for environmental factors is not critical until it is well established. York and Coble (1977) found similar results where fall panicum was removed two weeks after peanut emergence, the grass was small and did not cause significant peanut yield reductions. Fall panicum emergence occurs as early as late April in the Northeastern U.S.A., but greatest emergence of the grass occurs during the warmest period of the growing season, June to August (Vengris and Damon, 1976). Most annual grasses such as foxtails and large crabgrass (*Digitaria sanguinalis* (L.) Scop.) emerge early and compete with the crop throughout the growing season. Studies on foxtail species (Knake and Slife, 1965; Staniforth and Weber, 1950), another gramineae, have shown that weed-crop competition is critical the first three to four weeks after the crop emerges.

Late fall panicum emergence makes it a potential mid- and late season competitor of soybeans. Soybeans were planted on June 3 and June 1 in 1976 and 1977, respectively. These planting dates coincided with the period when there is adequate light intensity and enough soil moisture for fall panicum germination in New Jersey. Growth and development of fall panicum confirmed that severe competition does not occur until late June or early July, approximately three weeks after soybean emergence. It is well documented that most weeds compete severely with young soybeans, therefore, three weeks of weed-free conditions after planting are adequate for earlier crop establishment. Although the soybean canopy suppresses germinating weeds, it may not successfully eliminate late germinating grass such as fall panicum. Depending on the soybean variety and growth habits, foliage may not adequately cover bare ground where weed seeds are located. It is further believed that a grass competes successfully with a broadleaf species and vice-versa due to their differences in morphology and growth habits.

All experimental fall panicum densities slightly reduced yield in both years. The 1976 data showed a general yield reduction with increasing number of fall panicum plants per meter of soybean row. This response, however, was not evidenced in 1977. There were no significant differences between 6, 4, 3, 2, 1.3, and 1 plant(s) per meter of soybean row. The biggest difference was noticed in the check which had the most number of fall panicum plants around and within soybean rows. The differences in yield responses between 1976 and 1977 were due to lack of moisture early in the 1977 growing seasons (Table XXXXVII). The reasons for slight yield variations were due to

differences in plant vigor at various equidistant spacings. Intra weed competition for moisture, light, space and nutrients was not as crucial and the remaining fall panicum plants tillered profusely exerting equally severe competition as if there were more initial fall panicum plants.

The relationship between soybean yield and dry weights of fall panicum showed negative linear correlation in both quantitative and qualitative competition studies conducted in 1977. Although the data are somewhat inconclusive, the high coefficient of determination ($r^2 = -0.946$) indicated close to a perfect negative linear relationship between soybean yields and fall panicum dry weights. In order to keep the experiment at a manageable size, no plots were maintained with an intermediary number of fall panicum plants, as a result there were no data points in the center of the graph. Increases in fall panicum dry weights effected corresponding decreases in soybean yields. This finding confirms information reported by York and Coble (1977) where peanut yields were negatively correlated with weed density. It was interesting to note in this study that in the weed-free band and duration experiment, fall panicum dry weights were higher in 25.4-cm bands than those harvested in 50.8-cm bands regardless of the time of weed competition. This was a clear indication of intraspecific fall panicum competition. It is important to further emphasize the fact that the check, with all the fall panicum growing in competition with soybeans, yielded comparable dry weights of fall panicum with the 25.4-cm weed-free band experiments. This finding further reveals the importance of the soybean canopy which covers both sides of soybean rows, in influencing the weed proximity.

Low total nitrogen content in fall panicum in all treatments of weed-free band experiment was due to intraspecific weed competition. Regardless of the duration of competition, total nitrogen content in fall panicum plants was the same. It is apparent, however, that large amounts of nitrogen are assimilated within the first few weeks after weeds emerge. Nutrient study reports (Mani, 1975) indicate that substantial amounts of nitrogen are assimilated within five to six weeks after planting. This finding is in agreement with this study. Competition for soil nutrients and other environmental factors between weeds and crops is a well-known phenomenon.

The occurrence of aerial and subterranean competition is demonstrated by the higher total nitrogen content in less densely grown fall panicum. High amounts were found in vigorous, heavily tillered individual fall panicum plants. The highest quantities were analyzed from plots with 2, 1.3, and 1 plant(s) per meter of soybean row corresponding with 30.48, 45.72, and 60.96 cm fall panicum interval spacings, respectively.

It is important to mention yield parameters considered during this study. Differences in weights of 500 soybean seeds from each treatment in the weed-free band experiment were statistically non-significant. This was an indication of a more severe competition dictated by the quality of fall panicum. The high number of pods per plant compensated for weight loss in soybeans. Similar findings have been reported by Chaundhary and Singh (1974), and Pandey and Torrie (1973). Contrary to the results of the weed-free band experiment, fall panicum planted with equidistant spacings effected higher seed weights at 5% level of probability. Weed pressure was not nearly as

severe in this experiment as in the former experiment.

Soybean heights were not directly related to yield, however, excess soybean lodging was noticed in tall soybeans and harvesting was difficult. This was particularly evident in plots with excessively heavy fall panicum pressure and tall soybean plants. That soybean plant height indirectly effects soybean yield has been documented (Weber and Febr, 1966); different results may be produced with variation in locale and soybean cultivar.

The herbicides HOE 29152 and diclofop (HOE 23408) are phenoxy-phenoxy derivatives (double phenoxys) which have similar chemical structures, the only difference being the substituents on the ring structures. HOE 29152 has three flourine substituents on the ring, whereas, diclofop has two chlorines. Investigation of the latter compound indicates it has potential use in wheat, barley (*Hordeum vulgare* L.) and sugar beets (*Beta vulgaris* L.) for wild oats (*Avena fatua* L.) control. The data also indicate wide pre- and post-emergence use of this compound in many agronomic crops like soybeans, peanuts, cotton (*Gossypium hirsutum* L.) and alfalfa (*Medicago sativa* L.).

Better fall panicum control in greenhouse studies than in the field studies at the three-to-five leaf stage (25-35 cm tall) was indicative of the morphological and physiological responses of post-emergence sprays to phenoxy-like herbicides. Several studies have shown that 2,4-dichlorophenoxy acetic acid (2,4-D)-type herbicides are most active on grass-like plants when they are 25 to 45 cm tall and greatest tolerance is reported to be when plants are 5.0 to 10-cm tall (Ashton and Crafts, 1975; Ilnicki, 1955). Complimented with ideal growing conditions in the greenhouse, translocation of the compound was

highly favored. Uniformity in grass growth, vigor, area and lushness were all contributing factors for plant susceptibility. Similar responses were not obtained under field conditions, however, where the growing environment was not the same favoring rapid and uniform fall panicum growth.

Pre-emergence and soil applied preplant incorporated HOE 29152 provided poor fall panicum control. Degradation of phenoxy-type compounds is rapid and complete by soil microbes (Ashton and Crafts, 1975; Kearney and Kaufman, 1975). Several microorganisms responsible for this degradation have been isolated and identified. Since fall panicum is a late germinating grass, time of application of HOE 29152 was not ideal; it was applied too early. Results suggested that the compound decomposed into a biologically nonactive molecule by the time fall panicum emerged. Detoxification mechanisms of HOE 29152 by fall panicum plants may also account for poor control, however, metabolism of this herbicide is not yet completely known.

Post-emergence applications of HOE 29152 exhibited different biological expressions than 2,4-D-type herbicides. In both greenhouse and field conditions, symptoms of susceptible plants were not evident for several days following chemical application. There was a latent period before physiological functions were affected. Both the foliage and root growth wilted, chlorotic mottling was visible and the leaves exhibited grey and brown blotches. The latent period suggested that the mechanism of action of this compound is in the cell structures where photosynthetic activity occurs. Diclofop, a close relative of HOE 29152, has been reported to exhibit similar biological responses (American Hoechst Corp., Tech. Bull.).

Neither early nor late post-emergence applications of HOE 29152 adequately controlled fall panicum under field conditions except at the highest rates used. These results are not consistent with the preliminary greenhouse data when applications were made at the three-to-five leaf stage of fall panicum growth. Preliminary field data, however, from American Hoechst researchers indicate good perennial grass control of quackgrass (seedling) (*Agropyron repens* (L.) Beauv.) and johnsongrass (*Sorghum halepense* (L.) Pers.) (American Hoechst Corp., Tech. Bull.). Appreciable control of johnsongrass was evidenced when the compound was sprayed 15.0 to 30.0-cm tall. This kind of response from perennial grasses strongly suggests translocation of the material basipetally and acropetally during the warmer period of the year when growth conditions are ideal for these species.

Combinations of the HOE 29152 plus bentazon, a heterocyclic nitrogen compound, controls broadleaf weed species, whereas HOE 29152 has activity on grassy weed species; combining these two compounds could only be expected to provide broadspectrum weed control.

Combinations of an experimental diphenylether compound aciflourfen-sodium effected broadspectrum weed control. Control of fall panicum was remarkably improved. Acifluorfen-sodium has excellent potential for both pre- and post-emergence broadleaf control in soybeans. Preliminary research from Rohm and Haas Company indicated good fall panicum control at the 0.57 and 1.13 kg/ha rate when soybeans are at a one-to-two trifoliolate leaf stage (Yih et al., 1977). Similar results were found when acifluorfen-sodium at the same rates were used when soybeans were at the unifoliolate leaf stage. Control of foxtail species, barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) and

johnsongrass by this material has been reported (Rohm and Haas Company, Tech. Bull.). Inclusion of a nonphytotoxic oil at low concentrations (1/2 to 1% v/v) further improved control of all weed species investigated, particularly fall panicum.

All stages of soybean growth were found to be tolerant to acifluorfen-sodium, however, temporary short-lived injury to the youngest differentiating soybean leaves was noticed. Leaf cupping, crinkling, and speckling were observed. These responses were particularly noticeable at the highest rates used. Burning of mature foliage and malformations of developing leaves have been reported for other diphenylethers like p-nitrophenyl α,α,α -trifluoro-2-nitro-p-tolyl ether (fluorodifen), 2,4-dichlorophenyl-p-nitrophenyl ether (nitrofen), and methyl 5-(2,4-dichlorophenoxy)-2-nitrobenzoate (bifenox) (Ashton and Crafts, 1975; Weed Science Society of America Herbicide Handbook, 1974). Epinastic responses are somewhat typical plant reactions to diphenyl ether herbicides.

Nonionic surfactants enhanced activity of all the herbicides investigated. These surfactants are derivatives of reacting various amounts of ethylene oxides and acetylene glycol. Nonphytotoxic paraffinic oil was not as effective. Combinations of a surfactant and a nonphytotoxic oil improved herbicide activity. Uncontrolled broad-leaf weed species were reduced in vigor and temporary short-lived soybean injury was noticed two to three days after chemical application.

Results due to different phytotoxicity exhibited by surfactants are due to their chemical properties and herbicide compatibility. The chemistry and structural activity of the surfactants studied were not investigated, however, the following reasons seem plausible for

the different responses.

The nonphytotoxic paraffinic oil increased penetration of the chemical solutions into the intracellular spaces of the cuticle. It is a good wetting agent and is used as a carrier for many chemicals. Surfactants, besides increasing chemical penetration, also increase spray retention, area of solution contact and redistribution. They facilitate herbicide entrance into the plant cuticle by reducing surface tension.

In general, surfactants are wetting agents that provide better chemical adhesion to the aerial portions of the plant. This unique property is due to the chemical structure of the surfactants. These products are characterized by either an internal or terminal triple bond and adjacent hydroxyls. The highly electrophilic triple bond has high affinity for water (hydrophilic) (Tedeschi and Sims, 1976). Addition of surfactants to herbicides and herbicide combinations is presently under investigation by many weed scientists. Further extension in surfactants research is combining them with non-phytotoxic oils. In this study, a blend of a low viscosity oil (11 E) and surfactants was found to be somewhat superior than either one used alone. Combined different properties of the surfactants and oils accounted for superior phytotoxic weed response than when either was used alone. This investigation further revealed the safety and compatibility of combining herbicides, surfactants, and nonphytotoxic paraffinic oils. Antagonistic effects due to combined herbicides and/or surfactants were not evidenced in the course of this study.

VI. SUMMARY AND CONCLUSIONS

This investigation was designed to determine the quantitative and qualitative effects of fall panicum on soybeans.

The study indicates that growth stages requiring maximum light, water, nutrients and space occur at different times even though crops and weeds are growing during the same period. Both quantitative and qualitative fall panicum competition occurs in soybeans. Heavy and relatively low densities of fall panicum decreases soybean yield. Differences in plant size, canopy arrangement, and growth duration account for soybean yield loss.

It is apparent from this study that soybeans become more sensitive to fall panicum competition three weeks after emergence. Delaying chemical and/or cultural fall panicum control up to three weeks will not adversely affect soybean yield as long as adequate control is provided after the initial three week growth period.

Studies on the effect of herbicides on the growth and physiological processes of fall panicum indicated that the grass was generally susceptible to the experimental phenoxy-type compound, HOE 29152, at all stages. This compound has some potential in post-emergence fall panicum control in soybeans. The compound is more effective when used at high rates (0.57 kg/ha or 1.13 kg/ha). The experimental diphenylether compound, acifluorfen-sodium, has efficacy for post-emergence broadleaf and some grassy weed control in soybeans. Presently, post-emergence applications of bentazon for broadleaf weed control in soybeans is the generally accepted herbicide recommendation. Combinations of HOE 29152 with bentazon or acifluorfen-sodium applied

post-emergence provided excellent broadspectrum weed control in soybeans. Inclusion of surfactants in straight herbicide applications and herbicide combinations further improved weed control. Comparisons between non-ionic surfactants and low concentrations of nonphytotoxic paraffinic oil demonstrated that surfactants facilitate herbicide activity more than the spray oils. Combinations of the two spray adjuvants effected synergistic response providing better control than an oil or a surfactant alone. There was no antagonism in any of the chemical combinations studied, although short-lived temporary injury to soybeans was observed.

Although 1977 soybeans were not harvested due to inclement weather, it was evident from visual data ratings that better chemical or cultural weed control effected higher yields than the check or poorly controlled treatments.

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APPENDIX

Table I. Statistical analysis of soybean yields in weed-free band experiment and duration, 1976.

Source of Variation	df	SS	MS	F
Total	71	1237795.6		
Duration	3	39176.0	12665.8	215.8
Widths	2	596039.6	298019.8	4963.4*
D X W	6	26360.8	4399.0	66.4
Replications	5	28817.6	5760.2	
Residual	55	548397.6	9976.6	

* Significant at .01.

Table II. Statistical analysis of soybean yields in different fall panicum interval spacings, 1976.

Source of Variation	df	SS	MS	F
Total	44	293620.8		
Intervals	4	82468.8	20617.2	664.0*
Replications	8	46928.2	5859.8	
Residual	32	164223.8	5129.4	

* Significant at .01.

Table III. Analysis of variance of early season soybean pod counts as affected by fall panicum weed-free band and duration, 1976.

Source of Variation	df	SS	MS	F
Total	95	3051.6		
Treatment	15	1017.4	67.8	3.4*
Replications	5	537.6	107.5	
Residual	75	1497.0	20.0	

* Significant at .01.

Table IV. Analysis of variance of early season soybean pod counts as affected by fall panicum interval spacings, 1976.

Source of Variation	df	SS	MS	F
Total	44	1983.6		
Intervals	4	315.2	78.8	3.5*
Replications	8	948.4	118.6	
Residual	32	720.0	22.5	

* Significant at .05.

Table V. Analysis of variance of late season soybean pod counts as affected by fall panicum weed-free band and duration, 1976.

Source of Variation	df	SS	MS	F
Total	95	3906.1		
Treatment	15	1088.0	72.5	2.1*
Replications	5	194.1	38.8	
Residuals	75	2624.0	35.0	

* Significant at .05.

Table VI. Analysis of variance of late season soybean pod counts as affected by fall panicum interval spacings, 1976.

Source of Variation	df	SS	MS	F
Total	44	2404.4		
Intervals	4	172.5	43.1	0.8
Replications	8	447.7	56.0	
Residual	32	1784.2	55.8	

Table VII. Analysis of variance of the weight of 500 soybean seeds as affected by fall panicum weed-free band and duration, 1976.

Source of Variation	df	SS	MS	F
Total	95	2865.3		
Treatment	15	416.5	27.8	1.1
Replications	5	591.1	118.2	
Residual	75	1857.7	24.8	

Table VIII. Analysis of variance of the weight of 500 soybean seeds as affected by fall panicum interval spacings, 1976.

Source of Variation	df	SS	MS	F
Total	44	872.6		
Intervals	4	242.0	60.5	5.5*
Replications	8	279.1	34.9	
Residual	32	351.5	11.0	

* Significant at .05.

Table IX. Analysis of variance of soybean heights as affected by fall panicum weed-free band and duration, 1976.

Source of Variation	df	SS	MS	F
Total	95	2601.0		
Treatment	15	200.3	13.3	2.0
Replications	5	1228.0	245.5	
Residual	75	1240.3	15.8	

Table X. Analysis of variance of soybean heights as affected by fall panicum interval spacings, 1976.

Source of Variation	df	SS	MS	F
Total	44	1470.0		
Intervals	4	161.5	40.5	3.0
Replications	8	195.0	24.5	
Residual	32	1113.5	34.8	

Table XI. Analysis of variance of soybean yields as affected by weed-free bands and time of competition, 1977.

Source of Variation	df	SS	MS	F
Total	47	546306.0		
Duration	3	14027.0	4681.2	365.2
Widths	2	54016.4	27008.2	2141.4*
D X W	6	401504.2	66914.6	5312.0*
Replications	3	7835.2	2606.2	
Residual	33	68890.0	2091.6	

* Significant at 0.01.

Table XII. Analysis of variance of soybean yields as affected by different fall panicum equidistant spacings, 1977.

Source of Variation	df	SS	MS	F
Total	27	148204.8		
Treatment	6	98421.4	16400.8	1079.0*
Replications	3	4581.6	1527.2	
Residual	18	45201.8	2506.6	

* Significant at 0.01.

Table XIII. Analysis of variance of soybean yield as affected by soil-applied preplant incorporated (PPI) and preemergence HOE 29152 alone and in combination with dinoseb, 1977.

Source of Variation	df	SS	MS	F
Total	55	174565.6		
Treatment	13	87349.2	6723.0	531.2*
Replications	4	6341.2	2108.2	
Residual	39	80875.2	2075.0	
Mean	1211.8			
LSD 0.05	846.6			

Table XIV. Analysis of variance of soybean yield as affected by early postemergence application of HOE 29152 and acifluorfen-sodium and bentazon, 1977.

Source of Variation	df	SS	MS	F
Total	47	261566.2		
Treatment	11	160887.2	14624.6	1029.2*
Replications	3	22592.6	7536.4	531.2
Residual	33	78086.4	2373.8	
Mean	1610.2			
LSD 0.01	1195.2			

Table XV. Analysis of variance of fall panicum dry weights in weed-free band and duration, 1977.

Source of Variation	df	SS	MS	F
Total	35	168903027		
Treatment	8	75632466	9454058	2.54*
Replications	3	3788295	1262765	
Residual	24	89482266	372843	

*Significant at 0.05.

Table XVI. Analysis of variance of panicum in different fall panicum interval spacings, 1977.

Source of Variation	df	SS	MS	F
Total	27	339674857		
Intervals	6	315508923	52584821	49.4*
Replications	3	5003553	1667851	
Residual	18	19162381	1064577	

* Significant at 0.01.

Table XVII. Analysis of variance of percent total N content in fall panicum plants of various densities, 1977.

Source of Variation	df	SS	MS	F
Total	35	0.01		
Treatment	8	0.19	0.02	0.07
Replications	3	0.05	0.02	1.0
Residual	24	0.77	0.03	

Table XVIII. Analysis of variance of percent N content in fall panicum plants at various interval spacings, 1977.

Source of Variation	df	SS	MS	F
Total	27	2.32		
Intervals	6	1.28	0.21	2.63
Replications	3	0.35	0.12	1.8
Residual	18	1.42	0.08	

Table XIX. Analysis of variance of soybean pods as affected by weed-free bands and duration, 1977.

Source of Variation	df	SS	MS	F
Total	47	1432.2		
Treatment	11	497.7	45.2	1.7
Replications	3	38.9	13.0	3.5
Residual	33	895.6	27.1	

Table XX. Analysis of variance of soybean pods as affected by fall panicum interval spacings, 1977.

Source of Variation	df	SS	MS	F
Total	27	897.0		
Intervals	6	188.0	31.3	1.0
Replications	3	135.9	45.3	1.8
Residual	18	573.1	31.8	

Table XXI. Analysis of variance of soybean heights as affected by various fall panicum weed-free bands, 1977.

Source of Variation	df	SS	MS	F
Total	47	800.5		
Treatment	11	220.8	20.0	3.0
Replications	3	29.5	9.8	0.6
Residual	33	550.3	16.8	

Table XXII. Analysis of variance of soybean heights as affected by various fall panicum interval spacings, 1977.

Source of Variation	df	SS	MS	F
Total	27	405.5		
Intervals	6	140.8	23.5	4.0
Replications	3	9.0	3.0	0.5
Residual	18	255.8	14.3	

Table XXIII. Analysis of variance of preplant and preemergence fall panicum control by HOE 29152 alone and in combination with dinoseb, 1977.

Source of Variation	df	SS	MS	F
Total	47	2142.07		
Treatment	11	1269.46	115.41	5.58*
Replications	3	189.74	63.25	
Residual	33	682.87	20.69	

* Significant at 0.01.

Table XXIV. Analysis of variance of fall panicum control with HOE 29152 applied early postemergence alone and in combination with bentazon and acifluorfen-sodium, 1977.

Source of Variation	df	SS	MS	F
Total	43	2806.33		
Treatment	10	1944.44	194.44	7.62*
Replications	3	96.10	32.03	
Residual	30	765.79	25.53	

* Significant at 0.01.

Table XXIII. Analysis of variance of preplant and preemergence fall panicum control by HOE 29152 alone and in combination with dinoseb, 1977.

Source of Variation	df	SS	MS	F
Total	47	2142.07		
Treatment	11	1269.46	115.41	5.58*
Replications	3	189.74	63.25	
Residual	33	682.87	20.69	

* Significant at 0.01.

Table XXIV. Analysis of variance of fall panicum control with HOE 29152 applied early postemergence alone and in combination with bentazon and acifluorfen-sodium, 1977.

Source of Variation	df	SS	MS	F
Total	43	2806.33		
Treatment	10	1944.44	194.44	7.62*
Replications	3	96.10	32.03	
Residual	30	765.79	25.53	

* Significant at 0.01.

Table XXV. Analysis of variance of fall panicum control with HOE 29152 applied late postemergence alone and in combination with bentazon and acifluorfen-sodium, 1977.

Source of Variation	df	SS	MS	F
Total	43	2547.80		
Treatment	10	2004.97	200.5	11.1*
Replications	3	1.81	0.4	
Residual	30	541.02	18.1	

* Significant at 0.01.

Table XXVI. Analysis of variance of fall panicum control with acifluorfen-sodium applied postemergence alone and in combination with spray adjuvant, 1977.

Source of Variation	df	SS	MS	F
Total	38	1188.20		
Treatment	12	989.98	82.5	11.0*
Replications	2	17.45	8.7	
Residual	24	180.77	7.5	

* Significant at 0.01.

Table XXVII. Analysis of variance of pigweed control with acifluorfen-sodium applied post-emergence alone and in combination with spray adjuvant, 1977.

Source of Variation	df	SS	MS	F
Total	38	961.45		
Treatment	12	923.61	76.97	55.78*
Replications	2	4.62	2.31	
Residual	24	33.22	1.38	

* Significant at 0.01.

Table XXVIII. Analysis of variance of velvetleaf control with acifluorfen-sodium applied postemergence alone and in combination with spray adjuvant, 1977.

Source of Variation	df	SS	MS	F
Total	38	1035.61		
Treatment	12	907.38	75.62	14.32*
Replications	2	1.60	0.80	
Residual	24	126.63	5.28	

* Significant at 0.01.

Table XXVII. Analysis of variance of pigweed control with acifluorfen-sodium applied post-emergence alone and in combination with spray adjuvant, 1977.

Source of Variation	df	SS	MS	F
Total	38	961.45		
Treatment	12	923.61	76.97	55.78*
Replications	2	4.62	2.31	
Residual	24	33.22	1.38	

* Significant at 0.01.

Table XXVIII. Analysis of variance of velvetleaf control with acifluorfen-sodium applied postemergence alone and in combination with spray adjuvant, 1977.

Source of Variation	df	SS	MS	F
Total	38	1035.61		
Treatment	12	907.38	75.62	14.32*
Replications	2	1.60	0.80	
Residual	24	126.63	5.28	

* Significant at 0.01.

Table XXIX. Analysis of variance of the effect of postemergence applications of HOE 29152 and surfactants on fall panicum control, 1977.

Source of Variation	df	SS	MS	F
Total	59	969.39		
Treatment	19	574.06	30.21	2.92*
Replications	2	1.64	0.82	
Residual	38	393.69	10.36	

* Significant at 0.01.

Table XXX. Analysis of variance of the effect of postemergence applications of HOE 29152 and surfactants on fall panicum vigor, 1977.

Source of Variation	df	SS	MS	F
Total	59	2986.81		
Treatment	19	1256.68	66.14	1.50
Replications	2	55.33	27.67	
Residual	38	1674.80	44.07	

Table XXXI. Analysis of variance of the effect of postemergence applications of HOE 29152 and surfactants on pigweed control, 1977.

Source of Variation	df	SS	MS	F
Total	59	1413.41		
Treatment	19	814.59	42.87	2.92*
Replications	2	40.95	20.48	
Residual	38	557.87	14.68	

* Significant at 0.01.

Table XXXII. Analysis of variance of the effect of postemergence applications of HOE 29152 and surfactants on pigweed vigor, 1977.

Source of Variation	df	SS	MS	F
Total	59	355.14		
Treatment	19	181.88	9.57	2.57*
Replications	2	31.47	15.74	
Residual	38	141.79	3.73	

* Significant at 0.01.

Table XXXIII. Analysis of variance of the effect of postemergence applications of HOE 29152 and surfactants on velvetleaf control, 1977.

Source of Variation	df	SS	MS	F
Total	59	2496.68		
Treatment	19	1249.58	65.77	2.01*
Replications	2	5.11	2.56	
Residual	38	1241.99	32.68	

* Significant at 0.05.

Table XXXIV. Analysis of variance of the effect of postemergence applications of HOE 29152 and surfactants on velvetleaf vigor, 1977.

Source of Variation	df	SS	MS	F
Total	59	846.85		
Treatment	19	330.11	17.37	1.34
Replications	2	22.36	11.18	
Residual	38	494.38	13.01	

Table XXXV. Analysis of variance of the effect of bentazon alone and in combination with surfactants on fall panicum control, 1977

Source of Variation	df	SS	MS	F
Total	59	1712.85		
Treatment	19	593.60	31.24	1.8
Replications	2	488.53	244.27	
Residual	38	630.72	16.60	

* Significant at 0.05.

Table XXXVI. Analysis of variance of the effect of bentazon alone and in combination with surfactants on fall panicum vigor, 1977

Source of Variation	df	SS	MS	F
Total	59	496.43		
Treatment	19	153.97	8.10	1.1
Replications	2	72.76	36.38	
Residual	38	269.70	7.10	

Table XXXVII. Analysis of variance of the effect of bentazon alone and in combination with surfactants on pigweed control, 1977.

Source of Variation	df	SS	MS	F
Total	59	605.48		
Treatment	19	552.20	29.06	36.33*
Replications	2	22.96	11.48	
Residual	38	30.32	0.80	

* Significant at 0.01.

Table XXXVIII. Analysis of variance of the effect of bentazon alone and in combination with surfactants on pigweed vigor, 1977.

Source of Variation	df	SS	MS	F
Total	59	966.63		
Treatment	19	442.36	23.28	1.74
Replications	2	14.88	7.44	
Residual	38	509.39	13.41	

Table XXXIX. Analysis of variance of the effect of bentazon alone and in combination with surfactants on velvetleaf control, 1977.

Source of Variation	df	SS	MS	F
Total	59	997.07		
Treatment	19	957.38	50.39	48.45*
Replications	2	0.05	0.03	
Residual	38	39.64	1.04	

* Significant at 0.01.

Table XXXX. Analysis of variance of the effect of bentazon alone and in combination with surfactants on velvetleaf vigor, 1977.

Source of Variation	df	SS	MS	F
Total	59	1908.95		
Treatment	19	1384.24	72.85	5.42*
Replications	2	14.37	7.19	
Residual	38	510.34	13.43	

* Significant at 0.01.

Table XXXXI. Analysis of variance of the effect of postemergence applications of HOE 29152 in combination with bentazon and surfactants on fall panicum control, 1977.

Source of Variation	df	SS	MS	F
Total	26	817.33		
Treatment	8	811.66	101.46	298.41*
Replications	2	0.24	0.12	
Residual	16	5.43	0.34	

* Significant at 0.01.

Table XXXXII. Analysis of variance of the effect of postemergence applications of HOE 29152 in combination with bentazon and surfactants on fall panicum vigor, 1977.

Source of Variation	df	SS	MS	F
Total	26	923.11		
Treatment	8	569.50	71.19	3.39*
Replications	2	17.35	8.68	
Residual	16	336.26	21.02	

* Significant at 0.05.

Table XXXXIII. Analysis of variance of the effect of postemergence applications of HOE 29152 in combination with bentazon and surfactants on pigweed control, 1977.

Source of Variation	df	SS	MS	F
Total	26	829.68		
Treatment	8	806.70	100.84	78.78*
Replications	2	2.44	1.22	
Residual	16	20.54	1.28	

* Significant at 0.01.

Table XXXXIV. Analysis of variance of the effect of postemergence applications of HOE 29152 in combination with bentazon and surfactants on pigweed vigor, 1977.

Source of Variation	df	SS	MS	F
Total	26	733.94		
Treatment	8	415.45	51.93	3.22*
Replications	2	60.61	30.31	
Residual	16	257.88	16.12	

* Significant at 0.05.

Table XXXXV. Analysis of variance of the effect of postemergence applications of HOE 29152 in combination with bentazon and surfactants on velvetleaf control, 1977.

Source of Variation	df	SS	MS	F
Total	26	835.24		
Treatment	8	893.29	111.66	192.52*
Replications	2	32.64	16.32	
Residual	16	9.31	0.58	

* Significant at 0.01.

Table XXXXVI. Analysis of variance of the effect of postemergence applications of HOE 29152 in combination with bentazon and surfactants on velvetleaf vigor, 1977.

Source of Variation	df	SS	MS	F
Total	26	1155.42		
Treatment	8	814.39	101.80	5.68*
Replications	2	54.11	27.06	
Residual	16	286.92	17.93	

* Significant at 0.01.

Table XXXXVII. Rainfall records for Soils and Crops Research Center, Adelphia, N.J. for June and July, 1976 and 1977.

June, 1976		July, 1976	
Date	Rainfall (cm)	Date	Rainfall (cm)
1	0.83	3	0.25
2	2.15	7	0.75
6	0.15	8	0.15
17	0.40	16	0.75
21	0.40	23	0.25
28	0.90	29	1.53
30	4.75		
Total	9.58		3.68
June, 1977		July, 1977	
1	0.18	6	0.38
3	0.30	7	0.10
6	1.25	12	4.70
10	5.35	21	0.70
20	1.05	26	0.75
25	0.38		
28	0.88		
Total	9.38		7.63

VITA

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