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# Non-selective herbicide applicators for weed control in no-tillage snap beans

Christopher A. Franklin

To the Graduate Council:

I am submitting herewith a thesis written by Christopher A. Franklin entitled "Non-selective herbicide applicators for weed control in no-tillage snap beans." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biosystems Engineering.

Fred D. Tompkins, Major Professor

We have read this thesis and recommend its acceptance:

Charles Mullins, Larry S. Jeffery

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Christopher A. Franklin entitled "Non-selective Herbicide Applicators for Weed Control in No-tillage Snap Beans." I recommend that it be accepted for the degree of Master of Science, with a major in Agricultural Mechanization.

Fred D. Tompkins

Fred D. Tompkins, Major Professor

We have read this thesis and recommend its acceptance:

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Accepted for the Council:

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NON-SELECTIVE HERBICIDE APPLICATORS FOR WEED

CONTROL IN NO-TILLAGE SNAP BEANS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Christopher A. Franklin

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## DEDICATION

TO:

My wife Brenda for her unbounded patience, understanding and support.

My parents, Mr. and Mrs. M. S. Franklin, and my parents-in-law, Mr. and Mrs. W. H. Shamblin, for their encouragement and support.

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## ABSTRACT

A hooded sprayer and a rope-wick applicator were designed and constructed for application of glyphosate or paraquat in the row middles of no-tillage snap beans. The objectives of the study were to design and construct the applicators and to evaluate their effectiveness for interrow weed control.

Rows of snap beans received chemical treatment in two parts. Treatments were either preemergence banded or preemergence broadcast with a dinoseb and pendimethalin tank mix immediately after planting. Approximately five weeks later, the row middles received an application of either paraquat or glyphosate from one of the interrow applicators.

Weed data were collected from the drill (number and species per 6 linear feet) and in the row middles (number and species per 4 square feet). Treatment means and specific treatment contrasts were determined from the data.

The results showed that a one-time preemergence application of a dinoseb + pendimethalin tank mix did not provide adequate weed control throughout the entire growing season. Both interrow applicators were effective for controlling weeds in the row middles of plots treated with the tank mix. However, the hooded applicator provided better control of interrow weeds than the rope-wick applicator. Findings also indicated no difference in the effectiveness of glyphosate and paraquat, applied by the hooded sprayer, for weed control in the row middle.

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# CHAPTER I

# INTRODUCTION

## I. BACKGROUND AND PROBLEM DEFINITION

Spiralling energy costs and strong concerns in the area of soil conservation have demanded a closer examination of minimum and no-tillage practices in Tennessee. Minimum tillage, as defined by Lessiter (1980), is limited tillage, but where the total field surface is still worked by tillage equipment such as disk, chisel plow, or field cultivator. In comparison, no-tillage involves the preparation of soil in immediate proximity to the site of seed deposition. This is normally accomplished with the use of a chisel or coulter preceding the planter unit.

According to a 1979 survey by the Soil Conservation Service, total no-till acreage in Tennessee was 257,000 acres compared to 2,424,000 conventionally tilled and 666,000 minimum tilled acres. Unsurprisingly, 1980 projections for the state call for a 21 percent increase in no-till acreage, a 16 percent increase in minimum tilled land, and a 6 percent reduction in conventionally tilled ground (Lessiter, 1980).

Although no-tillage is most commonly practiced in production of corn, soybeans, and small grains (Lessiter, 1980), there is reason to believe that other crops might also perform adequately under no-tillage conditions. According to the American Vegetable Grower (1975), crops with short growing seasons are well suited for reduced tillage. Snap beans (Phaseolus vulgaris L.), an important vegetable crop to Tennessee producers, is one such crop. Grown on 17,000 acres in 1978 at an estimated value of about 6 million dollars (USDA, 1979), the crop has a growing season of 50 to 60 days. Such a short growing period suggests that snap beans could be practically produced under conditions of reduced tillage.

Upon this premise, Tompkins et al. (1976) investigated the feasibility of no-tillage snap beans. The research, performed at The University of Tennessee Plateau Experiment Station near Crossville, indicated that adequate plant populations were obtained by planting the no-tillage snap beans in small grain stubble. Unfortunately, the potential savings as a result of no-tillage snap bean production were only partially realized. Competitive weed species offered substantial resistance to the success of the system. The weeds not only competed with the comparatively weak-rooted beans for available light, water, and nutrients, but also appeared as a hinderance in the mechanical harvesting of the product (Tompkins et al., 1979). In response to the poor weed control obtained in the no-tillage snap beans and the total lack of an effective, postemergence herbicide for selective weed control, a study involving the postemergence application of non-selective herbicides was initiated.

## II. OBJECTIVES

The purpose of this study was to investigate the effectiveness of two chemical applicators for interrow weed control in snap beans planted in wheat stubble. The applicators evaluated were a proto-type hooded sprayer and a rope-wick applicator. The non-selective herbicides used in conjunction with the applicators were glyphosate and paraquat.

Specifically, the objectives of the study were:

1. Design and construct the applicators.
2. Evaluate the applicators for effectiveness of interrow weed control.

# CHAPTER II

# REVIEW OF LITERATURE

## I. NO-TILLAGE SNAP BEANS

### Advantages

An easily recognized benefit attributed to the practice of no-tillage farming is the reduction in soil losses due to wind and water erosion (Phillips and Young, 1973). In addition to the conservation of soil, reduction of soil losses from erosion will aid farmers in their effort to meet the clean water requirements of federal mandate PL 92-500 (Solutions, 1980).

Gallaher (1978) concluded that the surface organic material, produced as a result of no-tillage farming, was a positive factor for plant growth. The surface material conserves soil water from reduced water runoff and increased water infiltration (Jones *et al.*, 1969). The residue also serves to favorably control soil temperatures until the plant canopy is established. In the daytime it prevents some sunlight from reaching the soil; thus, a cooler daytime temperature is realized. At night, the residue serves as an insulator to reduce the loss of heat (Phillips and Young, 1973). The reduced consumption of fossil energy required for no-tillage production is an advantage of increasing importance. An Iowa State University study noted that a 320-acre Iowa farm with a 60:40 corn to soybean ratio used approximately 3,000 gallons of diesel fuel to plant and harvest the crop with conventional tillage. Further analysis performed by the University indicated that a total switch to no-tillage practices would reduce actual implement fuel requirement by as much as 1/3 (Vincent, 1980).

The practice of no-tillage farming helps to reduce soil compaction, labor costs, and machinery investments. An increased use of land and time may also be derived from the practice (Phillips and Young, 1973).

## Disadvantages

The apparent drawback of no-tillage farming is weed control. Weed control in no-tillage crops is totally dependent on availability and proper use of suitable herbicides. Efficient herbicides are not available for some of the crops grown under no-tillage conditions, and presently, there are no effective, non-selective, postemergence applied herbicides labeled for use in snap beans (Tompkins *et al*., 1979).

## History

The inception of no-tillage snap beans by Tompkins *et al*. (1976) developed from the belief that weed pressure would not be unduly severe in the crop since the growing season was 60 days or less. Tompkins' research, conducted at The University of Tennessee Plateau Experiment Station near Crossville, compared conventionally tilled snap beans with no-tillage snap beans. The conventional plots were turned with a moldboard plow, disked, and stirred with a power harrow. The no-tillage plots were planted in wheat stubble with a no-till planter unit. The unit was equipped with a fluted coulter for seed zone preparation. After planting, paraquat was applied at the rate of 0.5 pounds active ingredient per acre. The plots also received dinoseb broadcast at a rate of 2.0 pounds active ingredient per acre when the beans reached the cracking stage. Results from the work of Tompkins et al. (1976) indicated that pod quality, pod yields, and plant stands were not significantly different ($\alpha \leq 0.05$) for the two systems. The implication was that no-tillage snap bean production was feasible. However, continued problems with weed control caused further investigation to be initiated.

Herbicides typically used in conventionally tilled snap beans were impractical for no-tillage since they required incorporation. In 1978, Mullins and Swingle demonstrated that several preemergence herbicides normally used in corn also showed promise for control of weeds in conventionally tilled snap beans.

Unaware of what effect surface organic material would have on the activity of these herbicides, Tompkins et al. (1979) conducted follow-up research at the Plateau Experiment Station. Tests were performed to evaluate the effectiveness of dinoseb, metolachlor, and pendimethalin with varying degrees of seedbed preparation. Findings indicated that dinoseb mixed with either metolachlor, pendimethalin, or both, controlled weeds quite well in the conventionally tilled beans, but noticeably less in the no-tillage plots.

The effectiveness of the chemical combinations on the most prominent weed species, large crabgrass (Digitaria sanguinalis (L.) Scop.), giant foxtail (Setaria faberii Herrm.), fall panicum

(Panicum dichotomiflorum Michx.), common ragweed (Ambrosia artemisiifolia L.), and redroot pigweed (Amaranthus retroflexus L.) was unaffected by the method of seedbed preparation. However, yields in the no-till treatments were significantly lower than those in the conventional plots. The yield reduction was attributed to poor overall weed control in the no-tillage plots (Tompkins et al., 1979).

## II. HERBICIDE APPLICATION EQUIPMENT AND TECHNIQUES

### Techniques and Terminology

Prior to all herbicide applications, equipment should be inspected, repaired if necessary, and calibrated. After the appropriate herbicide has been obtained, the label should be studied carefully to insure proper use and avoid possible damage associated with incorrect use or handling. The label gives all the pertinent application information including application rates, approved crop use, and the time and method of application (Weekman, 1976).

Application rate, as defined in ASAE standard S327 (Agricultural Engineers Yearbook, 1980), is the amount of material applied per unit treated; it is typically given in gallons per acre (GPA), and should not be confused with the active chemical rate (lb. AI/A). Expressed in terms of mass per unit area, the active chemical rate is the amount of active ingredient applied per unit treated. In most cases, the proper application rate, imperative for effective weed control, can be changed by altering any of the following hydraulic sprayer parameters: nozzle spacing, nozzle size, pressure, and field speed (Phillips and Young, 1973).

The time and method of application is another important factor in obtaining adequate weed control. Anderson (1977) listed five basic methods of application; they are postemergence, preemergence, preemergence incorporated, preplant, and preplant incorporated. Postemergence refers to the application of a herbicide after the emergence of the specified weed or planted crop. Preemergence is described as an application prior to emergence of the specified weed or crop. A preemergence incorporated herbicide is one requiring incorporation into the soil above the planted seed. A surface application made prior to planting is termed a preplant application, and the same procedure followed with incorporation constitutes a preplant soil incorporated application.

Other relevant terms of application defined in ASAE standard S327 (Agricultural Engineers Yearbook, 1980) are band applications, broadcast applications, directed applications, and foliar applications. A broadcast application is the application of a chemical over the entire area to be treated. In comparison, a band application is the distribution of spray in parallel bands (12 - 14 inches wide) leaving an untreated area between the bands. Directed applications are those made to specific areas such as a row, bed, or plant base. An application made on plant leaves and stem is termed a foliar application.

Boom Sprayer

As described in ASAE standard S327 (Agricultural Engineers Yearbook, 1980), the boom sprayer is an apparatus consisting of a tank, pump, control valve components, and a boom with atomizers for the purpose of providing uniform liquid coverage to an area. The tank serves as a reservoir for the herbicide mixture. The pump, either operated off a PTO shaft or hydraulic motor, is responsible for moving the mixture from the tank to the atomizers along the boom. The control components (pressure regulators, gate valves, ball valves, and other plumbing fixtures) control and direct fluid flow through the system. The boom of the applicator is basically a structural component for supporting the atomizers and fluid conduit supplying them. Phillips and Young (1973) list flat fan and even spray nozzles as the two most commonly used in herbicide applications. Flat fan nozzles are used for broadcast applications, and even spray nozzles for band applications.

In no-tillage this particular sprayer is generally used for the broadcast application of a non-selective hebicide to kill existing vegetation prior to crop emergence. The boom sprayer is also used for the broadcast or directed application of selective herbicides after crop emergence.

## Wipe Applicators

Wipe applicators emerged in response to the development of a highly active systemic herbicide, glyphosate (Dale, 1978). The basic objective of all wipe applicators is to apply a systemic herbicide to weeds while avoiding any contact with the crop. One of the more simple applicators designed to accomplish this task is the rope-wick applicator (RWA).

Although the rope-wick applicator as it is known today was conceived in 1976 and first assembled in 1977, the basic idea had been present for a long while (Dale, 1978). Dr. Chester McWhorter, USDA weed researcher in Stoneville, Mississippi, recalled the 1950's practice of wrapping burlap sacks on a spray boom to wipe apply 2,4-D to weeds growing above the crop canopy. The risk of injury was high, of course, since the burlap sacks were very porous and the mixture sometimes dripped on the crop (Progressive Farmer, 1980).

The construction and operation of the rope-wick applicator is inexpensive and simple. Dale (1979) lists the two essential parts of the applicator as being a reservoir-boom and soft nylon rope. The reservoir-boom has been constructed with a variety of inert materials, but Poly-Vinyl Chloride (PVC) pipe is most commonly used.

Marine-type nylon rope is cut and fitted into holes that have been drilled into the reservoir-boom. The rope functions as a wick absorbing the chemical mixture from the boom by means of gravity and capillary action. Doughnut-shaped rubber grommets with a groove around the outside circumference are slipped onto the ropes and into the holes in the reservoir to help prevent seepage. A strong, inert, and leak-proof sealant is then applied to hold the essential components together (Dale, 1978).

The proper type and diameter of rope is necessary to insure sufficient flow throughout the system. John Arvik of Monsanto suggests Sears 1/2-inch nylon rope for reasons of effectiveness and accessibility (Progressive Farmer, 1980). The sealant holding the rope to the grommet or reservoir wall is another important flow determinant to consider.

Research performed by Dale (1979) demonstrated that the volume of herbicide (1:2, glyphosate:water) moved through wicks cemented with silicone cement was 40 percent greater than with wicks not sealed and those sealed with vinyl cement. Vinyl cement did, however, provide the strongest bond.

Dale (1978) lists several advantages of the rope-wick applicator over applicators designed to accomplish the same task. In addition to being mechanically simple and functionally effective, the rope-wick applicator is environmentally safe. The applicator applies chemical directly to the weed and eliminates the possibility of drift and contamination of non-target surfaces. Finally, the amount of chemical used on a per acre basis is substantially smaller than that used in many of the other application systems.

The roller-type applicator is another form of wipe system being used for the application of non-selective herbicides to weeds growing above the crop canopy. This applicator basically consists of a carpet-covered aluminum cylinder supported by a metal framework (Koehler et al., 1980). Herbicide is applied to the carpet of the rotating cylinder via a steel tube mounted above the roller. Proper application rates are maintained by means of an electronic moisture sensor. The sensor uses pairs of electrodes which ride on the carpet, a solenoid spray valve for controlling the application of the herbicide solution to the roller, and a control box for setting the desired moisture level. Koehler et al. (1980) explained that when the carpet became too dry, the electrical conductivity between the electrodes was lowered. This response was interpreted by the control box which opened the solenoid valve and allowed herbicide solution to be sprayed onto the carpet until the desired moisture level was reached again. Lang and Furrer (1980) found the roller to be 75 percent effective in controlling volunteer corn in no-tillage soybeans. Furrer (1980) found the same type roller applicator to be 83 percent effective for controlling weeds in no-tillage soybeans.

The Stoneville wiper developed by Chandler (1979) also used a carpet surface to wipe on herbicide. The unit consists of a molded fiberglass housing, a spray nozzle, and a pad of shag carpet. The carpet was attached face down over the lower part of the housing, and a cone nozzle was mounted in the housing to supply herbicide to the back of the carpet. Chandler (1979) showed that excellent perennial weed control could be obtained by using a systemic herbicide. This applicator, designed to make interrow band applications, provided a means of applying non-selective herbicides very close to the crop without risk of injury.

Welker (1978) reported the development of a wipe applicator designed for use in cranberry bogs. It employed the use of sponges glued around the circumference of a belt. The belt with the sponge attached passed around a pulley system and through a reservoir of herbicide. The excess solution was squeezed out of the sponge by a variable position press wheel. The wiper and a 1/2-horsepower, air-cooled engine were mounted on a frame supported by two bicycle wheels. The engine provided locomotion for the wiper and the frame. Using glyphosate, Welker (1978) obtained excellent control of tall weeds growing in the bog and observed no visible injury to the cranberry vines.

Recirculating Sprayers

The recirculating sprayer (RCS) concept was conceived in 1964 by Dr. Chester McWhorter of the USDA Agricultural Research Service in Stoneville, Mississippi. Designed to apply non-selective herbicides on weeds taller than row crops, the recirculating sprayer also recovered and recycled any spray solution not deposited on the target weeds. Initially, acceptance of this concept was poor since few suitable herbicides existed. Derting (1980) recognized the development of glyphosate as the reason for renewed interest in the applicator.

Recirculating sprayers typically apply straight streams of solution horizontally over the crop. Mounted opposite of the nozzles are baffled catch boxes constructed to collect any herbicide not intercepted by the weeds. After the herbicide mixture is collected in the catch boxes, it is either recycled through the nozzles or returned to the supply tank (Supak and Abernathy, 1977). Weed control has been very good with the recirculating sprayer, but splattering from the recovery process has caused noticeable crop damage (Lang and Furrer, 1980).

The wet apron, or canvas applicator, is a unit that employs both the wipe concept and the recirculating concept. The applicator consists of a catch box faced with a tightly stretched canvas. Nozzles mounted in the catch box saturate the canvas while runoff is continuously being recycled. The unit moves through the field applying herbicide much like a rope-wick applicator (Furrer, 1980).

## Hooded Sprayers

Hooded sprayers, or shielded sprayers, are designed to apply herbicides to interrow weeds growing below the crop canopy (Progressive Farmer, 1980). Jordan and Reames (1977) developed a hooded sprayer to control bermudagrass growing in cotton. The applicator had three hooded units connected to a skid frame by spring loaded swivel collars. The swivel collars provided both lateral and vertical flexibility to the units. Spray nozzles were mounted on metal rods attached to the inside riding edges of the hood. Other metal rods were positioned under the nozzles to hold weeds down and prevent spray pattern obstruction of the even spray nozzles. Fenders were mounted on the skid frame in front of each hooded unit to lift and guide the lower branches of the cotton plant. Results obtained by Jordan and Reames (1977) indicated that the hooded sprayer could be used to successfully control bermudagrass and many other weed species without injuring the cotton.

Another design similar to Jordan and Reames' (1977) was that of Williford and Barrentine (1977). Instead of using metal rods to prevent interference of the weeds with the spray pattern, they used metal rollers to push the weeds to the ground before spraying.

No-till Farmer (1978) presents yet another simple and effective variation of the hooded sprayer. The applicator uses long sheet metal housings affixed to the boom to cover the crop while interrows are banded with herbicide. Successfully used in no-tillage soybeans, this particular unit differs from the others in that it covers the untreated area and not the treated.

# III. HERBICIDES

Several herbicides are labeled and recommended by The University of Tennessee Agricultural Extension Service for use in conventionally tilled snap beans (see Table I). The herbicides used in this study and discussed in this section are dinoseb (2-sec-butyl-4,6-dinitrophenol), pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitroaniline], paraquat (1,1'-dimethyl-4,4'bipyridinuim dichloride), and glyphosate [N-(phosphonomethyl)glycine]. Glyphosate has received recent approval for preemergence use in snap beans, but paraquat and pendimethalin are not presently labeled for such use (Berg, 1980).

## Paraquat

Paraquat (Paraquat) is one of the bipyridiluim herbicides. Paraquat is a non-selective, non-residual herbicide and crop dessicant primarily used for the postemergence control of terrestrial plants (Anderson, 1977).

Paraquat kills living plant cell tissue upon contact. Once on the plant surface, paraquat is readily absorbed by plant cells where it will penetrate into the chloroplasts. In the chloroplasts, the herbicide functions as an electron acceptor acting in competition with natural acceptors present during photosynthesis. Interference with electron flow during the process of photosynthesis causes the rapid reduction and reoxidation of catalytic amounts of paraquat in the chloroplast. These reduction-reoxidation reactions are responsible for the continuous generation of hydrogen peroxide. The hydrogen peroxide

TABLE I

RECOMMENDED HERBICIDES FOR SNAP BEANS IN TENNESSEE*

| Chemical | Active Ingredient (lbs/acre) | Formulation Per Acre | Time of Application |
|---|---|---|---|
| EPTC (Eptam 7E) | 2 - 3 | 1-3/4 - 2-2/3 pts. | PPI |
| Dinoseb (Premerge 3) | 4 - 5 | 5-1/2 - 7-2/3 pts. | At, or shortly after planting |
| Trifluralin (Treflan 4EC) | 0.5 - 0.75 | 1 - 1-1/2 pts. | PPI |
| Trifluralin (Treflan 4EC) + EPTC (Eptam 7E) | 0.5 - 0.75 + 2 - 3 | 1 - 1-1/2 pts. + 3/4 - 2-2/3 pts. | PPI, up to 2 days before planting |
| Bentazon (Basagran) | 0.75 - 1 | 3/4 - 1 qts. | Early post |
| Profluralin (Tolban 4E) | 0.75 - 1 | 1-1/2 - 2 pts. | PPI |

*1979 Chemical weed control in fruits and vegetables (University of Tennessee Agricultural Extension and Experiment Station Staffs).

is considered to be the agent causing phytotoxicity in the plant (Anderson, 1977).

Although the herbicidal effect of paraquat is exerted much more rapidly in light, it will also cause death to plants in the dark. The action is believed to be in response to electron exchanges made during plant respiration (Kearney and Kaufman, 1976).

Paraquat is not metabolically degraded in plants, but it does undergo some photochemical degradation on the plant surface. The chemical is completely inactivated upon contact with the soil due to rapid absorption by soil colloids. Crop selectivity with paraquat can be achieved with applicators designed to prevent herbicide contact with the crop or by directed applications of the herbicide (Anderson, 1977).

Glyphosate

Glyphosate (Roundup) is a non-selective, systemic herbicide readily translocated throughout aerial and underground plant parts (Anderson, 1977). The herbicide was heralded as one of the most outstanding technical product achievements in the last decade (Probst, 1978).

Shaner and Lyon (1980) acknowledged that a close relationship existed between aromatic amino acids and the mode of action for glyphosate. However, the relationship and its inhibitory effect on plant transpiration have not been fully explained.

Duke and Hoagland (1978) speculated that increased levels of phenols were responsible for inhibited growth and eventual death to plants treated with glyphosate. Sprankle et al. (1975) suggested that glyphosate affected transpiration indirectly by inhibiting metabolic processes such as photosynthesis, respiration, and protein synthesis. Shaner and Lyon (1980) proposed that glyphosate affected the rate of protein synthesis by limiting the availability of phenylalanine and tryosine for incorporation into proteins.

Non-selectivity and a lack of residual activity have made glyphosate a popular herbicide for numerous preplant and post-harvest uses. Recent sprayer developments have made it an applicable post-emergence herbicide as well. Selectivity has been accomplished by directed or shielded applications whereby the herbicide is prevented from contacting the foliage or green stems of the desired plant (Probst, 1978).

Dinoseb

Dinoseb (Premerge 3) is a member of the phenol herbicide family. Phenol herbicides are contact toxicants used primarily for the control of broadleaved seedlings. Although they are usually applied as foliar treatments, they do have preemergence and residual activity when applied to soil surfaces (Anderson, 1977).

Anderson (1977) cites two possible modes of action for this herbicide. When phytotoxicity is rapid, the cell membranes of treated plant tissues are destroyed and leakage of cellular contents result in desiccation of the plant. If phytotoxicity is less rapid, toxic action results in the prevention of ATP formation from inorganic phosphorus by oxidative phosphorylation.

Dinoseb is highly toxic to man and animals when ingested or excessively inhaled, but residues of the chemical on foliage pose no hazard to livestock (Kearney and Kaufman, 1976). Chemical degradation of dinoseb in the soil is usually completed by microbial activity in a two-to-four-week time period. Even though dinoseb is non-selective, crop selection can be obtained by applying the herbicide early post-emergence to weeds prior to crop emergence (Anderson, 1977).

Pendimethalin

Pendimethalin (Prowl) is a member of the dinitroaniline herbicide family. This family of herbicides is principally used for preemergence control of annual grasses and broadleaved weeks. However, seedling grasses are generally more susceptible to pendimethalin than are seedling broadleaved plant species (Anderson, 1977).

The dinitroaniline herbicides, absorbed by seedling roots and shoots, are considered to be more effective for weed control when they are incorporated into the upper soil layer where weed seeds germinate. Seed of tolerant crop plants will germinate in soil in which the dinitroaniline herbicides have been incorporated. However, root development of these crop plants is usually adversely affected when these herbicides are present in their root zones (Anderson, 1977).

According to Kearney and Kaufman (1976), dinitroaniline herbicides exert their herbicidal effect by inhibiting both root and shoot growth, Anderson (1977) concluded that the chemical inhibits growth by interfering with mitotic cell division and adversely influencing the development of cell walls and membranes.

# IV. WEEDS

A great many weed species thrive under the favorable climatic conditions found on the Cumberland Plateau and over 30 species were observed in this study. Only the four most prominent weed species present prior to planting (redroot pigweed, yellow nutsedge (Cyperus esculentus L.), large crabgrass, and common ragweed) will be reviewed in this section.

## Redroot Pigweed

Redroot pigweed is a broadleaved summer annual that reproduces by seeds. The shallow, red taproot of this species serves as a distinguishing characteristic for the purpose of identification. Pigweed stems are erect and their long petioled leaves are rhombic-ovate shaped and a dull green.

Redroot pigweed is commonly found in cultivated fields, yards, fence rows, and wastelands. A troublesome, semi-cosmopolitan weed, it sometimes accumulates excess nitrates and becomes poisonous to cattle. Native to tropical america, redroot pigweed is found throughout the United States (USDA, 1971). On a world-wide basis it is considered to be a major weed in both corn and sugar beets (Holm et al., 1977).

## Common Ragweed

Common ragweed is a shallow-rooted summer annual that reproduces by seed. Common ragweed has hairy, erect stems that support both male and female reproductive structures. The male flowers at the tips of the branches while the female flowers are borne at the bases of leaves and in forks of upper branches. The plant produces an abundant source of pollen which proves injurious to hay fever sufferers each year (USDA, 1971).

Common ragweed has multi-lobed leaves that normally grow in an alternate pattern along the plant stem. Found widespread throughout the United States, ragweed inhabits old pastures, wastelands, roadsides, vacant lots, stubble fields, and cultivated fields. The weed is a native species of North America (USDA, 1971).

Large Crabgrass

Large crabgrass is an annual grass that reproduces by seed, and by branching and spreading. The culms grow prostrate, rooting at the nodes, while the flowering shoots ascend. Leaf blades are 5 to 15 centimeters long, 5 to 10 centimeters wide, and nearly always hairy. The plant houses its seeds in 3 to 13 fingerlike segments arranged in a whorled pattern (USDA, 1971).

Normally an annual, crabgrass will sometimes exhibit perennial growth by rooting at the nodes and forming mats in moist soil. A single plant has been observed to produce as many as 700 tillers and 150,000 seeds during one growing season (Holm et al., 1977).

Anderson (1977) listed the weed as one of the 18 most serious species in the world of agriculture. Recognized in the United States as a prominent weed in corn, peanuts, and soybeans, crabgrass is also considered a major problem in lawns (Holm et al., 1977). Crabgrass, a native of Europe, is found throughout most of the United States (USDA, 1971).

Yellow Nutsedge

Yellow nutsedge, a perennial reproducing by seeds and weak thread-like stolons, is also considered to be one of the 18 most serious weeds in world agriculture (Anderson, 1977). Yellow nutsedge, or nutgrass, is a light green sedge with three-sided culms. Swelling of the culm below the soil surface forms a basal bulb where stolons grow out and terminate in single undergound tubers called nuts. One tuber of this prolific weed notably produced 1,900 plants, almost 7,000 tubers and covered an area about 2 meters in diameter within one year (Holm *et al.*, 1977).

Yellow nutsedge is found in rich or sandy soil on low ground, moist fields, river banks, and roadsides (USDA, 1971). Holm *et al.* (1977) recognized yellow nutsedge in the United States as a serious weed in both corn and soybeans. The weed is a native of North America and a common species found throughout most of the United States (USDA, 1971).

# CHAPTER III

# DESCRIPTION OF APPLICATORS

A hooded sprayer and a rope-wick applicator were designed and constructed for the application of non-selective herbicides in the row middles of no-till snap beans. Both dispensing units mounted interchangeably on the main frame of the sprayer.

## I. HOODED SPRAYER

The hooded sprayer and supporting framework were fabricated in The University of Tennessee Agricultural Engineering Research Shop during the spring and summer of 1979 (see Figure 1). The welded frame supported a saddle-mounted, 25-gallon, poly-vinyl tank. Also attached to the frame was a pin-jointed, four-bar linkage onto which the hood (shield for nozzle output) was connected. The four-bar linkage allowed the hood to float vertically, thus maintaining contact with the ground at all times and minimizing the escape of any herbicide which might contact non-target plants.

The light gauged metal hood, resembling a prism with a flattened top, was approximately 30 inches in width, 10 inches in height, and 12 inches in length. The hood was equipped with skids to provide ground contact and protection for the dispensing unit as it was towed through the field. The hood housed three, 8002 flat fan nozzles equally spaced along its top. The nozzles were mounted at a height to insure sufficient overlap of the spraying pattern for uniform coverage. A metal rod was

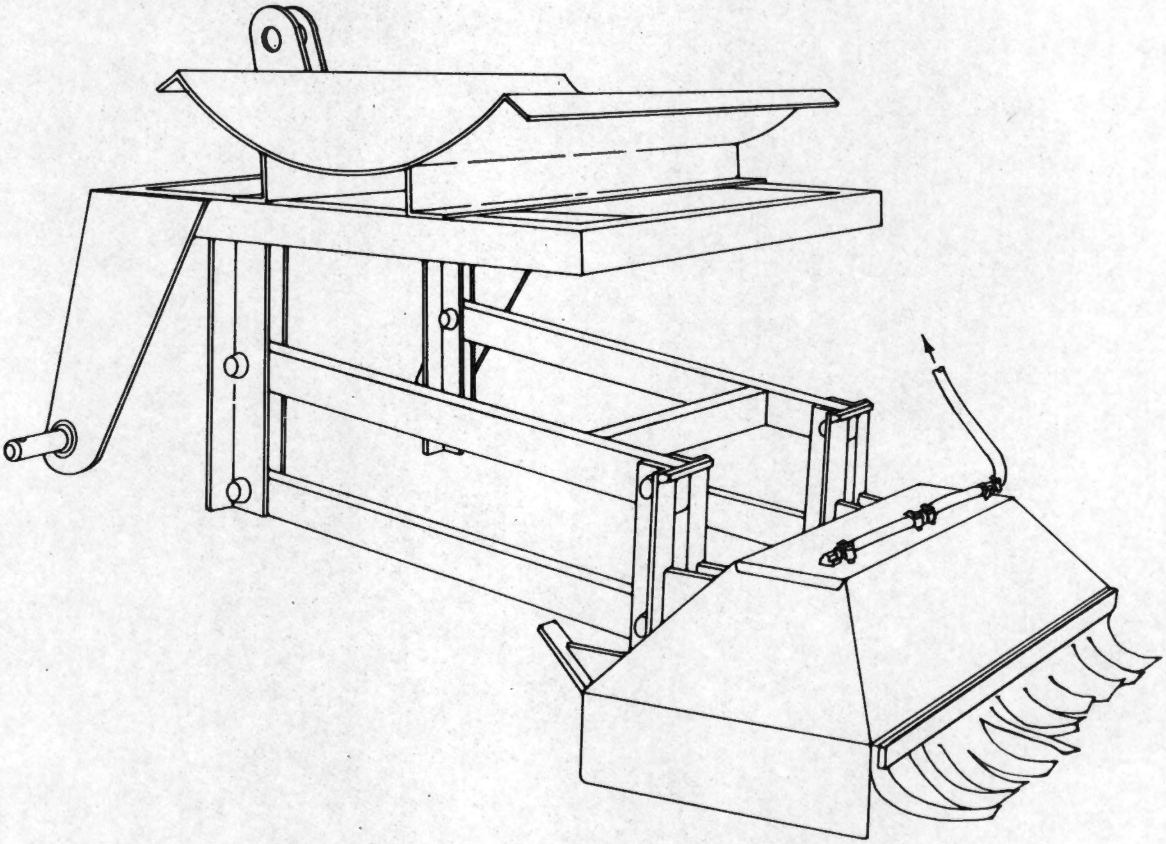

**Figure 1. The hooded sprayer and supporting framework used to apply glyphosate or paraquat to weeds growing in row middles of no-tillage snap beans in 1979 and 1980 plantings.**

positioned below the nozzles to hold down weeds that would have otherwise interferred with the spray pattern. Small canvas strips were then affixed to the back of the hood to prevent herbicide mist from escaping in the rear.

The entire unit mounted on the category I, three-point hitch of a John Deere 1020 tractor. The PTO driven, model-N6500, Hypro roller pump supplied fluid to the three nozzles. Control components and a plumbing schematic are shown in Figure 2.

## II. ROPE-WICK APPLICATOR

A rope-wick applicator composed of a PVC reservoir-boom and 1/2-inch soft nylon rope was constructed in The University of Tennessee Agricultural Engineering Research Shop during the spring of 1980. Basic guidelines for assembly of the rope-wick applicator were taken from the work of Dale (1978).

The reservoir-boom (wick assembly) was clamped along a length of angle iron that had been welded perpendicularly to two skid runners aligned parallel to the direction of travel (see Figure 3). These runners were attached to the four-bar linkage which extends down from the main framework. Thus, only four pins had to be removed and reinstalled to exchange the hooded dispensing unit with the rope-wick dispensing unit.

The rope-wick applicator reservoir-boom was constructed from a 30-inch length of 3-inch diameter PVC pipe. The ends of the pipe were fitted with caps and glued with PVC cement. A threaded fitting and cap were inserted into the pipe to provide an orifice for chemical

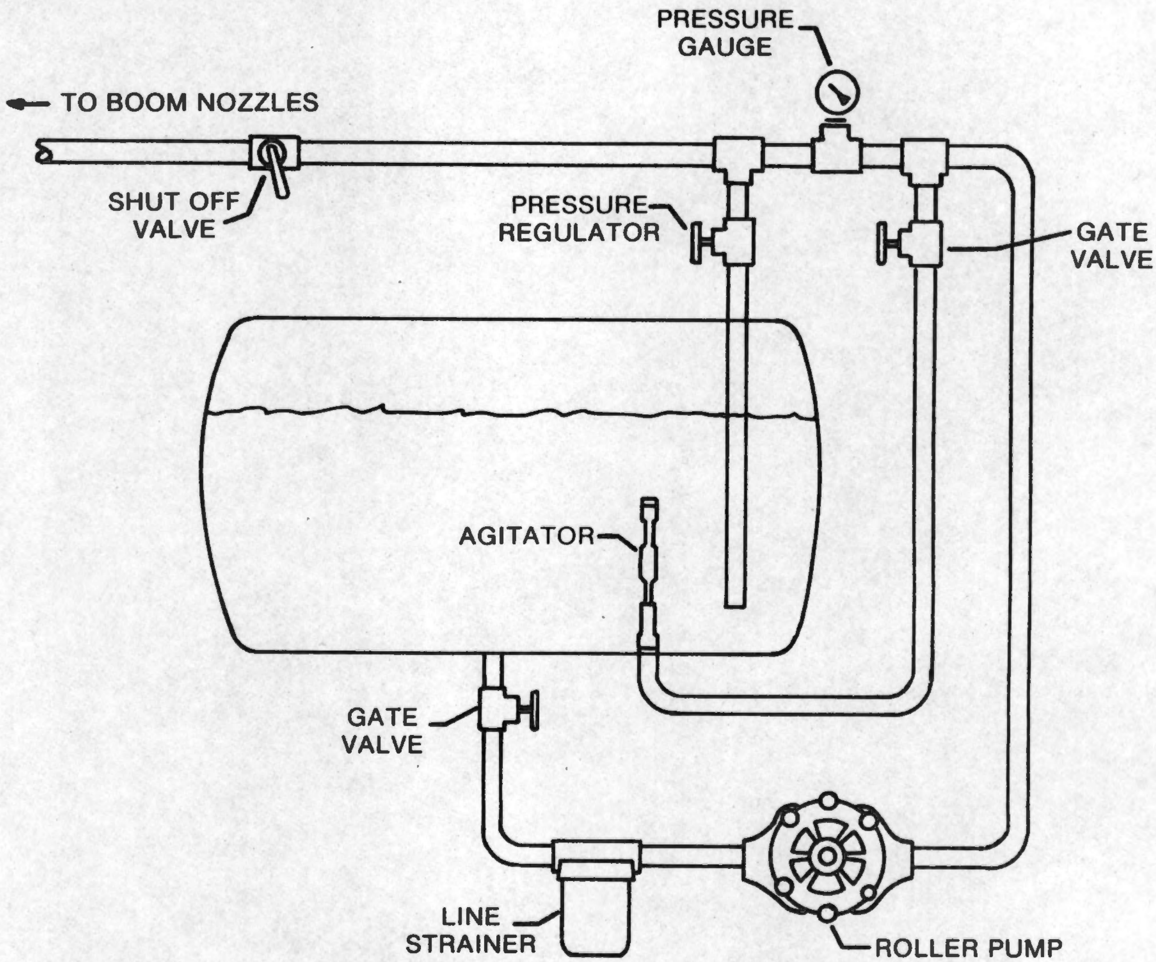


Figure 2. Plumbing schematic of the sprayer used to supply non-selective herbicides to the hooded dispensing unit for the control of interrow weeds in no-tillage snap beans.

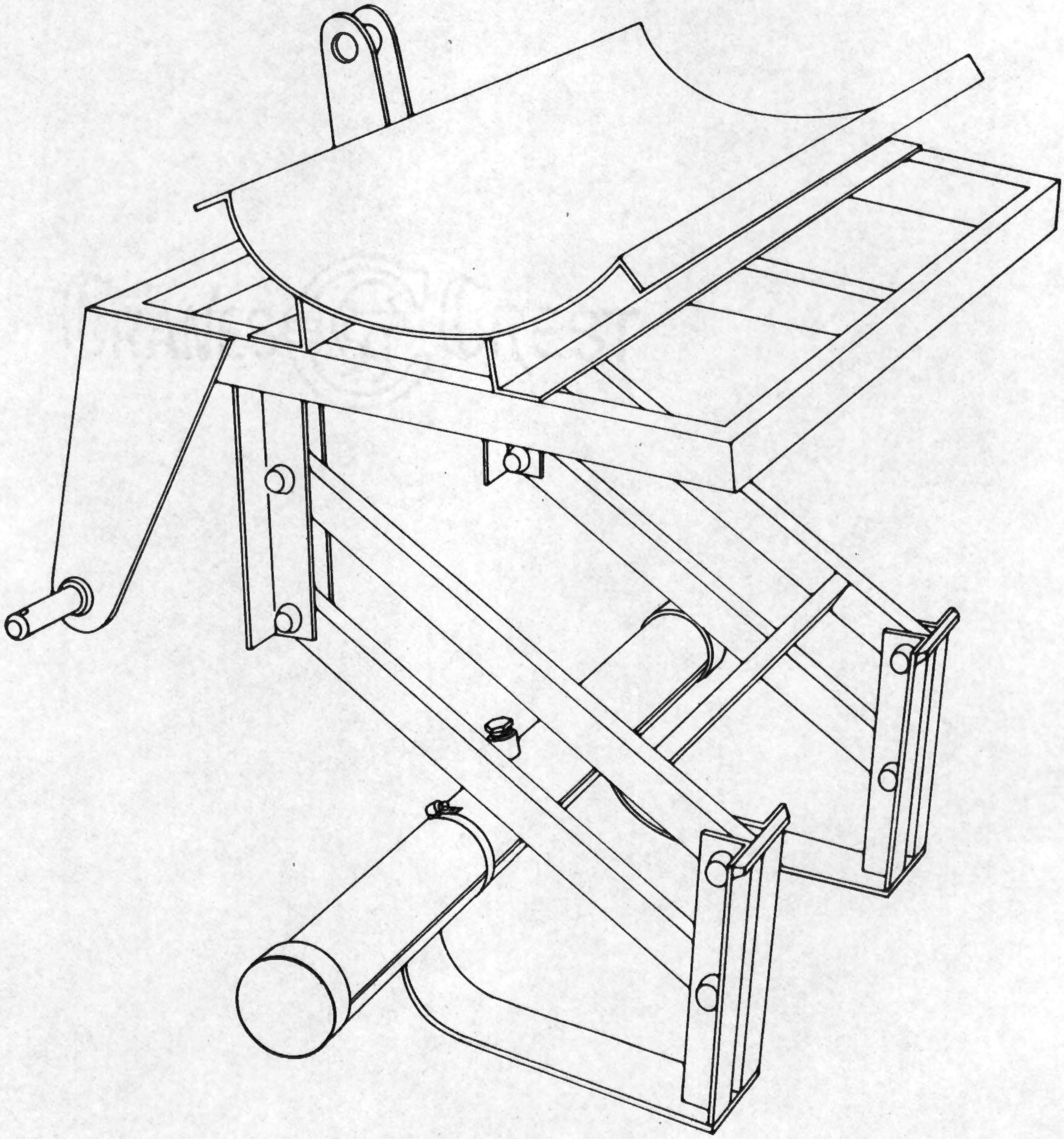

Figure 3. Rope-wick dispensing unit used to apply glyphosate to weeds growing in row middles of no-tillage snap beans in 1980 plantings.

formulation input and removal. A series of holes were drilled and fitted with rubber grommets measuring 1/2 inch in diameter on the inside and 1 and 1/32 inches diameter on the outside. Eleven-inch lengths of soft nylon rope were forced through the grommets and into the PVC pipe reservoir such that 8 inches of the rope were left exposed on the outer surface (see Figure 4). The reservoir-boom physically mounted on the skid frame such that only weeds measuring 4 inches and greater in height were treated.

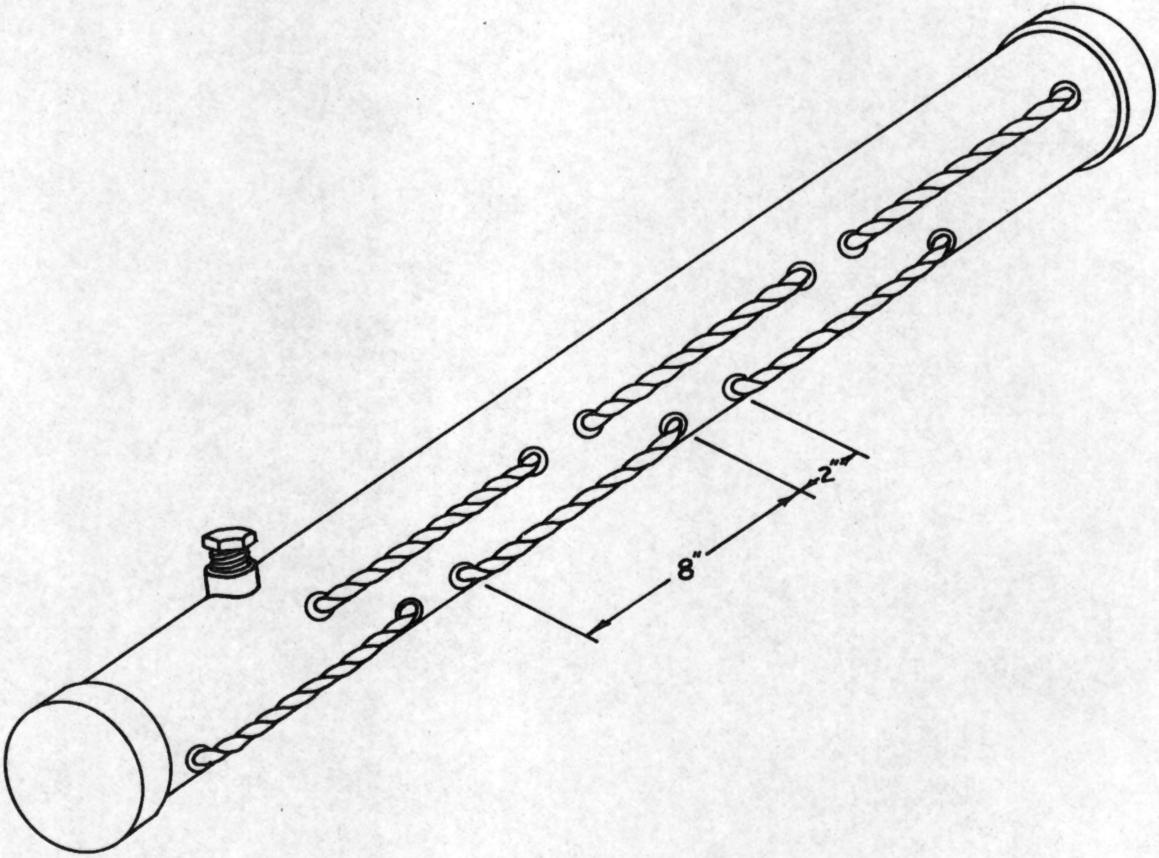


Figure 4. Poly-vinyl chloride (PVC) reservoir-boom of the rope-wich applicator used to apply glyphosate to weeds growing in row middles of no-tillage snap beans in 1980 plantings.

# CHAPTER IV

## EXPERIMENTAL METHODS AND PROCEDURE

### I. EXPERIMENTAL DESIGN

The experimental design used for this study was a randomized complete block with nesting. Nine treatments were to be replicated four times on three different planting dates for a period of two years. The full design was utilized in 1980, but a modified version was necessary for the 1979 plantings (construction of the rope-wick applicator was not completed in time for testing that year). The modified design included five treatments replicated four times on three different planting dates. All treatments were basically composed of a preemergence treatment and an application of either paraquat or glyphosate from one of the two interrow applicators. The treatments will be described in specific terms under the section on treatment application.

Weed population data, number per unit area in the row middle and number per unit length in the drill, were taken from each of the treatments and summed according to weed species. The different weed species were considered to be the dependent variables while planting date, replications within planting date, and treatments were considered to be independent. Treatments and planting dates were considered fixed effects in the design while replications were considered random.

Analyses of variance were calculated on each weed species for the entire year, then for each species within each planting date during the year. Analyses of variance were obtained through Statistical Analysis System (SAS79) available at The University of Tennessee Computing Center.

## II. PLOT PREPARATION

Field research was conducted during the summers of 1979 and 1980 at The University of Tennessee Plateau Experiment Station near Crossville, Tennessee. All plantings consisted of 4 replications separated by 15-foot alley ways. The replications included 9 experimental units, each consisting of 4 rows, 20 feet long and 38 inches apart.

The plots, measuring 125 feet by 126 feet 8 inches, were disked each fall and seeded to obtain a thick stand of winter wheat. In the spring, the cover crop was clipped with a rotary mower and sprayed with paraquat to kill existing vegetation. The paraquat was broadcast applied at the rate of 1 pound active ingredient per acre in 40 gallons of solution. Planting typically followed this application by three days to a week.

All plantings were made on Hartsells sandy loam soil with an Allis-Chalmers no-till planter (300 series). The two-row unit, equipped with fluted coulters for seed zone preparation, seeded the crop at a rate of 8 to 12 beans per foot of row. The snap bean cultivar, Early Gallatin, treated with Lorsban 25-SL and Orthocide 75 for protection against soil insects and rotting diseases, was used in all plantings. Terraclor, a soil fungicide for control of root and stem rot, was mixed with the seed when plantings were made under conditions of high soil moisture.

Planting dates for 1979, the first year of testing, were June 20, July 3, and July 31. Second year plantings were made on June 4, June 12, and June 24, 1980.

III. TREATMENT APPLICATION

Immediately following planting, a tank mix of dinoseb (3 lb. AI/A) and pendimethalin (0.75 lb. AI/A) was applied to all treatments except the weedy check plot where weeds were allowed to grow freely. Four treatments were given a 10-inch band application (centered over the row) of the tank mix while the other 4 were given a broadcast application of the mix.

Approximately five weeks after the tank mix applications were made, three of the banded plots and three of the broadcast plots received either an application of glyphosate or paraquat from the hooded sprayer or an application of glyphosate from the rope-wick applicator (see Table II). These treatments were applied to actively growing weeds in the row middle.

Operated at a pressure of 40 PSI, the hooded sprayer was used to apply glyphosate at the rate of 0.8 lb. AI/A in 30 gallons of solution, or paraquat at the rate of 0.5 lb. AI/A in 50 gallons of solution. The rope-wick applicator applied a 1:3 (volume:volume) mixture of glyphosate and water. To insure complete saturation of the rope wicks, the reservoir boom was filled with the mixture approximately one hour prior

TABLE II

DESCRIPTION OF CHEMICAL TREATMENTS TESTED FOR THE PURPOSE OF CONTROLLING WEEDS IN NO-TILLAGE SNAP BEANS - 1979 AND 1980 PLANTINGS

| Treatment Number | Treatment Description | Treatment Abbreviation* |
|---|---|---|
| 1 | Weedy Check | WC |
| 2 | Band (dinoseb + pendimethalin) and hooded sprayer - Glyphosate | Ba - H - G |
| 3 | Band (dinoseb + pendimethalin) and wick applicator - Glyphosate | Ba - W - G |
| 4 | Band (dinoseb + pendimethalin) and no control in row middles | Ba |
| 5 | Broadcast (dinoseb + pendimethalin) and hooded sprayer - Glyphosate | Bd - H - G |
| 6 | Broadcast (dinoseb + pendimethalin) and wick applicator - Glyphosate | Bd - W - G |
| 7 | Broadcast (dinoseb + pendimethalin) and no control in row middles | Bd |
| 8 | Band (dinoseb + pendimethalin) and hooded sprayer - Paraquat | Ba - H - P |
| 9 | Broadcast (dinoseb + pendimethalin) and hooded sprayer - Paraquat | Bd - H - P |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A)
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb AI/A)
P = paraquat (0.5 lb. AI/A)

to field operation. Since the rope-wick applicator was not available for use in 1979, a partial experiment involving the weedy check plot and treatments associated with the hooded sprayer was conducted that year. Periodic foliar applications of insecticides and fungicides necessary throughout the study were made by Experiment Station personnel.

## IV. WEED DATA COLLECTION

Weed data were randomly taken from the drill and row middle of the various experimental units when the beans reached harvest maturity. The two center rows of each treatment were designated as the record rows. Interrow and drill samples were taken from this location.

A yard stick was placed at random along each of the record rows. Weeds were pulled, counted and identified from these sections.

Next, a one foot square metal frame was used to randomly select four sites from the row middle. Weeds from these sites were also pulled, counted, and identified.

# CHAPTER V

## RESULTS AND DISCUSSION

Due to differences in environmental conditions existing among planting dates, analyses of variance for the separate planting dates within each year were used to estimate the error mean squares for each sub-group. The assumption of homogeneity for the sub-group variances was tested in the analysis and rejected.

In an attempt to stabilize these sub-group variances a logarithmic transformation of the data was obtained. The following equation was used to compute the logarithmic value:

$$\ln \text{ transform value} = \ln (\text{dependent variable value} + 1).$$

Subsequently, the transformed data was analyzed again as a composite analysis for all plantings within each year. The composite analysis revealed significant planting date by treatment interaction. As a result of this significant interaction, a sub-group (planting dates within years) analysis of the transformed data was used to calculate treatment means and perform predetermined treatment contrasts (Sanders, 1980).

Estimations of means were reported as the antilogarithms computed from the means of the transformed values. These conversions were made with the following equation:

$$\text{antilog mean} = \text{antilog } (\ln \text{ mean dependent variable}) - 1.$$

Estimates for mean infestations of the five most prominent weed species in each planting are shown in Tables III - XIV. Values for the indrill weeds estimate the number of a given species in 6 linear feet of row including approximately 2 inches either side of the drill. Weed mean estimates for row middles are given for a 4 square foot area.

Comparisons of the five most prominent weed species found in the drill with the five prominent interrow species (see Tables III - XIV) reveal instances where a particular weed species appears indrill, but does not appear in the row middle. Assuming the various weed species within a planting to be relatively uniform in their distribution, it seems reasonable to conclude that a species appearing indrill and not in the row middle was effectively controlled as a result of the interrow treatments. From making this comparison it can be seen in Tables III - XIV that common ragweed was consistently controlled throughout the experiment and other species (yellow nutsedge, fall panicum, wild turnip (Raphanus raphanistrum L.), and winter wheat (Triticum aestivum L.)) were controlled on occasions. Reducing the population of certain interrow species may have made it easier for other species to propagate in the row middles. This, of course, would help to explain the presence of a particular species found in the row middle, but not found in the drill.

Specific contrasts were used to compare treatment means for the following reasons:

1. They allow the researcher to directly test specific hypothesis of interest.

TABLE III

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (INDRILL) IN THE JUNE 20, 1979 PLANTING

| Treatment* | Number of Weeds Per 6 Linear Feet | | | | |
|---|---|---|---|---|---|
| | Redroot Pigweed | Yellow Nutsedge | Large Crabgrass | Common Ragweed | Winter Wheat |
| 1 (WC) | 0.7 | 0.8 | 0.7 | 0.2 | 0.6 |
| 2 (Ba-H-G) | 0.2 | 0.9 | 0.7 | 0.0 | 0.0 |
| 5 (Bd-H-G) | 1.9 | 0.2 | 0.9 | 1.1 | 0.0 |
| 8 (Ba-H-P) | 1.0 | 1.2 | 0.0 | 0.6 | 0.0 |
| 9 (Bd-H-P) | 4.4 | 0.5 | 0.2 | 0.4 | 1.1 |
| Overall Mean | 1.0 | 0.5 | 0.4 | 0.3 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE IV

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (ROW MIDDLE) IN THE JUNE 20, 1979 PLANTING

| | Number of Weeds Per 4 Square Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Large Crabgrass | Redroot Pigweed | Fall Panicum | Mouse Ear Chickweed | Wild Turnip |
| 1 (WC) | 2.0 | 10.3 | 4.2 | 2.2 | 1.1 |
| 2 (Ba-H-G) | 1.5 | 2.3 | 0.2 | 0.0 | 0.2 |
| 5 (Bd-H-G) | 1.6 | 0.2 | 0.0 | 0.5 | 0.0 |
| 8 (Ba-H-P) | 2.7 | 0.6 | 0.2 | 0.0 | 0.6 |
| 9 (Bd-H-P) | 2.4 | 1.0 | 0.6 | 0.0 | 0.0 |
| Overall Mean | 1.5 | 1.3 | 0.5 | 0.3 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE V

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (INDRILL) IN THE JULY 3, 1979 PLANTING

| | Number of Weeds Per 6 Linear Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Redroot Pigweed | Common Ragweed | Large Crabgrass | Wild Turnip | Winter Wheat |
| 1 (WC) | 2.2 | 0.3 | 0.3 | 0.0 | 0.0 |
| 2 (Ba-H-G) | 1.8 | 0.7 | 0.7 | 0.0 | 0.7 |
| 5 (Bd-H-G) | 2.3 | 1.0 | 0.3 | 0.0 | 0.0 |
| 8 (Ba-H-P) | 0.0 | 0.4 | 1.1 | 0.9 | 0.0 |
| 9 (Bd-H-P) | 0.5 | 0.7 | 0.3 | 1.2 | 0.4 |
| Overall Mean | 0.9 | 0.5 | 0.4 | 0.3 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE VI

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (ROW MIDDLE) IN THE JULY 3, 1979 PLANTING

| | Number of Weeds Per 4 Square Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Redroot Pigweed | Large Crabgrass | Wild Turnip | Carpetweed | Winter Wheat |
| 1 (WC) | 7.6 | 0.6 | 0.9 | 0.2 | 0.6 |
| 2 (Ba-H-G) | 1.6 | 0.3 | 0.4 | 0.0 | 0.2 |
| 5 (Bd-H-G) | 1.2 | 0.8 | 0.2 | 0.4 | 0.0 |
| 8 (Ba-H-P) | 0.9 | 1.3 | 0.2 | 0.6 | 0.0 |
| 9 (Bd-H-P) | 0.3 | 1.4 | 0.5 | 0.7 | 0.6 |
| Overall Mean | 1.2 | 0.7 | 0.3 | 0.3 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE VII

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (INDRILL) IN THE JULY 31, 1979 PLANTING

| | Number of Weeds Per 6 Linear Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Large Crabgrass | Redroot Pigweed | Mouse Ear Chickweed | Fall Panicum | Wild Turnip |
| 1 (WC) | 1.7 | 0.4 | 0.3 | 0.0 | 0.3 |
| 2 (Ba-H-G) | 0.2 | 0.0 | 0.3 | 0.4 | 0.0 |
| 5 (Bd-H-G) | 0.2 | 0.6 | 0.0 | 0.0 | 0.0 |
| 8 (Ba-H-P) | 3.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 (Bd-H-P) | 1.2 | 0.0 | 0.2 | 0.4 | 0.2 |
| Overall Mean | 0.7 | 0.1 | 0.1 | 0.1 | 0.1 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
G = glyphosate (0.8 lb. AI/A))
P = paraquat (0.5 lb. AI/A)

TABLE VIII

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (ROW MIDDLE) IN THE JULY 31, 1979 PLANTING

| | Number of Weeds Per 4 Square Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Large Crabgrass | Carpetweed | Mouse Ear Chickweed | Winter Wheat | Redroot Pigweed |
| 1 (WC) | 5.1 | 3.7 | 3.3 | 1.8 | 1.5 |
| 2 (Ba-H-G) | 1.9 | 0.0 | 0.0 | 0.3 | 0.0 |
| 5 (Bd-H-G) | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 (Ba-H-P) | 3.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 (Bd-H-P) | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 |
| Overall Mean | 1.4 | 0.3 | 0.3 | 0.2 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE IX

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (INDRILL) IN THE JUNE 4, 1980 PLANTING

| | Number of Weeds Per 6 Linear Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Redroot Pigweed | Large Crabgrass | Common Ragweed | Yellow Nutsedge | Fall Panicum |
| 1 (WC) | 9.1 | 2.3 | 1.4 | 0.0 | 0.0 |
| 2 (Ba-H-G) | 23.1 | 2.1 | 0.4 | 2.0 | 1.0 |
| 3 (Ba-W-G) | 13.8 | 1.8 | 2.6 | 4.2 | 0.0 |
| 4 (Ba) | 21.2 | 4.3 | 2.7 | 0.9 | 0.2 |
| 5 (Bd-H-G) | 19.6 | 5.8 | 6.3 | 0.8 | 0.2 |
| 6 (Bd-W-G) | 12.0 | 1.4 | 2.2 | 2.9 | 0.0 |
| 7 (Bd) | 15.9 | 0.9 | 2.0 | 2.9 | 0.4 |
| 8 (Ba-H-P) | 10.5 | 4.5 | 1.6 | 1.0 | 0.4 |
| 9 (Bd-H-P) | 5.2 | 2.2 | 2.1 | 5.0 | 0.0 |
| Overall Mean | 10.0 | 2.1 | 1.8 | 1.5 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE X

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (ROW MIDDLE) IN THE JUNE 4, 1980 PLANTING

| | Number of Weeds Per 4 Square Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Redroot Pigweed | Large Crabgrass | Yellow Nutsedge | Fall Panicum | Carpetweed |
| 1 (WC) | 29.3 | 23.1 | 1.1 | 2.4 | 2.3 |
| 2 (Ba-H-G) | 1.1 | 0.2 | 0.2 | 0.0 | 0.0 |
| 3 (Ba-W-G) | 32.7 | 16.4 | 2.6 | 1.1 | 1.4 |
| 4 (Ba) | 45.9 | 14.2 | 4.2 | 1.3 | 0.9 |
| 5 (Bd-H-G) | 0.7 | 0.0 | 1.6 | 0.0 | 0.0 |
| 6 (Bd-W-G) | 25.7 | 8.9 | 7.4 | 0.2 | 0.2 |
| 7 (Bd) | 29.4 | 11.5 | 5.1 | 1.4 | 1.0 |
| 8 (Ba-H-P) | 0.0 | 1.0 | 0.9 | 0.0 | 0.0 |
| 9 (Bd-H-P) | 1.1 | 0.3 | 1.7 | 0.0 | 0.0 |
| Overall Mean | 6.0 | 3.4 | 1.8 | 0.5 | 0.4 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75. lb AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE XI

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (INDRILL) IN THE JUNE 12, 1980 PLANTING

| | Number of Weeds Per 6 Linear Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Redroot Pigweed | Large Crabgrass | Common Ragweed | Carpetweed | Spotted Spurge |
| 1 (WC) | 38.3 | 3.1 | 0.9 | 0.3 | 0.0 |
| 2 (Ba-H-G) | 27.4 | 0.9 | 0.3 | 0.7 | 0.3 |
| 3 (Ba-W-G) | 18.4 | 1.9 | 0.6 | 0.2 | 0.3 |
| 4 (Ba) | 27.1 | 2.4 | 0.4 | 0.3 | 0.3 |
| 5 (Bd-H-G) | 26.4 | 1.7 | 0.6 | 0.0 | 0.2 |
| 6 (Bd-W-G) | 21.0 | 1.8 | 0.6 | 0.4 | 0.0 |
| 7 (Bd) | 28.6 | 1.5 | 0.6 | 0.2 | 0.4 |
| 8 (Ba-H-P) | 12.7 | 3.5 | 0.4 | 0.2 | 0.4 |
| 9 (Bd-H-P) | 10.2 | 2.3 | 0.6 | 0.9 | 0.2 |
| Overall Mean | 15.7 | 1.7 | 0.5 | 0.3 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE XII

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (ROW MIDDLE) IN THE JUNE 12, 1980 PLANTING

| | Number of Weeds Per 4 Square Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Redroot Pigweed | Large Crabgrass | Carpetweed | Spotted Spurge | Lambs-quarter |
| 1 (WC) | 58.4 | 3.1 | 0.2 | 0.3 | 0.3 |
| 2 (Ba-H-G) | 23.9 | 0.6 | 1.0 | 0.2 | 0.3 |
| 3 (Ba-W-G) | 17.0 | 0.9 | 1.6 | 0.6 | 0.2 |
| 4 (Ba) | 29.1 | 2.5 | 0.9 | 1.0 | 0.0 |
| 5 (Bd-H-G) | 10.7 | 1.5 | 0.7 | 0.0 | 0.0 |
| 6 (Bd-W-G) | 27.5 | 4.2 | 1.8 | 0.0 | 0.4 |
| 7 (Bd) | 50.7 | 3.0 | 0.4 | 0.6 | 0.0 |
| 8 (Ba-H-P) | 10.4 | 2.2 | 0.9 | 0.0 | 0.6 |
| 9 (Bd-H-P) | 10.3 | 2.6 | 0.9 | 0.0 | 0.2 |
| Overall Mean | 15.8 | 1.7 | 0.8 | 0.2 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE XIII

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (INDRILL) IN THE JUNE 24, 1980 PLANTING

| Treatment* | Number of Weeds Per 6 Linear Feet | | | | |
|---|---|---|---|---|---|
| | Redroot Pigweed | Carpetweed | Spotted Spurge | Large Crabgrass | Red Clover |
| 1 (WC) | 2.6 | 2.3 | 0.4 | 1.0 | 0.2 |
| 2 (Ba-H-G) | 0.4 | 0.2 | 0.4 | 0.0 | 0.0 |
| 3 (Ba-W-G) | 1.1 | 1.8 | 0.2 | 0.4 | 0.0 |
| 4 (Ba) | 0.9 | 0.2 | 0.4 | 1.4 | 0.3 |
| 5 (Bd-H-G) | 1.9 | 0.0 | 0.0 | 0.0 | 0.6 |
| 6 (Bd-W-G) | 2.1 | 0.7 | 0.7 | 0.2 | 0.6 |
| 7 (Bd) | 0.9 | 0.6 | 0.8 | 0.7 | 0.4 |
| 8 (Ba-H-P) | 0.8 | 0.3 | 0.2 | 0.2 | 0.0 |
| 9 (Bd-H-P) | 0.2 | 0.4 | 1.1 | 0.4 | 0.4 |
| Overall Mean | 0.9 | 0.5 | 0.4 | 0.4 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE XIV

EFFECT OF HERBICIDE TREATMENT ON WEED MEAN ESTIMATIONS FOR THE FIVE MOST PROMINENT SPECIES (ROW MIDDLE) IN THE JUNE 24, 1980 PLANTING

| | Number of Weeds Per 4 Square Feet | | | | |
|---|---|---|---|---|---|
| Treatment* | Carpetweed | Redroot Pigweed | Large Crabgrass | Common Ragweed | Spotted Spurge |
| 1 (WC) | 4.4 | 5.8 | 1.2 | 0.4 | 0.2 |
| 2 (Ba-H-G) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3 (Ba-W-G) | 3.3 | 1.7 | 0.3 | 0.0 | 0.3 |
| 4 (Ba) | 4.1 | 1.6 | 0.3 | 0.9 | 0.2 |
| 5 (Bd-H-G) | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 |
| 6 (Bd-W-G) | 2.9 | 1.2 | 0.4 | 0.2 | 0.9 |
| 7 (Bd) | 2.3 | 2.1 | 1.8 | 0.6 | 0.7 |
| 8 (Ba-H-P) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 (Bd-H-P) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Overall Mean | 1.1 | 0.8 | 0.3 | 0.2 | 0.2 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

2. They are statistically more powerful - smaller mean differences for a given number of replications can be identified (Sanders, 1980).

## I. INDRILL WEED CONTROL

Treatment contrasts were performed on the indrill weed data to determine if the tank mix of dinoseb and pendimethalin significantly reduced the weed populations in the plots. The specific contrast performed on the five most prominent weed species for each planting in 1979 was treatment 1 (WC) versus treatments 2 (Ba-H-G), 5 (Bd-H-G), 8 (Ba-H-P), and 9 (Bd-H-P). For the plantings in 1980, the specific contrast used was treatment 1 (WC) versus treatments 2 (Ba-H-G), 3 (Ba-W-G), 4 (Ba), 5 (Bd-H-G), 6 (Bd-W-G), 7 (Bd), 8 (Ba-H-P), and 9 (Bd-H-P) (consult Table II, page 33, for treatment descriptions).

The results indicated that redroot pigweed and carpetweed Mollugo verticillata L. (third planting, 1980) were the only species significantly controlled ($\alpha \leq 0.05$) throughout the growing season as a result of the preemergence applied tank mix of dinoseb + pendimethalin. Table XIII shows a mean estimate of 2.6 redroot pigweeds per 6 foot of row in treatment 1 of the third planting (1980). The same table shows mean estimates for redroot pigweed in treatments 2 through 9; the values are 0.4, 1.1, 0.9, 1.9, 2.1, 0.9, 0.8, and 0.2, respectively. Mean estimates for carpetweed from Table XIII indicate that there are 2.3 carpetweeds per 6 foot of row in treatment 1. Table XIII also shows mean estimates of 0.2, 1.8, 0.2, 0.0, 0.7, 0.6, 0.3, and 0.4 for treatments 2 through 9, respectively.

For practical purposes, the preemergence tank mix was not an effective treatment for indrill weed control throughout the entire growing season. This is not to say that there was no control as a result of the treatment; weeds were noticeably suppressed for the first couple of weeks following application.

## II. INTERROW WEED CONTROL

### Broadcast Application Versus Band Application

Treatments receiving broadcast applications of the pendimethalin + dinoseb tank mix were contrasted with those receiving a banded application of the mix. The treatment contrast performed on the five most prominent weed species for each planting in 1979 was treatments 5 (Bd-H-G) and 9 (Bd-H-P) versus treatments 2 (Ba-H-G) and 8 (Ba-H-P). Treatment contrasts 2 (Ba-H-G) versus 5 (Bd-H-G), 3 (Ba-W-G) versus 6 (Bd-W-G), and 8 (Ba-H-P) versus 9 (Bd-H-P) were conducted on the five prominent weed species for plantings in 1980 (see Table II, page 33, for treatment descriptions).

Contrast results showed large crabgrass (third planting, 1979) and redroot pigweed (second planting, 1980) to be the only species significantly controlled ($\alpha \leq 0.05$) in the row middle as a result of the preemergence mix being broadcast applied. In 1979, mean estimates for large crabgrass in the third planting were 0.4 and 0.7 plants per 4 square feet in treatments 5 and 9, and 1.9 and 3.2 plants per 4 square feet in treatments 2 and 8 (see Table VIII). Table XII lists weed mean estimates for redroot pigweed (second planting, 1980) as being 10.7

plants per 4 square feet in treatment 5 and 23.9 plants per 4 square feet in treatment 2.

In view of the poor overall control noted here and in the drill, it seems reasonable to conclude that little benefit was derived from the use of the tank mix.

Glyphosate Versus Paraquat

Specific treatment contrasts comparing the effectiveness of paraquat and glyphosate were performed on the dependent variables. Treatments 2 (Ba-H-G) and 5 (Bd-H-G) were contrasted with treatments 8 (Ba-H-P) and 9 (Bd-H-P) (see Table II, page 33, for treatment descriptions) for the five most prominent weed species in each planting (1979 and 1980). No significant contrasts ($\alpha \leq 0.05$) appeared in the two-year study. For the purpose of this study, the chemicals exhibited equal effectiveness in their control of weeds. This, of course, excludes any advantage glyphosate had on the control of perennial weeds over the course of time.

Hooded Sprayer Versus Rope-Wick Applicator

Specific contrasts comparing the effectiveness of the two applicators on the dependent variables were found to be significant in several of the plantings as can be seen in Tables XV and XVI. The comparison, possible only in 1980 since the rope-wick applicator was unavailable earlier, contrasted treatments 2 (Ba-W-G) and 5 (Bd-H-G) with 3 (Ba-W-G) and 6 (Bd-W-G), and treatments 3 (Ba-H-G) and 6 (Bd-W-G) with 8 (Ba-H-P) and 9 (Bd-H-P) (see Table II

TABLE XV

SIGNIFICANT CONTRASTS ($\alpha \leq 0.05$) FOR HOODED APPLICATOR (WITH GLYPHOSATE) VERSUS ROPE-WICK APPLICATOR IN THE CONTROL OF INTERROW WEEDS - 1980

| | | Population/4 $ft^2$ | | Population/4 $ft^2$ | | |
|---|---|---|---|---|---|---|
| Weed Species | Planting Date | Treatment* 2 (Ba-H-G) | Treatment* 5 (Bd-H-G) | Treatment* 3 (Ba-W-G) | Treatment* 6 (Bd-W-G) | PR > F |
| Yellow Nutsedge | 6/4/80 | 0.2 | 1.6 | 2.6 | 7.4 | 0.0220 |
| Redroot Pigweed | 6/4/80 | 1.1 | 0.7 | 32.7 | 25.7 | 0.0001 |
| | 6/24/80 | 0.0 | 0.0 | 1.7 | 1.2 | 0.0007 |
| Large Crabgrass | 6/4/80 | 0.2 | 0.0 | 16.4 | 17.2 | 0.0001 |
| Carpetweed | 6/4/80 | 0.0 | 0.0 | 1.4 | 0.2 | 0.0489 |
| | 6/24/80 | 0.0 | 0.2 | 3.3 | 2.9 | 0.0001 |
| Spotted Spurge | 6/24/80 | 0.0 | 0.0 | 0.3 | 0.9 | 0.0289 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

TABLE XVI

SIGNIFICANT CONTRASTS ($\alpha$<0.05) FOR HOODED APPLICATOR (WITH PARAQUAT) VERSUS ROPE-WICK APPLICATOR IN THE CONTROL OF INTERROW WEEDS - 1980

| Weed Species | Planting Date | Population/4 $ft^2$ Treatment* 8 (Ba-H-P) | Population/4 $ft^2$ Treatment* 9 (Bd-H-P) | Population/4 $ft^2$ Treatment* 3 (Ba-W-G) | Population/4 $ft^2$ Treatment* 6 (Bd-W-G) | PR > F |
|---|---|---|---|---|---|---|
| Yellow Nutsedge | 6/4/80 | 0.9 | 1.7 | 2.6 | 7.4 | 0.0494 |
| Redroot Pigweed | 6/4/80 | 0.0 | 1.1 | 32.7 | 25.7 | 0.0001 |
| | 6/12/80 | 10.4 | 10.3 | 17.0 | 27.5 | 0.0126 |
| | 6/24/80 | 0.0 | 0.0 | 1.7 | 1.2 | 0.0007 |
| Large Crabgrass | 6/4/80 | 1.0 | 0.3 | 16.4 | 17.2 | 0.0001 |
| Carpetweed | 6/4/80 | 0.0 | 0.0 | 1.4 | 0.2 | 0.0489 |
| | 6/24/80 | 0.0 | 0.0 | 3.3 | 2.9 | 0.0001 |
| Spotted Spurge | 6/24/80 | 0.0 | 0.0 | 0.3 | 0.9 | 0.0289 |

*WC = weedy check
Ba = band (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
Bd = broadcast (dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A))
H = hooded sprayer
W = rope-wick applicator
G = glyphosate (0.8 lb. AI/A)
P = paraquat (0.5 lb. AI/A)

for treatment descriptions). In all cases the hooded sprayer had smaller weed mean estimates associated with its use than did the rope-wick applicator. The hooded sprayer was demonstrated to be significantly better ($\alpha \leq 0.05$) than the wick applicator for the control of yellow nutsedge, redroot pigweed, large crabgrass, and carpetweed in the first planting of 1980. The control of redroot pigweed was significantly different for the applicators in the second planting of 1980, as was the control of redroot pigweed, carpetweed, and spotted spurge (Euphorbia maculata L.) in the third planting.

It should be noted that any weed seedlings or species less than 4 inches in height, at the time of application, were left untreated by the rope-wick applicator. The applicator simply passed over the top of the shorter weeds due to the 4-inch ground clearance of the applicator. Visual inspection of the plots indicated that neither applicator caused appreciable herbicide injury to the snap beans when properly used.

## Problems in Weed Data Collection

Slight variations in the time of interrow applications (applications were made approximately five weeks after planting) for the different plantings coupled with favorable environmental conditions may have been the difference between a plot with 30 weeds per square foot and a plot with none. The method of weed rating is suspect.

When the square metal frame, used to select sample sites within the row middle, was thrown into the untreated control plot where weeds were mature, it was not uncommon to select a site with one to three mature weeds per square foot. Whereas, sample sites taken from treated plots may have had as many as 30 weed seedlings per square foot. Although greater in number, the seedlings were probably no more a threat to crop yield than were the larger mature weeds, and definitely less of a hinderance in the mechanical harvesting of the crop. This is, of course, only speculation since plot yields taken were not included in the analysis due to inconsistency in establishing uniform plant stands.

Burrill et al. (1978) lists two advantages for the quantitative method of weed rating used in this study. It provides data not influenced by inconsistencies or the evaluator's bias, and secondly, it can develop subtle differences an evaluator might overlook when using a subjective method of evaluation.

The actual density of weeds can be very useful information when interpreted in terms of yield data. At the same time, Burrill et al. (1978) noted that weed counts fail to reflect the presence and practical effect of a few large weeds compared with a large number of small weeds.

Burrill et al. (1978) offers two other methods for making quantitative evaluations of weed populations. He suggests the full or partial harvest of weeds in a plot. Fresh weights are recorded. Then, species are separated by hand and grouped according to species. A problem associated with this particular method is the unequal loss of water for different species between harvesting and weighing of the fresh samples. For this reason, dry weights are sometimes determined. Dry weights alone, however, do not yield definitive data since large water content variations exist for different weed species.

The other method Burrill et al. (1978) suggests is to harvest the weeds and determine their height and weight. This method sometimes provides a useful measurement of weed competition. The method, however, can give misleading information since measurable differences in physical characteristics of the plant often have no effect on crop yield.

# CHAPTER VI

# SUMMARY AND CONCLUSIONS

## I. SUMMARY

A hooded sprayer and a rope-wick applicator were designed and constructed for the interrow application of non-selective herbicides in no-till snap beans. Objectives of the study were: (1) design and construct the applicators, and (2) evaluate the effectiveness of the two applicators for interrow weed control.

Experimental units received chemical treatments in two parts. Immediately after planting, treatments were either banded or broadcast with a dinoseb (3 lb. AI/A) + pendimethalin (0.75 lb. AI/A) tank mix at a rate of 40 gallons of solution per acre. Hooded sprayer and rope-wick applications of glyphosate or paraquat were made approximately five weeks later. The hooded sprayer applied either paraquat (0.5 lb. AI/A) in 50 gallons of solution per acre or glyphosate (0.8 lb. AI/A) in 30 gallons of solution. The rope-wick applicator was used to apply a 1:3 (glyphosate:water) solution.

The treatments were replicated four times in three plantings for two years. Only 5 of 9 treatments were conducted the first year since the construction of the rope-wick applicator was not completed in time for use in the first-year plantings.

When the snap bean pods reached harvest maturity, interrow weed samples were taken. Two random 3-foot sections were taken from the drill and 4, 1-foot square sections from the row middles. Weeds within the sample site were pulled, separated by species, and counted; no consideration was given to weed size. The weed count data were subjected to analyses of variance and specific contrasts were made to determine the effectiveness of the applicators.

## II. CONCLUSIONS

The following conclusions were drawn from this study:

1. No appreciable herbicide injury to snap bean plants was observed as a result of treatment from either of the applicators.
2. In general, lower weed mean populations were associated with plots receiving a chemical treatment from one of the two interrow applicators.
3. A preemergence application of the dinoseb + pendimethalin tank mix was not an effective treatment for indrill weed control.
4. In terms of interrow weed control, there was no difference between the plots receiving a preemergence broadcast application of the dinoseb + pendimethalin tank mix and those receiving a preemergence band applied application of the mix.
5. For our purpose, glyphosate and paraquat were equally effective in the control of interrow weeds.
6. The hooded applicator was more effective than the rope-wick applicator for the control of weeds in the row middle.

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## LITERATURE CITED

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