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## **Biology, control and competition of spotted spurge *Euphorbia Maculata* L. in soybeans**

Joe H. Hope

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To the Graduate Council:

I am submitting herewith a dissertation written by Joe H. Hope entitled "Biology, control and competition of spotted spurge Euphorbia Maculata L. in soybeans." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Plant, Soil and Environmental Sciences.

W. A. Krueger, Major Professor

We have read this dissertation and recommend its acceptance:

L. S. Jeffery, J. H. Reynolds, J. W. Hilty

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 dissertation written by Joe H. Hope, III, entitled "Biology, Control and Competition of Spotted Spurge Euphorbia maculata L. in Soybeans." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Plant and Soil Science.

William A. Krueger  
W. A. Krueger, Major Professor

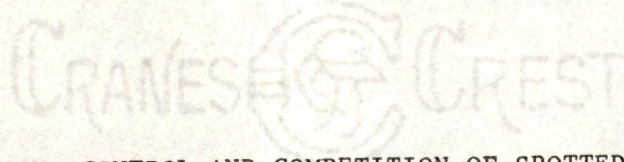
We have read this dissertation  
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BIOLOGY, CONTROL AND COMPETITION OF SPOTTED SPURGE

EUPHORBIA MACULATA L. IN SOYBEANS

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Joe H. Hope, III

June 1982

**3060874**



## ACKNOWLEDGMENTS

The author wishes to express sincere thanks to Dr. W. A. Krueger who served as chairman of my supervisory committee and to the other members of my committee, Drs. L. S. Jeffery, J. H. Reynolds, and J. W. Hilty, for their suggestions, friendship and advice during the course of this study. Special thanks to Dr. R. M. Hayes for his assistance and suggestions throughout this study. The author appreciates the help and fellowship from fellow graduate students throughout his study. The author would also like to thank Dr. L. F. Seatz for his guidance and for making a graduate research assistantship available to me. The author wishes to thank Mrs. Jean Nelson for her assistance throughout the course of study and for typing the manuscript.

The author wishes to express sincere thanks to his parents, Mr. and Mrs. Joe H. Hope, Jr., and his wife's parents, Mr. and Mrs. George F. Milne, for their encouragement and support over the last six years of graduate school.

I am grateful to my loving wife, Susan, for her understanding, assistance, drawing, encouragement, patience, and many sacrifices she made during the course of this study.

## ABSTRACT

Laboratory and greenhouse experiments to investigate factors affecting germination, dormancy, viability, and emergence of spotted spurge (Euphorbia maculata L.) were done from 1978 to 1981. Optimum germination temperatures were 25 to 30 C. The optimum pH for germination was 7. Germination was not significantly different at seed moisture levels of 4 and 11% during storage. Storage of spotted spurge seed at an alternating temperature regime of 4/21 C for 2 to 8 weeks reduced dormancy when compared to storage at -9/21 C and constant temperature treatments of -9, 4 and 21 C. Gibberellic acid significantly increased germination of dormant seed compared to other treatments. Seed stored at 4 C maintained viability for 2 years but declined during the third year of storage. Emergence of spotted spurge seedlings decreased with increased depth of planting and no emergence occurred from depths greater than 4 cm.

The preemergence and preplant-incorporated herbicides were applied to coincide with soybean planting dates at each location. The best and most long-lasting control of spotted spurge was with metribuzin [4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one] and alachlor [2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide] were applied preemergence. Linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea] applied preemergence provided poor control. Alachlor and metribuzin gave the most complete and longest-lasting control. Vernolate [S-propyl, dipropylthiocarbamate], trifluralin [ $\alpha,\alpha,\alpha$ -trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine], and pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzeneamine] applied pre-plant incorporated all



gave good control of spotted spurge. Herbicides applied to the soil were more effective than those applied postemergence. Bentazon [3-isopropyl-1H-2,1,3-benzothiadiazin-(4)3H-one 2,2-dioxide] and naptalam [N-1-naphthylphthalamic acid] + dinoseb [2-sec-butyl-4,6-dinitrophenol] applied postemergence provided poor control, but acifluorfen [sodium 5-[(2-chloro-4-trifluoromethyl)-phenoxy]-2-nitrobenzoate] gave fair control of spotted spurge.

Competition studies were conducted to determine the influence of two spotted spurge populations and three spotted spurge removal dates on soybeans. The results indicate soybean seed yields may be reduced more by spotted spurge competition in dry conditions than when adequate moisture is available.



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## CHAPTER I

### INTRODUCTION

Today there are fewer farmers per capita than in any previous period of time, yet these few are producing more food than ever before in the history of man. Significant factors for our high production of food are: (1) sophisticated, trained farmers, (2) increased soil fertility, (3) improved cultural technology, (4) development of vigorous and high yielding hybrids, and (5) the development and use of pesticides. The three billion arable acres of cultivated crops, or about 10% of the world's land surface, feed approximately 3.6 billion people a year (30). By the year 2000, due to the population sprawl, there will be an enormous decrease in the total possible number of arable acres available on which to produce food. Demographers and population ecologists predict there will be seven billion people to feed at that time (19). With this doubling of the present population, productive land will be at a premium, and waste by weeds will not be tolerable. Weed science research will increase in importance in the future as the use of new and different herbicides will cause shifts in weed populations. Weeds considered to be of minor importance now may become more troublesome as weed control programs change. Spotted spurge, Euphorbia maculata L. is an example of a weed becoming increasingly troublesome as weed control methods change.

Spotted spurge, also called nodding spurge, eye-bright, stubble spurge, ground spurge, slobber-weed, and eyebane, may be found in

gardens, cultivated fields, along roadsides, bare places in meadows and pastures, especially in dry soils (36). It is a native plant occurring throughout the eastern two-thirds of the United States and has been introduced along the Pacific coast from Washington to central California (42). It is an annual, reproducing by seeds which germinate in late spring and throughout the summer. The seed is dark brown or black, oblong, slightly pitted and occurs three per capsule. The plant has a shallow taproot and an erect growth habit. There are one to many reddish stems reaching approximately one meter in height which contain a milky sap. The leaves are 1-3 cm long, opposite, oblong with serrated edges usually having a red-purplish spot.

Spotted spurge does not cause extensive problems anywhere in its range, but it is subject to control measures in some areas (22). At this time, it is not a problem on large soybean acreages in Tennessee, but localized, heavy infestations occur in numerous areas. Control of more competitive weeds may have contributed to it being increasingly present in soybeans. Thus, it has become necessary to increase the research effort devoted to developing methods to control this species in soybeans.

To cultivate a weed for experimental purposes is often a difficult task (1), and spotted spurge is no exception. Since freshly harvested spotted spurge seed were dormant, suitable treatments which broke seed dormancy had to be found before the species could be cultivated for experimental purposes.

The purpose of this study was to (1) investigate factors affecting dormancy, viability, and emergence of spotted spurge, (2) determine



the response of spotted spurge to herbicides currently recommended in soybeans, and (3) determine the effects of spotted spurge competition on soybeans.



## CHAPTER II

### LITERATURE REVIEW

#### A. Biology of Euphorbia maculata L.

Linnaeus (34) first authored spotted spurge as Euphorbia foliis macula in Species Plantarum in 1753. Nuttall (38) in 1818 listed the name as Euphorbia maculata L. in his book, The Genera of the North American Plants. In 1897, Britton and Brown (7) used the species name Euphorbia nutans Lag. In the 1913 edition by the same authors, spotted spurge was placed in a different genus, listed Chamaesyce maculata (L.) Small. Considerable taxonomic confusion existed for this species and the genus Euphorbia from 1897 until 1950 when Fernald (25) in Gray's Manual of Botany, 8th Edition, classified it as Euphorbia maculata L. again. This is the spelling most taxonomists use today. In addition to the binomial name of Euphorbia maculata L., this species is commonly referred to in the literature as spotted spurge. It has also been called wartweed, nodding spurge, milk purslane, and blotched spurge, and most recently eye-bright, stubble spurge, ground spurge, slobber-weed, and eyebane (36). Spotted spurge is the recognized common name by the Weed Science Society of America (2).

Reed and Hughes (42) in 1970 provided the most complete description of spotted spurge:

Euphorbia maculata L. Annual herb, with a shallow taproot, reproducing by seeds, germinating late in the spring or early summer; stem simple or much branched, erect or spreading, 0.8 - 1 m tall with a milky juice, crisp-pubescent at the young tips, soon becoming glabrous and firm; leaves oblong, oblong-lanceolate

or lance-falcate, 0.8 - 3.5 cm. long, the edge slightly toothed, borne on short petioles, with conspicuous reddish spot or blotch; flowers (cyathia) solitary or clustered, with minute petals in the form of a cup, peduncle 0.5 - 5 mm. long; involucre 0.7 - 1 mm. in diameter; seed pods on short stalks from the cuplike base, smooth, 3-lobed ribbed, with 3 seeds; seeds 3-sided, obtusely angled, 1.1 - 1.6 mm. long, 0.9 - 1.1 mm. wide, oblong dark-brown or black, pitted with ridged surfaces.

Spotted spurge is generally associated with a mesophytic habitat.

Britton and Brown (7) listed the range of spotted spurge as eastern North America, except extreme north, extending west to the Rocky Mountains as of 1897. In 1913 the same authors listed its range as New England to Ontario, Wyoming, Florida and Texas. They noted that spotted spurge had apparently been introduced west of the Rocky Mountains in California. It had been introduced as a weed in other parts of the world by 1958 according to Gleason (26). Within this large geographical area spotted spurge is very abundant as a weed in lawns, waste places, meadows and open woods (26). Now, however, it is observed in productive agricultural land. In 1979, Dunn (22) gave its distribution as follows: Arkansas, "problems in cotton and soybeans"; Massachusetts, "economic in lawn and turf"; South Carolina, "bad weeds in fields, gardens and waste places." In Indiana, Kansas, Louisiana, Maryland, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, West Virginia, Texas, and Minnesota its occurrence ranges from "common" to "known to be present," and it is not regarded as noxious.

Spotted spurge is poisonous to livestock and has been considered the cause of photosensitization among lambs in the southeast (32). Animals will avoid eating the weed when other forage is available. In most cases, poisoning is caused by an acrid principle in the milky sap which



produces symptoms of severe irritation in the mouth and gastrointestinal tract, but rarely death in livestock other than sheep. Instances have been described by Case (12), in which losses reached 30 percent when flocks of Hampshire lambs were grazed on pastures where this plant was the main weed. He found that 0.62 percent of the lamb's weight of this weed was enough to kill lambs within a few hours. Surviving sheep often show severe photosensitization reactions. Poisoning often occurred in late July and August after drought-breaking rains caused spotted spurge to become the predominant plant on mixed clover-grass pastures. Toxicity is not lost upon drying, but the dried plant may be more palatable to livestock than the fresh plant (13).

Euphorbia maculata L. possesses many of the characteristics needed for longevity of a weedy plant to survive in today's monoculture cropping systems. These characters are: (1) broad geographical range; (2) growth adaptability to different temperatures encountered within this range; (3) preference for mesophytic habitats; (4) large number of seeds produced per plant; (5) sporadic germination throughout the normal growing season; and (6) dormancy to ensure viable seed maintenance through unfavorable environmental conditions.

Viable, mature seed that do not germinate under suitable conditions of temperature, moisture and oxygen are considered to be dormant. There are three types of dormancy: innate, enforced and induced or secondary (46). Innate dormancy refers to mechanisms that prevent germination of seed on the plant and prevent germination immediately after the seed is shed from the plant. Enforced dormancy is maintained by



some environmental condition. For example, certain weed seed may remain dormant for long periods of time so long as they are buried in the soil, but germinate immediately after a short exposure to light (48). Induced dormancy differs from enforced dormancy in that the dormant condition persists even after the unfavorable environmental factor is removed. Any one or a combination of these three dormancy types may impose a dormant condition upon the seed. Some seeds, such as cocklebur and sicklepod fail to germinate because their seed coats are impermeable to oxygen and water. These seeds will germinate only if the seed coat is ruptured. Such a condition is found in many other families of weeds including Malvaceae, Chenopodiaceae, Convolvulaceae, and Solanaceae (46). The presence of germination inhibitors in the seed prevents germination of some seeds (35). The cause of seed dormancy is not always clear since the response varies with the kind of seed and the environmental conditions under which the seed is exposed. Light induces the production of specific enzymes that are essential for growth in the seed. In some seeds, the light requirement can be partially or fully replaced by such compounds as gibberellin, cytokinin, and thiourea (15).

Viable seed will germinate only in a certain range of temperatures. The maximum and minimum temperatures for germination may vary within the same species according to geographic location (44). The response of enzymes crucial for germination can be related to these maximum and minimum temperatures (33). This would imply that temperature may be the most important ecological factor controlling germination.

It has often been demonstrated that certain seed have higher germination at alternating temperatures than in constant temperature

regimes. Harrington (28) found that germination of common bermudagrass (Cynodon dactylon L.) was greatly increased by alternating temperatures of 20/35 C when compared to germination at constant temperatures of 20 or 35 C. In general, constant temperatures usually result in less germination with less uniformity than alternating temperatures (6). However, significant germination responses to constant temperature treatment are observed in some species (16).

Considerable research has been conducted to determine the effect of soil pH on germination of weed seed (10). In studies involving sicklepod (Cassia obtusifolia L.), Creel (17) noted that substantial germination occurred over a soil pH range of 4.6 to 7.9.

Weed seed viability is very important to the farmer and the weed scientist, as it will determine the weeds that will be continuing problems. There is little information about the range of storage conditions which are optimum for seed of any weed species. This knowledge is required for the successful study of a particular weed. Temperature and moisture have been suggested as the two most important factors in maintaining seed viability (6). There seems to exist a complex interaction of environmental factors that affect viability and dormancy of seed.

#### B. Control and Competition of Euphorbia maculata L. in Soybeans

Production of synthetic organic herbicides in this country was 300 million kilograms in 1978 and has increased at an average rate of seven percent per year over the last five years (4). Thus, the



use of chemical weed control is becoming more important in agricultural operations in this country. It seems that improvements in chemical weed control will continue in the future because new and better compounds are being developed each year.

Herbicides are grouped on the basis of their characteristic herbicidal activity, application, or chemical similarity. In this investigation, representatives of nine groups of herbicides (Table 1) were tested to determine their effect on spotted spurge. Each group will be briefly reviewed for its general characteristics.

The acid amide group is composed of those herbicides that are derivatives of acid amides. They are named for their corresponding acids. The principle use of acid amide herbicides is the selective control of seedling grass and certain broadleaved weeds. Most of them are applied preemergence or preplant-incorporated, except benzadox, cypromid, and propanil are applied to the foliage of the weeds (4). Alachlor and naptalam are used extensively in combination with other herbicides for weed control in many crops. Alachlor is absorbed from the soil primarily by the shoot of emerging seedlings and secondarily by the roots.

Currey and Whitcombe (18) used alachlor to control spotted spurge in container grown ornamentals and achieved 80 percent or better control. In a later study, Davis (21) reported 98-100 percent control of spotted spurge in Ilex and Euonymus nursery plantings with alachlor. Bullock (11) reported 100 percent control of the weed in soybeans with alachlor in a three-year study.

The dinitroaniline herbicides are an important group of selective herbicides which were developed in the 1960s. They are incorporated

Table 1. Common and chemical names of herbicides referred to in the text.

Common Name	Chemical Name
Acifluorfen	sodium 5-[(2-chloro-4-trifluoromethyl)-phenoxy]-2-nitrobenzoate
Alachlor	2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide
Bentazon	3-isopropyl-1H-2,1,3-benzothiadiazin-(4)3H-one 2,2-dioxide
Dinoseb	2- <u>sec</u> -butyl-4,6-dinitrophenol
Linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
Metribuzin	4-amino-6- <u>tert</u> -butyl-3-(methylthio)- <u>as</u> -triazin- 5(4H)-one
Naptalam	<u>N</u> -1-naphthylphthalamic acid
Pendimethalin	<u>N</u> -(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzeneamine
Profluralin	<u>N</u> -(cyclopropylmethyl)- $\alpha,\alpha,\alpha$ -trifluoro-2,6-dinitro- <u>N</u> - propyl-p-toluidine
Trifluralin	$\alpha,\alpha,\alpha$ -trifluoro-2,6-dinitro- <u>N,N</u> -dipropyl-p-toluidine
Vernolate	<u>S</u> -propyldipropylthiocarbamate

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into the soil prior to planting to selectively control weeds in many crops. The germination process is not directly inhibited by the dinitroaniline herbicides. The toxic effect takes place between the time of radicle and shoot emergence from the seed and subsequent emergence of the seedling from the soil (41). The greatest use of this group has been in cotton and soybeans, but some of them are currently registered for use in several field, vegetable, and tree fruit crops (4). Trifluralin is the most prominent member of this group. It was found to control 80 percent of spotted spurge in tests with ornamentals grown in containers (18).

The diphenyl ether group of herbicides is used to control many annual weeds in several crops. They are generally considered to be contact herbicides, which can be absorbed by both leaves and roots of plants. Acifluorfen is used for postemergence broadleaf weed control in soybeans, and investigators have obtained good control of many broadleaf weeds with it while maintaining good crop tolerance (29).

The thiocarbamate group of herbicides is used to selectively control many grass and broadleaf weeds during seed germination or early seedling growth in numerous crops. Thiocarbamates are very volatile and require soil incorporation. They inhibit elongation of emerging shoots of weeds, especially grasses (20). Vernolate generally reduces crop vigor early in the season followed by rapid recovery and minimal effects on yield of soybeans (27).

The triazine group of herbicides is used for selective weed control in certain crops and nonselective weed control in non-crop areas.

Their greatest use has been as a selective herbicide in corn and non-selective herbicide on industrial sites (4). The principle use of metribuzin, an asymmetrical triazine herbicide, has been selective pre-emergence and early postemergence control of seedling grass and especially broadleaved weeds in soybeans and horticultural crops. Bullock (11) reported 100 percent control of spotted spurge in soybeans with metribuzin.

The urea herbicides are mostly nonselective, but selectivity may be obtained in certain crops by taking advantage of the water solubility and absorptive properties of the compound in relation to soil characteristics (4). Linuron is applied preemergence to control many broadleaved weeds in soybeans. It was found to be variable in control of spotted spurge: 20, 53, and 90 percent control was reported for a three-year study in soybeans (11).

Dinoseb is used as a selective contact herbicide and is the only substituted phenol type still widely used in many crops (4). It controls annual grass and broadleaved weeds in soybeans.

Bentazon selectively controls many broadleaved and sedge weeds mainly by contact action in most gramineous and large-seeded leguminous crops. Bentazon has a rather unique structure among herbicides and is not classified with any particular group of herbicides.

A number of studies have investigated the competitive effect of different annual weeds on soybeans and demonstrated that these weeds reduce soybean yields (5, 39, 43). Barrentine (5) reported that full-season competition by common cocklebur (Xanthium pensylvanicum Wallr.)



at densities of 3,300, 6,600, 13,000, and 26,000 plants/ha reduced soybean seed yields 10, 28, 43, and 53 percent, respectively. Oliver (39) showed that tall morningglory (Ipomoea purpurea L.) competition can also severely reduce soybean seed yields. Common cocklebur and tall morningglory cause yield reductions in soybeans by competition for light.

Staniforth and Weber (43) found the competitive influence of Pennsylvania smartweed (Polygonum pensylvanicum L.) and velvetleaf (Abutilon theophrasti Medic.) reduced soybean seed yield by 10 percent. No work has been reported on the competitive influence of spotted spurge on soybeans. According to Buchanan (9), weed competition experiments can increase the efficiency of control of a particular weed by determining the periods when weed competition causes greater crop reductions. This information allows the use of precise weed control measures to achieve a minimum level of control while maintaining high crop yield.



## CHAPTER III

### GERMINATION, DORMANCY, VIABILITY, AND EMERGENCE OF SPOTTED SPURGE (EUPHORBIA MACULATA L.)

#### A. Abstract

Laboratory and greenhouse experiments to investigate factors affecting germination, dormancy, viability, and emergence of spotted spurge (Euphorbia maculata L.) were done from 1978 to 1981. Germination tests were conducted on mature spotted spurge seed which had been hand harvested during early October of each year from four locations in Tennessee. Optimum germination temperatures were 25 to 30 C. Seed incubated at 10 C did not germinate. The optimum pH for germination was 7. Germination was not different at seed moisture levels of 4 and 11 percent during storage. Storage of spotted spurge seed at an alternating temperature regime of 4/21 C for 2 to 8 weeks reduced dormancy when compared to storage at -9/21 C and constant temperature treatments of -9, 4, and 21 C. Gibberellic acid significantly increased germination of dormant seed compared to  $\text{KNO}_3$  and thiourea. Seed stored at 4 C maintained viability for 2 years but declined during the third year of storage. Emergence of spotted spurge seedlings decreased with depth of planting and no emergence occurred at depths greater than 4 cm.

#### B. Introduction

Spotted spurge is a native annual species that has adapted to a wide range of habitats. It is a weed in gardens, cultivated fields,



pastures, and along roadsides throughout the eastern two-thirds of the United States and has been introduced along the Pacific Coast from Washington to central California (42). Spotted spurge has also been called nodding spurge, eyebright, stubble spurge, ground spurge, slobber-weed, and eyebane (37). The plant has a shallow taproot and an erect growth habit. Each plant has one to many reddish stems reaching approximately 1 m in height which contain a milky sap. The leaves are 1-3 cm long, opposite, oblong with serrated edges usually having a red-purplish spot. The seed is dark brown or black, oblong, slightly pitted, 1.1-1.6 mm long, 0.9-1.1 mm wide, and occurs 3 to a capsule (42).

Spotted spurge does not cause extensive problems anywhere in its range, but it is subject to control measures in some areas (22). At this time, it is not a problem on large soybean acreages in Tennessee, but localized, heavy infestations occur in several areas. It is the seventh most common weed in soybeans and special oil crops in Tennessee (40). Control of more competitive weeds may have contributed to its being increasingly present in soybeans. Thus, it has become desirable to devote a substantial amount of research to better understand the biology of this weed species.

The objectives of this research were to investigate factors affecting dormancy, viability, germination, and emergence of spotted spurge seed.

### C. Materials and Methods

Spotted spurge seed used in all germination tests were collected at four different locations in Tennessee over the four-year course of

the study which started in 1978 and ran through 1981. Seed were cleaned in an air screen separator. Germination tests were conducted on mature spotted spurge seed which had been harvested by hand during early October of each year. A completely randomized design with 4 replicates was used and experiments were repeated 2 times. Each experimental unit consisted of 25 seed distributed on Whatman #1 filter paper moistened with distilled water in a 100-mm-diam., plastic petri dish. The seed were germinated in the light at 23 to 25 C. Seed germination was defined as radicle emergence. Data were recorded as percent germination. Analysis of variance was used to determine if significant differences were present among treatment means, and Duncan's multiple range test was used to separate means that differed significantly. These conditions were used for all germination tests unless otherwise indicated.

#### Temperature Effects on Germination

Germination was determined using seed that was stored for three months at 4 C. The experiment was conducted in a dark incubator at temperatures of 10, 15, 20, 25, and 30 C. Germination counts were made at 2-day intervals over a 14-day incubation period.

#### Effect of pH on Germination

The methods of Wilson (49) were used for studying the influence of buffered pH solutions on germination. A range of pHs from 3-9 were used.



### Effect of Storage Temperature and Moisture Level on Seed Germination

Each year freshly harvested, dormant seed were stored at different temperatures and moisture levels of 4 and 11 percent. The 4 percent moisture level was obtained by drying seed at 30 C for 2 days. The 11 percent moisture level was obtained by placing 5 ml of water in 50 ml closed vessels with the seed. The seed moisture was determined in a forced-air oven at 100 C (3). Storage temperature regimes studied under low and high moisture conditions were -9, 4, 21, -9/21, and 4/21 C. The alternating temperature regimes were -9 C for 16 hours and 21 C for 8 hours; 4 C for 16 hours and 21 C for 8 hours. Germination tests were done at 1-week intervals from 2 to 10 weeks after harvest for each of the storage temperature treatment regimes.

### Effect of Chemical Germination Promoters

The effect of technical grade 0.5 percent potassium nitrate, 0.5 percent thiourea, and 0.1 percent gibberellic acid on germination was studied. Freshly harvested, dormant seed were used for these tests.

### Seed Longevity

Experiments were initiated immediately after harvest to determine length of viability of seed collected in 1978. Germination tests were done each year from 1978 to 1981. The seed were stored at 4 C.

### Depth of Emergence

Seed stored 3 months at 4 C were planted in flats at depths up to 6 cm in a Sequatchie loam soil. Five hundred seeds were planted per treatment. A cheesecloth restrictive barrier was used to keep the

seed at the depth of the treatment. Soils were initially moistened by subirrigation and then watered daily from the top. A randomized complete block design was used with 4 replications.

#### D. Results and Discussion

##### Temperature Effects on Germination

The highest germination was achieved at 25 C at which 82 percent of the seed germinated (Figure 1). There was no germination at 10 C and only 8 percent at 15 C. The optimum temperature range for germination was from 20 to 30 C with 68 and 78 percent of the seeds germinating, respectively. At temperatures below 20 C, germination was reduced.

##### Effect of pH on Germination

The optimum germination of spotted spurge seed occurred at pH 7, with 78-percent germination (Figure 2). Germination was reduced at pHs above and below pH 7. Germination was 0, 6, 32, 58, 45, and 16 percent at pH 3, 4, 5, 6, 8, and 9, respectively. The sensitivity of spotted spurge to pH extremes is similar to Canada thistle (49). Common milkweed was reported to be very tolerant of pH extremes (24).

##### Effect of Storage Temperature and Moisture Level

Low seed moisture during storage may adversely affect seed germination of some species while it has no effect on seed germination of other species (37). Seed moisture level during storage did not significantly affect germination of spotted spurge (Table 2).

Lower germination occurred at each seed moisture level with -9 C and



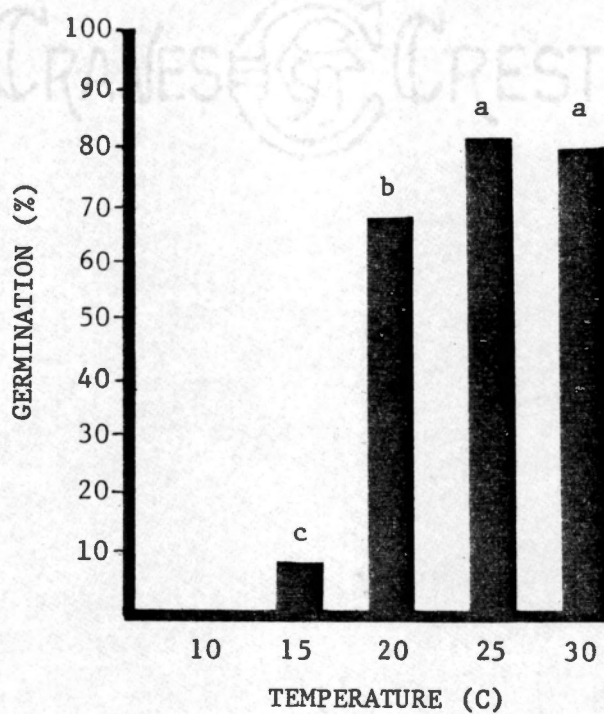


Figure 1. Effect of temperature on germination of spotted spurge seed stored for 3 months at 4 C. Bars indicated with the same letter represent means that are not significantly different according to Duncan's multiple range test ( $P \leq 0.05$ ).

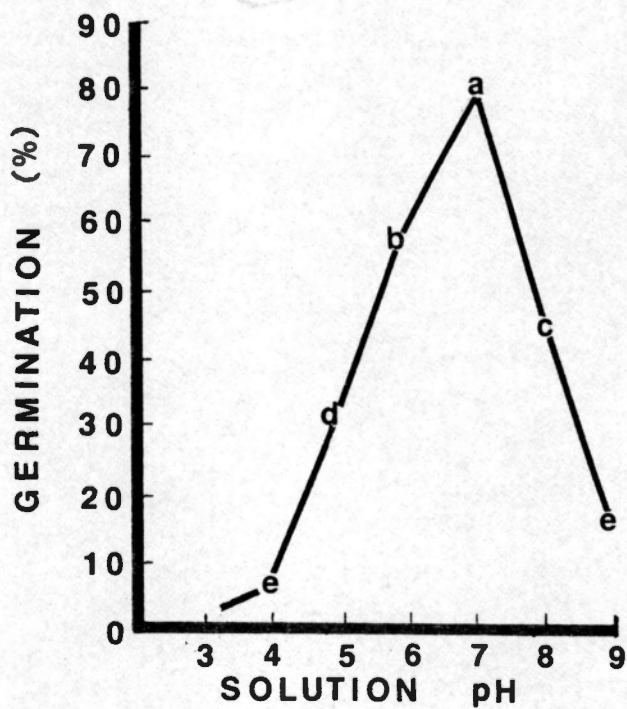


Figure 2. Effect of solution pH on spotted spurge seed germination. Means represented by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.



Table 2. Germination of spotted spurge seed following low and high moisture storage in constant and alternating temperature regimes for a 6-week period.

Temperature	Germination							
	1978		1979		1980		1981	
	Moisture		Moisture		Moisture		Moisture	
	Low	High	Low	High	Low	High	Low	High
C	%							
-9	32d	24c	44b	16d	50b	32d	28d	28d
4	73b	52b	66a	68b	76a	76a	66b	61b
21	60c	56b	68a	48c	52b	68b	56b	58b
-9/21	13e	26c	40b	44c	35c	52c	44c	40c
4/21	88a	90a	76a	80a	83a	76a	76a	72a

<sup>a</sup> Means within a column followed by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.

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Table 3. Influence of constant 21 C and alternating 4/21 C temperature regimes on spotted spurge seed germination.

Period of time weeks	Germination <sup>a</sup>							
	1978		1979		1980		1981	
	21 C	4/21	21 C	4/21	21 C	4/21	21 C	4/21
	%							
2	16d	46c	8d	38c	4d	24c	22c	16c
4	42c	68b	24c	60b	38c	56b	48b	32b
6	60b	88a	68b	76a	52b	83a	56b	76a
8	68ab	70b	76a	82a	76a	80a	82a	76a
10	72a	76b	80a	88a	72a	76a	78a	82a

<sup>a</sup>Means within a column followed by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.



alternating -9/21 C treatments. Highest germination occurred at alternating 4/21 C treatment, followed by 4 C and 21 C.

Seeds of some weeds may have higher germination at constant storage temperatures, but many of the commonly occurring weed seeds require alternation in storage temperatures (47, 6, 28). Spotted spurge seed stored at 21 C for 1-10 weeks were dormant the first few weeks after harvest, but by 8 to 10 weeks, germination rates were high. However, the seed stored at alternating 4/21 C had high germination rates much earlier after harvest (Table 3). This indicates that temperature may be the most important factor in regulating dormancy of spotted spurge seed.

#### Effect of Chemical Germination Promoters

Potassium nitrate ( $\text{KNO}_3$ ), thiourea, and gibberellic acid ( $\text{GA}_3$ ) have been shown to promote germination of a great variety of species (16). The germination of spotted spurge seed was not increased by  $\text{KNO}_3$  or thiourea (Figure 3). However, germination was 84 percent when seed were subjected to  $\text{GA}_3$ . According to Ikuma and Thiamann (31),  $\text{GA}_3$  can substitute for the temperature requirement of dormant seed and promote germination. Thus, dormancy of spotted spurge seed would seem to be regulated by temperature, perhaps mediated through  $\text{GA}_3$ .

#### Seed Longevity

The viability of most seeds gradually declines after they reach physiological maturity and their longevity depends on the environmental conditions to which they are exposed (16). Spotted spurge seed stored

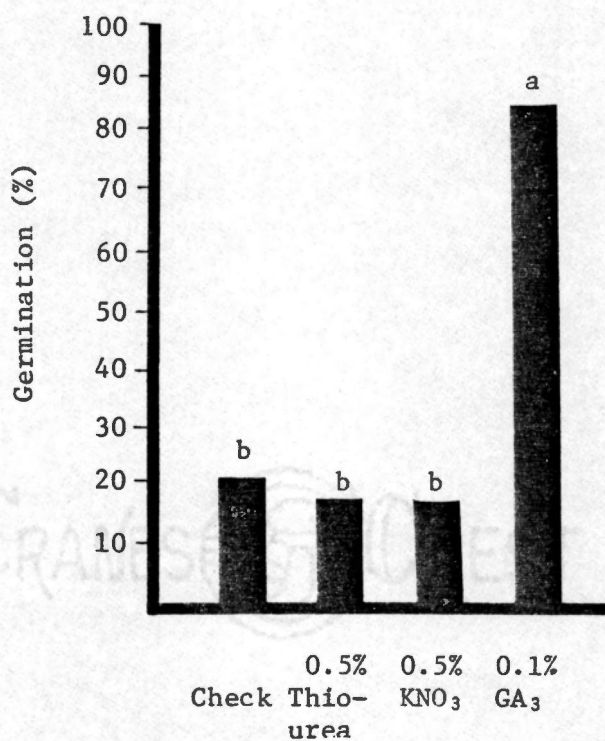


Figure 3. Germination of spotted spurge seed effected by thiourea, potassium nitrate, and gibberellic acid. Means above a bar followed by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.



at 4 C maintained viability for 2 years but declined during the third year of storage (Table 4). Seed subjected to germination conditions immediately after harvest had 12 percent germination. The second and third year it averaged 74 percent and decreased to only 60 percent germination the third year.

#### Depth of Emergence

Spotted spurge seed was found to germinate on the soil surface, but emergence from depths of 2 or 4 cm was greatly reduced. None emerged from 6 cm depth (Table 5). The surface seeding of 0 cm was the optimum treatment. These data suggest that plowing may reduce spotted spurge populations by placing seed at a depth of 2 cm or below the soil surface.



Table 4. Viability of spotted spurge seed after different durations of storage at 4 C.

---

Storage Duration	Germination <sup>a</sup>
(years)	(%)
3	60b
2	72a
1	76a
0	12c

---

<sup>a</sup> Means within a column followed by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.



Table 5. Influence of planting depth and seedlot on emergence of spotted spurge seed stored for 3 months at 4 C.

Planting depth (cm)	Emergence <sup>a</sup>		
	1978	1979	1980
0	75 a	67 a	73 a
2	8 b	15 b	14 b
4	3 b	4 c	3 c
6	0 b	0 d	0 c

<sup>a</sup>Means within a column followed by the same letter are not significantly different at the .05 level according to Duncan's multiple range test.

## CHAPTER IV

### CONTROL AND COMPETITION OF SPOTTED SPURGE (EUPHORBIA MACULATA L.) IN SOYBEANS

#### A. Abstract

Field studies to determine the response of spotted spurge (Euphorbia maculata L.) to herbicides currently recommended for controlling weeds in soybeans (Glycine max (L.) Merr.) were done at 1 location in 1979, 3 in 1980, and 2 in 1981 in Tennessee. The preemergence and preplant incorporated herbicides were applied to coincide with soybean planting dates at each location. The postemergence herbicides were applied when spotted spurge was approximately 5-10 cm tall. Spotted spurge was best controlled when metribuzin [4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5(4H)-one] and alachlor [2-chloro-2',6'diethyl-N-(methoxymethyl) acetanilide] were applied preemergence. Linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea] applied preemergence was poor in its control. Alachlor and metribuzin gave the most complete and longest lasting control. Vernolate [S-propyl dipropylthiocarbamate], trifluralin [ $\alpha,\alpha,\alpha$ -trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine], and pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzeneamine] applied preplant incorporated all gave good control of spotted spurge. Soil-applied herbicides were more effective than the postemergence herbicides. Bentazon [3-isopropyl-1H-2,1,3-benzothiadiazine-(4)3H-one 2,2-dioxide] and naptalam [N-1-naphthylphthalamic acid] + dinoseb [2-sec-butyl-4,6-dinitrophenol] applied postemergence provided poor



control, but acifluorfen [sodium 5-[(2-chloro-4-trifluoromethyl)-phenoxy]-2-nitrobenzoate] gave fair control of spotted spurge. Competition studies were done to determine the influence of 2 spotted spurge populations and 3 spurge removal dates on soybeans. The growth of spotted spurge and seed yield of soybeans varied between locations in 1980 and 1981. The greatest competition occurred at Knoxville in 1980 where all spotted spurge populations reduced yields. The effect of spotted spurge competition on soybeans was considerably less at Greeneville than Knoxville in 1981. The results indicate spotted spurge competition may reduce soybean seed yields more under dry conditions.

#### B. Introduction

Spotted spurge is a native plant that occurs throughout the eastern two-thirds of the United States and has been introduced along the Pacific coast and is now found from Washington to central California (42). It is an annual, reproducing by seeds which germinate in late spring and throughout the summer. It may be found in gardens, cultivated fields, along roadsides, bare places in meadows, and pastures, especially in dry soils (36).

Spotted spurge does not cause extensive problems anywhere in its range but is subject to control measures in some areas (22). At this time, it is not a problem on large soybean acreages in Tennessee; however, localized, heavy infestations occur in several parts of the state. It is the seventh most common weed in soybeans and special oil crops in Tennessee (40). Control of more competitive weeds may have

contributed to its being increasingly present in soybeans. Thus, it has become desirable to devote a substantial amount of research effort to work toward the control of this species in soybeans.

Spotted spurge was evaluated in no-till and conventionally planted soybeans for control by alachlor, linuron, and metribuzin in field experiments in Tennessee from 1977 to 1979. Alachlor at 2.2 kg/ha gave variable control of 85 and 100 percent, and metribuzin at rates of 0.6 and 1.1 kg/ha gave 100-percent control of spotted spurge (11). Results of this study indicate that control of spotted spurge was more effective under conventional tillage than under no-tillage.

The competitive influence of other annual broad-leaved weeds on soybeans has been determined and found to reduce bean yields (43). Barrentine (5) reported that full-season competition of common cocklebur (Xanthium pensylvanicum Wallr.) at densities of 3,300 and 26,000 plants/ha reduced soybean seed yields 10 and 52 percent, respectively. No work has been reported on the competitive influence of spotted spurge on soybeans.

The objectives of this investigation were to determine the response of spotted spurge to herbicides currently recommended in soybeans and the effect of spotted spurge competition on soybeans.

### C. Materials and Methods

#### Herbicide Study

Experiments with selected soybean herbicides were conducted at 3 locations in Tennessee from 1979 to 1981. The experiment was done



only at the Plant Science Farm near Knoxville in 1979. In 1980, experiments were also done at the Tobacco Experiment Station near Greeneville and the Milan Experiment Station, Milan. In 1981, experiments were done at Knoxville and Greeneville. The soil types were Sequatchie loam at Knoxville, Dewey silty clay loam at Greeneville, and Collins silt loam at Milan. Individual plots were 1.8 m by 2.5 m and were replicated 4 times in a randomized complete block design.

The soil was moldboard plowed in the fall. Phosphorus and potassium (19 and 37 kg/ha), respectively, were applied in early spring. Disking was used to incorporate the fertilizer and prepare the soil for fumigation. An area 10 m by 28 m was fumigated with methyl bromide at each location to kill weed seeds. After fumigation, the area was rototilled.

The preplant-incorporated herbicides applied each year were: vernolate (2.91 kg/ha), trifluralin (0.84 kg/ha), pendimethalin (0.84 kg/ha) and profluralin (0.84 kg/ha). The preemergence-applied herbicides were alachlor (2.24 kg/ha), linuron (0.56 kg/ha), and metribuzin (0.43 kg/ha). The postemergence herbicides applied were an overtop application of bentazon (0.84 kg/ha), naptalam (0.3 kg/ha) + dinoseb (0.6 kg/ha), and acifluorfen (0.56 kg/ha). The preplant-incorporated and preemergence herbicides were applied each year to coincide with soybean planting dates. The postemergence overtop herbicides were applied when the spotted spurge were approximately 5-10 cm in height. Herbicide applications were made using a hand-held carbon-dioxide powered sprayer calibrated to deliver 243 L/ha of spray solution at 4.2 kg/cm<sup>2</sup> pressure.



The experimental areas were artificially infested with spotted spurge by hand seeding. Plots were evaluated for weed control 4 and 8 weeks after planting. A visual rating system was used in which 0 percent indicated no weed control and 100 percent indicated complete control. A rating of 0-60 percent indicated poor control, 60-75 percent fair control, 75-90 percent good control, and 90-100 percent excellent control. Spotted spurge was harvested from plots before leaf-drop in the fall of each year and dry weight was determined. The yields of spotted spurge are expressed in percent of the weedy check because of substantial differences in weed yield at the different locations.

#### Competition Study

Field experiments to determine the effect of spotted spurge competition on soybeans were conducted at the Plant Science Farm near Knoxville in 1980 and 1981 on a Sequatchie loam and at the Tobacco Experiment Station near Greeneville in 1981 on a Dewey silty clay loam. Tillage methods and fertilizer application were the same as for the herbicide studies. An area 25 m x 25 m was fumigated with methyl bromide and later rototilled to prepare for planting. 'Essex' soybeans were planted in early June at a rate of 26 seeds/m of row with spacing of 76 cm between rows. Soybeans were treated with soybean inoculant before planting in 1981, but not in 1980. Hand weeding of other weed species was done at weekly intervals. Individual plots were 4 rows wide by 4.5 m long and were replicated 4 times in a randomized complete block design. Analysis of variance was computed on all data, and



significant differences were determined by using Duncan's multiple range test at the .05 level.

Spotted spurge seed was hand sown on individual plots at rates of 3,000 or 6,000 seed per plot immediately after soybeans had been planted. Spotted spurge was removed at either 6 weeks or 10 weeks after planting and at soybean grain harvest. Spotted spurge was removed from individual plots by cutting at ground level and the plots were kept weed-free thereafter. At each removal date the soybean growth stage was noted and the dry weight of the spotted spurge from an entire plot was determined after oven-drying at 65 C. Check plots were kept weed-free throughout the growing season. A total of seven treatments were involved with 4 replicates of each. The middle 2 rows of soybeans in each plot were harvested for grain yield with a stationary soybean thrasher.

In addition to natural rainfall, supplemental irrigations of approximately 2.5 cm each were applied at Knoxville on July 22, 1980, and August 12, 1980. Irrigation was applied at the same rate on July 18, 1981.

#### D. Results and Discussion

##### Weed Response

The average response of spotted spurge to the weed control treatments at Knoxville over 3 years is summarized in Table 6. Weed control differed from year to year because of environmental factors, mainly rainfall, especially for the postemergence overtop treatments. The

Table 6. Spotted spurge control and dry weight yield at Knoxville, Tennessee, 1979-1981.<sup>a</sup>

Treatments	Weed control				Dry wt. yield		
	1979	1980	1981	Avg.	1979	1980	1981
	----- % -----				- % of weedy check -		
Alachlor	--	100a	100a	100	--	0c	0e
Linuron	81c	40b	34d	52	14d	55ab	64b
Metribuzin	100a	100a	100a	100	0e	0c	0e
Profluralin	70d	--	--	70	12de	--	--
Pendimethalin	88b	88a	78bc	85	10de	4c	28cd
Trifluralin	64e	94a	91ab	83	8de	3c	12de
Vernolate	--	98a	87ab	93	--	4c	12de
Acifluorfen	--	41b	69c	55	--	12bc	39c
Bentazon	10f	14c	23de	16	49c	63a	68b
Naptalam + dinoseb	6f	13c	20e	13	62b	55ab	69b
Weedy check	0g	0d	0f	0	100a	100a	100a

<sup>a</sup>Means within a column followed by the same letter are not significantly different at the .05 level by Duncan's multiple range test.





greatest average weed control was obtained with metribuzin and alachlor applied preemergence, followed by vernolate applied preplant incorporated. The treatments pendimethalin, trifluralin, and profluralin applied preplant incorporated controlled 85, 83, and 70 percent, respectively. Linuron applied preemergence and acifluorfen applied postemergence overtop did not satisfactorily control spotted spurge. Acifluorfen controlled better compared to bentazon and naptalam + dinoseb applied postemergence overtop, which gave 16 and 13 percent weed control, respectively.

The average response of spotted spurge to herbicides at Greenville is summarized in Table 7. Excellent weed control was again achieved by metribuzin and alachlor applied preemergence. Vernolate and trifluralin applied preplant-incorporated gave excellent weed control. Pendimethalin applied preplant-incorporated gave good control. Acifluorfen applied postemergence overtop gave poor to fair weed control. All other treatments were poor in the control of spotted spurge.

Control of spotted spurge at Milan in 1980 was excellent in treatments of metribuzin and alachlor applied preemergence (Table 8). Vernolate, trifluralin, and pendimethalin applied preplant-incorporated also gave excellent weed control. Linuron applied preemergence gave fair weed control. All postemergence overtop applied herbicides gave poor control of spotted spurge at this location.

Metribuzin, alachlor, and vernolate gave excellent control of spotted spurge in all years and locations. Variable weed control from fair to excellent was provided with pendimethalin and trifluralin in

Table 7. Spotted spurge control and dry weight yield at Greeneville, Tennessee, in 1980 and 1981.<sup>a</sup>

Treatments	Weed control			Dry wt. yield	
	1980	1981	Avg.	1980	1981
	———— % —————			% of weedy check	
Alachlor	100a	100a	100	0d	0c
Linuron	44c	45c	45	32c	37c
Metribuzin	99a	100a	100	0d	0e
Pendimethalin	76b	65b	71	9d	28c
Trifluralin	100a	86a	93	0d	15d
Vernolate	98a	94a	96	4d	11de
Acifluorfen	46c	88a	67	6d	13d
Bentazon	2e	7e	5	67b	87b
Naptalam + dinoseb	11d	29d	20	42c	87b
Weedy check	0e	0e	0	100a	100a

<sup>a</sup>Means within a column followed by the same letter are not significantly different at the .05 level by Duncan's multiple range test.



Table 8. Spotted spurge control and dry weight yield at Milan, Tennessee, in 1980.<sup>a</sup>

Treatments	Weed Control	Dry wt. yield
	%	% of weedy check
Alachlor	100a	0c
Linuron	61b	26c
Metribuzin	100a	0c
Pendimethalin	94a	2c
Trifluralin	97a	5c
Vernolate	99a	1c
Acifluorfen	38c	24c
Bentazon	4d	56b
Naptalam + dinoseb	13d	57b
Weedy check	0d	100a

<sup>a</sup>Means within a column followed by the same letter are not significantly different at the .05 level by Duncan's multiple range test.





different years and locations. Pendimethalin gave 65 percent weed control at Greeneville in 1981 (Table 7) compared to 94 percent weed control at Milan (Table 8). Trifluralin gave 64 percent weed control at Knoxville in 1979 (Table 6) compared to 100 percent control at Greeneville in 1980 (Table 7). Linuron varied from 34 percent weed control in 1981 to 80 percent weed control in 1979 in Knoxville (Table 6). The performance of the postemergence overtop applied herbicides bentazon and naptalam + dinoseb was consistently poor in controlling spotted spurge. However, acifluorfen was extremely variable in its weed control. It varied from 38 percent weed control at Milan (Table 8) to 88 percent weed control at Greeneville in 1981 (Table 7). The data presented indicates that effective spotted spurge control can be achieved with most but not all preemergence and preplant-incorporated herbicides used in this study. Some of the herbicides varied in weed control between years and locations because of environmental factors such as rainfall patterns and available soil moisture. Herbicides applied to soil were much more effective than those applied postemergence overtop. Some type of post-emergence weed control may be necessary, in addition to the use of the postemergence overtop herbicides used in this study, to give satisfactory control of spotted spurge consistently if preemergence and preplant-incorporated herbicides have been ineffective.

#### Competition Study

At both locations, soybean plants emerged 7-8 days before the spotted spurge plants. The soybeans grew much more rapidly than the spotted spurge for the first month after emergence. During the months

of July and August spotted spurge grew at a faster rate than the soybeans. Spotted spurge reached approximately the same height as the soybeans in the second week of August; but after that, stayed about 5 cm shorter for the remainder of the season. Spotted spurge was observed to emerge until the end of August, especially following periods of precipitation.

Data on rainfall accumulation for each of the 2 locations in 1980 and 1981 are presented in Figure 4. Each location and year differed in amounts and distribution of rainfall. Yield of soybeans and growth of spotted spurge in each season and location reflected the total precipitation and the occurrence of dry periods (Figures 5-7). The seasons were similar at Knoxville in that each had a rather long period of low rainfall in mid-summer. However, the Greeneville location had no substantial dry period in 1981.

Soybean yields were reduced with longer duration of weed competition at Knoxville in 1980 (Figure 5). The influence of weed population density was not significant on soybean yields. The plots kept weed-free all season had the highest soybean yield, whereas yield was reduced 48 percent when spotted spurge was allowed to compete season long. The dry weight production of spotted spurge increased throughout the season. There was a reduction in dry weight of spotted spurge in plots left season long because these plots were harvested at soybean maturity when the spotted spurge plants had dropped their leaves.

Treatments of low weed population removed at 10 weeks and high weed population in which no removal occurred produced significant



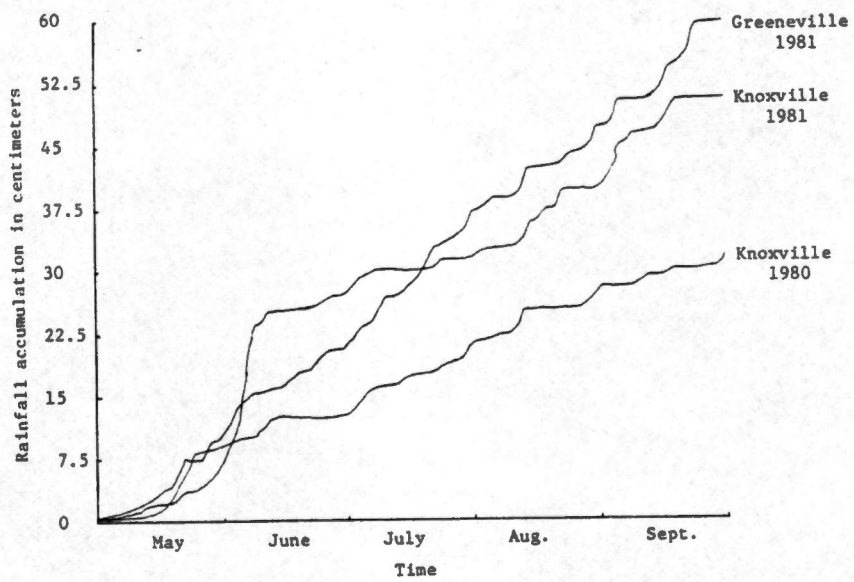


Figure 4. Cumulative rainfall for the growing seasons and locations of the competition experiments.

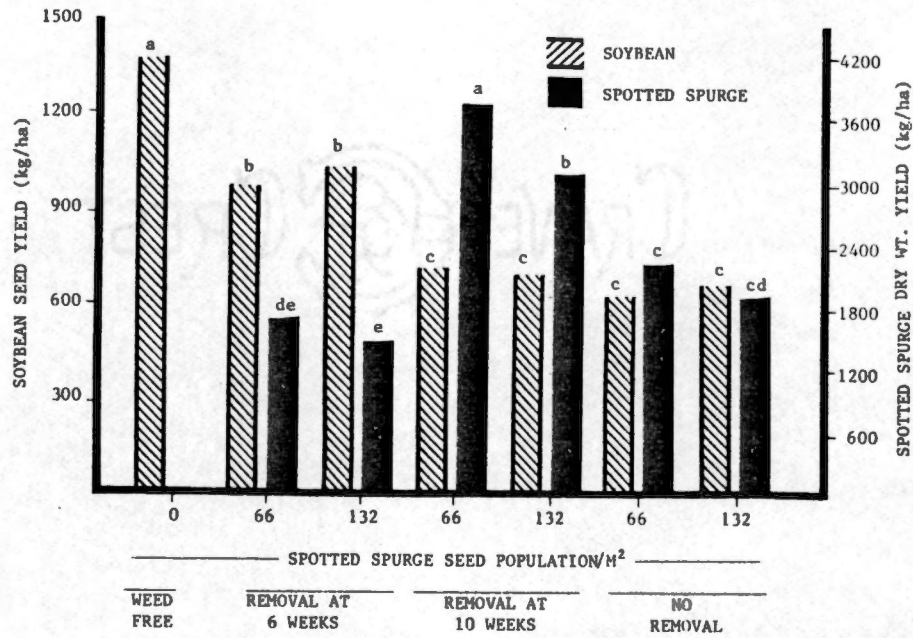


Figure 5. The effect of two different seeding rates and removal dates of spotted spurge on its dry weight yield and on the seed yield of soybeans in 1980 at Knoxville, Tennessee. Bars indicated with the same letter represent means that are not significantly different according to Duncan's multiple range test ( $P \leq 0.05$ ).



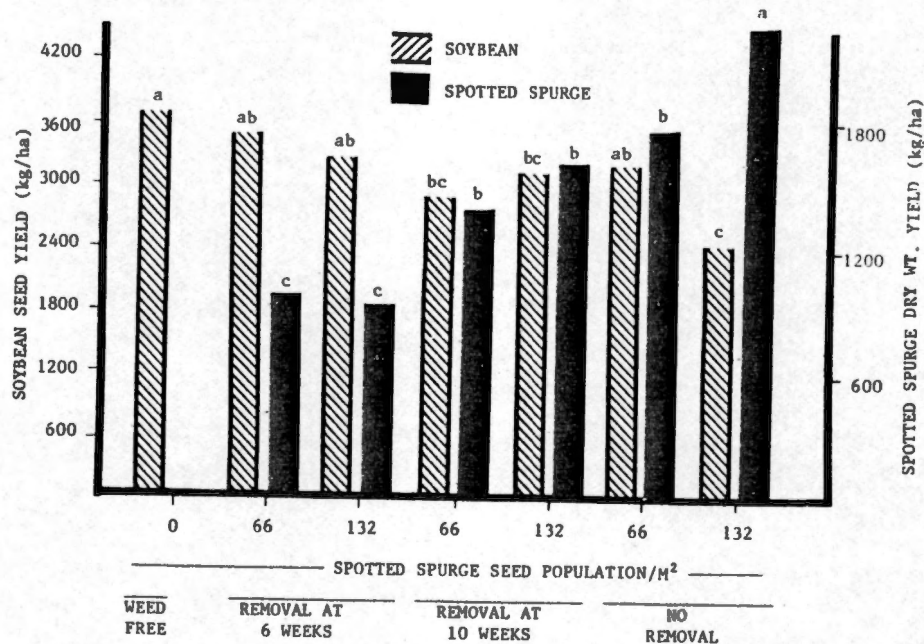


Figure 6. The effect of two different seeding rates and removal dates of spotted spurge on its dry weight yield and on the seed yield of soybeans in 1981 at Knoxville, Tennessee. Bars indicated with the same letter represent means that are not significantly different according to Duncan's multiple range test ( $P \leq 0.05$ ).

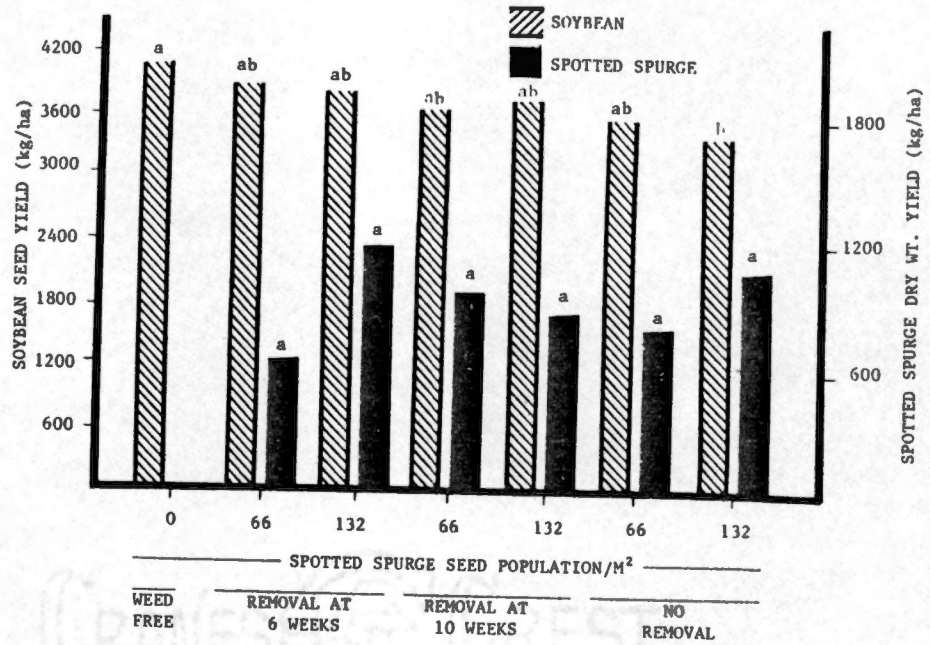


Figure 7. The effect of two different seeding rates and removal dates of spotted spurge on its dry weight yield and on the seed yield of soybeans in 1981 at Greeneville, Tennessee. Bars indicated with the same letter represent means that are not significantly different according to Duncan's multiple range test ( $P \leq 0.05$ ).



differences in soybean yields in 1981 at Knoxville (Figure 6). The soybeans kept weed-free yielded 3,725 kg/ha, and the high weed population plots in which no weeds were removed yielded 2,515 kg/ha. The dry weight of spurge increased throughout the growing season. Spotted spurge competition reduced soybean seed yields less in 1981 than in 1980 at Knoxville.

Soybean seed yield was significantly reduced only in the high weed population with no removal at Greeneville in 1981 (Figure 7). All other treatments did not significantly reduce soybean seed yields. The dry weight of spotted spurge harvested at each removal date did not increase consistently as the season progressed. The weed-free plots yielded 4,170 kg/ha of soybean seeds.

The growth of spotted spurge and seed yield of soybeans greatly varied between locations in 1980 and 1981. The greatest competition occurred at Knoxville in 1980 where all treatments were significantly lower than weed-free plots. Low rainfall during this season and lack of soybean inoculant were probably the principal reasons for the greater effect of spotted spurge competition. The results of the 1981 studies reflect the effect of spotted spurge competition on soybeans. Rainfall at Knoxville was less than at Greeneville, and most of it was in the beginning with a very dry mid-season. Greeneville had substantially more rainfall which was evenly distributed throughout the season. The effect of spotted spurge competition on soybeans was considerably less at Greeneville than Knoxville. Moisture supply probably was the principal environmental factor for which soybeans and spotted spurge

competed during the growing season. Soil fertility was high at both locations and spotted spurge did not overtop and seriously shade soybeans. Competition for these 2 factors, fertility and light, probably caused little reduction in soybean growth and seed yield.

Yield reductions were roughly proportional to the amount of growth made by spotted spurge. The growth of spotted spurge and seed yield of soybeans varied between locations in 1980 and 1981. The results indicate spotted spurge under dry moisture conditions may compete with soybeans reducing seed yield. The greatest competition occurred at Knoxville in 1980, where all spotted spurge populations reduced yields. The effect of spotted spurge competition on soybeans was considerably less at Greeneville and Knoxville in 1981. Season long competition of spotted spurge on soybeans will reduce yields making it advantageous to control this weed in most situations.



## CHAPTER V

### GENERAL SUMMARY

The purpose of this study was to (1) investigate factors affecting germination, dormancy, viability, and emergence of spotted spurge, (2) determine the response of spotted spurge to herbicides currently recommended in soybeans, and (3) determine the effect of spotted spurge competition on soybeans.

Laboratory and greenhouse experiments were done to investigate factors affecting the biology of this weed. Germination tests were conducted on mature spotted spurge seed which had been hand harvested during early October of each year. The optimum germination temperatures were 25 to 30 C, and seed incubated at 10 C did not germinate. The optimum pH for germination was 7. Germination was not different at seed moisture levels of 4 and 11 percent during storage. Storage of seed at an alternating regime of 4/21 C for 2 to 8 weeks reduced dormancy when compared to storage at -9/21 C and constant temperature treatments of -9, 4, and 21 C. Gibberellic acid significantly increased germination of dormant seed more than potassium nitrate or thiourea. Seed stored at 4 C maintained viability for two years but declined during the third year of storage. Emergence of spotted spurge seedlings decreased with increased depth of planting, and no emergence occurred at depths greater than four centimeters.

Field experiments to determine the response of spotted spurge to nine herbicides were done at one location in 1979, three in 1980, and

two in 1981 in Tennessee. The preemergence and preplant-incorporated herbicides were applied to coincide with soybean planting dates at each location. Spotted spurge was best controlled with metribuzin and alachlor applied preemergence in all years and locations. Vernolate applied preplant-incorporated also gave excellent weed control. Variable weed control from fair to excellent was provided with pendimethalin and trifluralin. Linuron applied preemergence varied in its control but was generally poor. The postemergence herbicides were applied when spotted spurge was 5-10 centimeters in height. Bentazon and naptalam + dinoseb applied postemergence provided poor control, but acifluorfen gave fair control of spotted spurge.

Competition studies were done to determine the influence of two spotted spurge populations and three spotted spurge removal dates on soybeans. The growth of spotted spurge and seed yield of soybeans varied between locations in 1980 and 1981. The results indicate this weed under dry moisture conditions may compete with soybeans to reduce seed yield. The greatest competition occurred at Knoxville in 1980 where all spotted spurge populations reduced yields. The effect of competition was considerably less at Greeneville and Knoxville in 1981.

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APPENDIX



APPENDIX A

Table 9. Herbicide application and harvest dates of spotted spurge at three locations in Tennessee in 1979-1981.

PRE + PPI* Application Date	POT* Application Date	Harvest Date	Location
6-03-79	7-08-79	10-03-79	Knoxville
6-01-80	7-09-80	9-20-80	Knoxville
6-05-80	7-29-80	10-03-80	Milan
6-13-80	7-16-80	10-09-80	Greeneville
6-16-81	7-20-81	9-05-81	Knoxville
6-12-81	7-14-81	10-02-81	Greeneville

\*PRE - Preemergence, PPI = Preplant-incorporated and POT = Postemergence over-the-top.

## VITA

Joe H. Hope, III, was born on November 14, 1952, in St. Louis, Missouri. He attended public schools in Abington, Pennsylvania, and in 1971 was graduated from Mountain Lakes High School, Mountain Lakes, New Jersey. He entered Clemson University, Clemson, South Carolina and one year later transferred to Moravian College, Bethlehem, Pennsylvania. He received his Bachelor of Science degree from Moravian College in June 1975. He entered The University of Tennessee, Knoxville, in September 1975 and later became a Graduate Research Assistant in the Department of Agricultural Biology. He received his Master of Science degree in June 1978. He became a Graduate Research Assistant in the Department of Plant and Soil Science in June 1978. He was a Senior Research Technician from September 1979 until September 1980 when he again became a Graduate Research Assistant. He received his Doctor of Philosophy degree in June 1982. He is a member of the Entomological Society of America and the Weed Science Society of America. He is married to the former Susan Jo Milne of Blairstown, New Jersey. They have two children, Heidi Katherine and Joe Edward.