THE CHEMICAL CONTROL AND GERMINATION OF LITTLE BARLEY

By

MARVIN LEON FISCHER

Bachelor of Science

Cameron University

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OF LITTLE BARLEY

Thesis Approved:

Jimmy T. Stritzke
Thesis Adviser

Robert L. Westerman

Eddie Basler

Norman N Durham
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Little barley is a cool-season weedy annual grass which is native throughout a large area of the United States. In some cases little barley can provide suitable forage for livestock, but in most instances, it is an undesirable species. It can present a problem in various crops, but is primarily a problem in pasture systems, small-grain production, and hay crops.

Heavy infestations of little barley can reduce early season yields of bermudagrass by competition for available moisture and nutrients. Contamination of the first cutting of bermudagrass hay with little barley can reduce the quality and therefore the value of the hay. Little barley produces a spike that can be a source of irritation to the eyes and mouths of livestock grazing on areas infested with the weed. The plant, like many other grasses, becomes unpalatable to livestock when it reaches maturity. Because of the nature of the spike the unpalatibility of the plant in late stages of maturity, livestock tend to avoid areas heavily infested with little barley and early season grazing may be lost from these areas.

Possible methods of controlling little barley would include spring mowing of pastures to prevent seed-head production or various types of chemical control. Factors which should be considered in the use of chemical control include selection of the proper herbicide, application

rate, and time of application. Preliminary studies indicated that after application of a contact herbicide in the fall, the little barley was present the following spring. This may have been due to a late fall germination or early germination in the spring or a combination of both. Because of this, experiments were designed to evaluate various herbicides for the control of little barley and to observe the germination and emergence characteristics of little barley in the laboratory and field.

The objectives of these experiments were to (1) evaluate various dates of application of paraquat, (2) determine the effectiveness of several residual herbicides, (3) determine the effect of various environmental factors on germination, (4) determine when seed becomes viable, (5) evaluate germination of little barley seed under various temperature regimes, (6) evaluate the germination of seed collected from plots treated with paraquat, and (7) observe seedling emergence and development of little barley planted at various dates under field conditions throughout the fall and spring.

CHAPTER II

LITERATURE REVIEW

Little barley (common and scientific names of all plants reviewed are listed in Table 1) is a native cool-season annual grass. Hitchcock (17) described the plant as having culms 10-35 cm tall, erect flat blades and a spike 2-7 cm long and 10-14 mm wide. He further noted that the first glume of the lateral spikelets and both glumes of the central fertile spikelets were dilated above the base and attenuated into slender awns 8-15 mm long. According to Hitchcock (17), little barley can be found growing throughout the majority of the continental United States, with the exception of the extreme north-eastern states.

In the past, efforts have been made by some to utilize the plant as part of a grazing system, while others consider it a weed and try to control it by using various herbicides. Whitfield et al. (34) reported the use of little barley to provide part of the spring graze in a year-round grazing system in Texas. Morgan (21) observed that weedy grasses such as little barley and the annual bromegrass could provide a high quality graze or hay in a pasture system. He stated that the plants must be utilized before heading since at that stage the plant becomes unpalatable to livestock. Smith (29) reported that little barley in a bermudagrass pasture could provide substantial forage for grazing during the period of bermudagrass dormancy. He noted that in the younger stages of development, the foliage is highly digestable

Table 1. Common and scientific names of plants.

Common name	Scientific name
Alfalfa	Medicago sativa L.
Annual bromegrasses	Bromus spp.
Bermudagrass	Cynodon dactylon var. dactylon (L.) Pers.
Chess	Bromus secalinus L.
Cogongrass	Imperata cylindrica (L.) Beauv.
Downy brome	Bromus tectorum L.
Fescues	Festuca spp.
Indiangrass	Sorghastrum nutans (L.) Nash
Japanese brome	Bromus japonicus Thunb.
Kentucky bluegrass	Pao pratensis L.
Little barley	Hordeum pusillum Nutt.
Old World bluestem	Bothriochloa ischaemum (L.) Keng
Pecan	Carya illinoensis (Wangenh.) K. Koch
Red fescue	Festuca rubra L.
Six-weeks fescue	Festuca octoflora Walt.
Slender oat	Avena barbata Brot.
Soft chess	Bromus mollis L.
Sugarcane	Saccharum officinarum L.
Tall fescue	Festuca arundinacea Schreb.
Winter wheat	Triticum aestivum L.

and desired by the grazing animal.

Even though the plant has some desirable qualities, its undesirable qualities are such that it is listed as one of the ten most troublesome weeds in pastures in Mississippi and Alabama, one of the ten most troublesome weeds in small-grain production in Alabama, Arkansas, Georgia, Louisiana, Oklahoma, and Tennessee, and is reported to be one of the ten most costly weeds in pastures in Mississippi (24, 25, 26, and 27).

One of the most undesirable traits is associated with the awns on the seed heads at maturity. Albert (5) reported that the awns on mature spikelets of little barley may cause irritations to livestock grazing on infested pastures or fed hay produced from pastures infested with little barley. Smith (29) also stated that the awns were a source of external and internal irritation to the grazing animal. The presence of little barley in the first cutting of bermudagrass hay can reduce the value of the hay (Albert, 5). Sholar and Stritzke (28) reported a significant increase in protein content of harvested forage, at one location, when little barley was controlled. They also noted a three-fold increase in bermudagrass production when little barley was controlled, this probably being due to reduced competition by little barley for available moisture and nutrients.

Little barley is also a problem in other crops. Runyan and Peeper (23) found that large amounts of little barley seed resulted in very low test weights of winter wheat. Pafford and Addink (22) reported on weed control in sugarcane with little barley being one of the annual grasses present. It was also present in work conducted on winter weed control in pecan orchards by Daniel and Hardcastle (9).

Control of Little Barley

There has been little research published on the control of little barley in bermudagrass pastures. Albert (4) reported that atrazine and simazine (common and chemical names of herbicides are listed in Table 2), applied when little barley was at the early tiller and full tiller stages, controlled the grass. Atrazine gave somewhat better control than simazine. He found that a rate of 1.68 kg/ha of atrazine gave almost 100% control. Sholar and Stritzke (28) found that atrazine applied in March, 1976 resulted in excellent control of little barley in bermudagrass pastures at three locations in Oklahoma. Albert (5) reported that paraquat (0.56 kg/ha) provided excellent control of little barley in bermudagrass pasture. He found that bermudagrass foliage which was present at the time of application was killed but regrowth appeared promptly. Sholar and Stritzke (28) also reported on the use of paraquat (0.28 kg/ha) but observed varying degrees of control depending on location. Frans (16) evaluated the use of picloram for controlling little barley in bermudagrass turf. He observed varying results of control and erratic response of bermudagrass to the herbicide. Stritzke (31) found that a fall application of glyphosate in bermudagrass controlled japanese brome but was not effective in controlling little barley.

Dickens et al. (1) reported that diphenamid, simazine, and EPTC controlled little barley in alfalfa and other fall-seeded forage crops. Pafford and Addink (22) reported little barley could be controlled in sugarcane by using tebuthiuron according to label recommendations. Daniel and Hardcastle (9) observed effective control of little barley and other summer and winter grasses in pecan orchards with several herbicides and herbicide combinations. Some of the effective treatments

Table 2. Common and chemical names of herbicides.

Common name	Chemical name
Atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine
Dalapon	2,2-dichloropropionic acid
Dichlobenil	2,6-dichlorobenzonitrile
Diphenamid	*N*,*N*-dimethyl-2,2-diphenylacetamide
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
EPTC	*S*-ethyl dipropylthiocarbamate
Glyphosate	*N*-(phosphonemethyl)glycine
Metribuzin	4,amino-6-*tert*-butyl-3-(methylthio)-*as*-triazin-5-(4*H*)-one
Paraquat	1,1'-dimethyl-4,4'bipyridinium ion
Picloram	4,-amino-3,4,6-trichloropicolinic acid
Simazine	2-chloro-4,6-bis(ethylamino)-*s*-triazine
Tebuthiuron	*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N*,*N*'-dimethylurea

were simazine (6.72 kg/ha in the spring and 6.72 kg/ha in the fall), simazine (4.48 kg/ha in the spring and 4.48 kg/ha in the fall) plus dalapon (5.6 kg/ha in the spring), diuron (4.48 kg/ha in the spring and 4.48 kg/ha in the fall), dichlobenil (6.72 kg/ha in the spring and 6.72 kg/ha in the fall) plus paraquat (0.56 kg/ha in the spring) and metribuzin (2.8 kg/ha in the spring and 2.8 kg/ha in the fall).

Germination

Effect of Temperature on Germination

There are several factors which may act to promote or inhibit germination. As in other biological processes, temperature is an important factor in germination. There are different types of apparatus which can be used to study a range of various temperatures simultaneously. Fox and Thompson (15), Timbers and Hocking (32), and Evans et al. (13) have reported on the use of a temperature-gradient bar to study germination and other biological investigations. Cleggs and Eastin (8) developed a thermo-gradient sandbox to study the effects of varying constant temperatures on seed germination and growth of plants. Although some germination of cool season annual grasses may occur at wide ranges of temperature, certain constant temperature regimes or the use of alternating temperatures may be needed to obtain maximum germination. Many researchers have studied the use of alternating temperatures in germination techniques. The Association of Official Seed Analysts (7) recommended an alternating of 20-30 C for germination of many of the cool season grasses.

Young et al. (35) observed that soft chess and slender oat showed higher germination in alternating temperatures than in constant temp-

eratures. Steinbauer and Grisby (30) reported that chess was highly germinable one month after harvest at constant temperatures between 15 and 30 C and at alternating temperatures of 20-30 C. Kearns and Toole (19) found that alternating temperatures were better than constant temperatures for breaking the dormancy of several fescue species. However, Hylton and Bass (18) found that a constant temperature of 20 C resulted in higher germination of six-weeks fescue than an alternating 15-25 C. Steinbauer and Grisby (30) reported that alternating temperatures were not required for the germination of downy brome and chess.

Effect of Potassium Nitrate on Germination

One of the most widely used chemicals to promote germination is potassium nitrate. Ahring and Todd (2) found that germination of bermudagrass was promoted by using a substrate moistened with a 0.2 % KNO_3. Dickens and Moore (10) observed that while KNO_3 did not increase germination of cogongrass in the light, it did increase germination after 15 days in the dark. The best environment for measuring the germination capacity of Bothriocloa ischaemum varieties includes the use of 0.2 % KNO_3 as the substrate moistening agent (Ahring and Harlan, 1). Evans and Young (14) reported that KNO_3 and combinations of KNO_3 and GA_3 were effective in breaking dormancy of downy brome in litter samples collected in the spring and fall, but not from collections in midwinter when the dormancy was the greatest.

In an experiment using various salts containing K^+ and NO_3^-, Ahring et al. (3) found that the NO_3^- was responsible for increasing germination and the K^+ had no effect. They also suggested that other salts such as

$Ca(NO_3)_2$ and NH_4NO_3 were equally effective in promoting germination. Young and Evans (36) found that downy brome seeds acquire a dormancy when exposed in field seedbeds over winter. They observed that germination was responsive to nitrate concentrations in the soil.

Effect of Light on Germination

The presence or absence of light may also affect germination. Evans et al. (13) reported that many winter annual weeds will germinate in the dark. Steinbauer and Grisby (30) found that light was not required for the germination of chess or downy brome.

While light may not be essential for germination, it may act to increase the percentage of total germination. Dickens and Moore (10) found that light increased both the total germination and the rapidity of germination of cogongrass. Emal and Conard (12) also observed that both the amount of light and the quality of light affected the germination of indiangrass. Bermudagrass seed also germinated better when exposed to light (Ahring and Todd, 2).

Effect of Pretreatments on Germination

Dormant seed may be induced to germinate by using various pregermination treatments. Prechilling and preheating alone or in combination with some of the previously mentioned chemicals may aid in breaking dormancy. Emal and Conard (12), Ahring and Todd (2), and Ahring et al. (3) have reported on the use of pretreatments to induce or increase seed germination. The Association of Official Seed Analysts (7) suggest prechilling for six weeks in combination with the use of KNO_3 for breaking dormancy of many seeds.

Effect of Paraquat on Germination

A portion of this review was directed at the effect of paraquat on seed germination. Appleby and Brenchley (6) reported that an application of paraquat (1.12 kg/ha) to grass seeds on the soil surface severely decreased seed germination. However, they found that a thin protective layer of soil on the seed was completely effective in protecting the seeds from the effects of paraquat. Watkin and Sagar (33) also reported that paraquat affected the germination of some grass seeds. Klingman and Murray (20) found that spraying the seeds of Kentucky bluegrass, red fescue and tall fescue with 2.2 kg/ha paraquat or covering the seeds with clippings from paraquat-treated turf, greatly reduced their germination.

CHAPTER III

METHODS AND MATERIALS

Control Studies

In the spring of 1978, three field experiments were initiated to evaluate various herbicides, rates and application dates for the control of little barley. The first was a herbicide screening using four residual herbicides, the second was an experiment testing two formulations and three rates of metribuzin, and the third was a date of application study with paraquat. The three studies will be referred to hereafter as Studies I, II, and III, respectively.

A location at the Agronomy Research Station, near Perkins, Oklahoma, was selected for the experiment. The area had a natural infestation of little barley. The experimental design for all three studies was a randomized complete block design. The plot size was 2.13 X 6.09 meters. All studies were replicated four times. The herbicides for Studies I and II were applied April 13, 1978. See Tables 3 and 4 for herbicide treatments in Studies I and II. See Table 5 for the dates of application for Study III. The herbicides were applied with a hand-held carbon dioxide broadcast sprayer, at a pressure of 2.1 ksc and a carrier volume of 243.2 l/ha with the exception of the granular formulation of tebuthiuron. The tebuthiuron granules were broadcast evenly through the plots by hand. See Tables 6 and 7 for plot infor-

Table 3. Application rates for Study I.

Herbicide	Rate (kg/ha)
Atrazine	1.12
Diuron	1.12
Simazine	1.12
Tebuthiuron 1/	0.56, 0.84, 1.12
Tebuthiuron 2/	0.56, 0.84, 1.12

1/ Wettable powder
2/ Granular

Table 4. Metribuzin formulation and rates for Study II.

Formulation	Rate (kg/ha)
Wettable powder	0.28
" "	0.56
" "	0.84
Flowable liquid	0.28
" "	0.56
" "	0.84

Table 5. Application date of paraquat, growth stages of little barley, and application rate for Study III.

Application date	Growth Stage	Rate (kg/ha)
4-13-78	Early tillering	0.28
4-20-78	Jointing	0.28
4-30-78	Boot	0.28
5-08-78	Flowering	0.28
5-19-78	Fruiting	0.28

Table 6. Plot information and spraying conditions for Studies I and II.

Date treated	April 13, 1978
Soil	Teller fine sandy loam
Dry Bulb Temperature	24 C
Humidity	31 %
Soil temperature (10 cm)	17 C
Wind speed and direction	6-8 kph, SE
Soil moisture	Excellent
Vegetative stage	
Little barley	Early tillering
Bermudagrass	Breaking dormancy

Table 7. Plot information and spraying conditions for Study III.

Date	4-13-78	4-20-78	4-30-78	5-8-78	5-19-78
Growth stage of little barley	Early tillering	Jointing	Boot	Flowering	Fruiting
Dry bulb temperature	22 C	16 C	23 C	24 C	32 C
Humidity	48 %	48 %	86 %	66 %	66 %
Soil temperature at 10 cm	18 C	19 C	19 C	24 C	24 C
Wind speed and direction	6-8 kph, SE	2-3 kph, NE	3-5 kph, SE	6-10 kph, SE	8 kph, SE
Time of day	5:00 p.m.	4:00 p.m.	4:00 p.m.	3:45 p.m.	3:45 p.m.
Soil moisture [1/]	Excellent	Good	Good	Excellent	Good

[1/] Teller fine sandy loam

mation and spraying conditions. Rainfall data is given in Table 8. NH_4NO_3 (67.2 kg/ha of nitrogen) was applied to the studies on May 8.

The control of little barley was evaluated by comparing forage production from treated and untreated plots. Prior to harvest, the percentage of bermudagrass, little barley, weedy grasses, and forbs were estimated for each plot. The plots were harvested June 8, 1978. Total forage production was removed from a 0.418 square meter sample area from each plot by hand-clipping. The forage samples were oven-dried and dry weights were recorded.

The data was subjected to a two-way classification analysis of variance. The LSD values were calculated at the five percent level to show statistical differences.

Germination Studies

Laboratory and field studies were conducted to observe the germination and emergence of little barley under various conditions. The seeds for the studies were collected in May and June, 1978. The laboratory studies were as follows: 1) The effect of temperature, light, moistening agents and prechill treatments on germination. 2) The optimum constant temperature for germination. 3) The germination of seed collected at various dates after flowering. 4) The germination of little barley seed collected from paraquat-treated areas. Since the individual spikelets of little barley contain one fertile floret, the spikelet was considered as one seed unit. Fifty seed units were selected at random for each treatment replication. Plastic boxes (7.6 X 7.6 X 2.5 cm) with lids were used as the germination containers in the tests. The seed units were evenly distributed on three layers

Table 8. The rainfall data from January, 1978 through June 1978.

Month	(cm)
January	2.34
February	6.68
March	3.71
April	4.70
May	18.49
June	11.66

of germination substrate moistened with 6 ml of de-ionized water or a 0.2 % KNO_3 solution. The lids of each germination box were taped to prevent moisture loss.

Effect of Environmental Factors on Germination

Two studies were conducted simultaneously to determine the effect of various factors on the germination of little barley. The main factors evaluated were moistening agent (de-ionized water and 0.2 % KNO_3), light conditions (continuous dark and 8 hours light plus 16 hours dark), and length of prechill treatment (0, 1, 2, 3, 4, 5, and 6 weeks) on moist substrate. One study was in a constant 20 C and the other in an alternating 20-30 C environment. The experimental design for both studies was a randomized complete block with a 2 X 2 X 7 factorial arrangement of treatments replicated four times.

Prechill treatment was storage at 5-10 C in the dark. Seeds were placed into prechill storage at weekly intervals until a range from 0-6 weeks was obtained. The germination boxes which were to be germinated in the dark were wrapped with aluminum foil prior to prechill. After the prechill, containers were placed into the respective germinators (constant 20 C or alternating of 16 hours at 20 C and 8 hours at 30 C).

After seven days, the containers were removed from the germinators and number of seeds with shoots recorded. The containers were then placed back into their respective chambers for another seven days. The aluminum foil was removed from the dark treatments after the first count to determine if the seed units would respond to light. After the second week, the boxes were again removed and number germinating and

number of firm seed remaining recorded.

The data was subjected to statistical analysis and LSD values were used to determine significant differences.

Optimum Constant Temperature for Germination

Another laboratory test was initiated to evaluate the germination of little barley at six different constant temperatures. The temperatures were 13, 17, 21, 25, 30, and 34 C. A thermo-gradient sand-box (originally designed by Clegg and Eastin, Univ. of Nebraska, 1978) was used so that all the temperature variants could be evaluated simultaneously. The box (15.2 X 91.4 X 91.4 cm) consisted of five tiers separated by 0.63 cm aluminum alloy plates (15.2 cm deep and 15.2 cm apart) welded to aluminum end plates. Stainless steel water tanks (91.4 X 14.6 X 15.2 cm) were attached to each end-plate. The temperature gradient was developed by heating one tank to 40 C and cooling the other tank to 9 C. This was possible by using seperate themostat-selenoid valve systems. Dilute ethyl-glycol circulated from the freon-ethylene glycol exchange system through coils in one tank was used to achieve the low temperature end. The high temperature in the other tank was maintained by an electrical heating coil. Small water pumps placed in each tank were used to maintain uniform temperatures at each end. The thermo-gradient sand-box, insulated with a 3.8 styrofoam and filled with washed sand, provided a linear temperature gradient.

Germination boxes, containing 50 seeds placed on substrate moistened with de-ionized water, were buried at uniform depths 15 cm apart through-out the length of each of the five tiers. Thermometers were positioned by each box to record the temperature at each position.

After seven days each box was removed from the unit and the number of germinated seedlings was recorded. The remaining seed units were then placed in an alternating 20-30 C environment to determine if the higher temperatures had affected the germination capacity of the seed. After the second week the containers were removed from the germinator and the number of germinated seedlings and firm seed was recorded. This entire procedure was repeated four times to give four replications with each replication having five subsamples.

The data from the five subsamples was averaged for each replication. It was then subjected to a two-way classification analysis of variance. Statistical differences were obtained by using LSD values calculated at the five percent level.

Viability at Different Dates After Flowering

In the spring of 1978, little barley spikes were collected at various intervals after flowering to determine when seed becomes viable. The collection dates were 11, 15, 18, 22, 26, and 31 days after flowering. The seed heads were seperated into upper and lower portions after all collections were made to determine if one portion became viable quicker than the other.

The germination test was conducted in an alternation of 16 hours of dark at 20 C and 8 hours of light at 30 C. De-ionized water was used as the moistening agent. A randomized complete block design with six replications was used for the test. The number of seed germinated was recorded at 7 and 14 days. After all seedlings were removed at the end of 14 days, the number of firm seeds remaining were recorded.

The data was analyzed by a two-way classification analysis of

variance. Statistical differences were found by using LSD values calculated at the five percent level.

Seed Germination from Paraquat-treated Plots

After dry weights were obtained from the forage samples collected from Control Study III, little barley seeds were removed from each treatment and replication. The seeds were then subjected to a test to evaluate their capacity to germinate. The paraquat had been applied to the areas at five different growth stages of little barley.

The germination environment was an alternating of 16 hours of dark at 20 C and 8 hours of light at 30 C. De-ionized water was used as the moistening agent. A randomized complete block design with four replications was utilized for the test. Germinated seedling counts were recorded at 7 and 14 days whereas, the number of firm seeds remaining at the end of the study were recorded after the 14-day count. Statistical analysis was the same as the previous study.

Date of Planting Study

A field study, to observe seedling emergence, was initiated in the fall of 1978 at the Agronomy Research Station, Stillwater, Oklahoma. See Table 9 for planting dates. A randomized complete block design replicated four times was used for the experiment. A plot consisted of seeding 50 seeds in 0.91 meter rows spaced every 0.3 meter. Seeds were planted 1.0 to 1.5 cm deep in one row at each planting date. Border rows were planted on each end of the four replications. The study was irrigated after each planting date to insure adequate moisture for germination. A recording soil thermometer was utilized to monitor soil

temperature throughout the duration of the experiment. See Table 10 for daily minimum and maximum temperatures. Seedling emergence was recorded at 7, 14, 21 and 28 days after each planting date.

Total plant growth was harvested on June 25, 1979, to evaluate differences in forage and seed production of the various planting dates. A sample was taken from each to determine the percentage, by weight, of seed head and vegetative growth. The number of seeds per head was then taken from each sample. These values were then converted to a total plot basis.

Table 9. The planting dates in the fall, 1978 and spring, 1979 of little barley.

Fall 1978	Spring 1979
09-20-78	3-14-79
10-04-78	3-28-79
10-18-78	4-11-79
11-01-78	4-25-79
11-22-78	

Table 10. The minimum and maximum daily soil temperatures (C) during field emergence study.

Day	Sept. Min.	Oct. Min.	Oct. Max.	Nov. Min.	Nov. Max.	Dec. Min.	Dec. Max.	Mar. Min.	Mar. Max.	Apr. Min.	Apr. Max.	May Min.	May Max.
1	--	--	--	8	18	2	9	--	--	12	13	12	19
2	--	--	--	9	19	6	11	--	--	8	15	13	21
3	--	--	--	12	20	-2	-1	--	--	8	13	--	--
4	--	15	--	12	19	-3	1	--	--	6	16	--	17
5	--	--	--	11	18	-1	7	--	--	7	--	10	24
6	--	--	--	7	8	-1	1	--	--	7	--	10	24
7	--	--	--	2	13	-2	1	--	--	10	--	11	27
8	--	--	--	3	13	-2	-2	1	11	13	--	17	27
9	--	--	--	6	14	-3	-2	4	11	--	--	18	26
10	--	--	--	8	16	-5	-2	1	11	--	--	13	15
11	--	15	--	5	10	-5	-2	0	14	--	--	8	--
12	--	--	--	4	9	-4	-1	3	18	--	--	--	--
13	--	--	--	9	14	-3	0	8	16	--	--	--	--
14	--	--	--	3	5	-2	1	3	16	--	--	--	--
15	--	--	--	2	3	-4	5	6	9	--	--	--	--
16	--	--	--	3	4	-2	3	6	7	--	--	--	--
17	--	--	--	1	6	-3	1	6	10	--	--	--	--
18	--	--	--	-1	11	1	4	10	17	--	16	--	--
19	--	13	20	4	11	7	11	8	9	14	22	--	--
20	24	13	21	2	5	6	8	6	16	16	18	--	--
21	--	12	18	1	5	--	--	9	16	--	23	--	--
22	--	15	21	2	6	--	--	13	19	11	24	--	--
23	--	12	13	7	13	--	--	9	11	13	27	--	--
24	--	8	16	7	13	--	--	6	14	12	28	--	--
25	--	12	18	8	12	--	--	6	18	16	28	--	--
26	--	5	16	6	12	--	--	8	19	11	24	--	--
27	18	4	17	2	7	--	--	8	18	9	15	--	--
28	--	6	18	0	8	--	--	13	20	6	15	--	--
29	--	6	18	3	9	--	--	16	23	6	20	--	--
30	--	7	19	3	9	--	--	16	23	7	24	--	--
31	--	9	19	--	--	--	--	13	22	--	--	--	--

CHAPTER IV

RESULTS AND DISCUSSION

Control Studies

Forage yields for Study I are given in Table 11. Forage production of little barley was reduced by all herbicides evaluated. Atrazine (1.12 kg/ha), the granular formulation of tebuthiuron (0.84 and 1.12 kg/ha) and the wettable powder formulation of tebuthiuron (0.56, 0.84 and 1.12 kg/ha) resulted in a significant decrease in forage production of little barley. Bermudagrass forage production was increased with all herbicides except the 0.84 kg/ha rate of the granular formulation of tebuthiuron. However, increased bermudagrass forage yields were significant only when treated with simizine (1.12 kg/ha) and the wettable powder formulation of tebuthiuron (0.84 and 1.12 kg/ha). Results of the forage production of the other weedy grasses and forbs were erratic and no significant differences were noted for any of the herbicides applied. Total forage production was not significantly affected by any of the treatments. The wettable powder formulations of tebuthiuron (0.84 and 1.12 kg/ha) resulted in the best control of little barley and the highest increase of bermudagrass forage production.

Simazine and diuron are primarily used as preemergence herbicides. It is possible that better control of little barley would have resulted if these herbicides were applied in the fall.

Table 11. Influence of various herbicides on forage production of little barley, bermudagrass and other weed components.

Treatment (April 13, 1978)	Rate (kg/ha)	Dry weight-kg/ha [1/]				
		Little Barley	Bermudagrass	Weedy grasses	Forbs	Total
Untreated	----	1670	1180	120	160	3130
Atrazine	1.12	340	1740	140	100	2320
Diuron	1.12	1050	1840	120	80	3110
Simazine	1.12	1130	1890	60	190	3270
Tebuthiuron [2/]	0.56	1590	1810	80	100	3580
Tebuthiuron [2/]	0.84	630	1060	220	240	2150
Tebuthiuron [2/]	1.12	600	1500	80	70	2250
Tebuthiuron [3/]	0.56	460	1490	60	90	2100
Tebuthiuron [3/]	0.84	180	1940	40	40	2200
Tebuthiuron [3/]	1.12	170	2250	40	30	2490
LSD 0.05		680	680	NS	NS	NS

1/ Harvested on June 8, 1978

2/ Granular formulation

3/ Wettable powder formulation

Forage production for Study II is listed in Table 12. The two highest rates (0.56 and 0.84 kg/ha) of both formulations of metribuzin significantly reduced the forage production of little barley. Increased forage production of bermudagrass was observed with these rates of both formulations, but was not significant at the levels tested. The production of other weedy grasses other than little barley was not significantly reduced by formulations of metribuzin at any of the rates tested. However, production of forbs was significantly reduced with all treatments except the 0.28 kg/ha rate of the flowable liquid formulation. The combined forage production of all yield components was not significantly different from the check for any treatment in the study.

Forage production for Study III is given in Table 13. The forage production of little barley was significantly reduced when paraquat (0.28 kg/ha) was applied on all dates evaluated as compared to the untreated areas. Bermudagrass forage production was increased only when paraquat (0.28 kg/ha) was applied on April 13, 1978 when the little barley was in the early tillering growth stage. Application of paraquat on April 20 and 30, 1978 when little barley was in the jointing and boot stages, respectively, and bermudagrass was actively growing, may have injured the bermudagrass since a significant increase in the forage production of other weedy grasses resulted from those application dates. The forage production of forbs was decreased when paraquat was applied on all dates evaluated but was significant only when applied on May 8 and 19, 1978. Total forage production was decreased by all treatments as compared to the untreated area. This was primarily due to the control of little barley, but some reduction may be due to bermudagrass injury at the later application dates.

Table 12. Influence of formulation and rate of metribuzin on forage production of little barley, bermudagrass, and other weed components.

Treatment (April 13, 1978)	Rate (kg/ha)	Dry weight-kg/ha [1/]				
		Little barley	Bermudagrass	Weedy grasses	Forbs	Total
Untreated	----	1290	950	220	290	2750
Metribuzin [2/]	0.28	1020	750	290	90	2150
MetribuzIn [2/]	0.56	700	1370	210	150	2430
Metribuzin [2/]	0.84	560	1470	280	100	2420
Metribuzin [3/]	0.28	1230	970	280	160	2640
Metribuzin [3/]	0.56	830	1130	190	120	2270
Metribuzin [3/]	0.84	470	1310	190	70	2030
LSD 0.05	----	400	NS	NS	140	NS

[1/] Harvested on June 8, 1978

[2/] Wettable powder

[3/] Flowable liquid

Table 13. Influence of application data of paraquat on forage production of little barley, bermudagrass, and other weed components.

Application date of paraquat 1/	Dry weight-kg/ha 2/				
	Little barley	Bermudagrass	Weedy grasses	Forbs	Total
Untreated	2820	1320	120	180	4440
April 13, 1978	550	1860	410	130	2950
April 20, 1978	260	1340	880	150	2630
April 30, 1978	270	1400	620	120	2410
May 8, 1978	60	1310	500	80	1950
May 19, 1978	480	1490	130	50	2150
LSD 0.05	654	299	381	84	868

1/ 0.28 kg/ha

2/ Harvested on June 8, 1978

Germination Studies

Effect of Environmental Factors on Germination

The effects of light, H_2O or KNO_3, and the length of prechill on the germination of little barley is a constant 20 C environment are shown in Figure 1. The germination percentage at 7 days is plotted against the length of prechill for both light and dark conditions. Germination, on H_2O moistened substrate, in light, was considerably higher than in the dark at the 0, 1, and 2 weeks of prechill. However, as the length of prechill increased from 3 to 6 weeks, the differences between light and dark were less noticeableable, with a steady decrease in germination with both light and dark. When KNO_3 was used as the moistening agent, germination in the light and dark were very similar. A one-week prechill duration increased seed germination under both light and dark conditions as compared to no prechilling. There was only a slight decrease in germination as the length of prechill increased.

The effects of these same factors, in an alternating 20-30 C environment are shown in Figure 2. Germination in light was approximately 10 percent higher than in the dark throughout all stages of prechill when H_2O was used as the moistening agent. As the length of prechill increased, there was a significant decrease in the germination of the seed. One week of prechill resulted in a higher germination than no prechill when KNO_3 was used to moisten the substrate. However, germination in light and dark was not significant for any prechill treatment durations. Seed germination was very similar with most of the prechill treatments. A slight decrease in germination

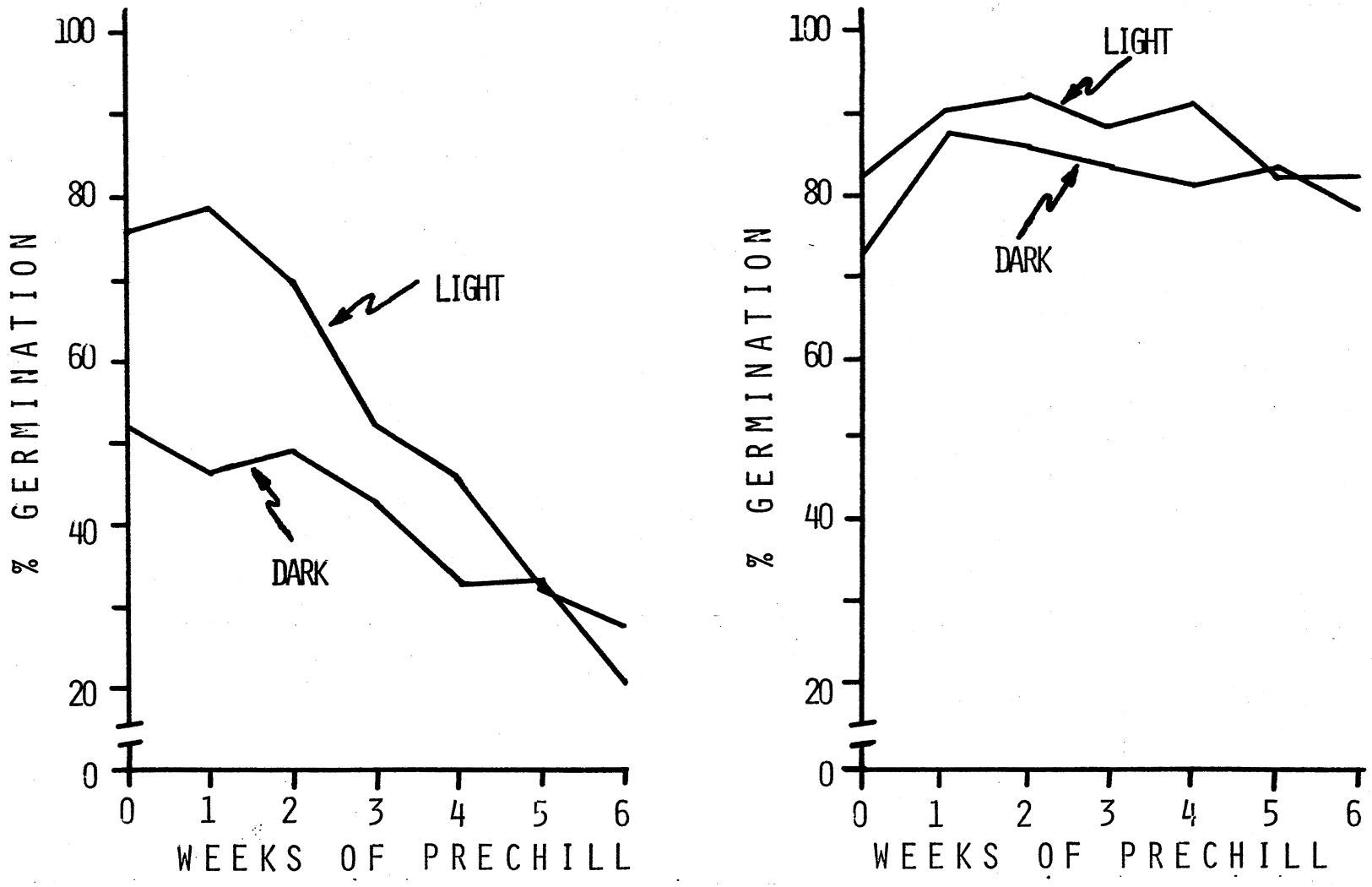

Figure 1. The effect of moistening agent, light, and prechill on germination of little barley after seven days in a constant 20 C. Water was used as the moistening agent in (a) and KNO_3 was used in (b).

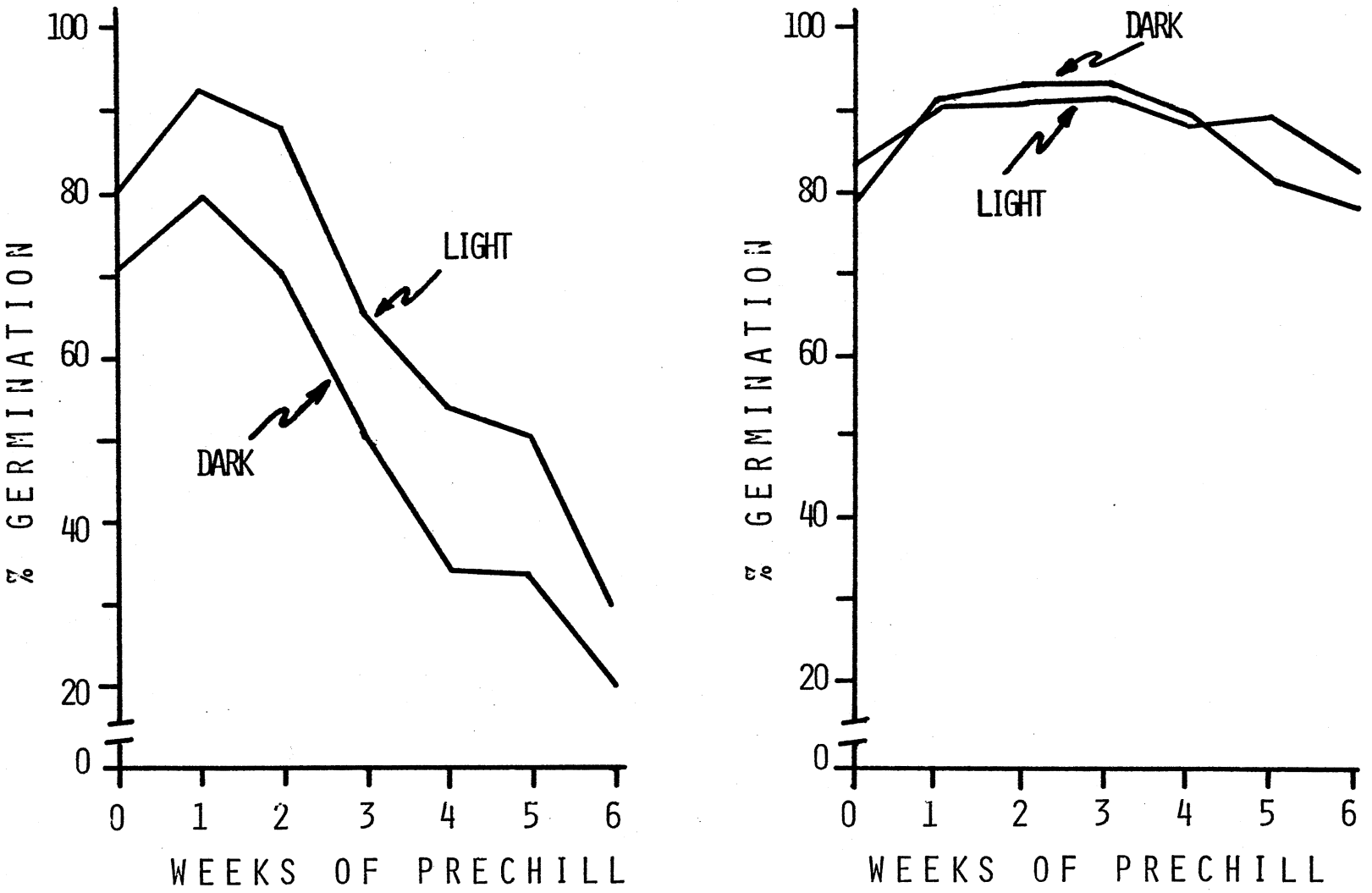

Figure 2. The effect of moistening agent, light, and prechill on germination of little barley after seven days in an alternating 20-30 C. Water was used as the moistening agent in (a) and KNO_3 was used in (b).

occured after three weeks of prechill.

The average germination at 7 and 14 days and the percent firm seed remaining for all treatment combinations in both environments are given in Table 14. The LSD values at the five percent level are listed to show statistical differences.

The percent germination, after 14 days in 20 C and the percent firm seed remaining is illustrated in Figure 3. In this graph, the average seed germination and firm seed remaining of both light and dark are plotted against the length of prechill on substrate moistened with H_2O and KNO_3. Little barley was highly germinable with no prechilling on both H_2O and KNO_3 moistened substrates. As the length of prechilling increased the 14-day germination with KNO_3 remained high (above 80%). However, the 14-day germination with H_2O decreased steadily and the firm seed remaining increased as the length of prechill increased. This indicates the moist prechill treatment induced seed dormancy in little barley. Apparently the use of KNO_3 was enough to overcome this induced dormancy, for germination remained high throughout all lengths of prechill when KNO_3 was used.

The data in Figure 4 illustrates the effects of some factors in the alternating 20-30 C environment. As in the previous figure, little barley is highly germinable without prechilling. The 14-day germination on KNO_3 moistened substrate is about the same for that treatment in the constant 20 C environment. However, on H_2O moistened substrate the 14-day germination without prechilling is 10% higher in the 20-30 C alternating than in the 20 C constant environment. The response to KNO_3 and H_2O is similar in both environments. Germination on KNO_3 moistened substrate remained high throughout all prechill treatments and

Table 14. Effect of moistening agent, light condition, and prechill duration on germination of little barley in two environments.

MA[1]	Light Condition	Length of Prechill	Environment: Constant 20 C ----Germ----- 7 day	14 day	Firm[2] Seed	Alternate 20-30 C ----Germ----- 7 day	14 day	Firm[2] Seed
		Weeks	(%)	(%)	(%)	(%)	(%)	(%)
H_2O	D	0	52	70	22	72	84	10
	D	1	46	60	32	80	85	8
	D	2	50	56	34	72	74	22
	D	3	42	44	52	50	52	44
	D	4	32	32	58	34	36	59
	D	5	33	34	60	31	31	64
	D	6	20	20	70	20	21	71
	L	0	76	78	14	81	89	7
	L	1	78	83	10	92	94	5
	L	2	69	74	17	88	90	6
	L	3	52	54	31	66	68	25
	L	4	46	46	44	54	60	39
	L	5	31	32	64	50	51	40
	L	6	26	28	68	30	30	62
KNO_3	D	0	73	92	3	80	89	8
	D	1	88	94	4	91	93	4
	D	2	87	88	4	93	94	2
	D	3	84	84	5	93	94	3
	D	4	81	81	8	89	90	8
	D	5	82	82	9	82	82	12
	D	6	78	78	10	78	78	13
	L	0	82	86	3	84	92	6
	L	1	90	92	3	90	92	5
	L	2	92	92	5	90	90	6
	L	3	88	88	4	92	93	3
	L	4	91	92	4	87	88	8
	L	5	82	82	10	89	89	8
	L	6	82	82	10	83	84	10
LSD 0.05			9.9	9.7	9.5	8.1	8.2	7.6

1/ MA designates moistening agent

2/ D designates dark throughout prechilling and first week in germination environment. L designates dark throughout prechilling and 8 hours light throughout the germination period.

3/ % firm seed remaining at 14 days.

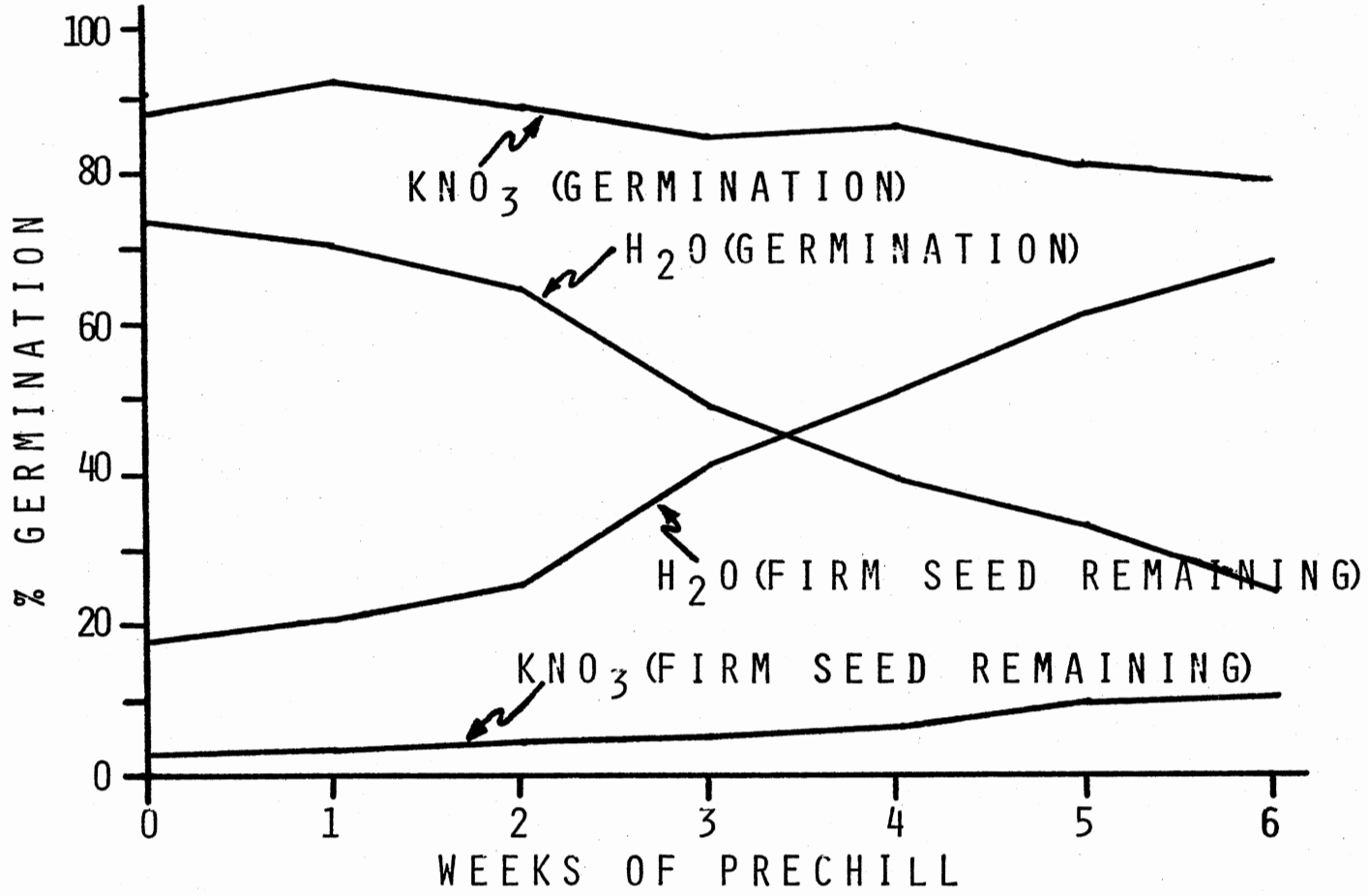

Figure 3. The effect of prechill and moistening agent on germination of little barley and firm seed remaining after 14 days in constant 20 C.

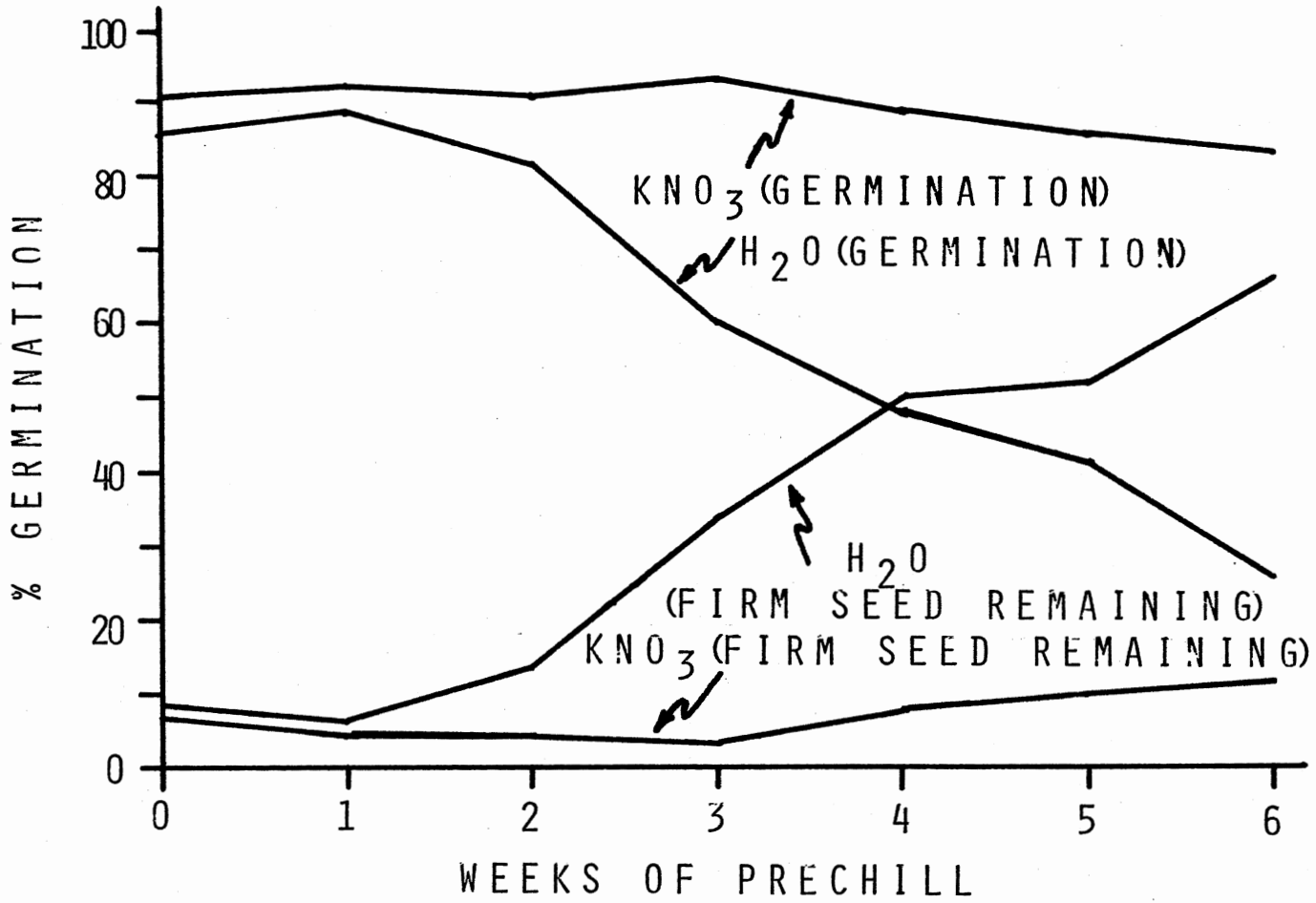

Figure 4. The effect of prechill and moistening agent on germination of little barley and firm seed remaining after 14 days in alternating 20-30 C.

on H_2O there was a steady decrease in germination. Seed remaining increased with each added increment of prechill when H_2O was used as a moistening agent. Induced seed dormancy of little barley was enhanced by moist prechill treatments. This induced dormancy may be similiar to the dormancy that Young and Evans (1978) found in downy brome seeds after being exposed in field seedbeds over winter. They also observed that germination was responsive to nitrate concentrations in the soil.

Optimum Constant Temperature for Germination

The effect of six constant temperatures from 13 to 34 C on the germination of little barley is given in Table 15. Of the six temperatures tested, 21 C resulted in the highest average germination (77%) at the end of 7 days. Average germination at 17 C was slightly less than at 21 C. The 7-day germination average at 13, 25, 30, and 34 C was significantly less than at 17 or 21 C. Germination average during the second week in an alternating 20-30 C environment indicated the remaining little barley seed was able to germinate even after a week in the warmest temperature (34 C) evaluated. Total average germination after two weeks was highest when the first week was at 17 or 21 C.

Viability at Different Dates After Flowering

The average germination capacity of seeds collected at various maturity stages are given in Table 16. Seed collected in the soft dough stage approximately 11 days after flowering had 49 and 40 % germination respectively for the upper and lower spikelets on the head. The upper spikelets germinated better than the lower spikelets in the earlier stages of maturity (11, 15, and 18 days after flowering). This indicates

Table 15. The effect of constant temperatures between 13 and 34 C on germination of little barley seed.

°C	Average % Germination		
	Environment		
	Thermogradient sand box Week I 1/	Alternating 20-30 C 2/ Week II	Total
13	5	77	82
17	67	21	88
21	77	11	89
25	60	25	85
30	19	62	81
34	1	77	78
LSD 0.05	15.7	14.4	4.5

1/ Germination after 7 days

2/ The germination boxes were removed from the thermogradient sand box after the first (7 day) count and placed in an alternating 20-30 C environment for 7 days.

Table 16. The germination of upper and lower spikelets of little barley spikes, collected in the soft dough through the shattering stage of maturity.

Days after flowering	Maturity stage	Position of spikelet	Average % Germination 7 days	14 days
11	soft dough	upper	26	49
11	" "	lower	20	39
15	medium dough	upper	45	56
15	" "	lower	13	27
18	firm dough	upper	47	59
18	" "	lower	38	46
22	ripe	upper	65	73
22	" "	lower	73	81
26	" "	upper	64	73
26	" "	lower	84	89
31	top shattering	lower	84	86
LSD 0.05			4.1	4.2

that the spike of little barley matures from the top to the bottom which is common for annual grasses with spike infloesences.

As the stage of seed maturity increased, the differences in germination between upper and lower spikelets were less. However, the germination of the lower spikelets were only slightly higher. Maximum germination (89 %) occured in the spikelet samples collected approximately 26 days after flowering from the lower part of the spike.

Seed Germination From Paraquat Treated Plots

The average germination of little barley seed collected from paraquat treated areas is listed in Table 17. In comparison to the untreated check, seed germination was significantly reduced at all maturity stages evaluated by the application by the application of paraquat. Since paraquat is a contact-type herbicide, seed collected from the early application dates developed on escaped plants or plants which emerged after the time of application. If the seed came from late emerging plants, immaturity at the time of harvest may account for the lower germination values. However, the seeds collected from the late application date were present at the time of application. One can only speculate from this study if the mechanism of germination of seed treated in the fruiting stage was affected directly by paraquat or if the decrease in germination was due to an indirect effect of paraquat. Whether the effects were directly or indirectly related to paraquat, the differences between the untreated and the treated areas were highly significant.

Table 17. Germination of little barley seed collected from plots treated with paraquat.

Date Sprayed	Stage of growth at treatment	Average % Germination 1/ 7 days	14 days	% Firm seed remaining
	Untreated	61.0	71.0	14.0
4-13-78	Early tillering	30.5	41.5	18.0
4-20-78	Jointing	42.0	53.5	4.0
4-30-78	Boot	22.0	34.5	2.5
5-08-78	Flowering	36.5	46.5	7.5
5-19-78	Fruiting	13.0	21.5	6.0
$LSD_{0.05}$		19.3	22.5	NS

1/ The seeds were collected on 6-8-78.

Date of Planting Study

Average emergence, forage production, and seed production are given in Table 18. Percent emergence of 50 seeds planted are shown at 7, 14, 21, and 28 days after planting. The first four planting dates averaged from 62 to 78 % emerged after 28 days. Seeds planted on November 22, 1978, did not emerge in the 28 days observed; however, 46% of the seed had germinated and emerged by February 28, 1979. Seedling emergence from the four planting dates in March and April was variable, ranging from 18-66%, 28 days after planting.

Total dry weight ranged from 77 to 639 grams per plot for the five fall planting dates and from 6 to 71 grams per plot for the four spring planting dates. Planting in the fall resulted in seed head production regardless of whether emergence was in the fall of the following spring. The earlier the planting date, the more tillering of the plants. The number of heads (indicating the number of tillers) ranged from 7 to 64 per plant for the fall planting dates. Heads harvested at these same dates averaged from 248 to 2039 seeds per plant.

The spring planting dates resulted only in vegetative growth and no seed heads were formed from any of these planting dates. This indicates that little barley, like many other winter annual grasses, requires a cold period for vernalization before seed production can occur.

Table 18. The seedling emergence and forage and seed production of little barley planted at various dates.

Planting date	Days after planting				Dry weight production [1]			Heads/Plant	Seeds/Plant
	7	14	21	28	Total	Forage	Heads		
	% seedling emergence				---------grams----------				
9-20-78	0	34	70	74	639	433	206	64	2039
10-4-78	36	58	64	64	477	320	157	45	1738
10-18-78	6	54	62	62	196	134	62	22	767
11-1-78	0	58	74	78	80	56	24	7	248
11-22-78	0	0	0	0[2]	77	43	34	15	635
3-14-79	0	0	28	28	71	71	0	0	0
3-28-79	0	20	36	36	28	28	0	0	0
4-11-79	0	18	18	18	9	9	0	0	0
4-25-79	0	64	66	66	6	6	0	0	0

[1] Weight was from 0.30 X 0.91 meter

[2] By February 28, 1979, 46 % of the seedlings had emerged.

CHAPTER V

SUMMARY

Field studies were conducted to evaluate the effectiveness of several residual herbicides for the control of little barley in an established bermudagrass pasture and to determine the optimum growth stage of little barley at which to apply paraquat. In addition, laboratory and field studies were initiated to evaluate the germination requirements and observe emergence and development of little barley planted at various dates in the fall and spring.

Forage production was used as an indicator of control of little barley and bermudagrass release. The wettable formulation of tebuthiuron was the only residual herbicide which controlled little barley and increased bermudagrass forage production. Atrazine and the granular formulation of tebuthiuron resulted in a significant decrease in little barley forage production. Simazine was the only other residual herbicide which resulted in a significant increase in bermudagrass production. The two highest rates of both formulations of metribuzin significantly reduced little barley production. It was found that application of paraquat at the early tillering stage of little barley was the only treatment stage which controlled little barley and increased bermudagrass production.

Initial germination studies indicated that little barley seeds readily germinate without prechilling, on substrate moistened with

either H_2O or a 0.2 % KNO_3 solution, regardless of environments studied. Prechilling on H_2O moistened substrate induced seed dormancy, but if prechilled on a 0.2 % KNO_3 moistened substrate, germination remained high. Although statistical comparisons were not made between the two environments, germination under an alternating 20-30 C environment seemed to be the more desirable of the two. The optimum constant temperature for 7-day germination was 21 C. It was observed that even after a week under moist conditions at 34 C, little barley would germinate readily in an alternating 20-30 C. Test results indicated that little barley seed becomes viable as early as 11 days after flowering. Germination of the upper spikelets was higher in the earlier stages of maturity, indicating that the inflorescence ripened from the top to the bottom. Although the test was not conclusive to the cause, application of paraquat to the growing little barley plant significantly decreased germination.

The field study, designed to observe seedling emergence and development of little barley planted on several different dates, indicated that the seeds are capable of germinating over an extended period in the fall and spring. Forage and seed production correlated well with the fall planting dates, with highest production of both being from the first planting date and decreasing with the later dates. Little barley remained vegetative after being planted in the spring, indicating that little barley requires a period of vernalization for seed production.

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VITA[2]

Marvin Leon Fischer

Candidate for the Degree of

Master of Science

Thesis: THE CHEMICAL CONTROL AND GERMINATION OF LITTLE BARLEY

Major Field: Agronomy

Biographical:

Personal Data: Born in Lawton, Oklahoma, July 25, 1955, the son of Sam and Mary Fischer.

Education: Graduated from Indiahoma High School, Indiahoma, Oklahoma, in May, 1973; received Bachelor of Science degree from Cameron University, Lawton, Oklahoma, with a major in Agriculture, in May, 1977; completed the requirements for Master of Science degree at Oklahoma State University in December, 1979, with a major in Agronomy.

Experience: Raised and worked on family farm near Indiahoma, Oklahoma, worked part-time at the local wheat elevator and as a carpenter, graduate teaching assistant and research assistant while at Oklahoma State University.

Member of: Southern Weed Science Society of America.