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Distribution & Life Cycle of Nodding Thistle (Carduus Nutans L.) in Kentucky

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DISTRIBUTION AND LIFE CYCLE OF NODDING THISTLE (*CARDUUS NUTANS* L.) IN KENTUCKY

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DISTRIBUTION AND LIFE CYCLE OF NODDING THISTLE

(CARDUUS NUTANS L.) IN KENTUCKY

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ABSTRACT

Carduus nutans L., commonly called nodding thistle or musk thistle, has been in the United States for over 50 years; however, it was not until the early 1940's that it was identified in Kentucky. It was first identified in Kentucky in Warren County, and by 1970 had spread to 88 of the 120 counties in Kentucky. The thistle is present in all regions of the state, but most of the counties not having the thistle are located in the mountainous region of Eastern Kentucky.

The thistle plant has a fleshy tap-root which is characteristically hollow near the soil surface. Flowering is determinate and the flowers vary in color from a deep pink at opening to near white at maturity. The plant is a prolific seed producer and may grow to a height of over eight feet in favorable growing conditions.

In Central Kentucky, nodding thistle seeds are disseminated from June through August. The seeds are about three millimeters long and vary in color from gray to straw-brown at maturity. There appears to be a minimum eight-week dormancy period before the seeds will germinate. Ninety percent germination was obtained using one-year-old seeds. After emergence, plants enter the rosette stage in which they over-winter. Rosettes may reach four feet in diameter prior to bolting. Bolting occurs between March and August, and flowering begins in mid-May and continues through August.

Nodding thistle plants in the study produced up to 561 heads per plant, and up to 1200 seeds per head. Individual plants produced from 200 to over 160,000 seeds. Nodding thistle plants in Central Kentucky may act as summer annuals, winter annuals, or biennials.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Although the nodding thistle or musk thistle (Carduus nutans L.) has been in the United States for over 50 years (8), it was not until the early 1940's that it was first identified in Kentucky. The first report of this weed in Kentucky was from Warren County. Since that time it has spread to many counties in Kentucky.

The nodding thistle has created a serious problem in Kentucky, especially in the Mammoth Cave area. According to the Agricultural Extension Agents in the Mammoth Cave area, the thistle has infested over 200,000 acres, and reduced pasture production up to 90 percent in highly infested areas. The nodding thistle is found in abandoned fields, roadsides, right of ways, pastures, lawns, small grain fields, and in some row crops.

Although the life cycle of nodding thistle has been studied in Nebraska by McCarty et al. (7), it has not been studied in Kentucky or adjoining states. The objective of the present study was to determine the life cycle of nodding thistle (Carduus nutans L.) in Kentucky.

CHAPTER II

REVIEW OF LITERATURE

Origin and Distribution

Nodding thistle or musk thistle (Carduus nutans L.) has been in the United States for over 50 years (4, 8). In the early 1900's it was listed as a weed in the area from Pennsylvania and New Jersey westward to Iowa. It is believed to have come from Europe where it was grown as an ornamental (Furrer and McCarty, 4). Nilson et al. (8), reported that about half of the counties in Kansas are infested to some extent with the nodding thistle. In Kansas, the thistle is spreading in a general southwesterly direction.

In 1959 the nodding thistle was such a pest in eastern Nebraska pastures and waste areas that the Nebraska Legislature declared it a noxious weed (4). In 1958 the nodding thistle had invaded hundreds of farms in the Warren County, Kentucky area and had gradually spread into adjacent counties (Freeman, 3).

The Commonwealth of Kentucky has regulatory legislation (SENATE BILL NO. 21) which provides for control of Canada and nodding thistle. This Act states in part that: "If any person who holds land on which Canada or nodding thistle is growing and likely to ripen seed, neglects or refuses to cut and destroy them, any person who considers himself aggrieved or about to be injured by the neglect

or refusal, or the Commissioner of Agriculture pursuant to section 2 of this Act, shall give five days' notice in writing to the person who holds the land, to cut and destroy the Canada or nodding thistles. On the neglect or refusal of the person who holds the land to cut and destroy them at the end of five days, any person aggrieved, or believing himself about to be injured, or the Commissioner of Agriculture may enter upon or hire other persons to enter upon the land and cut down and destroy the Canada or nodding thistle. The person so employed may recover from the person who holds the land, compensation at the rate of fifteen dollars per day."

Life Cycle

Nodding thistle has been described as a biennial (2, 3), as an annual or biennial (6), and as a winter or summer annual or biennial (7). McCarty and Scifres (7) used natural stands and established stands to study the life cycle of nodding thistle. Plant competition, drought, and low fertility were found to retard emergence and development. Thistle plants which were grown in the absence of competition or on fertile soils grew larger and produced more heads than those grown with competition or on less fertile soils.

Furrer and McCarty (4) described the nodding thistle as a prolific seed producer. Some plants produced over 100 heads and over 20,000 seeds per plant. Individual terminal heads have been found to contain as many as 1,500 seeds (5). Germination of nodding thistle seeds may be as high as 95 percent a short time after dissemination (4, 6).

Control

Some of the first work on nodding thistle control was done in Southeast Nebraska in 1957. Application of 1 to 2 lb/A of 2,4-D gave 75 to 100 percent control (4). Feldman, McCarty, and Scifres (1) found that rates of 1 to 2 lb/A of 2,4-D gave excellent control of nodding thistle when applied April 30 or May 10. Only the 2 lb/A rate gave good control when applied April 20. Nilson (8) reported that more than one treatment of 2,4-D per year may be necessary. Herron, Driskill, and Freeman (5) recommended the use of ester or amine salt of 2,4-D at rates of 1 to 2 lb/A. They suggested use of the lower rate when the temperature was above 60 F or before flower stalks elongated. They concluded that plants should be sprayed during late March or early April.

If thistle plants have been allowed to reach the bud or bloom stage, mowing will temporarily prevent seed production. It is only a temporary measure; however, as buds in the axils of the basal leaves will rapidly grow and produce seed if no further control measures are taken (4). Nilson (8) recommended that scattered plants in a field be removed by severing the rosette below the crown thus preventing further development.

CHAPTER III

MATERIALS AND METHODS

Distribution

A questionnaire, designed to provide information on the presence, date of identification, and distribution of the nodding thistle in Kentucky, was sent to the Agricultural Extension Agents in each county in Kentucky.

Germination Studies

Samples of mature seeds collected in June, 1970, were included in germination tests at weekly intervals over a twelve week period. Germination studies were also conducted using approximately 1-year-old seeds which were harvested in 1969. Fifty seeds were placed in a petri dish on a filter paper which was kept moist. The seeds which had germinated were removed daily over a 14-day period. Field observations were made on seedling emergence during the dissemination period in 1970.

Field Studies

Nodding thistle plants were observed throughout Central Kentucky during 1969 and 1970. Several hundred plants were observed in two natural sites. Site I was located north of Bowling Green in a field in which corn had been grown the previous year. The soil

was fertile and there was little competition from other plant species. Site II was located south of Bowling Green on a less fertile soil which had not been cultivated recently. There was competition from many other plant species at Site II. Ten plants were selected at Site I during the late bolting stage and observed periodically until all heads were mature. Each head was harvested individually and the number of heads per plant and number of seeds per head were determined. Eleven plants were selected at Site II and studied similarly.

In April, 1970, a nursery was seeded on a Pembroke silt loam soil on the Western Kentucky University Farm to study controlled plantings of nodding thistle. The nursery contained about 700 plants which were spaced approximately one meter apart within and between rows. Competition by other plant species was controlled by hand cultivation. These plants were used to study morphological development and the effect of defoliation on regrowth. At bi-weekly intervals during the summer and fall, three plants were cut immediately above the apical growing point and three plants were cut immediately below the growing point. Observations were made to determine whether regrowth occurred following these cutting treatments.

Two hundred plants in the rosette stage were selected at random to determine the correlation between various plant parts. Rosette diameter, number of leaves greater than three centimeters in length, and length of longest leaf were measured on each plant. The plants were dug and taken to the laboratory for further measurements. Each plant was washed with tap water and the root and shoot were separated. The diameter of the top of the root was

measured. The upper 10 centimeters of each root was weighed and oven-dired at 70C for 72 hours. The shoot was weighed and dried in the same manner. Simple linear correlations were calculated for all combinations of: diameter of rosette, diameter of root, number of leaves greater than three centimeters in length, length of longest leaf, root fresh and dry weights, and percent dry matter of shoot. Coefficients of determination were also calculated.

CHAPTER IV

RESULTS AND DISCUSSION

Distribution

Information on the distribution of nodding thistle was obtained from all counties in Kentucky. Results of the survey indicated that the nodding thistle was present in 88 of the 120 counties in Kentucky (Figure 1). The thistle was present in all regions of the state, but most of the counties not reporting the occurrence of the thistle were located in the mountainous region of Eastern Kentucky. Information on date of identification of the thistle in the various counties suggests that the thistle has spread rapidly in the past five years. The presence of the thistle in the border counties of Kentucky indicates that the thistle is likely present in most of the adjoining states.

Germination

Attempts were made to germinate seeds immediately after maturity and at weekly intervals over a subsequent 12-week period. Germination was less than 2 percent immediately after maturity (Table 1), and the percentage did not increase appreciably until about 8 weeks after maturity when the germination increased to about 50 percent. Using 1-year-old seed, germination increased to 90 percent (Table 2). Results of germination test using 1-year-old

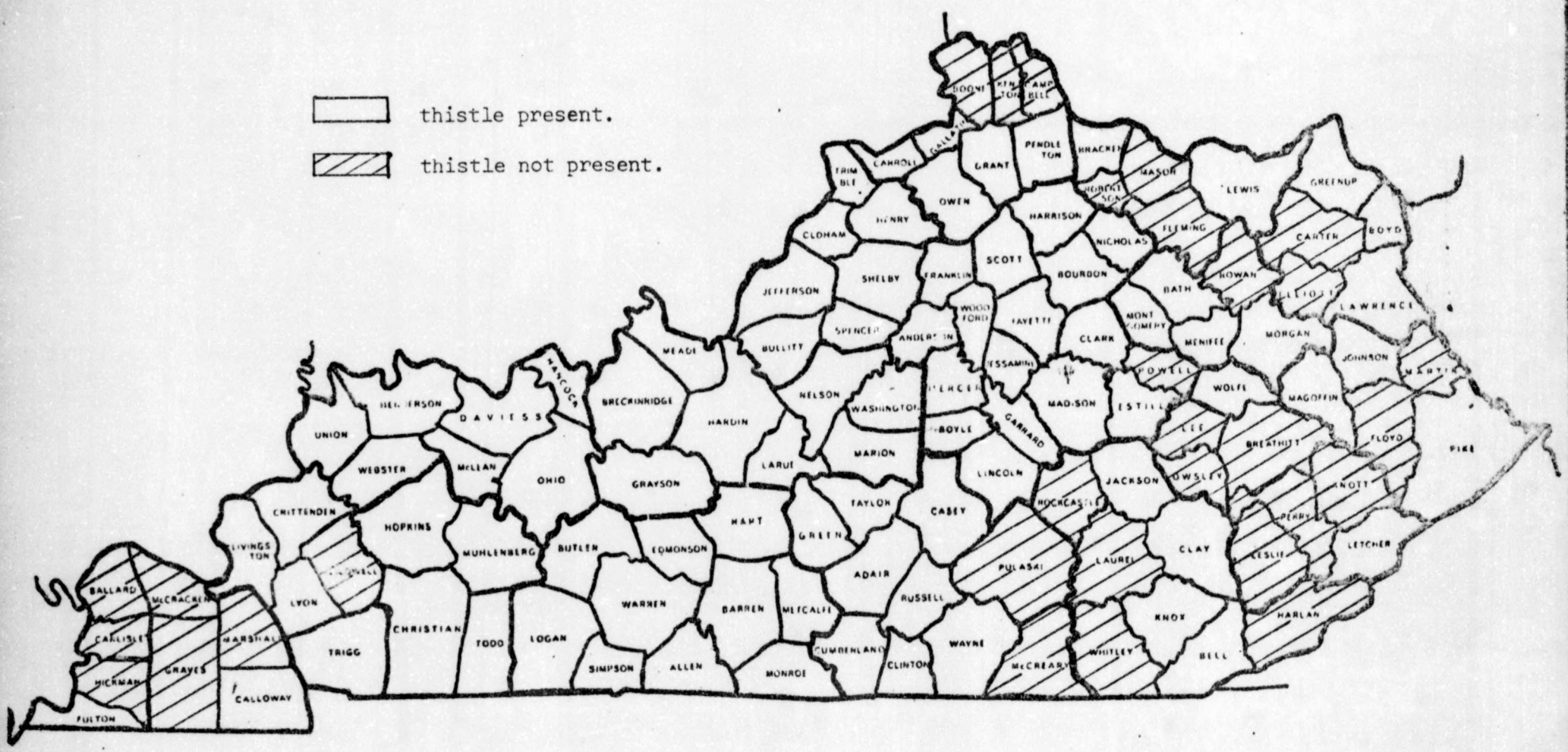

Figure 1. Distribution of nodding thistle by counties in Kentucky in 1970.

Table 1. Percentage germination of nodding thistle seeds collected north of Bowling Green in Warren County in 1970.

	Days after initiation of test*													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of seeds germinated	0	1	2	1	0	0	1	1	0	0	0	1	1	0
Percentage germination	0	.2	.4	.2	0	0	.2	.2	0	0	0	.2	.2	0
Cumulative percentage germination	0	.2	.6	.8	.8	.8	1.0	1.2	1.2	1.2	1.2	1.4	1.6	1.6

*Initiated 6/4/70. Results based on 500 seeds.

Table 2. Percentage germination of nodding thistle seed collected south of Bowling Green in Warren County in 1969.

	Days after initiation of test*													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of seeds germinated	0	296	108	11	5	1	2	8	11	1	2	4	0	1
Percentage germination	0	59.2	21.6	2.2	1.0	0.2	0.4	1.6	2.2	0.2	0.4	0.8	0	0.2
Cumulative percentage germination	0	59.2	80.8	83.0	84.0	84.2	84.6	86.2	88.4	88.6	89.0	89.8	89.8	90.0

*Initiated 3/14/70. Results based on 500 seeds.

seeds showed 59.2, 80.8 and 83.0 cumulative percent germination 2, 3, and 4 days, respectively, after initiation of the test. After 14 days a maximum of 90 percent germination was reached. Furrer and McCarty (4) reported 95 percent germination a short time after dissemination.

Seed dissemination began the first week in June; however, no new seedlings were observed in the field until the last week of July. At this time an abundance of new seedlings was found at both study sites. This observation, along with lower laboratory germination for new seeds, suggest that a dormancy mechanism was involved. Both the laboratory results and the field observations indicated that the dormancy period extended for a minimum of 8 weeks. McCarty et al. (7) reported that no dormancy mechanism was operative in nodding thistle seeds in Nebraska.

Life Cycle

After emergence of the seedlings, which began the last week of July, plants developed into the rosette stage. Rosettes of the plants studied contained as many as 83 leaves and some reached a diameter of 120 centimeters. The leaves were coarsely lobed and dark green with a light green mid-rib, smooth and hairless on both sides, and were alternately arranged. Each leaf lobe had 3 to 5 points which ended in a white or yellow-green spine. The thistle overwintered in the rosette stage.

Bolting began in late March and continued through early August. This growth stage begins when the seed stalk starts to form and continues until the first head appears. Some plants attained a height of about 2 meters during the bolting stage.

The plants were multi-branched and exhibited a determinate growth habit (Figure 2).

Flowering began in mid-May and continued through August. Flowering began in the terminal head and progressed downward on the plant. Flower color changed from a deep pink in the early flowering stage to a near white at the end of flowering. Size of head varied with position on the plant. Primary heads were largest with some having a diameter of 10 centimeters. Size decreased progressively for secondary, tertiary, quaternary, and quinary heads. Buds, flowers, and seeds were commonly observed on the same plant.

Number of heads per plant varied with plant size and extent of branching (Tables 3 and 4). At Site I where growing conditions were favorable, heads per plant ranged from 241 to 561 with an average of about 425. All of these plants had basal branches; therefore, they had more than one primary head. At Site II, where growing conditions were less favorable, the number of heads per plant was reduced. Heads per plant ranged from 1 to 18 with an average of about 8. There were no quaternary or quinary heads; nor was there any basal branching. In this study heads per plant ranged from 1 to 561. Nilson (8) reported a range of 1 to over 100 heads per plant.

Seeds per head ranged from less than 50 to 1200. When the number of heads and seeds per head were combined (Tables 5 and 6), plants in Site I produced an average of more than 120,000 seeds per plant; whereas, plants in Site II produced an average of about 4,500 seeds per plant. At Site I tertiary heads produced more seeds

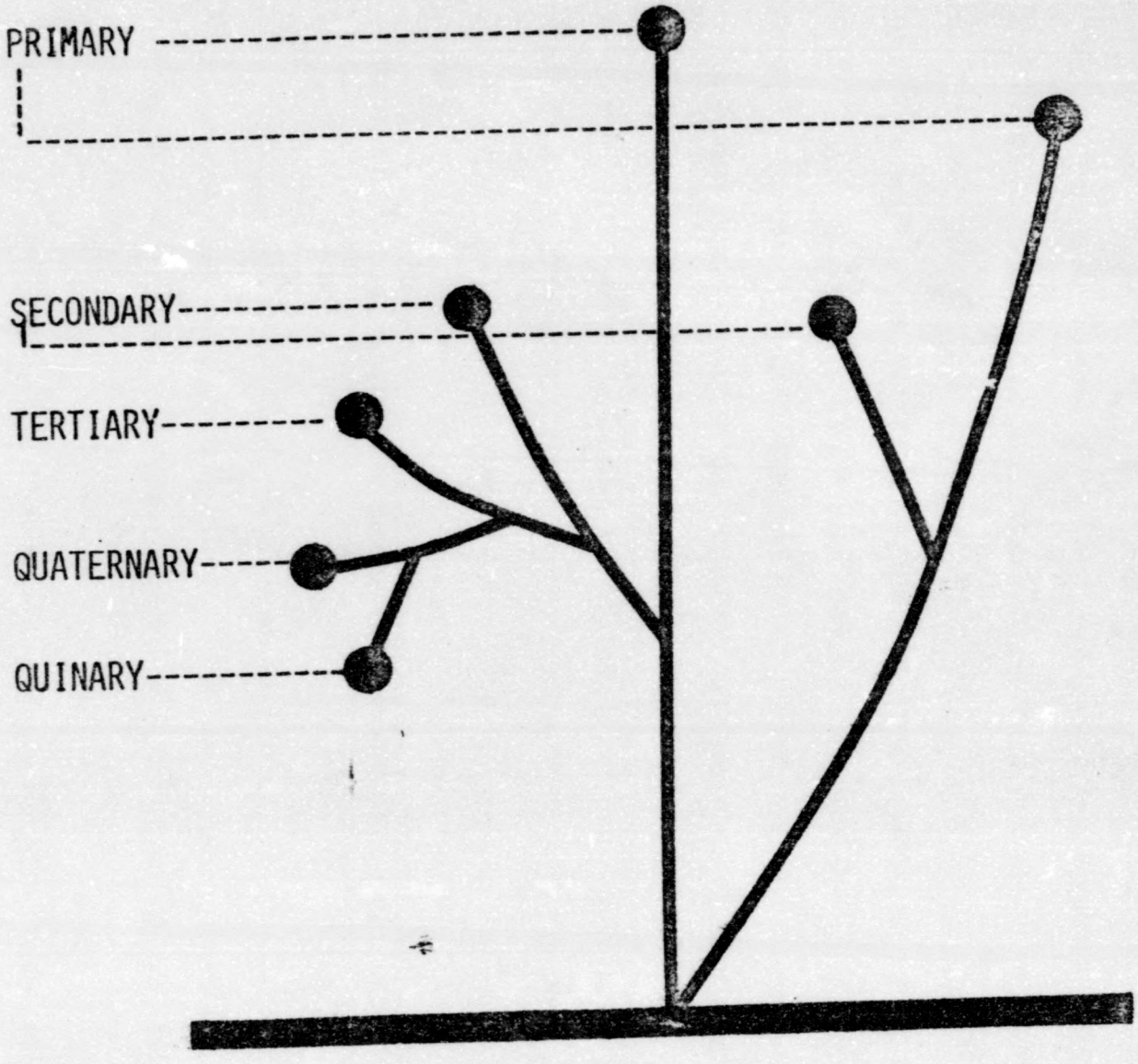

Figure 2. The nodding thistle is multi-branched.

Table 3. Number and position of heads on nodding thistle plants at Site I.

Plant	Primary	Secondary	Tertiary	Quaternary	Quinary	Total
1	8	88	298	154	13	561
2	2	54	174	105	49	384
3	5	53	206	169	32	465
4	3	17	137	75	9	241
5	5	41	342	79	4	471
6	6	44	318	129	4	501
7	6	28	260	22	0	316
8	6	67	379	103	1	556
9	6	58	196	130	2	392
10	2	41	176	94	49	362
Mean	4.9	49.1	248.6	106.0	16.3	424.9

Table 4. Number and position of heads on nodding thistle plants at Site II.

Plant	Primary	Secondary	Tertiary	Quaternary	Quinary	Total
11	1	6	2	0	0	9
12	1	4	4	0	0	9
13	1	5	1	0	0	7
14	1	3	3	0	0	7
15	1	1	0	0	0	2
16	1	6	5	0	0	12
17	1	2	2	0	0	5
18	1	2	0	0	0	3
19	1	7	10	0	0	18
20	1	0	0	0	0	1
21	1	3	7	0	0	11
Mean	1	3.6	3.1	0	0	7.6

Table 5. Number of seeds by position of heads of nodding thistle plants at Site I.

Plant	Primary	Secondary	Tertiary	Quaternary	Quinary	Total
1	9600	37239	82342	32850	1256	163287
2	2400	5964	22525	28489	8000	100745
3	6000	24967	61246	42970	6552	141735
4	3207	11589	52195	18721	1025	86737
5	3450	20230	103063	16270	489	143502
6	4416	18021	104090	33530	575	160632
7	6000	14478	75051	4085	0	99614
8	6000	30103	110458	20344	60	116965
9	5529	26199	47512	23275	175	102690
10	2242	21927	40385	21666	6345	92565
Mean	4884	21072	69887	24220	2448	120847

Table 6. Number of seeds by position of heads of nodding thistle plants at Site II.

Plant	Primary	Secondary	Tertiary	Quaternary	Quinary	Total
11	1100	3556	511	0	0	5167
12	837	2306	1273	0	0	4416
13	1100	4173	496	0	0	5769
14	702	1359	722	0	0	2783
15	400	269	0	0	0	669
16	1200	4801	2434	0	0	8435
17	1200	1550	1460	0	0	4210
18	1200	1271	0	0	0	2471
19	883	4344	5052	0	0	10227
20	246	0	0	0	0	246
21	900	1775	3303	0	0	5978
Mean	888	2310	1386	0	0	4579

than heads at any other position. However, at Site II secondary heads produced more seeds than did heads at the primary or tertiary positions. Feldman, McCarty, and Scifres (1) reported that nodding thistle plants produced an average of 10,000 to 11,000 seeds.

Seed dissemination began the first week in June and continued through early September. Seeds varied in color from gray to straw-brown at maturity. The seeds were about 3 millimeters long with one edge curved and the other edge almost straight. They were pointed at the tip and had a protrusion on the rounded base. The surface of the shiny seed was longitudinally grooved. These seeds are primarily distributed by wind. Other sources of infestation include surface water, man, livestock, wildlife, and machinery (8).

Plants which flowered during the summer were dead by early fall. Nodding thistle plants at this location acted as summer annuals, winter annuals and possibly as biennials. In the nodding thistle nursery which was seeded in April, 1970, some plants were producing seeds by the end of July. Approximately 10 percent of the plants flowered during the summer, the remaining plants are being observed to determine whether they are winter annuals or biennials.

Regrowth

Defoliation treatments were initiated during the first week of June when the plants were about two and one-half months old and continued at bi-weekly intervals through the summer and fall. Recovery occurred on all plants which were cut above the

apical growing point. None of the plants recovered when cut below the growing point during June. After this time less than 20 percent of the plants made some regrowth. Only about one-half of these plants made sufficient regrowth for survival; the others died. These results indicate that cutting the thistle above the growing point would not be an effective control procedure. Cutting below the growing point would be a more effective, but not a completely effective, control measure. The thistle has some potential for developing new shoots after the growing point has been removed.

When plants recovered after the growing point was removed, the new shoots came mainly from the upper one inch of the root. When digging is used to control the thistle, the root should be cut at a depth of two or more inches below the soil surface.

Correlations

All possible linear correlation coefficients were calculated among ten measured characteristics on 200 thistle plants (Table 7). The relationships between the above ground and below ground plant parts were of special interest. In studying the thistle, it would be desirable to make inferences about the roots by observing the tops of the plants.

Rosette diameter, number of leaves, and length of longest leaf were all positively and significantly related to diameter, fresh and dry weights, and percent dry matter of the root. Fresh and dry weights of the shoots were significantly and positively related to the measured root characteristics. Percent dry matter of the shoot was significantly related to only percent dry matter of the root characteristics.

Table 7. Simple correlation coefficients of above- and below-ground parts of nodding thistle.

	Root diameter	Number of leaves	Longest leaf	Root weight fresh	Root weight dry	Root % dry matter	Shoot weight fresh	Shoot weight dry	Shoot % dry matter
Rosette diameter	.826**	.800**	.332**	.715**	.633**	.551**	.836**	.812**	.239*
Root diameter		.890**	.346**	.885**	.851**	.529**	.890**	.890**	.117
Number of leaves			.307**	.874**	.856**	.426**	.935**	.935**	.117
Longest leaf				.247*	.223*	.208*	.301**	.327*	.062
Root weight fresh					.928**	.369**	.887**	.895**	.099
Root dry weight						.209*	.871**	.890**	.042
Root % dry matter							.375**	.353**	.489**

Table 7--Continued.

	Root diameter	Number of leaves	Longest leaf	Root weight fresh	Root weight dry	Root % dry matter	Shoot weight fresh	Shoot weight dry	Shoot % dry matter
Shoot weight fresh								.995**	.107
Shoot weight dry									.067

*Significant at .05 level of probability.

**Significant at .01 level of probability.

The coefficients of determination (Table 8) indicate the amounts of variability which the characteristics of the thistle plants had in common. From 30.3 to 68.2 percent of the variability in the root characteristics was associated with variability in rosette diameter. From 18.2 to 79.2 percent of the variability in the root characteristics was in common with variability in number of leaves. Only 4.3 to 12.0 percent of the variability of root characteristics was associated with variability in longest leaf. Approximately 80.0 percent of variability in the root characteristics was associated with variability in shoot fresh and dry weights. However, only 0.2 to 23.9 percent variability in root characteristics was associated with variability in shoot dry matter percentage.

These results indicate that shoot fresh or dry weights would be best for predicting root diameter or root weight. Since fresh weight is easier to determine, it would be the preferred indicator of these root characteristics.

Table 8. Coefficient of determination for above- and below-ground parts of nodding thistle.

	Root diameter	Number of leaves	Longest leaf	Root fresh weight	Root dry weight	Root dry matter percent	Shoot fresh weight	Shoot dry weight	Shoot dry matter percent
Rosette diameter	68.2	64.0	11.0	51.1	40.0	30.3	69.9	65.9	5.7
Root diameter		79.2	12.0	78.3	72.4	28.0	79.2	79.2	1.4
Number of leaves			9.6	76.4	73.3	18.2	87.4	87.4	1.4
Longest leaf				6.1	5.0	4.3	9.1	10.7	0.4
Root fresh weight					86.1	13.6	78.7	80.1	1.0
Root dry weight						4.4	75.9	79.2	0.2
Root dry matter percent							14.1	12.5	23.9

Table 8--Continued.

	Root diameter	Number of leaves	Longest leaf	Root fresh weight	Root dry weight	Root dry matter percent	Shoot fresh weight	Shoot dry weight	Shoot dry matter percent
Shoot fresh weight								99.0	1.1
Shoot dry weight									0.5

CHAPTER V

SUMMARY

Nodding thistle (Carduus nutans L.) was found in Warren County, Kentucky in the early 1940's. Since that time, it has spread to 88 of the 120 counties in Kentucky. The thistle is present in all regions of the state and has spread rapidly in the past five years.

In Central Kentucky nodding thistle seeds are disseminated from June to August. In this study, heads contained up to 1200 seeds, and individual plants produced as many as 160,000 seeds. There was evidence of a minimum 8-week dormancy period in seed germination. Ninety percent germination was obtained using 1-year-old seed.

After emergence the plants enter the rosette stage in which they overwinter. Rosettes had as many as 83 leaves and reached a diameter of 4 feet under the favorable growing conditions. Rosettes were found in infested areas throughout the year.

Bolting occurred between March and August, and flowering began in mid-May and continued through August. Plants produced as many as 561 heads per plant. Plants in Central Kentucky may act as summer annuals, winter annuals or biennials.

Thistle plants recovered when cut immediately above the apical growing point; however, less than 20 percent recovered when cut immediately below the apical growing point.

Fresh and dry weights of thistle shoots were highly correlated with root diameter and weight.

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VITA

Garry Dale Lacefield was born on August 22, 1945, in Ohio County, Kentucky. He attended Central Park Elementary School and Centertown High School. He served three years in the United States Army. He received the Bachelor of Science Degree in Agriculture from Western Kentucky University in June, 1970, and became a candidate for the Master of Science Degree in Agriculture at Western Kentucky University.