To the Graduate Council:

I am submitting herewith a thesis written by Marcel T. DeStefano entitled "Induction of Male Sterility in Wheat and Barley by 2-Chloroethylphosphonic Acid (Ethephon)." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Plant and Soil Science.

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INDUCTION OF MALE STERILITY IN WHEAT AND BARLEY BY 2-CHLOROETHYLPHOSPHONIC ACID (ETHEPHON)

A Thesis
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Degree
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ABSTRACT

Emphasis has been directed towards the potential use of ethephon (2-chloroethylphosphonic acid) as a possible gametocide for induction of male sterility. Currently ethephon has been used experimentally as a male gametocide on both wheat and barley.

The purpose of this research was to induce male sterility in winter wheat (*Triticum aestivum* L. em Thell), and winter barley (*Hordeum vulgare* L.) with foliar applications of ethephon.

The field study was conducted at the Plant Science Field Laboratory, Knoxville, Tennessee. Ethephon was foliarly sprayed on Arthur wheat and Volbar barley, at 0.00, 0.10, 0.20, and 0.40 percent active ingredient when the plants were in early, mid-, and late boot stages.

The most effective level was 0.40 percent ethephon in early, mid-, and late boot for Arthur wheat, and early, and late boot for Volbar barley.

Concentration, stage, and concentration*stage interaction were significant for all variables except for seed weight. No concentration, stage or concentration*stage interaction occurred for seed weight. However there were significant differences among concentrations and stages which directly influenced male sterility.

All ethephon treatments resulted in reduced plant heights and lodging. There was no apparent reduction in female fertility as a result of the treatments.

The results of this research indicated that ethephon might have possibilities as a rapid and easy means of hybridization in wheat and barley.

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CHAPTER I

INTRODUCTION

The ultimate goal in small grain breeding research is to improve the performance of cultivars and develop new ones with improved features. The exploitation of the phenomenon of hybrid vigor for increasing yields of desirable quality grain is unfortunately limited in wheat and barley. Because of the inadequate fertility restorer system and technical difficulties like the smallness of reproductive organs, laborious emasculation, hand pollination, and bagging which is time consuming and costly, chemical induced sterility would provide a system that is rapid, flexible and would not require a fertility restoration system.

In order to produce hybrid seed the technique of crossing consists of removing the anthers of the female parent before pollen shed, collecting viable pollen from the selected male parent, and transferring it to the stigma of the emasculated plant (10). Since barley and wheat are generally self pollinated and must be artifically cross pollinated using this laborious and tedious technique the induction of male sterility by chemical means appears, to be an excellent alternative to produce hybrids for use in the selection phase of a breeding program.

Current research is being directed towards the use of 2-Chloroethylphosphonic acid (ethephon) as a potential gametocide in barley and wheat (2, 4, 13, 14). The use of ethephon as a possible gametocide was based on the initial observations that applied liquid ethephon increased the number of pistillate flowers on monoecious cucumbers (8). Since then, liquid ethephon has been used experimentally as a gametocide on both wheat (13) and barley (2, 4, 13) and levels of male sterility up to 100 percent have been obtained with little reduction in female fertility (4).

The objectives of this study were to determine if:

1. Ethephon can be used as an effective gametocide.
2. Which concentrations and plant growth stage is most effective in inducing sterility.
3. What, if any, side effects are linked to induction of male sterility.

CHAPTER II

LITERATURE REVIEW

McMurray and Miller reported that monoecious cucumbers when treated with ethephon produced only pistillate flowers (8). They suggested the use of ethephon as a gametocide because of these induced changes in sex expression.

The most effective concentrations of ethephon were 120, 180, and 240 ppm. As many as 19 continuous pistillate nodes were observed. The most commonly observed morphological abnormality was the shortening of the internodes and resultant dwarfing of plants (8).

The results with ethephon on cucurbits suggested that it might have potential as a gametocide in other crops. In preliminary studies in 1969, it was determined that ethephon showed value as a gametocide in wheat by inducing male sterility with few adverse effects on plant development, female fertility, or seed yield (13, 9).

Rowell and Miller (13) demonstrated, in the greenhouse, that wheat plants sprayed with 100 and 250 ppm ethephon at the preboot and boot stage had significantly fewer seed per spike than the check. Some seed set was noted at 500 ppm, but at 750 to 2500 ppm 100 percent sterility was attained. Their results indicated that the later the stage of growth the greater the concentration of ethephon needed to obtain the same degree of sterility.

Fairey and Stoskoff (4) studied the feasibility of using a slow-release granular ethephon in an attempt to overcome some of the limitations of liquid ethephon. Three winter and six spring wheat cultivars were sprayed using concentrations of 2 to 8, 26 to 109.2, and 162 to 822 kg/ha.. These rates were applied at four stages of growth, at seeding, primary tiller emergence, initiation of spikelet primordia on the main culm, and during early boot. Sterility levels were 65, 71, and 80 percent for the respective rates. The most effective levels of sterility were reached when ethephon was applied at the highest rate during reproductive development on the main culm. No apparent morphological or physiological abnormalities of the plants were observed in these studies. However, high rates were needed and the average sterility in many of the treatments was less than 100 percent.

A chemical gametocide would be useful only if female fertility is not affected (9, 14). Rowell and Miller (14) completed a study to determine the effect of ethephon on female fertility.

The study showed the percent of F_1 hybrid seed produced on male sterile C lines did not differ significantly from the percent of F_1 seed produced on the male sterile B lines following hand pollination for both lines. The optimum stages for field application were pre-, early, and midboot at the rates of 1500 to 3000 ppm of ethephon. All rates of ethephon resulted in 87 percent seed set. Hybrid seed produced on C lines indicated that female fertility was high and not affected by sterilization with ethephon.

During 1958, 1959, and 1960, Porter and Wise (11) conducted studies to evaluate chemicals other than ethephon as possible gametocides. The results obtained indicated that maleic hydrazide, FW-450, potassium gibberellate, dalapon, triiodobenzoic acid, dimethylamine salt of trichlorobenzoic acid, napthalene acetic acid, ethanol and 2,4 D were not well suited as selective gametocides in wheat. Maleic hydrazide was the only chemical that caused any appreciable sterility. However, seed set was greatly reduced indicating that both male and female fertility were affected by the chemicals.

Chopra, Jain, and Swaminathan (3) studied the effectiveness of maleic hydrazide as a gametocide in wheat. Wheat plants were treated with 50, 100, 250, and 500 ppm of maleic hydrazide. They discovered that complete pollen sterility occurred at 100 ppm of maleic hydrazide sprayed three times and at 250 ppm sprayed one to three times prior to the emergence of the flag leaf.

Ethephon is known to break down in plant tissue at pH of 4.0 releasing ethylene, a molecule known to have hormonal properties in plants. Since hormones are thought to affect gene transcription, the effects of ethephon are therefore thought to alter the production of messenger RNA transcribed before meiosis but, necessary for pollen development several days later (1).

There is a critical period when ethephon must be applied if it is to effectively induce sterility. This is usually at the time meiosis is initiated in the pollen mother cells and includes premeiotic interphase (1, 7).

More work is still warranted in the uptake and utilization of ethephon as a chemical gametocide. The combination of the optimum concentration and timing sequence with minimum undesirable effects, are the major objectives in employing ethephon as a male gametocide.

CHAPTER III

MATERIALS AND METHODS

I. PLANT MATERIALS

"Volbar" barley and "Arthur" wheat were chosen as the experimental plant material for this study. These cultivars are recommended varieties for Tennessee, are well adapted to the area and are used as parental material in the respective breeding programs.

Volbar barley is a winter-hardy, six-rowed, tall, rough-awned variety. Volbar has yielded well in the state variety test and is highly resistant to lodging, and has slight tolerance to Barley Yellow Dwarf Virus disease (5).

Arthur wheat is an early, winter-hardy, soft red winter variety with good straw strength. Arthur has good test weight and is resistant to some races of powdery mildew and moderately resistant to leaf rust and loose smut. It is resistant to Hessian Fly, however, it is sensitive to acid soil (low pH) (5).

II. GAMETOCIDE

2-Chloroethylphosphonic acid was used in all the tests. The common name for this chemical is ethephon, and trade names are Bromoflor, Ethrel, Cepha, and Florel. The plant regulator activities were discovered by Amchem scientists in 1965. Ethephon has a molecular weight of 144.5, and its structural formula is: $ClCH_2CH_2\overset{O}{\overset{\|}{P}}\begin{smallmatrix}OH \\ OH\end{smallmatrix}$ (6).

Ethephon acts as a plant growth regulator with ethylene inducing responses in plants for leaf abscission, fruit ripening, flower induction, and breaking apical dominance (12). It is very soluble in water and is easily washed off of plant surfaces. Ethephon releases ethylene gas to plant tissue as its mechanism of action and degrades to naturally occurring substances (6).

III. EXPERIMENTAL PROCEDURES

Winter cultivars of barley and wheat were planted in the fall of 1977, at the University of Tennessee Plant Science Field Research Laboratory on Government Farm Road, Knoxville, Tennessee.

Treatments consisted of: three growth stages, early, mid-, and late boot: four chemical concentrations, 0.0, 0.10, 0.20, and 0.40 percent ethephon: two cultivars, Volbar barley and Arthur wheat. Test plots were arranged in a randomized complete block design (RCB) with six replications. Plots consisted of four rows spaced 30 cm apart and 2.75 meters in length. Treatments were applied to and all data collected from the center two rows of each plot.

Plants were considered to be in early boot when the flag leaf was exposed 2 cm to 8 cm; in midboot when the flag leaf was exposed 8 cm; in late boot when the sheath was slightly swollen until the tip of the spike was exposed (13).

To aid in keeping the chemical on the plants 7 ml of Tween 20 (Polyoxyethylene Sorbitan Monolaurate) a surfactant, were added to each spray mixture. Plants in the center two rows were sprayed until runoff, at the appropriate boot stage with a hand operated sprayer at 30 psi of pressure.

To estimate male sterility three heads were randomly selected from the center two rows and covered with a pollinating bag as soon after spray applications as possible. In addition, three open-pollinated heads were randomly cut from each plot. These randomly selected heads were harvested just prior to machine harvesting for yield. Estimates of the percent cross-pollination were obtained by the difference in percent seed set between the bagged heads and the open-pollinated heads.

Spring stand, plant height, and percent lodging were recorded. The two center rows were harvested, threshed and grain weighed in July 1978.

IV. STATISTICAL ANALYSIS

The IBM 360-65 computer at the University of Tennessee, Knoxville, computing center, was used to analyze the data.

The Statistical Analysis System (SAS 76) was used to analyze the following variables: percent sterility of bagged spikes, percent cross-pollination, percent sterility of unbagged spikes, 100 seed weight, yield, spring stand, plant height, and percent lodging. Duncans New Multiple Range Test was used for each variable to separate treatments means.

CHAPTER IV

RESULTS

I. MALE STERILITY IN WHEAT

Ethephon was applied to winter cultivars of wheat and barley at early, mid-, and late boot stages. The data obtained from the field study were used to determine the relationships among sterility, lodging, plant height, spring stand, and seed weight.

The data from the 1978 field study of four different chemical concentrations at three stages of plant development are shown in Table 1.

When Arthur wheat was sprayed in early boot with .10 to .40 percent ethephon, an increase in mean sterility of 86.3 to 95.2 percent was observed. When ethephon was applied at the same concentration during mid- and late boot mean sterility also increased. Midboot had a mean sterility of 78.2 to 88.6 percent, and late boot 84.4 to 85.7 percent.

The highest mean sterility was obtained at .40 percent ethephon in the early boot stage. The least effective concentration was .10 percent for midboot which reached a mean of 78.2 percent sterility, compared to the control of 82.4 percent sterility.

Table 1. Percent Sterility and Crossing of Wheat Treated with Ethephon.

Stage	Conc.	Percent Sterility		Percent Crossing
		Bagged	Open-Pollinated	
Early Boot	.00	82.7	52.1	30.6
	.10	86.3	56.0	30.3
	.20	88.5	64.3	24.2
	.40	95.2	77.0	18.2
Midboot	.00	82.4	49.4	33.0
	.10	78.2	53.6	24.6
	.20	83.0	57.4	25.6
	.40	88.6	61.3	27.3
Late Boot	.00	79.1	57.3	21.8
	.10	84.4	61.6	22.8
	.20	84.3	58.0	26.3
	.40	85.7	61.1	24.6

According to the analysis of variance, significant differences were observed among concentration and stage of application for both bagged and open-pollinated spikes. For the unbagged spikes the interaction stage*concentrations, and stage*concentrations*replication were also significant (Table 2).

According to the Duncan's New Multiple Range Test the .40 percent concentration was more effective than either the control or .10 percent concentration and the early boot application was more effective than either mid- or late boot (Table 3).

The greatest difference between sterility in the bagged and open-pollinated spikes occurred in the control at early boot and midboot and in the .10 percent concentration at early boot. The greatest differences in treated midboot were 27.3 percent at the .40 percent rate, and 26.3 percent in late boot at the .20 percent rate (Table 1).

Percent Crossing

Differences between the amount of seeds per spike in bagged and unbagged spikes represent a measure of cross-pollination. Seeds per spike on the bagged plants were lower than the unbagged spikes at all concentrations and stages. The number of seed per spike decreased with increased rates of ethephon and as a result of this the

Table 2. Probability of a Greater F Value for Appropriate Tests in the Analysis of Variance for Wheat Treated with Ethephon.

Source of Variation	Degrees of Freedom	Percent Lodging	Per-cent Spring Stand	Percent Sterility Bagged Spikes	Percent Sterility Unbagged Spikes	100-seed gm weight Bagged Spikes	100-seed gm weight Unbagged Spikes	Yield gm/plot	Plant Height cm
Conc.	3	.0139	.5624	.007	.0001	.01	.6160	.0001	.0001
Stage	2	.0001	.2019	.026	.0231	.07	.9986	.0001	.0001
Stage*Conc.	6	.1603	.9162	.616	.0403	.06	.8606	.0001	.0001
Stage*Conc.*Rep	52			.527	.0209	.01	.9091		

Table 3. Duncan's Multiple Range Test for Eight Characters Measured in Wheat.

Stage[1]	Percent Lodging	Per-cent Spring Stand	Percent Sterility Bagged Spikes	Percent Sterility Unbagged Spikes	100-seed gm weight Bagged Spikes	100-seed gm weight Unbagged Spikes	Yield gm/plot	Plant Height cm
Early Boot	3.7b	95.2a	88.2a	62.4a	3.7a	4.3a	316.8c	28.0c
Midboot	12.0a	93.1a	83.0b	55.4b	3.7a	4.7a	476.2b	30.8a
Late Boot	3.7b	90.4a	83.6b	59.5ab	3.7a	4.3a	372.0a	29.1b
Conc.[2]								
.00	21.7a	94.4a	81.5b	52.9b	3.8a	4.4a	531.1a	37.5a
.10	1.6b	95.5a	83.2b	57.1b	3.6a	4.3a	372.5b	27.8b
.20	2.1b	95.5a	85.3ab	59.9ab	3.8a	4.3a	344.7b	26.8b
.40	0.9b	86.1a	89.9a	66.5a	3.7a	4.8a	305.2c	25.0c

[1]Mean numbers followed by the same letters are not significantly different at the .05 percent level of probability according to Duncan's New Multiple Range Test.

[2]Mean numbers followed by the same letters are not significantly different at the .05 percent level of probability according to Duncan's New Multiple Range Test.

percent crossing decreased at all concentrations and in all three stages of growth (Table 1).

The analysis of variance indicated that the percent crossing was not significantly different at the .05 percent level of probability.

Lodging

All rates of ethephon were effective in reducing lodging. The lowest level of lodging was in late boot which had no lodged plants. Lodging was found to be significantly different in midboot. This was probably attributed to the higher plant height in this stage.

The results of the analysis of variance showed significant differences in stage and concentration (Table 2).

Plant Height

The retardation in plant height was a side effect of the ethephon and an indication of morphological change. The overall effect of ethephon was a decrease in plant height with increasing concentrations of ethephon (Table 3 and 4). The most important influence of shorter height was a very noticeable decrease in lodging.

All plant heights were significantly different at early, mid-, and late boot. The control 0.0 percent and .40 percent ethephon treatments were found to be significantly different (Table 3).

Table 4. Means for Six Characters Measured in Wheat.

Stages	Conc.	Percent Lodging	Percent Spring Stand	100-seed gm weight Bagged Spikes	100-seed gm weight Unbagged Spikes	Yield gm/plot	Plant Height cm
Early Boot	.00	14	95.8	3.9	3.7	500	37.8
	.10	1	95.0	4.5	3.6	353	27.0
	.20	1	96.6	4.2	3.8	261	25.6
	.40	T^1*	93.3	5.0	3.7	154	21.6
Midboot	.00	36	97.5	5.1	3.9	620	38.6
	.10	3	95.0	4.1	3.6	501	30.8
	.20	5	95.0	4.3	3.9	446	28.1
	.40	2	85.0	5.3	3.5	338	25.8
Late Boot	.00	15	90.0	4.1	3.8	473	36.0
	.10	0	96.6	4.3	3.6	264	25.6
	.20	0	95.0	4.3	3.6	328	26.8
	.40	0	80.1	4.3	3.9	423	27.6

*T^1 = trace

The analysis of variance showed significant differences for replication, stage, concentration and stage*concentration interaction (Table 2).

Yields

The mean yields showed that seed yield was affected by ethephon. There was a decrease in the mean yields at all three stages of growth, as levels of ethephon increased. As mean yields decreased, lodging decreased but sterility increased. The highest yields were obtained from the treatments at midboot at .10 percent ethephon. There were significant differences at all three stages of growth (Table 2) but the only significant differences in concentrations were at the .00 percent and .40 percent levels (Table 2).

100-Seed Weight

Results indicated that as the levels of ethephon increased so did 100 seed weight. This increase in 100 seed weight could be attributed to lack of filling of treated spikes as compared to the untreated spikes.

The highest 100 seed weight for bagged spikes were 5.3 gm at midboot at the .40 percent level, compared to the control of 5.1 gm (Table 4).

Results of the analysis of variance showed that there were significant differences among concentrations and Rep* Stage*Conc. interaction (Table 2).

II. MALE STERILITY IN BARLEY

Ethephon was applied to Volbar barley at early, mid-, and late boot stages. Data from the 1978 field study were used to determine the relationship among sterility, plant height, lodging, spring stand, and 100 seed weight. The data in Table 5 shows the percent mean sterility for each stage and concentration.

The highest male sterility for Volbar was at .40 percent ethephon in early and midboot stages with 42.0 and 58.8 percent sterility, respectively. The lowest mean sterility recorded was 6.7 percent for .40 percent ethephon in late boot. The control had 8.7 percent sterility.

Sterility increased from 19.2 percent to 42.0 percent with increasing rates of ethephon in early boot. In midboot .10 percent and .40 percent ethephon had the highest sterility of 45.6 percent and 58.8 percent (Table 5). Late boot had the highest mean sterility at .10 and .20 percent ethephon of 11.2 and 13.5 percent sterility (Table 5).

According to Duncan's New Multiple Range test revealed the late boot stage was significantly different from early and midboot stages (Table 6).

The greatest difference between percent sterility in the bagged and open-pollinated spikes occurred at early boot and was 21.1 percent at the .40 percent rate (Table 5). The

Table 5. Percent Sterility and Crossing of Barley Treated with Ethephon.

Stage	Conc.	Percent Sterility: Bagged	Percent Sterility: Open-Pollinated	Percent Crossing
Early Boot	.00	9.0	10.7	-1.7
	.10	19.2	21.0	-1.8
	.20	35.0	20.6	5.4
	.40	42.0	21.7	21.1
Midboot	.00	21.9	21.1	0.8
	.10	45.6	18.1	27.5
	.20	25.9	17.7	8.2
	.40	58.8	17.6	41.2
Late Boot	.00	8.7	11.7	3.0
	.10	11.2	10.1	1.1
	.20	13.5	8.7	4.8
	.40	6.7	14.4	-7.7

Table 6. Duncan's Multiple Range Test for Eight Characters Measured in Barley.

Stage[1]	Percent Lodging	Percent Spring Stand	Percent Sterility Bagged Spikes	Percent Sterility Unbagged Spikes	100-seed gm weight Bagged Spikes	100-seed gm weight Unbagged Spikes	Yield cm	Height gm/plot
Early Boot	36.3b	16.0a	22.2a	18.4a	3.2a	3.6b	348.9b	30.5b
Midboot	29.8b	10.7a	33.0a	18.7a	3.4a	3.2c	250.8b	29.3b
Late Boot	63.9a	12.2a	10.4b	11.2a	3.6a	3.9a	453.9a	36.2a
Conc.[2]								
.00	65.5a	15.5a	13.4a	14.5a	3.6a	3.8a	470.0a	37.1a
.10	50.6b	14.5a	22.5a	16.3a	3.3a	3.6ab	320.0b	30.7b
.20	26.3c	14.3a	23.3a	15.7a	3.5a	3.6ab	339.7b	30.7b
.40	29.0c	7.7a	28.7a	17.8a	3.2a	3.4b	275.2b	29.6b

[1]Mean numbers followed by the same letters are not significantly different at the .05 percent level of probability according to Duncan's New Multiple Range Test.

[2]Mean numbers followed by the same letters are not significantly different at the .05 percent level of probability according to Duncan's New Multiple Range Test.

greatest differences in midboot were 41.2 percent at the .40 percent rate, and 4.8 percent in late boot at the .20 percent rate (Table 5).

According to the analysis of variance significant differences were observed among replication, concentration, stage, stage*concentration, and replication*stage*concentration for bagged and open-pollinated spikes. However, concentration was not significantly different in the open-pollinated spikes (Table 7).

Plant Height

Ethephon treated barley showed a decrease in plant height as ethephon rates increased in concentration (Table 8). The lowest plant heights within a given stage of growth were recorded at the .40 percent rate at early boot (25.5 cm) and at the .20 percent rate in mid- (26.8 cm) and late boot (35.5 cm) (Table 8).

According to Duncan's Multiple Range Test plant heights for the early and midboot treatments were significantly different from late boot at .00 percent ethephon (Table 6). The analysis of variance showed significant differences for stage, concentration, and stage* concentration interaction (Table 7).

Lodging

Lodging was significantly reduced in early and midboot at all four rates of ethephon. However, lodging was not

Table 7. Probability of a Greater F Value for Appropriate Test in the Analysis of Variance for Barley Treated with Ethephon.

Source of Variation	Degrees of Freedom	Percent Lodging	Percent Spring Stand	Percent Sterility Bagged Spikes	Percent Sterility Unbagged Spikes	100-seed gm weight Bagged Spikes	100-seed gm weight Unbagged Spikes	Yield gm/plot	Plant Height cm
Conc.	3	.0001	.2881	.0001	.3025	.1981	.0579	.0007	.0001
Stage	2	.0001	.1979	.0001	.0001	.1269	.0001	.0096	.0001
Stage*Conc.	6	.0096	.5155	.0001	.0424	.7651	.1318	.1727	.0001
Stage*Conc.*Rep.	54			.0001	.0001	.1632	.4400		

Table 8. Means for Six Characters Measured in Barley.

Stages	Conc.	Percent Lodging	Percent Spring Stand	100-seed gm weight Bagged Spikes	100-seed gm weight Unbagged Spikes	Yield gm/plot	Plant Height cm
Early Boot	.00	75	17.8	3.6	3.9	476	37.8
	.10	48	23.6	3.2	4.0	417	29.1
	.20	15	14.3	3.1	3.5	288	29.8
	.40	7	8.5	2.7	3.2	215	25.5
Midboot	.00	57	16.0	3.6	3.6	447	36.3
	.10	32	11.5	2.9	2.9	188	27.1
	.20	17	10.3	3.5	3.3	214	26.8
	.40	14	5.0	3.5	3.1	154	27.1
Late Boot	.00	65	12.8	3.5	4.0	488	37.1
	.10	72	8.3	3.5	4.0	355	36.0
	.20	47	18.3	3.7	3.9	517	35.5
	.40	74	9.6	3.4	3.9	457	36.1

significantly reduced in late boot. The lodging in late boot at the .10 percent and .40 percent rates were 72 and 74 percent respectively, compared to the control of 65 percent. Late boot had the highest plant heights which attributed to the higher amount of lodging (Table 8).

Duncan's Multiple Range Test showed significant differences in mean lodging for .00 and .10 percent ethephon and for late boot (Table 6). The results of the analysis of variance for lodging showed significant differences for stage, concentration, and stage*concentration interaction (Table 7).

Yields

There was a decrease in yields at early and midboot as the concentration of ethephon increased. Late boot was not as sensitive to ethephon as early and midboot stages.

The lowest yields of 215 gm at early boot and 154 gm at midboot were obtained at the .40 percent rate of ethephon. The highest yields of 517 gm were obtained at late boot at the .20 percent rate (Table 8).

Duncan's Multiple Range Test showed significantly higher yields for late boot compared to early and midboot treatments, but no significant differences among any of the concentrations (Table 6). The analysis of variance showed significant differences among replications, stage, and concentration but no significant differences due to stage* concentration interaction (Table 7).

100-Seed Weight

No significant differences in 100 seed weight were observed for barley. The lowest seed weight of 2.7 gm compared to the control of 3.6 gm was obtained at early boot at the .40 percent level of ethephon (Table 8).

The results of the analysis of variance indicated no significant differences in 100 seed weight due to the treatments (Table 7). According to Duncan's Multiple Range Test there were no significant differences in the treatments due to stages or concentrations (Table 6).

CHAPTER V

DISCUSSION

Naturally occurring levels of male sterility exists in Arthur and Volbar. In the absence of ethephon sterility means of 82.7 percent for Arthur and 9.0 percent for Volbar were observed in early boot with bagged spikes. However, in late boot naturally occurring sterility decreased for both Arthur and Volbar. This much sterility in wheat is unusual and the hot humid environment within the pollinating bag may have been a contributing factor.

The results obtained from this study indicated that ethephon can be used effectively to induce sterility when applied at the proper time and in the proper concentrations.

From the results obtained it is apparent that the effectiveness of ethephon varies with concentration and stage of application. The most effective concentration and stage of development for Arthur and Volbar were as follows: Arthur was most effective at .40 percent ethephon in early and late boot. Volbar was sensitive at .40 percent ethephon in late boot.

All of the treatments were effective in reducing plant heights, which resulted in a reduction in the percent lodging. Yields were significantly reduced along with 100 seed weight.

Even though liquid ethephon has the practical use as a gametocide, there are some limitations that need to be considered. Additional research is needed to know how long the effects last, the precise dosage needed, and which stage of development is most conducive to sterility. If ethephon is to be put into practical use, an easier, more efficient method of application must be worked out. Furthermore, studies should be conducted to take advantage of the dwarfing effects due to the retardation of plant height.

The results from this study indicated that ethephon could be used to develop populations from which selections can be made. Since none of the treatments gave 100 percent sterility with complete female fertility, hybridization should be performed by the conventional method for genetic studies which require 100 percent hybrid seeds.

CHAPTER VI

SUMMARY AND CONCLUSION

In order to determine the value of liquid ethephon as a male gametocide in winter wheat and winter barley, cultivars were treated with ethephon in early, mid-, and late boot stages of growth. Arthur wheat and Volbar barley were treated with 4 concentrations of ethephon: 0.0, 0.10, 0.20, 0.40 percent active ingredient.

The most effective level was 0.40 percent active ingredient in early, mid-, and late boot for Arthur, and early and late boot for Volbar. Sterility in Arthur reached 95.2 percent compared to 82.7 percent for the control, and in Volbar sterility reached 58.8 percent compared to 21.9 percent for the control.

All ethephon treatments resulted in shorter plant stature, percent lodging, grain yields and 100 seed weight.

Concentration, stage, and concentration*stage interaction were significant for all variables except seed weight. No concentration, stage or concentration*stage interaction occurred for seed weight seed. There were significant differences among concentration rates and stages of application, which directly affected male sterility. Since these two factors had such a strong influence on the induction of male sterility, it can be concluded that research should be continued in order to gain more information about the mechanisms which will maximize sterility without injury to the developing plant or female fertility.

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