AN ABSTRACT OF THE THESIS OF

Ali Osman Ekse for the degree of Master of Science

in Crop Science presented on December 10, 1980

Title: Chemically Induced Male Sterility and Natural Out-Crossing in Selected Wheat Cultivars (*Triticum aestivum* L. em Thell).

Abstract approved: Redacted for Privacy

Three chemicals SD 55446, SD 55447 and WL 84245 were found to induce male sterility in cultivars of wheat or triticale. Both SD 55446 and SD 55447 when applied at a concentration of 0.896 kg/ha resulted in 90% male sterility. However, SD 55447 caused female sterility at the same concentration either in single or split applications. Both chemicals reduced plant height and grain yield and inhibited spike emergence. The phytotoxic effects were reduced when the applications were delayed until the early stage of spikelet formation.

A chemical x cultivar interaction was observed in both wheat and triticale when the concentration of 0.67 kg/ha and/or 0.84 kg/ha of SD 55446 were applied at the second node detectable of stem elongation stage and the early stage of spikelet formation. The chemical induced male sterility up to 98.8% depending on cultivars and concentrations without influencing female fertility.

Using two genetic marker lines (blue aleurone) and two chemicals SD 55446 and WL 84245, an estimate of the amount of induced and natural out-crossing was obtained. Induced out-crossing was found to range from 17% to 23% depending on the location. A higher percentage of

out-crossing was noted with SD 55446 than WL 84245. Natural out-crossing in two cultivars, Yamhill and Stephens, was found to be less than one percent. The amount of induced and natural out-crossing varied depending on the direction and distance from the blue aleurone pollen source. No blue seed was obtained at a distance beyond 20 meters from the pollinator.

All three chemicals induced more than 90% male sterility; however, some female sterility was also observed. This latter factor, plus other phytotoxicity, can be minimized by using optimum application times and concentrations. However, these adverse effects coupled with limited out-crossing in induced male sterile plots appear to prohibit the use of these chemicals for large scale commercial hybrid seed production.

# Chemically Induced Male Sterility and Natural Out-Crossing in Selected Wheat Cultivars (*Triticum aestivum* L. em Thell.)

by

Ali Osman Ekse

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1981

APPROVED:

Redacted for Privacy

Professor of Agronomy in charge of major

Redacted for Privacy

Head of Department of Crop Science

Redacted for Privacy

Dean of Graduate School

Date thesis is presented: December 10, 1980

Typed by Kathie Klahn for: Ali Osman Ekse

IN DEDICATION TO

my wife and my parents

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisor, Dr. Warren E. Kronstad, for his guidance, encouragement, patience and friendship throughout the course of my study and for his constructive criticism during the preparation of this thesis as well as for his willingness and concern to review and correct the thesis.

I extend my appreciation to Dr. Willis McCuistion, Dr. Fred A. Cholick and each member of the Cereal Research Team for their friendship, understanding and help during my graduate study.

I wish to express my special thanks to Dr. Roger G. Petersen for his assistance in the analyses of data. Thanks are extended to Dr. W. E. Kronstad, Dr. R. G. Petersen, Dr. W. L. McCuistion and Dr. R. L. Powelson for serving on my graduate committee.

I am very much indebted to my wife, Feryal, for her patience, understanding, working in the field and encouragement throughout the duration of my study.

I also wish to express my gratitude to the Government of Turkey and the Rockefeller Foundation for sponsoring my study at Oregon State University.

Finally, I wish to express my appreciation to Shell Development Company, Modesto, California for their support to this project.

# TABLE OF CONTENTS

## LIST OF FIGURES

LIST OF TABLES

## LIST OF APPENDIX TABLES

| Table | | Page |
|---|---|---|

# CHEMICALLY INDUCED MALE STERILITY AND NATURAL OUT-CROSSING IN SELECTED WHEAT CULTIVARS (*Triticum aestivum* L. em Thell).

## INTRODUCTION

With potential yield plateaus appearing in many of the major crop species, breeders of self-pollinating plants are looking toward developing hybrid cultivars as a means of avoiding this problem. In wheat, the discovery of a genetic factor which would restore fertility to a cytoplasmic male sterile line accelerated the interest in evaluating the potential of developing commercial hybrid wheat cultivars. Unfortunately, subsequent investigations revealed that a number of problems existed. The major concern involves the time and expense of developing and maintaining satisfactorily male sterile and restoring lines for the production of hybrid seed. A second uncertainity is the amount of out-crossing that can be expected in wheat which is normally highly self-pollinated.

If an economically effective chemical could be identified which could serve as a male gametocide, the major problem associated with fertility restoring and cytoplasmic male sterile lines could be avoided. With such a chemical, the plant breeders could make many different hybrid combinations with very little investment in time and energy. Such a system would also be useful in breeding approaches where recurrent selection is practiced. In the latter situation large populations could be recycled through a sexual cycle thus allowing for greater genetic recombination.

Even with the identification of a chemical gametocide the question regarding the amount of out-crossing must be answered if the system is to be economically feasible. This study was developed to answer three questions: 1) if three chemicals could be used as gametocides and if so, what concentrations and when in the growing cycle should they be applied, 2) is there a cultivar x chemical interaction in wheat and triticale and 3) how much out-crossing occurs in induced male sterile wheat and under natural conditions.

# LITERATURE REVIEW

## Chemically Induced Male Sterility

Chemically induced male sterility could be used for the production of hybrid seed in some normally self-pollinating crops thus avoiding the more costly cytoplasmic or genetic mechanisms now being investigated. Such a gametocide would be useful only if acceptable level of male sterility can be achieved without effecting female fertility. Also, such a chemical treatment can not result in other adverse effects to plant development.

In the late 1950's, Porter and Wiese (1961) evaluated several chemicals to determine if they could induce male sterility in wheat. They reported that sodium 2,3-dichloro-isobutyrate (FW 450) at various concentrations caused considerable plant damage, delayed maturity and decreased plant height when applied at various stages of growth. However, none of the treatments caused an appreciable reduction in fertility or seed set. Other chemicals which they tested included: 1) sodium 2,2-dichloropropinonate (dalapon) which caused severe plant damage and appeared to be of no value as a gametocide, 2) gibberellic acid was not phytotoxic but did not cause male sterility, 3) maleic hydrazide caused severe plant damage resulting in both male and female sterility; and 4) when triiodobenzoic acid (TIBA), napthalene acetic and 5) dimethylamine salt of trichlorobenzoic acid were applied at the late jointing and boot stages induced no appreciable sterility. Results obtained in this latter study indicated that none of the chemicals tested were suited to be used as selective gametocides in wheat. However, Kaul and Singh (1967) reported on the possible gametocide properties of FW 450, maleic hydrazide and dalapon on wheat (Triticum aestivum), onion (Allium cepa) and sunn-hemp (Crotolaria juncea). They found complete pollen sterility in all three species depending on the specific chemical used. Male sterility in wheat was obtained with both maleic hydrazide at the concentrations of 0.5% and higher and with dalapon at the concentration of 0.05%. Maleic hydrazide at the concentrations of 0.01 and 0.025% induced complete male sterility in onions. FW 450 sprayed twice at a 0.5% concentration caused complete male sterility in sunn-hemp. The concentration of these chemicals needed to induce complete male sterility was often accompanied by a high degree of female sterility, however.

A chemical which appeared promising in inducing male sterility was ethrel (2-chloroethylphosphonic acid) as suggested by McMurray and Miller (1969) and Robinson et al. (1969). They observed that the number of pistillate flowers was increased by foliar applications of ethrel on monoecious cucumbers. Rudich et al. (1969) reported that ethrel treatments on cucumber, squash and musk melon induced the formation of female flowers on lower nodes where previously only male flowers were found in untreated plants. The potential of ethrel as a male gametocide to produce hybrid wheat was indicated by Rowell and Miller (1971). They investigated the possible gametocide properties of ethrel under greenhouse and field conditions. Plants were treated with concentrations of ethrel up to 3000 ppm at early boot, mid-boot, late boot, heading and pre-anthesis stages. There was an increasing degree of male sterility with increasing ethrel concentrations until complete male sterility was reached at 2000 - 3000 ppm concentrations when applied at the early boot, mid-boot and late boot stages. A high degree of female receptiveness was retained. At higher concentrations and early applications in terms of growth stages plant height was severely reduced and there were problems with spike emergence.

Ethrel applied to wheat in the greenhouse at 2000 ppm prior to meiosis gave full male sterility (Hughes et al., 1974). Rowell and Miller (1971) obtained similar results in greenhouse studies when ethrel was applied at the same stage and concentration. Ethrel, however, reduced the number of fully developed spikelets per spike in the study by Hughes et al. (1974).

The highest level of male sterility was achieved with ethrel when applied at 2000 ppm and 3000 ppm concentrations when the ligule first appeared on the flag leaf (Dotlacil and Apltauerova, 1978). Kernel number per spike obtained was less than 5% of the control. However, the most effective time of application was at the booting stage with 3000 ppm for hybrid seed production. Seed set was always higher in unbagged spikes than bagged spikes. Among the progenies of unbagged spikes from treated plants, 28.0 to 55.8% were F1's. In treated plants, plant height was reduced as much as 32%. Ethrel prolonged the vegetation period of the plants, however, this did not exceed two days.

Granular ethephon (ethrel) reduced seed set in wheat when applied at different concentrations and at various growth stages (Fairey and Stoskopf, 1975). Applications were made during four growth stages (seeding, primary tiller emergence, initiation of spikelet primordia on the main culm and early boot) at 12 rates of application ranging from 2 to 822 kg/ha (2, 3, 4, 8, 26.9, 54.8, 82.2, 109.2, 164.5, 270, 548, 822). Male sterility levels reached 89% when the highest rate of granular ethrel was applied during initiation of spikelet primordia on the main culm. Lower concentrations were more effective on winter than spring wheat cultivars. The investigations concluded that the granular form may be more suited to practical use than the liquid by avoiding the necessary precision in the time of spraying and undesireable effects which were observed with the spray. No apparent morphological or physiological abnormalities were observed with the use of granular ethrel.

Ethrel reduced grain yield and plant height and caused a complete failure of the heads to emerge in barley and oats (Corral, 1973). Induced male sterility never approached 100% in this study. Low cross-pollination and seed set and phytotoxicity indicated that ethrel could not be used as a male gametocide for the production of hybrid seed in oats or barley. In another study ethrel had no effect on female receptiveness of two Indian barley cultivars (Verma and Kumar, 1978). However, higher doses (3000 - 3500 ppm) were needed for the induction of high levels of male sterility.

Ethrel is not recommended as a gametocide on tef, because it reduced female fertility as well as inducing male sterility (Berhe and Miller, 1978). There were no phytotoxic symptoms on the plants in the treated plots, however, a slight chlorosis of the leaves at the high level (1200 ppm) and with repeated applications was observed. Ethrel delayed panical emergence by about one week. There was also poor development of some florets located at the base of the panicle.

Various concentrations of ethrel were applied to two common wheat cultivars and one durum cultivar in the study by Borghi et al. (1973). They obtained the best result of nearly 100% male sterility and 85% hybrid seed set when the chemical was applied at the mid-boot stage with 4000 ppm of material. At 8000 ppm, total male sterility was obtained with single treatments but yield was reduced to 12-45% of the check.

In greenhouse studies with barley using RH 531 (sodium 1-(p-chlorophenyl)-1,2 dihydro-4,6-dimethyl-2-oxonicotinate) applied at 1.5 kg/ha several days before meiosis, the pollen mother cells induced complete male sterility (Wang and Lund, 1975). The result of iodine staining of pollen suggested that male sterility induced by RH 531 was related to the absence or the decrease of pollen carbohydrate content. Jan et al. (1974) worked with the same compound (RH 531) under field conditions. Rohm and Haas 531 was applied to spring wheat cultivars using several rates and several growth stages. It was concluded that the two varieties differed greatly in their response to RH 531. However, the chemical was the most active as a gametocide when applied a few days before meiosis with 90-98% male sterility achieved. Even though male sterility was induced, the floret response was not favorable to out-crossing. Plant height was also reduced by RH 531 although a triple dwarf type showed less reduction than a semi-dwarf cultivar.

Rohm and Haas 531, RH 532, RH 2956 and RH 4667 were also evaluated for their gametocidal properties (Miller and Lucken, 1977). RH 532 was the most effective in reducing male fertility to a 0.10% level for the wheat cultivars tested. Increasing rates of RH 532 significantly decreased fertility, grain yield, plant height and spike length. Seed set on the hand-crossed spikes of the male sterile check plots was 81%. Seed set percentage on the hand-crossed spikes of the treated plants was significantly decreased with levels as low as 2% observed. In other words, RH 532 was also effective in reducing female fertility.

In another study comparing RH 531, ethrel and Uniroyal D513, it was found that ethrel increased male sterility in hexaploid triticale with increasing concentrations (Sapra et al., 1974). The lowest seed set (8.5%) was achieved with an early boot stage application at the concentration of 10,000 ppm. Ethrel also decreased plant height at all concentrations applied. RH 531 was more effective than ethrel in reducing seed set (2.8% at early boot stage with concentrations of 1500 ppm). Decreased plant height were also observed in the RH 531-applied plots. However, Uniroyal D513 did not appreciably reduce seed set and proved to be relatively ineffective as a gametocide. The lowest seed set was obtained at early boot stage at 6000 ppm concentration (40.3%). All three chemicals decreased 1000 kernel weight when applied at various concentrations at three growth stages (pre-boot, early boot, mid-boot).

DPX 3778 (3-(p-chlorophenyl)-6-methoxy-s-triazine-2,4-(1H,3H)dione, triethanolamine salt) was tested on spring wheat and spring oats as a possible gametocide (Johnson and Brown, 1976). The chemical reduced plant height in wheat and oats when applied at various concentrations. There was no effect on spikelet number in wheat. They obtained complete male sterility in wheat when the chemical was applied at 9 kg/ha and above while female fertility remained high. Although they did not obtain

100% male sterility in oats, the chemical reduced seed set when applied at various concentrations. Anthesis was delayed three to five days in the treated plots so that there was only slightly more seed set on unbagged spikes than bagged spikes in oats.

To date there are no chemicals which are being used on a commercial scale to induce male sterility in the production of hybrid seed. Though many chemicals have been identified which act as gametocides, the phytotoxic side effects make them unacceptable.

## Induced and Natural Out-Crossing in Wheat

Seed production is one of the main problems of commercial hybrid wheat production. Large scale cross-pollination is necessary to economically produce hybrid seed. Although wheat is normally a self-pollinating crop, it generally disperses abundant pollen. Through the utilization of male-sterile lines, either cytoplasmic or chemically induced, cross-pollination can be achieved by wind-borne pollen from other cultivars. Numerous investigators have tried to evaluate the extent of out-crossing in wheat. Since the early 1960's, almost all of the experiments have used cytoplasmic male sterile lines. Recently, some experiments have been conducted with chemically induced male sterile lines.

Cross pollination in wheat by using cytoplasmic male sterile lines was evaluated by Wilson and Ross (1962). Percent of seed set obtained was 72.6, 70.3 and 69.8 for the 1:1, 2:1 and 3:1 female to male ratios, respectively. The seed set on male sterile plants decreased slightly when the distance of the pollinator increased.

Several cytoplasmic male sterile lines were tested by Miller and Lucken (1976) under several environments for hybrid seed production in North Dakota. Cytoplasmic male sterile and restorer lines were planted in alternate drill strip arrangements. A single drill strip was 3.1 m wide with male sterile to pollinator ratios being 1:1, 2:1 and 3:1. Overall average yields were 13.7, 10.0 and 8.4 quintals/ha for 1:1, 2:1 and 3:1 ratios, respectively. The average yield of the pollinators was 18.3 quintals/ha. Narrowing the drill strip width to 1.5 m did not increase the yields of hybrid seed. Earlier, Amand and Sharma (1973) obtained almost the same result. They worked with cytoplasmic male sterile lines to evaluate out-crossing to produce hybrid wheat seed in India. They found that the seed set was greater near the pollen source and it gradually decreased as the distance between pollinator and the male sterile lines was increased. There was a great difference in seed set between two different male sterile lines. Maximum seed set was 77.56% in one line and only 15.99% in the second line.

Out-crossing percentages for twenty-seven cytoplasmic male sterile lines were evaluated for three to five years at Davis by Jan et al. (1977). Each male sterile line and pollinator was planted in a double row 30 cm apart. The out-crossing percentage varied from year to year. Also, the variation among the cultivars was much greater ranging from 1.5 to 57.6%. They concluded that seed set was too low for any of the cultivars to be used in commercial production.

The optimum ratio for hybrid seed production was 1:2 or 1:3 male strip to female ratio (Keydel, 1978). The best distance between male and female strips was 2.5 m. It was also reported that environmental effects (year to year variation) was higher than male to female ratios on seed set. Hughes and Bodden (1978a) found that 1:1 ratio in three strips was the optimum giving 43-63% of the pollinator yield. They compared seed set of 13 cytoplasmic male sterile lines which were wind pollinated by seven restorer or pollinator lines. The average seed set per spikelet varied in each male sterile line depending on the pollinator. However, three of the male sterile lines out of 13 produced a higher seed set with all seven pollinators. They concluded that shorter lines produced more seed set than taller lines. Also, pollinators with poor anther extrusion resulted in low seed set on male sterile lines. In another study, Hughes and Bodden (1978b) evaluated outcrossing on ethrel induced male sterile lines. Seed set ranged from .73 to 1.97 seeds per spikelet on unbagged spikes with the estimated percentage of hybrid seed ranging from 62.6 to 97.3%.

In one study the amount of seed set on the female lines from different ratios of male to female rows depended on the width of the female strip (DeVries, 1974). The yield of hybrid seed per hectare decreased with an increase of the pollinator:male sterile ratios. When the distance from the pollinator increased, the percentage of the seed set of cytoplasmic male sterile lines decreased. A comparison of the pollinator:male sterile ratios showed that there were no major differences between 2:1 and 1:1 ratios in percentage seed set. However, he obtained very low seed set in his experiment (26.2, 26.3 and 31.3% with 1:2, 1:1

and 2:1 pollinator:male sterile ratios, respectively).

When cytoplasmic male sterile lines were planted in a square plot (12 m X 12 m) significant differences were observed depending on the distances of the male sterile lines from the pollinator (Rajki and Rajki, 1968). When the experiment was planted using a 1:1 male sterile and pollinator line, the seed set in male sterile lines was 80.6 - 93.6% of fertile counterparts. However, Zeven (1968) found that the distance from the pollinator and the wind direction affected seed set on male sterile lines. The highest seed set was 67% when the pollinator was 0.25m away. It decreased when the distance between male sterile lines and pollinators was increased. The prevailing wind direction was south-west to northeast in Holland where the experiment was conducted. The highest seed set obtained was from the east and north side of the experimental plots.

That quantity of pollen shed varied among different wheat cultivars was reported by Joppa _et al_. (1968). In their material the spring bread wheats shed more total pollen than the spring durum cultivars. Evidently pollen shedding was influenced by the genotype of the cultivar.

That locations may also affect seed set in male sterile lines in wheat was suggested by Zuzens _et al_. (1969). Male sterile lines and pollinators were planted at four locations in alternate rows which were at least two or more meters wide. The highest seed set obtained was 32.1% in Winnipeg with 2.4 m distance from the pollinator. They also observed about 25% ergot in male sterile lines at Lethbridge.

Natural out-crossing in winter wheat was found to be less than one percent by Garber and Qu senberry (1923). The extent of out-crossing is influenced by genotypic and environmental factors and may range from three to four percent (Allan, 1980), five to 70 percent (Heyne and Smith, 1967), depending upon the cultivar and specific environmental conditions.

Therefore the amount of natural out-crossing in wheat appears to be low. The question remains even if an effective gametocide can be identified, is there sufficient out-crossing in wheat to make the production of hybrid seed economical?

# MATERIALS AND METHODS

The materials and methods section will be presented as three separate studies conducted to investigate the effectiveness of specific chemicals to induce male sterility in wheat and triticale. Two growing seasons (1978-79 and 1979-80) were employed with three experimental sites. Study I was conducted to determine the most effective concentrations and time of application of the chemicals in relation to the stage of growth for inducing male sterility. The intent of Study II was to determine possible cultivar x chemical interactions in relation to male sterility and phytotoxicity. In Study III, induced male sterility and natural out-crossing in wheat were investigated.

## Study I

Stephens winter wheat served as the experimental material for this study. A description of the variety Stephens is provided in Appendix Table 1. Two chemicals (SD 55446 and SD 55447)[1] were evaluated for their possible male gametocide properties. Four concentrations of the chemicals applied singly and in combination (0.224 + 0.224, 0.224 + 0.448, 0.448 + 0.448 and 0.896 kg/ha of active ingredient (a.i.)) were sprayed by a wheel sprayer at growth stages 32 and 34 using Zadoks scale (Appendix Table 2). A surfactant check and an untreated check were also included with each test. Individual plots were planted in a split plot design with four replications at the Hyslop Agronomy Farm in 1978-79. The soil type is Woodburn silt loam. Treatments represented the main

[1]The chemicals SD 55446 and SD 55447 were provided by Shell Development Company, Modesto, CA. Chemicals identification was not disclosed.

plots, bagged-unbagged representing the subplots. Plot size consisted of six rows with 2.25 cm between rows and with a row length of six meters. A 100 kg/ha seeding rate was employed. Three hundred and thirty-six kg/ha of 16-20-0 was applied prior to seeding. At the elongation stage of growth, two further applications of urea were applied. Karmex at 1.8 kg/ha of active material was applied as a post emergence spray for weed control.

To measure the possible male gametocide properties, 20 spikes were bagged in each plot prior to anthesis to prevent cross-pollination. They were used as a measure of self-pollination. Twenty unbagged spikes were harvested from each plot to compare with bagged spikes to determine the amount of cross-pollination. Ten spikes in each plot were mechanically emasculated and bagged. Subsequently, they were pollinated with pollen from untreated plots to evaluate possible chemically induced female sterility.

To assess other possible phytotoxic reactions, the following measurements were made. Plant height was measured at two different dates: 1) The first measurement in centimeters was made from the ground to the tip of the tallest leaf at three weeks after spraying. 2) Height was measured again at maturity in centimeters from the ground to the tip of the tallest culm, excluding awns.

The number of spike-bearing tillers was recorded from two separate one-meter sections of rows within the plot. The average of the two samples was considered as the number of tillers per meter row. Spike length was measured in centimeters. The number of spikelets per spike were counted in both bagged and unbagged samples. Grain yield per plot was obtained by harvesting the central four rows with a Hege combine. The outer two rows and one meter at each end of the plot were not harvested to avoid border effects. Grain was cleaned and recorded in grams.

In the second year (1979-80), Stephens was fall-planted at the Schmidt Farm which adjoins the Hyslop Agronomy Farm. The soil type was Woodburn silt loam. Six rows, six meters long with 22.5 cm row spacings were arranged in split plot design. Two replications were used for each of the two nitrogen levels. Fertilizer and Karmex applications were applied as in 1978-79. The chemical SD 55446 was used in two concentrations (0.56 and 0.84 kg/ha a.i.) at two growth stages: 1. early stage of spikelet formation (first date) and 2. prior to meiosis (second date) with a high nitrogen level. Zadoks scale was not used in second year experiments in order to be more precise in terms of growth stages. The 0.84 kg/ha of chemical was only applied at the second date on low nitrogen level plots. Therefore, the data from the nitrogen treatments were analyzed separately.

Ten spikes in each plot were bagged prior to anthesis to prevent cross-pollination and measure possible self-pollination. Five spikes in each plot were mechanically emasculated, bagged and pollinated with pollen from untreated plots to evaluate possible chemically induced female sterility. Ten unbagged spikes from each plot were harvested to determine the amount of out-crossing. Spike length, number of spikelets per spike and 50 kernel weight from bagged and unbagged spikes were measured. Plant height and grain yield per plot were recorded in a similar manner as in 1978-79.

## Study II

The possible differential effectiveness of the chemicals in inducing male and female sterility and the amount of subsequent out-crossing in wheat and triticale cultivars were investigated. This study was conducted at the Hyslop Agronomy Farm in 1978-79. Nine genetically diverse wheat and three triticale cultivars represented the experimental material for this study. A description of these cultivars is provided in Appendix Table 1. Plots were arranged in a strip plot design with two replications. Cultivars were the main plots, chemical was in a strip within cultivars and bagged vs unbagged was at random within the chemical strips. Plot size, fertilizer and Karmex applications were carried out as in Study I. SD 55446 was applied at stage 32 on Zadoks scale at a concentration of 0.67 kg/ha a.i. Twenty spikes in each plot were bagged prior to anthesis to prevent cross-pollination. Ten spikes in each plot were mechanically emasculated and pollen from untreated plots was used to determine effectiveness of the chemical on female sterility. Twenty unbagged spikes in each plot were harvested and compared with the bagged spikes to determine the amount of out-crossing.

Spike length, number of spikelets per spike, plant height and grain yield per plot were measured as previously noted to evaluate possible phytotoxicity. Maturity dates were also recorded to determine if the chemical altered maturity.

For the second year (1979-80), Yamhill, Stephens, Hyslop, Daws, Maris Hobbit and Luke were fall-planted at the East Farm (the soil type was a Chehalis silt loam) and the Schmidt Farm. Plots were arranged in strip-plot design with two replications at the East Farm and one replication at the Schmidt Farm. The cultivars were planted in six rows, six meters long with 22.5 cm row spacing. Fertilizer and Karmex applications were the same as the previous year. SD 55446 was sprayed by a wheel sprayer in 1.5 meter strips at the concentration of 0.84 kg/ha at two growth stages: 1. early stage of spikelet formation (first date) and 2. prior to meiosis (second date).

Ten spikes in each plot were bagged to prevent cross-pollination and five spikes were mechancially emasculated and pollinated with pollen from untreated plots to determine possible reduced female sterility. To evaluate cross-pollination, ten unbagged spikes in each plot were harvested to compare with bagged spikes.

Spike length, number of spikelets per spike and plant height were measured in a similar manner as in 1978-79 to determine possible phytotoxicity.

## Study III

To assess the induced male sterility and natural out-crossing in wheat, Yamhill and Stephens were fall-planted in square plots at the East Farm in 1979. Each plot was surrounded by Blue Bart and Blue Narco, two cultivars with blue aleurone. The blue aleurone character served as a genetic marker and made it possible to determine out-crossed seed at harvest time. The experimental field was 27.5 m long by 27.5 m wide and was seeded at a rate of 100 kg/ha. Seeding rate was 100 kg/ha for Blue Bart and Blue Narco. They were planted in 1.8 m wide strips. Three hundred and thirty-six kg/ha of 16-20-0 fertilizer was applied at seeding time, an additional 168 kg/ha of urea was applied in the spring. Karmex (1.8 kg/ha a.i.) was applied as a post emergence application. The chemically treated plots were arranged randomly in four directions. The size of each area was 1.5 m wide by 9 m long. Two chemicals (SD 55446 and WL 84245[1]) were sprayed by a wheel sprayer at two growth stages: 1. early stage of spikelet formation (first date) and 2. prior to meiosis (second date) at the concentration of 0.84 kg/ha a.i. Ten spikes in each plot were bagged prior to anthesis to prevent cross-pollination. Five spikes in each plot were mechanically emasculated and pollinated with pollen from untreated plots to evaluate possible induced female sterility.

Ten unbagged spikes were harvested to compare with bagged spikes to determine cross-pollination. Ten spikes in six distances (22.5 cm, 1 m, 2 m, 4 m, 8 m, 13.5 m from blue aleurone plants) were harvested and blue and white seeds counted. The ratio of the blue seed to total seed was used as a measure of the percentage of cross-pollination.

Plant height, spike length, number of spikelets per spike and grain yield per plot were measured as previously noted to determine possible phytotoxicity.

In addition, Stephens was fall-planted in a 54-meter diameter circle surrounded with Blue Narco and Blue Bart at the Schmidt Farm in 1979. Fifty-four meters was selected as it is the distance currently required for adequate isolation in the Oregon Certification program. Blue Narco and Blue Bart were planted at two dates in order to provide effective pollen dispersal. Plot sizes were 1.5 m wide and 22.5 m long. Plots

[1]The chemical WL 84245 was provided by Shell Development Company, Modesto, CA Chemical identification not disclosed.

were arranged in randomized complete block design in each of four directions. The seeding rate was 100 kg/ha. Three hundred and thirty-six kg/ha of 16-20-0 fertilizer was applied at seeding time. Karmex (1.8 kg/ha a.i.) was applied as a post-emergence application for weed control. One hundred and sixty-eight kg/ha of urea was applied in the spring. Two different compounds (SD 55446 and WL 84245) were sprayed by a wheel sprayer at two growth stages: 1. early stage of spikelet formation (first date) and 2. prior to meiosis (second date). Twenty spikes in each plot were bagged at heading time to prevent cross-pollination. Ten spikes in each plot were mechanically emasculated and pollinated with pollen from untreated plots to note possible female sterility. Ten unbagged spikes were randomly selected compare with bagged spikes to evaluate cross-pollination.

Natural out-crossing, again using the blue aluerone genetic marker, was investigated. Samples were harvested from seven distances from the blue aleurone marker stocks (0.3 m, 1 m, 2 m, 4 m, 8 m, 12 m and 16 m) and eight directions (north, northeast, east, southeast, south, southwest, west and northwest). At each distance in the eight directions a sample of 60 cm in length from one row was harvested to determine out-crossing. After threshing, blue and white seed were separated and counted. The ratio of the blue seed to the total seed was considered as a percentage of natural out-crossing at specific distances.

Ten spikes in each of eight distances (0.3 m, 1 m, 2 m, 4 m, 8 m, 12 m, 16 m and 20 m from blue aleurone pollinator) were taken from treated and untreated plots. They were threshed separately and blue and white seeds counted. The ratio of blue seed to total seed number was considered the out-crossing ratio at specific distances.

Analyses of variance, including bagged-unbagged data were used for each trait to detect whether differences existed among treatments and/or bagged vs unbagged spikes. Also, analyses of variance were used to evaluate possible phytotoxicity including female sterility. The F test was utilized to determine if significant differences existed among treatments and between N levels. Mean values for seeds per spike, spike length, number of spikelets per spike, F1 seeds per spikelet, grain yield per plot and plant height were compared using the Duncan's multiple range test. Mean values for bagged and unbagged spikes were compared using LSD values. The percentage of reduction for seed set was calculated using the following formula:

$$100 - \frac{\text{seed set in treated spikes}}{\text{seed set in control spikes}} \times 100 = \text{percentage of reduction}$$

# RESULTS AND DISCUSSION

The results and discussion section will be presented with regard to three investigations conducted: 1) Chemicall induced male sterility, 2) Chemical x cultivar interaction and 3) Induced male sterility and natural out-crossing.

## Chemically Induced Male Sterility

Chemicals SD 55446 and SD 55447 (treatments) when applied at grwoth stages 32 and 34 (Zadoks scale: principle growth stage 3 is stem elongation; 32 stands for second node detectable and 34 stands for fourth node detectable. Application dates were April 18 and April 25 for first and second date, respectively.) resulted in differences for most traits studied (Appendix Tables 3 and 4). The one exception was for tiller number (Appendix Table 4). Differences were also observed for the bagged vs unbagged spikes for seeds per spike, spike length and number of spikelets per spike (Appendix Table 3). The spikes were bagged to avoid any foreign pollen from confounding the data in determining male sterility. Also, these spikes were compared with unbagged spikes to evaluate the amount of out-crossing.

In Table 1, the mean values are presented for three traits as influenced by the ten treatments. Also, the influence of the bagged vs unbagged spikes can be noted. The difference in seeds per spike between treated bagged and unbagged spikes might suggest that the glycine bag may have adversely affected seed set; even though the differences were not significant. This effect may have also been the

Table 1

Mean values for seeds per spike, spike length and number of spikelets per spike for Stephens wheat treated with SD 55446 and SD 55447 at four concentrations at two dates at Hyslop Agronomy Farm in 1978-79.

| Treatment Number | Chemical | Application Rate and Date | | Seeds per Spike | | Spike Length (cm) | | Spikelets per Spike | |
|---|---|---|---|---|---|---|---|---|---|
| | | Apr. 15 | Apr. 25 | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged |
| 1 | SD 55446 | 0.224 | + 0.224 | 56.47 a* | 49.89 ab | 11.31 | 9.40 | 18.91 | 16.70 |
| 2 | | 0.224 | + 0.448 | 19.75 c | 24.32 c | 10.38 | 8.85 | 17.82 | 15.18 |
| 3 | | 0.448 | + 0.448 | 20.28 c | 23.99 cd | 10.18 | 8.65 | 18.22 | 15.05 |
| 4 | | | 0.896 | 6.99 d | 12.71 ef | 10.30 | 8.96 | 18.88 | 15.55 |
| 5 | SD 55447 | 0.224 | + 0.224 | 40.68 b | 41.26 b | 10.45 | 9.15 | 18.79 | 16.04 |
| 6 | | 0.224 | + 0.448 | 7.06 d | 14.34 de | 10.70 | 8.77 | 18.06 | 14.92 |
| 7 | | 0.448 | + 0.448 | 5.57 d | 11.71 ef | 10.93 | 8.99 | 18.37 | 15.20 |
| 8 | | | 0.896 | 1.56 d | 2.94 f | 11.47 | 10.52 | 19.27 | 17.31 |
| 9 | Surfactant Check | | | 50.95 a | 51.84 a | 9.83 | 9.40 | 19.18 | 17.89 |
| 10 | Control | | | 58.48 a | 58.39 a | 9.89 | 10.40 | 18.66 | 18.96 |
| | $S_{\bar{x}}$ | | | 3.25 | | 0.58 | | 0.83 | |
| | $t_{.05}$ | | | 2.048 | | 2.048 | | 2.048 | |
| | $LSD_{.05}$ | | | 5.80 | | 1.24 | | 1.79 | |

*Ranking of the mean values using Duncan's multiple range test.

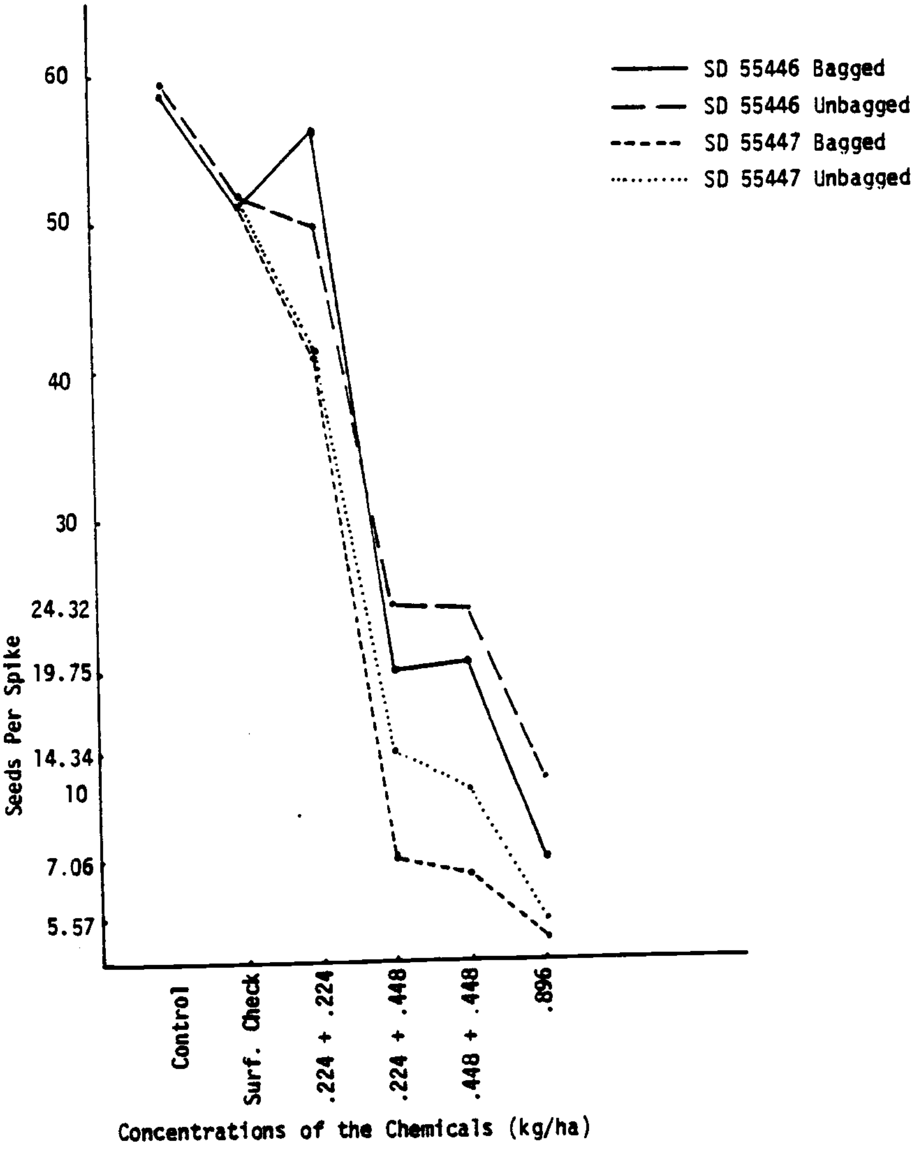
result of substantial out-crossing on unbagged spikes. However, natural out-crossing in thought to be very low in Stephens wheat and was ignored as a variable contributing to differences between bagged and unbagged spikes. Since the actual differences between bagged and unbagged spikes for seed set in the control plots were very low, it was assumed that the glycine bag had little effect on seed set.

Comparing mean values for seeds per spike, it can be noted that SD 55446 did not significantly effect seeds per spike in bagged spikes at the concentration of 0.224 + 0.224 kg/ha active ingredient (Treatment 1) when compared to the control. SD 55447 reduced seed set in bagged spikes at the same concentration (Treatment 5).

Concentrations of 0.224 + 0.448 and above reduced seed set in both bagged and unbagged spikes. When only bagged spikes are considered, the lowest seed set (1.56 seeds) was obtained in Treatment 8. However, 100% induced male sterility was not obtained in any treatments. The highest rate applied (Treatments 4, 7 and 8) approached this level with 1.56 seeds per spike or 97.34% male sterility obtained with Treatment 8 and 6.99 seeds per spike or 88.05% with Treatment 4 applied plots.

Mean values of seeds per spike decreased for both bagged and unbagged spikes when concentrations were increased. There was a significant difference between the chemicals at higher concentrations with SD 55447 reducing seed set in both bagged and unbagged spikes more than SD 55446 (Figure 1). When the two chemicals are compared

Figure 1. Mean values for seeds per spike for bagged and unbagged spikes of Stephens wheat cultivar treated with two chemicals at Hyslop Agronomy Farm in 1978-79.



for the 0.224 + 0.448 kg/ha concentration, SD 55447 reduced seed set to a value of 7.06 seeds per bagged spike while SD 55446 reduced seed set to 19.75 seeds per bagged spike. For the 0.448 + 0.448 kg/ha application, the values were 5.57 and 20.28 seeds per bagged spike for SD 55447 and SD 55446, respectively. A similar condition was observed for the unbagged spikes with the values of 14.34 for SD 55447 and 24.32 for SD 55446 with the concentration of 0.224 + 0.448 kg/ha. The values of 11.71 seeds per spike for SD 55447 and 23.99 for SD 55446 with the concentration of 0.448 + 0.448 kg/ha were recorded.

Seeds per unbagged spike differed from seeds per bagged spike in Treatments 6 and 8 (Table 1). These results indicated that out-crossing played a major role in producing the differences between bagged and unbagged spikes for seed set. In other words, seeds per spike in bagged spikes were the result of self-pollination as well as cross-pollination. The largest mean difference between bagged and unbagged spikes for seed set was obtained in Treatment 6 where 11.71 and 5.57 seeds per spike for unbagged and bagged spikes, respectively, were found. The 5.57 seeds per spike was a result of 100% self-pollination while the value of 11.71 seeds was the result of both out-crossing and self-pollination. Reduced seed number per spike in unbagged spikes can be from induced adverse morphological effects of the chemicals resulting in delayed anthesis, slow spike emergence or female sterility. These same adverse effects could also be true for bagged spikes as well.

Spike length was also affected by both chemicals (Table 1). SD 55446 tended to increase spike length in all concentration but it was not signficantly different from the control whereas SD 55447 increased spike length at the concentration of 0.896 kg/ha when applied to the plots. For unbagged spikes, SD 55447 decreased spike length compared to control plots.

The glycine bag had some effect on spike length. Mean values of the spike length were greater in the bagged than the unbagged with the exception of the controls (Table 1). The greatest influence of the bagged vs unbagged spike on spike length was Treatment 7 where a 1.34 cm difference can be noted. Differences between bagged and unbagged spikes for spike length were observed in Treatments 1, 2, 3, 4, 5, 6, and 7.

Number of spikelets per spike was also influenced by the chemical treatments. Both chemicals decreased the number of spikelets per spike as the chemical concentrations increased with the exception of the plots where 0.896 kg/ha was applied (Table 1). By using $LSD_{.05}$ (1.79) values, differences between bagged and unbagged spikes for number of spikelets per spike were found in all treatments applied.

The mean values for F1 seeds per spikelet, grain yield and plant height are presented in Table 2. F1 seeds per spikelet was used as a measure of the female sterility. Using Duncan's multiple range test to compare means of F1 seeds per spikelet, it can be noted that Treatments 3, 4, 6, 7 and 8 differed from the control (Treatment 10). The chemical SD 55447 affected female receptiveness at the concentrations of 0.224 + 0.448 kg/ha and higher and SD 55446 affected it at the concentrations of 0.448 + 0.448 and 0.896 kg/ha. Comparison between the two chemicals for F1 seeds per spikelet indicates that SD 55447 was more effective in

Table 2

Mean values for Fl seeds per spikelet, grain yield and plant height for Stephens wheat treated with SD 55446 and SD 55447 chemicals at four concentrations at two dates at Hyslop Agronomy Farm in 1978-79.

| Treatment Number | Chemicals | Application Rates and Dates | | Fl Seeds Per Spikelet | Grain Yield (kg/plot) | Plant Height | |
|---|---|---|---|---|---|---|---|
| | | Apr. 18 | Apr. 25 | | | May 15 | July 11 |
| 1 | SD 55446 | 0.224 + | 0.224 | 1.30 ab | 2.115 c | 57.0 bcd | 83.8 b |
| 2 | | 0.224 + | 0.448 | 1.12 abc | 1.490 d | 56.3 bcd | 81.3 bcd |
| 3 | | 0.448 + | 0.448 | 0.98 bc | 1.439 d | 51.8 d | 80.0 bc |
| 4 | | | 0.896 | 0.87 c | 0.673 f | 62.8 b | 78.3 cd |
| 5 | SD 55447 | 0.224 + | 0.224 | 1.12 abc | 1.924 c | 60.5 bc | 82.0 bc |
| 6 | | 0.224 + | 0.448 | 0.91 bc | 0.972 e | 56.0 bcd | 81.3 bc |
| 7 | | 0.448 + | 0.448 | 0.85 c | 0.944 e | 55.5 cd | 80.8 bcd |
| 8 | | | 0.896 | 0.26 d | 0.192 g | 62.5 bc | 77.0 d |
| 9 | Surfactant Check | | | 1.20 abc | 2.730 b | 76.0 a | 93.8 a |
| 10 | Control | | | 1.44 a | 2.988 a | 80.8 a | 96.8 a |
| | $S_{\bar{x}}$ | | | 0.1234 | 0.0795 | 2.1069 | 1.3743 |
| | $t_{.05}$ | | | 2.052 | | | |

*Ranking of the mean values using Duncan's multiple range test.

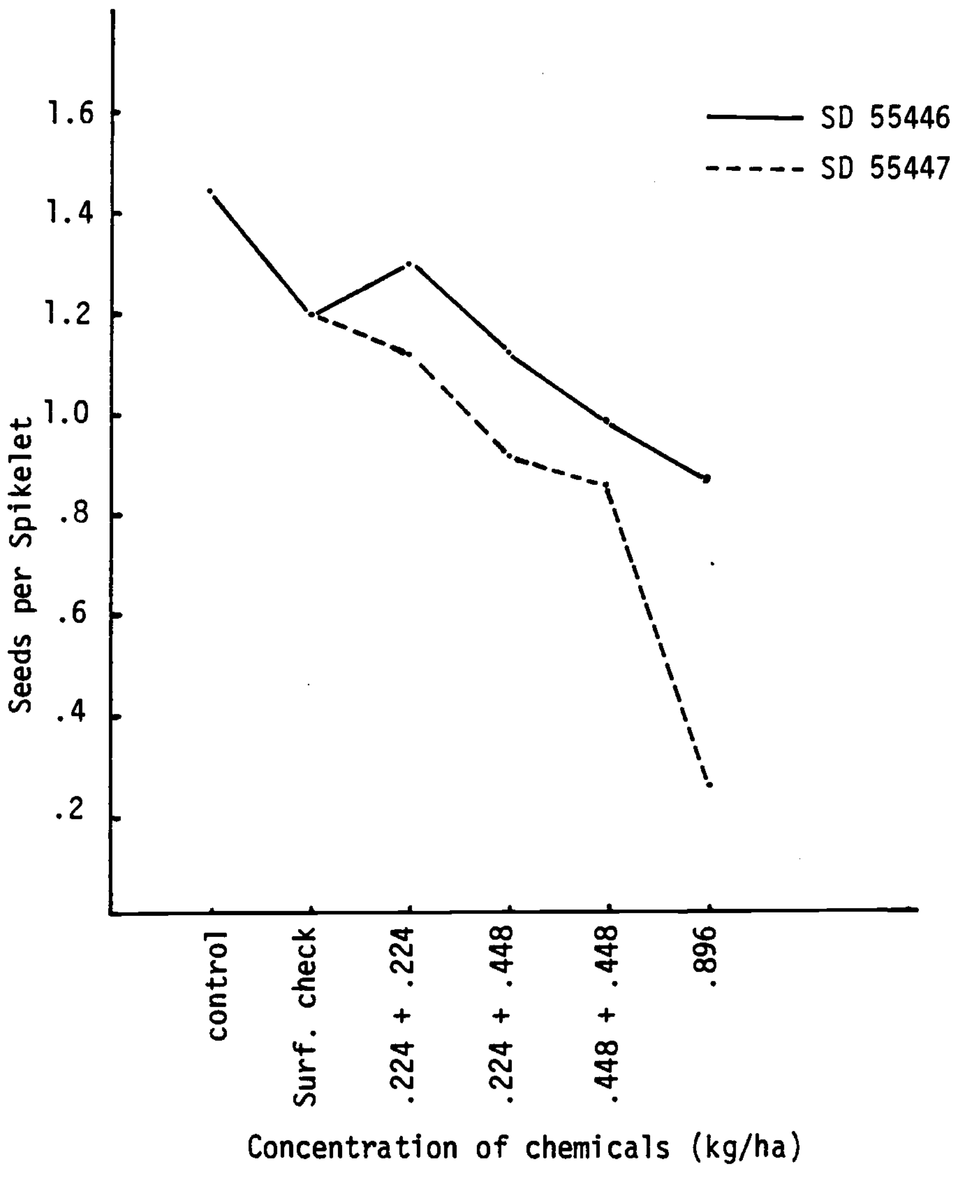
reducing F1 seeds per spikelet than SD 55446 (Figure 2). For example, it can be noted that the value of 0.87 seeds per spikelet was obtained in Treatment 4 (0.896 kg/ha SD 55446) and 0.26 seeds per spikelet was obtained from the plot receiving the same concentration of SD 55447.

Grain yield was significantly reduced by application of the chemicals at all concentrations (Table 2). Some reduction in grain yield may have been due to delayed anthesis and slow spike emergence in the treated plots. In general there was a decrease in grain yield with increasing the concentration. Also, split applications had less effect than a single application. Although both chemicals had an effect on reducing grain yield, SD 55447 caused a greater reduction. Grain yield in surfactant check plots differed from control plots. The lowest yield was 0.192 kg/plot for Treatment 8 applied plots. Grain yield of the control plot was 2.988 kg/plot. This result suggest that the chemical had an adverse effect on grain yield.

Plant height was reduced by both chemicals (Table 2). There was no difference between the two chemicals for plant height measured at the two dates. The concentration of 0.896 kg/ha of both chemicals was more effective in reducing plant height than the other concentrations when plant height was measured on July 11. The reduced plant height may be a morphological advantage which could increase the level of out-crossing in female plants for commercial hybrid wheat seed production (Hughes and Bodden, 1978a).

The summary of mean square values obtained during the second year (1979-80) for seven traits involving a high nitrogen level when SD 55446 was applied at two growth stages (the early stage of spikelet formation)

Figure 2. Mean seed per spikelet following hand pollination of two florets in each spikelet for Stephens wheat cultivar at Hyslop Agronomy Farm in 1978-79.



(first date) and prior to anthesis (second date)) are presented in Appendix Tables 5 and 6. Differences among the treatments were observed for seeds per spike, number of spikelets per spike, grain yield and plant height. Differences were also found for seeds per spike and the number of spikelets per spike when the bagged and unbagged spikes are considered.

It was found that all chemical treatments significant reduced seed set of bagged spikes when compared to control plots (Table 3). There was no difference in seed set when the two chemical rates were applied at the same growth stage (.95 and 1.35 for the first date and 16.65 and 26.44 for the second date). However the first application date was more effective. The concentration of 0.84 kg/ha was more effective than at the concentration of 0.56 kg/ha in reducing seed set on bagged spikes. The lowest seed set was obtained when SD 55446 was applied at the concentration of 0.84 kg/ha at the first date (0.95).

Seed set in unbagged spikes were higher than in bagged spikes with the exception of the control plots. Significant out-crossing was not obtained when SD 55446 was applied at the concentration of 0.84 kg/ha at the first date. The largest difference between bagged and unbagged spikes was obtained in the plots which received 0.56 kg/ha of SD 55446 applied at the first date (1.35 vs 22.6, respectively). Seeds per spike in bagged spikes were the result of self-pollination and seeds per spike in unbagged spikes resulted from both self-pollination and out-crossing. The value of 1.35 seeds was a result of self-pollination while the value of 22.6 seeds was the result of out-crossing and self-pollination.

Table 3

Mean values for seeds per spike, spike length, number of spikelets per spike, 50 kernel weight, F1 seeds per spikelet, plant height and grain yield on Stephens wheat grown under a high nitrogen level and treated with SD 55446 chemical at two concentrations at two stages of growth at Schmidt Farm in 1979-80.

| Treatment Number | Concentration | Application Time | Seeds Per Spike | | Spike Length (cm) | | Spikelets Per Spike | | 50 Kernel Weight | | F1 Seeds Per Spikelet | Plant Height | Grain Yield (kg/plot) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | | | |
| 1 | 0.56 | First Date | 1.35 c* | 22.6 b | 10.48 | 10.10 | 18.15 ab | 18.2 ab | 2.96 | 2.68 | 0.55 | 102.5 a | 1.954 ab |
| 2 | 0.84 | First Date | 0.95 c | 5.0 c | 10.72 | 10.72 | 19.01 a | 18.9 a | 2.71 | 2.66 | 0.97 | 97.5 ab | 0.694 c |
| 3 | 0.56 | Second Date | 26.44 b | 38.7 a | 10.15 | 9.55 | 17.71 b | 16.75 c | 2.34 | 2.60 | 1.59 | 90.0 b | 1.910 ab |
| 4 | 0.84 | Second Date | 16.65 b | 40.5 a | 10.35 | 10.72 | 18.25 ab | 16.95 c | 2.63 | 2.78 | 0.83 | 87.5 b | 1.390 bc |
| 5 | Control | | 50.46 a | 44.7 a | 10.64 | 10.18 | 18.85 a | 17.5 bc | 1.96 | 2.46 | 1.62 | 105.0 a | 2.482 a |
| | | $S_{\bar{x}}$ | 4.3428 | | NS** | | 0.2435 | | NS | | NS | 2.958 | 0.189 |
| | | $t_{.05}$ | 2.592 | | | | 2.5779 | | | | | | |

*Ranking of the mean values using Duncan's multiple range test.
**NS: not significant

Significant differences were found between the control and the plots which received 0.56 kg/ha SD 55446 at the second date involving bagged spikes for spikelets per spike. For unbagged spikes, the chemical reduced the spikelet number when applied at the second date as compared to the first date. An increase in the number of spikelets was observed when the chemical was applied at the first date at the concentration of 0.84 kg/ha.

As previously observed, seeds per unbagged spike were reduced when chemical concentration increased. Reduction in seed set in unbagged spikes could be accounted for by adverse morphological effects of the chemical on spike emergence or female receptiveness. To determine possible induced female sterility the F1 seeds per spikelet was again used. The chemical did not significantly reduce F1 seeds per spikelet in this experiment (Table 3).

SD 55446 did reduce grain yield when applied at both growth stages and at the two concentrations (Table 3). The chemical had a depressing effect on grain yield when applied at the concentration of 0.56 and 0.84 kg/ha at both growth stages. When 0.84 kg/ha was applied at the first date, 0.694 kg/plot grain yield was obtained. Reduction in grain yield in treated plots could be accounted for by deleterious effects of the chemical on spike emergence and perhaps the lack of adequate pollen in the field.

The chemical also had an effect on plant height (Table 3). The reduction of plant height at the 0.56 and 0.84 kg/ha rate of

SD 55446 applied at the second date was significant when compared to the control.

The mean square values of seven traits for Stephens grown under low nitrogen levels treated with SD 55446 at two concentrations and two growth stages are presented in Appendix Tables 7 and 8. Treatment differences were observed for seeds per spike and grain yield. Seeds per spike and 50 kernel weight were different when the bagged vs unbagged spikes are considered.

The mean values of these traits are also presented in Table The chemical reduced seeds per spike in bagged spikes when applied at two concentrations at the first date. Seed set in the bagged spikes increased when the chemical was applied at the concentration of 0.56 kg/ha at the second date but it was not significantly different when compared to the control. For unbagged spikes, seeds per spike decreased when 0.84 kg/ha of SD 55446 was applied at the first date when compared to the control. The difference between the two application dates was observed when 0.56 kg/ha of SD 55446 was applied with a greater reduction being noted with the earlier application date. The concentration of 0.84 kg/ha was the most effective in reducing seeds per spike in this experiment.

Seeds per spike in unbagged spikes were greater than in bagged spikes. The difference between bagged and unbagged spikes for seeds per spike in treated plots which were compared using $LSD_{.05}$ (2.948) was probably due to out-crossing. Significant differences were obtained when SD 55446 was applied at the concentration of 0.56 kg/ha at the early stage of spikelet formation.

The chemical did not affect kernel weight when applied at two concentrations and at two growth stages. However, the bag did have an affect on reducing kernel weight. The significant difference between the means of bagged and unbagged values for kernel weight ($LSD_{.05}$ = .3857) was found when 0.56 kg/ha of SD 55446 was applied at the first date (Table 4).

Grain yield was affected by SD 55446 when applied at two rates at both growth stages (Table 4). The chemical reduced grain yield when applied at both concentrations at the first date. A difference was found between the two concentrations when the chemical was applied at the first date. Although it was not significant, increased grain yield was observed when the chemical was applied at the second date at the concentration of 0.56 kg/ha.

When the results of the two years were analyzed, it would appear that both SD 55446 and SD 55447 do induce male sterility and thus are gametocides. This was especially true at the higher concentrations (0.896 kg/ha) when applied at the growth stage 34 (fourth node detectable, second date). Unfortunately, the successful use of chemically induced male sterility must avoid other phytotoxic effects which impair the normal development of the plant. In these studies, both chemicals were phytotoxic in terms of their effects on female receptiveness, spike

Table 4

Mean values for seeds per spike, spike length, number of spikelets per spike, 50 kernel weight, F1 seeds per spikelet, plant height and grain yield on Stephens wheat grown under low nitrogen level and treated with SD 55446 chemical at two concentrations and at two stages of growth at Schmidt Farm in 1979-80.

| Treatment Number | Concentration | Application Time | Seeds Per Spike | | Spike Length (cm) | | Spikelets Per Spike | | 50 Kernel Weight | | F1 Seeds Per Spikelet | Plant Height (cm) | Grain Yield (kg/plot) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | | | |
| 1 | 0.56 | First Date | 21.280b* | 35.90 b | 8.18 | 8.88 | 15.40 | 16.40 | 1.84 | 2.16 | 1.22 | 87.5 | 1.242 b |
| 2 | 0.84 | First Date | 14.80 b | 20.90 c | 8.58 | 8.28 | 15.95 | 15.75 | 2.47 | 2.48 | 1.39 | 82.5 | 0.682 c |
| 3 | 0.56 | Second Date | 40.61 a | 47.95 a | 8.84 | 9.75 | 16.79 | 18.15 | 2.49 | 2.70 | 1.41 | 90.0 | 2.089 a |
| 4 | Control | | 35.05 a | 39.70 ab | 8.28 | 8.58 | 16.15 | 16.75 | 2.61 | 2.86 | 1.41 | 90.0 | 1.861 a |
| | $S_{\bar{x}}$ | | 2.7309 | | NS* | | NS | | | | NS | NS | 0.126 |
| | $t_{.05}$ | | 2.948 | | | | | | | | | | |
| | $LSD_{.05}$ for bagged-unbagged | | | | | | | | 0.3857 | | | | |

*Ranking of the mean values using Duncan's multiple range test.
**NS: not significant

emergence, number of spikelets per spike and grain yield. SD 55447 was more effective in increasing male sterility than SD 55446 but it also resulted in a greater reduction in female receptiveness at the highest concentration tested. SD 55446 did not adversely influence female fertility in either year at the concentrations used or at the growth stages applied. It did cause some phytotoxicity in the other traits measured; however, this was reduced when the applications were made at the latter stages of plant development. For example, in the first year's experiment, spike length and spikelet number were affected when it was applied at the growth stages 32 and 34 (stem elongation, second and fourth node detectable). In the second year's experiment, it did not affect spike length and number of spikelets when applied at the latter stages (the early stage of spikelet formation and prior to meiosis).

Even though the chemicals were consistently more effective in inducing male sterility at the higher nitrogen levels, there were no significant differences between nitrogen levels in this respect.

## Chemical X Cultivar Interaction

Observed mean square values for six traits involving 12 cultivars when treated with SD 55446 are presented in Appendix Tables 9, 10 and 11. Differences were observed for cultivars for all six traits measured.

The treatment of .67 kg/ha application was significant for all traits with the excpetion of F1 seeds per spikelet. The significant higher order interactions made it difficult to draw conclusions about the main effect of chemical, bagged vs unbagged and the response of the cultivars to the chemical. The coefficients of variation ranged from a high of 14.19% for F1 seeds per spikelet to a low of 2.64% for plant height.

SD 55446 decreased seed set in bagged spikes of all cultivars tested with the exception of Bezostaja-1 (Table 5). Comparison of the means in seeds per bagged spike showed that Luke, Bezostaja and Centurk wheats and WSU I triticale were not affected by SD 55446 at the concentration of 0.67 kg/ha when applied at growth stage 32. The same result can be seen by comparing mean values of unbagged spikes, with the exception of WSU I. Reduction of seed set in Yamhill wheat was the highest among the cultivars tested. Number of seeds per spike was reduced 47.23 or 38% for this cultivar. The concentration of the chemical applied was not sufficient to obtain 100% male sterility in any of the cultivars.

The difference in seeds per spike between bagged and unbagged spikes in wheat cultivars might be due to out-crossing or adverse bag effect (Table 5). Comparing bagged and unbagged spikes in control plots showed that there was no significant bag effect in

Table 5

Mean values for seeds per spike, spike length, number of spikelets per spike, F1 seeds per spikelet, plant height and grain yield for nine wheat and three triticale cultivars treated with the concentration of 0.67 kg/ha of SD 55446 chemical at Hyslop Agronomy Farm in 1978-79.

| Varieties | Chemical Application Rate | Seeds Per Spike | | Spike Length (cm) | | Spikelets Per Spike | | F1 Seeds Per Spikelet | Plant Height (cm) | Grain Yield (kg/plot) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | | | |
| Yamhill | Check | 76.18 | 76.75 | 9.10 | 8.93 | 23.39 | 23.15 | 1.71 | 115.0 | 5.650 |
| | 0.67 | 47.23 | 47.37 | 6.87 | 6.24 | 19.16 | 17.68 | 1.61 | 91.5 | 4.224 |
| Stephens | Check | 73.30 | 75.40 | 11.70 | 12.10 | 21.95 | 21.30 | 1.27 | 97.5 | 6.407 |
| | 0.67 | 54.78 | 50.85 | 10.23 | 9.83 | 18.49 | 17.92 | 1.37 | 88.5 | 5.311 |
| Hyslop | Check | 72.10 | 71.00 | 9.24 | 9.33 | 22.13 | 22.25 | 1.67 | 103.5 | 7.230 |
| | 0.67 | 52.04 | 56.23 | 7.72 | 8.09 | 18.69 | 18.80 | 1.76 | 82.0 | 5.249 |
| Daws | Check | 72.65 | 72.70 | 10.30 | 10.35 | 22.75 | 22.15 | 1.84 | 103.5 | 5.913 |
| | 0.67 | 48.43 | 51.50 | 7.90 | 8.28 | 18.20 | 18.00 | 1.68 | 91.5 | 4.874 |
| Maris Hobbit | Check | 72.30 | 70.85 | 11.38 | 11.20 | 22.55 | 22.00 | 1.48 | 87.5 | 6.587 |
| | 0.67 | 60.21 | 66.79 | 9.82 | 10.55 | 21.80 | 21.77 | 1.30 | 80.0 | 5.271 |
| Luke | Check | 59.58 | 59.55 | 9.23 | 8.95 | 20.95 | 20.75 | 1.69 | 98.5 | 4.971 |
| | 0.67 | 53.38 | 54.23 | 8.30 | 8.12 | 19.70 | 18.35 | 1.58 | 82.5 | 5.239 |
| Bezostaia | Check | 49.71 | 46.83 | 10.31 | 10.28 | 20.60 | 19.75 | 1.66 | 126.5 | 5.955 |
| | 0.67 | 54.10 | 43.19 | 11.56 | 8.91 | 22.61 | 18.64 | 1.41 | 101.0 | 4.773 |
| Centurk | Check | 49.96 | 53.55 | 8.13 | 8.40 | 19.67 | 19.70 | 1.51 | 137.0 | 5.610 |
| | 0.67 | 46.90 | 43.83 | 8.85 | 7.38 | 18.54 | 16.22 | 1.51 | 120.0 | 4.648 |
| Faro | Check | 73.13 | 91.45 | 5.18 | 5.28 | 22.83 | 23.80 | 1.32 | 100.0 | 5.268 |
| | 0.67 | 58.83 | 68.83 | 4.34 | 4.61 | 20.30 | 20.20 | 1.10 | 88.5 | 4.185 |
| WSU I | Check | 59.58 | 84.70 | 12.90 | 13.33 | 31.13 | 33.80 | -- | 155.0 | 6.947 |
| | 0.67 | 52.18 | 48.63 | 10.99 | 9.58 | 24.59 | 22.78 | -- | 122.5 | 5.443 |
| OSU I | Check | 69.94 | 69.14 | 12.85 | 11.93 | 33.40 | 34.13 | -- | 167.5 | 5.225 |
| | 0.67 | 42.55 | 45.03 | 9.70 | 8.87 | 26.11 | 23.60 | -- | 145.0 | 4.430 |
| OSU II | Check | 88.70 | 97.73 | 15.05 | 16.08 | 34.56 | 35.00 | -- | 168.5 | 5.977 |
| | 0.67 | 69.44 | 65.43 | 12.39 | 11.81 | 27.47 | 26.83 | -- | 153.5 | 4.620 |
| $S_{\bar{x}}$ | | 4.059 | | 0.4172 | | 0.8143 | | 0.29 | 2.97 | 0.43 |
| $t_{.05}$ | | 2.146 | | 2.136 | | 2.137 | | 2.262 | 2.189 | 2.18 |

the cultivars in terms of seeds per spike with the exception of Faro. Since there is some natural out-crossing in triticale, the difference in mean values of seeds per spike in unbagged spikes and in bagged spikes was most likely due to cross-pollination.

Comparing the mean values of seeds per unbagged spike, treated and untreated plots showed that the chemical SD 55446 decreased seed set in all cultivars tested. This result may be due to the chemical having an inhibitory effect on spike emergence, delaying anthesis or female sterility.

SD 55446 reduced spike length in all cultivars tested with the exceptions of Luke, Centurk and Faro for both bagged and unbagged spikes (Table 5). Differences among the cultivars were observed for spike length. This was due to cultivar difference rather than chemical effect. The bag effects were different depending on the cultivars. As an example, while the bag decreased spike length in the Hyslop treated plots (7.72 for bagged and 8.09 for unbagged spikes), it increased spike length in plots with Bezostaja, (11.56 for bagged and 8.91 for unbagged spikes).

Number of spikelets per spike regardless of whether bagged or unbagged were different among the cultivars tested with the exceptions of Maris Hobbit, Luke and Bezostaja for bagged and unbagged spikes and Centurk for bagged spikes (Table 5). A decrease in the number of spikelets per spike was observed when the chemical was applied at 0.67 kg/ha at growth stage 32. The effectiveness of the chemical was different depending on the cultivars. There was also a bag effect in terms of spikelet number per spike. However, interaction between bagged vs unbagged and application rate showed that the chemical rate and bag interaction was an important factor in the number of spikelets per spike affected.

To determine possible induced male sterility, F1 seeds per spikelet values were used. There was no difference between control and treated plots in terms of F1 seeds per spikelet. Thus the chemical did not induce female sterility. However, there were differences among the cultivars for F1 seeds per spikelet; this may have been a varietal effect rather than a chemical effect (Table 5). The effectiveness of the chemical on female sterility in triticale was not studied.

SD 55446 reduced plant height when applied at the concentration of 0.56 kg/ha at the growth stage of 32. There was no difference in the effectiveness of the chemical on reducing plant height between taller vs shorter wheat cultivars and wheat vs triticale. However, the effectiveness of the chemical on reducing plant height was different depending on the cultivars.

Differences were observed for grain yield among the cultivars. The chemical resulted in reducing grain yield in all cultivars with the exception of Luke wheat, where yield increased when SD 55446 was applied; however it was not significant (Table 5). The greatest reduction in grain yield was observed in Hyslop with a 26.5% reduction. The grain yield was not different in Daws and Centurk wheats and OSU I triticale when treated and untreated plots within cultivars were compared.

SD 55446 delayed maturity when applied at the concentration of 0.67 kg/ha at the growth stage 32 (Table 6). The differences between treated and control plots for maturity ranged from seven to more than 11 days depending on the cultivars.

Observed mean square values of six traits involving six wheat cultivars treated with SD 55446 at two growth stages in 1979-80 are presented in Appendix Tables 12 and 13. Spike length, spikelets per spike, kernel weight and plant height were different depending on the cultivar. Treatment was significant for all traits studied with the exception of F1 seeds per spikelet. Differences were also found for bagged vs unbagged spikes for seeds per spike and kernel weight. The interactions between cultivars and treatment for plant height and among cultivars, treatment and bagged vs unbagged were also significant.

The mean values of all traits studied are presented in Table 7. The chemical effectively reduced seeds per spike when applied at both stages. Comparing mean values for seeds per spike for bagged spikes within the cultivars showed that the chemical was more effective when applied at the first date. However, there was no significant difference for seeds per spike between the two application dates for Hyslop and Maris Hobbit wheats. The lowest seed set was obtained in Yamhill when SD 55446 was applied at the first date (0.56). The chemical reduced seeds per spike up to 0.90 or 98.8% in bagged spikes. This is probably due to induced male sterility. Comparison of seeds per spike for

Table 6. The observed values for maturity date for twelve cultivars treated with SD 55446 at the concentration of 0.67 kg/ha at growth stage 32 at Hyslop Agronomy Farm in 1978-79.

| | Days to maturity from January 1. | |
|---|---|---|
| Cultivars | Treated | Control |
| Yamhill | 201 | 190 |
| Stephens | 201 | 193 |
| Hyslop | ...* | 193 |
| Daws | 201 | 192 |
| Maris Hobbit | ... | ... |
| Luke | 203 | 192 |
| Bez. | 193 | 183 |
| Centurk | 193 | 185 |
| Faro | 195 | 188 |
| WSU I | 202 | 191 |
| OSU I | 196 | 189 |
| OSU II | 196 | 189 |

* matured later than 202 days.

Table 7

Mean values for seeds per spike, spike length, number of spikelets per spike, 50 kernel weight, F1 seeds per spikelet and plant height for six cultivars treated with SO 55446 at the concentration of 0.84 kg/ha and at two stages of growth at the East Farm in 1979-80.

| Varieties | Application Time | Seeds Per Spike | | Spike Length (cm) | | Spikelets Per Spike | | 50 Kernel Weight (gm) | | F1 Seeds Per Spikelet | Plant Height |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | | |
| Yamhill | First Date | 0.56 | 2.93 | 7.02 | 7.05 | 20.20 | 19.87 | 1.34 | 1.39 | 1.02 | 106.67 |
| | Second Date | 15.70 | 35.00 | 7.26 | 7.90 | 20.03 | 21.03 | 2.18 | 2.20 | 0.47 | 98.33 |
| | Check | 47.81 | 53.02 | 6.94 | 7.37 | 19.14 | 18.91 | 1.84 | 20.4 | 1.04 | 118.33 |
| Stephens | First Date | 3.63 | 18.91 | 9.54 | 10.86 | 17.21 | 18.46 | 2.03 | 2.77 | 1.26 | 98.33 |
| | Second Date | 23.61 | 29.83 | 10.78 | 9.76 | 18.16 | 17.63 | 2.60 | 2.95 | 1.44 | 96.67 |
| | Check | 37.40 | 50.04 | 8.57 | 9.44 | 15.44 | 17.63 | 2.62 | 2.63 | 1.53 | 103.33 |
| Hyslop | First Date | 24.87 | 32.62 | 10.00 | 9.35 | 21.66 | 20.03 | 2.42 | 2.38 | 1.19 | 95.00 |
| | Second Date | 28.39 | 31.57 | 9.55 | 9.30 | 20.65 | 20.93 | 2.26 | 2.37 | 1.06 | 103.33 |
| | Check | 50.07 | 49.63 | 8.85 | 8.23 | 19.70 | 19.27 | 2.23 | 2.55 | 1.22 | 108.33 |
| Daws | First Date | 14.97 | 25.00 | 8.50 | 8.86 | 19.60 | 19.90 | 2.19 | 2.38 | 1.57 | 100.00 |
| | Second Date | 29.11 | 34.65 | 9.77 | 9.87 | 21.19 | 20.92 | 2.24 | 2.16 | 1.28 | 100.00 |
| | Check | 47.87 | 56.67 | 8.69 | 8.80 | 19.52 | 19.10 | 2.12 | 2.21 | 1.18 | 105.00 |
| Maris Hobbit | First Date | 8.13 | 13.13 | 9.86 | 10.90 | 20.36 | 20.96 | 2.88 | 3.07 | 1.28 | 90.00 |
| | Second Date | 12.23 | 27.93 | 10.79 | 10.08 | 20.90 | 20.30 | 2.71 | 3.00 | 1.25 | 93.33 |
| | Check | 50.07 | 58.23 | 9.42 | 9.04 | 19.96 | 19.44 | 1.66 | 2.11 | 1.48 | 95.00 |
| Luke | First Date | 3.17 | 13.90 | 8.74 | 9.76 | 18.58 | 19.63 | 2.45 | 2.74 | 1.50 | 103.33 |
| | Second Date | 18.97 | 28.40 | 9.22 | 9.56 | 19.09 | 20.33 | 2.49 | 2.74 | 1.23 | 95.00 |
| | Check | 39.72 | 44.93 | 8.72 | 8.36 | 17.54 | 17.97 | 1.98 | 2.23 | 1.42 | 105.00 |
| $S_{\bar{x}}$ | | 4.737 | | 0.1027 | | .6667 | | 0.1732 | | NS | 2.06 |
| $t_{.05}$ | | 2.047 | | 2.0554 | | 2.04 | | 2.038 | | | 2.03 |

unbagged spikes within the cultivars showed almost the same results. Differences were not observed in Stephens, Hyslop and Daws when the seeds per spike between the two application dates were compared.

Differences in seeds per spike were found between bagged and unbagged spikes. The number of seeds per unbagged spike differed from the seeds per bagged spike in Yamhill and Maris Hobbit when the chemical was applied at the first date. Since the difference in seeds per spike between bagged and unbagged spikes was not significant in control plots, these results indicated that out-crossing played a major role in producing the differences. The largest mean difference was obtained in Yamhill. The value of 15.70 seeds was the result of self-pollination while the value of 35.0 seeds was the result of out-crossing as well as self-pollination.

The significant three-way interaction made it difficult to interpret the main effect of chemical application for spike length. However, differences were found among the cultivars for spike length. This was a cultivar effect rather than a chemical effect. The chemical increased spike length in bagged and unbagged spikes in all the cultivars treated at two growth stages with the exceptions of Yamhill and Daws at the first date.

SD 55446 increased the number of spikelets per spike in both bagged and unbagged spikes. Comparison of the mean values between chemical applied and the control plots for number of spikelets per spike showed that there were significant differences in Stephens and Daws for bagged spikes and in Yamhill and Luke for unbagged spikes when the chemical was applied at the first date. The differences among the cultivars were also observed for the number of spikelets per spike. These differences were due to the nature of the cultivars.

Kernel weight was affected by the chemical. SD 55446 increased the kernel weight in Luke and Maris Hobbit when applied at the two growth stages while decreasing the kernel weight in Yamhill for both bagged and unbagged spikes; and in Stephens for bagged spikes when applied at the first date. In general, the bag appeared to have an inhibitory effect on kernel weight.

As mentioned previously, the chemical decreased seed set in unbagged spikes when applied at the two growth stages. This was probably due to male or female sterility or both. In order to determine the chemcial effects on female receptiveness, the F1 seeds per spikelet were analyzed. The results indicated that the chemical did not affect female fertility in any of the cultivars. The reduced seed set in bagged spikes was probably due to induced male sterility.

SD 55446 reduced the plant height when applied at the two growth stages. Differences between application dates for plant height were found for Yamhill, Hyslop and Luke.

In Study II, wheat and triticale appeared to respond similarly to the chemicals; however, a cultivar x chemical (application date) was observed for the wheats tested. The concentration of 0.56 kg/ha was not sufficient to obtain 100% male sterility in any of the cultivars studied in the first year. This was also true for the second year as well, however, more than 90% male sterility was obtained for certain cultivars (Yamhill, Stephens, Luke). The chemical did delay anthesis and maturity seven to eleven days depending on the cultivars.

Reduced grain yield was also observed when SD 55446 was applied at the growth stage 32. In the second year, delayed application of the chemical in terms of growth stage did result in less phytotoxic effects than the first year. The concentration of 0.84 kg/ha when applied at the first date appeared to be more effective in inducing male sterility in all cultivars tested in the second year.

Seed set was reduced in bagged spikes (98.8% in Yamhill, 90.3% in Stephens, 50.33% in Hyslop, 68.73% in Daws, 83.76% in Maris Hobbit and 92.02% in Luke) when SD 55446 was applied at the concentration of 0.84 kg/ha at the first date in the second year's experiment. In the first year's experiment, seed set was reduced up to 38% for wheat cultivars and from 12 to 39.2% for triticale when SD 55446 was applied at the concentration of 0.67 kg/ha at the growth stage 32. These results indicated that SD 55446 could not be used as a general gametocide since genotypes responded differently to applications of this chemical.

## Induced Male Sterility and Natural Out-Crossing

Observed mean square values for seven traits for Yamhill wheat treated with SD 55446 and WL 84245 at two dates at the East Farm in 1979-80 are presented in Appendix Tables 14 and 15. There were differences in the effects of the two chemicals for all traits with the exception of the effects on the number of seeds per spike and on grain yield. With the exception of spike length, all the traits were affected by treatments. The number of spikelets per spike and 50 kernel weight were affected by chemical x treatment interaction. There were also differences in the number of seeds per spike in the bagged vs unbagged spikes. The number of seeds per spike, spike length and spikelets per spike were affected by the interaction between treatments and bagged vs unbagged heads. The interaction of treatments x chemical x bagged-unbagged affected kernel weight. The coefficients of variation ranged from 16.95% for grain yield to 1.26% for plant height.

In Table 8, the mean values of the seven traits as influenced by the treatment are presented. The chemicals SD 55446 and WL 84245 reduced seed set in bagged spikes when applied at both growth stages. However, they were more effective when applied at the first date than when applied at the second date. When applied at the first dates, WL 84245 reduced seed set to 0.21 or 99.63% while SD 55446 reduced seed set to 3.3 or 93.52%. Comparing seed set in unbagged spikes showed almost the same results. The lowest seed set in unbagged spikes was obtained in the plots that received WL 84245 at the first date. There was little difference in the seed set of bagged and unbagged spikes in the control plots, showing that bag had little effect on seed set in control plots. The differences between unbagged and bagged spikes for seeds per spike were the results of out-crossing in treated plots. Seeds per bagged spikes were the results of self-pollination. The values of 3.30 and 0.21 seeds per bagged spike were the results of self-pollination, while the values of 21.00 and 13.80 seeds per spike for unbagged spikes were the results of cross-pollination as well as self-pollination from the plots which received SD 55446 and

Table 8

Mean values for seeds per spike, spike length, number of spikelets per spike, 50 kernel weight, $F_1$ seeds per spikelet and plant height for Yamhill wheat treated with SD 55446 and WL 84245 chemicals at the concentration of 0.84 kg/ha and at two stages of growth at the East Farm in 1979-80.

| Chemicals | Application Dates | Seeds per Spike | | Spike length (cm) | | Spikelets per spike | | 50 kernel weight (gm) | | $F_1$ Seeds Per Spikelet | Plant Height (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | | |
| SD 55446 | First Date | 3.30 c* | 21.00 cd | 6.81 ab | 7.70 a | 20.98a | 21.55 a | 2.53 ab | 2.78 a | 1.22 ab | 107.25 d |
| | Second Date | 15.97 b | 34.05 b | 7.12 a | 7.06 b | 20.62ab | 20.20 b | 2.75 a | 2.73 a | 1.46 ab | 111.00 cd |
| | Control (1st) | 50.95 a | 49.10 a | 7.18 a | 6.78 b | 19.95ab | 18.95 c | 2.28 b | 2.35 b | 1.63 a | 124.75 a |
| WL 84245 | First Date | 0.21 c | 13.80 d | 6.48 b | 6.85 b | 19.76b | 20.20 b | 1.53 c | 0.89 c | 0.44 c | 113.25 bc |
| | Second Date | 23.73 b | 28.70 bc | 7.01 ab | 6.75 b | 19.78b | 18.98 c | 2.26 b | 2.13 b | 1.06 b | 117.75 b |
| | Control (2nd) | 56.72 a | 53.35 a | 7.22 a | 6.86 b | 20.16ab | 19.48 bc | 2.30 b | 2.32 b | 1.62 a | 125.25 a |
| | $S_{\bar{x}}$ | 3.7306 | | 0.1656 | | 0.3293 | | 0.1179 | | 0.1649 | 1.4717 |
| | $t_{.05}$ | 2.115 | | 2.123 | | 2.122 | | 2.122 | | 2.131 | 2.131 |

*Ranking of the mean values using Duncan's multiple range test.

WL 84245 at the first date.

Treatment x bagged vs unbagged interaction indicated that treatment and bag affected seeds per spike differently (Table 8). The chemicals applied at both dates reduced seed set in unbagged spikes. Reduced seed set in unbagged spikes was possibly the result of adverse morphological effects of the chemicals or female sterility. Significant first order interaction (treatment x bagged vs unbagged) for spike length showed that the chemical affected spike length differently. The difference between the chemicals indicated that SD 55446 increased spike length while WL 84245 did not affect spike length when they were applied at the first date for unbagged spikes.

SD 55446 increased the number of spikelets per spike for unbagged spikes when applied at both dates while WL 84245 did not affect the number of spikelets at either one. The significant first order interactions (treatment x bagged vs unbagged and chemicals x treatment) showed that the chemicals affected bagged and unbagged spikes differently. The chemicals also had a variable effect depending on application times for the number of spikelets per spike.

The significant second order interaction was caused by changes in the magnitude of treatment differences rather than by changes in rank. SD 55446 increased kernel weight, while WL 84245 decreased kernel weight when applied at the first date for both bagged and unbagged spikes. SD 55446 also increased kernel weight for bagged and unbagged spikes while WL 84245 did not affect this trait when applied at the second date.

The chemicals reduced plant height at both dates. When applied at the same date, SD 55446 affected plant height more than WL 84245 did. Plant height was reduced to 107.25 cm or 14.03% by SD 55446 while it was reduced to 113.25 cm or 9.58% by WL 84245 when they were applied at the first date.

F1 seeds per spikelet data were used to determine possible induced female sterility when both chemicals were applied at both dates. The number of F1 seeds per spikelet was reduced when the chemicals were applied at both dates. When mean values are compared, WL 84245 caused female sterility when applied at either dates while SD 55446 did not affect female sterility in Yamhill wheat (Table 8). Difference was also found between two application dates for the plots receiving WL 84245.

Grain yield was reduced by both chemicals when they were applied at both dates (Table 9). There were no significant differences between the effects of the two chemicals on grain yield. However, there was a significant difference between the effects of application time on the reduction of grain yield. WL 84245 reduced grain yield to 92.63 gm or 98.3% while SD 55446 reduced grain yield to 719.14 gm or 84.89% when applied at the first date.

As mentioned before, WL 84245 reduced seed set by 99.63% in bagged spikes and reduced grain yield by 98.3% compared to control values, while SD 55446 reduced seed set by 93.52% in bagged spikes and reduced grain yield by 84.89% compared to control values. These results suggest that WL 84245 probably reduced grain yield mostly was the result of induced female sterility rather than adverse phytotoxic effects on spike emergence and delayed anthesis (anthesis was delayed approximately two days). Generally WL 84245 had a greater

Table 9 . Mean values for grain yield for Yamhill treated with two chemicals at the concentration of 0.84 kg/ha at two stages of growth at the East Farm in 1979-80.

| Chemicals | Application dates | Grain yield gm/10m$^2$ |
|---|---|---|
| SD55446 | First date | 719.14 c* |
| | Second date | 1828.72 b |
| | Control (1st) | 4758.03 a |
| WL84245 | First date | 92.63 c |
| | Second date | 2234.21 b |
| | Control (2nd) | 5424.96 a |

* Ranking of the mean values using Duncan's multiple range test.

effect than SD 55446 for almost all traits studied.

The percentage of induced and natural out-crossing for the Yamhill plots is presented in Table 10. The data for the plots located on the west side were not included because of the poor stand of the pollinator (genetic marker source). The highest out-crossing value (17.11%) was obtained in the north plots when SD 55446 was applied at the first date. With increasing distance from the pollinator, the amount of out-crossing decreased. Blue aleurone seed was found as far away as 8.0 meters. The highest natural out-crossing (0.7%) was obtained in the south plot. Comparing induced and natural out-crossing showed that induced out-crossing was almost 25 times more than natural out-crossing in the experiment.

Observed mean square values of seven traits of Stephens are presented in Appendix Tables 16 and 17. The differences were observed between the chemicals for seeds per spike, kernel weight, F1 seeds per spikelet and grain yield. The treatment affected all traits with the exceptions of spike length and number of spikelets per spike. Seeds per spike, kernel weight and F1 seeds per spikelet were affected by chemicals x treatment interaction. The presence of bags on spikes affected the number of seeds per spike and kernel weight. Replications were also significant for grain yield. The coefficients of variation ranged from a high of 13.36% for the number of seeds per spikelet to a low of 1.22% for plant height.

The mean values of these traits for the treatments employed are presented in Table 11. The number of seeds per spike decreased when the chemicals were applied at both dates with the exception

Table 10. Percentage values for induced and natural out-crossing in Yamhill treated with the concentration of 0.84 kg/ha of SD 55446 at two stages of growth at the East Farm in 1979-80.

| Directions | Application dates | Distance from pollinator (meter) 0.225 % | 1.0 % | 2.0 % | 4.0 % | 8.0 % | 13.5 % |
|---|---|---|---|---|---|---|---|
| North | First date | 17.11 | 4.35 | 1.54 | 0.0 | 2.92 | 0.0 |
| | Second date | 0.39 | 1.24 | 0.0 | 0.26 | 0.0 | 0.0 |
| | Control | 0.36 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| East | First date | 3.13 | 3.24 | 0.69 | 1.37 | 0.0 | 0.0 |
| | Second date | 1.95 | 0.30 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| South | First date | 1.84 | 4.71 | 0.55 | 1.02 | 1.71 | 0.0 |
| | Second date | 5.5 | 5.18 | 2.81 | 0.0 | 0.0 | 0.0 |
| | Control | 0.7 | 0.43 | 0.22 | 0.0 | 0.0 | 0.0 |

Table 11. Mean values of seeds per spike, spike length, number of spikelets per spike, 50 kernel weight, $F_1$ seeds per spikelet and plant height for Stephens wheat variety treated with the concentration of 0.84 kg/ha of SD 55446 and WL 84245 chemicals at two stages of growth at the East Farm in 1979-80.

| Chemical | Application date | Seeds/Spike Bagged | Seeds/Spike Unbagged | Spike length Bagged | Spike length Unbagged | Spikelet/spike Bagged | Spikelet/spike Unbagged | 50 kernel weight(gr) Bagged | 50 kernel weight(gr) Unbagged | $F_1$ seeds spikelet | Plant height cm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SD55446 | First date | 2.10 c | 8.98 c | 9.56 | 9.90 | 17.44 | 17.72 | 3.06 a | 3.30 a | 0.52 bc | 105.00 ab |
| | Second date | 22.85 b | 36.95 b | 9.66 | 9.35 | 17.84 | 17.42 | 3.07 a | 3.14 ab | 0.84 b | 104.75 ab |
| | Control (1st) | 41.52 a | 49.35 a | 9.35 | 9.70 | 16.88 | 17.05 | 2.96 a | 3.19 ab | 1.63 a | 108.25 a |
| WL84245 | First date | 4.62 c | 18.42 c | 9.53 | 9.30 | 17.64 | 17.32 | 1.59 c | 1.83 c | 0.45 c | 101.50 b |
| | Second date | 42.01 a | 40.80 ab | 9.14 | 8.95 | 16.85 | 16.80 | 2.40 b | 2.74 b | 1.27 a | 102.50 b |
| | Control (2nd) | 34.76 a | 48.82 ab | 9.40 | 9.61 | 16.49 | 17.22 | 3.13 a | 3.00 ab | 1.39 a | 108.25 a |
| $S\bar{x}$ | | 3.92 | | NS | | NS | | 0.1557 | | 0.1153 | 1.2832 |
| t .05 | | 2.1113 | | | | | | 2.12 | | 2.131 | 2.131 |

of WL 84245 when it was applied at the second date in both bagged and unbagged spikes. The two chemicals had more effect on seeds per spike when applied at the first date than when applied at the second date. SD 55446 decreased seed set to 2.10 seeds or 94.94% while WL 84245 decreased seed set to 4.62 seeds or 87.08% when applied at the same date. There was a difference between the mean seed set of bagged and unbagged spikes in spikes where SD 55446 was applied at the second date and those where WL 84245 was applied at the first date. This was also true for the second control plots. Differences between bagged and unbagged spikes for seed set in control plots probably were due to bag effect rather than out-crossing. Differences between bagged and unbagged spikes for seed set in treated plots probably were due to bag effect as well as out-crossing. Number of seeds per spike in unbagged spikes was decreased by as much as 8.98 seeds or 81.8% when the chemicals were applied at the first date.

The two chemicals did not affect spike length or number of spikelets per spike. However, WL 84245 did affect kernel weight (Table 11). It decreased kernel weight in bagged spikes when applied at both dates and in unbagged spikes, when applied at the first date. A difference was also found between application time. When WL 84245 was applied at the first date, a greater reduction in kernel weight was observed. The presence of bags on spikes reduced kernel weight in the plot where WL 84245 was applied at the second date.

Comparing the mean F1 seeds per spikelet showed that the chemicals reduced F1 seeds per spikelet in this experiment. In other words, both chemicals caused female sterility when they were applied at the first date. SD 55446 also caused female sterility when applied at the second date. There was no difference between two application dates for SD 55446 but there was a difference between two chemicals when applied at the second date. WL 84245 did not cause either male or female sterility when applied at the second date.

Both chemicals tended to reduce plant height when applied at the two dates. However, SD 55446 did not reduce plant height significantly.

The two chemicals reduced grain yield when applied at both dates (Table 12). Reduction of the grain yield was greater when the chemicals were applied at the first date. Although there was no significant difference between the two chemicals, WL 84245 reduced grain yield more than SD 55446 when applied at the same date.

The percentage of induced and natural out-crossing in Stephens grown at the East Farm is presented in Table 13. The highest amount of out-crossing (11.50%) was obtained in the plot 0.225 meters from the genetic marker and located in a southerly direction (when SD 55446 was applied at the first date). The highest amount of natural out-crossing (0.46%) was obtained in the plot four meters from the genetic marker and also located in a southerly direction. The amount of induced out-crossing varied depending on direction (11.50% to the south, 11.17% to the west and 1.88% to the east at 0.225 meter from the genetic marker pollinator at the first application date). As in the Yamhill experiment, the highest out-crossing values were obtained in the plots

Table 12. Mean values for grain yield in Stephens treated with two chemicals at the concentration of 0.84 kq/ha at two stages of growth at the East Farm in 1979-80.

| Chemicals | Application dates | Grain yield |
|---|---|---|
| SD55446 | First date | 535.37 d* |
| | Second date | 3970.36 c |
| | Control | 6187.80 b |
| WL84245 | First date | 1160.50 d |
| | Second date | 2946.21 c |
| | Control | 8253.89 a |

* Ranking of the mean values using Duncan's multiple range test.

Table 13. Percentage values for induced and natural out-crossing for Stephens treated with the concentration of 0.84 kg/ha of SD 55446 at two stages of growth at the East Farm in 1979-80.

| Directions | Application dates | 0.225 % | 1.0 % | 2.0 % | 4.0 % | 8.0 % | 13.5 % |
|---|---|---|---|---|---|---|---|
| | | Distances from pollinator (meters) | | | | | |
| North | First date | -- | 0.0 | 4.84 | 2.78 | 2.94 | 0.0 |
| | Second date | 0.0 | 0.0 | 0.0 | 0.0 | 0.27 | 0.0 |
| | Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| East | First date | 1.88 | 6.59 | 4.72 | 0.0 | 0.0 | 0.0 |
| | Second date | 0.19 | 0.59 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Control | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| South | First date | 11.50 | 13.25 | 4.55 | 0.0 | 0.0 | 0.0 |
| | Second date | 2.13 | 3.03 | 0.21 | 0.54 | 0.2 | 0.0 |
| | Control | 0.2 | 0.28 | 0.0 | 0.46 | 0.0 | 0.0 |
| West | First date | 11.17 | 3.05 | 2.4 | 2.11 | 0.0 | 0.0 |
| | Second date | 0.0 | 0.23 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Control | 0.15 | 0.21 | 0.0 | 0.21 | 0.0 | 0.0 |

which were located to the south.

As mentioned before, both chemicals induced male sterility in Stephens more than 85% (87.1% for WL 84245 and 94.94% for SD 55446) when they were applied at the first date. SD 55446 was more effective than WL 84245 in reducing seed set in bagged spikes. However, in the Yamhill experiment WL 84245 had greater effect inducing male sterility. Unfortunately, both chemicals had adverse effects on female receptiveness, spike emergence and grain yield. Comparing the adverse effect on female receptiveness of the chemicals between Stephens and Yamhill showed that WL 84245 induced female sterility in both cultivars while SD 55446 induced female sterility only in Stephens. These results suggest that SD 55446 affected female receptiveness differently depending on cultivars. Generally, WL 84245 had a greater adverse effect than SD 55446 for kernel weight and plant height.

Even though induced out-crossing increased in SD 55446 applied plots when compared to control, it appears that the chemical is not promising for use in commercial hybrid seed production.

Observed mean square values for six traits involving Stephens wheat when treated with two chemicals at two application dates at the Schmidt Farm are presented in Appendix Tables 18 and 19. Differences were observed for the chemicals for 50 kernel weight and F1 seeds per spikelet. Treatment also resulted in differences for the number of seeds per spike, F1 seeds per spikelet and grain yield. The presence of the bag resulted in differences for seeds per spike, spike length and number of spikelets per spike. Interactions between treatment and bagged vs unbagged were different for seeds per spike and 50 kernel weight.

Chemicals x treatment for F1 seeds per spikelet was also different. Replications resulted in differences for grain yield only. The coefficients of variation ranged from 12.83% for the number of seeds per spike to 2.58% for the number of spikelets per spike.

The mean values for all traits for treatments employed are presented in Table 14. Both chemicals reduced seeds per spike when they were applied at the first date in the bagged spikes. SD 55446 reduced seed set to 6.15 or 87.3% and WL 84245 reduced seed set to 8.06 seeds or 83.2% when compared to their respective controls. Although there was no difference between two application dates, the chemicals decreased seed set more when applied at the second date. The differences between seed set for bagged and unbagged spikes in control plots showed that the bag had an effect on reducing seed set (48.40 vs 61.29 and 48.01 vs 55.70, respectively for the two controls). In control plots, this was probably a bag effect rather than due to cross-pollination. The difference between seed set of bagged and unbagged spikes in treated plots was probably the result of the bag effect and cross-pollination. There was no difference between bagged and unbagged spikes for seed set when the chemicals were applied at the first date. The number of seeds per spike for unbagged spikes was decreased when the chemicals were applied at both dates.

The chemicals did not affect spike length or the number of spikelets per spike. However, the bag reduced spike length in all treatments with the exception of the plot where WL 84245 was applied at the second date and second control (Table 14). The bag also reduced the number of spikelets per spike in all treatments with the exception of the

Table 14

Mean values of seeds per spike, spike length, number of spikelets per spike, 50 kernel weight, F1 seeds per spikelet for Stephens wheat treated with SO 55446 and WL 84245 chemicals at the concentration of 0.84 kg/ha at two stages of growth at the Schmidt Farm in 1979-80.

| Chemicals | Application Dates | Seeds per Spike | | Spike length (cm) | | Spikelets per Spike | | 50 Kernel Weight (gm) | | F1 Seeds Per Spikelet | Grain Yield gm/plot |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | Bagged | Unbagged | | |
| SO 55446 | First Date | 6.15 b | 6.04 c | 10.56 | 11.72 | 19.80 | 21.26 | 2.95 a | 2.98 a | 0.68 d | 496.00 b |
| | Second Date | 7.30 b | 14.38 c | 10.01 | 11.01 | 19.13 | 21.12 | 3.14 a | 3.06 a | 0.82 cd | 1784.75 b |
| | Control (1st) | 48.40 a | 61.29 a | 9.81 | 10.60 | 18.80 | 20.24 | 2.41 b | 2.64 ab | 1.50 a | 6358.00 a |
| WL 84245 | First Date | 8.06 b | 13.28 c | 9.90 | 10.84 | 18.88 | 20.26 | 2.44 b | 2.35 b | 1.12 bc | 665.75 b |
| | Second Date | 11.20 b | 25.76 b | 9.90 | 10.50 | 19.12 | 21.09 | 2.83 ab | 2.62 ab | 1.22 ab | 1877.50 b |
| | Control (2nd) | 48.01 a | 55.70 a | 10.20 | 10.09 | 19.53 | 19.58 | 2.41 b | 3.06 a | 1.43 ab | 6316.00 a |
| | $S_{\bar{x}}$ | 3.2672 | | | | | | 0.1466 | | 0.1153 | 449.14 |
| | $t_{.05}$ | 2.105 | | | | | | 2.104 | | 2.131 | |
| | $LSD_{.05}$ (for bagged-unbagged) | | | 0.7428 | | 1.2341 | | | | | |

second control.

Kernel weight was affected by the chemicals. SD 55446 increased the kernel weight while WL 84245 had no effect on the kernel weight when bagged spikes were considered. For unbagged spikes, WL 84245 decreased kernel weight while SD 55446 had no effect when applied at the first date. Also, treatment x bagged vs unbagged interaction showed that the chemicals affected the kernel weight differently when they were applied at different application dates for bagged and unbagged spikes. When WL 84245 was applied at the first date, the kernel weight decreased in unbagged spikes while remaining almost the same as the control for bagged spikes.

To assess possible induced female sterility, the F1 seeds per spikelet was used. The F1 seeds per spikelet was decreased when SD 55446 was applied at both dates. SD 55446 was more effective when applied at the first date than when applied at the second date. WL 84245 decreased the F1 seeds per spikelet when applied at both dates but it was not significantly different compared to the second control.

Grain yield was reduced by both chemicals when they were applied at both dates. Comparing the mean values there was no difference between the two chemicals nor two application dates in terms of grain yield. The differences among the replication may be the result of out-crossing which was favored depending on the particular wind direction and pollen shedding time.

As previously noted, both chemicals induced male sterility (83.2% and 87.3% when SD 55446 and WL 84245 were applied at the first date, respectively). The chemicals applied at the first date resulted in 94.94% (2.10 seeds) and 87.08% (4.62 seeds) male sterility in Stephens in the experiment conducted at the East Farm (Table 11). These results indicated that the chemical SD 55446 was not consistent in effecting male sterility between locations. This chemical was more effective at the East Farm than at the Schmidt Farm. WL 84245, however was not affected by locations in terms of the amount of male sterility induced.

The percentage of induced and natural out-crossing in Stephens grown at the Schmidt Farm is presented in Table 15. The highest out-crossing obtained in the overall experiment was 23.12% which corresponded with the SD 55446 applied at the first date in the east plot. SD 55446 was more effective than WL 84245 resulting in higher out-crossing in the east and west plots. In the control plots, the highest out-crossing was 0.89% in the west plots. The amount of out-crossing generally decreased markedly when the distance from the genetic markers increased after four meters. There are some exceptions as can be seen in Table 15.

SD 55446, when applied at the first date, resulted in increased out-crossing up to one meter away from the genetic marker source when compared to the control regardless of the direction. WL 84245 was the most effective in inducing out-crossing in the north plot when applied at the second date next to the genetic marker source (Table 15).

Both chemicals resulted in increased out-crossing when applied to Stephens wheat. They were more effective in the plots which received the chemicals at the first date; however, even in the highest plot the

Table 15

Percentage of out-crossing in Stephens wheat chemically treated at two dates and control plots where 10 heads were sampled four directions at the Schmidt Farm in 1979-80.

| Direction | Treatments and Application Date | Distance from genetic marker rows (in meters) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0.3 | 1.0 | 2.0 | 4.0 | 8.0 | 12.0 | 16.0 | 20.0 |
| North | SD 55446 | | | | | | | | |
| | First Date | 8.00 | 10.14 | 9.09 | 4.76 | 1.41 | 0.00 | 0.00 | 0.00 |
| | Second Date | 9.09 | 3.90 | 0.00 | 0.41 | 4.00 | 2.44 | 0.81 | 0.00 |
| | Control | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | WL 84245 | | | | | | | | |
| | First Date | 9.15 | 2.24 | 0.81 | 0.00 | 0.59 | 0.00 | 0.00 | 0.00 |
| | Second Date | 16.83 | 3.57 | 0.00 | 1.90 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Control | 0.00 | 0.34 | 0.00 | 0.00 | 0.18 | 0.00 | 0.31 | 0.00 |
| East | SD 55446 | | | | | | | | |
| | First Date | 23.12 | 20.00 | 16.67 | 0.00 | 0.00 | 5.00 | 0.00 | 0.00 |
| | Second Date | 1.22 | 0.00 | 0.28 | 0.00 | 0.78 | 1.56 | 0.00 | 0.00 |
| | Control | 0.568 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | WL 84245 | | | | | | | | |
| | First Date | ---* | 1.59 | 9.92 | 2.94 | 0.00 | 0.77 | 1.92 | 0.00 |
| | Second Date | 0.00 | 0.27 | 0.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Control | 0.35 | 0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 | 0.00 |
| South | SD 55446 | | | | | | | | |
| | First Date | --- | 21.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Second Date | --- | 2.96 | 6.82 | 1.77 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Control | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.22 | 0.00 |
| | WL 84245 | | | | | | | | |
| | First Date | 1.27 | 4.31 | 1.64 | 1.61 | 3.55 | 0.61 | 0.38 | 0.00 |
| | Second Date | 0.44 | 3.19 | 1.79 | 5.36 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Control | 0.00 | 0.00 | 0.44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| West | SD 55446 | | | | | | | | |
| | First Date | 21.60 | 22.86 | 21.33 | 3.45 | 0.96 | 1.39 | 2.44 | 0.00 |
| | Second Date | 0.88 | 6.14 | 11.90 | 2.34 | 0.00 | 0.62 | 0.93 | 0.00 |
| | Control | 0.89 | 0,54 | 0.21 | 0.17 | 0.17 | 0.00 | 0.00 | 0.00 |
| | WL 84245 | | | | | | | | |
| | First Date | --- | 7.58 | 1.52 | 1.17 | 2.78 | 0.00 | 0.00 | 0.00 |
| | Second Date | 4.59 | 1.97 | 0.00 | 0.77 | 1.55 | 0.30 | 0.78 | 0.00 |
| | Control | 0.49 | 0.18 | 0.41 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 |

*Samples were not taken because of lack of chemical effectiveness.

amount of out-crossing was very low (23.12%).

Observed natural out-crossing in Stephens grown at the Schmidt Farm surrounded by blue aleurone genetic marker cultivars are presented in Table 16. The highest natural out-crossing obtained in the overall experiment was 0.7% in the rows next to the genetic marker source. There were differences also depending on the direction as to where the samples were taken. These results probably could be due to the direction of the prevailing winds. When the distance from the genetic marker rows increased, the amount of out-crossing decreased. Only one blue aleurone seed was found in the samples taken 16 meters away in an easterly direction. When samples were examined that were obtained at 12 meters from the genetic marker rows, blue seed was found in the southwest and west plots. Blue aleurone seed was also found in the samples taken eight meters away in the easterly, southeasterly, southerly and northwesterly directions. When the samples were taken at four meters away from the genetic marker, blue seeds were found in the southwesterly, westerly and northwesterly directions. The blue seed was found in the samples taken two meters and less from the genetic marker source at all eight directions with the exception of the samples taken at two meters away in the northerly direction.

These results indicate that the natural out-crossing was less than one percent in Stephens wheat even at the closest distance of 0.3 meter and decreased rapidly as the distance from the blue pollen source increased (Figure 3).

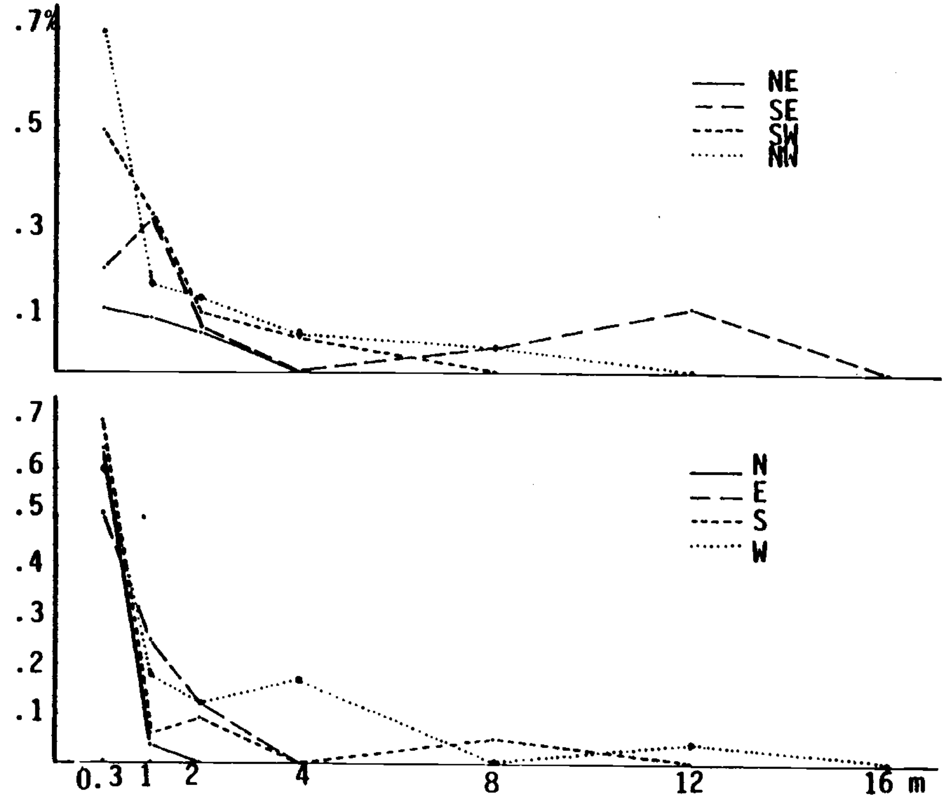
Table 16

Natural out-crossing in Stephens wheat by using blue aleurone genetic marker pollinators where 60 cm rows were sampled eight directions at the Schmidt Farm in 1979-80.

| Direction | Number of seeds and Ratio | Distance from genetic marker rows (in meters) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0.3 | 1.0 | 2.0 | 4.0 | 8.0 | 12.0 | 16.0 |
| North | White | 2013 | 2365 | -- | -- | -- | -- | -- |
| | Blue | 13 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Percent | .64 | .04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Northeast | White | 2306 | 1852 | 2412 | -- | -- | -- | -- |
| | Blue | 3 | 2 | 2 | 0 | 0 | 0 | 0 |
| | Percent | .13 | .11 | .08 | 0.00 | 0.00 | 0.00 | 0.00 |
| East | White | 2342 | 2426 | 2451 | -- | 2498 | -- | 2881 |
| | Blue | 12 | 6 | 3 | 0 | 1 | 0 | 1 |
| | Percent | .51 | .25 | .12 | 0.00 | 0.00 | 0.00 | 0.03 |
| Southeast | White | 2383 | 2238 | 2242 | -- | 2102 | 3056 | -- |
| | Blue | 5 | 7 | 2 | 0 | 1 | 4 | 0 |
| | Percent | .21 | .31 | .09 | 0.00 | .05 | .13 | 0.00 |
| South | White | 2261 | 1789 | 2557 | -- | 2061 | -- | -- |
| | Blue | 16 | 1 | 2 | 0 | 1 | 0 | 0 |
| | Percent | .70 | .06 | .09 | 0.00 | .05 | 0.00 | 0.00 |
| Southwest | White | 1814 | 2764 | 2582 | 2669 | -- | -- | -- |
| | Blue | 9 | 9 | 3 | 2 | 0 | 0 | 0 |
| | Percent | .49 | .32 | .12 | .07 | 0.00 | 0.00 | 0.00 |
| West | White | 2668 | 2213 | 1705 | 2884 | -- | 2265 | -- |
| | Blue | 16 | 4 | 2 | 5 | 0 | 1 | 0 |
| | Percent | .60 | .18 | .12 | .17 | 0.00 | .04 | 0.00 |
| Northwest | White | 2608 | 2178 | 1958 | 2637 | 1944 | -- | -- |
| | Blue | 18 | 4 | 3 | 2 | 1 | 0 | 0 |
| | Percent | .69 | .18 | .15 | .08 | .05 | 0.00 | 0.00 |

Figure 3.

Percentage of natural out-crossing in Stephens grown at the Schmidt Farm in 1979-80.



Results from the experiment conducted on the Schmidt Farm were similar to those obtained at the East Farm with regard to induced male sterility and subsequent out-crossing. In both situations, the levels of induced male sterility were high; however, the amount of cross-pollination and subsequent fertilization were very low. Several factors may have contributed to this condition. First there may not have been a sufficient amount of pollen from the genetic marker stocks due to either not enough rows or the timing of pollen dispersal did not nick with the receptiveness of the female flowers of Stephens. Also, possible phytotoxic effects induced by the chemicals such as increased female sterility and poor spike emergence might have adversely influenced seed set.

These data suggest that the Oregon State University's Certification agency's isolation distance requirement of 27 meters is very adequate in preventing contamination in Stephens wheat.

# SUMMARY AND CONCLUSION

The main objective of this study was to investigate the effectiveness of specific chemicals on induced male sterility in wheat and triticale. One hundred percent male sterility was not achieved with any of the treatments employed; however, more than 99% male sterility was induced depending on the concentration, date of application, chemical employed and cultivar. All of the chemicals tested resulted in inducing some male sterility; unfortunately, adverse effects such as the inducing of female sterility were also observed.

Differing varietal responses to SD 55446 were noted. The wheat cultivars Luke, Bezostaja, Centurk and the WSU I triticale exhibited less induced male sterility as evidenced by greater seed set on bagged spikes. At the earlier application date, this chemical had more phytotoxicity as reflected by poor spike emergence, delayed anthesis and maturity and reduced plant height. SD 55446 produced more phytotoxic effects in Yamhill than in other cultivars tested.

Spike length, number of spikelets per spike and kernel weight were evaluated as a further measure of phytotoxicity resulting from the treatment. The response was variable, increasing or decreasing the expression of these traits depending on chemical applied and application times. The three chemicals employed consistently reduced plant height and grain yield.

Induced out-crossing up to 23.12% was obtained for rows next to the pollinators which had the blue aleurone genetic marker. Differences were found depending on the direction in which samples were taken from the pollen source.

Natural out-crossing was observed in both Stephens and Yamhill; however, it was less than one percent. Blue seed was not found in the samples taken from the rows which were grown more than 20 meters away from the pollinators.

Due to the low level of induced out-crossing and phytotoxic effects of the chemicals, use of these chemicals do not appear promising for commercial hybrid seed production.

# BIBLIOGRAPHY


Allan, R. E. 1980. Wheat. In. W. R. Fehr and H. H. Hadley (ed.) Hybridization of Crop Plants, 709-720. American Soc. of Agr. and Crop Sci. Soc. of Am. Madison, Wisconsin.

Anand, S. C. and S. C. Sharma. 1973. Seed set in relation to pollen dispersal in male sterile wheat varieties. Proc. 4th Int. Wheat Gen. Symp. 319-320.

Bennet, M. D. and W. L. Hughes. 1972. Additional mitosis in wheat pollen induced by ethrel. Nature 240:566-568.

Berhe, T. and D. G. Miller. 1978. Studies of Ethephon as a possible selective male gametocide on Tef. Crop Sci. 18:35-38.

Bitzer, M. J. and F. L. Patterson. 1967. Pollen dispersal and cross pollination of soft red winter wheats. Crop Sci. 7:482-484.

Borghi, B., F. Bonali and G. Boggini. 1973. Induction of male sterility in wheat with ethephon for hybrid seed production. Proc. 4th Int. Wheat Genetic Symposium, Missouri Agric. Exp. Sta., Columbia:337-343.

Brown, C. M. and E. B. Earley. 1973. Response of one winter wheat and two spring oat varieties to foliar applications of 2-chloroethylphosphonic acid (ethrel). Agron. J. 65:829-832.

Corral, L. R. 1973. Some effects of ethrel on oats and barley. M.S. Thesis. The Ohio State University, Columbus, Ohio.

Devries, A. P. 1974. Some aspects of cross-pollination in wheat (Triticum aestivum L.). 4. Seed set on male sterile plants as influenced by distance from the pollen source, pollinator: male sterile ratio and width of the male sterile strip. Euphytica 23:601-622.

Dotlacil, L. and M. Apltouerova. 1978. Pollen sterility induced by ethrel and its utilization in hybridization of wheat. Euphytica 27:353-360.

Fairey, D. T. and N. C. Stoskopf. 1975. Effects of granular ethephon on male sterility in wheat. Crop Sci. 15:29-32.

Garber, R. J. and K. S. Quinsenberry. 1923. Natural crossing in winter wheat. J. Am. Soc. Agron. 15:508-512.

Heyne, E. G. and G. S. Smith. 1967. Wheat Breeding. In K. S. Quisenberry and L. P. Reitz (ed.). Wheat and Wheat Improvement, Agronomy 13:269-306, Am. Soc. of Agron., Madison, Wisconsin.

Hughes, W. G., M. D. Bennett, J. J. Bodden and S. Galanopoulou. 1974. Effects of time of application of ethrel on male sterility and ear emergence in wheat (Triticum aestivum). Annals of Applied Biology 76 (2):243-252.

______________ and J. J. Bodden. 1977. Single gene restoration of cytoplasmic male sterility in wheat and its implications in the breeding of restorer lines. Theor. Appl. Genet. 50:129-135.

______________ and ____________. 1978 (a). An assessment of the production and performance of F1 hybrid wheats based on *T. timopheevi* cytoplasm. Theor. Appl. Genet. 53:219-228.

______________ and ____________. 1978 (b). Production and yield assessment of F1 hybrid wheats using ethephon induced male sterility. Z. Pflanzensuchtg 81:17-23.

Jan, C. C., C. O. Qualset and H. E. Vogt. 1974. Chemical induction of sterility in wheat. Euphytica 23:78-85.

_________, D. Hille Ris Lambers and C. O. Qualset. 1977. Evaluation of three sources of pollen fertility restoration genes and natural out-crossing of cytoplasmic male-sterile wheat. Euphytica 26:681-685.

Johnson, J. W. and F. L. Patterson. 1977. Interaction of genetic factors for fertility restoration in hybrid wheat. Crop Sci. 17:695-699.

Johnson, R. R. and C. M. Brown. 1976. Chemical control of pollination in wheat and oats. Crop Sci. 16:584-587.

Johnson, V. A. and J. W. Schmidt. 1968. Hybrid wheat. Advances in Agronomy 20:199-232.

Joppa, L. R., F. H. McNeal and M. A. Berg. 1968. Pollen production and pollen shedding of hard red spring (*T. aestivum*) and durum (*T. durum*) wheats. Crop Sci. 8:487-490.

Kaul, C. L. and S. P. Singh. 1967. On induced male sterility in wheat, sunn-hemp and onion. Indian J. Pl. Physiol. 10:112-118.

Keydel, F. 1978. (The influence of pollinator and various strip ratios on the seed yield of hybrid wheat). Z. Pflanzensuchtg 81: 319-326.

Law. J. and N. C. Stoskopf. 1973. Further observations on ethrel as a tool for developing hybrid cereals. Can. J. Plant Sci. 53:765-766.

McMurray, A. L. and C. H. Miller. 1969. The effect of 2-chloroethyl-phosphonic acid (ethrel) on the sex expression and yield of *Cucumis sativus*. J. Amer. Soc. Hort. Sci. 94:400-402.

Miller, J. F. and K. A. Lucken. 1976. Hybrid wheat seed production methods for N. Dakota. Crop Sci. 16:217-221.

__________ and ___________. 1977. Gametocidal properties of RH-531, RH-532, RH-2956 and RH-4667 on spring wheat. Euphytica 26: 103-112.

Mohan Ram, H. V. and P. N. Rustagi. 1966. Phytogametocidal compounds. Sci. Cult. 32:286-291.

Petersen, G. R. 1976. Experimental designs for agricultural research in developing areas. OSU Bookstores, Inc., Corvallis, Oregon.

Porter, K. B and A. F. Wiese. 1961. Evaluation of certain chemicals as selective gametocides for wheat. Crop Sci. 1:381-382.

Rajki, E. and S. Rajki. 1968. Research work on hybrid wheat at Martonvasar, III. Euphytica 17, Suppl. No. 1:43-48.

Robinson, R. W. S. Shannon and M. D. DeLaGuardia. 1969. Regulation of sex expression in the cucumber. Bio. Sci. 19:141-142.

Rowell, P. L. and D. G. Miller. 1971. Induction of male sterility in wheat with 2-chloro ethylphosphonic acid (etherel). Crop Sci. 11:629-631.

___________. 1972. The effect of 2-chloroethylphosphonic acid (ethrel) on male sterility, female fertility and anther and pollen development in wheat (T. aestivum L.). Ph.D. Thesis, Washington State University, Pullman, Washington.

____________ and D. G. Miller. 1974. Effect of 2-chloroethylphosphonic acid (ethephon) on female fertility of two wheat varieties. Crop. Sci. 14:31-34.

Rudich, J., A. H. Halevy and N. Kedar. 1969. Increase in femaleness of three cucurbits by treatment with ethrel, an ethylene releasing compound. Planta 86:69-76.

Sapra, V. T., G. C. Sharma and J. L. Hughes. 1974. Chemical induction of male sterility in hexaploid triticale. Euphytica 23:685-690.

Stoskopf, N. C. and J. Law. 1972. Some observations on ethrel as a tool for developing hybrid cereals. Can. J. Plant Sci. 52:680-683.

Svenson, G. 1972. Prospects for hybrid wheat and hybrid barley in northwestern Europe. Proc. Sixth Congr. Eucarpia, Cambridge, 1971. pp. 67-76.

Tottman, D. R. and R. J. Makepeace. 1979. An explanation of the decimal code for the growth stages of cereals with illustrations. Ann. Appl. Biol. 93:221-234.

Trupp, C. R. 1972. Effectiveness of two gametocides on winter wheat and triticale under greenhouse conditions. Agron. Abstr. 29.

Verma, M. M. and J. Kumar. 1978. Ethrel, a male gametocide that can replace the male sterility genes in barley. Euphytica 27: 865-868.

Wang, R. C. and S. Lund. 1975. Studies on male sterility in barley induced by sodium 1-(p-chlorophenyl)1,2-dihydro-4,6-dimethyl-2-oxonicotinate.

Wilson, J. A. and W. M. Ross. 1962. Cross breeding in wheat, (Triticum aestivum L.) II. Hybrid seed set on a cytoplasmic male-sterile winter wheat composite subjected to cross-pollination. Crop Sci. 2:415-417.

Zeven, A. C. 1968. Pollination and sources of restorer genes in wheat and a semi-hybrid variety. Euphytica 17, Suppl. No. 1: 75-81.

Zuzens, D., M. N. Grant, D. S. McBean, L. H. Shebeski, E. A. Hurd. 1969. Wind pollination of male sterile wheat. Can. J. of Plant Sci. 49:98-99.

# APPENDICES

Appendix Table 1. Pedigree and description of cultivars.

Yamhill: Heines VII-Redmond (Alba)

A low tillering, medium height, high yielding, awnless soft white winter wheat cultivar released by Oregon State University. Late maturity, large fertile spikes and medium to large kernels.

Stephens: Nord Desprez-Pullman Selection 101

A medium height, strong white stem, relatively large kernels, awned soft white winter wheat cultivar released by Oregon State University.

Hyslop: Nord Desprez-Selection $101^2$

A soft white common, semi-dwarf, awned, mid-dense spike, high yielding winter wheat cultivar released by Oregon State University. Medium earliness, large head size, medium kernel weight.

Bezostaja 1: Lutescens 17-Skorospelka-2

Developed in the Kuban region of the USSR. An awnless, hard red, mid-dense and mid-long spike, low tillering, large kernel, high yielding, early maturing winter wheat cultivar.

Faro: CI 13748-Moro

A soft white club, medium short, very dense spike, awnletted winter wheat cultivar developed and released by the Oregon and Washington Agricultural Experiment Stations in cooperation with

FR-SEA-USDA. Adapted for growing in the lower precipitation areas of eastern Oregon and eastern Washington.

Daws: CI 14484 X CI 13645-PI 178383

A semi-dwarf, bearded, lax spike, soft white winter wheat developed by the ARS, USDA and Washington State Agricultural Research Center and released jointly by the Agricultural Experiment Stations of Washington, Oregon and Idaho and the ARS in 1976.

Luke: PI 178383-Burt$^2$ X CI 13438

A semi-dwarf, soft white, lax spike with long awns, winter wheat cultivar developed cooperatively by the Agricultural Research Service, USDA and Washington State Agricultural Research Center and released jointly by the Agricultural Experiment Stations of Washington, Oregon and Idaho and the Agricultural Research Service in 1970.

Centurk: Kenya 58/2/Newthatch/3/Hope/2*Turkey/4/Cheyenne/5/Parker

A hard red, awned, winter wheat developed cooperatively by the Nebraska Agricultural Experiment Station and the Agricultural Research Service, USDA and released by the Agricultural Experiment Stations of Nebraska, Colorado, Illinois, Kansas, New Mexico, Oklahoma, South Dakota and Texas and the Plant Science Research Division of the Agricultural Research Service, USDA.

<u>Maris Hobbit: Professeur Marchal//Marne/Vogel 9144/4/CI 12633/
4*Cappelle//Heine 110/Capelle/3/Nord</u>

Short-strawed, long awnless spike, soft red winter wheat developed in England.

<u>OSU I</u>

Tall fertile hexaploid triticale line developed by OSU/USDA.

<u>OSU II</u>

Tall fertile hexaploid triticale line developed by OSU/USDA.

<u>WSU I</u>

Tall fertile hexaploid triticale line, developed by WSU.

Appendix Table 2. Specific growth stages from the Zadoks scale used in the experiments.[1]

<u>Principal growth stage</u> <u>3 = stem elongation</u>

30 = (H) Pseudo-stem erection. Only applicable to cereals with a prostrate or semi-prostrate early growth habit.

31 = (I) First node detectable

32 = (J) 2nd node detectable

33 = 3rd node detectable

34 = 4th node detectable

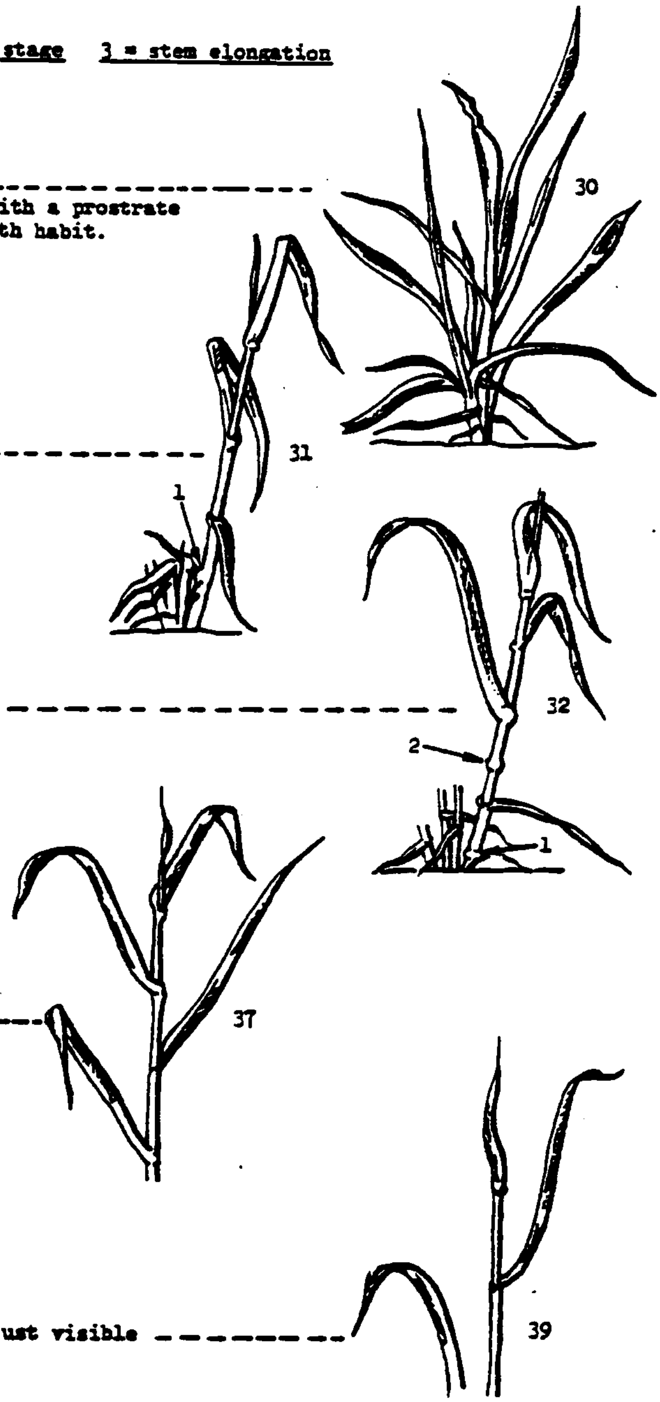
35 = 5th node detectable

36 = 6th node detectable

37 = (K) Flag leaf just visible

38 =

39 = (L) Flag leaf ligule/collar just visible
Pre-boot stage




Stages 31 and 32 = Jointing stage.

The node number referred to is for 'Above-crown' nodes.

[1] Zadoks scale as contributed by Shell Development Co., Modesto, CA.

Appendix Table 3.

Level of significances for seeds per spike, spike length and number of spikelets per spike for Stephens wheat treated with SD 55446 and SD 55447 chemicals at two dates at Hyslop Agronomy Farm in 1978-79.

| Sources of Variation | df | Seeds Per Spike | Spike Length | Spikelets Per Spike |
|---|---|---|---|---|
| Replications | 3 | NS | NS | NS |
| Treatments | 9 | ** | * | ** |
| Error (a) | 27 | | | |
| Bagged-Unbagged | 1 | * | ** | ** |
| Treatments X Bagged-Unbagged | 9 | NS | NS | NS |
| Error (b) | 30 | | | |

NS: Not Signficant
*Significant at the five percent probability level.
**Significant at the one percent probability level.

Appendix Table 4

Level of significances for F1 seeds per spikelet, grain yield, tiller number and plant height for Stephens wheat treated with SD 55446 and SD 55447 chemicals at two dates at Hyslop Agronomy Farm in 1978-79.

| Sources of Variation | df | F1 Seeds Per Spikelet | Grain Yield | Tiller Number | Plant Height | |
|---|---|---|---|---|---|---|
| | | | | | May 15 | July 11 |
| Replications | 3 | NS | NS | NS | * | ** |
| Treatments | 9 | ** | ** | NS | ** | ** |
| Error | 27 | | | | | |

NS: Not significant
*Significant at the five percent probability level.
**Significant at the one percent probability level.

Appendix Table 5

Level of significances for seeds per spike, spike length, number of spikelets per spike and 50 kernel weight from bagged and unbagged spikes on Stephens wheat grown under high N level and treated with SD 55446 chemical at two concentrations at two stages of growth at Schmidt Farm in 1979-80.

| Source of Variation | df | Seeds per Spike | Spike Length | Spikelets Per Spike | 50 Kernel Weight |
|---|---|---|---|---|---|
| Replications | 1 | NS | NS | NS | NS |
| Treatments | 4 | ** | NS | ** | NS |
| Error (a) | 4 | | | | |
| Bagged-Unbagged | 1 | * | NS | * | NS |
| Treatments X Bagged X Unbagged | 4 | NS | NS | NS | NS |
| Error (b) | 5 | | | | |

NS: Not Significant
*Significant at the five percent probability level.
**Significant at the one percent probability level.

Appendix Table 6

Level of significances for F1 seeds per spikelet, grain yield per plot and plant height for Stephens wheat grown under high nitrogen level and treated with SD 55446 chemical at two concentrations and at two stages of growth at Schmidt Farm in 1979-80.

| Source of Variation | df | F1 Seeds Per Spikelet | Grain Yield | Plant Height |
|---|---|---|---|---|
| Replications | 1 | NS | NS | NS |
| Treatments | 4 | NS | ** | * |
| Error | 4 | | | |
| CV % | | 15.74 | 11.21 | 3.08 |

NS: Not Significant
*Significant at the five percent level of probability
**Significant at the one percent level of probability.

Appendix Table 7

Level of significances for seeds per spike, spike length, number of spikelets per spike and 50 kernel weight from bagged and unbagged spikes for Stephens wheat grown under low N level and treated with SD 55446 chemical at two concentrations and at two stages of growth at Schmidt Farm in 1979-80.

| Source of Variation | df | Seeds per Spike | Spike Length | Spikelets Per Spike | 50 Kernel Weight |
|---|---|---|---|---|---|
| Replications | 1 | NS | NS | NS | NS |
| Treatments | 3 | * | NS | NS | NS |
| Error (a) | 3 | | | | |
| Bagged-Unbagged | 1 | ** | NS | NS | * |
| Treatments X Bagged-Unbagged | 3 | NS | NS | NS | NS |
| Error (b) | 4 | | | | |

NS: Not Significant
*Significant at the five percent probability level.
**Signfiicant at the one percent probability level.

Appendix Table 8

Level of significances for F1 seeds per spikelet, grain yield per plot and plant height on Stephens wheat grown under high nitrogen level and treated with SD 55446 chemical at two concentrations and at two stages of growth at Schmidt Farm in 1979-80.

| Source of Variation | df | F1 Seeds Per Spikelet | Grain Yield | Plant Height |
|---|---|---|---|---|
| Replications | 1 | | | |
| Treatments | 4 | | | |
| Error | 4 | | | |
| C.V. % | | 30.0 | 8.59 | 7.0 |

NS: Not Significant

*Significant at the 5 percent probability level.
**Significant at the 1 percent probability level.

Appendix Table 9

Level of significances for seeds per spike, spike length and number of spikelets per spike from bagged and unbagged spikes for ine wheat and three triticale cultivars treated with the concentration of 0.67 kg/ha SD 55446 chemical at Hyslop Agronomy Farm in 1978-79.

| Source of Variation | df | Seeds Per Spike | Spike Length | Spikelets Per Spike |
|---|---|---|---|---|
| Replications | 1 | NS | NS | NS |
| Cultivars | 11 | ** | ** | ** |
| Error (a) | 11 | | | |
| Treatment | 1 | ** | ** | ** |
| Error (b) | 1 | | | |
| Treatment X Cultivars | 11 | ** | ** | ** |
| Error (b) | 12 | | | |
| Bagged-Unbagged | 1 | ** | * | * |
| Bagged-Unbagged X Cultivars | 11 | * | * | NS |
| Bagged-Unbagged X Treatment | 1 | ** | ** | ** |
| Bagged-Unbagged X Cultivars X Treatment | 11 | * | * | NS |
| Error (d) | 24 | | | |

NS: Not Significant
*Significant at the 5% level of probability.
**Significant at the 1% level of probability.

Appendix Table 10

Level of significances for Fl seeds per spikelet for nine wheat cultivars treated with the concentration of 0.67 kg/ha of SD 55446 chemical at Hyslop Agronomy Farm in 1978-79.

| Source of Variation | df | Fl Seeds Per Spikelet |
|---|---|---|
| Replications | 1 | NS |
| Cultivars | 8 | ** |
| Error (a) | 8 | |
| Treatment | 1 | NS |
| Treatment X Cultivars | 8 | NS |
| Error (b) | 9 | |

NS: Not Significant
**Significant at the 1% level of probability.

Appendix Table 11

Level of significances for grain yield and plant height for nine wheat and three triticale cultivars treated with the concentration of 0.67 kg/ha of SD 55446 chemical at Hyslop Agronomy Farm in 1978-79.

| Source of Variation | df | Grain Yield | Plant Height |
|---|---|---|---|
| Replications | 1 | NS | NS |
| Cultivars | 11 | ** | ** |
| Error (a) | 11 | | |
| Treatment | 1 | ** | ** |
| Cultivars X Treatment | 11 | NS | * |
| Error (b) | 12 | | |

NS: Not Significant
*Significant at the 5% level of probability.
**Significant at the 1% level of probability.

Appendix Table 12

Level of significances for seeds per spike, spike length, number of spikelets per spike and 50 kernel weight from bagged and unbagged spikes for six wheat cultivars treated with SD 55446 at the concentration of 0.84 kg/ha at two stages of growth at the East Farm in 1979-80.

| Source of Variation | df | Seeds Per Spike | Spike Length | Spikelets Per Spike | 50 Kernel Weight |
|---|---|---|---|---|---|
| Replications | 2 | NS | NS | NS | NS |
| Cultivars | 5 | NS | ** | ** | ** |
| Error (a) | 10 | | | | |
| Treatment | 2 | ** | ** | ** | ** |
| Cultivars X Treatment | 10 | NS | NS | NS | * |
| Error (b) | 24 | | | | |
| Bagged-Unbagged | 1 | ** | NS | NS | ** |
| Cultivars X Bagged-Unbagged | 5 | NS | NS | NS | NS |
| Treatment X Bagged-Unbagged | 2 | NS | ** | NS | NS |
| Cultivars X Treatment X Bagged-Unbagged | 10 | NS | ** | NS | NS |
| Error (c) | 36 | | | | |

NS: Not Significant

*Significant at the 5% probability level.
**Significant at the 1% probability level.

Appendix Table 13

Level of significances for F1 seeds per spikelet and plant height for six wheat cultivars treated with SD 55446 at the concentration of 0.84 kg/ha and at two stages of growth at the East Farm in 1979-80.

| Source of Variation | df | F1 Seeds Per Spikelet | Plant Height |
|---|---|---|---|
| Replications | 2 | NS | NS |
| Cultivars | 5 | NS | * |
| Replications X Cultivars | 10 | | |
| Treatment | 2 | NS | ** |
| Replications X Treatment | 4 | | |
| Cultivars X Treatment | 10 | NS | * |
| Replications X Cultivars X Treatment | 20 | | |

NS: Not Significant
*Significant at the 5% probability level.
**Significant at the 1% probability level.

Appendix Table 14

Level of significances for seeds per spike, spike length, number of spikelets per spike and 50 kernel weight from bagged and unbagged spikes for Yamhill wheat treated with SD 55446 and WL 85245 chemicals at the concentration of 0.84 kg/ha and at two stages of growth at the East Farm in 1979-80.

| Source of Variation | df | Seeds per Spike | Spike Length | Spikelets Per Spike | 50 Kernel Weight |
|---|---|---|---|---|---|
| Replications | 3 | NS | NS | NS | NS |
| Chemicals | 1 | NS | * | * | ** |
| Treatment | 2 | ** | NS | ** | ** |
| Chemicals X Treatment | 2 | NS | NS | * | ** |
| Error (a) | 15 | | | | |
| Bagged-Unbagged | 1 | ** | NS | NS | NS |
| Chemicals X Bagged-Unbagged | 1 | NS | NS | NS | NS |
| Treatment X Bagged-Unbagged | 2 | ** | ** | ** | NS |
| Treatment X Chemicals X Bagged-Unbagged | 2 | NS | NS | NS | ** |
| Error (b) | 18 | | | | |

NS: Not Significant
*Significant at the 5% probability level.
**Significant at the 1% probability level.

Appendix Table 15

Level of significances for F1 seeds per spikelet, grain yield and plant height for Yamhill wheat treated with SD 55446 and WL 85425 at the concentration of 0.84 kg/ha and at two stages of growth at the East Farm in 1979-80.

| Source of Variation | df | $F_1$ Seeds Per Spikelet | Grain Yield | Plant Height |
|---|---|---|---|---|
| Replications | 3 | NS | NS | NS |
| Chemicals | 1 | ** | NS | ** |
| Treatment | 2 | ** | ** | ** |
| Chemical X Treatment | 2 | NS | NS | NS |
| Error | 15 | | | |
| C.V. % | | 13.29 | 16.95 | 1.26 |

**Significant at the 1% probability level.
NS: Not Significant

Appendix Table 16

Level of significances for seeds per spike, spike length, number of spikelets per spike and kernel weight from bagged and unbagged spikes for Stephens wheat treated with the concentration of 0.84 kg/ha of SD 55446 and WL 84245 chemicals at two stages of growth at the East Farm in 1979-80.

| Source of Variation | df | Seeds Per Spike | Spike Length | Spikelets Per Spike | 50 Kernel Weight |
|---|---|---|---|---|---|
| Replications | 3 | NS | NS | NS | NS |
| Chemicals | 1 | * | NS | NS | ** |
| Treatment | 2 | ** | NS | NS | ** |
| Chemicals X Treatment | 2 | * | NS | NS | ** |
| Error (a) | 15 | | | | |
| Bagged-Unbagged | 1 | ** | NS | NS | * |
| Chemicals X Bagged-Unbagged | 1 | NS | NS | NS | NS |
| Treatment X Bagged-Unbagged | 2 | NS | NS | NS | NS |
| Treatment X Chemicals X Bagged-Unbagged | 2 | NS | NS | NS | NS |
| Error (b) | 18 | | | | |

NS: Not Significant
*Significant at the 5% level of probability.
**Significant at the 1% level of probability.

Appendix Table 17

Level of significances for Fl seeds per spikelet, grain yield and plant height for Stephens wheat treated with the concentration of 0.84 kg/ha of SD 55446 and WL 84245 chemicals at two stages of growth at the East Farm in 1979-80.

| Source of Variation | df | Fl Seeds Per Spikelet | Grain Yield | Plant Height |
|---|---|---|---|---|
| Replications | 3 | NS | * | NS |
| Chemicals | 1 | NS | NS | NS |
| Treatment | 2 | ** | ** | ** |
| Chemicals X Treatment | 2 | * | ** | NS |
| Error | 15 | | | |
| C.V. % | | 11.31 | 11.50 | 1.22 |

*Significant at the 5% probability level.
**Significant at the 1% probability level.
NS: Not Significant

Appendix Table 18

Level of significances for seeds per spike, spike length, number of spikelets per spike and 50 kernel weight from bagged and unbagged spikes for Stephens wheat treated with the concentration of 0.84 kg/ha of SD 55446 and WL 84245 chemicals at two stages of growth at the Schmidt Farm in 1979-80.

| Source of Variation | df | Seeds Per Spike | Spike Length | Spikelets Per Spike | 50 Kernel Weight |
|---|---|---|---|---|---|
| Replications | 3 | NS | NS | NS | NS |
| Chemicals | 1 | NS | NS | NS | * |
| Treatment | 2 | ** | NS | NS | NS |
| Chemicals X Treatment | 2 | NS | NS | NS | * |
| Error (a) | 15 | | | | |
| Bagged-Unbagged | 1 | ** | ** | ** | NS |
| Chemicals X Bagged | 1 | NS | NS | NS | NS |
| Treatment X Bagged | 2 | * | NS | NS | ** |
| Chemicals X Treatment X Bagged | 2 | NS | NS | NS | NS |
| Error (b) | 18 | | | | |

*Significant at the 5% level of probability.
**Significant at the 1% level of probability.
NS: Not Significant

Appendix Table 19

Level of significances for F1 seeds per spikelet and grain yield forStephens wheat treated with SD 55446 and WL 84245 chemicals at the concentration of 0.84 kg/ha at two stages of growth at the Schmidt Farm in 1979-80.

| Source of Variation | df | F1 Seeds Per Spikelet | Grain Yield |
|---|---|---|---|
| Replications | 3 | NS | * |
| Chemicals | 1 | ** | NS |
| Treatment | 2 | ** | ** |
| Chemical X Treatment | 2 | * | NS |
| Error | 15 | | |
| C.V. % | | 8.47 | 10.89 |

*Significant at the 5% level of probability.
**Significant at the 1% level of probability.

NS: Not Significant