# GERMINATION, SEED MATURITY AND VIABILITY, AND FIELD EMERGENCE OF RESCUEGRASS

By

DJIBRIL BA

Diplome d'Agronomie Approfondie

Ecole Nationale Superieure
d'Agronomie et des Industries
Alimentaires

Nancy, France
1985

Submitted to the faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1989

GERMINATION, SEED MATURITY AND

VIABILITY, AND FIELD

EMERGENCE OF

RESCUEGRASS

Thesis approved:

Jimmy F. Stritzke
Thesis Adviser

Don S. Murray

P. Larry Claypool

Norman N. Durham
Dean of the Graduate College

## ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my major adviser, Dr. Jim Stritzke, Professor of Agronomy, for the patience, understanding, and guidance throughout the course of study. My appreciation also goes to the other members of my graduate committee, Dr. S. Donald Murray, Professor of Agronomy, and Dr. P. Larry Claypool, professor of Statistics, for their assistance and advice.

Special appreciation is given to my wife Jennifer for her love, support, and sacrifices and also for giving me a beautiful daughter (Awa) in such a special time. To my parents and particularly to my mother Anta M'Baye, I would like to express my profound recognition for their sacrifices and relentless help. My gratitude also goes to my parents in law, Colonel and Mrs Joe B. Thurston for their help.

Immense is my debt to the Agronomy department at Oklahoma State University for the use of the land, and equipment that made this research possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

## TREATMENTS INDEX

| | |
|---|---|
| Loc | Seed location |
| STL | Stillwater |
| CHI | Chickasha |
| Coat | Seed coat condition |
| INTC | Intact seed (lemma and palea intact) |
| CAR | Bare caryopses (lemma and palea removed) |
| Sub | Substrate moistening agent |
| KN | Potassium nitrate |
| P-chill | Pre-chilling |
| P-heat | Pre-heating |

# GERMINATION, SEED MATURITY AND VIABILITY OF RESCUEGRASS

Abstract. Rescuegrass (*Bromus catharticus* Vahl) seed was collected at maturity in 1987 from Stillwater and Chickasha to characterize dormancy and field emergence. The effects of seed origin, seed coat conditions, substrate moistening agents, and a moist pre-chilling or dry pre-heating on seed germination were evaluated. In 1988, maturity and viability of freshly harvested rescuegrass seed were also evaluated. Seed appeared to be affected by a coat dormancy released by potassium nitrate and an embryo dormancy released by pre-chilling. A pre-heating of the seed reinforced both types of dormancy and only caryopses (bare seed) were able to recover from this reinforced dormancy. Percent emergence from bare soil conditions was highest with October plantings, but total forage dry weight and seed production were highest with September plantings. Field emergence of rescuegrass in alfalfa (*Medicago sativa* L.) was highest with September planting and decreased as the planting time proceeded into fall and winter. Cutting condition of alfalfa did not influence emergence but did affect growth and development of rescuegrass. Highest

dry matter and seed production resulted with early fall planting into uncut alfalfa.

# INTRODUCTION

Bromegrasses (Bromus spp.) were introduced into the United States mainly from South America (7). They are usually winter annuals, but can act as spring annuals or biennals depending upon the growth conditions (1, 7). As winter annuals, they germinate in the fall, grow and develop in the winter, and produce seed in late spring or early summer. As spring annuals, they germinate in the spring and produce seed late that same summer (7). Some bromes such as the California brome (Bromus carinatus Hook. and Arn.), may behave as either annuals or short-lived perennials (7). In some places in the United States, bromegrasses are cultivated and used as forage because of their abundant forage growth during the winter. However, the bromes often cause serious weed problems in horticultural and agronomic crops (4, 5, 7).

Various control measures have been used to control bromes. These control measures vary depending upon the nature of the crop infested. Herbicides registered for the control of bromes include dicamba (3,6-dicloro-o-anisic acid), terbacil (3-tert-butyl-5-chloro-6-methyluracil), and ethofumesate [(±)-2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranyl-methanesulfonate] used to control downy brome (Bromus tectorum L.) in grass seed fields (7). For some grass seed crops, no selective herbicidal treatments are available, so the weedy brome seed is harvested with the grass seed (7). After seed harvest from perennial grasses, there are several herbicides such as atrazine [2-chloro-4-(ethylamio)-6-(isopropylamino)-s-triazine], simazine [2-chloro-4,6-bis(ethylamino)-s-triazine ], chlorpropham (isopropyl m-chlorocarbanilate), terbacil, and ethofumesate that can be effectively used for downy brome control. Some control of downy brome has been possible in cereal grains with herbicides such as trifluralin (trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine), paraquat (1,1'-dimethyl-4,4'-bipyridinium ion), and metribuzin [4-amino-6-tert-butyl 3-(methylthio)-s-triazin-5-(4H)-one] (15). Some of these herbicides are only marginally selective, so timing and application rate are important to avoid crop damage. Alfalfa (Medicago sativa L.) is one of the many agricultural crops that have severe brome infestation (1, 2, 4, 5). In California, where annual bromes are cultivated as forage, Bromus spp. invade alfalfa during the mild wet winter (3). Not only do Bromus spp. reduce digestibility and protein content of the hay, but they also reduce alfalfa yield by competing for light and moisture and by altering temperature conditions (1, 2, 4, 5). The competitive and weedy nature of weedy bromes in alfalfa is attributed to their status as winter annuals. They escape growers detection in the fall and winter by being concealed by alfalfa fall regrowth and then they grow during the winter and early spring while alfalfa is still dormant. The seed of many weedy bromes mature before the first alfalfa spring harvest assuring a seed supply for future infestations.

Rescuegrass was introduced into the United States from South America and then used as a forage. It now has migrated to other areas and is a weed problem in alfalfa in South Central Oklahoma (6). Currently, little is known about the phenologic of rescuegrass.

The goal of this study is to provide informations about rescuegrass that can help set the bases of control of this weed in alfalfa stands.

The objectives are to investigate the following:

1. Effects of substrate moistening agents, seed coat, and temperature on seed germination.
2. Viability of seeds at various stages of maturity.
3. Field emergence.

# MATERIALS AND METHODS

## Germination of rescuegrass

Rescuegrass seed used in the three germination experiments in 1987 were collected from Stillwater and Chickasha after seed maturity in May 1987. The seed were air-dried, cleaned, and processed through a seed blower to obtain mature seeds of unform weight. Seed processed in this way included a caryopsis enclosed in its lemma and palea.

In all germination experiments, 50 seeds were placed in each germination box (7.5 x 7.5 x 3 cm) on three layers of paper towel and then incubated for 4 weeks in a seed germinator under the following conditions:

- Light and dark periods of 8 and 16 hours, respectively
- Day and night temperatures of respectively 30 and 20 C.

The seed were considered germinated when seedling length was 2 mm. Germinated seeds were counted and removed from the boxes weekly for 4 weeks.

Experiment I

This experiment was conducted to evaluate the response of seed collected from Stillwater and Chickasha to two substrate moistening agents, water or 0.2% potassium nitrate. The study was a 2 (locations) by 2 (moistening agents) factorial experiment in a randomized complete block design with four replications. Seeds were placed in germination boxes on paper towel moistened with 8 ml of either water or 0.2 % potassium nitrate. The boxes were then placed in a seed germinator (one replication per shelf) and germination determined weekly for four weeks.

Experiment II

This experiment was conducted to assess the response of rescuegrass seeds collected at Stillwater and Chickasha to seed origins, seed coat conditions, substrate moistening agents, and pre-chilling. The experiment was conducted in a 2 (seed origin) by 2 (seed coat condition) by 2 (substrate moistening agent) by 5 (pre-chilling time) factorial arrangement of treatments in a randomized complete block design with four replications. The levels of the different factors were as follows:

1. Seed origin, Stillwater or Chickasha.
2. Seed coat conditions, "bare caryopsis" (lemma

and palea removed by hand) or "intact seeds".

3. Substrate moistening agents, water or 0.2 % potassium nitrate.

4. Pre-chilling of seeds at 4 C for 0, 1, 2, 3, or 4 weeks.

The lemma and palea were removed by rubbing the seeds on a board to loosen them and each caryopsis was then removed by hand. Caryopsis or intact seeds from Stillwater or Chickasha were placed in germination boxes on paper towel moistened with 8 ml of either water or 0.2 % potassium nitrate. The boxes were stored at 4 C in the dark for 0, 1, 2, 3, or 4 weeks. Placement of the boxes into the cold was staggered weekly so that all pre-chilling treatments terminated at the same time. At the end of the pre-chilling treatment, germination counts were made and then the boxes were placed into the seed germinator and counts taken weekly for four weeks.

Experiment III

This experiment evaluated the response of seeds from the two locations to seed origin, seed coat condition, substrate moistening agent, and pre-heating. The study was conducted in a 2 (origin) by 2 (seed coat condition), by 2 (substrate moistening agents) by 5 (pre-heating time) factorial arrangement of treatments in a randomized complete block design with four replications. Conditions of seed origin, seed coat condition, and substrate moistening agents were identical as in experiment II. The levels of pre-heating time were 0, 12, 24, 48, or 96 hours. Envelopes containing 50 seeds each (caryopsis or intact seeds), were heated in an oven at 65 C for 0, 12, 24, 48, or 96 hours. Placement of seed into the oven was staggered by time intervall so that all pre-heating treatments terminated at the same time. The seeds were then placed into germination boxes on paper towel moistened with 8 ml of either water or 0.2% potassium nitrate. The boxes were placed into the seed germinator and counts taken weekly for 4 weeks.

## Seed maturity and viability

Rescuegrass seed used in this study was collected from Stillwater and Perkins at various time periods after flowering in 1988. Rescuegrass flowering dates were April 18 and 27, 1988 for Stillwater and Perkins respectively. At Stillwater the seeds were collected at 9, 23, 30, 37, 44, and 51 days after flowering. At Perkins, seeds were collected only at the first four time periods. Seed were hand stripped from the plants at the designated period after flowering and maturity recorded. Collected seed were then placed in storage (in paper envelopes) at room temperature until viability studies were conducted. After approximately 2 months of storage, the seed from each location were cleaned and processed through a seed blower to assure weight uniformity. Seed viability for each collection period was then assessed by means of germination experiments conducted seperately for each seed origin. Each experiment was a randomized complete block design with four replications.

Seed from each location were placed into germination boxes on paper towel moistened with 0.2% potassium nitrate and then pre-chilled at 4 C for 2 weeks in the dark. At the end of the pre-chilling treatment, seeds were placed into the germinator and counts taken weekly for 4 weeks.

## Field emergence of rescuegrass

Field emergence experiments were initiated in the fall of 1987 at the Stillwater station (using seeds collected in Stillwater) and at the Perkins station (using seeds collected in Chickasha). At the Stillwater station, units of 50 seed were planted at various dates in 1-meter rows into an area where all vegetation had been removed. Plantings were made on September 14, September 28, October 12, October 26, November 9, November 23, and December 7, 1987 and on February 22 and March 14, 1988. The plots, at each planting date, were irrigated after planting to insure adequate moisture conditions for germination. The experiment was a randomized complete block design with four replications.

At the Perkins location, units of 50 seeds were planted between the two center rows of 4-row plots of alfalfa (alfalfa rows were 25 cm apart). Plot length was 1 meter. The study was a 3 (alfalfa cutting condition) by 5 (planting dates) factorial experiment in a randomized complete block design with three replications. Alfalfa cutting conditions were alfalfa uncut and left standing, alfalfa cut on September 14, 1987, and alfalfa cut on December 8, 1987. Plantings were made on September 11, October 9, and November 6, 1987, and January 19, and February 22, 1988.

For both locations (Stillwater and Chickasha), field emergence was recorded weekly after each planting date and the forage and seed production was determined at seed maturity in the spring of 1988. The rescuegrass production in each plot was divided into two components, total dry matter and total seed number.

# RESULTS

## Germination of rescuegrass

### *Experiment I. Effects of substrate moistening agents on rescuegrass seed germination*

Interactions between locations and substrate moistening agents were significant for all weeks of germination after week 1 (Table 1). Seed from both locations germinated better in potassium nitrate than in water. Total germination for both locations was less than 7% in water versus 42 and 20% in potassium nitrate for Stillwater and Chickasha respectively. These observations suggested that seed from both locations were mostly dormant and that potassium nitrate was only partially effective in getting the dormant seed to germinate. This led to experiment II and III that were conducted to investigate the effects of seed coat condition and pre-chilling or pre-heating on seed dormancy.

Experiment II. Effects of seed origin, seed coat condition, substrate moistening agent, and pre-chilling on rescuegrass seed germination.

The seed (intact seed or caryoses) under certain treatment combinations, manifested an ability to germinate in the cold while still in pre-chilling before removal and placement in germination environment (week 0 of germination). The fourth-order interactions of location, coat condition, substrate moistening agent, and pre-chilling associated with this germination at 0 week was significant (Table 2). Caryopses from both locations germinated better than intact seed (Table 3). Also the germination of the caryopses during pre-chilling tended to level off after 3 weeks, whereas, the germination of intact seed increased with 4 weeks of pre-chilling. Germination after 1 and 4 weeks was essentially identical (Figure 1 and 2) and their analyses of variance was also similar (Table 2). The third-order interactions of coat condition, substrate moistening agent, and pre-chilling for germination after week 1 and 4 was highly significant. Germination of caryopses peaked with only 2 weeks of pre-chilling, whereas, some increase of germination of intact seed was observed with 4 weeks of pre-chilling (Figure 1 and 2). The substrate moistening agent component of the third-order interactions of coat condition, substrate moistening agent, and pre-chilling indicated that substrates were comparable for germination of caryopses but with intact seed, germination in potassium nitrate was better than that in water at pre-chilling times exceeding 2 weeks. It could be inferred from these observations that the seed were affected by a seed coat dormancy that was at least partially released by potassium nitrate. However, the effect of potassium nitrate on seed coat seemed to be limited in the cold since about 60% of the total germination of intact seed in such medium was completed within a week after removal from pre-chilling. The response of caryopses to pre-chilling indicated that the seed were also affected by an embryo dormancy (probably innate dormancy) released by pre-chilling.

The third-order interaction of location, seed coat condition, and substrate was also highly significant and similar for week 1 and 4 (Figure 3 and 4). Germination of seed in water was significantly increased when seed coat was removed with total germination being highest with caryopses from Stillwater. Germination of intact seed was drastically increased on the potassium nitrate substrate, and after 1 week in the germinator, percent germination of intact seed was higher than 60% and comparable to germination of caryopses (Figure 3).

Experiment III. Effects of seed origin, seed coat condition, substrate moistening agents, and pre-heating on rescuegrass seed germination.

The fourth-order interactions of location, coat condition, substrate moistening agent, and pre-heating were not significant for any of the weeks (Table 4). Third-order interactions of coat condition, substrate moistening agent, and pre-heating were significant, for both week 1 and 2 and are illustrated in Figure 5 and 6. Pre-heating for as little as 12 hours reduced germination of caryopses in both water and potassium nitrate (Table 5). If there were any inhibitory effect of pre-heating on intact seed, it could not be evaluated, since germination without pre-heating was less than 5%. Caryopses manifested some ability to recover from the pre-heating inhibitory effect, since the same interaction (seed coat condition, substrate, and pre-heating) was less significant in week 2 of germination and disappeared by week 4. Caryopses on water substrate appeared more reactive than those on potassium nitrate (Table 5).

The third-order interactions of location, coat condition, and substrate were significant for both week 2 and 4 of germination and are illustrated in Figure 7 and 8. Germination of intact seed from both locations was less than 20% in water or potassium nitrate. The inhibitory effect of pre-heating on germination of caryopses was greater with the potassium nitrate substrate (Table 5). It took 48 hours of pre-heating to significantly reduce germination of caryopses in water, but only 12 hours with potassium nitrate after they were subjected to heat treatments. Most of the 3-way interaction was attributable to the fact that caryopses from Chickasha appeared unaffected by the substrate type, whereas, germination of caryopses from Stillwater was decreased when placed in potassium nitrate averaged over pre-heating (Figure 8). Intact seed and caryopses showed almost the same trend in response to pre-heating; just 12 hours of pre-heating decreased significantly germination of both intact seed and caryoses. These results suggested that pre-heating, which was showed earlier to affect early germination (week 1) of caryopses in water, had actually only a temporary effect on caryopses, since it did not affect their total germination in water.

## Maturity and viability of rescuegrass seed

Some seeds collected in Stillwater were viable as soon as 9 days after flowering versus 30 days for seed collected at Perkins((Table 6). Only seeds collected at Stillwater were able to germinate at soft dough stage of maturity , whereas, for Perkins, only seed collected past the soft dough stage (4 weeks after flowering) manifested some viability. Significant germination (45 and 30% for Stillwater and Perkins seed respectively) occured by medium to firm dough stage of maturity which is 4 to 5 weeks after flowering. The highest percent germination was recorded for Stillwater (86%) with seeds collected at a ripe maturity stage (51 days after flowering). Comparisons made within the same collection date indicated that seeds collected from Stillwater were more mature and viable than those collected from Perkins.

## Field emergence of rescuegrass

### Emergence of rescuegrass in field without vegetation, Stillwater station

Maximum emergence of rescuegrass resulted with the October planting dates (Table 7). There was over 60% emergence for both October planting dates. However, in terms of the time elapsed from planting to the time at which maximum emergence was recorded (in the time period of the experiment), the September plantings reached their maximum emergence in 7 weeks versus up to 25 weeks for October plantings (data not shown). This was true for all planting after September since it required between 20 and 27 weeks to achieve maximum emergence. Weekly emergence of the first four planting dates are illustrated in Figure 9. The differences in emergence among the four plantings were very significant in the early weeks of germination. However, with time, the differences in emergence decreased and after the fourth week, they were similar. The delay in emergence was consistent with the drop of temperature characteristic to the approach of the winter (see temperature curve, Figure 9).

The highest total dry weight and seed number resulted with the two early fall planting dates of September 14 and 28 (Table 7). Dry weight production for all other planting dates was under 70 grams per meter row and seed number less than 160 per plant. Rescuegrass had been reported in the literature to actively grow during the winter. Plants that do not emerge early can not take advantage of this winter growth period. Thus, it would appear that early emergence is more important than number of plants finally emerging on competitiveness of rescuegrass. It would also appear that vernalization is required for seed production since no seed were produced from plants from the February 22 and March 14 plantings.

Emergence of rescuegrass
in alfalfa stands,
Perkins station

There was no significant interactions between cutting conditions and planting dates on emergence of rescuegrass. As a result, the analysis of emergence response to planting dates was based on cutting main effect. The maximum seed emergence (60%) was with the first planting date (September 11, 1987) and emergence then decreased as planting dates proceeded into winter (Table 8). Seeds planted in winter did not show significant differences in maximum emergence. Seeds planted in early fall (September 11) reached maximum emergence between 4 and 9 weeks versus up to 25 weeks for seed planted a month later (data not shown). This was consistent with a drop of temperature as fall proceeded. The first fall planting date, taking advantage of good weather conditions, achieved maximum emergence in a much shorter time; whereas beginning October, there was less rain and a lowering of temperature, both which could result in delay of emergence. Differences between cuttings conditions were significant only for the first planting date of September 11 . The best emergence (60%) resulted in the plots that were not cut. This may have been due to improved germination conditions with the standing forage. There were significant interactions associated with cutting conditions and planting dates for both dry matter and seed production. These interactions were very significant for the early planting dates, but after November, planting dates remained unaffected by cutting conditions. This was particularly true for the two cutting dates of September 11 and December 8, which did not show any significant differences after October. The best production of dry matter and seed resulted with planting in the early fall into uncut alfalfa stands. Plants in these plots emerged in about 4 to 9 weeks and then could take full advantage of the winter season for vegetative development.

# DISCUSSION

The results of the germination study suggested that two types of dormancy were present in recuegrass seed, a coat dormancy and an embryo dormancy. Potassium nitrate partially overcame the coat dormancy, while a pre-chilling treatment of about 2 weeks was very effetive in releasing embryo dormancy. Treatment combination of either potassium nitrate or seed coat removal (both releasing coat dormancy) and pre-chilling for two weeks or more resulted in the best germination. Another cold-related phenomenon was the ability of seeds to germinate while still in pre-chilling conditions; at least 2 weeks of pre-chilling was necessary for the achievement of this type of germination.

The heat pre-treatment reinforced both seed coat and embryo dormancy. Bare caryopses, in water-moistened substrate, were able to recover from this inhibition after 2 weeks of germination . However, this recovery was not observed for seed under any other treatment combination.

At the Stillwater station (where rescuegrass seed was planted on plots without vegetation) late fall and early winter planting gave the best total emergence but dry weight and seed production essentially decreased as planting was delayed. The drop in temperature prevailing in late fall and early winter resulted in delayed emergence. Seed planted in the early fall emerged quickly and resulted in the highest dry weight yields and seed production. There were some increased emergence with some of the other planting dates, but total dry weight and seed production were significantly decreased with delayed planting.

At the Perkins station (where rescuegrass seed was planted into established alfalfa), cutting treatments did not affect the pattern of seed emergence in response to planting dates. Seed emergence decreased significantly as planting proceeded into winter. Cutting treatments were not significantly different except for the first planting date of September 11 for which, uncut alfalfa plots resulted in a significantly better emergence . In terms of dry matter and seed production, the response pattern of rescuegrass to planting dates was influenced by the cutting conditions for at least the early planting dates. Seed planted into uncut alfalfa in early fall yielded the highest rescuegrass dry matter and seed production. The lowest dry matter and seed production resulted with the September cutting. This would indicate that cutting in September at the time of emergence of the rescuegrass would be a good weed management practice to minimize the problem of rescuegrass.

# LITERATURE CITED


1. Finnerty, D. W. and Dayton L. Kungaman. 1962. Life cycle and control studies of some weed bromegrasses. Weed Sci. 10:40-47.

2. Kapuska, George and C. F. Strieker. Selective control of downy brome (Bromus tectorum) in alfalfa (Medicago sativa). Weed Sci. 23:202-206.

3. Norris, R. F., W. R. Cothran, and V. E. Burton. 1984. Interactions between winter annual weeds and egyptian alfalfa weevil (Coleoptera: Curculionidae) in alfalfa. J. Econ. Entomol. 77:43-52.

4. Peters, Elroy J., Robert A. Mc Kelvey, and Richard Mattas. 1984. Controlling weeds in dormant and non-dormant alfalfa. Weed Sci. 32:154-157.

5. Pike, David R. and Jimmy F. Stritzke. Alfalfa (Medicago sativa)-cheat (Bromus secalinus) competition. 1984. Weed Sci. 32:751-756.

6. Stritzke, J. F. and G. W. Cuperus. 1987. Control of cool-season weeds in asteablished alfalfa. NCWCC Proc. 40:70

7. Young, J. A., R. A. Evans, W. O. Lee, and D. G.Swan. 1984. Weedy bromegrasses and their control. Farmers Bull. U. S. Dep. Agric. Washington, D. C.: The Department ( 2278 ) 23 p. ill.

Table 1. Accumulative germination of rescuegrass seed from Stillwater or Chickasha after placement on water or potassium nitrate substrate and placed into germinator [a].

| Location | Substrate | Weeks in germination | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | | -------(% Germinated)-------- | | | |
| | Water | 0 | 0 b | 0 b | 0 b |
| Stillwater | KNO | 0 | 36 a | 40 a | 42 a |
| | Water | 0 | 0 a | 4 b | 6 b |
| Chickasha | KNO | 0 | 9 a | 20 a | 24 a |

[a]For each location, values within the same column followed by the same letter are not significantly different (P = 0.05) according to the protected LSD test.

Table 2. Partial analysis of variance results for week 0, 1, and 4 of germination of intact seed and caryopses of rescuegrass seed from Stillwater and Chickasha after pre-chilling in water or potassium nitrate substrate followed by placement into germinator.

| SOURCE | DF | Week 0 | Week 1 | Week 4 |
|---|---|---|---|---|
| | | ( P F) | | |
| Loc | 1 | 0.0545 | 0.0001 | 0.0001 |
| Coat | 1 | 0.0001 | 0.0001 | 0.0001 |
| Sub | 1 | 0.0608 | 0.0001 | 0.0001 |
| P-chill | 4 | 0.0001 | 0.0001 | 0.0001 |
| Loc * Coat | 1 | 0.0187 | 0.1952 | 0.1975 |
| Loc * Sub | 1 | 0.0345 | 0.0624 | 0.0637 |
| Coat * Sub | 1 | 0.0023 | 0.0001 | 0.0001 |
| Loc * P-chill | 4 | 0.5830 | 0.7694 | 0.7891 |
| Coat * P-chill | 4 | 0.0001 | 0.0035 | 0.0027 |
| Sub * P-chill | 4 | 0.0002 | 0.0001 | 0.0001 |
| Loc * Coat * Sub | 1 | 0.0924 | 0.0033 | 0.0034 |
| Loc * Coat * P-chill | 4 | 0.0030 | 0.6266 | 0.6289 |
| Loc * Sub * P-chill | 4 | 0.2158 | 0.3548 | 0.3783 |
| Coat * sub * P-chill | 4 | 0.0407 | 0.0001 | 0.0001 |
| Loc * Coat * Sub * P-chill | 4 | 0.0304 | 0.5307 | 0.5183 |

Considered level of the significance was 0.05.

Table 3. Germination of intact seed and caryopses of rescuegrass from Stillwater and Chickasha after pre-chilling on water or potassium nitrate substrate.[a]

| Treatments | | | Location of collected seed | |
| --- | --- | --- | --- | --- |
| Seed coat condition | Sub | Weeks in Pre-chill | Stillwater | Chickasha |
| Intact | Water | | (% germinated) | |
| | | 0 | 0 c | 0 c |
| | | 1 | 0 c | 0 c |
| | | 2 | 6 c | 1 c |
| | | 3 | 20 b | 10 b |
| | | 4 | 52 a | 24 a |
| | KNO | | | |
| | | 0 | 0 c | 0 c |
| | | 1 | 0 c | 0 c |
| | | 2 | 2 c | 0 c |
| | | 3 | 30 b | 28 b |
| | | 4 | 52 a | 53 a |
| Caryopses | Water | | | |
| | | 0 | 0 c | 0 c |
| | | 1 | 0 c | 0 c |
| | | 2 | 74 b | 70 b |
| | | 3 | 77 ab | 72 b |
| | | 4 | 83 a | 93 a |
| | KNO | | | |
| | | 0 | 0 c | 0 c |
| | | 1 | 0 c | 0 c |
| | | 2 | 67 c | 62 b |
| | | 3 | 76 a | 82 a |
| | | 4 | 82 a | 88 a |

[a] Values within the same column followed by the same letter are not significantly different (P = 0.05) according to the protected LSD test. Comparisons should be made within each combination of coat condition and substrate moistening agent.

Table 4. Partial analysis of variance results for week 1, 2, and 4 of germination of intact seed and caryopses of rescuegrass seed from Stillwater and Chickasha after dry pre-heating followed by placement in water or potassium nitrate substrate and placement into germinator.

| SOURCE | DF | Week 1 | Week 2 | Week 4 |
|---|---|---|---|---|
| | | (P F) | | |
| Loc | 1 | 0.9258 | 0.0023 | 0.0049 |
| Coat | 1 | 0.0001 | 0.0001 | 0.0001 |
| Sub | 1 | 0.0014 | 0.0001 | 0.0026 |
| P-heat | 4 | 0.0001 | 0.0001 | 0.0001 |
| Loc * Coat | 1 | 0.7327 | 0.7375 | 0.3065 |
| Loc * Sub | 1 | 0.4756 | 0.6322 | 0.3988 |
| Coat * Sub | 1 | 0.0038 | 0.0001 | 0.0001 |
| Loc * P-heat | 4 | 0.9844 | 0.0454 | 0.2324 |
| Coat * P-heat | 4 | 0.0001 | 0.0001 | 0.0473 |
| Sub * P-heat | 4 | 0.0098 | 0.0001 | 0.0001 |
| Loc * Coat * Sub | 1 | 0.5147 | 0.0036 | 0.0032 |
| Loc * Coat * P-heat | 4 | 0.9958 | 0.1402 | 0.7809 |
| Loc * Sub * P-heat | 4 | 0.9760 | 0.2361 | 0.8148 |
| Coat * sub * P-heat | 4 | 0.0058 | 0.0333 | 0.1940 |
| Loc * Coat * Sub * P-heat | 4 | 0.9395 | 0.2078 | 0.9508 |

Considered level of the significance was 0.05.

Table 5. Accumulative germination of intact seed and caryopses of rescuegrass seed from Stillwater and Chickasha after dry pre-heating followed by placement in water or potassium nitrate substrate, and placement into germinator.[a]

| Treatments collected seed | | | Weeks in germinator | | | |
|---|---|---|---|---|---|---|
| | | | 2 | | 4 | |
| Seed coat condition | Sub | Hours in Pre-heat | Stil | Chi | Stil | Chi |
| Intact | Water | | ------(% germinated)------- | | | |
| | | 0 | 4 | 1 | 11 | 4 |
| | | 12 | 1 | 1 | 4 | 3 |
| | | 24 | 3 | 1 | 6 | 4 |
| | | 48 | 2 | 5 | 8 | 9 |
| | | 96 | 1 | 2 | 9 | 6 |
| | KNO | | | | | |
| | | 0 | 30 a | 4 | 47 a | 23 a |
| | | 12 | 1 b | 1 | 12 b | 8 b |
| | | 24 | 2 b | 2 | 8 b | 5 b |
| | | 48 | 3 b | 1 | 12 b | 7 b |
| | | 96 | 1 b | 1 | 12 b | 6 b |
| Caryopses | Water | | | | | |
| | | 0 | 67 a | 59 a | 73 a | 63 a |
| | | 12 | 48 b | 44 b | 66 ab | 59 ab |
| | | 24 | 45 bc | 41 b | 63 ab | 56 ab |
| | | 48 | 39 c | 26 c | 56 b | 47 bc |
| | | 96 | 32 c | 26 c | 56 b | 49 bc |
| | KNO | | | | | |
| | | 0 | 64 a | 62 a | 66 a | 65 a |
| | | 12 | 20 b | 20 b | 34 b | 39 b |
| | | 24 | 22 b | 27 b | 38 b | 41 b |
| | | 48 | 21 b | 23 b | 37 b | 41 b |
| | | 96 | 24 b | 20 b | 31 b | 34 b |

[a]Values within the same column followed by the same letter are not significantly different ($P = 0.05$) according to the protected LSD test. Comparisons should be made within each combination of coat condition and substrate moistening agent.

Table 6. Accumulative germination of seed collected at different stages of maturity from Stillwater and Perkins[a].

| | | Stillwater | | | Perkins | | |
|---|---|---|---|---|---|---|---|
| | | Weeks in germinator | | | Weeks in germinator | | |
| Days after flowering[b] | Maturity stage | 1 | 2 | 4 | 1 | 2 | 4 |
| | -(dough)- | % germinated | | | | | |
| 9 | Soft | 5 c | 6 c | 6 c | 0 b | 0 b | 0 b |
| 23 | Soft | 12 c | 14 c | 14 c | 0 b | 0 b | 0 b |
| 30 | Medium | 37 b | 42 b | 42 b | 3 b | 5 b | 5 b |
| 37 | Firm | 43 ab | 44 b | 45 b | 28 a | 30 a | 30 a |
| 44 | Ripe | 55 a | 60 b | 61 b | - | - | - |
| 51 | Ripe | 60 a | 75 a | 86 a | - | - | - |

[a] Values within the same column followed by the same letter are not significantly different (P = 0.05) according to the protected LSD test.

[b] Rescuegrass flowering dates were April 18, 1988 for Stillwater and April 27, 1988 for Perkins.

Table 7. Maximum seedling emergence (max emerg) and forage and seed production of rescuegrass planted in 1-meter row at various dates into bare soil conditions.[a]

| Planting dates | Max emerg | Total dry Weight | Total seeds | Seeds per plant |
|---|---|---|---|---|
| | --%-- | -(grams)- | --(No.)-- | |
| Sept 14, '87 | 53 b | 461 a | 20189 a | 762 |
| Sept 28, '87 | 49 b | 211 b | 12254 b | 500 |
| Oct 12 '87 | 69 a | 69 c | 5948 c | 157 |
| Oct 26,'87 | 63 a | 41 cd | 3784 d | 120 |
| Nov 9, '87 | 49 b | 20 d | 1719 de | 70 |
| Nov 23, '87 | 54 b | 14 d | 977 e | 36 |
| Dec 7, '87 | 46 b | 7 d | 344 e | 15 |
| Feb 22, '88 | 27 c | 1 d | 0 e | 0 |
| Mar 14, '88 | 13 | 2 d | 0 e | 0 |

[a]Values within the same column followed by the same letter are not significantly different (P = 0.05) according to the protected LSD test.

Table 8. Field emergence, forage yield, and seed production of rescuegrass seeded into established alfalfa with various cutting conditions.[a]

| Treatment: Alfalfa cutting | Treatment: Planting date | Max emergence | Total dry matter | Seed production |
|---|---|---|---|---|
| | | ----%---- | -(grams)- | ---(No)--- |
| Not cut | | | | |
| | Sept 11 | 60 a | 22 a | 1951 a |
| | Oct 9 | 48 b | 20 a | 1760 a |
| | Nov 6 | 42 b | 7 b | 712 b |
| | Jan 29 | 12 c | 3 c | 119 c |
| | Feb 26 | 17 c | 1 c | 0 c |
| Cut Sept 11 | | | | |
| | Sept 11 | 47 a | 6 a | 487 a |
| | Oct 9 | 44 ab | 2 b | 30 b |
| | Nov 6 | 35 b | 2 b | 0 b |
| | Jan 29 | 5 c | 1 b | 0 b |
| | Feb 26 | 10 c | 1 b | 0 b |
| Cut Dec 8 | | | | |
| | Sept 11 | 51 a | 13 a | 1101 a |
| | Oct 9 | 52 a | 6 b | 517 b |
| | Nov 6 | 36 b | 3 c | 30 c |
| | Jan 29 | 7 c | 1 c | 0 c |
| | Feb 26 | 15 c | 1 c | 0 c |

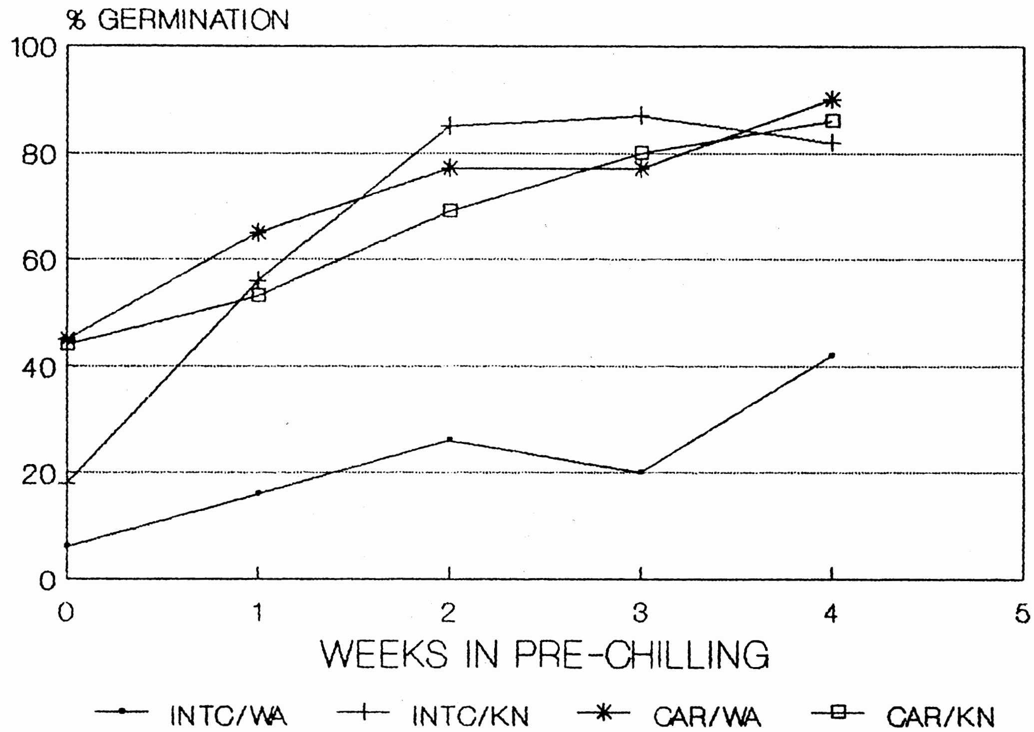
[a]Values within the same column and under same cutting condition are not significantly different (P = 0.05) according to the protected LSD test.

Table 9. Rainfall at Perkins station from September 1987 to April 1988.[a]

| Date: Month | Day | Inches of rain |
|---|---|---|
| September | | |
| | 7 | 0.44 |
| | 10 | 1.75 |
| | 12 | 0.12 |
| | 13 | 0.23 |
| | 16 | 0.50 |
| | 18 | 1.70 |
| | 19 | 0.30 |
| | 21 | 0.40 |
| | 27 | 0.21 |
| | 28 | 0.50 |
| October | | |
| | 23 | 0.10 |
| | 31 | 0.75 |
| November | | |
| | 7 | 0.15 |
| | 16 | 0.25 |
| | 17 | 0.18 |
| | 25 | 0.26 |
| | 26 | 0.88 |
| | 27 | 0.28 |
| December | | |
| | No rain | |
| January | | |
| | 19 | 0.11 |
| February | | |
| | 19 | 0.46 |
| March | | |
| | 2 | 1.00 |
| | 3 | 2.00 |
| | 4 | 0.25 |
| | 6 | 0.23 |
| | 17 | 0.27 |
| | 18 | 0.36 |
| | 29 | 1.27 |
| | 31 | 0.21 |
| April | | |
| | 1 | 2.00 |
| | 2 | 0.25 |
| | 10 | 0.88 |
| | 18 | 1.78 |
| | 19 | 0.10 |

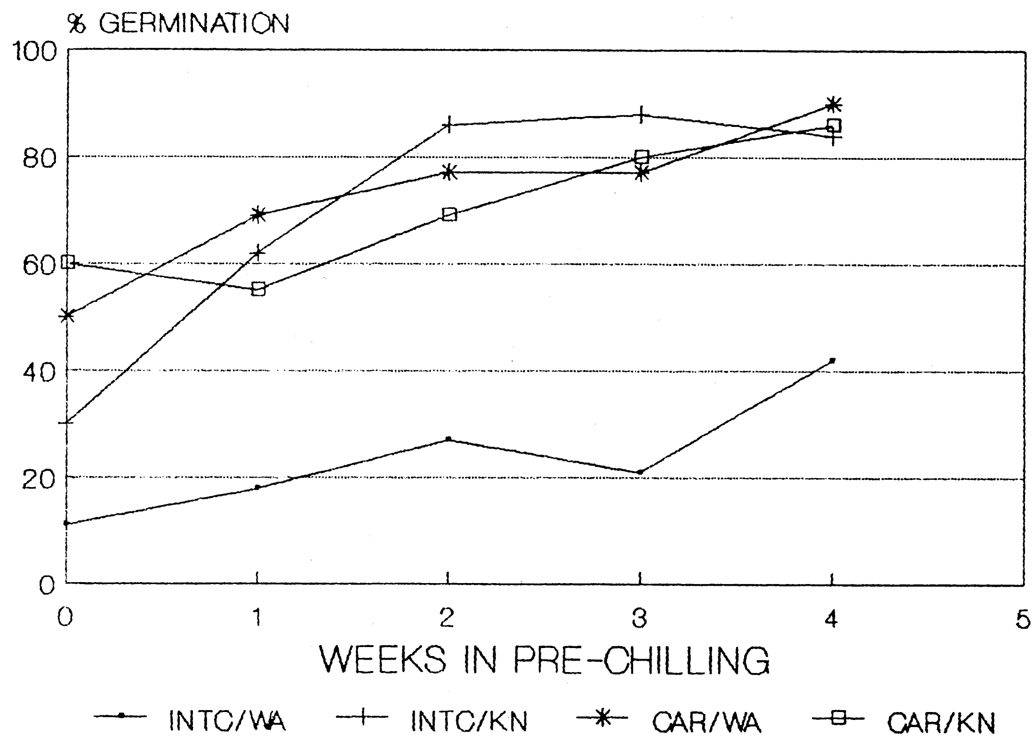
[a]Days with amount of rain less than that 0.10 are not shown.

**FIGURE 1. COAT, SUBSTRATE, AND PRE-CHILLING INTERACTION**



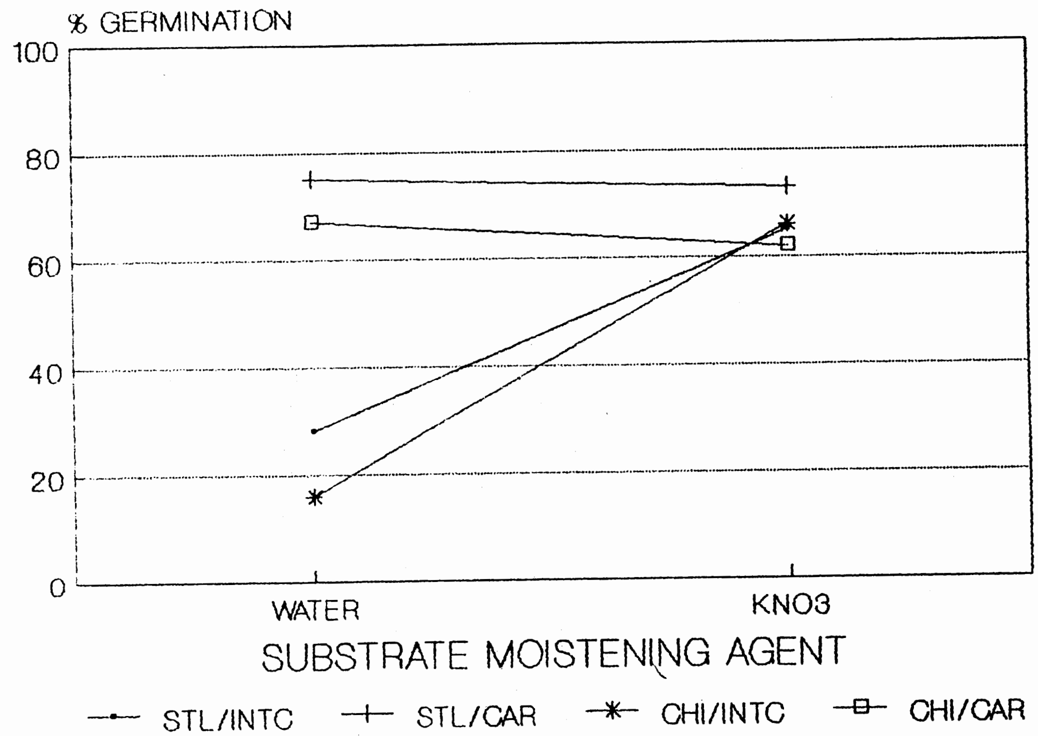

EXPERIMENT II, WEEK 1 OF GERMINATION

**FIGURE 2. COAT, SUBSTRATE, AND PRE-CHILLING INTERACTION.**




EXPERIMENT II, WEEK 2

**FIGURE 3. LOCATION, COAT, AND SUBSTRATE INTERACTION.**




EXPERIMENT II, WEEK 1.

**FIGURE 4. LOCATION, COAT, AND SUBSTRATE INTERACTION.**

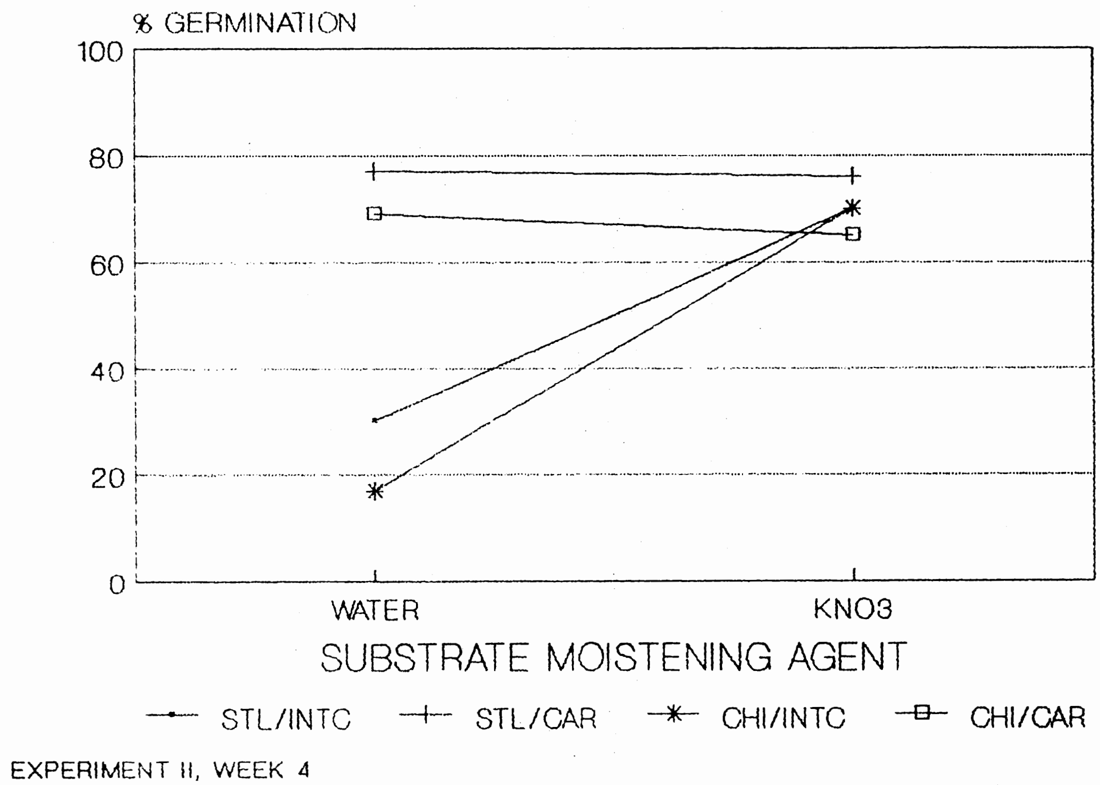
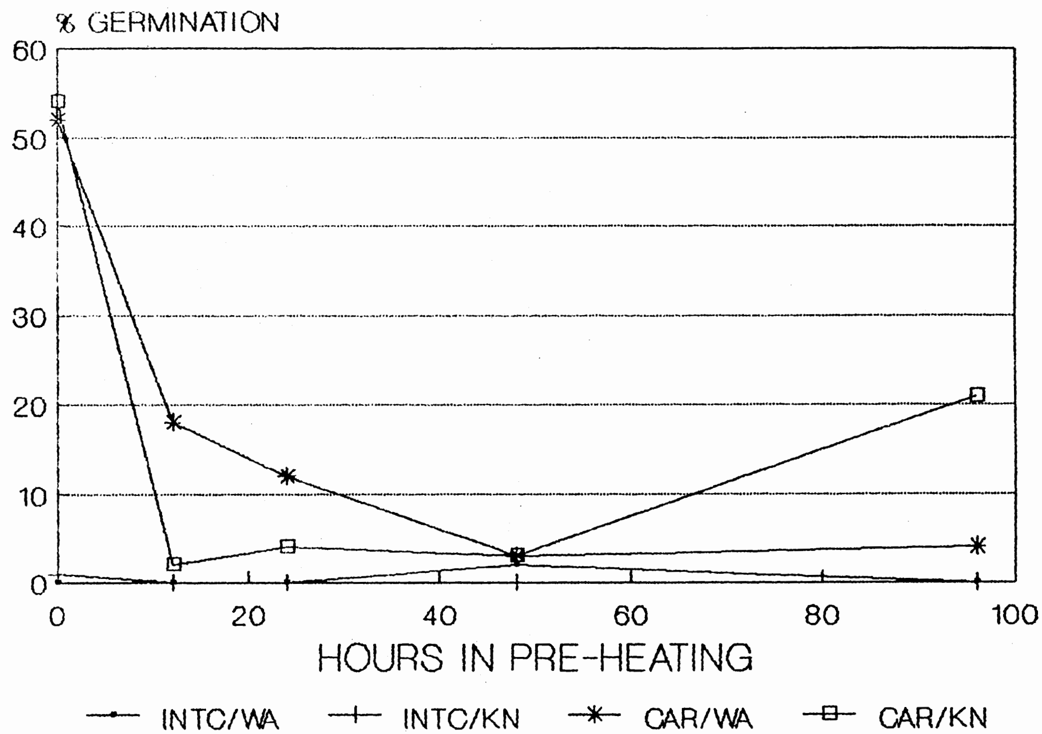
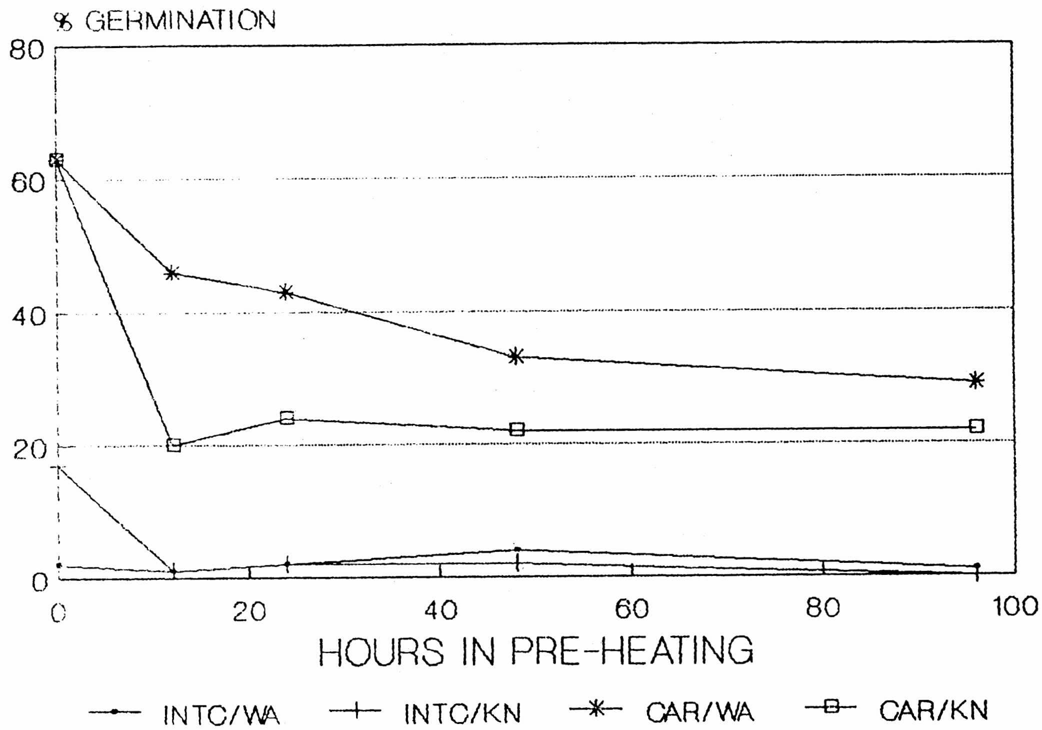


FIGURE 5. COAT, SUBSTRATE, AND PRE-HEATING INTERACTION.



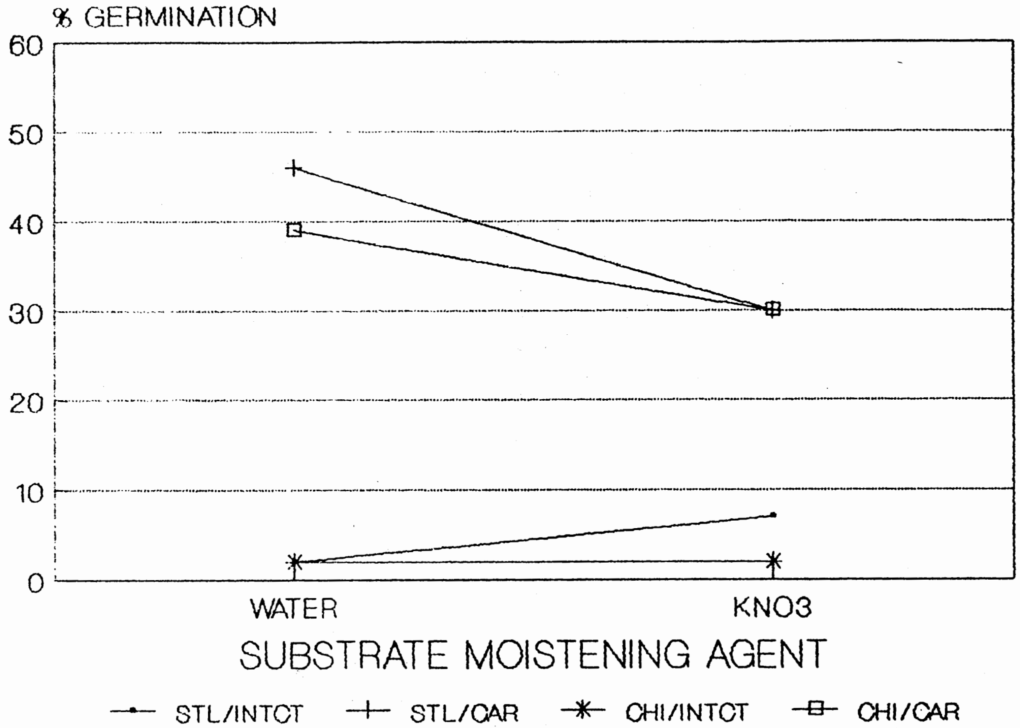

EXPERIMENT III, WEEK 1.

FIGURE 6. COAT, SUBSTRATE, AND PRE-HEATING INTERACTION.



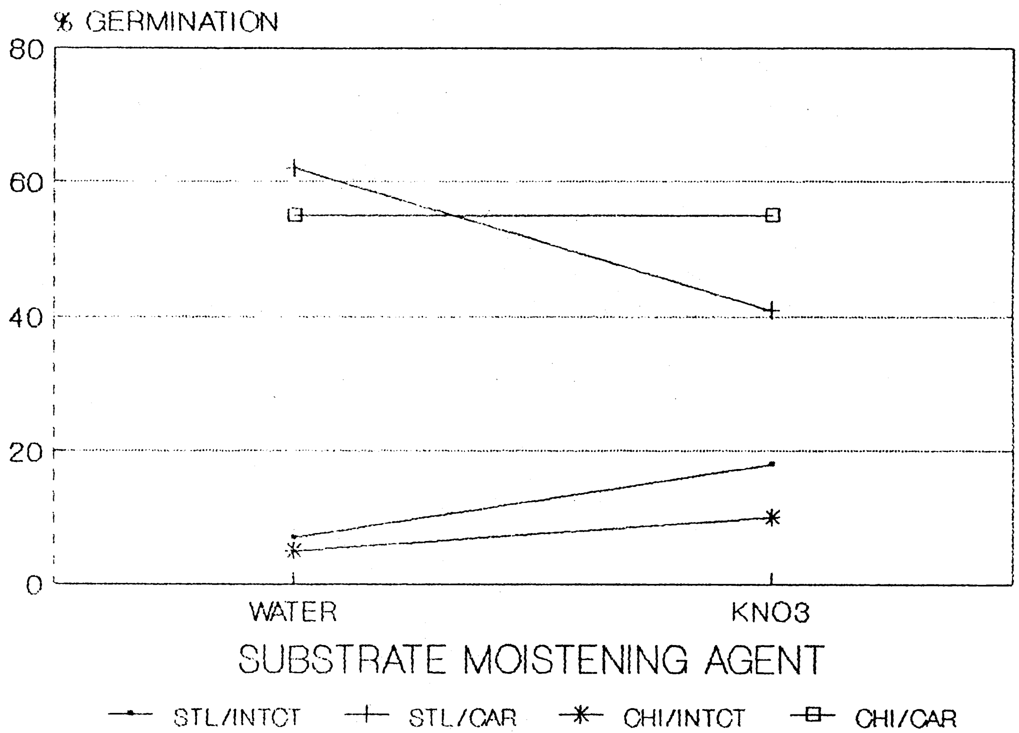

EXPERIMENT III, WEEK 2.

**FIGURE 7. LOCATION, COAT, AND SUBSTRATE INTERACTION.**




EXPERIMENT III, WEEK 2.

**FIGURE 8. LOCATION, COAT, AND SUBSTRATE INTERACTION.**




EXPERIMENT III, WEEK 4.

FIGURE 9. FALL EARLY EMERGENCE
STILLWATER STATION

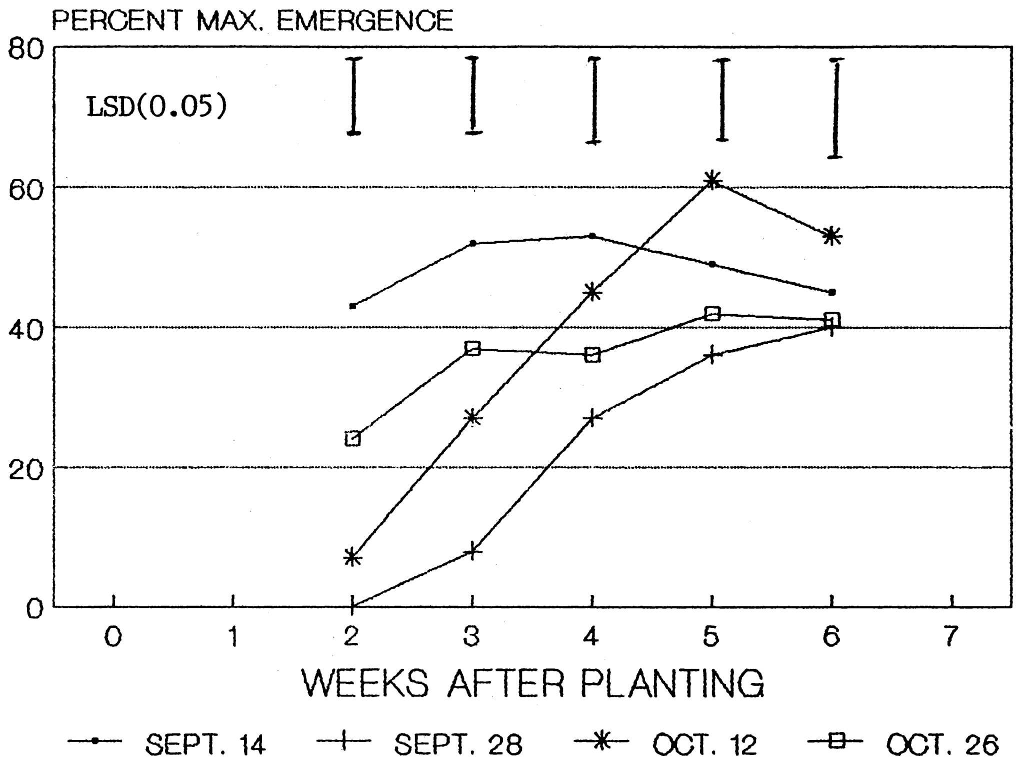
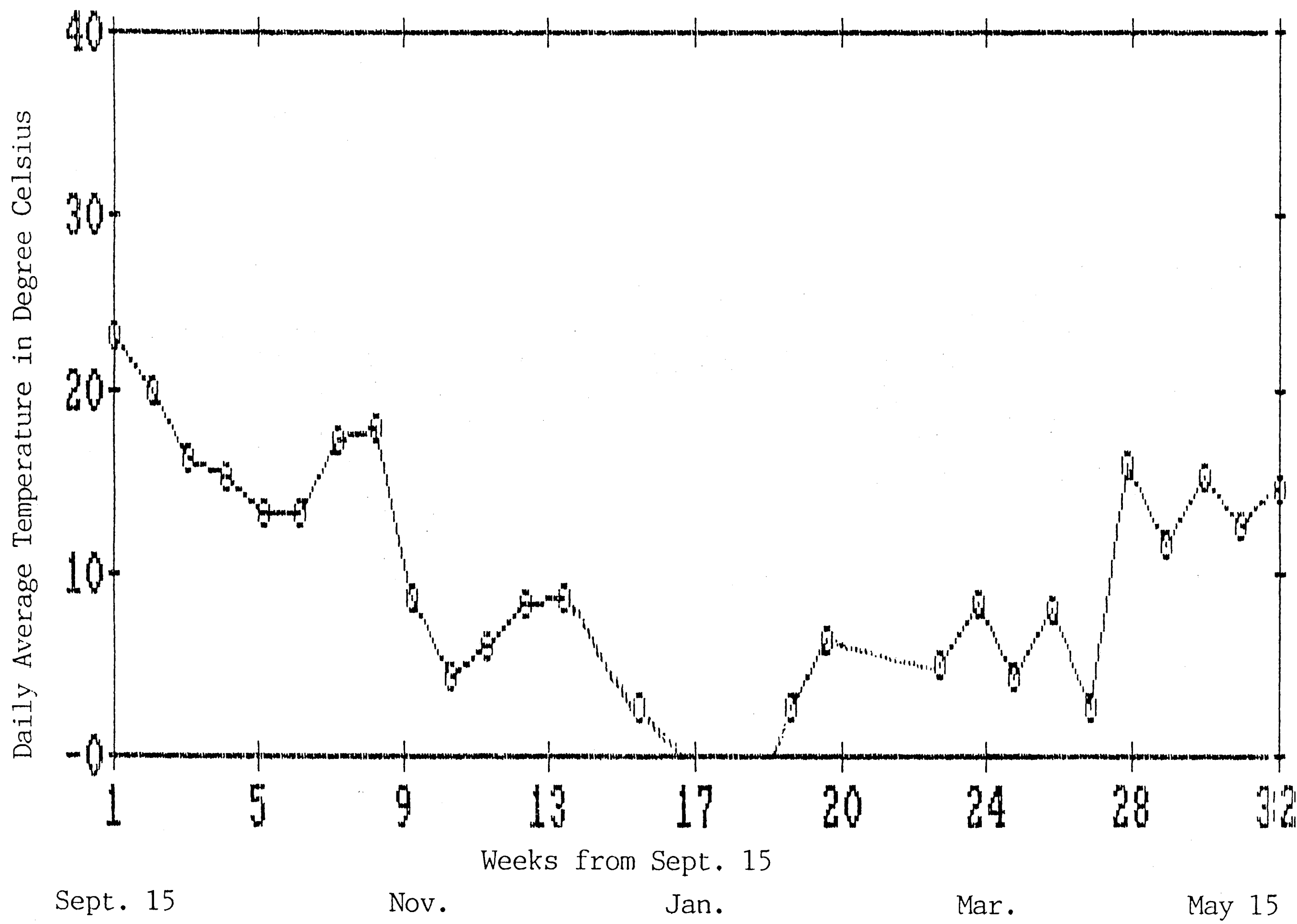


FIGURE 10 AIR TEMPERATURE AT STILLWATER

Variation of air temperature at Stillwater from Sept. 15, 1987 to May 15, 1988. (Temperatures below 0 C are not shown)



VITA

Djibril Ba

Candidate for the Degree of

Master of Science

Thesis: GERMINATION, SEED MATURITY AND VIABILITY, AND FIELD EMERGENCE OF RESCUEGRASS

Biographical:

Personal Data: Born on March 1, 1957 at Dakar, Republic of Senegal, the son of Beytir and N'Deye Anta M'Baye.

Education: Graduated from Blaise Diagne High School in June, 1978; received the Maitrise de Sciences Naturelles (Option: Biology, Chemistry,and Geology) from University de Dakar, Senegal in June, 1982; received a Diplome d'Agronomie Approfondie in October 1985 from The Ecole Nationale Superieure d'Agronomie et des Industries Alimentaires of Nancy, France; completed the requirements for the Master of Science Degree at Oklahoma State University.

Professional Experience: Calligrapher in Summer while in Senegal; Worked as a teaching assistant in Geology at Dakar University from 1982 to 1983.