A STUDY OF THE RELATIONSHIP OF SEED GERMINATION AND SEEDLING BEHAVIOR OF FIVE GRASSES IN THE GERMINATOR TO THEIR PERFORMANCE IN THE FIELD

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TABLE OF CONTENTS

LIST OF APPENDIX TABLES

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Plant growth and development are dependent on the plant's genetic constitution and environmental factors. The environment of terrestrial plants, which includes biotic, edaphic and climatic factors, is so complex it defies a completely logical analysis. Each factor is subject to vast quantitative variations as the result of constant interaction between factors. A change in one factor will influence the effect of others. It would be difficult to ascribe certain definite effects on growth of isolated biotic or physical factors such as temperature, soil, light and water without considering them as a group. Thus it is hard to say that a particular factor is more, or less, important than any other.

Since different environmental factors induce plant variations, variability is perhaps the most general and fundamental problem in the study of growth and development.

This study was designed to determine the relationship of seed germination and seedling growth in an artificial environment of 5 turf and pasture type grasses to their rate of growth in the field. The objective of this investigation was to develop a technique to predict growth rate in the field of these various grasses by determination of critical germination limits, speed of germination and seedling growth in a germinator.

Since environmental factors which influence seed germination and seedling growth could conceivably be a separate study in itself, the decision was made to concentrate specifically on two of the factors namely, temperature and light for major emphasis.

CHAPTER II

LITERATURE REVIEW

Very little literature can be cited that deals to any extent with the scope of this study. Various papers will be reviewed in relation only to certain phases of this problem.

Peirce (9) [1] reported that during seed germination heat is produced and set free and there is an extensive transformation and movement of energy reserves from storage organs to the growing seedling.

According to Thatcher (11), different species of plants, given the same conditions of nutrition and environment, produce organs of the widest conceivable variety in form, color, and function. The form and size of leaves, position and branching of the stem, color, size, and shape of the flower, coloration and markings of the fruit, within the same species, are relatively constant and subject to only very slight modifications. It is the commonly accepted assumption that the fixed habit of growth of the species is transmitted from generation to generation through the chromosomes of the germ cells. This unvarying habit of growth is one of the fixed laws of plant life, with only an occasional deviation. A plant, which under normal conditions of growth, develops in a fixed way, may, when exposed to unusual environmental conditions, alter its habit of growth in an attempt to adjust itself to the new conditions. This phenomenon of

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[1] Figures in parenthesis refer to Literature Cited.

adjustment of a species of plants to new conditions is of common occurrence and is often utilized to economic advantage in the introduction of new strains of crops.

It was stated by Thatcher (11) that water is often a limiting factor in plant growth. Experiments repeated many times and under widely varying conditions show that when water is supplied to a plant in varying amounts, the growth of the plant increases up to a certain point and then falls off when excess water reduces the supply of oxygen available to the plant roots. Hence, water is, in general, an essential factor in plant growth.

Causes of variability in seed germination have been studied extensively by Toole and Toole (12). They state that many seeds in some seed lots are in such a physiological condition that germination or lack of germination is determined by minute differences in one or more environmental factors. They also state that when the radiation energy is near the minimum required for the germination of many of the seeds, small differences in other factors determine whether germination starts. The germination requirements of different kinds of seed vary depending on conditions during development, as to stage of maturity at time of harvest and age.

Experiments reported by Marsden-Jones and Turrill (8) have shown that different soil types may affect the seed of various plants in their ability to germinate. The size and erectness of the plant, vigor of the vegetative organs, depth of the root systems, and susceptibility to drouth, frost, and parasites were also shown to be influenced by the soil type.

It was reported by Isely (7), that seedling emergence is conditioned not only by the characteristics of the seeds themselves but by the environmental conditions to which they are exposed. If the measurement of seed viability, a function of seed testing, is to have any more than illusory reality and application, it is essential that all variables affecting seed germination be held constant. His results showed that substrate moisture conditions in petri dishes were highly variable, even in humidified germinators.

Results of a series of tests conducted by Shenberger (10) were among the first reported as to the conditions that exist in certain types of germinators now in general use. He observed the moisture content of the substrate in all the germination environments tested as ranging from saturation to almost complete dryness at the end of an 11-day test period. The rapidity of the temperature alternation of the blotters in petri dishes in the germinators varied from 28 to 400 minutes. The temperature differential between the top and the bottom trays was as much as 4° C. during the cycling of the germinator. The intensity of the light at any one point on the trays varied with the distance of that point from the lamps, the amount of space between the trays, the transmission of light through the glass walls, the age of the lamps and the amount of day light. The light intensity in the day-light germination chamber supplemented with artificial light varied from 6 to 150 foot-candles.

Uniformity trials on germination of switchgrass seed conducted by Ahring, et al., (1) showed a significant difference between tray levels in percent germination in three of the four germination environments tested. The variability which they measured in the 30° C. constant temperature and the 20-30° alternate environment was highly significant, whereas the 20-35° alternate environment was not significant. The 20-30° environment as opposed to the 20-35° environment exhibited the smallest average germination differential from top to bottom trays within the germinator. Their test indicated that small differences in environment within a germinator influence the percent germination and that a random replication of each seed sample by tray is needed to give a more realistic estimate of the germination of a given seed lot.

The use of daily alternations of temperature is one of the most common methods of germinating a great number of the grasses according to Harrington (5). The alternating temperatures most frequently used are 15-30° and 20-30° C. He stated that germinators are usually set for an alternate 16 hours night, at the lower temperature, and 8 hours day at the higher temperature. Stults germinators thermostatically controlled for the various temperature combinations were the type utilized in his study.

In greenhouse studies on bermudagrass, the relationship of shoot-growth to root-growth was reported by Boyd (4). He stated: "In the first 2-weeks growth, the roots exceeded the top growth." The primary roots were practically the only ones in evidence at the end of 2 weeks with only one plant showing development of any adventitious roots. After a 4-week growth interval the tops began to show greater development than the roots until at the final observation, the tops weighed almost eight times that of the roots.

Root measurements at the end of ten weeks showed that the roots had grown to a length of 683 mm. as compared to the top growth of 750 mm. The box used in this portion of Boyd's greenhouse growth measurement studies was one meter long by one-half meter wide, and 10 cm. deep. When the roots were removed from the box at the end of a 21-week period they had reached the bottom of the box and were spread out and tightly netted.

CHAPTER III

MATERIALS AND METHODS

The study reported here was an attempt to develop a method of determining the rate of growth in the field of certain turf and pasture type grasses by: 1) determination of critical germination limits, 2) speed of germination and, 3) rate of shoot and root development, in an artificial environment. These tests were conducted during 1959 and 1960 at the U.S.D.A. Grass Seed Research Laboratory and the Oklahoma State University Agronomy Research Station located at Stillwater, Oklahoma.

Preliminary investigations were conducted during the summer and fall of 1959 utilizing five grass varieties. The grasses used during both years of study were:

Cultivated Variety	Latin name
NK-37 bermudagrass	Cynodon dactylon
Common bermudagrass	Cynodon dactylon
U-3 bermudagrass	Cynodon dactylon
Creeping red fescuegrass	Festuca rubra
Penncross bentgrass	Agrostis palustris

The five grasses utilized in this study consisted of three bermudagrasses: one a forage type, another exhibiting either forage or turf characteristics and the third principally a turf type. The other two grasses included a bentgrass and a fescuegrass, both of which are considered to be turf types. The description given by Hitchcock (6), in his "Manual of Grasses" published in 1950, classify the bermudagrasses as perennials spreading extensively by creeping, scaly rhizomes or by strong, flat stolons. The bentgrasses are classed as delicate to moderately tall annuals or usually perennials, with flat or sometimes involute, scabrous blades, and open to contracted panicles of small spikelets. This variety is primarily a cool-season type adapted mostly in northern sections of the United States and in Canada. Hitchcock (6) describes red fescuegrass as a perennial which exhibits more of an erect type of growth. Its adaptation, like the bentgrasses, is essentially the cooler regions of the northern hemisphere.

These investigations consisted of exposing 100 seeds from each of these five varieties of grass to five germination environments. The environments used were 40-45°, 20-35°, 20-30°, and 5-15° C. alternate and a 30° constant temperature. Stults germination chambers were used for each environment studied.

The two most optimum environments for seed germination were selected for the tests conducted in 1960. These environments were the 20-30° and the 20-35° C. alternate temperatures. The alternating temperature period for both environments was 16 hours of darkness at the lower temperature and 8 hours of light at the higher temperature for each 24-hour cycle as shown in Figures 1 and 2.

An experimental procedure was designed whereby all of the grass varieties would be subjected to the same environmental conditions. The procedure of study covered three phases: 1) seed germination and selection of plant material in the laboratory, 2) transplanting and mainten-

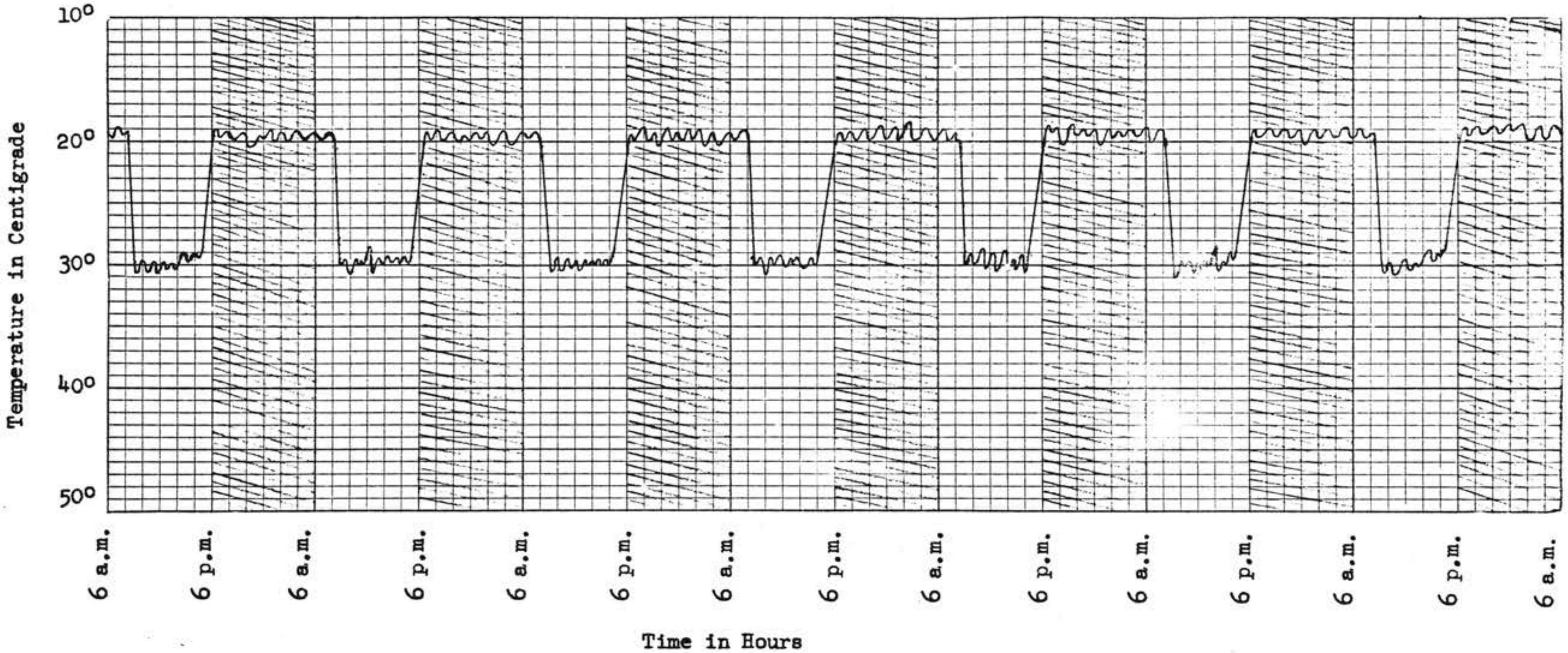


Figure 1. Temperature chart for the 20-30° centigrade alternate germination environment showing the diurnal and nocturnal phases of the cycle with 16 hours of the 20° occurring as the dark phase and 8 hours of the 30° as the light phase.

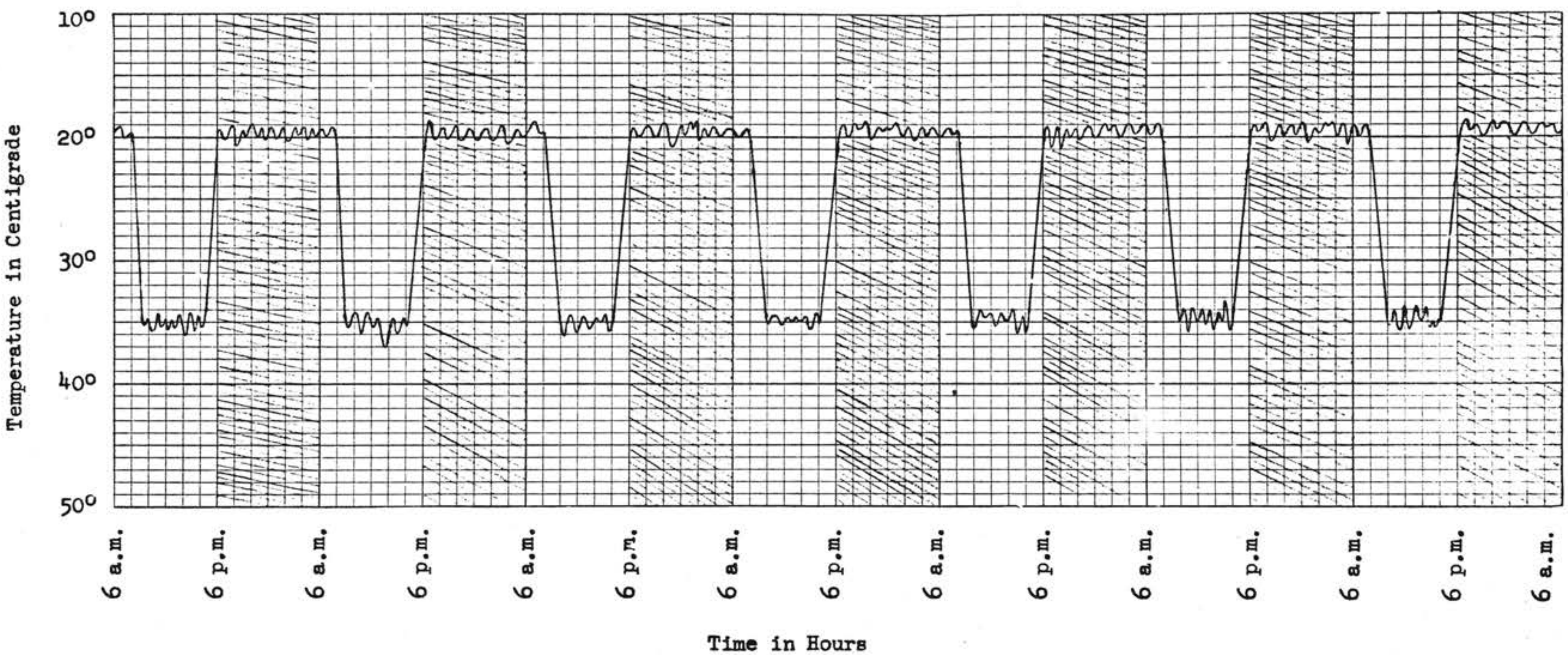


Figure 2. Temperature chart for the 20-35° centigrade alternate germination environment showing the diurnal and nocturnal phases of the cycle with 16 hours of the 20° occurring as the dark phase and 8 hours of the 35° as the light phase.

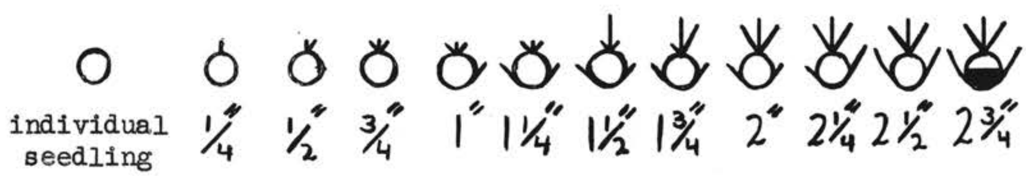
ance in the greenhouse, and 3) transplanting, maintenance, and measurements in field plots. A comparison of the growth rates, of each phase for the five grasses studied, were made within each variety. Comparisons were made within the variety because of the different growth habits between varieties.

From the results of the procedure used in the preliminary test in 1959, a refined germination procedure was utilized in 1960, using only the alternate 20-30^{o} and 20-35^{o} C. environments. Four plastic boxes, $5\frac{1}{4}$ by 5 by $1\frac{1}{4}$ inches in size, with lids were used as the germination containers for each of the 5 grass varieties. Each box was filled with 28 grams of vermiculite and 145 ml. of distilled water to serve as the germination substrate. Two hundred seeds were selected at random from each variety studied. Each lot containing 200 seeds was divided into two replicates of 100 seeds. Each replicate of 100 seed units was spaced in a plastic germination box in 10 rows with 10 seeds per row.

One replication of each variety was placed at random on each of two trays. Trays, assigned as replicates, were then placed within each germination environment. The trays were centrally located and in close proximity to each other to reduce the effect of variation in temperature within the germinator. This procedure gave two replications, of 100 seeds per replication for each of the five grasses, in both of the two germination environments. This method does not strictly adhere to the rules prescribed for seed testing adopted by the Association of Official Seed Analysts (3). Temperature levels and germination procedure employed for the various kinds of seed used in this study were based in part on the specifications set down by this Association.

The moisture content of each plastic box was checked daily and any excess water in the substrate was removed from the box with the aid of a pipette. Under conditions of water loss, due to evaporation, distilled water was added to a low saturation level and then the excess water was removed with a pipette. An attempt was made to maintain the moisture level in each germination box near field capacity.

At the time the daily moisture check was made each box was closely examined for seed initiating germination. Upon observation of the first germination, records as to date of germination and measurements of seedling shoot-growth were started for each of the individual seeds. Starting from the date of initial seed germination the boxes were checked and records made at progressive 3-day intervals for a period of 17 days. The measurements of shoot growth were made in 1/4 inch increments utilizing Anderson's (2) scatter diagram technique as follows:



These symbols were recorded with various color designations for germination data and progressive growth measurements.

At the end of the 17-day observation period selections of individual seedlings were made from each replication. The root length of each seedling selected was measured and recorded. It was observed in this 17-day period some seedlings exhibited a faster rate of shoot and/or root growth than the others, while some were much slower in this respect. As a result of these marked differences in growth rate, those plants which exhibited a rapid rate of growth will hereafter be referred to as "rapid", while those with a pronounced slow rate of growth will be called "slow". Plants which were neither rapid nor slow growers in the germinator, but had an equal chance for either classification in the field were placed in the category of "intermediates".

Only the seedlings appearing to fall within the category of extremes, rapid and slow, discarding the intermediate types, were transplanted to greenhouse conditions.

Approximately 60 seedlings including both rapid and slow growers from each replication were selected, giving a total of approximately 120 seedlings from each variety within each environment. Each seedling selection was transplanted into a flat, 24 by 18 by 4 inches in size, containing 130 vita-bands. The vita-bands were 1 1/4 by 1 1/4 by 3 inches in size filled with 2 inches of sterilized sandy loam soil. Each flat contained the total number of seedlings selected for study of one of the five grasses from a particular environment. The seedlings were allowed to grow in the greenhouse for a period of 30 days. The plants were watered at regular intervals to assure ideal moisture conditions. They were also closely checked while in the greenhouse to guard against insect and/or disease damage.

At the end of the 30-day period, random selections were made from both the rapid and slow growing seedlings within each flat and transplanted to field plots. The field tests were conducted on a Kirkland silt loam soil. To reduce the possibility of any soil gradients from affecting field performance the seedlings selected from each replication of each variety were randomly transplanted in the same rows. The plants of a replicate were grouped together since comparisons were to be made only within a variety and not cross varietal lines. The field layout consisted of randomizing each of the replications, four for each variety studied.

Each of the bermudagrass selections was transplanted in the field on five foot centers still enclosed within the vita-band. The row spacings and distance apart within the row of bent and fescuegrasses was reduced to three feet because of their slow lateral growth habit.

The daily rainfall record for the Agronomy Research Station at Stillwater is shown in the Apendix Table I. The field plants received supplemental irrigation as required to assure adequate moisture between periods of rainfall.

Lateral spread for all the growing plants in the field plots was used as a basis of measuring the rate of growth. Measurements of growth for each plant were made and recorded after exposure to field conditions for a period of 90 days. Calculations and comparisons were made for each plant using the data collected in the field and the seed germination and seedling measurements obtained in the laboratory. On the basis of these data, determinations as to the respective classification of each plant were made as either a rapid or slow plant type.

CHAPTER IV

RESULTS AND DISCUSSION

To develop a technique for the selection of desired plant types in the seedling stage, careful observation of the individual plant and a complete record of its performance is essential. However, to understand and utilize the data one must carefully study the complete germination performance of each variety within the various environments. It is a common opinion among seed analysts, seed technologists, agronomists, and plant breeders that germination tests are not being used to their fullest advantage.

The screening test conducted in the preliminary studies indicated that the two most optimum environments for germination of these grasses were the 20-30° and the 20-35° C. alternating temperatures. Only these two environments were used in the data presented in this paper.

Effect of Environment on the Germination of the Five Grass Varieties

The average germination within both environments of the five grasses studied in 1960 ranged from 79 to 99%, as shown in Figure 3. The percent germination in the 20-30° environment was high, but in each case the 20-35° environment gave a 1 to 6% higher average germination value with the exception of U-3 bermudagrass where there was almost a 17% increase. This indicates that the germination of the cultivated variety U-3 bermudagrass

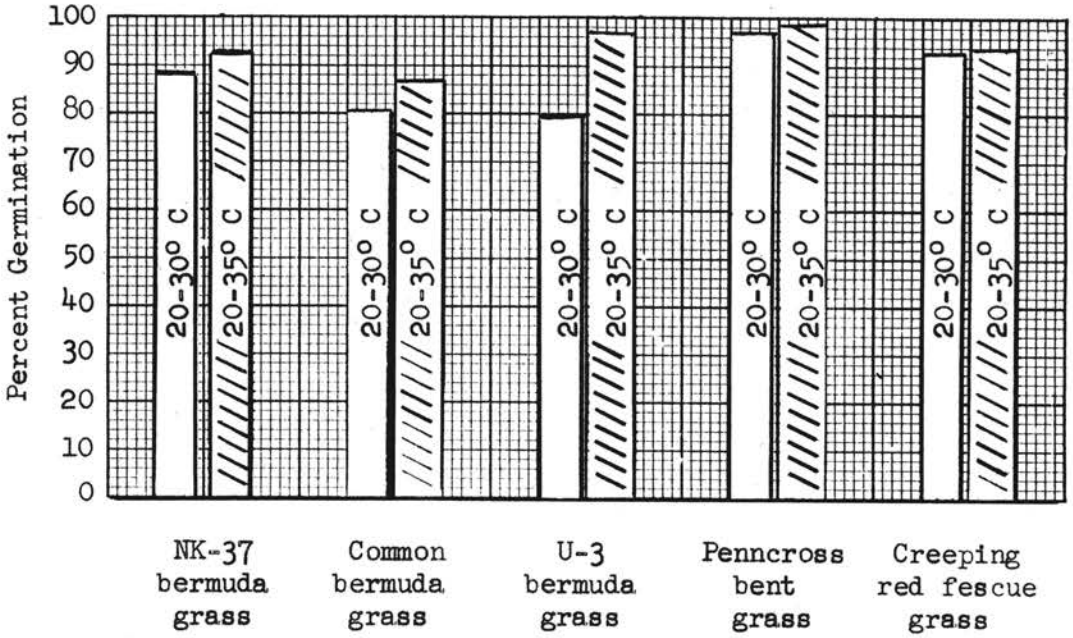


Figure 3. Average percent germination for each of the five grass varieties studied within both the 20-30° and 20-35° C. alternate environments.

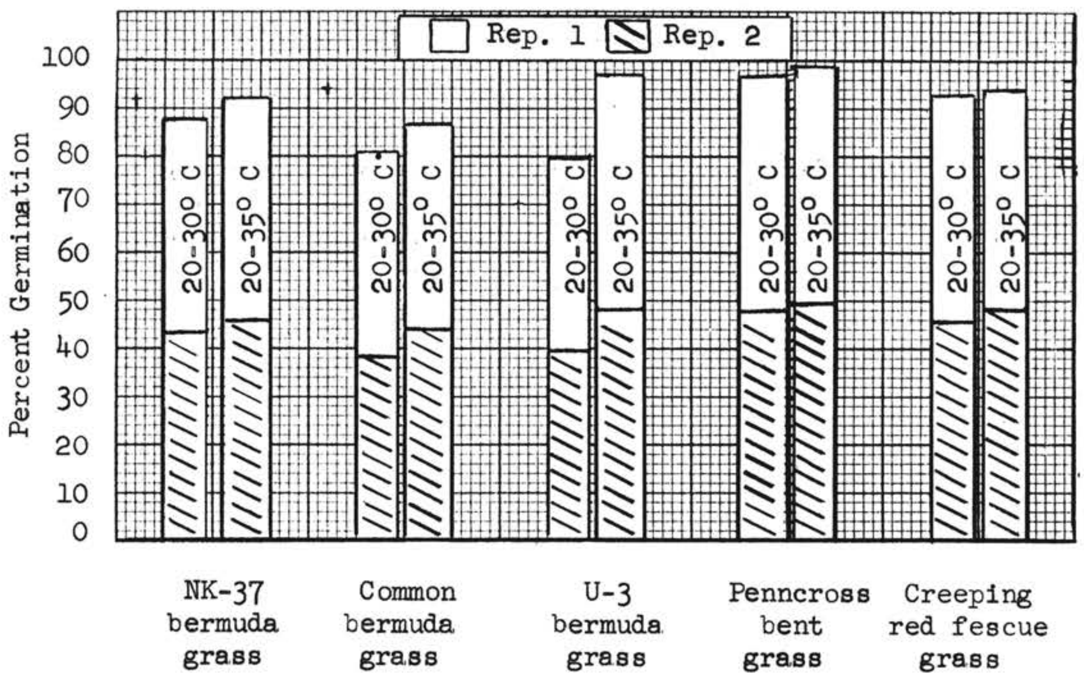


Figure 4. Percent germination of each grass studied in 1960 by replications within each environment.

favors a 20-35° alternate environment. Further evidence of this was found by an average difference of approximately 17% germination between environments. The percent germination by replicates within each environment is shown in Figure 4. It would appear that little difference in germination existed between replicates of each variety within either germination environment.

The percent germination within each environment for NK-37, common and U-3 bermudagrasses, Penncross bent and creeping red fescuegrasses is shown in Figures 5, 7, 9, 11, and 13 respectively.

The differences which occurred between varieties and environments in the number of days required for the initiation of germination is rather striking, Figures 5 and 13. The cultivated grass varieties of NK-37 bermuda and creeping red fescue required only 3 days to attain a germination level of approximately 84 and 86, and 89 and 90% within the 20-30° and 20-35° C. environments respectively. Very few of the remaining seeds germinated. This indicates that within these two environments one can expect a rapid and near total germination of all viable seeds of these two varieties by the end of a 7-day interval.

A distinct contrast exists when the germination performance of NK-37 is compared to U-3 and common bermudagrass varieties as shown in Figures 7 and 9. Where 3 days were required for almost complete seed germination in NK-37, 17 days were required by common and U-3 to initiate approximately the same germination percent.

The majority of the total seed units of the cultivated bermudagrass varieties common and U-3 initiated germination in the 20-35° C. environment at the end of 5 days, but required 14 days to obtain the level reached by NK-37 in 7 days. The 20-30° alternate environment appeared

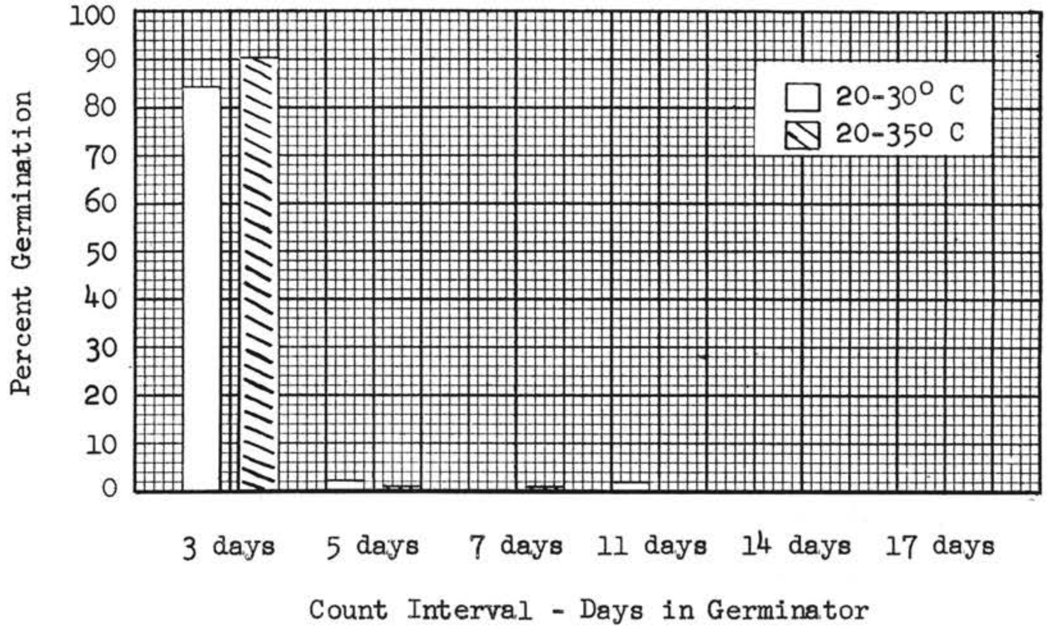


Figure 5. Percent germination of NK-37 bermudagrass within the 20-30° and 20-35° C. alternate environments at various count intervals.

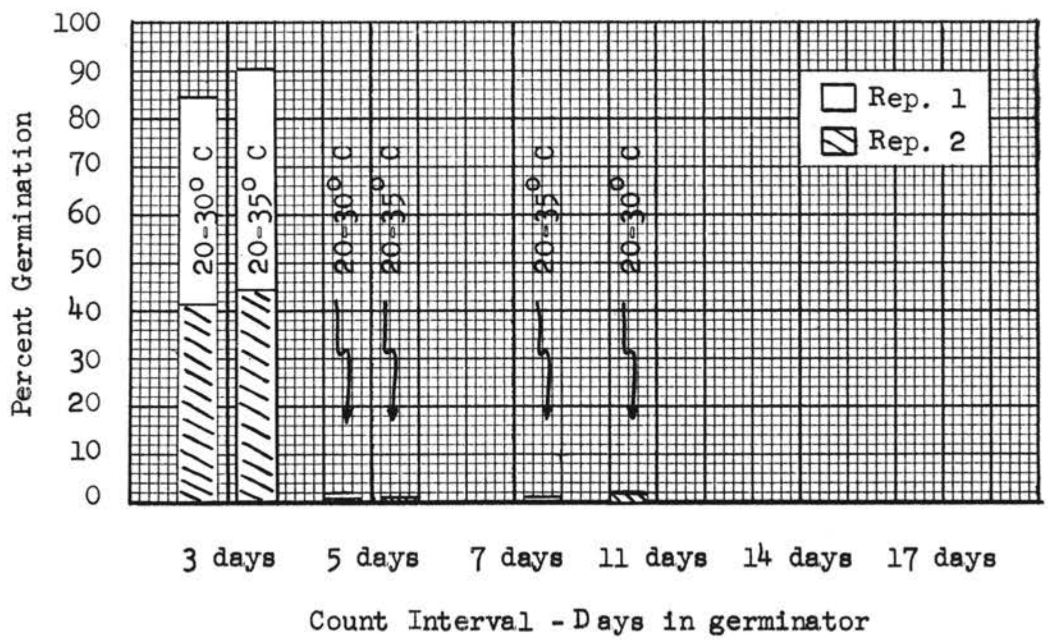


Figure 6. Percent germination of NK-37 bermudagrass by replicates within the 20-30° and 20-35° C. alternate environments at various count intervals.

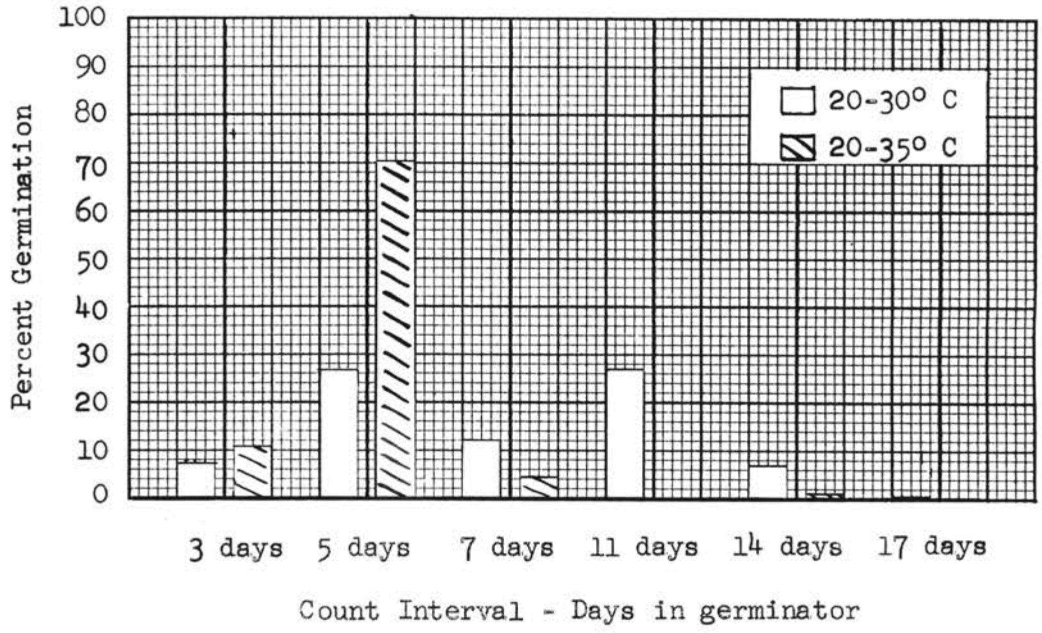


Figure 7. Percent germination of common bermudagrass within the 20-30° and 20-35° C. alternate environments at various count intervals.

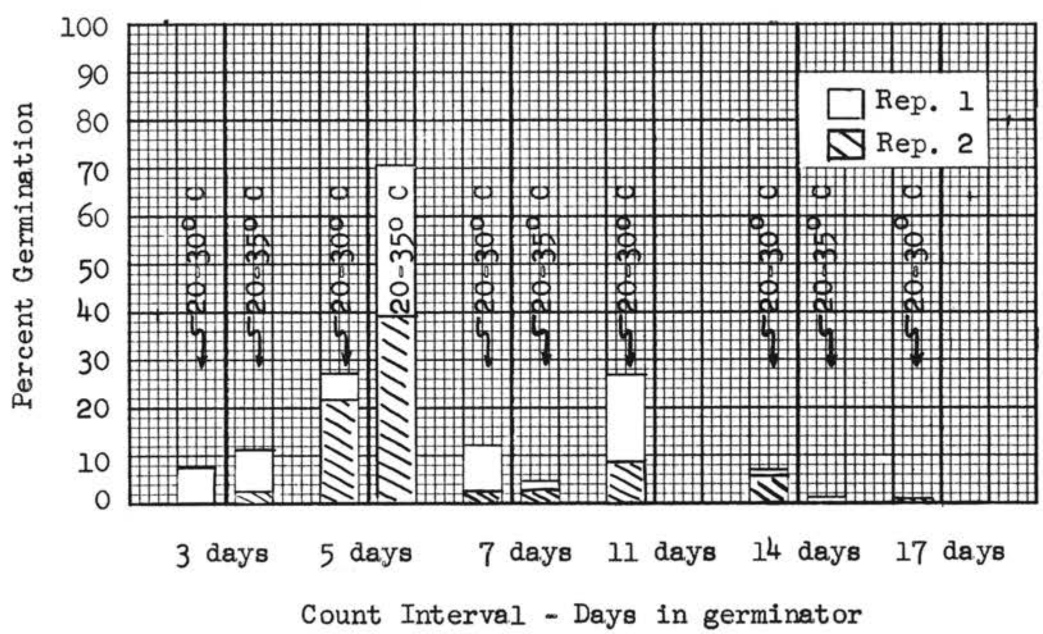


Figure 8. Percent germination of common bermudagrass by replicates within the 20-30° and 20-35° C. alternate environments at various count intervals.

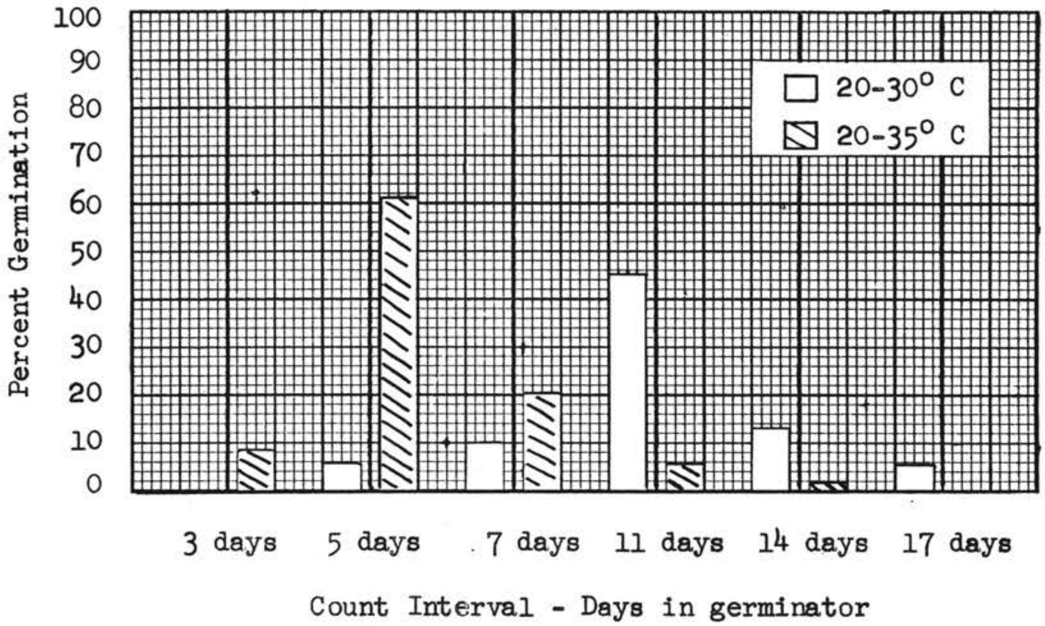


Figure 9. Percent germination of U-3 bermudagrass within the 20-30° and 20-35° C. alternate environments at various count intervals.

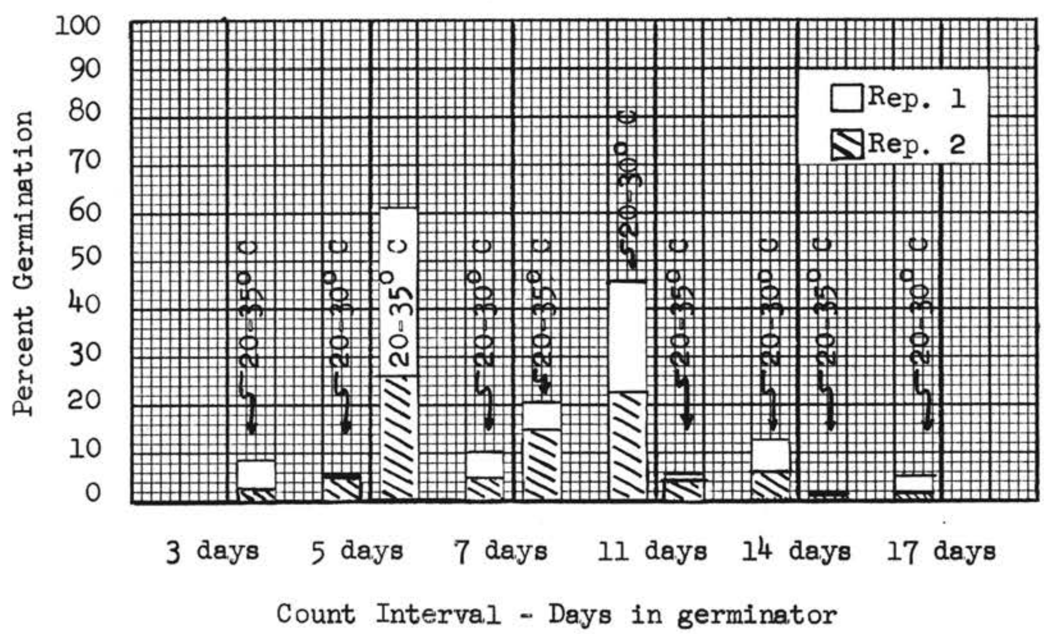


Figure 10. Percent germination of U-3 bermudagrass by replicates within the 20-30° and 20-35° C. alternate environments at various count intervals.

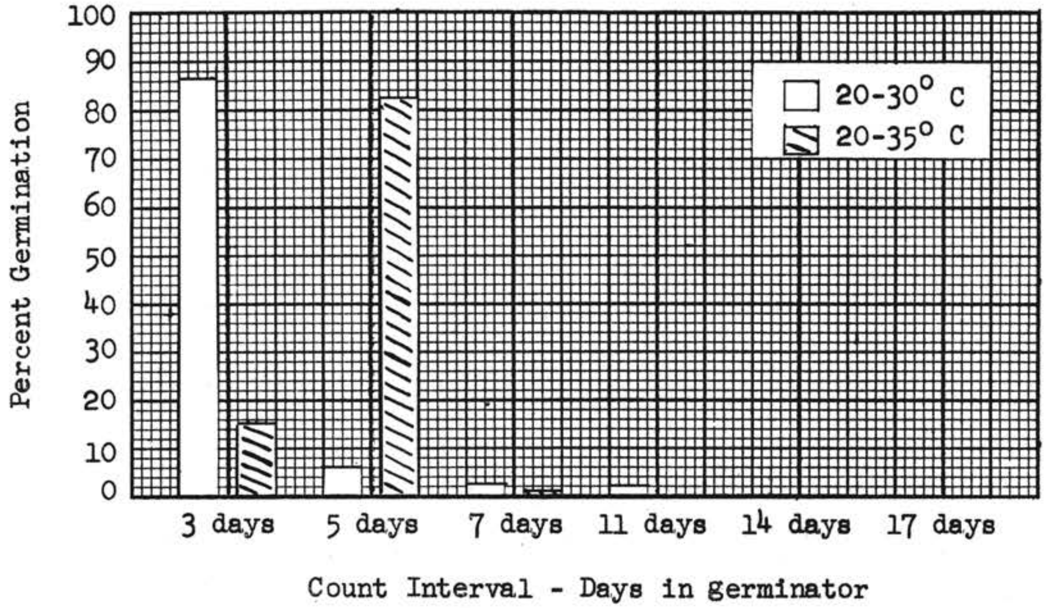


Figure 11. Percent germination of Penncross bentgrass within the 20-30° and 20-35° C. alternate environments at various count intervals.

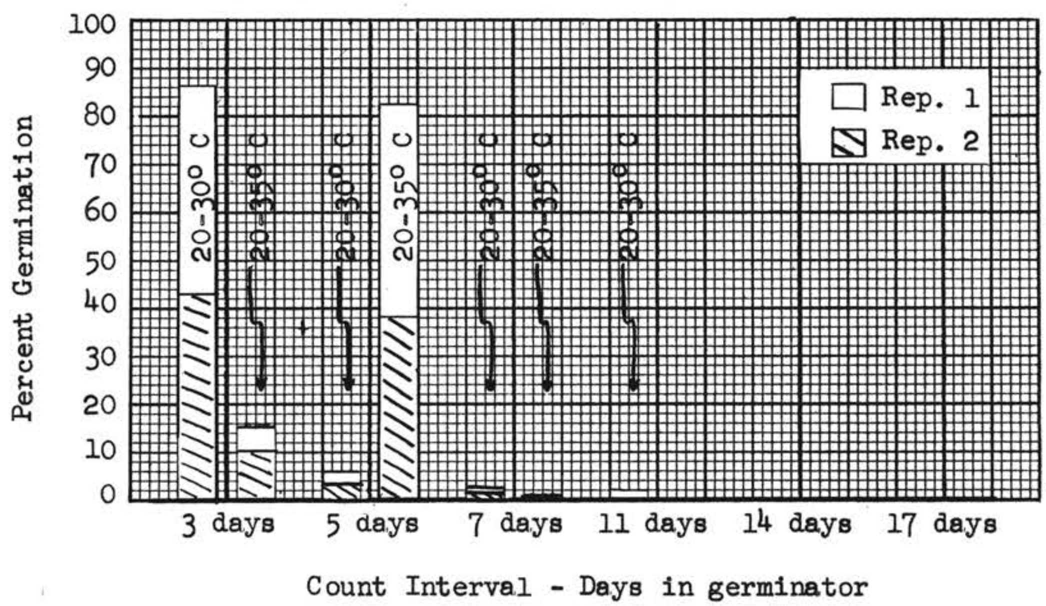


Figure 12. Percent germination of Penncross bentgrass by replicates within the 20-30° and 20-35° C. alternate environments at various count intervals.

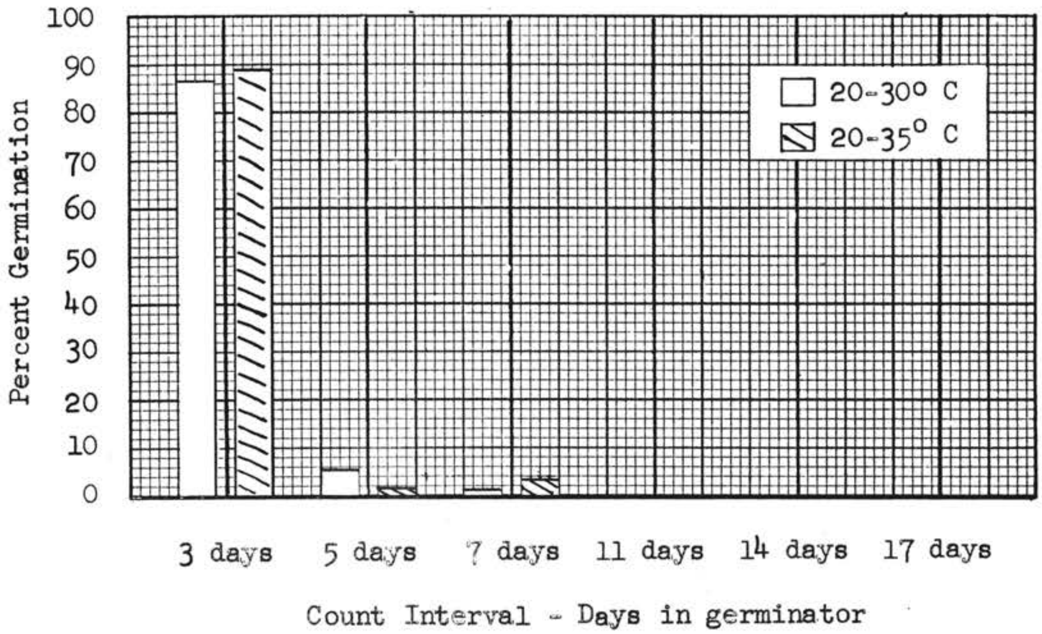


Figure 13. Percent germination of creeping red fescuegrass within the 20-30° and 20-35° C. alternate environments at various count intervals.

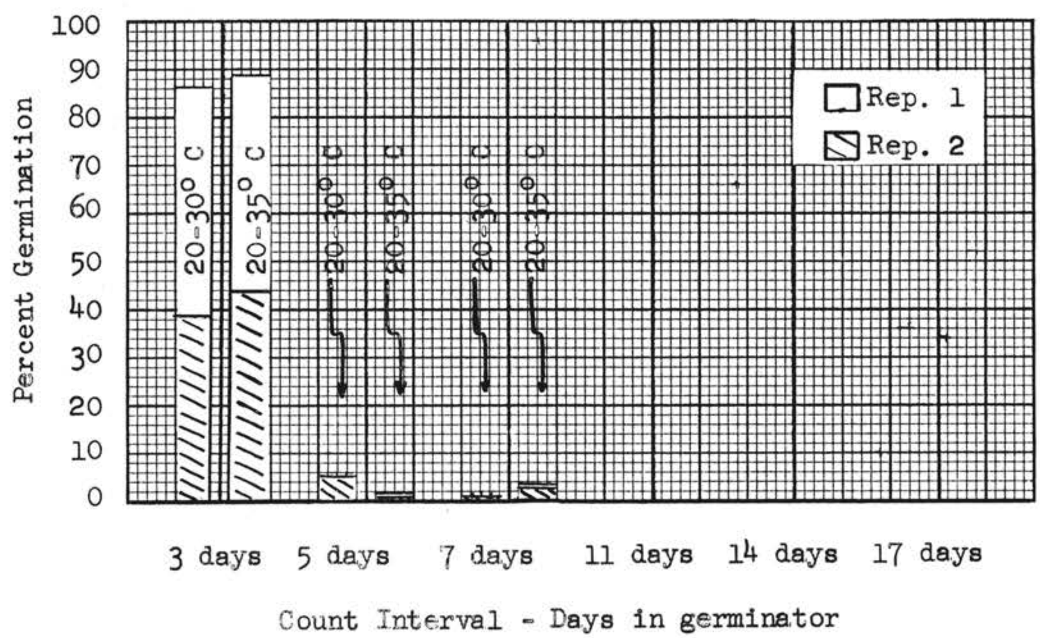


Figure 14. Percent germination of creeping red fescuegrass by replicates within the 20-30° and 20-35° alternate environments at various count intervals.

to suppress the initiation of seed germination and to require a longer period for the completion of germination.

In the 20-35° C. environment, 68 and 82% of the total seed units of U-3 and common bermudagrass respectively, germinated at the end of 5 days. In contrast, only 5 and 34% of the total seed units germinated for U-3 and common respectively within the 20-30° environment for the same length of time. At the end of 7 days, within the 20-35° environment, approximately 90% of the common and U-3 seed units had germinated. In comparison, only 15 and 46% of the total seed units germinated in the same length of time within the 20-30° environment. In effect, this illustrates the suppression of seed germination of these two cultivated bermudagrass varieties in a 20-30° alternate environment.

The germination levels of Penncross bentgrass, Figure 11, shows a remarkably high and early initiation of germination in the 20-30° C. alternate environment. The 20-35° environment also produced a high germination percentage but where 3 days were required for the initiation of 86% germination in the 20-30° chamber, it took 5 days to acquire 98% in the 20-35°. The interval for completion of germination in the 20-35° environment required only 7 days as compared to 11 days required in the 20-30° environment. The indication, based on these data, for the most favorable seed germination environment for Penncross bentgrass is in the environmental range of 20-30° alternate.

Field Performance

The habit of growth of the bermudagrass varieties under field conditions was variable. The rate of lateral spread was used primarily as a measure of growth to classify the plants as either rapid or slow growers. Lateral growth measurements of NK-37 plants, a forage-type bermudagrass, classified as rapid, ranged on an average from 28 to 43 inches. The range for those plants designated as rapid growers of common bermudagrass, which includes both forage and turf types, and U-3 bermudagrass, primarily a turf type, was 40 to 72 and 41 to 59 inches respectively.

As a result of the sparse and erratic stolon growth of NK-37, lateral measurements, which were made to classify individual plant growth, were restricted to the dense portion of the lateral shoot development. This in part explains the shorter lateral spread measurements recorded for NK-37 as compared to common and U-3 bermudagrass. Common and U-3 bermudagrass exhibit more of a solid turf-type of spread as compared to NK-37.

The lateral growth of the Penncross bent and creeping red fescuegrasses was very small. Penncross bentgrass spread laterally in the range of 1/2 to 10 inches, while creeping red fescuegrass produced only 1/4 to 3 inches of lateral growth.

Although individual records were taken as to vigor of both shoot and root growth, field data indicated that shoot growth measurements as seedlings was not a good indicator of a plant's field performance. The field data did indicate that the rate of root growth of a seedling apparently was a more reliable indicator. Since this seemed to be evident in all varieties studied only the data pertaining to the root measurements were considered significant in achieving the objective of this study. Based on this decision, it seemed expedient to discuss root measurements for the variety and omit the shoot measurements as a basis of plant seedling selection.

The plants classified as rapid and slow growers in the field, the germination environment from which they were selected, and the root length measurements of each at the time of transplanting from the germinator to the greenhouse are schematically presented in Figures 15, 16, 17, 18, and 19.

The field performance of the bermudagrass varieties selected on the basis of root development as rapid and slow type seedlings, from within both 20-30° and 20-35° C. alternate temperature chambers, was far superior when germination was initiated in a 20-30° environment. This is clearly shown in Figures 15 and 16, however, there is a slight deviation from this generalization in the case of U-3 bermudagrass which performed essentially the same regardless of the germination environment, as shown in Figure 17. NK-37 bermudagrass shows good correlation of rapid growing plants in the field to a long root development in the germinator. More significantly, these rapid growing plants which developed long root length during the germination period were more prevalent in the 20-30° environment. Conversely, the slow growing plants can be correlated well with short root lengths of the seedlings produced primarily in the 20-35° environment.

This tendency is still further exhibited by creeping red fescuegrass, Figure 19, and, in part, by Penncross bentgrass in Figure 18. Although common and U-3 bermudagrass produced root measurements all along the range, they tended to follow this same general trend.

The normal seedling root development varied as to variety and environment. In NK-37 bermudagrass, the majority of plants selected as "slows" had an average root length of 3/4 inch, whereas, the majority of the "rapids" were 1 1/4 to 1 1/2 inches long (Figure 15). The root measurement of the majority of common and U-3 bermudagrass plants, classified

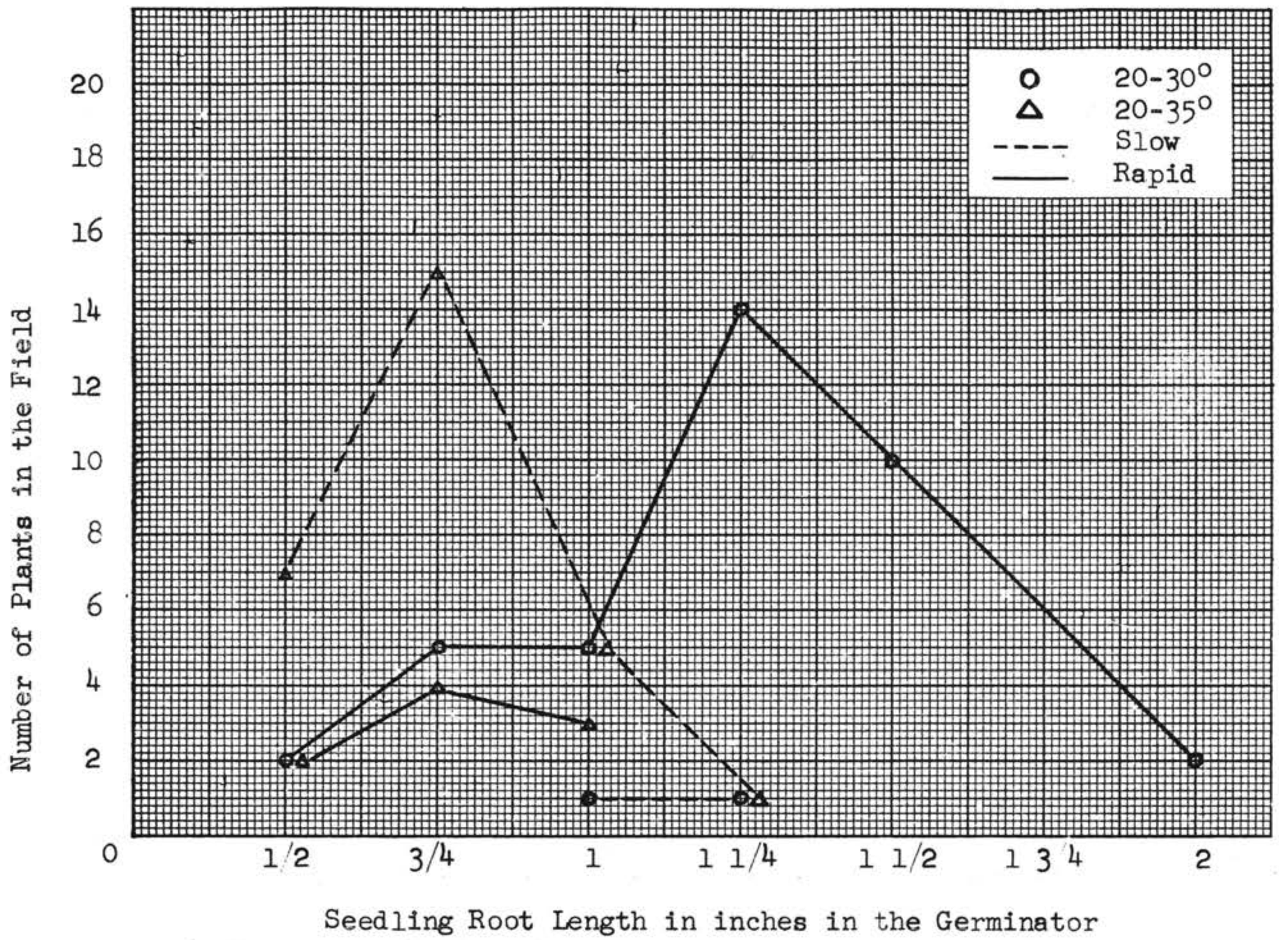


Figure 15. A comparison of the environmental influence and seedling root growth in the germinator to the number and classification (slow or rapid) of NK-37 bermudagrass plants in the field.

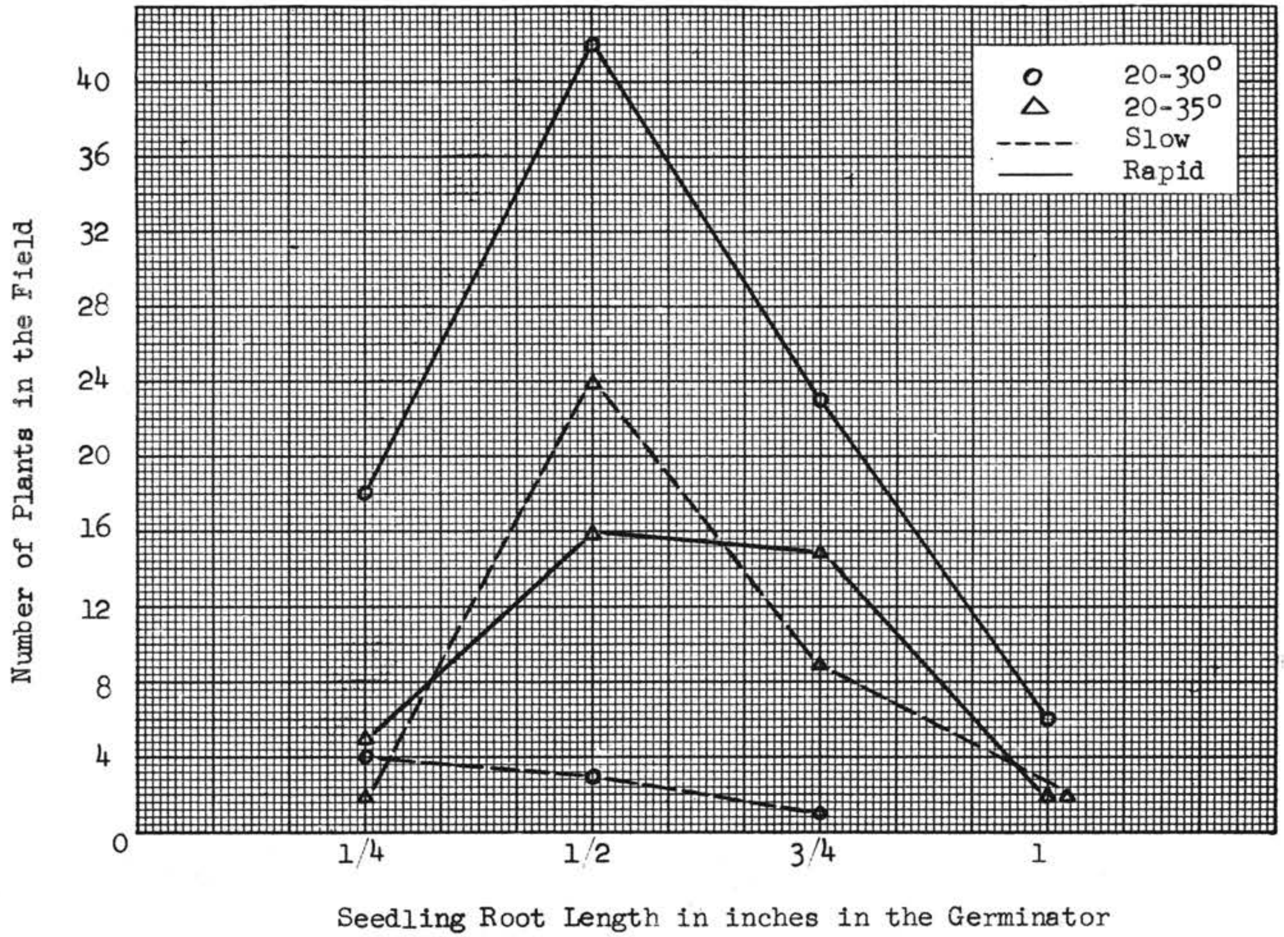


Figure 16. A comparison of the environmental influence and seedling root growth in the germinator to the number and classification (slow or rapid) of common bermudagrass plants in the field.

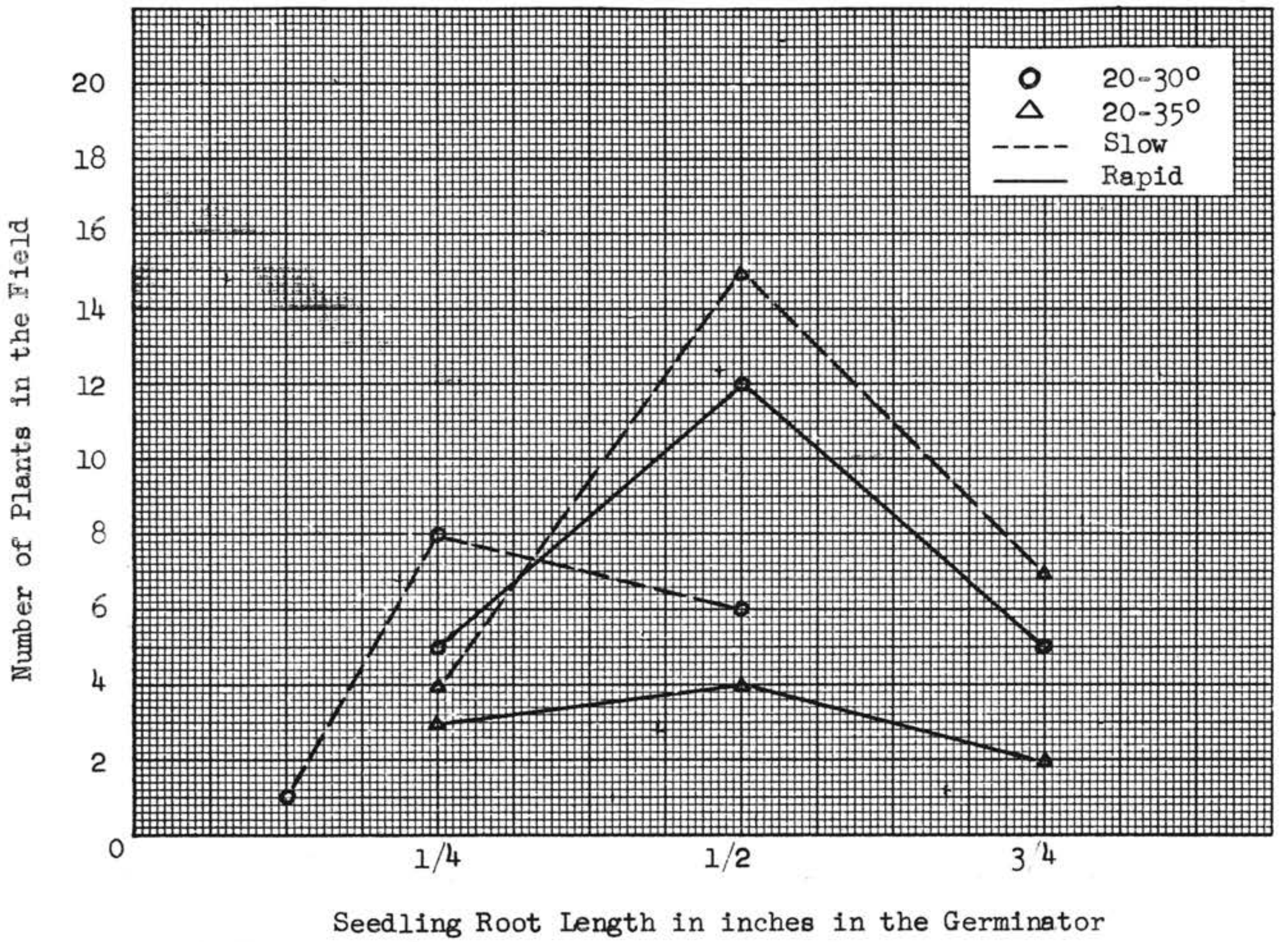


Figure 17. A comparison of the environmental influence and seedling root growth in the germinator to the number and classification (slow or rapid) of U-3 bermudagrass plants in the field.

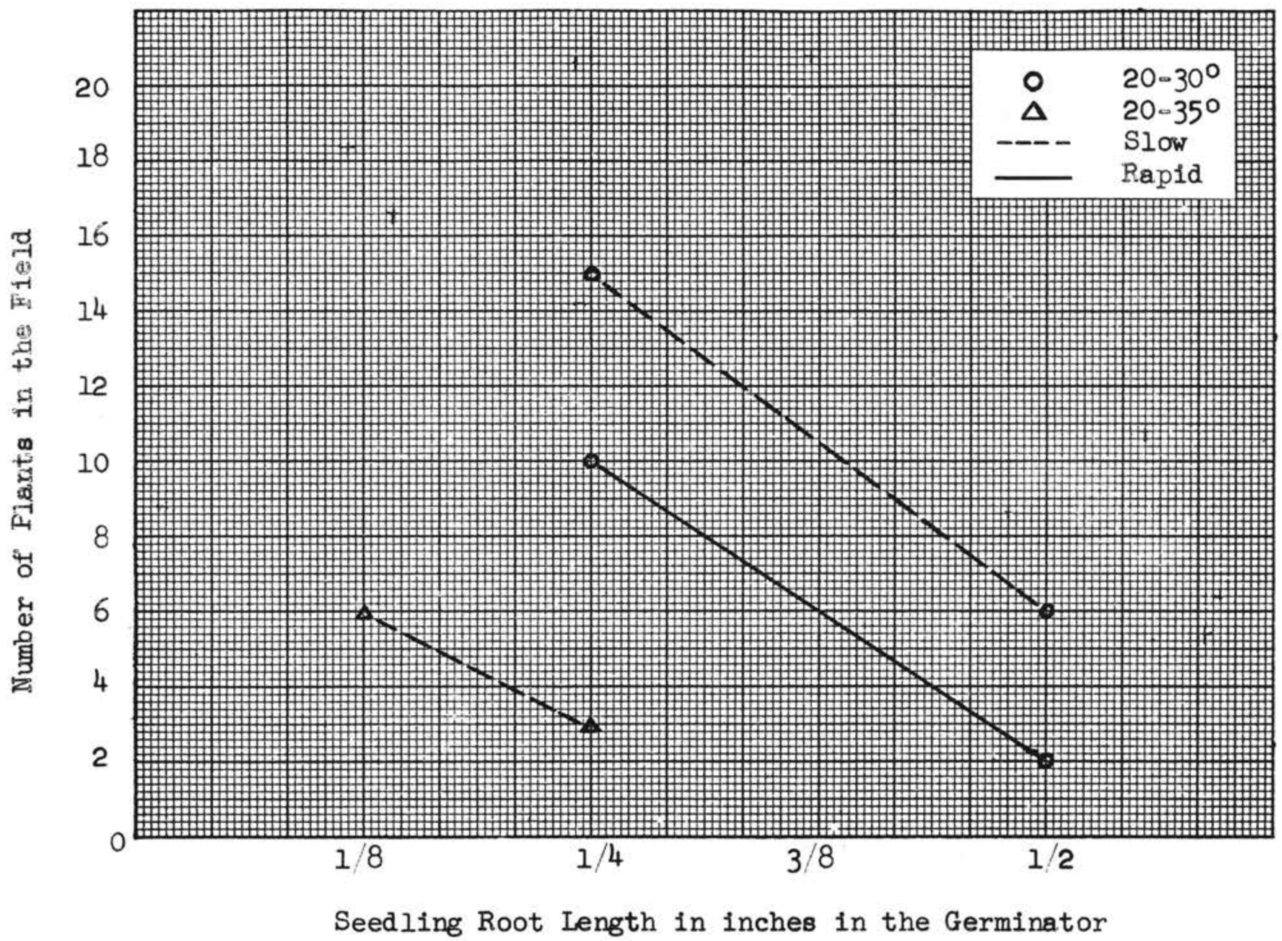


Figure 18. A comparison of the environmental influence and seedling root growth in the germinator to the number and classification (slow or rapid) of Penncross bentgrass plants in the field.

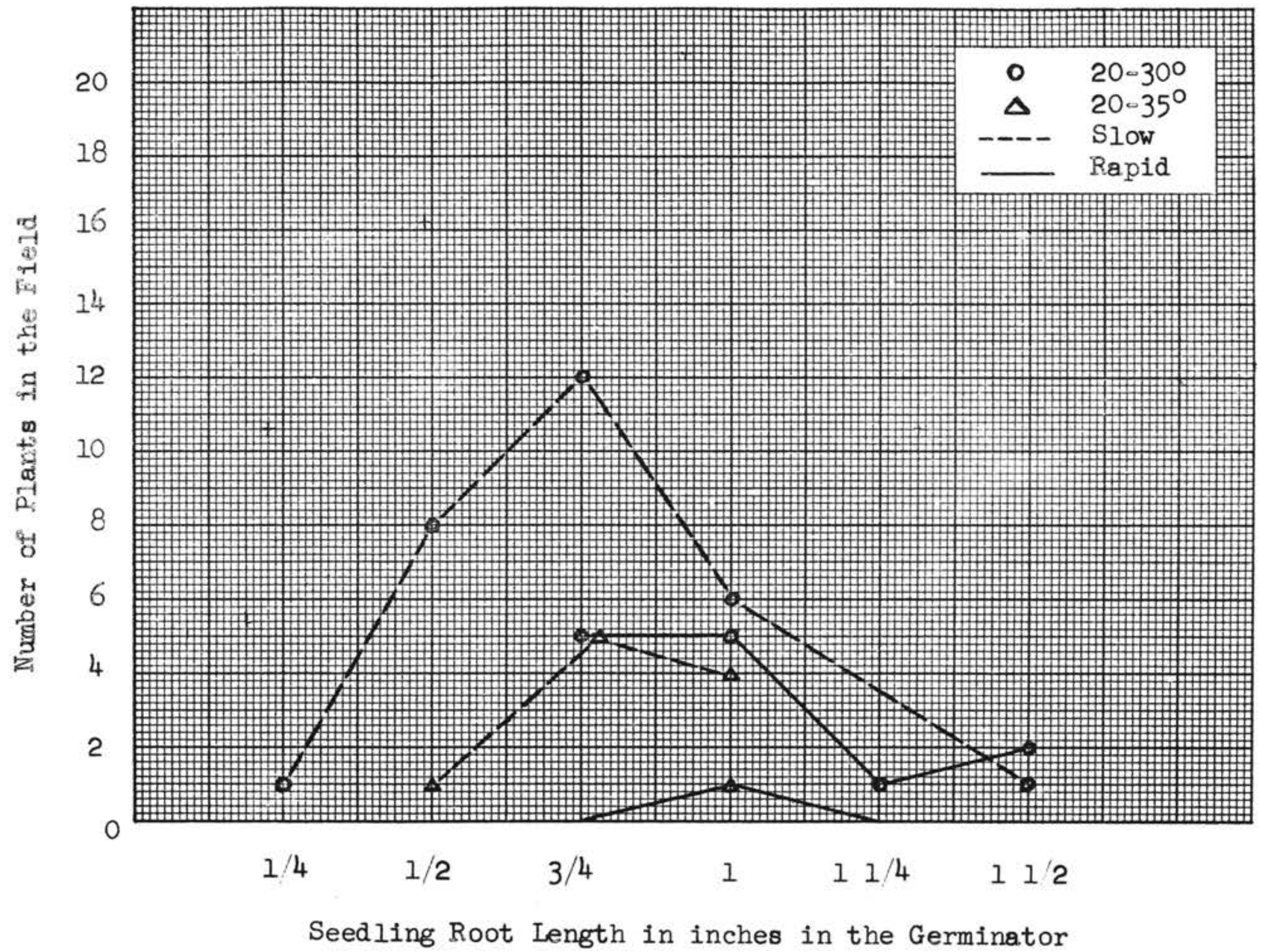


Figure 19. A comparison of the environmental influence and seedling root growth in the germinator to the number and classification (slow or rapid) of creeping red fescuegrass plants in the field.

as either slow or rapid growers, was 1/2 inch in length. The bulk of the rapid and slow growing plants of Penncross bentgrass produced roots of 1/4 inch in length when measured in the germinator. The majority of the plants of creeping red fescuegrass selected as "rapids" exhibited root measurements of 3/4 to 1 inch, whereas, those of the seedlings classed as "slows" were approximately 3/4 inch in length.

The range of root measurements of the seedlings selected for field observations of NK-37 bermudagrass were from 1/4 to 2 inches long, whereas, those of common and U-3 bermudagrass ranged from 1/4 to 1 1/8 and from 1/8 to 1 1/2 inches in length respectively. In this same respect, Penncross bentgrass roots measured 1/8 to 1/2 inch in length as compared to 1/8 to 1 1/2 inches for creeping red fescuegrass.

In a comparison of the range in root measurements of NK-37 to common and U-3 bermudagrass it was found that NK-37 had the most vigorous roots while common and U-3 bermudagrass exhibited a somewhat slower root development. This may be due in part to differences in types where NK-37 bermudagrass is primarily a forage, common bermudagrass can exhibit either forage or turf characteristics. The U-3 bermudagrass is considered solely as a turfgrass variety. Although the cultivated variety creeping red fescuegrass finds extensive use as a turfgrass in some areas, it too, like common bermudagrass, can fall in the forage classification. In this same respect, it also exhibits a root length range very similar to that of common and U-3 bermudagrass. A deviation showing the other extreme of this trend brings into focus the cultivated variety Penncross bentgrass, which is primarily a turf-type grass. The range in measurements of root length produced by this grass shows a considerable reduction in rate of root elongation as compared to all the other grasses studied.

These data indicate a correlation exists between the basic root measurement range of each variety in the germinator, and its classification as to growth habit in the field.

Where the average root length measurement of 3/4 inch was used as the basis for classifying NK-37 bermudagrass plants as slow growers, there were 7 and 24 seedlings selected in this category from the 20-30° and 20-35° C. environments respectively (Appendix Tables II and III). When the average length of lateral spread was used as an indication of growth habit in the field, 5 of the 7 seedlings originally selected in the 20-30° environment as "slows", had a spread of 25 to 43 inches in the field and were reclassified as "rapids". In the final analysis none of these original slow selections were found to remain within the slow category of having a 1 to 19 inches lateral spread. However, of the 24 plants selected as "slows" within the 20-35° environment 15 or 63% remained as "slows" under field conditions.

The field performance of those seedlings selected as slow growers from the 20-30° C. alternate temperature environment in the germinator tend to support the observation that this environment favors the development of "rapid" rather than "slow" plant growth.

From 21 plants of NK-37 bermudagrass, selected as "rapids" from the 20-30° C. environment, having root measurements of 1 1/4 inches and 14 plants with roots measuring 1 1/2 inches in length 14 or 67% and 10 or 71% respectively, exhibited a rapid lateral spread under field conditions. Only 1 or 3% of these original 35 seedlings selected as "rapid" were found to be slow growers under field trials. The remaining plants of this total fell into the category of intermediates having an average lateral spread of 20 to 27 inches in the field.

Of the total number of 39 rapid-type seedlings selected, from NK-37 bermudagrass within the 20-30° C. environment, 26 of these exhibited a rapid growth in the field as compared to none for the 4 original rapid seedlings selected from the 20-35° environment. However, of the total number seedlings selected as "slows" in the 20-30° environment, only 1 plant was a slow-type in the field. The reverse of this was true with plants selected as "slows" from the 20-35° environment. Of the total number of 56 seedlings, 27 or 48% of these plants were slow-types in the field, 32% were "intermediates", and 16% were "rapids".

Although root measurements were shorter and the classification of a rapid and slow grower was based on different standards than NK-37 bermudagrass, the trend in performance under field conditions in relation to the initial germination environment was the same in common bermudagrass, Appendix Tables IV and V, and U-3 bermudagrass, Appendix Tables VI and VII.

As a result of the very short root measurement range exhibited by the Penncross bentgrass seedlings, Appendix Tables VIII and IX, it was difficult to set up a scale of classification for rapid or slow growers. The difficulty arose essentially from the fact that Penncross bentgrass showed considerable intolerance to hot, dry growing conditions. Because of the delicate nature of this grass a large percentage of the original seedling selections failed to recover from the initial shock of transplanting into the field. The plants of this variety which survived in the field were reduced further in number when they were subjected to a moderate drouth stress. However, a few of these remaining plants exhibited an outstanding performance in respect to their tolerance to drouth and heat conditions. The majority of these seedlings had a root measurement of 1/4 inch in the 20-30° environment and 1/8 to 1/4 inch in the 20-35° C. environment.

A few of the plants selected as "rapids" of Penncross bentgrass, from the 20-30° C. environment, were possibly affected by the stress placed on them in the field. This would seem to be evident when we consider that only 22% of those plants which survived actually showed a rapid development in the field.

The general trend of the seedlings of Penncross bentgrass selected as "slows" in the germinator, for both environments, was as a slow grower in the field.

Creeping red fescuegrass, like Penncross bentgrass, is essentially a cool-season plant. Drouth and prolonged heat conditions also posed considerable stress on the development of this variety. The large number of fatalities which occurred can probably be attributed to the same conditions as those which affected Penncross bentgrass.

The fatality rate of the total number of seedlings of creeping red fescuegrass selected for field studies was 41% in the 20-30° and 77% in the 20-35° C. environment. For Penncross bentgrass the fatality rate was 55% in the 20-30° and 76% in the 20-35° environment. The main significance of these figures is they point out that the majority of the plant fatalities occurred when selections were made from within the 20-35° as opposed to the 20-30° environment.

These data on the performance of creeping red fescuegrass, showed only 36% of the seedlings selected as "rapids" in the 20-30° C. environment (Appendix Tables X and XI) were lost as compared to a 69% loss of the rapid selections in the 20-35° environment.

In Penncross bentgrass the mortality rate of the seedlings selected as "rapids" in the germinator was 44% in the 20-30° environment and 100% in the 20-35° C. environment. These results further tend to strengthen the indications that for seed germination and subsequent effect on the seedlings in the field the 20-30° environment is more favorable than the 20-35° environment.

The majority of the seedlings of creeping red fescuegrass classified as "slows" from both environments had an average root measurement of 3/4 inch. Of the plants, with a 3/4 inch root, which survived from the 20-30° C. environment 33% remained in the slow range, 14% exhibited a rapid growth, and the remaining 53% fell in the intermediate classification. The plants selected as "slows" from the 20-35° germination environment, when classified in the field, were found to be about 50% "slows" and the other half in the intermediate range. The bulk of the seedlings classed as rapid-growers, from both environments, had a root length of 1 inch.

The plants of creeping red fescuegrass, from the 20-30° C. environment, which survived in the field consisted of 38% classified as "slows" and 31% "rapids". From the 20-35° environment, 31 and 8% exhibited slow and rapid growth development respectively. These results lend additional strength to the favorability of the germination environment 20-30° over 20-35° in relation to inducing better plant development in the field. This trend seems to be present in all the grasses tested with the exception of possibly Penncross bentgrass.

A detailed tabular presentation for all 5 grasses of the number of seeds that germinated, seedlings selected and their growth rate classification in each environment at various germination intervals is given in Appendix Table XII. The total germination shown here is an actual numerical count compiling both replicates within their respective environment. The total selection figures represent the actual number of seedlings transplanted into the field. The total survival counts are those actually recorded at the close of the field studies. The survival counts also show the combined number of plants classified as rapid, intermediate, or slow growers in the field.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objective of this study was to develop a technique to predict growth rate in the field of 5 turf and pasture type grasses by determination of critical germination limits, speed of germination and seedling growth in a germinator. These investigations were conducted during 1959 and 1960 at the U.S.D.A. Grass Seed Research Laboratory and the Oklahoma State University Agronomy Research Station located at Stillwater, Oklahoma. The five grasses used in this study included NK-37, common and U-3 bermuda, creeping red fescue and Penncross bentgrasses.

Selections were originally based on germination and seedling performance in an artificial environment. The two optimum seed germination environments, for the five varieties studied, seemed to be the 20-30° and the 20-35° C. alternate. The 20-35° environment produced higher germination percentages than the 20-30° environment.

When the field performance of each plant is studied in relation to its speed of germination and rate of seedling root growth, it becomes evident that the most desirable plant growth in the field is produced by those plants which were derived from the 20-30° C. environment. On the basis of these results, the 20-30° environment was the most optimum for measuring seedling variation. This suggests for the selection of plants which will produce the most rapid growth under field conditions, the germinating seeds should have a 20° nocturnal and 30° diurnal temperature.

It was found that the measurements of seedling shoot growth, within the germination chambers, was not a reliable character to base predictions of growth rate when transplanted under field conditions. However, the indications are that a plant which develops rapidly in the field may be the results of a vigorous root growth as a seedling. The growth rate of the root seemed to be dependent upon the germination environment.

The average root growth was more rapid in the 20-30° than in the 20-35° C. alternate environment. Most of the seedlings selected as "rapids", that survived in the field, were selected from the 20-30° environment. The majority of the seedlings selected as "rapids" in the 20-35° environment had a slower rate of root growth than most of the "rapids" selected from the 20-30° environment. In comparison, based on seedling root growth, nearly all of the seedlings germinated within the 20-35° would have been classified in the slow group of the 20-30° environment.

These data indicate a correlation exists between the basic root measurement range of each variety in the germinator, and its classification as to growth habit in the field.

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APPENDIX

TABLE I

DAILY RAINFALL RECORD FOR THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION LOCATED AT STILLWATER FROM MAY 1 TO SEPTEMBER 31, 1960

Day of Month	May	June	July	August	September
1		.27			
2					
3	.48				
4	.29		1.94		
5	1.59				
6		.54	.27		
7		.14			
8					.09
9					
10					
11					
12			.06		
13					
14					
15				.01	
16					
17			1.58	.92	
18	.80				
19	.35				
20	.90	.42			.40
21					
22			1.22		
23			.06		.50
24	.64	.25		3.66	
25				1.35	
26			.40	.02	.04
27	.27				
28	.74				
29					
30			.02		
31					
Monthly Totals	6.06	1.62	5.55	5.96	1.03

TABLE II

TOTAL NUMBER OF NK-37 BERMUDAGRASS SEEDLINGS TRANSPLANTED INTO FIELD PLOTS AND THEIR INITIAL RATE OF ROOT ELONGATION CLASSIFIED BY ENVIRONMENT

		20-30° C.		20-35° C.	
		Slow Root	Rapid Root	Slow Root	Rapid Root
Slow	1/4	1	0	0	0
	1/2	6	0	18	0
	3/4	7	0	24	0
	1	9	0	14	0
Rapid	1 1/4	0	21	0	3
	1 1/2	0	14	0	1
	1 3/4	0	2	0	0
	2	0	2	0	0
	Totals	23	39	56	4

TABLE III

FIELD PERFORMANCE OF NK-37 BERMUDAGRASS PLANTS WHICH SURVIVED AND RATED AS TO LATERAL SPREAD IN INCHES BY ENVIRONMENT

		20-30° C.			20-35° C.		
		Slow (1-19")	Inter. (20-27")	Rapid (28-43")	Slow (1-19")	Inter. (20-27")	Rapid (28-43")
Slow	1/4	0	1	0	0	0	0
	1/2	0	3	2	7	8	2
	3/4	0	1	5	15	4	4
	1	1	3	5	5	6	3
Rapid	1 1/4	1	6	14	1	1	0
	1 1/2	0	4	10	0	0	0
	1 3/4	0	2	0	0	0	0
	2	0	0	2	0	0	0
	Totals	2	20	38	28	19	9

TABLE IV

TOTAL NUMBER OF COMMON BERMUDAGRASS SEEDLINGS TRANSPLANTED INTO FIELD PLOTS AND THEIR INITIAL RATE OF ROOT ELONGATION CLASSIFIED BY ENVIRONMENT

		20-30° C.		20-35° C.	
		Slow Root	Rapid Root	Slow Root	Rapid Root
Slow	1/4	16	0	14	0
	1/2	35	0	58	0
Rapid	3/4	0	19	0	28
	1	0	6	0	6
	Totals	51	25	72	34

TABLE V

FIELD PERFORMANCE OF COMMON BERMUDAGRASS PLANTS WHICH SURVIVED AND RATED AS TO LATERAL SPREAD IN INCHES BY ENVIRONMENT

		20-30° C			20-35° C		
		Slow (1-30")	Inter. (32-38")	Rapid (40-72")	Slow (1-30")	Inter. (32-38")	Rapid (40-72")
Slow	1/4	2	1	13	4	7	3
	1/2	1	5	28	24	15	16
Rapid	3/4	0	1	18	9	4	15
	1	0	0	6	2	2	2
		3	7	65	39	28	36

TABLE VI

TOTAL NUMBER OF U-3 BERMUDAGRASS SEEDLINGS TRANSPLANTED INTO FIELD PLOTS AND THEIR INITIAL RATE OF ROOT ELONGATION CLASSIFIED BY ENVIRONMENT

		20-30° C.		20-35° C.	
		Slow Root	Rapid Root	Slow Root	Rapid Root
Slow	1/8	1	0	0	0
	1/4	25	0	9	0
Rapid	1/2	0	26	24	0
	3/4	0	9	0	17
	1	0	0	0	1
	1 1/8	0	1	0	0
	Totals	26	36	33	18

TABLE VII

FIELD PERFORMANCE OF U-3 BERMUDAGRASS PLANTS WHICH SURVIVED AND RATED AS TO LATERAL SPREAD IN INCHES BY ENVIRONMENT

		20-30° C			20-35° C		
		Slow (1-35")	Inter. (36-40")	Rapid (41-59")	Slow (1-35")	Inter. (36-40")	Rapid (41-59")
Slow	1/8	1	0	0	0	0	0
	1/4	8	11	5	6	0	3
Rapid	1/2	5	9	12	15	4	4
	3/4	0	2	7	7	3	2
	1	0	0	0	0	1	0
	1 1/8	0	0	0	0	0	0
	Totals	14	22	24	28	8	9

TABLE VIII

TOTAL NUMBER OF PENNCROSS BENTGRASS SEEDLINGS TRANSPLANTED INTO FIELD PLOTS AND THEIR INITIAL RATE OF ROOT ELONGATION CLASSIFIED BY ENVIRONMENT

		20-30° C		20-35° C	
		Slow Root	Rapid Root	Slow Root	Rapid Root
Slow	1/8	0	0	40	0
	1/4	44	44	16	16
Rapid	1/2	0	16	0	2
	Totals	44	60	56	18

TABLE IX

FIELD PERFORMANCE OF PENNCROSS BENTGRASS PLANTS WHICH SURVIVED AND RATED AS TO LATERAL SPREAD IN INCHES BY ENVIRONMENT

		20-30° C			20-35° C		
		Slow (1/2-3")	Intermediate (3 1/2-5 1/2")	Rapid (6-10")	Slow (1/2-3")	Intermediate (3 1/2-5 1/2")	Rapid (6-10")
Slow	1/8	0	0	0	7	5	0
	1/4	17	11	10	3	3	0
Rapid	1/2	6	1	2	0	0	0
	Totals	23	12	12	10	8	0

TABLE X

TOTAL NUMBER OF CREEPING RED FESCUEGRASS SEEDLINGS TRANSPLANTED INTO FIELD PLOTS AND THEIR INITIAL RATE OF ROOT ELONGATION CLASSIFIED BY ENVIRONMENT

		20-30° C.		20-35° C.	
		Slow Root	Rapid Root	Slow Root	Rapid Root
Slow	1/4	2	0	0	0
	1/2	22	0	26	0
	3/4	63	0	50	0
Rapid	1	0	24	0	41
	1 1/4	0	5	0	7
	1 1/2	0	7	0	0
	Totals	87	36	76	48

TABLE XI

FIELD PERFORMANCE OF CREEPING RED FESCUEGRASS PLANTS WHICH SURVIVED AND RATED AS TO LATERAL SPREAD IN INCHES BY ENVIRONMENT

		20-30° C.			20-35° C.		
		Slow (1/4-1")	Intermediate (1 1/4-1 3/4")	Rapid (2-3")	Slow (1/4-1")	Intermediate (1 1/4-1 3/4")	Rapid (2-3")
Slow	1/4	1	0	0	0	0	0
	1/2	8	5	0	1	2	0
	3/4	12	19	5	5	5	0
Rapid	1	6	5	5	4	8	1
	1 1/4	0	1	1	0	2	0
	1 1/2	1	2	2	0	0	0
	Totals	28	32	13	10	17	1

TABLE XII

COMPLETE BREAKDOWN FOR EACH OF THE FIVE GRASS VARIETIES FROM TOTAL GERMINATION TO GROWTH RATE CLASSIFICATION OF SURVIVING PLANTS IN THE FIELD BY ENVIRONMENT AND RATE OF GERMINATION

		3 days		5 days		7 days		11 days		14 days		17 days	
		20-30	20-35	20-30	20-35	20-30	20-35	20-30	20-35	20-30	20-35	20-30	20-35
NK-37 Bermuda Grass	Total Germ.	169	181	4	2		2	4					
	Total Selected	60	60					2					
	Total Survival	59	56					1					
	Total Rapid	37	9					1					
	Total Inter.	20	19										
	Total Slow	2	28										
Common Bermuda Grass	Total Germ.	15	22	54	141	24	9	54		14	2	1	
	Total Selected	8	13	25	89	14	3	23		6	1		
	Total Survival	8	12	25	87	14	3	22		6	1		
	Total Rapid	7	4	24	30	13	2	17		4			
	Total Inter.	1	2	1	25	1	1	3		1			
	Total Slow		6		32			2		1	1		
U-3 Bermuda Grass	Total Germ.		17	11	122	20	41	91	11	26	3	11	
	Total Selected		6	5	33	9	11	37		9	1	2	
	Total Survival		5	5	28	8	11	36		9	1	2	
	Total Rapid			3	6	5	3	12		3		1	
	Total Inter.		1	2	5	2	2	14		3		1	
	Total Slow		4		17	1	6	10		3	1		
Penncross Bent Grass	Total Germ.	173	31	12	165	5	2	4					
	Total Selected	103	15	1	58		1						
	Total Survival	47	5	0	13		0						
	Total Rapid	12											
	Total Inter.	12	1		7								
	Total Slow	23	4		6								
Creeping Red Fescue Grass	Total Germ.	173	178	11	3	2	7						
	Total Selected	121	123	4		2							
	Total Survival	67	28	4		2							
	Total Rapid	13	1										
	Total Inter.	28	17	2		2							
	Total Slow	26	10	2									

VITA

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Master of Science

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