



PRE-SOWING TREATMENT OF KENTUCKY
BLUEGRASS SEED TO ACCELERATE
FIELD GERMINATION

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By

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AN ABSTRACT

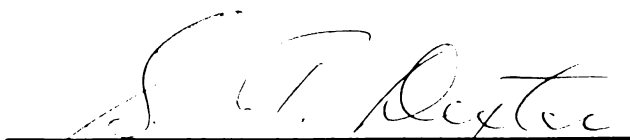
Submitted to the College of Agriculture of Michigan
State University of Agriculture and Applied
Science in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

Department of Farm Crops

1960

Approved



This investigation was carried out to find out the effects of gibberellin and temperature alternations during the pre-sowing period on the rate of germination of Kentucky bluegrass seeds in the laboratory and in field seedings.

Four lots of bluegrass seeds--4026 (Kentucky Merion bluegrass), 4020 (Merion bluegrass), 4-5639 (Kentucky bluegrass) and 8H1-2 (Kentucky bluegrass)--were used. Treatment involved temperature alternations for several days of seeds treated with tap water, gibberellin or KNO_3 solutions, after which germination tests were conducted both in the laboratory and field.

The effects on rate of germination and total germination as measured by germination percentages taken on different days was found to depend on the origin, variety and size of the seeds. Lots 4026 and 4-5639 were consistently faster in germination than lots 4020 and 8H1-2. Replicates agreed excellently only in germination tests with pure live seeds carried out in the laboratory.

Both gibberellin and temperature alternations applied at the pre-sowing stage accelerated the speed of germination of seeds planted in the laboratory but did not help field seedings. It is suggested that for success in accelerating the rate of germination of Kentucky bluegrass in the field, very careful management practices may have to be combined with gibberellin and temperature alternations applied at the pre-sowing stage.

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INTRODUCTION

Kentucky bluegrass (Poa pratensis) is a cool-season perennial grass which, although native of Europe, has achieved high distinction in pasture, turf and lawns in mid-western United States (8, 17). Farmers and lawnmakers have generally observed slow emergence and thinner stands than desired from their seedings. Various factors may be responsible for this.

To accelerate seed germination in seed testing, the official method adopted by the seed analysts is as follows: Seed samples are chilled for 5 days before planting. Pure live seeds of Kentucky bluegrass are placed in covered petri dishes with two layers of blotters and exposed to a daily temperature alternation of 15° C (59° F) for 16 hours and at 30° C (86° F) for approximately 8 hours in the presence of light daily for 28 days. The blotters are moistened with 0.1% KNO₃ solution. The first count is taken on the 10th day and the final count on the 28th day (23).

In many cases, growth-promoting substances have been applied to seeds to increase their rate of germination. Gibberellin is one of the best known of these, and is one of a group of related chemical substances known to exert marked effects on plant behavior, particularly with respect to cell elongation, cell division, and the breaking of certain types of "dormancies" (21, 24). Responses to gibberellin are often greatest at relatively low temperatures.

Since rapid establishment of a good initial stand of bluegrass is difficult to obtain, it was thought desirable to investigate the effects of gibberellin and alternation of temperatures during a pre-sowing period on the rate of germination of Kentucky bluegrass seeds in the laboratory and in field seedings. Rapid emergence would reduce the hazards from drought and seedling diseases and help control the weed problem.

REVIEW OF LITERATURE

Edwards (25) in 1940 first suggested the promotion effect of gibberellin on seed germination when he observed that "seeds from the ears of corn infected with Gibberella fujikuroi grew more rapidly."

Wittwer and Bukovac (25) reported that gibberellin had promise as a seed treatment and that a concentration of 500 to 1000 ppm was most effective for pea, bean and sweet corn seeds. They however observed a lower final percentage emergence in the field than they obtained in the greenhouse.

Gibberellin is known to promote normal growth rates at sub-normal temperature (13, 24). Wittwer and Bukovac also mentioned that treating seeds with gibberellin promotes faster and more uniform emergence and a better crop stand with cotton, pea, beans and sweet corn. It was mentioned that the promotive effects of gibberellin seed treatments on seedling emergence are most apparent in early spring when temperatures were otherwise too low for normal performance.

Gibberellin is reported to break dormancy in "green potato" (24), it appears to show promise in breaking the dormancy of wild oat seeds (9, 10), the positional bud dormancy in asparagus (24) and epicotyl dormancy in tree peony (24). It substitutes for light requirement in the germination of Grand Rapid lettuce (15, 24), and Sudia (20) reported that gibberellin will replace vernalization requirement and also substitute for day length requirement.

Brian (2) attributes the activity of gibberellin to the neutralization of a growth-inhibitory system which normally limits growth. This may well explain why it breaks the dormancy of some seeds.

Koller (14) reported that gibberellin will substitute for the cold requirement of dwarf plants obtained by denying the embryos of cold-requiring seeds the normal cold treatment. Gibberellin is also said to substitute for cold in rosette plants, and may cure hereditary dwarfism in pea, corn, etc.

In his experiment on the effect of gibberellic acids on laboratory germination of creeping red fescue Button (4) observed that gibberellic acids gave significantly higher germination rate over the control up to and including the 19th day of count; there was no significant difference between the two sources of gibberellic acid--the potassium salt of the acid and a combination of two acid forms ($C_{19}H_{24}O_6$ and $C_{19}H_{22}O_6$), but that there was no significant effect on total germination percentage. The most promising range of concentration of gibberellic acid was from 20 to 30 ppm (.20 to .30 mg per 100 seeds in 10 cc of water). Button observed that the seventh day count might place the germination percentage of gibberellic acid treated seeds well within the tolerance allowable for the labelled germination.

Scherry (18) observed that a single climax point cannot be chosen to fairly evaluate all bluegrass seeds since they may vary from

region to region, from lot to lot and in weight fractions. Each seed lot has its own personality. He also reported that under the prevailing cooler temperature at planting seasons, bluegrass will seldom sprout significantly before 15 days except when heavy seeds from southern sources are used.

The causes of variability in the rate and total germination of seeds are attributed to differences in the sampling, the distribution of dead and live seeds and lack of proper balance of the prechilling (22). Toole and Toole also remarked that the germination requirement of a given seed may vary with conditions which existed during its development, on maturity and age of the seed, harvesting procedure, handling and storage conditions.

Elliot and French (7) pointed out that root growth is dependent on temperature and not on light. Maximum root growth occurs between 25 and 30° C.

In a later work, Scherry (19, 26) observed that soaking seeds before planting them appears to help slowly germinating grasses, but that it showed no consistent advantage with Kentucky and Merion bluegrass.

Porter and Rice (16) noticed in the laboratory that the germination of treated and untreated beet seeds planted in sand or in blotters showed no significant difference, whereas only approximately one-third as many sprouts per 100 seed balls was obtained in the field as in the laboratory.

Crosier and Cullinan (5) reported that observations and statistical records from 169 lots of grass seeds indicate that KNO_3 is of little value in securing an accurate germination from the average sample. KNO_3 however improved the rate of germination of an occasional sample of Kentucky and Merion bluegrass seeds. The KNO_3 -soaked substrates unfortunately tend to increase the severity of blighting in the 28 day tests of Kentucky bluegrass. Only immature freshly harvested Kentucky bluegrass seeds require both light and 0.2% KNO_3 (6).

It appears that both the degree of dormancy and the duration of dormancy in Kentucky bluegrass seeds vary from year to year and probably from field to field. The prevailing preharvest environmental conditions and plant population are possibly controlling factors. Also, the interval required before all the viable seeds will germinate varies from year to year and it may be affected by the stage of maturity and the germination method employed (6, 12). Bass (6) however stated that the stage of maturity when harvested influenced the germination of Kentucky bluegrass most.

Andersen (1) applying gibberellin at a concentration of 50 mg per liter on Merion bluegrass seeds reported a slightly fungicidal effect of the chemical.

MATERIALS AND METHOD

Four lots of bluegrass seeds were used:

- a. Lot 4026--Kentucky Merion bluegrass, Washington grown.
Germination percentage = 79%.
- b. Lot 4020--Merion bluegrass from Michigan. Germination
percentage = 76%.
- c. Lot 8H1-2--Kentucky bluegrass, grown in South Dakota.
- d. Lot 4-5639--Kentucky bluegrass from Ohio. Germination
percentage = 75%.

The overall method of procedure included:

- I. Laboratory trials for determining the best pre-sowing
treatments.
- II. Field trials with cold nights.
- III. Field trials with warm nights.
- IV. Further laboratory trials using pure live seeds only.

In brief, treatment involved temperature alternations for several days of seeds treated with water, gibberellin or KNO_3 solutions.

Approximately 5 cc bluegrass seeds from each lot was put in separate test tubes and later covered with a 30 ppm gibberellin solution, or a 0.1% KNO_3 solution or tap water. After a period of one hour, excess solution or water was drained off, a plug of cotton wool was then applied to the mouth of each test tube, and the test tubes were arranged in beakers placed in a refrigerator whose temperature reading was

always about 40° F. After the desired length of time had expired, the test tubes containing the moist grass seeds were transferred into the germination chamber maintained at 86° F. The test tubes with their contents were returned to the refrigerator at the appropriate time depending on the particular hours of temperature alternations. Tap water was added to moisten any lot of seeds in the test tubes when they showed signs of drying up. The length of the pre-treatment varied from 6 to 9 days depending on the particular experiment.

After the alternation of temperature pretreatment, the seeds were removed from the test tubes and exposed to air in thin layers on clear sheets of paper towels to dry a little in order to make counting of the seeds easier. One hundred seeds (not selected) were counted from each seed lot and arranged in rows on thoroughly soaked two-layered germination blotters in sterile plastic 3-inch diameter petri dishes. The substrate was usually gibberellin solution 30 ppm, 0.1% KNO_3 solution or just tap water. The covered petri dishes were then arranged in the germinators kept at 86° F (30° C) for 8 hours in the day in the presence of light, and at 59° F (15° C) for the next 16 hours in darkness. The corresponding replicates of each treatment were kept on the same shelf in the germinator to even out the environmental conditions at germination time. The seeds were watered adequately whenever they showed signs of drying up.

The first germination count was taken after $2\frac{1}{2}$, 3 or 4 days depending on the experiment in question. Most of the experiments

were stopped after the germination count had been recorded for the 15th day, although one was continued to the 28th day.

The first attempt for a field planting was on May 13th, in the spring, before soil conditions were right for seedbed preparation. Small plastic flats filled with unsterilized soil were therefore used to substitute for true field planting. Three lots of bluegrass seeds-- 4026, 4020 and 4-5639--were used and 6 treatments were applied.

1. Check; i. e. untreated seeds.
2. Soaking the seeds in 30 ppm gibberellin solution for 24 hours prior to planting.
3. Soaking the seeds in 0.1% KNO_3 solution for 24 hours prior to planting.
4. Soaking the seeds in tap water for 24 hours prior to planting.
5. Soaking the seeds in 30 ppm gibberellin solution plus 6 days 48 hourly temperature alternations at 40 and 86° F.
6. Soaking the seeds in 0.1% KNO_3 solution plus 6 days 48 hourly temperature alternations at 40 and 86° F.

The pretreated seeds were all partially air dried to make counting easier before 200 seeds from each lot were counted at random and planted in the unsterilized soil in the small plastic flats which were placed out of doors. Fine soil from the Farm Crops laboratory was sprinkled on the seeds as coverage (1/8 inch deep) in 23 of the flats and fine sand used on the remaining 31 flats. Two big holes were

drilled into the bottom of each plastic flat so that excess water could easily drain out of the soil. The seeded plastic flats were later arranged in a split plot design. All the plastic flats were arranged on a band of coarse sand in order to ensure that the area surrounding the flats would be well drained. Watering was carried out with tap water as occasion demanded and all flats were watered on the same days. Germination counts were made on the 11th, 14th and 17th days. The minimum daily temperatures during the experimental period (May 13 to May 29) ranged between 38 and 59° F with an overall average of 48.59° F, while the maximum daily temperature ranged between 50 and 79° F with an overall average of 68.82° F.

On June 25, seeds of lots 4020, 4026 and 4-5639 were planted in the field after being subjected to the same type of treatment. Each plot was 2 feet by 4 feet. Equal numbers of seeds were used but the weights of the seeds varied with the lots. Lot 4020 weighed 0.6144 grams per plot; lot 4026 weighed 0.544 grams per plot and lot 4-5639 weighed 0.5088 grams per plot. The planting design was a split plot design.

Unfortunately, there was only 0.64 inches of rain throughout the duration of the experiment despite the rain forecasts by the Weather Bureau. Germination counts were made on the 12th, 14th and 17th days. The minimum temperatures recorded during the experimental period (June 25th to July 12th) were between 48° F and 66° F with an overall

average of 55.3° F , while the maximum temperatures ranged between 73° F and 83° F with an overall average of 78.1° F .

The last germination test was carried out in the laboratory with seeds from lots 4020 and 4026 which had previously been blown to remove inert matter, empty glumes and dead seeds thus leaving pure live seeds (as done by the official seed analysts) to work with. Five treatments were applied and there were 4 replicates to each treatment.

Five hundred seeds of lots 4020 and 4026 were immersed in 2 cc of 30 ppm gibberellin or $0.1\% \text{ KNO}_3$ solutions. They were soaked for one hour. Excess solution was drained off and 6 days temperature alternation was applied to each 500 seed lot starting with 48 hours at 40° F , followed by 86° F for 48 hours and finally at 40° F for another 48 hours. The other three treatments included 30 ppm gibberellin solution, $0.1\% \text{ KNO}_3$ solution or tap water as substrates at planting time. There was neither temperature alternation nor pre-soaking treatment for these. One hundred seeds were used as germination sample for each of the 5 treatments and there were 4 replicates for each.

RESULTS

I. Preliminary Experiments

Some preliminary experiments were conducted with seeds from lots 4026 (Kentucky Merion bluegrass) and 8H1-2 (Kentucky bluegrass) in order to find out whether alternation of temperatures in combination with gibberellin, KNO_3 or tap water could be helpful in speeding up the rate of germination of the various lots of Kentucky bluegrass seeds. The germination tests were carried out on blue blotters in covered plastic petri dishes placed in the germinator. The germination temperature was 86°F for 8 hours accompanied by light, and 59°F for 16 hours in darkness.

Results from these investigations gave the following indications:

Alternation of temperatures at the pre-sowing stage always increased early germination and was by far superior to prechilling alone. The germination rate of all seed lots was improved by alternation of temperatures in combination with gibberellin. Results with 0.1% KNO_3 solution were erratic. Early germination was better with gibberellin than with KNO_3 or water, which were in turn better than no treatment. The final germination count at the end of the test was however identical for all the treatments and no treatment. Six to 8 days of alternating temperatures appeared most promising; while 72 to 96 hours cold and at least 72 hours warmth appeared to give the

greatest promotive effects on the rapidity of germination of the seeds.

Many difficulties were encountered during these preliminary experiments and they tended to affect the results. These were in connection with the seed samples, seed size, number of empty glumes, uniformity of treatments with chemicals and microclimatic conditions during germination tests.

II. Laboratory Trials with Farmers' Bluegrass Seeds

By "farmers' bluegrass seeds," is meant bluegrass seeds put out for sale, which were neither blown nor specially treated, in an attempt to obtain just the pure live seeds as used by the official seed analysts.

A. Lot 4026 seeds (Kentucky Merion bluegrass) were soaked in various solutions--30 ppm gibberellin, 0.1% KNO_3 , tap water--and subjected to 6 and 8 days alternation of temperature pre-sowing treatment respectively. The seeds were later germinated in plastic petri dishes in the laboratory.

The results (see Tables 1 and 2) clearly showed that 6 days alternation of temperatures was much better than 8 days during the pre-sowing stage since the final germination count at the end of the 15th day was within tolerance in most cases.

The 48 hourly and 12 hourly temperature alternations for 6 days at the pre-sowing stage were most effective in increasing the rate of germination of the seeds. The 48 hourly temperature alternation was however more consistent (see Table 1).

TABLE 1. Average percentage germination at 59° F - 86° F of Lot 4026 (Kentucky Merion bluegrass) treated with 30 ppm gibberellin solution, 0.1% KNO₃ solution or tap water during the 6 days alternation of temperature pre-sowing period.

PRE-SOWING TREATMENTS		Germination percentage in			
Chemical	Temperature alternation (cold=40° F, warm=86° F)	4 days	6 days	7 days	15 days
30 ppm gibberellin	48 hrs. cold \rightleftharpoons 48 hrs. warm	37.0	59.5	62.0	75.5
0.1% KNO ₃	" "	18.0	56.0	65.0	77.5
Water	" "	11.0	38.0	45.5	71.0
30 ppm gibberellin	36 hrs. cold \rightleftharpoons 12 hrs. warm	28.0	53.0	60.0	70.5
0.1% KNO ₃	" "	3.0	15.0	27.0	39.0
Water	" "	1.0	3.0	7.0	39.5
30 ppm gibberellin	12 hrs. cold \rightleftharpoons 12 hrs. warm	61.5	69.5	70.0	73.0
0.1%	" "	36.0	44.0	47.0	55.5
Water	" "	41.5	56.5	58.0	70.0
None (Control)	None	0.5	2.5	11.0	74.0

TABLE 2. Average germination percentage at 59° F - 86° F of Lot 4026 treated with 30 ppm gibberellin solution, 0.1% KNO₃ solution or tap water during the 8 days alternation of temperature pre-sowing period.

PRE-SOWING TREATMENTS		Germination percentage in			
Chemical	Temperature alternation (cold=40° F, warm=86° F)	4 days	6 days	7 days	15 days
30 ppm gibberellin	48 hrs. cold \rightleftharpoons 48 hrs. warm				
0.1% KNO ₃	" "	8.3	21.0	31.5	40.8
Water	" "	6.5	24.5	40.5	58.0
30 ppm gibberellin	36 hrs. cold \rightleftharpoons 12 hrs. warm	1.5	11.5	24.3	40.8
0.1% KNO ₃	" "	0.0	3.5	13.5	42.5
Water	" "	0.0	4.8	10.0	30.8
30 ppm gibberellin	12 hrs. cold \rightleftharpoons 12 hrs. warm	42.5	56.5	59.0	60.8
0.1%	" "	17.5	47.3	49.8	58.0
Water	" "	15.5	41.8	44.0	50.0
None (Control)	None	0.0	0.3	3.8	54.8

Alternation of temperatures always helped since the germination percentages of all the treated seeds were better than those of the control up to and including the germination count taken on the 7th day after the seeds were planted. By the 15th day however, the germination percentage of the control had caught up with those of the treated seeds (see Tables 1 and 2; Fig. 1). With the 6 days pre-sowing treatment, the germination counts on the 15th day in all the seeds subjected to the 48 hourly alternation of temperature at the pre-sowing stage were well within tolerance.

Seedlings from gibberellin-treated seeds emerged more rapidly than any others. By the end of the experiment, the germination percentages of those with 6 days total alternation of temperatures were all within the tolerance limit irrespective of the different combinations of hours of cold and warmth at the pre-sowing stage. (See Fig. 1; Table 1.) In addition, the gibberellin treated seeds gave rise to the tallest and most vigorous seedlings (see Fig. 2). Some of the seedlings however looked wiry and slightly curved. The results from seeds treated with 0.1% KNO_3 or tap water were sometimes impressive. Root formation was not adversely affected in most of the seedlings although a few had inadequate root systems.

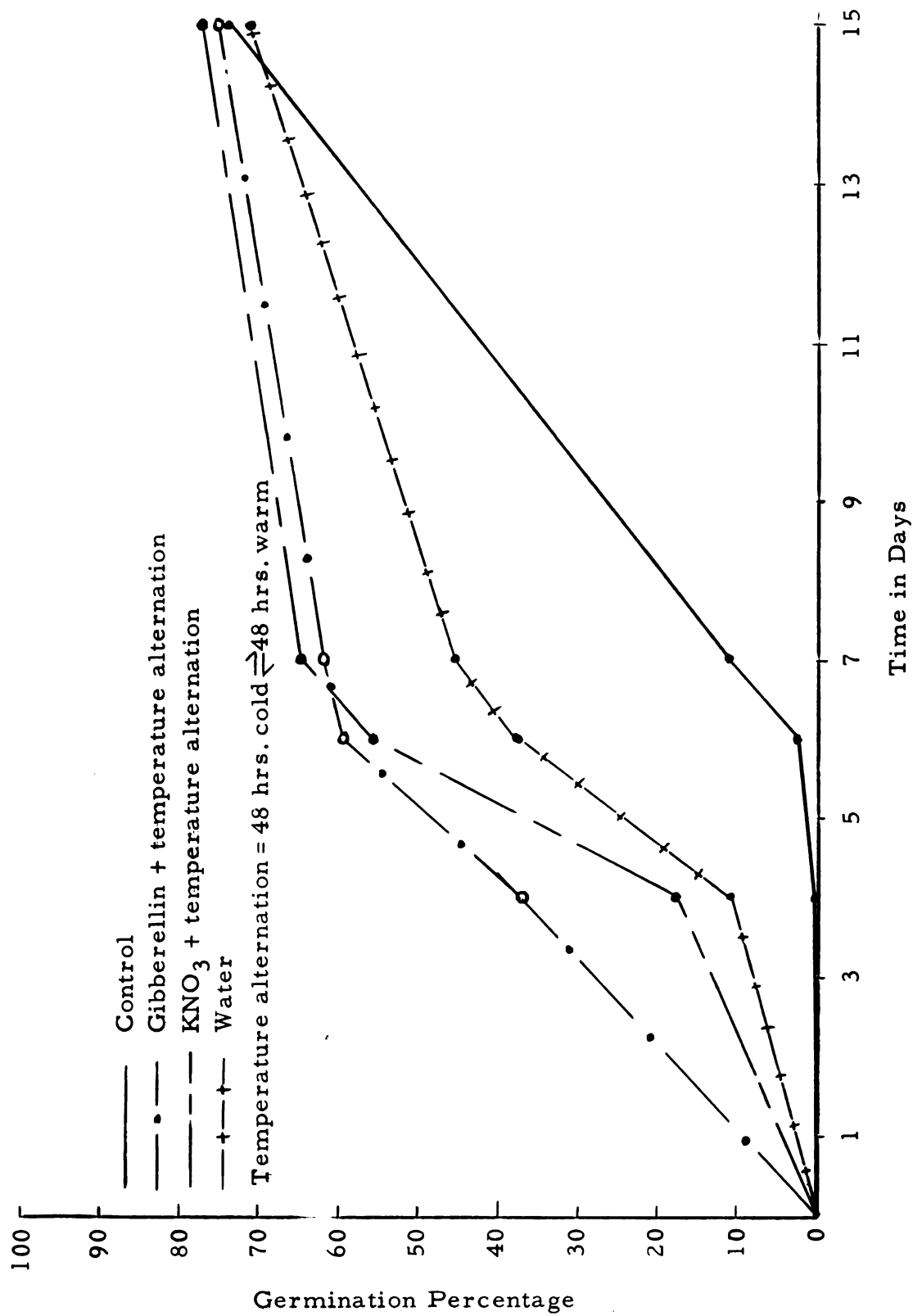


FIGURE 1. A comparison of the effects of different treatments on rate of germination and total germination of Lot 4026 seeds (farmers' seeds).

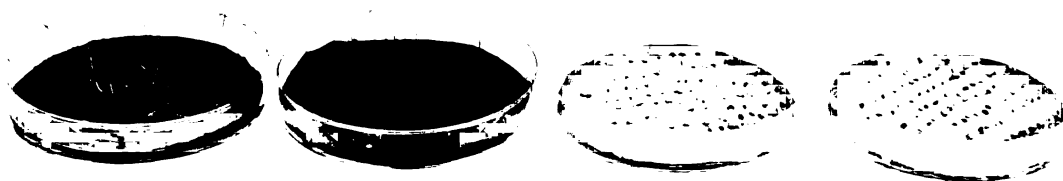


FIGURE 2. The effects of different treatments on rate of germination, height and vigor of seedlings from Lot 4026 seeds.

- I. 30 ppm gibberellin + 6 days 48 hourly temperature alternation
- II. Control (no treatment)
- III. 0.1% KNO_3 + 6 days 48 hourly temperature alternation
- IV. Water + 6 days 48 hourly temperature alternation

NB: Photo taken 13 days after seeds planted

B. The four lots of farmers' bluegrass seeds--4020 (Merion bluegrass), 4026 (Kentucky Merion bluegrass), 4-5639 (Kentucky bluegrass) and 8H1-2 (Kentucky bluegrass)--were treated as in IIA except that the 36 hours cold-12 hours warmth alternation of temperature treatment was omitted. The duration of the pre-sowing treatment was 6 days, and there were 4 replicates per treatment. The results in Table 3 showed that in all cases, seedlings from the gibberellin-treated seeds were superior as regards rapidity of germination to seedlings from all other treatments with the exception of those from the 12 hourly temperature alternation of Lot 4-5639.

With 48 hourly temperature alternation applied at the pre-sowing stage, the germination counts of lots 4020 and 4026 were within tolerance by the 13th day of count. Lot 4020 appeared most helped by gibberellin.

By the 28th day after the seeds were planted, the germination count of the control had caught up with those of the treated seeds except in Lot 4-5639.

A fungal score was carried out on the last day of count, i. e. the 28th day. The system of scoring was as follows:

- 1 for no fungus
- 2 for slight fungal infection
- 3 for badly infected
- 4 for very badly infected

The average fungal score for the treatments were:

gibberellin treated seeds = 1.84
KNO₃ treated seeds = 3.22
water treated seeds = 2.72

TABLE 3. Average germination percentage at 59°F - 86°F of four lots of seeds treated with 30 ppm gibberellin solution, 0.1% KNO₃ solution or tap water during the 6 days alternation of temperatures pre-sowing period.

PRE-SOWING TREATMENTS			LOT 4026				LOT 8H1-2				LOT 4-5639				LOT 4020			
Chemical	Temperature alternations		Germination percentage in				Germination percentage in				Germination percentage in				Germination percentage in			
	Cold=40 ^o F	Warm=86 ^o F	4 days	7 days	13 days	28 days	4 days	7 days	13 days	28 days	4 days	7 days	13 days	28 days	4 days	7 days	13 days	28 days
30ppm gib.	12 hrs. cold⇌12 hrs. warmth		32.0	55.8	63.3	65.0	25.8	46.3	59.8	62.5	33.5	42.3	48.0	52.3	20.3	43.5	59.8	65.5
0.1% KNO ₃	"	"	1.5	11.0	53.3	58.0	0.0	3.0	15.8	40.3	1.8	7.3	33.5	37.0	4.3	8.0	27.0	42.5
Water	"	"	29.0	42.0	52.3	54.3	8.8	16.0	34.5	46.8	25.8	36.0	51.0	55.8	0.5	2.0	20.0	44.8
30ppm gib.	48 hrs. cold⇌48 hrs. warmth		59.3	70.8	72.0	72.5	18.3	47.8	54.5	56.5	39.8	59.3	63.8	65.0	21.8	56.3	70.3	73.8
0.1% KNO ₃	"	"	3.3	14.8	41.0	41.8	0.8	3.3	26.8	42.0	12.0	14.8	23.5	25.3	8.3	12.5	42.5	52.8
Water	"	"	27.5	42.0	52.3	54.5	6.0	13.0	27.8	44.3	21.3	29.0	39.8	43.0	0.3	0.8	13.8	54.0
None (control)	None		8.3	45.0	71.5	76.0	5.3	19.5	39.8	47.3	1.8	6.8	15.8	17.8	0.5	5.0	32.0	46.3

Gibberellin was therefore slightly fungicidal (1). The pooled result of the four lots of seeds shown in Table 4 revealed that the promotive effect of gibberellin in accelerating the rate of germination of the blue-grass seeds was by far superior to those of all the other treatments and the control. The final count on the 28th day was almost identical for the KNO_3 and water-treated seeds and the control.

TABLE 4. Average germination percentage at 59°F - 86°F of the pooled results of the 4 lots of seeds of Table 3.

PRE-SOWING TREATMENTS		Germination percentage in			
Chemical	Temperature alternation (cold= 40°F , warm= 86°F)	4 days	7 days	13 days	28 days
30 ppm gibberellin	12 hrs. cold \rightleftharpoons 12 hrs. warm	27.9	46.9	57.7	61.3
0.1% KNO_3	" "	1.9	7.3	32.4	44.5
Water	" "	16.0	24.0	39.5	50.4
30 ppm gibberellin	48 hrs. cold \rightleftharpoons 48 hrs. warm	34.8	58.6	65.2	66.9
0.1% KNO_3	" "	6.1	11.3	33.5	40.5
Water	" "	13.8	21.2	33.4	48.9
None (Control)	None	3.9	19.1	39.8	46.8

Gibberellin-treated seeds with 48 hourly temperature alternation at the pre-sowing stage were somewhat better than those subjected to 12 hourly temperature alternation in speed of germination.

The most striking thing however, was that the different lots of seeds varied greatly in speed of germination. (See Table 3.)

III. Field Trials with Farmers' Bluegrass Seeds

A. Three lots variously treated seeds--4020 (Merion bluegrass), 4026 (Kentucky Merion bluegrass) and 4-5639 (Kentucky bluegrass)--were planted in small plastic flats exposed to cold nights and warm days.

TABLE 5. Average percentage germination at 59°F - 86°F of 3 lots of bluegrass seeds planted in plastic flats out of doors (May 13th to 29th).

PRE-SOWING TREATMENTS		Days *	Germination percentage		
Chemical	Temperature alternations (cold=40°F warm=86°F)		Lot 4020	Lot 4026	Lot 4-5639
None (control)	None	11th	4. 5	15. 2	20. 5
		14th	14. 2	30. 0	33. 7
		17th	17. 7	35. 7	38. 0
0. 1% KNO ₃	48 hrs. cold⇌48 hrs. warm	11th	3. 9	25. 0	21. 2
		14th	13. 7	36. 7	29. 5
		17th	19. 7	42. 9	33. 4
30 ppm gib.	48 hrs. cold⇌48 hrs. warm	11th	11. 0	24. 0	26. 4
		14th	27. 2	38. 2	35. 5
		17th	37. 0	42. 0	35. 9
24 hours soaking before planting					
0. 1% KNO ₃	"	11th	6. 4	26. 0	30. 2
		14th	14. 9	48. 4	46. 7
		17th	19. 4	54. 4	45. 5
30 ppm gib.	"	11th	6. 5	10. 2	18. 9
		14th	16. 7	26. 0	36. 0
		17th	22. 9	34. 4	39. 7
Water	"	11th	6. 9	12. 4	21. 5
		14th	17. 0	29. 4	34. 0
		17th	22. 2	34. 2	36. 2

* Days when germination counts were made.

The results as shown in Table 5 indicated that: The rate of germination of the control, seeds treated with either water or 30 ppm gibberellin solution 24 hours prior to planting, and seeds treated with 0.1% KNO_3 solution for 6 days at a 48 hourly temperature alternation during the presowing period, appeared about equally good. Soaking seeds in 0.1% KNO_3 solution, 24 hours before planting or in 30 ppm gibberellin solution with 6 days 48 hourly temperature alternation during the pre-sowing period were effective in speeding up the rate of germination.

It was observed that the germination percentage at any level was considerably lower than the corresponding laboratory germination percentage. One reason, may be weather conditions. The temperatures during the experimental period were far from optimum. Moreover, the 16 hours to 8 hours ratio of cold to warm periods which the seeds enjoy during laboratory germination tests were denied them.

The results were statistically analyzed. The following are the tables of the analysis of variance:

TABLE 6. Analysis of variance of Kentucky bluegrass germination test
11th day result

Source	ss	df	M. Sq	F
Main plots				
Replicates	2489.9	2	1244.9	-
Lots	10570.3	2	5285.2	60.8**
Replicates x lots = error _a	347.8	4	86.95	
Subplots				
Treatments	2463.7	5	492.7	4.75**
Lot x treatments	1757.7	10	175.8	1.69
Error _b	3110.3	30	103.7	
Totals	20739.7	53		

** = significant at the 1% level (highly significant)

* = significant at the 5% level

Mean germination percentage for treatments

Pre-sowing treatments	Mean germination percentage	
Control	27.1	RE ₆ 5% = 11.05
Gibberellin + 24 hours soaking	23.7	1% = 14.69
Water + 24 hours soaking	27.0	L. S. D. 5% = 9.83
KNO ₃ + 48 hourly temp. alternation for 6 days	33.2	1% = 13.26
Gibberellin + 48 hourly temp. alternation, 6 days	39.8	
KNO ₃ + 24 hours soaking	41.7	

Mean germination percentage for lots

Mean germination percentage	RE ₃	5% = 8.82
		1% = 14.96
	L. S. D.	5% = 8.65
		1% = 14.32
4020	13.0	
4026	37.1	
4-5639	46.2	

RE₆ or RE₃ refer to the total number of means compared in the respective tables.

Any difference less than the corresponding L. S. D. value should not be considered significant at that level. Any difference greater than the corresponding RE value may be considered significant at that level. All differences between the corresponding L. S. D. and RE values may be considered questionable as to their significance.

TABLE 6B. Analysis of variance of Kentucky bluegrass germination test.
14th day results

Source	ss	df	M. Sq	F
Mainplots				
Replicates	1830.5	2	915.3	
Lots	15940.7	2	7970.4	24.95**
Replicates x lots = error _a	1277.4	4	319.4	
Subplots				
Treatments	3730.9	5	746.2	3.269*
Lot x treatments	3824.4	10	382.4	1.675
Error _b	6845.4	30	228.2	
Totals	33449.3	53		

Mean germination percentage for treatments		RE ₆	5%=16.38
			1%=21.77
Pre-sowing treatments	Mean germination percentage	L.S.D.	5%=14.57
			1%=19.61
Check	51.9		
Gibberellin + 24 hours soaking	52.4		
H ₂ O + 24 hours soaking	53.6		
KNO ₃ + 48 hourly temp. alternation for 6 days	54.3		
Gib. + 48 hourly temp. alternation for 6 days	67.2		
KNO ₃ + 24 hours soaking	73.2		

Mean germination percentage for lots		R. E ₃	5% = 16.88
Lots	Mean germination percentage		1% = 28.63
4020	34.5	L.S.D.	5% = 16.55
4026	70.1		1% = 27.41
4-5639	71.8		

TABLE 6C. Analysis of variance of Kentucky bluegrass germination test.
17th day results

Source	ss	df	M. Sq	F
Mainplots				
Replicates	1410.0	2	705.0	
Lots	12803.5	2	6401.8	43.11**
Replicates x lots = error _a	593.9	4	148.5	
Subplots				
Treatments	2887.9	5	577.6	2.59*
Lots x treatments	4725.4	10	472.5	2.12
Error	6677.4	30	222.6	
Totals	29098.1	53		

Mean germination percentage for treatments		R. E ₆ 5%=16.15
		1%=21.47
Pre-sowing treatments	Mean germination percentage	L.S.D. 5%=14.36
		1%=19.33
Check	60.9	
Gibberellin + 24 hours soaking	64.6	
H ₂ O + 24 hours soaking	61.7	
KNO ₃ + 48 hourly temp. alternation for 6 days	63.9	
Gib. + 48 hourly temp. alternation for 6 days	76.5	
KNO ₃ + 24 hours soaking	79.3	

Mean germination percentage for lots		R. E ₃ 5% = 11.50
Lots	Mean germination percentage	1% = 19.51
		L.S.D. 5% = 11.28
4020	46.2	1% = 18.68
4026	81.1	
4-5639	76.2	

In brief, the statistical analysis shows that: Seed lots varied significantly in rapidity of germination and in total germination. There was no significant difference between adjacent treatment means for any day. There was a highly significant difference between the best and the three poorest treatments.

B. Farmers' bluegrass seeds from lots 4020 (Merion bluegrass), 4026 (Kentucky Merion bluegrass) and 4-5639 (Kentucky bluegrass) were differently treated as in IIIA and later planted in 2 feet by 4 feet plots on the Farm Crops farm on June 25th.

Results in Table 7 failed to show any actual difference in promotive effect among the different treatments.

Dry weather during most of the experimental period affected the results adversely as artificial irrigation was carried out only three times throughout the experimental period of 17 days as the Weather Bureau forecase rain which failed to fall. The drought affected the final count most severely as very many of the seedlings died. The dead seedlings were not counted.

A statistical analysis of the results (see Table 8) was carried out and it found that there was no significant difference among treatments, lots or replicates. This may be a pointer to the fact that very good care of bluegrass seedlings would be necessary before the effects of the treatments could show properly.

TABLE 7. Average germination count of Lots 4026, 4020 and 4-5639 seeds planted in the field. (June 25th to July 12th.)

PRE-SOWING TREATMENTS			Germination count			
Chemical	Temperature alternations (cold=40°F warm=86° F)		Days**	Lot 4020	Lot 4026	Lot 4-5639
None (control)	None		12th	83.3	87.7	64.3
			14th	137.0	180.3	149.3
			17th	160.3	160.3*	130.7*
0.1% KNO ₃	48 hrs. cold 48 hrs. warm	12th	46.7	85.7	91.7	
		14th	98.0	173.3	206.3	
		17th	97.3*	188.3	213.3	
30ppm. gib.	48 hrs. cold 48 hrs. warm	12th	44.8	108.7	188.3	
		14th	90.3	178.0	328.3	
		17th	69.3*	155.3*	261.3*	
24 hours soaking before planting						
30ppm gib.	"		12th	80.0	83.0	64.7
			14th	168.0	148.3	161.3
			17th	224.3	176.3	180.0
0.1% KNO ₃	"		12th	41.0	102.7	96.0
			14th	62.0	211.3	209.0
			17th	95.0	241.7	210.0
Water	"		12th	87.0	72.7	168.0
			14th	151.3	124.3	268.0
			17th	137.3*	91.0*	234.0*

**Days when germination counts were made.

*Germination count adversely affected by drought, hence the drop.

TABLE 8. Analysis of variance of germination of Kentucky bluegrass seeds
12th day results

Source	ss	df	M. Sq	F
Mainplots				
Replicates	19,158.1	2	9576.1	
Lots	20,877.5	2	10438.8	1.49
Replicates x lots = error _a	28,040.8	4	7010.2	
Subplots				
Treatments	14,650.1	5	2930.0	0.798
Lots x treatments	37,332.3	10	3733.2	1.018
Error _b	110,058.8	30	3668.6	
Totals	230,317.9	53		

14th day results

Mainplots				
Replicates	151,175.1	2	70587.6	
Lots	94,659.1	2	47329.6	1.52
Replicates x lots = error _a	124,230.5	4	31057.6	
Subplots				
Treatments	13,363.7	5	2672.7	0.39
Lots x treatments	93,197.4	10	9319.7	1.36
Error _b	204,931.5	30	6831.1	
Totals	681,557.3	53		

17th day results

Mainplots				
Replicates	47,452.1	2	23726.0	
Lots	213,758.8	2	106879.4	4.31
Replicates x lots = error _a	99,106.8	4	24776.7	
Subplots				
Treatments	11,579.8	5	2315.9	0.41
Lots x treatments	104,921.4	10	10492.1	1.88
Error _b	167,579.1	30	5585.6	
Totals	644,398.0	53		

No significant difference.

IV. Laboratory Germination Tests with Pure Live Seeds

The farmers' bluegrass seeds of lots 4026 (Kentucky Merion bluegrass) and 4020 (Merion bluegrass) were blown with a machine to remove all the inert matter, dead seeds and empty glumes. The pure live seeds obtained were planted in covered petri dishes containing two blotters each. Five treatments were applied in four replicates each. The results are contained in Table 9.

Results shown in Table 9 indicate that:

1. Treatment with gibberellin appears slightly better than KNO_3 or water in accelerating germination.
2. Presoaking seeds for 6 days accompanied by alternation of temperatures before placing the seeds in the germinator gave more rapid germination than when dry untreated seeds were placed on germination blotters.
3. The 6 days of damp alternation of temperature storage in the test tubes were approximately equivalent to an equal number of days on the germination blotters.
4. There was a much greater difference in the rapidity of germination than in total percentage germination in the two lots of seeds (see Figs. 3 and 4). Gibberellin treated seeds gave rise to the tallest and most vigorous seedlings. Those treated with 0.1% KNO_3 were next best while the untreated seeds, i. e. control gave rise to the smallest and shortest seedlings. (See Figs. 5A and 5B.)

TABLE 9. Average percentage germination at 59° F - 86° F of pure live seeds of lots 4026 and 4020 under five different treatments.

PRE-SOWING TREATMENTS													
Chemical	Temperature alternation		Germination substrate	LOT 4026				LOT 4020					
	Cold = 40°F	Warm = 86°F		5 days	7 days	10 days	13 days	5 days	7 days	10 days	13 days		
1. 30 ppm gib.	48 hrs.	C \rightleftharpoons 48 hrs.	W \rightleftharpoons 48 hrs.	C	30 ppm gib.	45.3	70.5	72.3	74.5	6.0	26.0	51.8	66.5
2. 0.1% KNO ₃	"	"	"	"	0.1% KNO ₃	36.0	71.0	77.3	78.0	4.0	17.0	47.5	62.5
3. None		None			30 ppm gib.	1.5	41.3	68.3	72.0	0.3	12.0	46.0	63.0
4. None		None			0.1% KNO ₃	0.0	18.5	61.3	67.5	0.3	5.8	38.5	57.0
5. None		None			Water (Control)	0.0	16.3	66.3	73.5	0.0	2.0	30.8	50.8

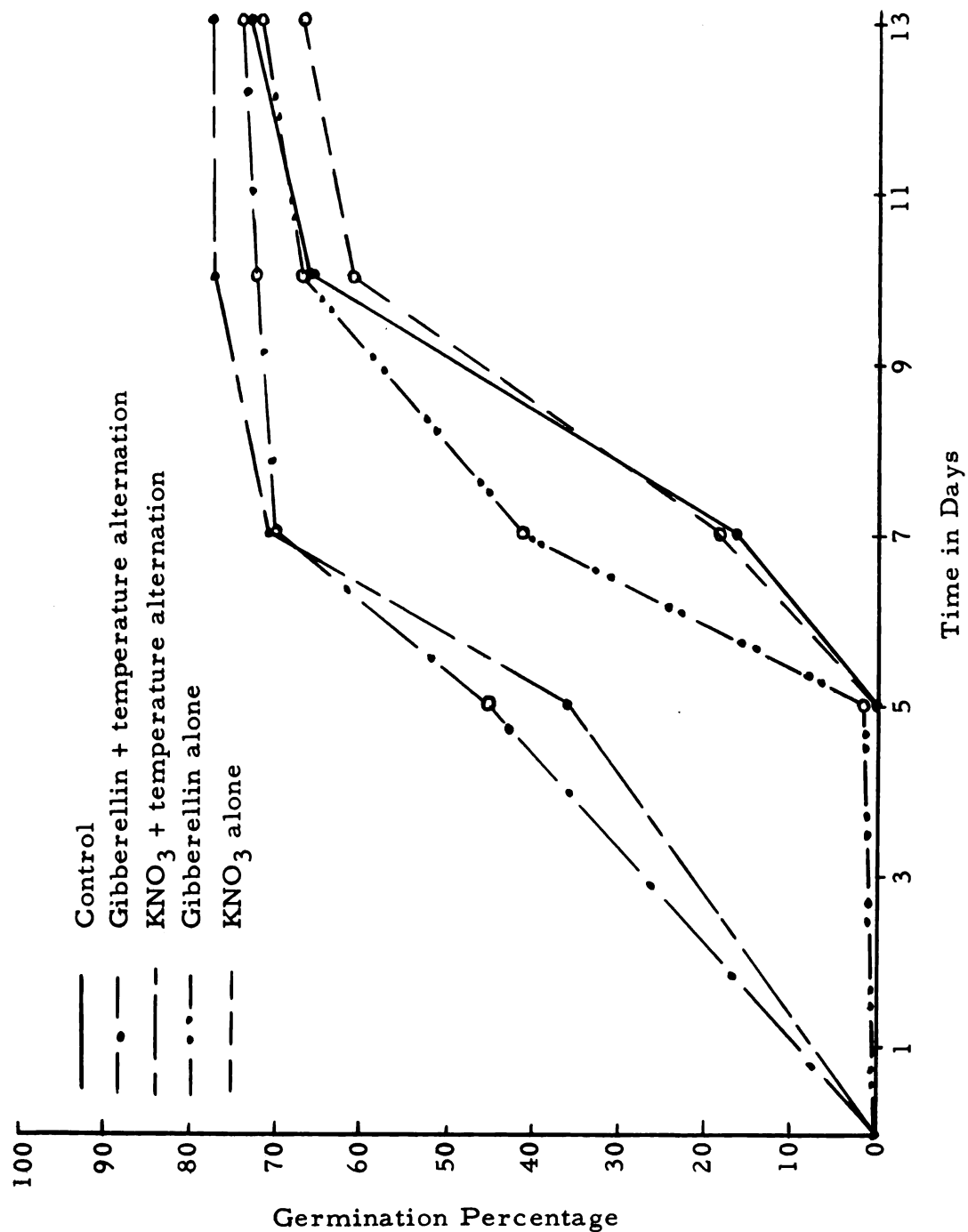


FIGURE 3. The effects of different treatments on rate of germination and total germination of Lot 4026 seeds (pure live seeds).

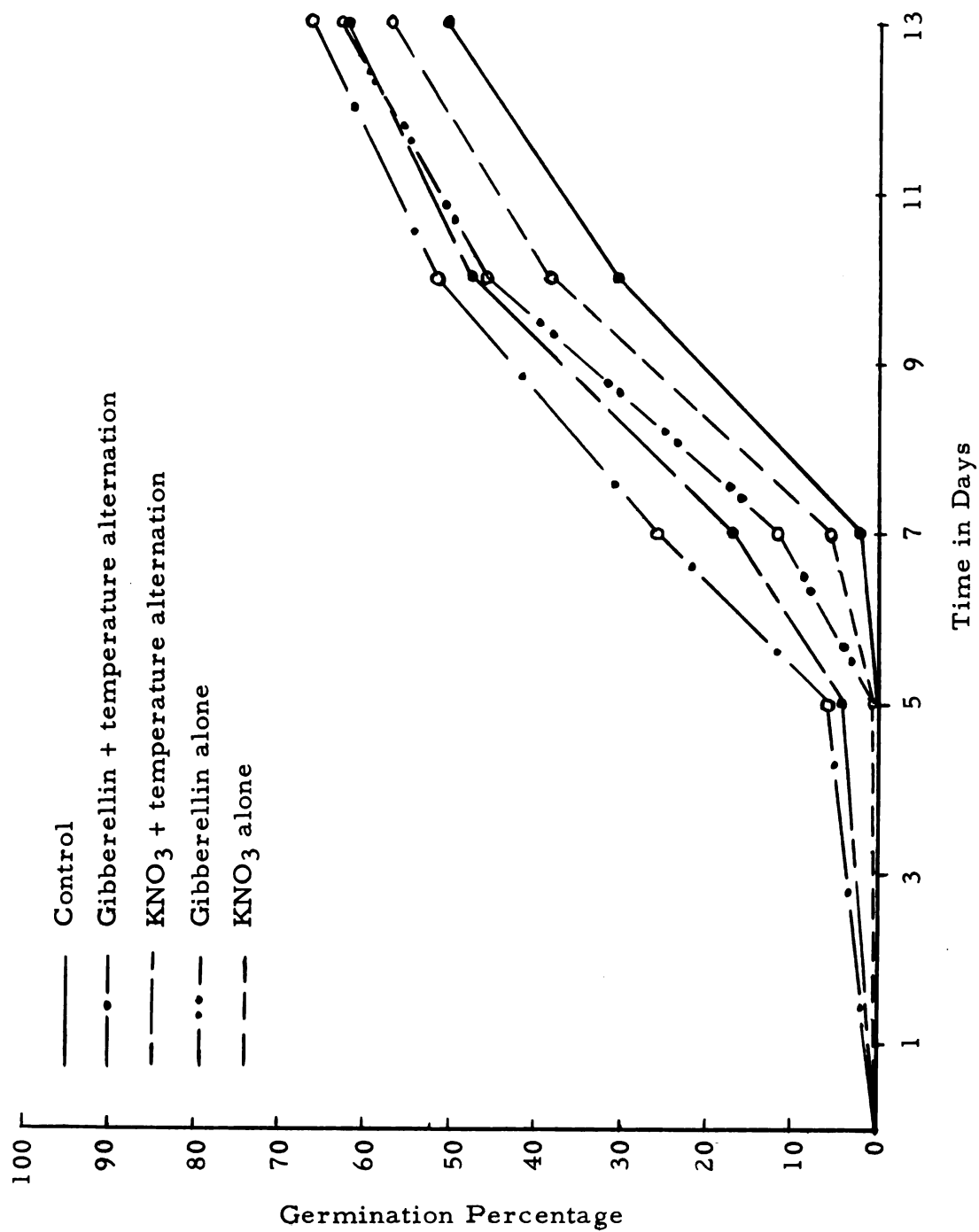


FIGURE 4. The effects of different treatments on rate of germination and total germination of Lot 4020 seeds (pure live seeds).



FIGURE 5A. The effects of different treatments on rate of germination, height and vigor of seedlings (from Lot 4020 seeds).



FIGURE 5B. The effects of different treatments on rate of germination, height and vigor of seedlings (from Lot 4026 seeds).

- I. 30 ppm gibberellin + 6 days 48 hourly temperature alternation
- II. 0.1% KNO_3
- III. 30 ppm gibberellin
- IV. 0.1% KNO_3
- V. Control (no treatment)

NB: Photo taken 9 days after seeds were planted.

DISCUSSION

The object of the experiment was to attempt to improve the rate of germination of Kentucky bluegrass seeds. It was felt this could probably be achieved by treating the seeds with gibberellin in combination with alternation of temperature at the pre-sowing stage.

Temperature alternation from 40°F to 86°F was tried since the natural temperature alternation between the days and nights in early spring when bluegrass seeds are usually planted approximates to that. In the experiments, temperature alternation at the pre-sowing stage did actually help speed up the rate of germination of the seeds. This might be attributed to the fact that at higher temperatures, the bluegrass seeds probably respired faster; and since oxygen concentration in plant tissues rapidly diminishes with increasing temperature above 25°C (77°F) (James, 1953; 11, 3), (an effect attributed to the high temperature coefficient of respiration and the reduced solubility of oxygen at higher temperatures) the lowering of the temperature from 86°F to 40°F probably pushed the seeds to faster germination as more oxygen could then diffuse through the compact cells of the bluegrass seeds in order to satisfy the oxygen requirement of the already rapidly respiring embryo. This suggests that the slow rate of germination in Kentucky bluegrass seeds may perhaps be due to the low oxygen concentration within its compact seeds. Earlier work by Delouche (6) on germination of Kentucky bluegrass seeds revealed that seeds whose lemma and

palea were removed germinated faster and achieved maximum germination percentage regardless of the stage of maturity at which the seeds were harvested. This might indicate that the lemma and palea may be responsible for limiting oxygen entry into the seeds and gaseous exchange as well.

Forty-eight hourly temperature alternation was the most consistent in speeding up the rate of germination of the seeds. This may have resulted because the initial 48 continuous hours at low temperature provided a high concentration of oxygen within the seeds. This in turn might enable a high rate of respiration to become established during the subsequent 48 hours at 86° F. Similarly, during a second 48 hour period at low temperature, oxygen could be supplied in amounts adequate for high respiration continuing throughout the next warm period. Emphasis may be placed on the relative and absolute lengths of time at the different temperatures--40° and 86° F. The 12 hours cold ⇌ 12 hours warm alternation may not have permitted as vigorous a respiration to become established due to the shorter warm periods. In the 36 hours cold ⇌ 12 hours warm alternations, relative durations of cold and warmth may have been in poor balance for establishing rapid respiration. In the 48 hours cold ⇌ 48 hours warm and 12 hours cold ⇌ 12 hours warm alternations, the much greater total period of low temperature than in 36 hours cold ⇌ 12 hours warm alternations may have accentuated the beneficial low temperature effects of gibberellin (13, 24).

In the experiments with pure live seeds, both the 0.1% KNO₃ and 30 ppm gibberellin solutions in combinations with temperature

alternation at the pre-sowing stage performed about equally well. (See Table 9 and Figs. 3 and 4.) Without the temperature alternation however, gibberellin-treated seeds got off to a faster start. This may suggest that gibberellin is probably more efficient than KNO_3 in speeding up the germination of bluegrass seeds under a condition of lower oxygen tension. [The seeds were set in the germinator at 86°F (30°C).] Moreover, it was possible that gibberellin probably took advantage of the 16 hours at 59°F which existed throughout the germination period.

Despite the generally good response of the seeds to the treatments--especially to gibberellin and temperature alternation at the pre-sowing stage--the various seed lots were observed to have shown differences in their response to the treatments (Table 9 and Figs. 3 and 4). This was not surprising as Scherry (12, 18) had earlier observed that "a single climax cannot be chosen to fairly evaluate all bluegrass seeds since they may vary from region to region, from lot to lot and in weight fractions. Each seed lot has its own personality." The lots of seeds used came from Washington (4026), Michigan (4020), South Dakota (8H1-2) and Ohio (4-5639). They also varied in weights. In addition, the variations observed in the rapidity of germination between lots and in even the best seed sample could be attributed to several factors such as:

1. the varying maturity levels at which the different seeds in each lot were harvested and the time interval after

- harvesting the seeds (6, 22);
2. the difficulty in giving uniform treatment with the chemicals at the pre-sowing stage (22);
 3. the size of seeds--which varied with the lots (18);
 4. the number of empty glumes and dead seeds in each lot and in each seed sample drawn for the germination test. [This does not apply in the experiment with pure live seeds (22).]
 5. the difficulty in providing adequately identical experimental conditions;
 - a. in the germinator, owing to microclimatic differences in the various shelves of the germinator, and
 - b. in the soil, owing to the differences in soil texture, structure, fertility gradient etc.
 6. the differences in the condensation of water on the plastic petri dish covers and the differences in the drying rate of the structures.

The lower total germination percentage obtained both in the field and in the small plastic flats was most probably due to the far from optimum conditions which prevailed at the time of the experiments. The evaporation rate of water from the soil was certainly higher than it was in the laboratory. This high loss of water must have created dry environments in the neighborhood of the seeds. The bad effect was more felt in field planting where little water must have

been available to the seeds due to lack of adequate rainfall during the experimental period. (Only 0.64 inches of rain fell throughout the 17 days of the experiment.) Also, the temperature alternation in both cases during the germination period was from an average of 55.3°F to 78.1°F for field planting and an average of 48.59°F to 68.82°F for the small plastic flat plantings. This did not compare quite favorably with the 40°F to 86°F range used for laboratory germination tests. Moreover, the temperature alternations in field and small plastic flats experiments did probably not follow the regular 16 hours cold at 40°F and 8 hours warm at 86°F which obtained during the laboratory germination tests. The results however seem to be in line with the findings of Porter and Rice (16) who found that, approximately one-third as many sprouts per hundred seed balls of sugar beets was obtained in the field as against the laboratory performance.

The results for the germination tests in the small plastic flats were not unexpected since it was assumed that the natural temperature alternation in early spring might be a help to those treatments which hadn't any alternation of temperatures. The fact that the seeds soaked in 0.1% KNO_3 24 hours prior to planting gave the best result (See Tables 5 and 6) was not surprising. Other factors such as: the number of empty glumes and dead seeds in each sample, and the difficulty of giving a uniform treatment with the chemicals at the pre-sowing stage were probably responsible for this.

Soaking the seeds 24 hours before planting them was expected to help in speeding up the rate of germination of the seeds if water uptake alone was the limiting factor in slowing down the rate of germination. This treatment was effective only once, and that was with the 0.1% KNO_3 on seeds planted in the small plastic flats. The promotive effect was probably due partly to the natural temperature alternation of the early spring when the experiment was conducted.

Replicates agreed excellently in the germination tests with pure live seeds as compared with those in which farmers' bluegrass seeds were used. This could be explained by the fact that true samples could not be obtained from farmers' bluegrass seeds since no attempt was made to sort out the pure live seeds.

SUMMARY

Four lots of Kentucky bluegrass seeds--2 of certified Merion and 2 of common Kentucky bluegrass--were used. The various seed lots were pre-soaked in 30 ppm gibberellin solution, 0.1% KNO_3 solution or tap water with or without alternation of temperatures in different combinations of days and hours.

Germination tests were carried out:

- a. in the laboratory on blotters in covered plastic petri dishes at an alternating temperature of 59°F and 86°F ;
- b. in soil placed in small plastic flats exposed to cold nights and fairly warm days during spring; and
- c. a special germination test was also carried out in the laboratory in covered plastic petri dishes using only pure live seeds.

The rate of germination and total germination percentage were recorded.

CONCLUSIONS

From this study, the following conclusions could be drawn:

1. The different lots of bluegrass seeds differed considerably in their response to treatments.

2. Alternation of temperatures applied at pre-sowing stage was always helpful in speeding up the rate of germination of the bluegrass seeds in the laboratory. The 48 hourly alternation from 40° F to 86° F for 6 days had the most consistent promotive effects.

3. Gibberellin was the most helpful treatment in accelerating germination of the bluegrass seeds in the laboratory. In addition, gibberellin was somewhat fungicidal.

4. There was no noticeable difference in the promotive effects of 0.1% KNO₃ and 30 ppm gibberellin solutions on pure live seeds if preceded by 6 days 48 hourly alternation of temperatures at 40° F and 86° F.

5. Acceleration of field germination of bluegrass seeds was not significant in these trials, either in May or late June plantings. Something else--probably some extra care aside from the gibberellin and alternation of temperature treatment--may be necessary for success in the field.

6. Gibberellin plus temperature alternations at the pre-sowing stage may soon replace the present method used by the official seed analysts for bluegrass laboratory germination tests in order to cut

down testing time. It should be remembered that time now involved to complete laboratory testing of Kentucky bluegrass seeds is a vital factor to the seed industry and seed users.

LITERATURE CITED

1. Andersen, A. M. The effect of certain fungi and gibberellin on the germination of Merion Kentucky bluegrass seed. USDA Bettsville, Maryland. Assn. of Official Seed Analysts of N. America. Proceedings, 1957.
2. Brian, P. W. Role of gibberellin-like hormones in regulation of plant growth and flowering. *Nature* 181 (4616):1122-23. 1958.
3. Burton, W. G. 1950. Studies on the dormancy and sprouting of potatoes. The oxygen content of the potato tuber. *New Phyt.* 49: 121-34.
4. Button, E. F. Effect of gibberellic acids on laboratory germination of Creeping Red Fescue. *Agron. Jour.* 51: 60-61. 1959.
5. Crosier, W. & Cullinan, B. Some observations in the germination of grass seeds. Proceedings of the Assn. of Official Seed Analysts, p. 69. 1941.
6. Delouche, J. C. Germination of Kentucky bluegrass harvested at different stages of maturity. Proceedings of the Assn. of Official Seed Analysts. 1958.
7. Elliot, R. F. and French, C. S. Germination of light sensitive seed in crossed gradients of temperature and light. *Plant Physiol.* 34:454-6. 1959.
8. Fergus, E. N. A second look at bluegrass. *Crops and Soils*, p. 15. Aug-Sept., 1956.
9. Helgeson, E. A. and Green, J. G. Gibberellic acid vs. wild oats. *North Dakota Farm Research Bimonthly Bul.* Vol. 20, No. 7, Sept-Oct., 1958, pp. 7-8.
10. _____. 1957. New weapon against wild oats. *North Dakota Agr. Expt. Sta. Bimonthly Bul.* 19:121-122.
11. Hussey, G. An analysis of the factors controlling the germination of the seeds of the Oil Palm--*Elaeis guineensis* (Jacq). *Annals of Bot.* 1958. pp. 259-284.

12. Jensen, L. More dormant seed found in new crops. *Crops and Soils*, p. 31, Jan., 1960.
13. Kline, J. W. Growth responses of gibberellin-treated celery plants. *Bot. Gaz.* 120, No. 2:122-124. 1958.
14. Koller, Dov. Germination. *Scientific American*, April, 1959.
15. Leben, C. and Barton, L. V. Effect of gibberellic acid on growth of Kentucky bluegrass. *Sci.* 125:494-5. 1957.
16. Porter, R. H. and Rice, W. N. Laboratory and field germination of treated and untreated beet seed. *Proceedings of the Assn. of Official Seed Analysts.* 1939.
17. Scherry, R. W. The story of bluegrass. *Hort.* 37:530-31. 1959.
18. _____. Bluegrass sprouting under stress. The Lawn Institute, Route 4, Kimberdale, Marysville, Ohio.
19. _____. Lawn seeding. *Crops and Soils*, pp. 13-14. April, 1959.
20. Sudia, T. W. Influence of temperature on the response of germinating barley grains to potassium gibberellate. *Plant Physiol.* 34:473-5. 1959.
21. Toole, E. H. Hendricks, S. B., Borthwick, H. A. and Toole, V. K. Physiology of seed germination. *Annual Rev. of Plant Physiol.* Vol. 7:299-319. 1956.
22. Toole, E. H. and Toole, V. K. Variability in germination as affected by physiological condition of seeds and germination microclimate. *Proceedings of the Assn. of Official Seed Analysts.* 1955.
23. USDA. Manual for Testing Agricultural and Vegetable Seeds.
24. Wittwer, S. H. and Bukovac, M. J. The effects of gibberellin on economic crops. *Econ. Bot.* Vol. 12, No. 3, July-Sept., 1958, pp. 213-55.
25. _____. Gibberellin and higher plants. Seed treatments for beans, peas and sweet corn. *Mich. Agr. Exp. Sta. Quart. Bull.* 40:215-224. 1957-58.
26. Wolff, W. H. For better results, try pre-germination. *Hort.* 37:14. 1959.

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