Proceedings of the Iowa Academy of Science

Volume 57 | Annual Issue | Article 7

1950

Effect of Wave Length Bands of Filtered Light on Germination of Seeds of Kentucky Bluegrass (Poa Pratensis)

Louis N. Bass
Iowa Agricultural Experiment Station

Effect of Wave Length Bands of Filtered Light on Germination of Seeds of Kentucky Bluegrass (*Poa Pratensis*)[1]

By Louis N. Bass

Botanists have long known that light, supplied during the germination period, may increase germination percentages. Most studies concerning the effects of light on the germination of seeds have utilized the entire visible spectrum. Only a few workers have studied the effects of various portions of the spectrum. However, results of these studies, dealing with a number of species, have not been consistent. The effect of color of light on germination of Kentucky bluegrass seed has not been previously investigated. Since it is a light sensitive species it was felt that such a study would provide additional basic information on the problem of wave length effect.

Because of the limited amount of work which has been done on the effects of wave length of light on the germination of seeds, the literature review includes most of the previous work as a matter of information rather than because it has a direct bearing on the work with Kentucky bluegrass.

Cieslar (1) in 1883 obtained the same germination of *Poa nemoralis* with either white or yellow light, while violet light gave a lower germination, about the same as that obtained in darkness. Heinricher (10) obtained better results with yellow than with blue light.

Kinzel (11, 12, 13) found that germination of *Nigella sativa* L. seeds was retarded by light of all colors but seeds of *Drosera spathulata* Labill germinated well with either dark red, dark blue, orange, yellow or violet light. *Myricaria germanica* Desc. seeds germinated equally well under either white, green, blue-green, violet or blue light and *Pinguicula vulgaris* L. seeds germinated best with orange, red or white light. *Veronica peregrina* L. seeds germinated less with red or blue light than they did in the dark while for seeds of *Allium suaveolens* green light gave best results.

Kommerell (14) studied several kinds of seeds and concluded that for any specified wave length, the effectiveness of the radiation was proportional to the energy falling on the seed. The greatest absorption by the seed coat was at 5100 Angstrom units (A). Gilles (8) used a mercury vapor lamp and found that irradiation

1 Journal paper No. J-1786 of the Iowa Agricultural Experiment Station, Ames, Iowa Project. 1083.

for a short period increased germination of numerous kinds of seeds, but after a certain length of time further irradiation resulted in decreased germination. Exposure to ultra violet light for 1 — 10 minutes accelerated germination (9).

Flint (2, 3, 4), studying effects of light on lettuce seed, found that equal intensities of red, orange, and yellow light were equally effective in promoting germination of dormant seed, but green or blue light inhibited germination. Moist, non-dormant lettuce seed exposed to blue light would not germinate subsequently in the dark but germinated under white, red or other favorable light. Leggatt (15) also found that blue light inhibited germination of lettuce seed.

Flint (4) reported that the shorter wave lengths 4000 — 5200A have an inhibiting effect on the germination of light-sensitive lettuce seeds. The most effective wave lengths were about 4000 and 4800A. Flint and McAlister (5, 6, 7) found a band in the region of 7600A which inhibited the germination of light-sensitive lettuce seed even more effectively than the region of 4200 — 4500A. The wave lengths between 5200 — 7000A were found to stimulate the germination of light-sensitive lettuce seed with the wave length of 6600A being the most effective. They suggest that, since some components of white light promote germination while others inhibit it, the net effect of white light depends upon whether the seed used absorbs more of the radiation which promotes germination or whether it absorbs more of the radiation which inhibits germination.

Meischke (16) made tests on several kinds of seed to show the effects of monochromatic light on germination of light-favored and light-inhibited seed. He used wave lengths from 3400 — 8340A but could not find a direct correlation between wave length and germination. For light-favored seed, wave lengths of 4350 — 4900 and 7500A gave the poorest germination and the wave lengths of 5500 and 6000 — 6550A gave the best germination. The degree of sensitivity to spectral regions varied with the species, and the effectiveness of the radiation was proportional to its absorption by the seed.

Materials and Methods

The studies reported in this paper extended over a two year period. They were undertaken to determine if the wave length of light provided during germination of Kentucky bluegrass seed affected the total germination.

For experiments with 1947 crop seed, eight samples were taken at random from commercial lots received for germination testing in the Iowa State College Seed Laboratory.

The 1948 crop seed was hand harvested from four locations in the vicinity of Ames, Iowa. Two collections were made from each location, first (June 14-16) when the moisture content was approximately 35 per cent and again (July 6-7) when the seed was completely air dry and had a moisture content of approximately 8 per cent. The high moisture content (immature) collections were divided into two parts for drying. One half was spread out in a large box in front of an electric fan for fast drying. These seeds were stirred several times a day to facilitate drying. The other half of each lot was put in a double paper bag and set on a table in the laboratory to dry more slowly. Three weeks after harvest when both portions had dried to a constant weight, one half of each was stored at 32° C., the other at 2° C. Random samples were drawn from all lots of seeds and prepared for germination by hand threshing and blowing to remove the chaff and other inert material.

The filters used for this study were dyed gelatin films on glass plates, prepared according to an unpublished method kindly made available through private correspondence by R. B. Withrow of the Smithsonian institution. The following dyes were used: Victoria pure blue BO, Crystal violet, Methyl violet B crystals, Brilliant green cert. crystals, Pontamine fast yellow 5 GL, Chrysoidine Y purified, and Orange G. Cupric acetate was also used.

For each germination test 2 x 100 seeds counted on a vacuum counter were planted in petri dishes on quartz sand moistened with a 0.1 per cent potassium nitrate solution. After planting, the seeds were placed at an alternating temperature of 15-30° C. to germinate. The low temperature was maintained for 15 hours and the high temperature for 9 hours each day. Light was supplied during the high temperature period each day except Sunday. The tests were of 28 days duration.

The petri dishes containing the seeds were placed in light-tight wooden boxes and covered with the filters, thus excluding stray light. The distance between each filter and light source was so adjusted that the transmission was approximately 10 foot candles (f. c.) at the bottom of the box when measured by a Weston light meter.

The filters were divided into two groups. One group was used under fluorescent light and the other group under incandescent light. The filters used under the incandescent light could not be used under the fluorescent light as their transmission was mostly in the red and infrared, beyond the wave lengths of the emission spectrum of the fluorescent lamps. The transmission spectra of some of the filters used with fluorescent light go beyond the emission spectrum (0.38 — 0.74 Mu) of the source. That part of their transmission spectra beyond 0.74 Mu was disregarded for this study.

The transmission curves for the various filters were obtained with a Goertner monochrometer with a projection lantern as the light source. The percentage transmission of each wave length for each filter was calculated from the deflection of a galvanometer

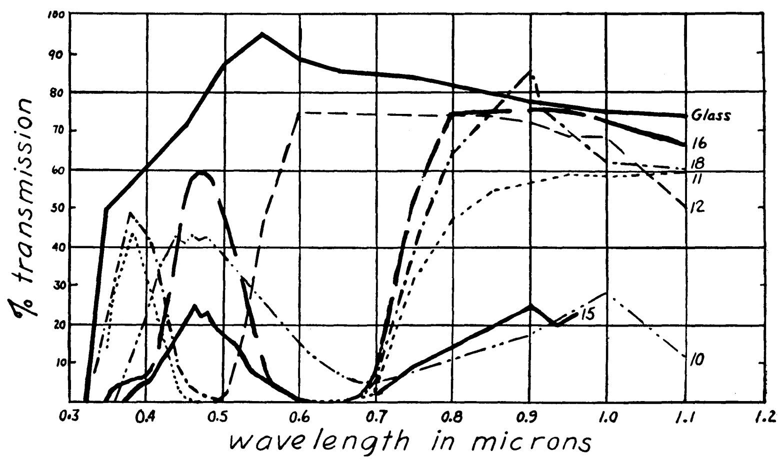

Figure 1. Transmission curves of filters used with fluorescent light.

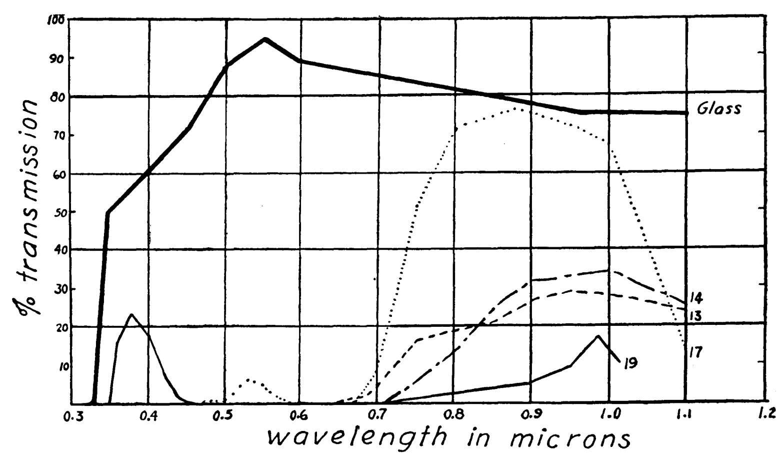

Figure 2. Transmission curves of filters used with incandescent light.

connected to a photoelectric cell. The transmission curves of the filters used with fluorescent light are shown in Figure 1 and those of the filters used with incandescent light are shown in Figure 2.

Experimental Results

The 1947 crop seed tests under fluorescent light were planted July 21 and October 22, 1947 and April 6, 1948. Tests under incandescent light were planted July 28 and October 22, 1947 and April 6, 1948. A check test was made with each set of filters for each planting, using frosted glass and 10 f. c. of light and also a dark test. The results of the three sets of tests under both fluorescent and incandescent light are presented in Table 1.

In July the germinations under filters 18 and 11 and in the dark were a great deal lower than those under the other filters, while on the later tests there were no large differences. Both filters 11 and 18 were blue and had transmission ranges of 0.35 — 0.45 Mu (3500 — 4500A) and 0.35 — 0.50 Mu respectively. The wave length range of both these filters fall, at least in part, in the range 4000 — 5200A found by Flint and McAlister (5, 6, 7) to inhibit germination of light sensitive lettuce seed.

Under incandescent light there were no large differences in germination under any of the filters for any of the tests. However, the germination under all the filters averaged 10 per cent lower in July than for the later tests. The difference between the dark germination for July 21 and July 28 was 25.8 per cent.

Tests on the 1948 crop were made with seed harvested at two stages of maturity. Both the immature and mature seed were planted immediately after harvest. The immature seed was planted again after one week and the mature seed after 10 days. A third planting of the immature seed was made 13 weeks after harvest while a third planting of the mature seed was made 3 weeks after harvest.

The average germinations of all lots for each planting of both immature and mature seed under fluorescent light are presented in Table 2 and those for the incandescent light in Table 3. The immature seed germinated very little under any filter when tested immediately after harvest, while the mature seed gave an average germination of over 80 per cent. There was also a wide difference in germination between the immature and mature seed in the second test. The third tests were not comparable in length of storage period.

For the first and second tests, filters 12 (orange), 10 (green) and 15 (green) gave highest germinations for the immature seed

Table 1

Effect of wave length of filtered light on germination of Kentucky bluegrass seed (ave. 16 x 100 seeds). (New crop seed). (1947).

10 f. c. Fluorescent light

Date of test	Dark	Frosted glass	Filter number					
			18	11	16	10	12	Ave.
7-21-47	36.1	70.1	52.8	54.8	71.8	70.8	71.3	61.1
10-22-47	75.6	75.6	73.8	75.5	74.8	76.3	75.0	75.2
4-6-48	73.8	74.6	77.3	73.9	75.0	77.0	75.9	75.3
Average	61.8	73.4	67.9	68.1	73.9	74.7	74.1	70.5

10 f. c. Incandescent light

Date of test	Dark	Frosted glass	Filter number				
			17	13	19	14	Ave.
7-28-47	61.9	64.3	64.8	60.1	61.0	65.8	63.0
10-22-47	75.6	73.9	76.1	75.4	72.3	76.0	74.9
4-6-48	73.8	73.3	—	75.0	73.5	73.0	73.7
Average	70.4	70.5	70.5	70.2	68.9	71.6	70.5

Table 2

Effect of wave length of filtered fluorescent light (10 f. c.) on germination of freshly harvested Kentucky bluegrass seed (ave. of 8, 16 or 32 x 100 seeds). (1948 crop).

Date of test	Dark	Frosted glass	Filter number 18	11	16	10	15	12	Ave.
Immature seed									
6-17-48	0.0	0.9	1.5	2.3	3.4	6.6	10.6	8.6	4.2
6-24-48	9.0	47.9	8.6	18.2	19.8	43.3	58.6	53.9	32.4
9-23-48	80.5	84.2	79.9	84.4	—	85.3	85.7	83.6	83.2
Average	29.8	44.3	30.0	35.0	11.6	45.1	51.6	48.7	39.9
Mature seed									
7-9-48	67.0	81.0	80.0	81.0	85.5	86.0	90.5	88.0	82.4
7-19-48	85.0	91.0	89.0	89.5	90.0	91.0	93.0	92.0	90.1
7-30-48	80.5	89.5	85.0	88.5	90.0	88.5	88.5	90.5	87.6
Average	77.5	87.2	84.7	86.3	88.5	88.5	90.7	90.2	86.7

Table 3

Effect of wave length of filtered incandescent light (10 f. c.) on germination of freshly harvested Kentucky bluegrass seed (ave. of 8, 16, or 32 x 100 seeds). (1948 crop).

Date of test	Dark	Frosted glass	Filter number 17	13	19	14	Ave.
Immature seed							
6-17-48	0.0	3.3	1.8	1.1	1.0	0.5	1.3
6-24-48	9.0	23.9	5.4	13.7	17.3	5.4	10.9
9-23-48	80.5	86.4	85.7	85.5	85.3	86.3	84.9
Average	29.8	37.9	31.0	33.4	34.5	30.7	35.4
Mature seed							
7-9-48	67.0	83.3	81.0	88.3	83.4	77.3	80.0
7-19-48	85.0	90.4	86.8	91.0	88.0	89.9	88.5
7-30-48	80.5	86.5	65.8	86.6	87.0	78.7	80.9
Average	77.5	86.7	77.9	88.6	86.1	81.9	83.4

and filters 12 (orange), 13 (red) and 15 (green) gave highest results for the mature seed. The germination of the mature seed on the second test was about the same under all the filters as it was by the corresponding check test. Even the dark test was almost as high as the check. But for the immature seed even the check test did not give complete germination until the third test at which time the germination was essentially the same under all the filters.

Under the filters, the differences in germination due to storage temperature were not large; consequently they are not shown. The only filters to give germination result much lower than the dark test were no. 14 and 17 (red) for the mature seed after 10 days storage.

The data presented indicate that all wave lengths tested stimulated germination of Kentucky bluegrass; however, the amount of stimulation depended upon the maturity and states of after-ripening of the seed. When completely after-ripened, the seed lost its sensitivity to light regardless of wave length.

Discussion

The dark tests for July 21 and July 28, on the commercial samples of Kentucky bluegrass seed demonstrate how rapid the germination under a given condition can change. The conditions of the two tests were the same; yet after one week the germination increased 25.8 per cent. This increase was probably due to after-ripening of the samples during the week which elapsed between the two tests. Therefore after-ripening probably influenced the germination under the filters with incandescent light making it higher than it would have been had the test been started a week earlier.

The blue filters (Nos. 11, 18 and 19) all had a large portion of their transmission in the range (4000 — 5200A) found by Flint and McAlister (5, 6, 7) to inhibit the germination of light sensitive lettuce seed. The red filters (Nos. 13, 14 and 17) had almost all of their transmission in the region beyond 7000A where a band in the region of 7600A was also found to inhibit germination of light sensitive lettuce seed. However, these regions did not effectively inhibit the germination of Kentucky bluegrass, they merely provided less stimulation than the orange or green light when used to test immature, non-after-ripened seed.

The immature seed did not give maximum germination under any of the filters on the first and second tests. The second test was left in the germinator 6 additional days and resulted in an average increase in germination of 22.7 per cent. Such a large increase in germination with additional time suggests that the effect of the filters was lack of stimulation rather than inhibition of germination. Since all the filters gave a higher germination than did darkness, it is evident that all wave length bands used had a certain amount of stimulatory effect on the seed. The increase in germination with extended time in the germinator shows that germination time is important for immature seed which is not completely after-ripened. There was generally an increase in germination under all the filters with either maturity or after-ripening, except that the mature seed showed a small decrease in germination between the second and third set of tests under all the filters. This decrease was probably due to a change in the physiological condition of the seed during the 10 days of storage since even the dark test gave a 5 per cent lower germination on the third test.

Since only 10 f. c. of light was employed for these tests, it is possible that a higher intensity of radiation would have resulted in complete germination under all the filters. It is also possible that some of the differences obtained for immature, non-after-ripened seed may have been due to temperature differences under the filters as the heating effect of the various wave length bands were not the same. Non-after-ripened bluegrass seed is generally considered to be more temperature sensitive than after-ripened seed.

Summary

When incandescent and fluorescent light was filtered and used at a uniform 10 f. c. some wave lengths were more effective than others in promoting germination of Kentucky bluegrass seed. The effectiveness of a given filter depended upon the maturity of the seed at harvest and/or the length of time after harvest that the test was made. The best germination of immature non-after-ripened seed was obtained with orange or green light, and the poorest germination was obtained with blue or red light. There were no large differences in germination obtained under the various filters for after-ripened seed. Seed that was fully matured when harvested germinated almost equally well under all of the filters used, or in darkness after the first planting.

Acknowledgement

The writer wishes to thank Dr. R. B. Withrow for information on construction of the gelatin filters.

Literature Cited

1. Cieslar, A. Untersuchung über den Einfluss des Lichtes auf die Keimung der Samen. Forsuch. Geb. Agrik. Physik. 6:270-295. 1883.
2. Flint, L. H. Light sensitivity in relation to dormancy in lettuce seed. Proc. Inter. Seed Test. Assoc. 6:487-489. 1934.

3. ——— Light in relation to dormancy and germination in lettuce seed. Sci. 80:38-40. 1934.
4. ——— Sensitivity of dormant lettuce seed to light and temperature. Jour. Wash. Acad. Sci. 25:95-96. 1935. (abst.)
5. ——— and E. D. McAlister. Wave length of radiation in the visible spectrum inhibiting germination of light sensitive lettuce seed. Smith. Misc. Coll. 94:No. 5. 1935.
6. ——— and ——— The action of radiation of specific wave length in relation to the germination of light sensitive lettuce seed. Proc. Inter. Seed Test. Assoc. 8:1-4. 1936.
7. ——— and ——— Wave length of radiation in the visible spectrum promoting the germination of light sensitive lettuce seed. Smith. Misc. Coll. 96:No. 2. 1937.
8. Gilles, E. Effects de faibles irradiations au moyen de la lampe a vapeur de mercure sur la germination. Compt. Rend. Seanc. Soc. Biol. Paris. 109:739-741. 1932.
9. ——— Influence des rayons ultra-violets sur la germination des graines irradiees a l'etat sec. Compt. Rend. Seanc. Soc. Biol. Paris. 110:841-843. 1933.
10. Heinricher, E. Ein Fall beschleunigender Wirkung des Lichtes auf die Samenkeimung. Ber. Deutsch. Bot. Gesellsch. 17:308-311. 1899.
11. Kinzel, W. Über den Einfluss des Lichtes auf die Keimung "Lichtharte" Samen. Ber. Deutsch. Bot. Gesellsch. 25:269-276. 1907.
12. ——— Die Wirkung des Lichtes auf die Keimung. Ber. Deutsch. Bot. Gesellsch. 26A:105-115. 1908.
13. ——— Lichtkeimung; Einige bestätigende und ergänzende Bemerkungen zu den verläufigen Mitteilungen von 1907-1908. Ber. Deutsch. Bot. Gesellsch. 26A:631-645. 1908.
14. Kommerell, E. Quantitative Versuche über den Einfluss des Lichtes verschiedener Wellenlangen auf die Keimung von Samen. Jahrb. Wiss. Bot. 66:461-512. 1927.
15. Leggatt, C. W. A contribution to the study of dormancy in seeds. Can. Jour. Res., C, 26:194-217. 1948.
16. Meischke, D. Über den Einfluss der Strahlung auf Licht und Dunkel Keimen. Jahrb. für Wiss. Bot. 83:359-405. 1936.

BOTANY AND PLANT PATHOLOGY SECTION
IOWA AGRICULTURAL EXPERIMENT STATION
AMES, IOWA