Effects of Environment on Germination and Occurrence of Sixweeks Fescue

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The objectives of this study were to determine basic physiological and ecological attributes of sixweeks fescue (Festuca octoflora Walt.). At Central Plains Experimental Range1 sixweeks fescue is unpalatable to cattle and they tend to avoid grazing in areas infested with this annual grass.

During the summer of 1958 the utilization of blue grama (Bouteloua gracilis (H.B.K.) Lag) was impaired by the abundance of sixweeks fescue. The fescue was dense on the upland sites and sparse on the bottomland sites. Heavy-use pastures instead of having a uniform slicked-off appearance were grubbed to the ground on bottomlands and very lightly grazed on uplands. Moderate-use pastures received heavy use on bottomlands while the uplands were essentially ungrazed. This unusual type of utilization appeared to be due primarily to the occurrence of sixweeks fescue. At the close of the 1958 summer grazing season, total beef gains were below those expected from current perennial grass production. The loss in gross return per heifer in 1958, as a result of poor utilization attributed to sixweeks fescue, amounted to about $25 per head.

Laboratory Seed Germination

Sixweeks fescue seeds harvested at Central Plains Experimental Range were used in a laboratory study of factors affecting germination. Seeds were collected on June 25, July 6, and July 22, 1959. They were stored at room temperatures of 10 to 30°C until germination tests were started in October 1959.

Cleaned seeds from each harvest date were planted on top of 2 thicknesses of moistened filter paper in 9-centimeter Petri dishes. Initial moistening of the substrata was with tap water or a 0.2-percent KNO₃ solution; thereafter, all substrata were kept moist with tap water. The seeds were subjected to the following light (fluorescent) and temperature conditions:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Dark Light Duration (hr)</th>
<th>(hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10° constantly</td>
<td>intermittently³</td>
<td></td>
</tr>
<tr>
<td>15° constantly</td>
<td>15 9</td>
<td></td>
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<tr>
<td>20° constantly</td>
<td>15 9</td>
<td></td>
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<tr>
<td>10° for 15 hr; 30° for 9 hr</td>
<td>15 9</td>
<td></td>
</tr>
<tr>
<td>15° for 15 hr; 25° for 9 hr</td>
<td>15 9</td>
<td></td>
</tr>
<tr>
<td>15° for 15 hr; 30° for 9 hr</td>
<td>15 9</td>
<td></td>
</tr>
<tr>
<td>20° for 15 hr; 30° for 9 hr</td>
<td>15 9</td>
<td></td>
</tr>
</tbody>
</table>

Alternating temperatures were obtained by using electronically controlled germinators. Relative humidity in these germinators ranged from 95 to 100 percent. Constant temperatures were obtained with the germinators or temperature-controlled chambers.

Germination counts were started after the seeds had been in the germinators for 7 days and were continued at 7-day inter-

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1 Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and Colorado State University, Fort Collins, Colorado. Revised portion of a thesis by the senior author; directed by Dr. Donald F. Hervey, Head of the Department of Range Management, and Dr. Richard T. Ward, Assistant Professor of Botany and Plant Pathology, at CSU; Dr. Louis N. Bass, Plant Physiologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the junior author, Fort Collins, Colorado. Presented to a Graduate Committee at CSU in partial fulfillment of the requirements for the degree of Master of Science.


3 Seeds in 10° constantly received light only when counted or when someone was in the chamber doing other work.

4 Density is used as the percent of ground area covered by a species when viewed from directly above.
vals through 42 days. A seed was recorded as germinated if the shoot and the root had elongated at least one-eighth inch from the testa. During the count, the seedlings were removed, and if necessary the substratum was moistened with tap water.

Figures 1 and 2 and Table 1 show the average percent of total germination was significantly different between all temperatures except 20-30° and 15-30°, and between 10° and 15-25° C. At the environmental conditions shown in Table 1, the total germination was significantly different between the July 6 and the July 22 harvest dates. Total germination was significantly higher on substrata moistened with a 0.2-percent KNO₃ solution than on substrata moistened with tap water.

Germination speed as well as total germination was influenced by temperature, stage of seed ripeness, and moistening agent. In general, germination began between 7 and 14 days after the seeds were placed in the germinator at most temperatures. Under 20°, however, germination began between 0 and 7 days. Generally, germination speed reached its peak between 14 and 21 days at constant temperatures and between 28 and 35 days at alternating temperatures. Germination speed and total germination were highest at the constant temperature of 20°. The alternating temperature of 15-25° was practically as good, however, and probably more nearly simulates natural conditions.

Germination speed was generally greater for seeds harvested July 22 than for seeds harvested July 6 or June 25. Seeds moistened with a 0.2-percent KNO₃ solution generally germinated more rapidly than seeds moistened with tap water.

**Plant Development on Two Sites**

Measurements of growth and development of sixweeks fescue were taken from 5 plants at each of 8 stations on March 19, April 4, April 25, May 9, and June 9, 1959. Four stations were selected in sites with a sandy loam surface soil and four in sandy clay sites.

The lengths of the plant shoot (portion above seed coat) and longest root were recorded in millimeters. The number of roots was recorded until the roots became too numerous and matted to count.

Data in Figure 3 show a relation between surface-soil texture and development of the roots and shoots of six weeks fescue. The roots and shoots developed more rapidly in sandy loam than in sandy clay. During seedling emergence and growth the roots were approximately three times as long as the shoots. This condition gradually became more pronounced until the transition from the vegetative to the bloom stage. At this time the roots were

<table>
<thead>
<tr>
<th>Date of harvest</th>
<th>10° C</th>
<th>15° C</th>
<th>20° C</th>
<th>10-30° C</th>
<th>15-25° C</th>
<th>15-30° C</th>
<th>20-30° C</th>
<th>Harvest date</th>
<th>H₂O average</th>
<th>KNO₃ average</th>
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</thead>
<tbody>
<tr>
<td>June 25</td>
<td>75</td>
<td>64</td>
<td>29</td>
<td>97</td>
<td>93</td>
<td>98</td>
<td>1</td>
<td>19</td>
<td>66</td>
<td>96</td>
</tr>
<tr>
<td>July 6</td>
<td>88</td>
<td>94</td>
<td>35</td>
<td>85</td>
<td>73</td>
<td>84</td>
<td>4</td>
<td>14</td>
<td>67</td>
<td>85</td>
</tr>
<tr>
<td>July 22</td>
<td>79</td>
<td>93</td>
<td>57</td>
<td>95</td>
<td>96</td>
<td>99</td>
<td>5</td>
<td>27</td>
<td>79</td>
<td>97</td>
</tr>
<tr>
<td>Temperature average</td>
<td>82</td>
<td>66</td>
<td>90</td>
<td>12</td>
<td>82</td>
<td>41</td>
<td>41</td>
<td>41</td>
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</tr>
</tbody>
</table>
Table 2. Average density of sixweeks fescue for 11 years, under various grazing treatments. (Each average based on four pastures for each degree of grazing and four exclosures for no grazing).

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Heavy</td>
<td>.183</td>
<td>.017</td>
<td>.002</td>
<td>.002</td>
<td>.064</td>
<td>.021</td>
<td>.001</td>
<td>.007</td>
<td>.170</td>
<td>.027</td>
<td>.001</td>
</tr>
<tr>
<td>Moderate</td>
<td>.253</td>
<td>.050</td>
<td>.008</td>
<td>.001</td>
<td>.020</td>
<td>.017</td>
<td>.013</td>
<td>.012</td>
<td>.290</td>
<td>.050</td>
<td>.029</td>
</tr>
<tr>
<td>Light</td>
<td>.256</td>
<td>.044</td>
<td>.017</td>
<td>.001</td>
<td>.022</td>
<td>.019</td>
<td>.001</td>
<td>.001</td>
<td>.068</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>No grazing</td>
<td>.025</td>
<td>.065</td>
<td>1</td>
<td>.001</td>
<td>.004</td>
<td>.004</td>
<td>.001</td>
<td>.012</td>
<td>.009</td>
<td>.004</td>
<td>.013</td>
</tr>
<tr>
<td>Year average</td>
<td>.179</td>
<td>.044</td>
<td>.007</td>
<td>.001</td>
<td>.027</td>
<td>.015</td>
<td>.004</td>
<td>.005</td>
<td>.120</td>
<td>.022</td>
<td>.009</td>
</tr>
</tbody>
</table>

Percent of 1941: 24.6 3.9 0.6 15.1 8.4 2.2 2.8 67.0 12.3 5.0

1 Data were not available.

about three and one-half times as long as the shoots. After this period, the shoots elongated rapidly and the roots began to dry and decompose. The lengths of the roots and shoots were about the same during the transition from the bloom to the dough stage. By the end of the dough stage the shoots were approximately one and one-half times as long as the roots. The number of roots increased until about the dough stage. More roots were produced on plants in sandy loam than in sandy clay.

Relation of Experimental Findings to Observed Field Conditions

Data collected at the Central Plains Experimental Range for a 20-year period, 1941-1960, were scrutinized for information on the occurrence of sixweeks fescue. The density of this grass was tabulated by grazing intensity and year. Percentage composition, as it varied by degree of grazing intensity, was found for the years 1940-42, 1946-48, and 1952-53 (Kliippe and Costello, 1960). Temperature and rainfall records for August, September, and October of several years were examined.

Density of sixweeks fescue varied sharply from year to year (Table 2). The occurrence of this fescue was slightly influenced by grazing, generally being favored by heavy and moderate grazing over light grazing. Grazing of all intensities, however, favored sixweeks-fescue density over no grazing.

Field temperature and rainfall records for the fall months of 1940 and 1957 indicated favorable germination conditions for sixweeks fescue when compared with germination conditions used in the laboratory. Sixweeks fescue was most abundant in 1941 and 1958. Field records for the fall months of 1956 showed less favorable germination conditions than existed in 1940 or 1957. Sixweeks fescue density in 1957 was lower than in 1941 or 1958.

During September 1940, the mean daily field temperature was 17°C. The average minimum and maximum temperatures for the month were 11 and 23°C respectively. These temperatures approximated the 15-25°C alternating temperature that allowed good germination in the laboratory. Total precipitation during September 1940 was 4.54 inches. This precipitation was well distributed over the month. The following year, 1941, sixweeks-fescue density was the highest on record. In the course of 13 days, August 15 through August 27, 1957, the average minimum and maximum field temperatures were 12 and 27°C respectively. The mean daily temperature was 19°C. The best temperature conditions in the laboratory studies were 15-25°C alternating and 20°C constantly. The total rainfall received in the...
period was 1.38 inches. Sixweeks-fescue density in 1958 was the second highest on record.

Early August 1956 moisture was available but temperature conditions were not favorable for optimum germination of sixweeks fescue. Rainfall from July 30 to August 19 amounted to 2.32 inches. Average field temperatures during this period were 12° minimum and 29° maximum. These temperatures approximated the 10-30° alternating temperature which allowed extremely poor germination in the laboratory. Sixweeks-fescue density in 1957 was low compared with its density in 1941 and 1958.

Discussion

Went (1948) reported that final population of annuals was solely a reflection of their germination response. Germination control, and not subsequent survival of the fittest, determined the floristic composition of annuals in the area he studied. We believe, as a result of this and other studies, that once the seeds of annuals have germinated, their chance for survival is good. Even when moisture after germination is low, an annual produces at least one flower stalk and gives rise to one or more seeds.

Determinations in this study, with respect to temperature requirements for laboratory germination, agree closely with those of other workers who studied seedling emergence under field conditions (Tevis, 1958; Went, 1948 and 1949). Indications are that the optimum temperature for germination and emergence of sixweeks fescue is generally 15 to 25° C. When temperatures are outside of this range, a significant decrease in germination results. From these determinations it is conceivable that large annual differences in sixweeks-fescue density may be related directly to the prevailing temperature during moisture availability. Therefore, we believe that extremely high or low sixweeks-fescue density may be predicted in the Central Great Plains by careful examination of the temperature and moisture conditions during August, September, and October preceding the summer growing season.

Field observations of the growth and development of sixweeks fescue disclosed some physiological and morphological attributes which enable it to survive and perpetuate under extreme climatic conditions. We found that the seeds germinated and the seedlings emerged in the fall. The seedlings then remained dormant until late winter or early spring, when they resumed growth. Measurements of the roots and shoots showed that the roots developed much earlier than the leaves and culms. After the roots were well established, the upper appendages responded and developed rapidly. As the seed-ripen stage approached, the roots became completely dry and partially decomposed. At this time the leaves and culms began to dry and turn brown. We believe that most of the seeds were mature enough to germinate any time after the beginning of the seed-ripe growth stage.

Field data indicated that the occurrence of sixweeks fescue was slightly influenced by different grazing intensities. The major difference in the occurrence of sixweeks fescue, however, was between no grazing and grazing, regardless of the intensity. Fescue occurrence was favored by grazing.

Summary

Germination data from laboratory experiments were obtained by subjecting seeds harvested at three different stages of ripeness to various temperatures and using tap water or a 0.2-percent KN03 solution as the moistening agent. Germination counts were taken at 7-day intervals through 42 days.

Phenological data were collected from 2 types of surface soils at various growth stages from March 19 through June 9, 1959. Density of sixweeks fescue was compiled from records at the Central Plains Experimental Range for each year from 1941 through 1960. Fall temperature and rainfall records for this period were investigated.

Results of this study are summarized as follows:

1. The constant temperature of 20° C allowed the best germination under laboratory conditions. Also, 15-25° was the best alternating temperature.

2. Average percent germination was significantly increased when a 0.2-percent KN03 solution was used as the moistening agent rather than tap water.

3. Phenological data indicated that during seedling growth the roots were much longer than the shoots. As the plant approached maturity, this relation gradually reversed. The rate of structural development of the plant appeared to be related to surface-soil texture.

4. Records of plant densities at the Central Plains Experimental Range from 1941 through 1960 revealed that sixweeks-fescue density was the highest in 1941 and the second highest in 1958. Records of climatic data for the same period showed that the temperature and moisture conditions in late August and early September of 1940 and 1957 closely paralleled those found to be most favorable for the germination of sixweeks fescue in the laboratory.

LITERATURE CITED


WENT, F. W. 1948. Ecology of desert plants I. Observations on germina-
A Grid Method for Obtaining Loop Readings on Small Plots

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The adaption of loop-transect techniques1 to small plots is useful in relating loop measurements to trends in range vegetation sampled by other methods. For this purpose, Driscoll (1958) described a method of obtaining loop measurements of ground cover on small, permanent, circular plots. The method, however, samples a restricted area of the plot, and loop positions are difficult to duplicate in repeat measurements. This note describes the design and use of equipment to obtain similar measurements, but with loop positions gridding the plot and with greater accuracy in duplicating positions during remeasurement.

The method described herein obtains a grid of 50 loop readings each on a series of 24-square-foot circular plots aligned along a 100-foot transect. The equipment was primarily designed to sample ground cover on very stony soils commonly only 4 inches deep, two factors which prohibited the use of numerous stake-type reference points. With equipment and technique modifications, the method can be adapted to many vegetation types, to other intensities and methods of measurement (such as the point method of analysis), and to plots of different size, shape, and distribution.

Equipment

Essential equipment includes a ¾-inch loop equipped with a two-way leveling bubble, a T-shaped frame used as a jig for guiding placement of the loop, and a 100-foot steel measuring tape for reference in controlling frame positions within each plot (Figure 1).

The main parts of the frame are cut from 1x2x1-inch channel aluminum. The length of the cross member, shown at right angles to the tape, is 6 feet. This length is governed by plot diameter. The axial member, parallel to the tape, and the three adjustable legs are each approximately 2 feet long.

The axial member is bolted at right angles to the cross member, with one of its edges intersecting the center of the cross member. In Figure 1, the left edge of the axial member, as viewed by the operator, is the centered edge. The axial member also extends one-fourth inch beyond the back edge of the cross member, as shown in Figure 2. The reasons for this offset and extension of the axial member are brought out in the method of use.

A flat aluminum bar is bolted to the underside of the cross member, with three-eighths inch of the bar protruding beyond the front edge of the cross member to form a lip along the entire span. Eight notches, spaced at the predetermined loop-grid interval of 0.7 foot, are cut on the

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2 Parker, p. 7b (See footnote 1.)