Influence of Temperature on Growth and Metabolism of Ryegrass Seedlings.

I. Seedling Growth and Yield Components

Leonard Bevers and J. P. Cooper

THE effects of extreme temperatures on plant growth can be readily demonstrated. Thus, growth usually ceases above 50° C. and below 0° C. Within these extremes, however, considerable variation in growth rate can occur depending upon the temperature. While this effect of temperature on growth is generally recognized less is known of the manner in which this influence of temperature is exerted.

Blackman (6) in discussing plant growth likened the increase in dry weight of a plant growing without competition to a system of continuous compound interest. Thus, the increment in dry weight produced in any interval added to the capital for growth in the subsequent period. Although this concept has undergone various modifications throughout the years, it follows, as Watson (19) points out, that dry weight yield will be dependent upon (a) the initial capital, (b) the relative growth rate, and (c) the length of the growth period. Gregory (10) further suggested that dry weight yield would be determined by the efficiency of the plant which could be measured in terms of dry matter production per unit leaf area in unit time. This measurement is termed net assimilation rate, N.A.R. As well as being determined by this photosynthetic efficiency, however, the dry matter production will depend on the relative proportion of photosynthetic to nonphotosynthetic tissue. The ratio of leaf surface (photosynthetic area) to total plant weight gives an indication of the proportion of photosynthetic surface and is usually termed leaf area ratio, L.A.R. The relative growth rate (R.G.R.) can be assessed as the product of N.A.R. and L.A.R.

In the present experiments controlled environmental facilities were used to study the influence of temperature regime on the vegetative growth, leaf and tiller development, and metabolism of ryegrass. This paper presents data on the vegetative growth of ryegrass in three temperature regimes and the results are examined in terms of classical growth analysis.

MATERIALS AND METHODS

Italian ryegrass (Lolium multiflorum Lam.) and Irish perennial ryegrass (Lolium perenne L.) seeds were sown in garden loam contained in 18- X 12- X 8-inch boxes. Twelve boxes, 6 containing Italian ryegrass and 6 containing Irish perennial ryegrass, were placed in each of 3 controlled environment chambers. Illumination was 650 foot-candles at the soil surface. The photoperiod was 16 hours with a subsequent dark period of 8 hours. The temperature regimes in respective growth rooms were 12° C, continuously (referred to as 12-12), 25° C, continuously (25-25), and 25° C. day and 12° C. night (25-12).

The relative humidity in all 3 rooms was maintained at 75% and water was supplied as required throughout the 10-week experimental period. Records were made of the rate of leaf appearance on the main stem as described by Mitchell (15) and leaf areas were calculated as length X width at the mid-point (7, 12). Plants were harvested by cutting off the aerial portions at approximately ⅛ inch above the soil surface at 4, 7, and 10 weeks after sowing. The number of tillers, leaves, and total leaf area of the shoot material on 18 or 24 plants of each species from each treatment were recorded at each harvest date. At each sampling, care was taken to avoid plants from the outside rows in any box. Thorne (17) has shown that leaf sheath and stem material can play a part in contributing to the photosynthetic activities of the barley plant, and suggests that stem surface area should be incorporated into leaf area measurements used in growth analysis. However, as the plants in the present experiment were only in the vegetative stage it was considered unlikely that the small amount of leaf sheath present would be making any major contribution to photosynthesis. The dry weight of the shoot material was obtained after it had dried overnight in an oven at 85° C.

The underground parts were carefully removed from the soil and separated from adhering soil particles by washing under running water. These washed roots were dried overnight at 85° C. and their dry weight recorded.

Total plant dry weight was calculated as the sum of root and shoot dry weights. In order to facilitate statistical analysis of figures with a wide range, the data were transformed to the natural logarithm.

Net Assimilation Rate, N.A.R. on a leaf area basis was calculated from the formula (Gregory, 11):

\[ (W_i - W_d) / (A_i - A_d) \]

where \( W_i \) and \( A_i \) are the mean dry weights and leaf areas of plants harvested at \( t_i \), and \( W_d \) and \( A_d \) are the mean dry weights and leaf areas of plants harvested at \( t_d \). The mean dry weight and leaf areas of plants at one sampling date were taken as the initial values for those harvested at the next sampling.

The other growth attributes, Relative Growth Rate (R.G.R.), Relative Leaf Growth Rate (R.L.G.R.), and Leaf Area Ratio (L.A.R.) were calculated from the following formulas from Thorne (18):

\[ R.G.R. = \frac{\log A_i - \log A_d}{t_i - t_d} \]

\[ R.L.G.R. = \frac{\log A_i - \log A_d}{t_i - t_d} \]

\[ L.A.R. = \frac{A_i}{W_i} \]

where \( W_i , A_i, W_d , A_d \) represent dry weights and leaf areas at the beginning and end of time interval, \( t_i - t_d \).

From the measurements made it was possible to study the growth components for the 4- to 7- and 7- to 10-week periods.

RESULTS

Dry matter production. The mean plant dry weight at the 10-week harvest date is shown in Table 1 along with the mean shoot dry weight and root dry weight. Reduced temperature greatly lowered the dry matter yield of the plants and Italian ryegrass generally produced a greater amount of dry matter than Irish perennial ryegrass. Both species grew best, in terms of dry matter accumulation, in the 25-12 regime.

Relative growth rate. In view of the above effect of temperature on total yield of ryegrass and the constant species

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* Species means differing significantly at the 5% level. Averages in the same column followed by the same letter do not differ significantly at the 5% level.