The Efficiency of Photosynthesis and Respiration in Loblolly Pines: Variation [1/]

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INTRODUCTION

Four questions govern our investigations concerning the variation and inheritance of photosynthetic efficiency and its association with vigor: (1) Is there variation in photosynthetic efficiency? (2) Is vigor an attendant quality? (3) Does photosynthetic efficiency, as measured, reflect a peculiar genic inheritance? (4) Can this measure of photosynthetic efficiency be used as a method of selecting superior vigorous strains?

During the past year several trials have been carried out to study the variation in rates 'of photosynthesis and respiration in pines. One of these trials involving eight one-parent progeny groups of loblolly pine seedlings will be discussed in this paper.

Carbon dioxide absorption and emission were measured to determine rates of apparent photosynthesis and respiration, respectively. Measurements of photosynthesis are complicated by the fact that respiration occurs simultaneously. Therefore, photosynthesis as measured in this study actually represents apparent photosynthesis. Respiration was measured because it is an indicator of metabolic activity and may prove to be a better way of expressing efficiency.

METHODS

The loblolly pine seedlings sampled in this trial were selected from eight one-parent progeny groups. Each progeny group was composed of ten one-year-old seedlings. These seedlings were removed from the greenhouse and placed in a controlled environmental room approximately three weeks prior to sampling.

The uptake of CO2 during photosynthesis and the release of CO_2 during respiration for each seedling were measured by a model 15A Beckman/Liston Infra-Red Analyzer. At the beginning of each sampling the system was flushed with fresh air after which the system was closed. The absorption curve for photosynthesis and the emission curve for respiration were produced on a recorder chart for a 5-minute time interval with constant recycling of the used air through the analyzer. As the purpose of the study was to make comparisons of gas exchange rates among progeny groups and not to determine absolute amounts of CO2 absorption and emission, the numerical recorder readings were used directly in the statistical analysis.

An inverted battery jar with inlet and outlet for circulating air was used as the plant chamber. The chamber, resting upon plates of aluminum, was sealed around the base of the seedling to be measured. Each seedling enclosed in the chamber was placed under a light bank in the controlled environment room for the measurement of photosynthetic rates. The seedling chamber was draped with a black plastic cover before recording the rates of respiration.

Environmental conditions inside the control room were approximately constant at all time and were conducive to sustaining a healthy state of all seedlings. Control room conditions were maintained at 40% of full sunlight, relative humidity at 80%, temperature at 85^0-90^0 F, and a 12 hour photoperiod. During the dark period temperatures were 15 -20 F cooler. Seedlings were watered daily and fertilized weekly with Hyponex.

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The size of all seedlings were measured after sampling. The various measurements of seedling size included total seedling dry weight, needle dry weight, and stem dry weight.

Seedlings were placed in a randomized complete block experimental design inside the control room. An analysis of variance and an analysis of covariance were used to test for significant differences in rates of photosynthesis and respiration among progeny groups. The analysis of covariance adjusted the mean rates of photosynthesis and respiration for differences in total seedling dry weights, needle dry weights, and stem dry weights. The analysis of variance was used to determine if significant differences existed among progeny groups for unadjusted mean rates of photosynthesis and respiration, for rates of photosynthesis and respiration on a per unit dry weight basis, and for dry weights of the loblolly pine seedlings.

RESULTS AND DISCUSSION

In analyzing for performance, mean rates of photosynthesis and respiration among the eight progeny groups when adjusted for seedling dry weight and needle dry weight by the analysis of covariance were not significantly different. The anlysis of variance for unadjusted mean rates of photosynthesis did not reveal any significant differences, but the unadjusted mean rates of respiration among the progeny groups were significantly different at the 5 percent level. In analyzing for variation in size, significant differences occurred among the progeny groups for seedling dry weights, needle dry weights, and stem dry weights. The differences in respiration among progeny groups may, therefore, be due to the larger size of seedlings in some of the progeny groups. However, the significant differences in seedling sizes among progeny groups had no affect on the rates of photosynthesis.

An analysis of variance of photosynthesis per unit seedling dry weights showed no signigicant differences, but photosynthesis per unit needle dry weight among the progeny groups was significantly different at the 1 percent level. These results tend to show that the rates of photosynthesis may not depend on the mass of green plant tissue alone, but that these seedlings may differ in their genetic capacity for rates of photosynthesis. However, volume measurements for seedling size, which were not available for this trial, may have been more preferable as a measure of functional green tissue. The significant difference of photosynthesis per unit needle dry weight may be due to an unrealistic quantification of photosynthesis. The process of photosynthesis occurs in hydrated green tissue which would be more accurately measured by volume or surface area.

The analysis of variance for respiration per unit seedling weight, per unit needle weight, and per unit stem weight revealed no significant differences among progeny groups. These findings furnish further evidence that significant differences among progeny groups for unadjusted mean rates of respiration were due to seedling size.

In general the results as presented for this trial agree with the results of other trials in this study using loblolly pine seedlings. In another trial, rates of photosynthesis and respiration of detached branches from slash pine clones were measured with similar results. However, the mean rates of photosynthesis and respiration for each of these clones will be compared with various morphological traits.

The use of covariance analysis methods may prove to be an important statistical tool in analyzing real differences in rates of photosynthesis and respiration among pine seedlings. In this trial photosynthetic and respiratory rates were adjusted for differences in seedling sizes, and no differences in performance were observed. Better parameters of functional tissue may be needed to relate gas exchange rates to the efficiency of these processes. The number of stomates per unit needle area or the concentration of chlorophyll in functional green tissue may provide such useful parameters.