RENEWAL OF GROWTH BY GUAYULE TRANSPLANTS

T. C. BROYER

(WITH TWO FIGURES)

Guayule seedlings were received from the federal nursery of the Emergency Guayule Project at various times of the year for use in a general study of the growth of this species under greenhouse conditions (1). Stock removed from the nursery at different times of the year showed markedly different powers of regeneration when transplanted to soil in the greenhouse. The best growth was obtained from stock transplanted from the nursery during the winter. As the season advanced from winter toward summer, a progressive decrease was observed in the ability of nursery stock to resume growth in certain soils. The resumption of growth of stock received from the nursery in June was very poor. A comparison of regeneration in soil contrasted with that in water culture is of particular interest.

Seedlings were shoot pruned in the nursery beds at successive intervals from late December, 1942, to early July, 1943. Shortly thereafter, as is usual in preparing for transplantation, these seedlings were removed from the soil after partial root pruning. The effects of pruning were accentuated at the time of experimentation by further abscission to reduce the transpiration surface to a minimum and by root trimming to expose fresh root surfaces for more ready entry of water. Seedlings were transplanted as soon as convenient after shipment—usually 1 to 2 weeks after removal from the nursery soils. Whenever possible, storage temperatures were maintained at about 15° C. Experiments were performed in vessels containing nutrient or soil media.

Successive lots of plants transplanted into the same type of soil renewed growth progressively more slowly, and the percentage regeneration decreased. The same phenomenon obtained when plants were placed directly in nutrient solutions—however, to a much smaller degree. In aqueous solutions the regeneration at all times was more rapid and a larger percentage of renewed growth was obtained. Within relatively wide time limits the absolute regeneration observable is merely a measure of rate. The rate of renewal of growth is possibly related, in one way or another, to the time of shoot and root pruning in relation to the phase of the plant's periodic growth cycle.

Conceivably, the availability of moisture in soils is a prime factor governing the regeneration relative to nutrient solution cultures. To test this point, when resumption of growth in soils was otherwise poor, successively increasing average moisture percentages were maintained in lots of Fresno fine sandy loam and Danville clay loam (from Richmond). The rate of

1 A report of observations reported at the Winter Research Conference of the Guayule Emergency Rubber Project, Salinas, California, February 5, 1944.
regeneration was essentially the same throughout the series. Scoring of the root stump did not influence the results. Further, pre-treatment of plants in these same soils, by subjecting the roots to maintained low temperatures (5° to 15° C.), did not affect their inability to renew growth when subsequently transferred to more favorable temperatures.

Another approach was made to the problem of regeneration in the summer season. Nursery plants were placed in a large tank containing Fresno fine sandy loam immediately and after intervals of 2 hours, 8 hours, 2 days, 4 days, and 1 week of presoaking of the roots in water. At this time, in

![Image](https://www.plantphysiol.org/)

**Fig. 1.** Growth of plants transplanted into nutrient solution and soil: Plant 1 was transplanted into Fresno fine sandy loam at 12 per cent. moisture (wet basis) and at the end of two weeks was transferred to aerated standard nutrient solution for 5 weeks; plant 2 was left in the Fresno fine sandy loam for 7 weeks; and plant 3 was transplanted to the soil for 2 weeks, transferred to aerated standard nutrient solution for 1 week, and then returned to the soil for another 4 weeks. All plants were transplanted to the soil on June 2 and photographed July 27, 1943.

the course of 2 to 3 weeks only about 5 per cent. of the plants regenerated in the soil, with no relation to the control treatment or to the interval of root presoaking. Yet similar plants whose roots were held in water, in dilute calcium sulphate or in a standard nutrient solution, with or without forced aeration, produced a high percentage of regeneration (root and shoot development was initiated in about 1 week). Further, the dormant plants from the soil, when subsequently transferred to an aerated standard nitrate nutrient solution very soon resumed root and shoot development and continued active growth. If plants subjected to the soil treatment,
followed by the nutrient solution treatment until root and shoot development was resumed, were then returned to the soil, continued growth was markedly retarded. Figure 1 shows representative plants from these treatments. Although no conclusion could be drawn from these observations, several suggestions may be offered. Aeration in the soil may be inadequate for plants to renew growth at the particular season of the year. Toxic substances or inhibitors of regeneration may be found in the soil, associated with a seasonal effect on the growth rate of certain soil microflora. Similar substances may be produced in the field stock, progressively higher in concentration as the season, size of plant, or physiological cycle of growth advances. (Note that in midwinter with nursery plants received in January, the regeneration in this soil was nearly complete.) These substances might be slowly lost to the rooting medium; in the solution they might be diluted enough to be relatively ineffective, or in the solution or within the plant itself they might be oxidized by higher aeration, whereas in the soil they might be retained at or near the root surface by the soil colloids and possibly at a lower oxidative level.

To test these possibilities, further soil cultures were arranged. Plants in soil, held within a favorable moisture range and aerated (by means of a carbon aerator placed along the bottom of the tank), were comparable with controls without aeration. Regeneration in sterilized soil was equal to, or perhaps slower than, that from check treatments. The resumption of growth was neither markedly increased nor inhibited by presoaking in solutions of β-indole acetic acid (50 p.p.m.) or of other growth factors (thiamin, nicotinic acid, pyridoxin, ascorbic acid, glycine), or by application of such solutions to soil. Addition of the standard nutrient solution to the soil had no beneficial influence. Alternate heavy wetting and relative drying proved less satisfactory than a maintained favorable moisture condition. A 1:1 soil-water extract of Fresno fine sandy loam in which guayule nursery plants had failed to grow actively (fig. 1) was prepared. With this 1:1 extract as a nutrient solution, growth was compared with that of plants similarly placed in a synthetic standard nitrate nutrient solution. Both aerated and unaerated cultures were compared for the two solutions. As figure 2 shows, development in the soil extract was less favorable than in the control nutrient. This was particularly true where aeration was not adequate.

Smith (5) has recently published his results of an independent study carried on over the same interval of time, in which he presents detailed observations on the inhibition of growth of transplants as affected by topping and defoliation. He relates the inhibition to an inhibiting agent coming from the leaves and terminal buds. He states "... topping was apparently instrumental chiefly in removing the inhibiting organs." When "growth was resumed within a few days time" it was considered that "the residual agent was inactivated or 'used up.'" Smith (4) has reported a favorable growth response by nursery stock whose roots were soaked in solutions of indole butyric acid (1 p.p.m.) prior to transplanting. These
results, suggesting, first, an inhibition of regeneration by factors in the shoots of transplants and, second, a beneficial effect of pretreatment by indole butyric acid are difficult to explain, as is the general mechanism of auxin function [compare (5), p. 335].

TINGEY, FOTE, SAMPSON, and COWLEY (6), in a study of the effects of top and root clipping as related to time of planting, found that less pruning gave better regeneration on transplanting. ERICKSON (2) found that preparation of nursery stock for transplanting by hardening, either through chilling or reducing the moisture percentage of the plants, was beneficial for regeneration. HILGEMAN (3) reported that in Arizona the percentage survival of transplants increased from June to January. In the course of the year, apart from specialized treatments applied to nursery stock to maintain a high percentage of regeneration on transplanting, there appears to be an annual cycle imposed upon this species in its ability to regenerate on transplanting in soil.

In the present study the nursery stock was similarly pruned within an experiment and as the season advanced. The differences here, therefore,
are not primarily related to the topping or defoliation conditions but were strikingly affected by environmental situations arising from the differential root culture; i.e., soil and solution (or water) media. It is difficult to visualize the soils employed as poorly aerated. Regeneration actively occurred in unaerated water even in the summer season when growth renewal was poorest in soils. Although the difference in regeneration may be related to the presence of growth inhibitors it seems unlikely that they are reduced in effective concentration directly within the plant in these experiments.

LITERATURE CITED