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SPEEDING UP THE GROWTH OF SEEDLINGS THROUGH ELECTRIC LIGHT ILLUMINATION

V. M. Leman

The rapid growing of trees is one of the most urgent tasks in carrying out the Stalin shelter belt planting plan. One of the means which can be used in speeding up the planned transformation of nature is the method of growing seedlings under artificial light.

V. P. Mal'chevskiy, the Soviet scientist who was killed during the siege of Leningrad, obtained very interesting and valuable results from his experiments in growing seedlings under artificial light. His experiments, which became known only in 1946, have shown that many kinds of tree seedlings can be grown under artificial light and that their growth under such light is more rapid than under natural light. His experimental plants outgrew those used as controls five, ten, and even twelve times during the first year of life. His dog roses (Rosa canina) bloomed during their first year when kept continuously under electric light. After having been under electric light continuously for six months, spruce (Picea), birch (Betula), honeysuckle (Lonicera xylosteum), mountain ash (Sorbus), and dog rose seedlings safely spent two winters in the open air without suffering ill effects. According to Mal'chevskiy's data, the reaction of various kinds of trees to intensity and duration of illumination is not identical. Thus, for instance, spruce hastens its growth under continuous illumination but does not react when its intensity is increased beyond 4,000 luxes; pine (Pinus) grows more rapidly when the light is turned off at night; but larch (Larix) and birch grow more rapidly under continuous illumination with the intensity of the light not less than 4,000 luxes.

The reaction of oak (Quercus) and several other species to electric light has ~~by this time~~ been studied in detail in the Moscow Agricultural Academy imeni K. A. Timiryazev. Experiments made under the supervision of N. A. Maksimov in recent years have shown that oak, birch, pine, and other seedlings definitely react to changes in lighting and to an increase in the length of the day.

In experiments conducted between 1944 and 1948, all plants were grown in small 10-centimeter diameter clay pots standing on a wooden rack under electric lamps. The soil used in the pots was ordinary podzolic soil and was not fertilized. The plants were watered once ~~every~~ each 24 hours. The lamps hanging over the plants were ordinary 500-watt lamps with shades. Each lamp illuminated an area one meter square, which accomodated up to 100 pots. The distance between the tops of the plants and the lamp bulbs varied between 50 and 70 centimeters. Because of inadequate voltage in the electric line, the lamps did not burn brightly and illuminated the plants with an intensity not exceeding 1,500-1,600 luxes; the plants farthest removed from the center of light received only 1,000-1,100 luxes.

Air temperature at the surface of the soil in the pots was 20-22 degrees C. Relative humidity was held between 65 and 75 percent. Seeds were usually planted in November or December and shoots appeared after the middle of December. As soon as the seeds had sprouted, the plants were placed under lights. After 4-5 months, the seedlings were transplanted in the open outside the building.

Ordinary oak (Quercus pedunculata Ehrh.), which is the primary species to be used in shelter belt creation work, was especially responsive to supplementary illumination.

It is a matter of common knowledge that, when grown from seed,

oak grows very slowly - more slowly than most deciduous and coniferous species - during the first 10 years of life.

Under natural conditions, oak seedlings stop growing in height about a month after sprouting and begin accumulating supplies of plastic matter. Growth in the diameter of the stem accompanies this accumulation process. With the advent of cold weather, the plants shed their leaves and enter a period of rest, which continues until the following spring.

A different pattern was observed when seedlings were kept under continuous electrical illumination. Under those circumstances, the life of the seedlings consisted of alternating periods of intensive growth in height accompanied by formation of new leaf rosettes and periods of comparative rest, during which the leaves did not fall. During the rest periods, brownish dormant nodules formed at the top of the plants. Each rest period was followed by a growth period and growth by rest throughout the time that seedlings were exposed to continuous illumination. The growth periods were usually 7-10 days long, the rest periods considerably longer, 10-40 days. Thus, a complete cycle of growth and rest varied in length between 17 and 50 days.

Upon completion of each growth period, the leaves quickly increased in size and took on normal shape. Their epidermis became rough and light green in color. Each new leaf rosette differed little from the rosettes formed in successive years when seedlings are grown in nurseries.

In experiments conducted in 1944-1945, seedlings had developed from 7 to 9 leaf rosettes (corresponding to from 7 to 9 growth periods) after 10 months of continuous illumination. The growth periods were separated by rest periods of varying duration. The plants, at the end

of 10 months, had grown to between 105 and 160 centimeters in height, i. e., they had grown 15-18 centimeters in height during each growth period.

In 1945-1946 experiments, seedlings had developed up to six leaf rosettes after six months of continuous illumination. They had grown 10-12 centimeters per growth period, or as tall as 70 centimeters at the end of six months. Experiments made in 1947 and 1948 duplicated these results. In 1949 experiments, seedlings had developed five leaf rosettes, grown to a height of 72 centimeters, and had more than 30 leaves.

In early spring, the seedlings were transplanted to an outdoor location. Before transplanting took place, the building was aired frequently so that the plants became accustomed to fresh air. Transplanting was usually accomplished without injury to the roots of the plants by inverting the pots, planting the seedlings with balls of earth around their roots, and watering the plants after planting.

The plants grew little the first year after transplanting. New leaves appeared only at the top and some old leaves sometimes fell off. But by fall, the seedlings were well acclimatized, their stems had become thicker, their bark had turned a deeper green, and their roots had gone down 0.5-0.6 meter into the earth.

The plants stood three winters with temperatures as low as 30 degrees below zero exceptionally well, even when there was little snow cover. There was little frost damage to their branches, not more than to those of the control plants. By the fourth year, there was no difference in appearance between the experimental plants and ordinary plants.

Leafing time in spring and leaf size and shape of experimental plants were entirely normal. A group of 60 seedlings transplanted in the spring of 1945 after six months' illumination had developed as follows by 1949: height, up to 160 centimeters; diameter of stem

just above roots, up to 25 millimeters; number of leaves per plant, 200 and more; average length of leaves, 120 millimeters; average width of leaves, 50 millimeters. These plants did not differ in external appearance from 6-8 year old oaks growing on podzolic soil in Moscow Oblast.

When seedlings are held under electric light culture for longer periods of time, their development is even greater. For example, after 10 months of light culture and four years in the open, oak seedlings attained a height of 230-260 centimeters. Diameter of their stems, just above the roots, varied between 20 and 45 millimeters, leaves numbered 400-500, leaf length averaged 130 millimeters, and leaf width averaged 60 millimeters. In external appearance, there was hardly any difference between these plants and 10-12 year old plants grown in the usual way.

In addition to oak seedlings, pine, birch, larch, and other kinds of seedlings were grown under continuous illumination. All outstripped their counterparts growing under natural conditions of illumination. Planted in May, they had reached the following heights by August (heights of controls in parenthesis): pine, 7 centimeters (4.5 cm); larch, 12 centimeters (5.3 cm); birch, 44 centimeters (21 cm).

Still better development was attained when seedlings were grown under electric lights in the wintertime. By April of the following year, larch had reached a height of 33 centimeters (control, 5.3 cm); birch, 103 centimeters (21 cm); ash (Fraxinus), 44 centimeters (24 cm); dog rose, 40 centimeters (7 cm); pine, 12 centimeters (4.5 cm).

Besides greater height, the experimental plants had better branch development and more leaves. Pine and larch needles were longer and thicker in diameter. Falling of leaves and needles was negligible.

The light culture method can be practically utilized by planting

tree seeds which do not require stratification (oak, larch, pine, birch, maple) immediately after they have been collected in the fall. They are planted in small boxes or clay pots; when sprouts appear, they are transferred from the nursery to hothouses or greenhouses. They receive natural light during the day, electric light during the night. Recent experiments have proved that night illumination can be comparatively weak; therefore, a 100- or even 60-watt bulb giving off 300-600 luxes is adequate for one square meter of illuminated area.

Most tree seedlings are shade tolerating. Under natural conditions, they grow in shady places under other trees or under bushes. Apparently, when seedlings are subjected to artificial light culture they retain their tolerance for shade. Therefore, there was little difference in the development of oak seedlings which received 1,500 luxes and those which received 700-800 luxes. While their growth under the influence of 800 luxes was somewhat less than under 1,500 luxes, the seedlings developed 2-3 leaf rosettes each with 4-6 leaves. Ordinarily, Plant photosynthesis takes place mainly during light day time hours and little additional development is noted during the 10-12 dark nighttime hours. Although plants growing in a nursery have considerably stronger light during the summer than those under electric light culture during the winter, they grow more slowly. Consequently, the decisive factor is not so much intensity as duration of illumination. Oak seedlings artificially lighted only 12 hours instead of 24 developed only one leaf rosette and then entered a rest period which lasted more than six months. But when again subjected to 24-hour illumination, they quickly began to form new leaf rosettes.

If acorns are planted at the end of October or beginning of November, they will sprout in December. If they are illuminated

during the next five months (150 days), the average night illumination period will be about 12 hours. Using a 100-watt lamp per square meter of space, power consumption per lamp will be 180 kilowatts for the 5-month period. If 100 plants are illuminated per square meter of space, the cost per plant will be 29 kopeks. If acorns are planted later, in December, the illumination period will be shorter and the cost less.

The light culture method is especially practical in regions where adequate electric power is available and where power is cheap (for example, near the DneproGES).

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