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Root and Shoot Growth Rate Relationships of Two Cultivars of Japanese Holly[1]

W. C. Mertens and R. D. Wright
Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Additional index words. plant nutrition, *Ilex crenata*

Abstract. **Rooted linears of *Ilex crenata* Thunb. 'Helleri' and 'Rotundifolia' were grown in polyvinyl chloride pipe sections from which longitudinal sections could be removed for root observations. Plants were fertilized at either 150 or 300 ppm N with a 20N–8.7P–16.5K soluble fertilizer. Rate of root and shoot growth was determined through 2-3 flushes of growth by taking weekly measurements of shoots and roots. Root growth of both cultivars was episodic in nature with active root growth usually preceding a shoot growth flush by 1 to 2 weeks. This growth pattern was observed in both fertility levels.**

As more nurserymen grow woody nursery plants in containers, root growth becomes an increasingly important consideration. In contrast to field-grown plants, the root system of container-grown plants is above ground and is subject to extremes in temp, moisture, and nutrient levels, and hopefully to greater control by the grower. Before control can begin, however, some knowledge of root growth patterns during the growing season is required.

Woody plants which have one annual flush of shoot growth normally exhibit root growth in spring and fall (7, 10). However, if moisture and nutrition are adequate, nursery plants produce shoot growth in multiple flushes during the summer months.

Gilliam and Wright (4) showed that fertilizer applied to 'Helleri' holly during the 2-week period following the cessation of stem elongation of one shoot flush, and before the beginning of the next flush, resulted in more effective N uptake and greater shoot growth compared to plants fertilized at other times during the flush. One explanation was that root growth may occur in an episodic pattern like shoot growth, with the most active root growth following the cessation of stem elongation in each shoot flush. This hypothesis is supported by the fact that nutrient uptake has been associated with young growing tips (2, 9).

This study was to determine when active root growth occurs in relation to the shoot flushes of 'Helleri' and 'Rotundifolia' holly grown at 2 fertilizer levels.

Materials and Methods

Expt. 1. Single-stem 'Helleri' cuttings (7 cm long) were taken Feb. 8, 1977, and placed in metal flats containing a medium composed (by vol) of 2 peat: 2 perlite: 1 Weblite (Webster Brick Company, Roanoke, VA 24012). Cuttings were rooted under intermittent mist (10 sec/10 min) and subsequently grown in a greenhouse at 28°C (day)/21° (night) under natural photoperiod until Sept. 30, when long day conditions were maintained with incandescent light at about 162 lux from 11 PM until 2 AM. After 4 weeks, 50 uniform rooted cuttings were transplanted into polyvinyl chloride (PVC) pipe sections, 3.8 cm diam × 30.5 cm long, containing the above medium.

For viewing and measuring root systems, a longitudinal section was cut from one side of each pipe according to Murdoch (8). The section was secured in place with masking tape and a rolled sheet of transparent acetate plastic was inserted to cover the inside of each pipe. A piece of nylon shade cloth was wired to the botton of each pipe to retain the growing medium. Pipe sections were transplanted cuttings were then placed at a 45° angle against a shelf with the window side down.

Twenty ml of 20N–8.7P–16.7K soluble fertilizer was applied weekly at levels of 150 or 300 ppm N. Micronutrients were applied once with a Hoagland and Arnon (5) micronutrient solution in which 5 ppm of iron was supplied in the form of NaFeEDTA. A randomized block design with 5 plants per treatment in each of the 5 replicates was used.

On April 24, 3 shoots and 3 roots per plant were selected for weekly measurements until Dec. 13. Growth occurring between measurements was determined, divided by the no. of days in the period, and plotted as growth rate (cm day^{-1}).

Soluble salt levels were determined for 5 tubes (1 from each replicate) on Oct. 5 and showed low readings indicating low

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fertility in tubes. Fertilization was changed on Oct. 14 by placing the tubes in a tub containing the fertilizer solution.

Expt. 1 was repeated from Sept. 18, 1977 to Feb. 2, 1978 except that cuttings were rooted directly in the pipe sections.

Expt. 2. Single stem 'Rotundifolia' holly cuttings (7 cm long) were propagated, grown, and measured as in Expt. 1 with the following exceptions: (a) cuttings were rooted directly in the pipe sections under intermittent mist to prevent transplant shock; (b) fertilizer treatments were begun July 26, 1977; (c) a randomized block design with 5 plants per treatment in each of the 4 replicates was used; (d) measurements were taken weekly from July 28, 1977 to Dec. 27, 1977.

Expt. 3. Container-grown 'Helleri' holly plants, about 25.5 cm in diam, were transplanted into PVC pipe sections, 15.2 cm diam × 40.7 cm long, on Nov. 3, 1977. A randomized block design with 2 plants per treatment in each of 4 replicates was used. The 2 fertilizer treatments were initiated Nov. 11, 1977, and due to the large soil surface area of the tubes, surface fertilizer application was used for the duration of the experiment. The length of 5 shoots and 5 roots per plant were recorded at weekly intervals from Dec. 1, 1977 to Feb. 16, 1978.

Results

Root growth of both cultivars of Japanese holly in all experiments was episodic with each root flush usually preceding a shoot flush by 1 to 2 weeks (Fig. 1 and 2). Growth patterns for 'Rotundifolia' holly (Expt. 2) were identical to 'Helleri' holly and therefore are not shown. Episodic responses were observed at both fertility levels in each of the 3 experiments and the rate of root growth for each experiment and cultivar was shown to be greater at 300 ppm N than at 150 ppm, although not significantly at the 5% level (data not shown).

Exceptions to the chronological order of root growth to shoot growth occurred in Expt. 1 and 2. Following the 2nd root and shoot growth flush in Expt. 1, there was a period of 2 to 3 months in which no shoot growth occurred (Fig. 1). Root growth, however, continued throughout this period of inactive shoot growth. After bottom fertilization was begun on Oct. 14, shoot growth began again within 3 weeks with a concurrent decrease in root growth.

Data from the repeat of Expt. 1 (Fig. 2) shows the normal patterns of shoot growth for 'Helleri' holly grown under adequate nutritional programs in a nursery. This experiment presents a clear picture of the chronological relationship of root to shoot growth.

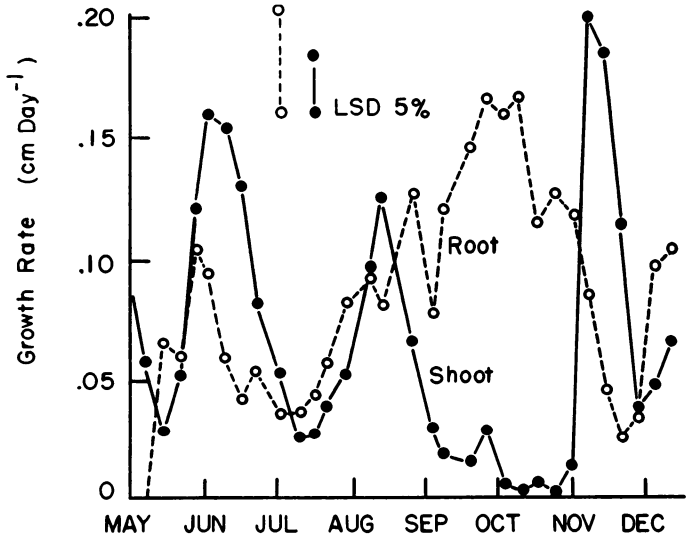

Fig. 1. Root and shoot growth rates of 'Helleri' holly grown at 300 ppm N applied as 20N–8.7P–16.5K soluble fertilizer.

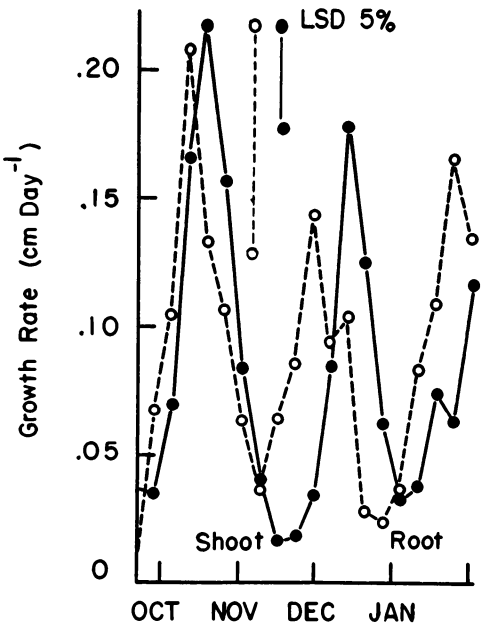

Fig. 2. Root and shoot growth rates of 'Helleri' holly grown at 150 ppm N applied as 20N–8.7P–16.5K soluble fertilizer.

The cycles of root and shoot growth in Expt. 3 were similar to the cycles that had occurred in Expt. 1 and 2 (data not shown) indicating that the relationship of root growth preceding shoot growth holds for larger plants comparable in size to plants that are grown in 4 ℓ containers in the nursery industry.

Discussion

A period of active root growth preceded each shoot flush of 'Helleri' and 'Rotundifolia' holly. These finding are similar to those reported by Kulasegaram and Kathiravet (6) who showed that the feeder roots in tea exhibit periodic growth similar to the multiple flushes of the top parts of the tea plant.

One theory which might explain the results of the above study and these reported in this investigation is as follows. N absorbed by plant roots tends to react first with carbohydrates in the roots (1, 11). As the root system develops to the extent that it can absorb higher levels of fertilizer, nutrients in excess of what is needed for root growth are translocated to the plant tops where they are used in conjunction with carbohydrates there for protein synthesis and shoot growth. Consequently, less carbohydrates remain for translocation to the roots, and root growth is then limited relative to the shoot growth. Since root growth, and hence nutrient absorption, is at a low level, new shoot growth eventually depletes the nutrient level within the plant, and growth of the plant top ceases. Carbohydrates become available again for translocation to the roots, root growth and nutrient absorption begin again, and the cycle repeats itself. In agreement with this theory, Gilliam and Wright (3) have shown with 'Helleri' holly that the tissue N concentration of the plant top is at its highest level when shoot growth begins and at its lowest level when shoot growth ceases.

Periods of active root growth preceding successive top flushes would explain further results obtained by Gilliam and Wright (4) who found fertilizer to be more efficiently used by 'Helleri' holly when applied during a period following the cessation of shoot elongation and preceding the next flush of shoot growth.

A nutritional correlation between periods of root and shoot growth as described above would also explain the 2 to 3 month periods in Expt. 1 in which no shoot growth occurred (Fig. 1).

The 20 ml of fertilizer solution applied to each plant at the soil surface was insufficient to penetrate to the lower portions of the containers where root growth was most active. The low fertilizer level was adequate for root growth which continued until fertilizer levels were increased by bottom fertilization. When higher fertilizer levels reached the roots in the lower portions of the tubes, root growth decreased and shoot growth increased.

With this knowledge, and if similar trends are recorded for other container-grown woody plants, nurserymen should be able to positively manipulate both root and shoot growth by timing fertilizer applications to correspond with the most active periods of root growth.

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Promotion of Inflorescence Development by Growth Substance Treatments to Tomato Plants Grown in Insufficient Light Conditions[1]

J. M. Kinet, D. Hurdebise, A. Parmentier, and R. Stainier[2]

Centre de Physiologie Végétale Appliquée (I.R.S.I.A.), Département de Botanique, Université de Liège, Sart Tilman, B-4000 Liège, Belgium

Additional index words. Lycopersicon esculentum, benzyladenine, gibberellins, carbohydrates

Abstract. **The development of the inflorescence of tomato (*Lycopersicon esculentum* Mill.) plants grown in adverse light conditions was stimulated by exogenous applications of benzyladenine (BA) and gibberellin (GA) directly on the inflorescence. These two compounds had sequential effect in regulating the development of the inflorescence, the action of BA being exerted first and that of GA only subsequent to BA action. In combination with BA, GA_{4+7} was more effective than GA_3 in promoting the development of the inflorescence. Determinations of carbohydrate contents in the inflorescences showed that during the treatment period with the growth substances, the soluble sugars and starch levels increased temporarily. Studies on the partitioning of the dry matter between the different plant portions suggested that the growth substances modified the distribution pattern of the assimilates within the plant; the inflorescence being favored at the expense of the young leaves above.**

The development of the inflorescence of tomato plants grown in adverse light conditions is greatly enhanced by applications of growth substances localized on the inflorescence (20). BA and GA_3 applied simultaneously are particularly effective. Thus, the use of these chemicals could be valuable in practice, especially during winter periods when abortion of the inflorescence is common due to insufficient light conditions (2, 8, 9).

The mechanism by which these growth substances favor the development of the inflorescence in tomato is not clear. A possible action could be by redirecting the flow of assimilates as has been previously shown for cytokinins (29, 34) and for gibberellins (14, 18) in other species.

The present study was undertaken with the objective of answering the concern as to the effectiveness of the growth substances, and the suitability of these procedures which would permit recommendations for commercial usage.

Materials and Methods

Growth conditions. All the experiments were carried out in the growth rooms of the phytotron of the Botanical Department at Liège. Seeds of "King Plus" tomato (supplied by Pannevis, Duffel, Belgium) were germinated at 26°C in peat compost (TKS1 from Floratorf, Oldenburg, Germany). After 2 weeks, plants were pricked out into 7 cm pots and later transplanted into 14 cm pots, both filled with TKS2 peat compost (Floratorf). For the studies on the partition of dry matter, the plants were grown from seeds in perlite. Water was supplied daily and a modified Hoagland solution (38) was provided once a week as long as the plants were maintained in 7 cm pots. After transplanting to 14 cm pots the nutrient solution was supplied twice a week. During growth, the day

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[2]Centre National de Production et d'Etude des Substances d'Origine Microbienne (C.N.P.E.M.), 32, Boulevard de la Constitution, B4020 Liège, Belgium. The authors gratefully acknowledge Prof. R. M. Sachs (Dept. of Landscape Horticulture, Univ. of California, Davis), Prof. G. Bernier and Dr. M. Bodson (Dept. of Botany, University of Liège) for their constructive criticisms of the manuscript.