INFLUENCE OF EXOGENOUS AUXIN APPLICATION ON THE MINERAL NUTRIENT STATUS OF 'CONVEXA' HOLLY CUTTINGS DURING INTERMITTENT MIST PROPAGATION

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Abstract. Hardwood stem cuttings of *Ilex crenata* 'Convexa' Thunb., treated with and without indolebutyric acid (IBA), were inserted into a perlite rooting medium and misted with deionized water during intermittent mist propagation in a controlled-environment chamber. Initially, and at weekly intervals for 6 weeks, leaves, upper stems (portion of stem above rooting medium) and lower stems (portion of stem in rooting medium) were analyzed for N, P, K, Ca, and Mg. At the conclusion of the study, both nontreated and IBA-treated cuttings showed a slight increase in dry weight with detectable but slight leaching of N and K and no detectable leaching of P, Ca, and Mg. Mineral nutrient mobilization to the lower stem was not detected during root initiation for nontreated and IBA-treated cuttings. Following root initiation and later budbreak on the upper stem, N, P, K, Ca, and Mg were all mobilized from the leaves of nontreated and IBA-treated cuttings to the upper stem, whereas only N, P, and K were mobilized to the lower stem of IBA-treated cuttings. For nontreated cuttings, all nutrients were mobilized from the lower stem to the upper stem, while for IBA-treated cuttings only Ca and Mg were mobilized from the lower stem to the upper stem. Root development, as influenced by IBA treatment and budbreak on the upper stem, had a strong influence on mineral nutrient mobilization.

During intermittent mist propagation of nonauxin-treated 'Convexa' holly cuttings, Blazich and Wright (2) reported no mobilization of N, P, K, Ca, and Mg from the upper portions (leaves and upper stems) of the cuttings into the stem base (portion of stem in rooting medium) during root initiation. Their data also suggested that up to the time of root initiation, there was little or no leaching of these mineral nutrients, in contrast to reports of leaching from cutting of other plants during mist propagation (5).

One provocative aspect of rooting with respect to nutrient mobilization is the role of exogenously applied auxin. Although workers have investigated the effects of applied auxin on mobilization of carbohydrates (1,4,10) and N (9,10) it appears that no research has addressed the question of whether or not applied auxin has any influence on mobilization of such mineral nutrients as P, K, Ca, and Mg. To consider this hypothesis and enhance knowledge of mist propagation, the following investigation was undertaken to explore the influence

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of exogenous auxin application on the mineral nutrient status of 'Convexa' holly cuttings during intermittent mist propagation.

MATERIALS AND METHODS

Uniform, hardwood, terminal stem cuttings, 12 cm long were taken on February 25, 1981 from containerized 'Convexa' holly stock plants growing out-of-doors at uniform fertility levels at Suffolk, Virginia. As cuttings were collected, they were wrapped in moist paper towels, placed in a cooler, and transported to Raleigh, North Carolina. The following day, the experiment was initiated at the Southeastern Plant Environment Laboratory (Phytotron) at Raleigh.

Cuttings were trimmed from the base to 10 cm in length and leaves removed from the basal 4 cm. Two rooting treatments were employed: nontreated and 5000 ppm IBA. When treating cuttings with IBA, the basal 2 cm were dipped into a 5000 ppm IBA solution for 1 sec. followed by 15 min. of drying before insertion into the rooting medium. The IBA solution was prepared by dissolving reagent grade chemical in 50% isopropyl alcohol.

Following treatment, cuttings were inserted to a 4-cm depth in plastic flats (53.0 × 37.5 × 6.5 cm) containing a moist medium of unscreened perlite, which had been thoroughly leached with deionized water. The flats were then placed in a Sherer CEL 38-15 growth chamber at day/night ambient air temperatures of 24/18 ± 0.5°C. An 11-hr. photoperiod was provided daily from 0700 to 1800 hours by a combination of cool white fluorescent and incandescent lamps providing a photon flux density (photosynthetic radiation between 400 and 700 nm) of 120 to 125 $\mu mol/m^2/s$ (8.8 to 9.0 klx) plus a radiant power density (photomorphogenic radiation between 750 and 830 nm) of 2.1 to 2.2 W/m^2 measured at the top of the flats with Li-Cor LI 185A quantum/radiometer/photometer. Relative humidity was maintained at 97 ± 1%. The chamber was equipped with an intermittent mist system, utilizing deionized water which operated 20 sec. every 30 min. from 0630 to 1830 hours daily.

Initially, and at weekly intervals for 6 wk., the leaves, upper stems (portion of stem above rooting medium) and lower stems (portion of stem in the rooting medium) were analyzed for N, P, K, Ca, and Mg. For each rooting treatment, 4 replicates each consisting of the particular plant parts from 20 randomly selected, viable cuttings were oven-dried for 48 hours at 70°C, weighed, and ground in a Wiley mill to pass a 20-mesh screen. Total N was determined by a modified micro-Kjeldahl method (8), Ca, Mg, and K by atomic absorption spectrophotometry, and P colormetrically (11). Data were subjected to analysis of variance procedures and regression analysis.

RESULTS

Dry weight and total mineral nutrient status after 6 weeks. During propagation there was highly significant increase and a significant increase in the dry weight of the

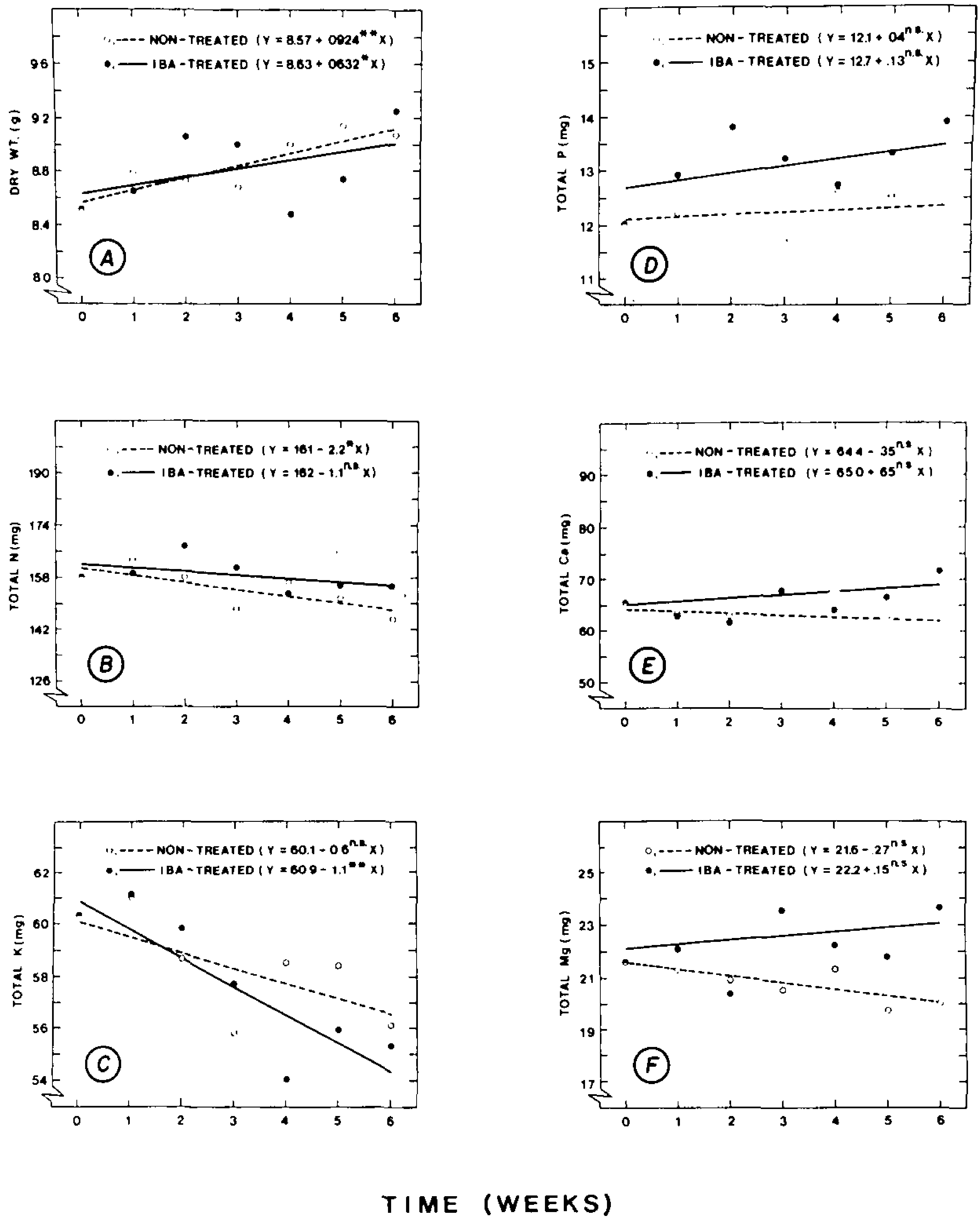

Figure 1. Dry weight and total N, K, P, Ca, and Mg content of nontreated and IBA-treated *'Convexa'* holly cuttings during intermittent mist propagation for 6 weeks. Each data point represents the mean of 4 observations. The superscripts n.s., * or ** above each regression coefficient indicate the following: n.s. = nonsignificant, * = significant at 0.05 level, and ** = significant at 0.01 level.

nontreated and IBA-treated cuttings, respectively (Fig. 1A). A significant decrease of total N was found for nontreated cuttings while IBA-treated cuttings showed a decrease that was not significant for the same parameter (Fig. 1B). A similar but reversed relationship was noted for total K. The K content of nontreated cuttings decreased but not significantly while a highly significant decrease in total K was noted for the IBA-treated cuttings (Fig. 1C). However, no significant differences were found in a comparison of the regression coefficients for nontreated versus IBA-treated cuttings with respect to total N and K. For the other mineral nutrients considered in this study, there were no significant changes in the total P, Ca, and Mg content of the nontreated and IBA-treated cuttings (Figs. 1D, 1E, and 1F).

Changes in dry weight and mineral nutrient content of leaves, upper stem and lower stem after 6 weeks. At 6 weeks, major changes were noted in dry weight and in distribution of N, P, K, Ca, and Mg expressed as a percent change in fraction of total (Tables 1 and 2). The leaves of both nontreated and IBA-treated cuttings showed a highly significant decrease in all 6 parameters. The opposite, a highly significant increase for the same parameters was noted for the upper stem (Table 2). The magnitude of the dry weight increase in the upper stem was considerably greater in the nontreated cuttings in comparison to the IBA-treated cuttings (72% vs. 55%). The lower stem of nontreated cuttings, which included the newly formed roots (approximately 5 primary roots) exhibited a nonsignificant decrease in dry weight and a highly significant decrease in N, P, K, Ca, and Mg (Table 2). Conversely, for the lower stem of IBA-treated cuttings, which also included the newly formed roots, (approximately 70 primary roots), a highly significant increase was noted for dry weight, N, P, and K while a highly significant decrease was found for Ca and Mg (Table 2).

Table 1. Dry weight and distribution of N, P, K, Ca, and Mg in leaves, upper stem, and lower stem of 'Convexa' holly cuttings before treatment (time 0) expressed as a percent of total for each parameter.[z]

Portion of cutting	Percent of total					
	Dry wt.	N	P	K	Ca	Mg
Leaves	58.2	80.7	63.1	72.2	73.4	79.6
Upper stem	20.4	9.3	17.8	13.4	15.2	10.3
Lower stem	21.4	10.1	19.2	14.4	11.4	10.1

[z] Values represent intercept means of the regression lines for each portion of nontreated and IBA-treated cuttings.

Table 2. Percent change in fraction of total dry weight and distribution of total N, P, K. Ca, and Mg in leaves, upper stem, and lower stem of nontreated and IBA-treated 'Convexa' holly cuttings during intermittent mist propagation for 6 weeks.[z]

Portion of cutting	Nontreated					
	Dry wt.	N	P	K	Ca	Mg
Leaves	-22**[y]	− 25**	− 42**	− 41**	− 3**	− 6**
Upper stem	+72**	+245**	+169**	+247**	+29**	+97**
Lower stem	− 8 n.s.	− 18**	− 22**	− 31**	−19**	−53**
	IBA-treated					
Leaves	-27**	− 34**	− 49**	− 51**	−10**	− 12**
Upper stem	+55**	+180**	+137**	+203**	+61**	+134**
Lower stem	+23**	+102**	+ 40**	+ 73**	−13**	−34**

[z] Values are based on individual regression lines for each portion of cutting.
[y] (+) indicates an increase and (−) a decrease; n.s. indicates nonsignificant and ** significant at the 0.01 level.

DISCUSSION

Since no significant differences were found in a comparison of the regression coefficients for nontreated and IBA-treated cuttings with respect to total N and K (Figs. 1B and 1C) and, in addition, they agree in sign, we conclude that N and K were leached from both nontreated and IBA-treated cuttings during intermittent mist propagation. However, loss of total N and K in 6 weeks was small, amounting in nontreated and IBA-treated cuttings, respectively, to 8.1 and 4.1% N, and 5.8 and 10.8% K.

Leaching of N and K, as the data indicate, supports a previous report showing these mineral nutrients can be leached from stem cuttings of a wide variety of plants during intermittent mist propagation (5). This same report also showed that leaching of N, P, K, Ca, and Mg was more pronounced from hardwood than herbaceous and softwood stem cuttings. The previous statement is intriguing because hardwood 'Convexa' holly cuttings were used in the present study and only slight leaching of N and K was detected with no apparent loss of P, Ca, and Mg.

Although our data indicate that slight but detectable leaching of N and K occurred, a portion of these losses may have been due to flower bud development. By the fourth week of this study profuse flower bud development was noted on both nontreated and IBA-treated cuttings. However, due to the small size and fragile nature of the floral tissue, most of this material was lost in sample preparation, particularly during drying and grinding. Loss of this tissue may have contributed to N and K loss. If indeed this occurred, then leaching of N and K might have been less than reported.

Slight increases, although nonsignificant, in total P content for nontreated and IBA-treated and total Ca and Mg content for IBA-treated cuttings were noted (Figs. 1D, 1E, and 1F). Since deionized water was used to mist the cuttings and analysis of the water and rooting medium showed trace amounts of these mineral nutrients, the increases can most easily be explained as sampling variation.

One week after the study was initiated, the basal portion of both nontreated and IBA-treated cuttings showed noticeable swelling, indicating root initiation had taken place. Swelling was more pronounced on the IBA-treated cuttings. In addition to the swelling, many of the auxin treated cuttings had vertical cracks in the epidermal tissue on the basal stem. This is usually observed as roots prepare to emerge. By 2 weeks, roots were observed emerging on both the nontreated and IBA-treated cuttings. Apparently root initiation took place within the first week whether or not cuttings were treated with auxin. The cracking of the epidermal tissue on some of the IBA-treated cuttings also suggests that for these cuttings, root initiation had occurred and root development and growth were progressing.

Comparison of lower stem dry weight and mineral nutrient data before treatment (time 0) and the first week showed some change in most parameters measured (data not presented). However the changes, particularly an increase, when noted were never of sufficient magnitude to suggest or conclude that mineral nutrient mobilization took place during root initiation regardless of the rooting treatment. Nonmobilization of mineral nutrients while 'Convexa' holly cuttings are undergoing root initiation is in agreement with previous work on this cultivar (2). In the weeks following root initiation, mineral nutrient mobilization particularly into the lower stem of IBA-treated cuttings could be observed as nutrients were mobilized in support of root development. Thus, it appears mineral nutrient mobilization does not occur until root initiation has taken. place and root development and growth commences.

At the conclusion of the study, it was shown that redistribution of mineral nutrients took place in response to terminal budbreak (observed at 3-weeks for nontreated and IBA-treated cuttings) and root development on the lower stem. Redistribution of mineral nutrients during rooting and budbreak as observed in this study supports previous research (6).

Nutrients were mobilized to the lower stem in response to root development and (approximately 5 primary roots on nontreated cuttings vs. 70 primary roots on treated cuttings) and to possible sinks created by budbreak on the upper stem (Table 2). The partitioning of mineral nutrients between the upper and lower stem of IBA-treated cuttings is reflected in less of an absolute increase in the dry weight of the upper stem of these cuttings in comparison to the non-treated cuttings. This probably occurred because in the nontreated cuttings, nutrient mobilization took place only in response to budbreak on the upper stem, whereas in the IBA-treated cuttings mobilization took place in response to both terminal budbreak and auxin stimulated root development. As suggested by Booth *et al.* (3) the effect of applied auxin on the transport of substances within the plant may be indirect as a result of auxin-induced growth stimulation and subsequent movement of various substances to these areas of growth.

As observed for the nontreated cuttings, IBA-treated cuttings showed highly significant increases in all 6 parameters for the upper stem (Table 2). For the lower stem of IBA-treated cuttings, highly significant increases in dry weight and N, P, and K content were observed which probably resulted from extensive root development. However, there was a highly significant decrease in the Ca and Mg content of the lower stem despite greater root development in comparison to the nontreated cuttings. It appears the sink created by budbreak on the upper stem had a stronger influence on Ca and Mg mobilization than the developing roots. As reported by Mengel and Kirby (7) the preferential movement of Ca to the upper stem of nontreated and IBA-treated cuttings may have resulted from the synthesis of indoleacetic acid (IAA) in the shoot apex which caused the growing point to become a sink for Ca accumulation (7). Why Mg was also mobilized out of the lower stem of both nontreated and IBA-treated cuttings is subject to speculation and might be related to the role of Mg as a constituent of chlorophyll. Perhaps a higher chlorophyll content in the newly developing tissue on the upper stem in comparison to a lower chlorophyll concentration in the lower stem had some bearing on this movement.

Initially, the leaves of the cuttings contained the greatest proportion of N, P, K, Ca, and Mg (Tables 1 and 2). The fact that leaves of both nontreated and IBA-treated cuttings showed a highly significant decrease in dry weight with a concomitant decrease in N, P, K, Ca, and Mg (Table 2), demonstrates that a large portion of the new growth produced by the cuttings was a result of mineral nutrients supplied by the leaves. These data demonstrate that when rooting cuttings, nutrients should be applied when roots are present to prevent depletion of nutrients from the leaves.

It is generally agreed that N, P, K, and Mg are mobile in plants and Ca is immobile (7). The data in Table 2 support the mobility of these mineral nutrients and show that under conditions such as reported herein, Ca is also mobile.

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