taken immediately to prevent undue loss. All dead or damaged cuttings should be removed at once. Any leaves which may have fallen from nearby cuttings should be removed and the whole area cleaned and groomed.

Semesan Control:

Then the immediate area of attack should be treated with double strength Semesan and the whole greenhouse treated with single-strength Semesan. We have found that this mercury compound is superior to any other in the control of this disease and if the treatment is applied rapidly, the disease is stopped in its tracks.

This seems to end the problems with which we have been faced, with the exception of the item which is to be dealt with by the next speaker, and that is "Leaching."

There seem to be certain types of cuttings which are just not responsive to mist culture and I believe that these have to be determined by trial and error. Deciduous Azaleas are among these. The cuttings are taken in a very soft condition. They are always slow to root and with the steady application of mist over a period of two and a half month to three months, the cuttings almosts invariably collapse before rooting.

I mention this because I have no answer for it and I am therefore waiting eagerly to hear the comments of the next speaker, who I hope will give me the answer to the problem.

MODERATOR HESS: Another problem which has been called to our attention by the excellent work of Dr. Harold Tukey, Jr. and his graduate students at Cornell University is leaching by mist. We are fortunate to hear from Mr. George Good who is actively working on this problem.

THE INFLUENCE OF INTERMITTENT MIST ON THE MINERAL NUTRIENT CONTENT OF CUTTINGS DURING PROPAGATION

G. L. GOOD AND H. B. TUKEY, JR.
Department of Floriculture & Ornamental Horticulture
Cornell University, Ithaca, New York

INTRODUCTION

Foliar leaching is the removal of metabolites from plant parts by aqueous solutions, (Tukey, 1962). Leaching has been shown to be of importance in plant nutrition, in the distribution and recycling of nutrients in an ecosystem, and in the quality of certain food crops. It has also been shown that many factors may affect the leaching of nutrients. For instance, the age and the maturity of the plant tissue can influence the amount of leaching which occurs from plant tissue. Young, actively grow-

Contribution NYO-2598-28 of Atomic Energy Commission Contract AT(30-1)-2598

ing plant tissue is difficult to leach, whereas, more mature tissue is relatively easy to leach.

There are reports by various workers that cuttings propagated under mist undergo extensive losses of nutrients during the rooting period (See Good and Tukey, 1964). Since a large number of ornamental plants are commercially propagated under mist, it was of interest to survey cuttings from a wide range of ornamental plants to determine the extent of nutrient leaching.

METHODS

Herbaceous cuttings of carnation (*Dianthus caryophyllus* cv. 'White Sim'), chrysanthemum (*Chrysanthemum morifolium* cv. 'Indianapolis White'), coleus (*Coleus blumei*), and poinsettia (*Euphorbia pulcherrima* cv. 'Barbara Ecke Supreme'); softwood cuttings of currant (*Ribes alpinum*), two species of euonymus (*Euonymus alatus* and *E. fortunei vegeta*), honeysuckle (*Lonicera tatarica*), pachysandra (*Pachysandra terminalis*) and privet (*Ligustrum ibolium*); and hardwood cuttings of arborvitae (*Thuja plicata*), boxwood (*Buxus sempervirens*), English ivy (*Hedera helix*), forsythia (*Forsythia intermedia*) and yew (*Taxus cuspidata capitata*) were all surveyed for leaching when rooted under mist.

Forty uniform cuttings of each species were standardized as to leaf number and fresh weight. Before rooting, one-half of each group was oven dried, weighed and analyzed for nitrogen, phosphorus, potassium, calcium, and magnesium. The other half were placed in a rooting medium of coarse quartz sand under an intermittent mist of distilled water. After they were rooted, they were also dried, weighed and analyzed for the same nutrients.

The leachate from the cuttings was collected and analyzed in the same manner as the cuttings.

Chrysanthemum cuttings were used to study the redistribution of nutrients within cuttings during rooting. Three hundred and sixty uniform cuttings were selected so that each had three fully expanded leaves. The 360 cuttings were divided into six groups of 60 cuttings each and each group was inserted into a 1:1 vermiculite: perlite medium under an intermittent mist of distilled water. One of each of the groups was removed from under the mist after 0, 3, 6, 9, 12 and 15 days. Each cutting was cut into 3 segments (a) the 3 oldest leaves which were on the cutting at the beginning of the experiment, (b) the stem apex and new leaves, and (c) the basal one inch of stem and newly developed adventitious roots. The plant tissue was dried, weighed and analyzed for nitrogen, phosphorus, and potassium.

RESULTS

Influence of Cutting Maturity:

Herbaceous cuttings. In the first experiment herbaceous cuttings of chrysanthemum, carnation, coleus and poinsettia were rooted under the intermittent distilled water mist. The cuttings were analyzed both before and after rooting to determine the nitrogen, phosphorus, potassium, calcium and magnesium content. Table 1 shows the results from the analyses of two representative species of this group, chrysanthemum and carnation. There was no change in the nutrient content before and after rooting except in the case of magnesium in chrysanthemum. This indicated little or no leaching of the nutrients by the mist. Cuttings of poinsettia and coleus showed similar results in that little or none of the nutrients were leached.

Table 1 Nutrient content of herbaceous cuttings before and after rooting under intermittent mist[1]

Species	N	P	Nutrient K	Ca	Mg
			(mg/cutting)		
Chrysanthemum morifolium					
Before Rooting	25.3	4.1	25.4	8.3	3.3
After Rooting	25.5	4.8	28.1	9.7	1.3*
Dianthus caryophyllus					
Before Rooting	20.7	2.1	18.1	2.6	1.4
After Rooting	19.9	2.1	18.2	2.2	1.5

*Significant decrease at the 5% level due to leaching.
[1]From Good and Tukey, Proc Am Soc Hort Sci. (in press)

Softwood cuttings. In a second experiment, softwood cuttings of currant, euonymus, honeysuckle, pachysandra and privet were rooted under the distilled water mist. Table 2 shows the results of the analysis both before and after rooting of two representative species of this group, currant and honeysuckle. Currant showed leaching of potassium only, while honeysuckle showed leaching of potassium and magnesium. The other softwood cuttings in this group showed similar results in that little

Table 2. Nutrient content of softwood cuttings before and after rooting under intermittent mist.[1]

Species	N	P	Nutrient K	Ca	Mg
			(mg/cutting)		
Ribes alpinum					
Before Rooting	15.6	1.9	10.9	9.7	1.2
After Rooting	16.6	1.6	8.6*	9.3	1.6
Lonicera tatarica					
Before Rooting	34.8	2.3	21.5	13.8	3.0
After Rooting	36.0	2.4	17.6*	12.6	1.1*

*Significant decrease at the 5% level, due to leaching
[1]From Good and Tukey, Proc Amer Soc Hort Sci (in press)

Table 3 Nutrient content of hardwood cuttings before and after rooting under intermittent mist.[1]

Species	N	P	K	Ca	Mg
			Nutrient (mg/cutting)		
Forsythia intermedia					
Before Rooting	21.6	2.6	12.9	16.7	3.8
After Rooting	20.7	1.5*	10.3*	11.1*	0.8*
Ribes alpinum					
Before Rooting	13.7	2.6	10.5	12.4	1.6
After Rooting	11.6*	1.8*	6.5*	8.2*	1.6

*Significant decrease at the 5% level, due to leaching
[1]From Good and Tukey, Proc Amer Soc Hort Sci (in press)

or no nutrients were leached during rooting under mist. Thus, softwood cuttings proved difficult to leach.

Hardwood cuttings. Since it has been reported that more mature plant tissue is relatively easy to leach (Tukey, 1962), hardwood cuttings of arborvitae, boxwood, currant, English ivy, forsythia, and yew were taken from stock plants in September before frost. The cuttings were analyzed both before and after rooting under mist. The results of the analyses of two representative species, forsythia and currant are shown in Table 3. Unlike herbaceous and softwood cuttings, hardwood cuttings showed extensive leaching of mineral nutrients. Forsythia lost appreciable amounts of phosphorus, potassium, calcium, and magnesium, and currant lost nitrogen, phosphorus, potassium and calcium.

Thus, the maturity of the cutting plays a key role in determining the extent of nutrient leaching under mist. This is demonstrated in Table 4 where the nutrient content of both soft-

Table 4. Leaching of nutrients from cuttings of *Ribes alpinum* propagated under intermittent mist as influenced by the maturity of the cuttings[1]

Cutting Maturity	Nutrient				
	N	P	K	Ca	Mg
Softwood					
Before Rooting	15.6	1.9	10.9	9.7	1.2
After Rooting	16.6	1.6	8.6	9.3	1.6
Nutrient Leached			2.3*		
Hardwood					
Before Rooting	13.7	2.6	10.5	12.4	1.6
After Rooting	11.6	1.8	6.5	8.2	1.6
Nutrient Leached	2.1*	0.9*	3.9*	4.1*	

*Significant decrease at the 5% level, due to leaching
[1]From Good and Tukey, Proc Amer Soc Hort Sci (in press)

wood and hardwood cuttings of currant are compared before and after rooting under mist. The softwood cuttings taken in the spring lost only significant amounts of potassium, but hardwood cuttings of the same species taken in September lost significant amounts of nitrogen, phosphorus, potassium and calcium.

Growth and Redistribution in Cuttings During Rooting:

Dry weight of all the cuttings were recorded both before and after rooting under mist. As shown in Table 5 cuttings weighed substantially more after rooting than before indicating that growth had occurred as the cuttings rooted. Herbaceous cuttings of chrysanthemum increased more than 300% in dry weight during rooting while herbaceous cuttings of carnation and softwood cuttings of currant and honeysuckle increased 50% or more. These increases in dry weight came from additions of carbohydrates from photosynthesis, as there was no increase in the nutrient content (Tables 1 and 2).

Hardwood cuttings of currant and forsythia also grew, during rooting. but not to the extent of either the softwood or herbaceous cuttings.

Since the cuttings did grow during rooting, a more detailed analysis of the growth and distribution of nutrients within parts of each cutting was made with the intent of explaining, in part, the difference is leachability of various cuttings.

Cuttings of chrysanthemum were rooted under the distilled water mist for 0, 3, 6, 9, 12 and 15 days, after which they were cut into 3 sections, (a) the oldest leaves, (b) the apex and any new leaves, (c) and the basal one inch of stem which included the new roots. Each segment was weighed to determine dry weight and analyzed for nitrogen, phosphorus, and potassium.

Table 5. Dry weight (g/cutting) of herbaceous, softwood, and hardwood cuttings before and after rooting under intermittent mist.

Maturity and Species	Dry Wt. Before Rooting (g/cutting)	Dry Wt. After Rooting (g/cutting)
Herbaceous cuttings		
Chrysanthemum morifolium	.70	1.97*
Dianthus caryophyllus	.43	.71*
Softwood cuttings		
Ribes alpinum	.66	1.08*
Lonicera tatarica	1.00	1.50*
Hardwood cuttings		
Forsythia intermedia	1.06	1.30*
Ribes alpinum	.74	.88*

*Significant increase at 5% level due to carbohydrate increase

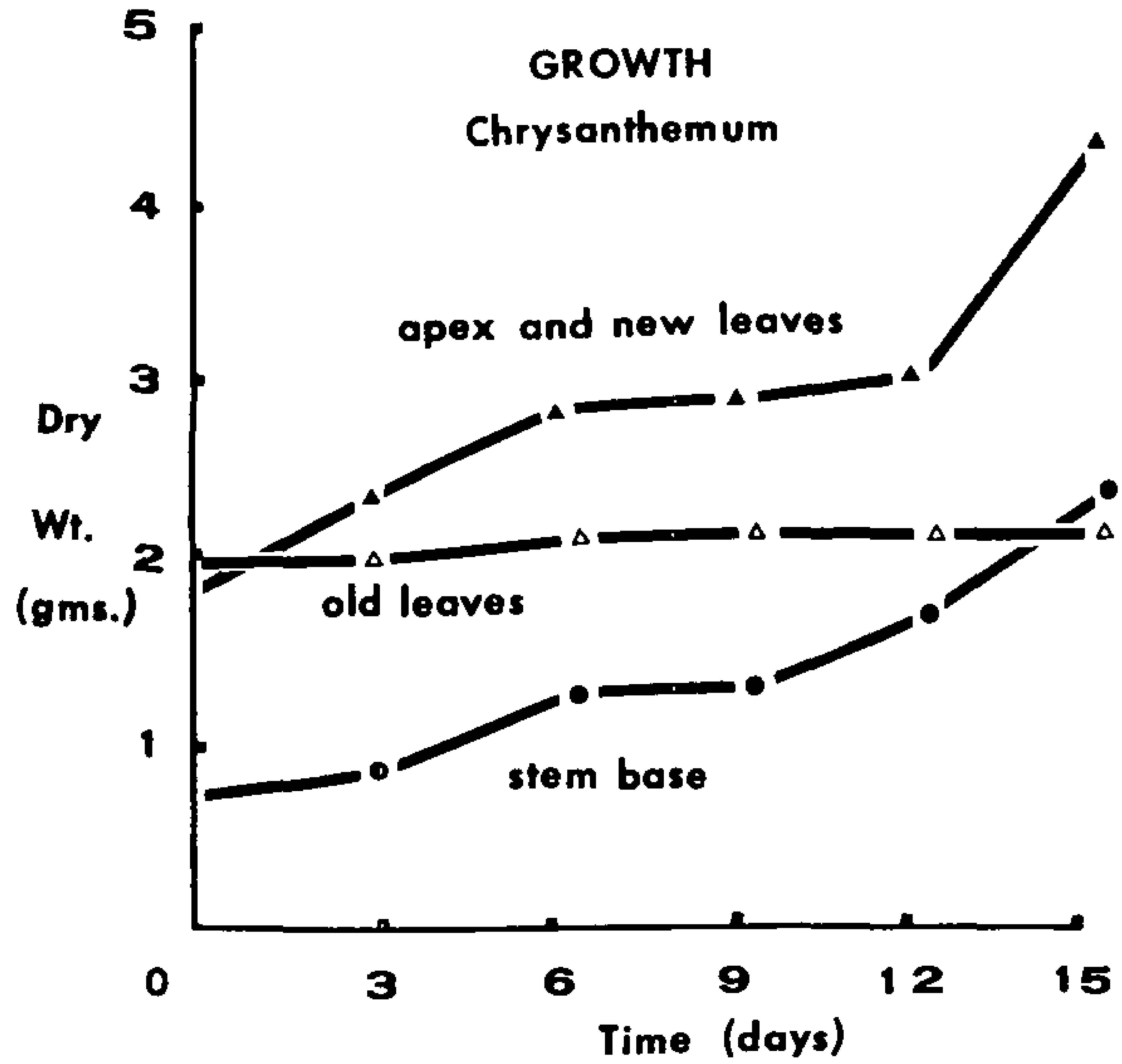

Figure 1. Growth (dry wt.) of the (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist

Comparison of the growth of the three sections of the cuttings is shown in Fig. 1. Initially, the average dry weight of the 3 oldest leaves was 2.00 g/cutting. At the end of the 15-day period, the average dry weight of these 3 oldest leaves was 2.13 g/cutting indicating very little growth in this segment during the rooting period.

The apex and new leaves made considerable growth and more than doubled in dry weight from 1.85 g/cutting to 4.23 g/cutting during the rooting period.

Likewise, the basal one inch of stem showed increases in dry weight due to the initiation and development of the roots. Originally, the segment averaged 0.71 g/cutting, but at the end of the rooting period the dry weight had more than tripled to 2.30 g/cutting.

Thus, cuttings are capable of growth particularly in the regions where new leaves and roots are being formed. How this differential growth affected the distribution of nitrogen, phosphorus and potassium is shown in the next three figures which shows the per cent of the total nutrient content in each of the 3 segments.

Fig. 2 shows that nitrogen was transported out of the three oldest leaves to the apex and new leaves particularly during the first and last 3 days of the experiment. Nitrogen transport to the new roots was greatest during the last 3 days of rooting when root growth was at a maximum. There appeared to be no translocation of nitrogen to the basal one inch of the cutting when roots were initiated during the first 3 days of the experiment.

Phosphorus (Fig. 3) was translocated out of the 3 oldest leaves to both the new leaves and roots generally throughout the rooting period. Translocation to the roots was associated with both root initiation and root development.

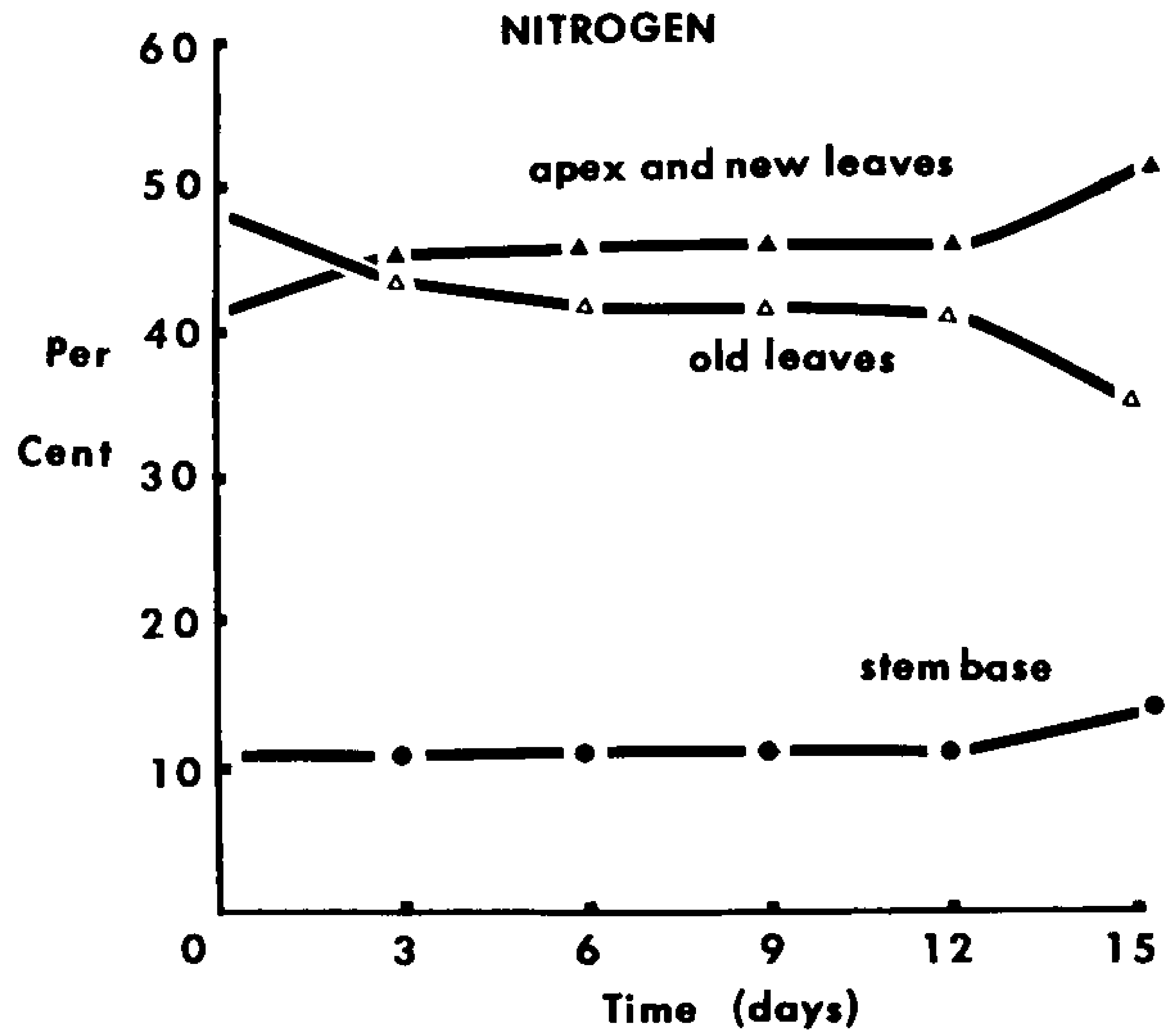

Figure 2 Distribution of nitrogen in (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist.

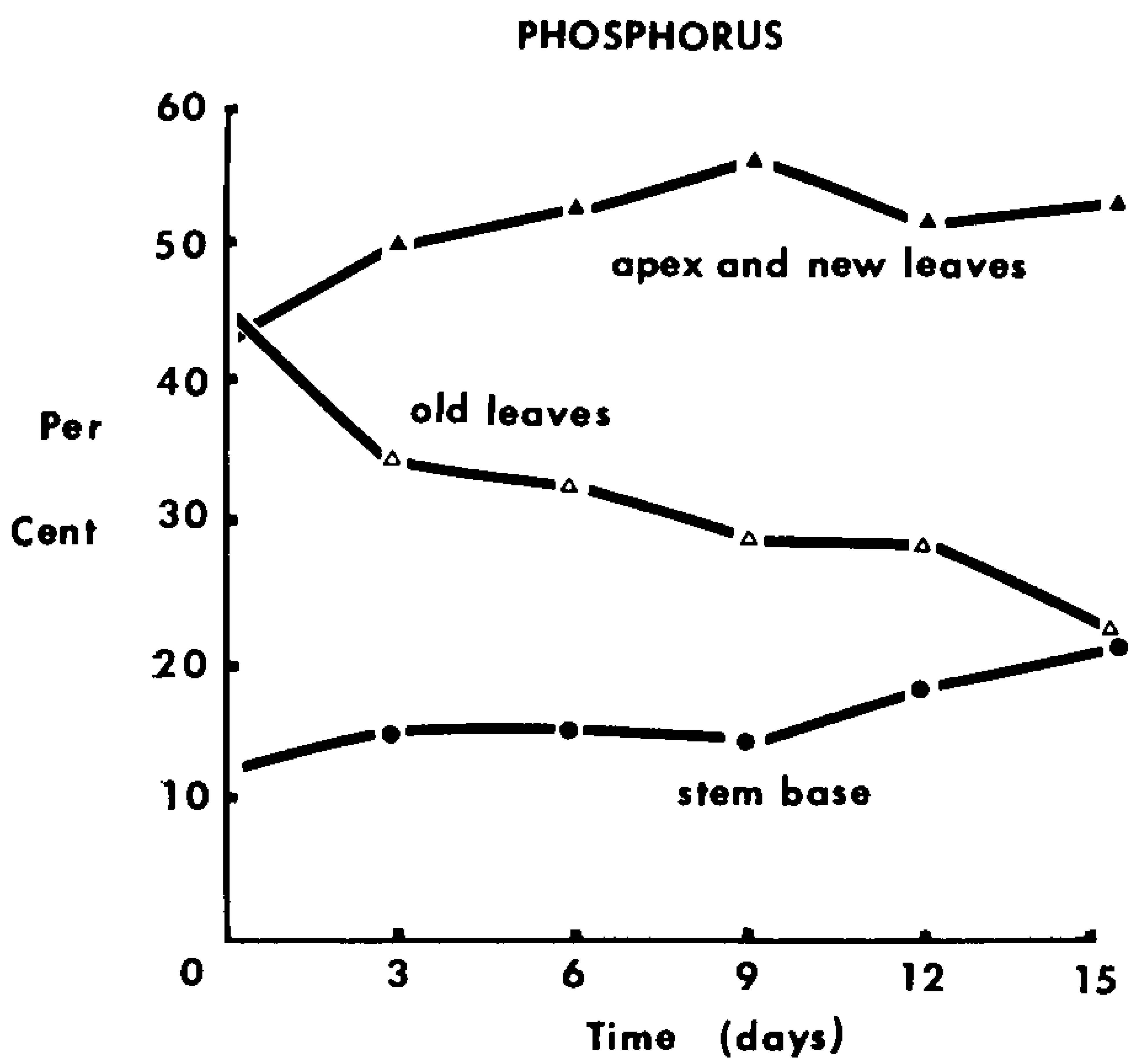

Figure 3 Distribution of phosphorus in (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist.

Potassium (Fig. 4) was translocated from the three oldest leaves to the new leaves throughout the rooting period, but very little moved to the new roots.

Discussion

These experiments show that the leaching of mineral nutrients from cuttings propagated under mist was influenced by the maturity of the cuttings. Herbaceous and softwood cuttings were difficult to leach while hardwood cuttings were relatively easy to leach when rooted under mist. The fact that mature plant tissue is easier to leach than young, succulent tissue agrees with reports from other workers (Tukey, 1962).

The ease or difficulty with which cuttings were leached by the mist corresponded to the growth the cuttings made while rooting. Softwood cuttings which were difficult to leach were capable of growing a great deal during rooting, whereas hardwood cuttings which were relatively easy to leach exhibited very little growth (Table 5). From Fig. 1 through 4, it is shown that nutrients were translocated from the older leaves, which had essentially ceased growing, to the growing new leaves and roots. Previous work has shown that materials are not leached from growing tissues because they are bound up within cells where they cannot be leached (Tukey, 1962). Thus, softwood and herbaceous cuttings had a considerable portion of nutrients bound within growing tissue which accounted for the fact that these cuttings were difficult to leach. Hardwood cuttings, on the other hand had relatively little growing tissue, hence, they were relatively easier to leach.

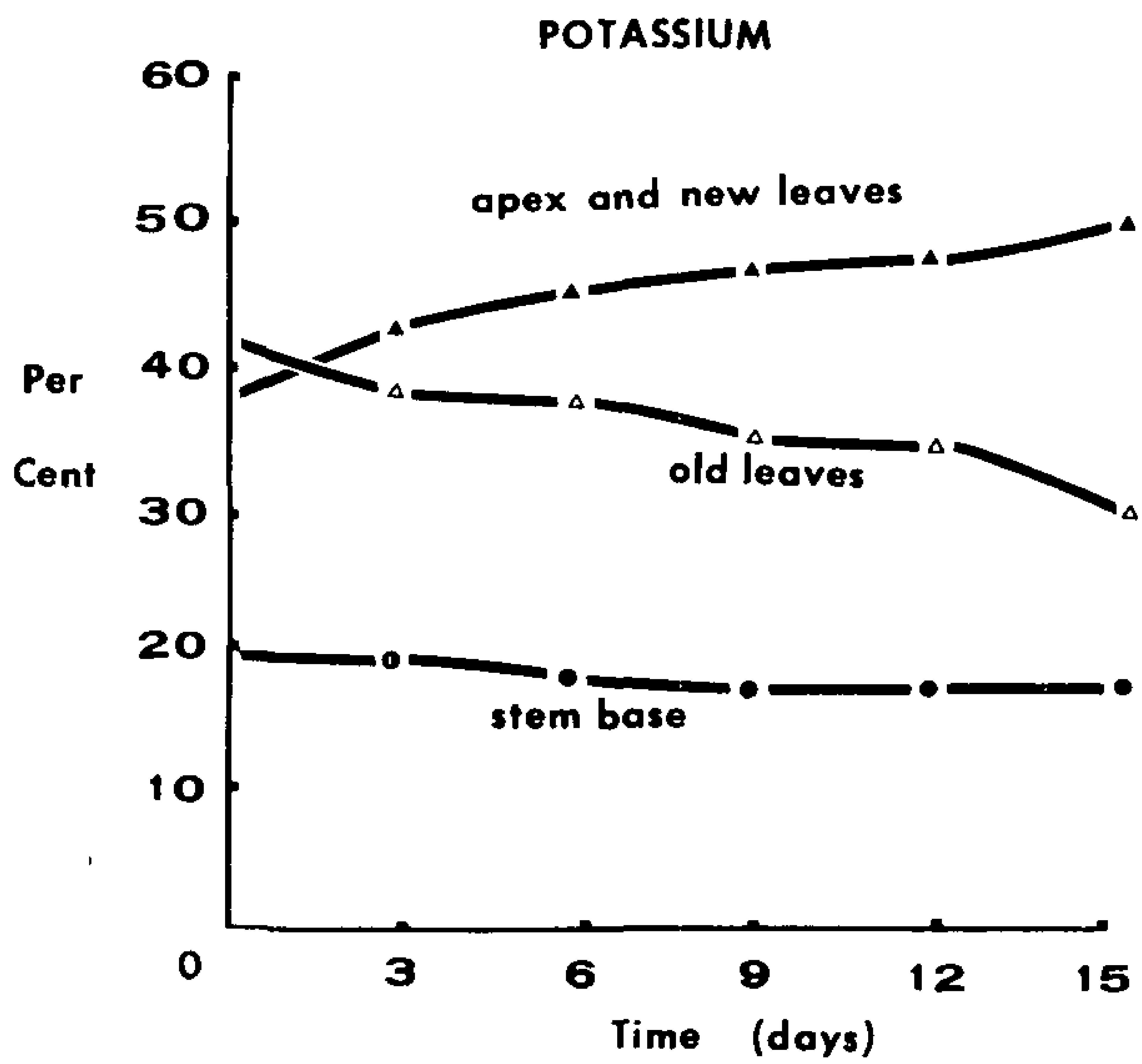

Figure 4 Distribution of potassium in (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist

There have been reports in the literature that nutrient deficiencies commonly occur in cuttings rooted under mist. These deficiencies could be due to two factors. First, mineral nutrients are leached from the cuttings as was the case with mature hardwood cuttings. Second, the cuttings grow through additions of carbohydrates from photosynthesis, and the nutrients retained in the cuttings are not sufficient for the new growth. In either case, additional nutrients supplied to the cuttings during rooting may be an important factor in rooting and in the subsequent growth and development of the rooted cutting.

Summary

Cuttings from numerous ornamental plants were surveyed in order to determine the extent of nutrient leaching when propagated under mist. Herbaceous and softwood cuttings proved very difficult to leach whereas hardwood cuttings were relatively easy to leach. Cuttings were capable of substantial growth during rooting due to the growth of new leaves and roots. Nutrients held in the older, fully expanded leaves of chrysanthemum were translocated to the growing new leaves and roots from where they were not readily leached. Nutrient deficiencies which commonly occur in cuttings rooted under mist could be due to (a) the leaching of nutrients, and (b) the diluting of mineral nutrients by additions of carbohydrates from photosynthesis.

LITERATURE CITED

1. Good, G L, and H B Tukey, Jr 1964 Leaching of nutrients from cuttings under mist. Proc 14th Plant Propagators' Soc. pp 138-141
2. Good, G. L, and H B Tukey, Jr Leaching of metabolites from cuttings propagated under mist Proc Amer Soc Hort Sci (in press)
3. Tukey, H. B, Jr 1962. Leaching of metabolites from above ground parts, with special reference to cuttings used for propagation. Proc 12th Plant Propagators Soc pp 63-70

MODERATOR HESS: Now we will turn our attention to the area of new techniques. An obvious solution to solve the leaching problem would be to add nutrients to the mist. To tell us about his experiments with nutrient mist is Mr. John Wott.

PROPAGATION OF CUTTINGS UNDER NUTRIENT MIST

JOHN A. WOTT AND H. B. TUKEY, JR.
Department of Floriculture & Ornamental Horticulture
Cornell University
Ithaca, New York

Introduction

Many workers have reported that mineral nutrients can be leached from cuttings propagated under mist with the subsequent development of nutrient deficiency symptoms (Ang 1958, Evans 1951, Good and Tukey 1964, Sweet and Carlson