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## Determination of Several Elements in Orchid Plant Parts by Neutron Activation Analysis<sup>1</sup>

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*Additional index words.* neutron activation analysis, senescence, *Dendrobium nobile*

**Abstract.** Concentrations of several elements in orchid plants (*Dendrobium nobile* Lindl) were determined by instrumental neutron activation analysis, a rapid and sensitive method for Na, K, Mg, Ca, Mn, Zn, Fe, Cl and Br. Among young and old leafless shoots, an increase in content of Br and a decrease of Fe and Zn were found with age.

During the past few years, there has been an increasing recognition of the importance of the trace element chemistry in biological systems. Some physical methods of analyses are applied (13) and used extensively for the estimation of small quantities of metallic elements. Spectrographic methods, particularly those using direct-reading equipment, are of great importance in routine analyses. The instrumental neutron activation analysis (INAA) without radiochemical separations seems to be an attractive analytical method because of its simplicity, speed and sensitivity (6, 5). With small samples, several elements are simultaneously detected by INAA.

Emission spectrography as a survey tool (11) and X-ray fluorescence in the analysis of kale (1) have been used, however, the former often suffers from lack of sensitivity for many elements of interest and the latter determines a limited number of elements.

In this paper, the concentration and distribution of several elements were determined by INAA, and the results obtained are discussed in relation to senescence among the shoots of an orchid.

### Materials and Methods

*Dendrobium* orchid plants were grown in a greenhouse between 20° to 27°C with occasional 30° peaks in summer and at a minimum of 12° in winter. Plants were grown in 12 cm diameter pots containing sphagnum moss and were fertilized with Hyponex; no fertilizer was given for several months before

harvest. Four-year-old plants, 40-50 cm in height and in bloom were harvested for tissue analyses from Feb. to March.

Flower, leaf, and shoot-fresh weight samples were 2.0 g and aerial roots were 0.8 g. The lower, middle, and upper parts of shoots were also prepared and elemental concentrations were compared between young and old shoots. This orchid has a new shoot each year coming from a bud at the base of an old shoot. The new shoot terminates in clusters of flowers and never blossoms again (Fig. 2). "Shoot I," "Shoot II," (flowering) and "Shoot III" (old, leafless) were analyzed by INAA (Table 1).

Each specimen was sealed with a polyethylene pouch as soon as detached from the plants after a short rinse of distilled water. These specimens were irradiated in the rotary specimen rack ( $6 \times 10^{11}$  n/cm<sup>2</sup> sec) of Rikkyo (St. Paul) University's atomic reactor TRIGA Mark II. Mg, K, Al, Mn, Cl, Na and Ca were determined by counts per 100 sec after 60 sec irradiation and 120 sec decay. Other elements were determined by counts per 1000 sec, after 6 hr irradiation and 7 days' decay. The samples activated for 6 hr were picked out of the polyethylene pouches to be sealed with another cooled one in order that the radioactive counts of the samples might be counted more exactly without disturbances of the elements originated from activated polyethylene pouches. Gamma counting was done using a Ge-(Li)-detector and a 4000 multi-channel analyzer.

NBS Standard orchard leaves 1571 were used as standards for the analyses (6). The data were calibrated by the NBS Orchard Leaves Standard of which Morrison et al. reported the determination of the elements by INAA (6, 5).

### Results and Discussions

Patterns of INAA show gamma-ray's energy (KeV) horizontally and radioactive counts vertically; counts of each gamma-ray's energy are in proportion to the amounts of the elements in the biological materials (Fig. 1). It is noted on this

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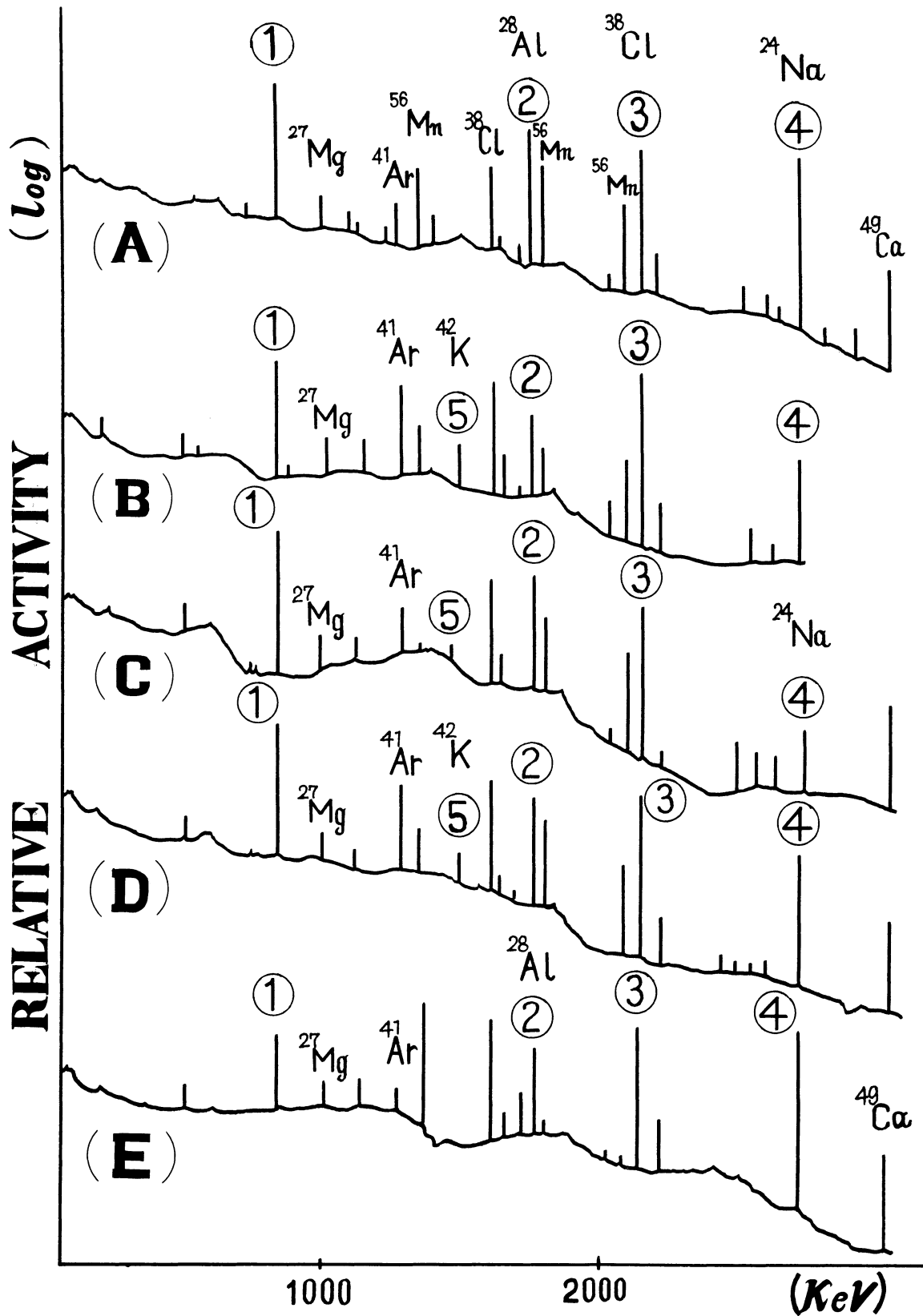


Fig. 1. Gamma-ray spectra of orchid plant parts after 1 min irradiation at  $6 \times 10^{11}$  n/cm<sup>2</sup> sec, 2 min decay and 100 sec count on a Ge(Li)-detector. A) Shoot (top); B) Flowers; C) Leaves; D) Aerial roots; E) Shoot (bottom). 2.0 g (fresh weight) of each specimen were used, except aerial roots (0.8 g). Elemental concentrations are shown in Table 2. Peak ① = <sup>27</sup>Mg (844 KeV, intensity 70%) <sup>56</sup>Mn (KeV, intensity 70%), peak ② = <sup>28</sup>Al (1779 KeV, intensity 100%), peak ③ = <sup>38</sup>Cl (2167 KeV, intensity 40%), peak ④ = <sup>24</sup>Na (2754 KeV, intensity 52%), peak ⑤ = <sup>42</sup>K (1525 KeV, intensity 100%).

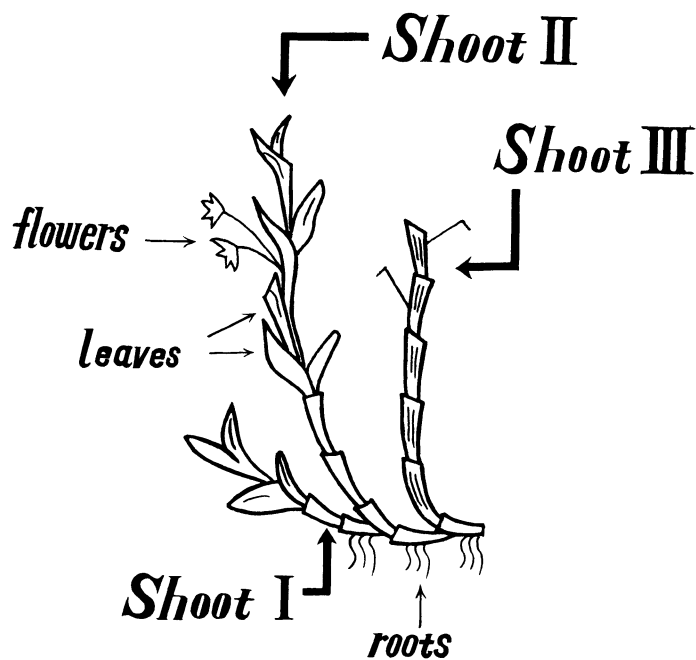


Fig. 2. Shoot growth of orchid.

diagram that the levels of radioactive counts from  $^{24}\text{Na}$ ,  $^{38}\text{Cl}$ , and  $^{56}\text{Mn}$  are split into multiple fine structures, adding to their escaped peaks, and that the backgrounds in the lower energies of gamma-rays are higher because of the Compton effect. The peaks of  $^{41}\text{Ar}$  were originated from the activated argon (energy 1294 KeV, intensity 100%) of the air in the pouches. The peaks  $\odot$  were overlapped with ones of  $^{27}\text{Mg}$  (844 KeV, 70%) and  $^{56}\text{Mn}$  (847 KeV, 70%).

The peaks  $\odot$  of  $^{28}\text{Al}$  (1779 KeV, 100%) comparing with the  $^{38}\text{Cl}$  peaks  $\odot$  (2167 KeV, 40%) of the leaves and the upper part of the shoot are higher than others; thus that is considered to be the accumulation of Al in the leaves and upper part of the shoot. In a previous study (12), a larger amount of Al in comparison with the upper part of stems was found to be accumulated in the roots of pineapple plants, suggesting the screening through the roots for elements in the soil. The orchid accumulated Al in the upper part of the shoot. This may depend on the roots of the epiphyte.

The peaks  $\odot$  of  $^{24}\text{Na}$  (2754 KeV, 52%) compared with peaks  $\odot$  of  $^{38}\text{Cl}$  of the shoots are higher than the ones of the other parts of this plant, and the peaks  $\odot$  of  $^{42}\text{K}$  (1525 KeV,

100%) are found in the patterns of flowers, leaves and aerial roots; a large amount of Na is considered to be in the shoot, while a small amount of K is in the shoot compared with flowers, leaves and aerial roots. Accumulations of Na and K might be due to the selective transport of these ions to the organs.

The elemental concentrations from Fig. 1 are shown in Table 2. Only one set of tissue analyses is given here, but the reproducible tendency was found in several sets of tissue analyses.

Radioactivities of  $^{28}\text{Al}$  on the upper part of Shoot II and Shoot III were more than in Shoot I (Table 1); this might be considered the deposition of Al in the upper part of the older shoots.

The larger counts of  $^{56}\text{Mn}$  were found in the bottom of Shoot III and the upper parts of Shoot II and Shoot I. Poole and Sheehan (7) reported that Mn appeared to be preferentially translocated to mature leaves rather than accumulated in roots or pseudobulbs of *Cattleya*. In the previous study of pineapple plants (12), Mn accumulated in the fruits. In case of the orchid plant, Mn might be amassed in vigorous parts such as the top of the flowering Shoot II.

Larger amounts of Na and Cl were found in the bottom of each shoot and little K was detected. Davidson (3) observed that deficiencies of N and P limited growth of *Cattleya* more drastically than did K, Ca or Mg in gravel culture, and it is reasoned that plants lacking an external supply of K, Ca or Mg are capable of translocating these nutrients from old tissues. The upward and downward translocations of  $^{14}\text{C}$  of sunflower plants had been reported by Shiroya (9). The concentrations of these elements in tissues, though it is momentary data in the life of the plant, might show translocation and accumulation trends of the elements in the plant.

The larger amounts of  $^{59}\text{Fe}$  and  $^{65}\text{Zn}$ , and the smaller one of  $^{82}\text{Br}$  in Shoot III were found in comparison with Shoot I (Table 1). The same tendency was found in the pineapple that has a terminal inflorescence and fruit, and continues postfruiting growth by means of one or more axillary buds growing into vegetative branches (12). Spiller (10) found Zn to be implicated in cell division, expansion and dry matter accumulation of sugarbeet leaves. Chang and Jjung (2) found Zn as one of the requirements for mitosis in the root tips of 'Sanilac' navy bean. Poole and Sheehan (7) found that Zn was accumulated preferentially in roots and that only a small portion was translocated to leaves and pseudobulbs of *Cattleya*. They (8) reported that N and K contents of *Phalaenopsis* leaves decreased dramatically with age, while Ca and Mg increased slightly with age. In *Cattleya*,  $\text{SiO}_2$  was found to increase in the leaves with age by Erickson (4).

Table 1. Elements in orchid plant parts detected by INAA.

Elements	Shoot I		Shoot II		Shoot III	
	Top	Bottom	Top	Bottom	Top	Bottom
Mg (%)	0.056 ± .003 <sup>Z</sup>	0.086 ± .004	0.059 ± .004	0.109 ± .005	0.076 ± .004	0.082 ± .004
K (%)	0.066 ± .013	0.102 ± .016	0.038 ± .011	0.064 ± .013	0.091 ± .015	0.058 ± .013
Al (ppm)	4.2 ± .1	6.2 ± 0.1	18.7 ± .2	3.9 ± .1	12.5 ± .2	5.6 ± .1
Mn (ppm)	13.6 ± 0.5	8.4 ± 0.4	31.3 ± .7	2.9 ± .2	5.4 ± .3	8.1 ± .4
Cl (%)	0.032 ± .001	0.072 ± .002	0.057 ± .001	0.096 ± .002	0.009 ± .001	0.039 ± .001
Na (ppm)	21.3 ± .9	68.3 ± 1.6	48.8 ± 1.3	91.7 ± 1.7	26.0 ± 1.0	71.5 ± 1.6
Ca (%)	0.056 ± .004	0.067 ± .004	0.091 ± .005	0.052 ± .004	0.045 ± .004	0.034 ± .003
Br (ppm)		3.6 ± .33		6.6 ± .46		2.0 ± .26
Zn (ppm)		14.2 ± .86		24.9 ± 1.1		26.4 ± 1.2
Co (ppm)		0.021 ± .004		0.005 ± .002		0.008 ± .002
Fe (ppm)		25.0 ± 5.0		66.4 ± 7.5		91.3 ± 8.3

<sup>Z</sup> ± SD.

Table 2. Elemental concentrations of orchid plant parts.

Elements	Shoot (top)	Flowers	Leaves	Aerial roots	Shoot (bottom)
Mg (%)	0.059 ± .004 <sup>Z</sup>	0.012 ± .001	0.227 ± .010	0.072 ± .003	0.109 ± .005
K (%)	0.038 ± .011	0.178 ± .020	0.198 ± .020	0.254 ± .025	0.064 ± .013
Al (ppm)	18.2 ± .2	1.2 ± .1	40.2 ± .6	7.0 ± .1	3.9 ± .1
Mn (ppm)	31.3 ± .7	2.7 ± .4	176 ± 4	24.5 ± .6	2.9 ± .2
Cl (%)	0.057 ± .001	0.023 ± .001	0.018 ± .001	0.088 ± .002	0.096 ± .002
Na (ppm)	48.8 ± 1.3	3.2 ± .3	0.4 ± .04	21.2 ± .6	91.7 ± 1.7

<sup>Z</sup> ± SD.

Shoot I had a larger amount of <sup>82</sup>Br and lower of <sup>59</sup>Fe and <sup>65</sup>Zn; it may be considered that Br increased but Fe and Zn decreased with age. Yamaguchi (12) reported that the increase of Br and Cl and/or the decrease of Zn, Co and Fe might be correlated with senescence of the pineapple plant. In practice, young orchid plants are trimmed away from old leafless shoots of parental plants and transplanted in other pots; thus it may be considered that decreasing amounts of Zn and Fe, and/or increasing Br with age adversely affect the growth of young plants. This change in elemental concentration may not affect vegetative growth but may be important for flowering.

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## Effect of Contact Application of Glyphosate and 2,4-D on Black Barrenberry under Greenhouse Conditions<sup>1</sup>

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**Abstract.** A greenhouse study was conducted to investigate the herbicidal effects of N-phosphonomethylglycine (glyphosate) and 2,4-dichlorophenoxyacetic acid (2,4-D) on black barrenberry *Aronia melanocarpa* (Michx.) Ell. Phytotoxicity symptoms were more evident and regrowth was less in plants receiving 2,4-D than those treated with glyphosate. Placement of herbicides on all foliage caused more visual injury than placement on half the foliage but did not influence survival. Higher rates of both herbicides resulted in more injury and reduction in plant survival than the lower rates.

Black barrenberry (syn. chokeberry, chokepear) is a serious weed problem in native lowbush blueberry fields (largely *Vaccinium angustifolium* Ait.) in Eastern Maine. Barrenberry grows in close association with the lowbush blueberry making the latter difficult to harvest without inadvertently including some barrenberry fruit. Since black barrenberry and blueberry fruit are of similar size, shape and specific gravity, they are difficult to separate on the packing line (4). The presence of

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