The granular formulation was applied to the surface of the soil and the soil was stirred to incorporate the material into the top inch of soil. The treated plants were then watered lightly, labeled and placed on benches.

### Treatment and Concentrations Used

The following treatments were evaluated for effectiveness and phytotoxicity.

1. Meta-Systox-R. 25.4% (2 lb. active/gallon) was used at rates of 1 pint and 1 quart per 100 gallons. Each concentration was used as a dip and drench.
2. Di Syston—65.7% liquid concentrate (6 lb. active/gallon) was used at concentrations of 1 pint and 1 quart per 100 gallons. Each concentration was used as a dip and a drench.
3. Baygon—13.9% spray concentrate (1.5 lb. active/gallon) was used at concentrations of 1 and 2 quarts per 100 gallons. Each concentration was used as a dip and a drench.
4. Dimethoate—267-E Concentrate (2 lb. active/gallon). This material was used at concentrations of 1 and 2 quarts per 100 gallons.
5. Phorate—47.5% E.C. containing 4 lb. active/gallon. This material was used as a dip and a drench at a concentration of 1 quart per 100 gallons.
6. Experimental insecticide U.C. 21149—10% granular. This was applied at the rate of 20 lbs. per acre.
7. Malathion—50% E.C. (4 lb. active/gallon) was used at the rate of 1 quart per 100 gallons. It was used as a dip.

### Results and Discussion

Effectiveness of the treatment was determined by examing the root mass under a binocular microscope for mealybugs and eggs. The initial examination was made 12 days after treatment. Three additional examinations were made at approximately one week intervals with the exception of the Dimethoate and Baygon treatments which caused severe plant injury and the granular treatment. No living mealybugs or mealybug eggs were found in any of the treatments applied as a dip or drench after a period of five weeks. Live mealybugs were found on the roots of plants treated with the granular formulation. Results of the examinations are given in Table 1.

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# EFFECT OF APPLICATION TIME OF SLOW RELEASE AND READILY AVAILABLE NITROGEN AND POTASSIUM SOURCES ON GROWTH AND CHEMICAL COMPOSITION OF RHODODENDRON INDICUM 'FORMOSA'

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### Abstract

*Experiment 1*—A 3x2x2x2 factorial experiment was initiated April 5, 1965, to test effects of slow release urea-formaldehyde (UF), encapsulated ammonium sulfate (CN) and K frit (frit) applied at experiment's initiation or in split applications versus ammonium nitrate (AN) and KCl applied in solution monthly or bimonthly on growth, quality and chemical composition of *Rhododendron indicum* 'Formosa.'

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Plants were grown in a 1-1-1 soil mixture by volume of sphagnum peat, horticultural perlite and fine sandy soil in 6" metal containers under 50% polypropylene shade. N applied at rate of 900 and K at 374 ppa per year.

Treatment combinations involving split application of UF and CN with split applications of frit or KCl monthly or bimonthly, were as good in size and quality as plants given AN and KCl monthly or bimonthly, and were better than plants given UF or CN and frit only at start of experiment. There was no difference in size and quality of plants given AN and KCl either monthly or bimonthly.

Generally, split applications of frit were more effective in preventing K deficiency symptoms than frit applied only at start of experiment, but development of symptoms varied depending on N source and application interval. KCl applied monthly or bimonthly prevented development of K deficiency symptoms with UF, CN and AN at both application times of these materials. K in foliage of K deficient plants, with one exception, ranged from 0.14 to 0.17 percent while leaves from plants showing none to slight symptoms varied from 0.40 to 0.72 percent.

*Experiment 2*—A 3x3 factorial experiment was initiated March 25, 1965, to test effects of 3 levels each of N from AN and K from frit on growth and development of K deficiency symtoms on 'Formosa' azalea. Growing conditions, except for treatments, were the same as experiment 1. As N levels increased, size and quality decreased, while increasing K levels increased size and quality. Increasing K levels from 0 to 166 to 332 ppa per year was less effective in preventing the appearance of K deficiency symptoms for each increase in N levels from 500 to 1000 to 1500 ppa per year.

## Introduction

Dickey and Poole (3) working with 'Formosa' azalea grown in metal containers in a 1964 experiment, found that plants receiving slow release N sources, urea-formaldehyde and coated urea only at start of experiment, were poorer in growth and quality than plants given ammonium nitrate monthly. They applied K as the slow release frit at experiment's initiation or readily available KCl monthly at rates of 83 and 249 ppa per year. No K deficiency symptoms developed at either K level when KCl was the K soure. Plants given low *level of frit* showed K deficiency symptoms which were increased in severity by the high N level (900 ppa per year), and plants receiving high frit showed symptoms of K deficiency only if given the high N level from ammonium nitrate.

## Materials and Methods

*Experiment 1*—This experiment was initiated April 5, 1965, to test effects of 3 N sources, 2 K sources and 2 application intervals each of N and K, in factorial combination, on growth, quality and chemical composition of *Rhododendron indicum* 'Formosa.' The experiment was set up in randomized block design with 4 replications and an experimental unit of 2 plants.

Uniform 'Formosa' azalea liners were potted, one plant per 6" metal container (145 cu. in) in a 1-1-1 soil mixture by volume of sphagnum peat, horticultural perlite and fine sandy soil and placed under polypropylene cloth shade. Soil analyses of original potting mixture samples gave the following concentrations of these elements: P—25 ppa, K—44 ppa, Ca—195 ppa, Mg—100 ppa and nitrate ($NO_3$) very low.

The variables were: N sources (NS)—urea-formaldehyde (UF)[2], coated N (CN)[2], and ammonium nitrate (AN); K sources (KS)—K frit (frit)[2] and potassium chloride (KCl); N application interval (NAI)—slow release UF and CN applied all at start of experiment or in split applications (½ April 5-½ July 1), while AN was applied in solution monthly or bimonthly; K application interval (KAI)—frit applied all at start or in split applications (½ April 5-½ July 1), while KCl was applied in solution monthly or bimonthly. N was applied at rate of 900 ppa per year and K at 374 ppa per year. UF, CN and frit were incorporated in the mix before potting for those treatments receiving all of these materials at experiment's initiation, while split application treatments of UF, CN and frit had the first application incorporated with the mix while the second application was made to surface of medium. P ($H_3PO_4$) and Mg ($MgSO_4.7H_2O$) were applied in solution to all plants at rates of 43.6 ppa P and 24 ppa Mg in 2 applications, at start of experiment and July 1. Copper sulfate ($CuSO_4.5H_2O$) was applied in solution at rate of 50 ppa only at start

[2]Urea-formaldehyde—"Blue Chip" (38% N) of Hercules Powder Company; coated N—encapsulated ammonium sulfate (19% N) of Archer-Daniels-Midland Company; K frit (24.9% K) of Ferro Corporation.

of experiment. The experiment was terminated after 6 months, and all plants had received a total of 450 ppa of N and 187 ppa of K.

Treatments effects were expressed as growth index (height plus spread and sum/2), visual grade and rating of relative severity of K deficiency symptoms. Visual grade and K deficiency symptoms were determined by comparing plants in the experiment against a set of standards for both growth measurements. Visual grade was determined by using a grading range of 1 to 4 simulating standards set forth by Bush (1) in Part I of Grades and Standards for Nursery Plants of Division of Plant Industry of the State Department of Agriculture. No. 1 was equivalent to Florida No. 3, No. 2 to Florida No. 2, No. 3 to Florida No. 1 and No. 4 to Florida Fancy. K deficiency injury to foliage was determined by rating degree of injury according to this rating system: 1—normal; 2—slight; 3—moderate; 4—severe; 5—very severe symptoms. Data presented of these measurements of treatment effects, with 2 exceptions, were taken October 1.

Recently matured leaves were taken October 1, 1965 and chemically analysed for N, P, K, Ca and Mg according to procedures previously outlined (2).

*Experiment 2*—This experiment was initiated March 26, 1965 and terminated 6 months later to test effects of 3 N levels and 3 K levels, in factorial combination, on growth, quality and chemical composition of 'Formosa' azalea. The experiment was set up in randomized block design with 4 replications and an experimental unit of 2 plants.

The variables were: N levels—500, 1000 and 1500 ppa per year from AN and K levels—0, 166 and 332 ppa per year from frit. AN was applied in solution monthly and frit incorporated in the medium before planting. Materials and methods of this experiment, except for treatments, were the same as those described for experiment 1.

## Results and Discussion

### Experiment 1

#### *Growth Measurements*

*Growth Index and Visual Grade*—Data of significant growth index NS-NAI interaction are given in Table 1. Plants given split applications of UF and CN were as large as plants receiving AN either monthly or bimonthly, and plants of these 4 treatments were larger than those receiving all the UF and CN at start of experiment. There was no difference in size of plants given AN either monthly or bimonthly.

Visual grade produced several significant interactions, but results can best be explained by considering the significant 4 factor interaction data of Table 2. Best quality plants were those given UF and CN in split applications and K from split applications of frit or from KCl either monthly or bimonthly, and AN monthly or bimonthly with K from frit in split applications or KCl monthly or bimonthly. The lower quality plants were produced by treatments receiving UF and CN at beginning of experiment combined with any source or application interval of K, and UF and CN in split applications with K from frit only at start of experiment, also AN applied monthly and bimonthly with K from frit applied at experiment's initiation.

Dickey and Poole (3) found that 'Formosa' azalea plants receiving slow release N materials, UF and coated urea, at rate of 900 ppa per year all at start of experiment, were poorer in growth and quality than plants given ammonium nitrate in solution monthly. The low K deficiency score of plants given UF only at start of experiment indicates that reduction in visual grade was caused largely by reduction in N supplied by UF as the season progressed. When CN in split applications was combined with frit applied all at start of experiment, the further reduction in visual grade, compared with CN and frit all applied at start of experiment, was caused by the resulting severe K deficiency which developed (Tables 1, 2). K was probably already low and the need for K was further increased by growth stimulus of July 1 application of CN, and the very low foliage K of this treatment was further confirmation of this.

KS or KAI did not affect plant size in this experiment, and KS (KCl versus frit) did not affect plant size in the 1964 experiment (3).

Table 1. Effect of 3 N sources and 2 N application intervals on growth index (cm)[1] of 'Formosa' azalea.

| Nitrogen source | N - All at start or bimonthly | N - April & July or monthly |
|---|---|---|
| Urea-formaldehyde | 33.7 | 37.7 |
| Coated nitrogen | 34.3 | 39.0 |
| Ammonium nitrate | 38.4 | 37.8 |
| LSD | .05 | .01 |
| Within table means | 1.4 | 1.8 |

[1]Growth index - Height plus spread and sum/2.

Table 2. Effect of 3 N sources, 2 K sources and 2 application intervals of N and K on visual grade[1] and K deficiency rating[2] of 'Formosa' azalea.

| Nitrogen source | N - Applied all at start or bimonthly | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Frit | | | | KCl | | | |
| | All at start | | April & July | | Bimonthly | | Monthly | |
| | Visual grade | K Def. | Visual grade | K Def. | Visual grade | K Def. | Visual grade | K Def. |
| Urea-formaldehyde | 2.50 | 1.00 | 2.13 | 1.25 | 2.50 | 1.00 | 2.62 | 1.13 |
| Coated nitrogen | 1.75 | 2.38 | 1.83 | 2.88 | 2.38 | 1.25 | 2.38 | 1.13 |
| Ammonium nitrate | 2.25 | 3.00 | 3.63 | 1.25 | 3.63 | 1.00 | 3.75 | 1.00 |
| N source | N - Applied in April and July or monthly | | | | | | | |
| Urea-formaldehyde | 2.38 | 2.75 | 4.00 | 1.00 | 3.63 | 1.00 | 3.63 | 1.25 |
| Coated nitrogen | 1.00 | 5.00 | 3.50 | 1.50 | 3.50 | 1.00 | 4.00 | 1.50 |
| Ammonium nitrate | 2.12 | 3.13 | 3.75 | 1.25 | 3.75 | 1.38 | 3.65 | 1.25 |
| LSD | | | .05 | | .01 | | | |
| Visual grade means | | | .62 | | .82 | | | |
| K deficiency means | | | .67 | | .87 | | | |

[1]Visual grade - No. 1 - Florida No. 3; No. 2 - Florida No. 2; No. 3 - Florida No. 1; No. 4 - Florida Fancy.

[2]K deficiency rating - 1 - normal; 2 - slight; 3 - moderate; 4 - severe; 5 - very severe.

## Potassium Deficiency

Symptoms similar to those diagnosed as K deficiency by previous work (3) appeared on some plants in certain treatments of this experiment by first week of June.

The K deficiency rating data produced several significant interactions, but results are best explained by considering the significant 4 factor interaction data of Table 2. KCl applied monthly or bimonthly prevented K deficiency symptoms from developing with UF, CN and AN at both application times of these materials. When UF was combined with frit, there was none to slight K deficiency symptoms, except that moderate symptoms developed when UF in split applications was combined with frit applied at start of experiment. When CN was applied at experiment's initiation, moderate K deficiency developed with both application intervals of frit, but when CN was given in split applications, severe K deficiency developed only when all the frit was applied at experiment's initiation. Moderate K deficiency symptoms developed on plants receiving AN either monthly or bimonthly when frit was applied at start of experiment, but only slight symptoms appeared when split applications of frit were used.

In 1964 Dickey and Poole (3) found that frit incorporated in mix before planting at rate of 249 ppa per year of K prevented development of K deficiency symptoms on 'Formosa' azalea with N sources UF, AN and coated urea at rate of 300 or 900 ppa per year of N. In this experiment, however, when frit was applied all at start of experiment at rate of 347 ppa per year of K, satisfactory prevention of K deficiency was not obtained with CN applied all at start of experiment or in split applications, UF in split applications and AN either monthly or bimonthly (Table 2). Some seasonal variation in response to treatments such as these is to be expected because of variation in rainfull, temperature, light and other factors affecting growth.

## Chemical Composition

Space limitations prevent use of all chemical analyses data from both experiments; however, some points of interest are presented.

*Nitrogen*—The significant NS-NAI foliage analyses data are given in Table 3. 'Formosa' azalea plants fertilized with UF and CN all at start of experiment and bimonthly with AN had less foliage N than plants fertilized with split applications of UF and CN or monthly with AN.

*Phosphorus*—Plants receiving N all at start or bimonthly contained more foliage P than plants given N in split applications or monthly. The difference, though significant, was small and probably of no biological significance.

Table 3. Effect of N source and N application interval on percent dry weight of N in 'Formosa' azalea foliage.

| Nitrogen source | N - All at start or bimonthly | N - April & July or monthly |
|---|---|---|
| Urea-formaldehyde | 1.79 | 2.13 |
| Coated nitrogen | 1.76 | 2.39 |
| Ammonium nitrate | 2.01 | 2.23 |
| LSD | .05 | .01 |
| Within table means | .21 | .27 |

*Potassium*—There were significant NS-KS, KS-NAI and KS-KAI interactions. Plants receiving UF and CN had more foliage K when given KCl as compared with frit, but there was no difference in foliage K between KCl and frit of plants receiving AN. There was no difference in foliage K between NAI when KCl was K source, but plants given frit had more foliage K when N was applied at the start or bimonthly, versus split applications or monthly. Plants receiving split applications of frit had more foliage K than plants given frit only at experiment initiation. There was no difference in foliage K between plants receiving KCl either monthly or bimonthly.

K in foliage of 'Formosa' azalea plants showing K deficiency symptoms, with one exception, ranged from 0.14 to 0.17 percent, while leaves from plants showing none or very slight symptoms varied from 0.40 to 0.72 percent. This is similar to the deficiency range of 0.15 to 0.19 for foliage K reported for the 1964 experiment with 'Formosa' azalea (3).

*Magnesium and Calcium*—Generally, those treatments which reduced foliage K content increased that of Mg and Ca., while conversely, treatments that increased foliage K decreased foliage content of Mg and Ca. These K, Ca and Mg antagonisms have been reported many times in the literature. All foliage Mg values were considered to be in the "luxury consumption" range.

## Experiment 2

### Growth Measurements

*Growth Index*—Simple effects of significant N and K level variables are given in Table 4. As N levels increased growth index decreased, and as K levels increased growth index increased.

In experiment 1 and the 1964 experiment with 'Formosa' azalea (3), K source and level had relatively little effect on growth. However, in this experiment increasing N levels decreased growth and increasing K levels increased growth, but these differences were slight and could not be detected visually.

Table 4. Simple effects of 3 N levels and 3 K levels on growth index (cm)[1] and visual grade[2] of azalea 'Formosa'. Experiment 2.

| Nitrogen level | | Visual grade Aug. 11 | Visual grade Oct. 1 | Growth index (cm) Oct. 1 |
|---|---|---|---|---|
| $N_1$ - 500 ppa | | 2.83 | 2.08 | 37.4 |
| $N_2$ - 1000 ppa | | 2.04 | 1.50 | 36.4 |
| $N_3$ - 1500 ppa | | 1.54 | 1.12 | 35.1 |
| LSD | .05 | .28 | .27 | 1.8 |
| | .01 | .37 | .36 | 2.4 |
| Potassium level | | | | |
| $K_1$ - 0 ppa | | 1.67 | 1.46 | 35.0 |
| $K_2$ - 166 ppa | | 2.13 | 1.54 | 36.2 |
| $K_3$ - 332 ppa | | 2.67 | 1.71 | 37.8 |
| LSD | .05 | .28 | NS | 1.8 |
| | .01 | .37 | NS | 2.4 |

[1]Growth index - Height plus spread and sum/2.
[2]Visual grade - 1 - poor; 2 - fair; 3 - good; 4 - very good plants.

*Visual Grade*—Simple effects of significant N and K level variables for August 11, and N levels for October 1, sampling dates are given in Table 4. As N levels increased visual grade decreased, because of increased K deficiency symptoms, for both sampling dates, while increasing K levels improved visual grade only at August 11 sampling date.

### Potassium Deficiency

K deficiency symptoms appeared in some treatments by mid-May and increased in amount and severity as the season progressed.

The significant NL-KL interaction data of August 5, K deficiency rating are presented in Table 5. Increasing K levels from 0 to 166 to 332 ppa per year was increasingly less effective

Table 5. Effect of 3 levels each of N and K on K deficiency rating[1] of 'Formosa' azalea, August 5, 1965. Experiment 2.

| Nitrogen level | K level - ppa K $K_1$-0 | $K_2$-166 | $K_3$-332 |
|---|---|---|---|
| $N_1$ - 500 ppa | 2.25 | 2.00 | 1.13 |
| $N_2$ - 1000 ppa | 4.50 | 3.25 | 2.37 |
| $N_3$ - 1500 ppa | 4.87 | 4.50 | 3.12 |
| LSD | .05 | .01 | |
| Within table means | .57 | .78 | |

[1]K deficiency rating - 1 - normal; 2 - slight; 3 - moderate; 4 - severe; 5 - very severe.

in preventing the appearance of K deficiency symptoms for each increase in N levels from 500 to 1000 to 1500 ppa per year.

The N-K interaction on degree of K deficiency symptoms reported in 1964 experiment with 'Formosa' azalea (3) was confirmed in this experiment. Painter et al. (4) working with tung in Florida, found that when a low level of K was supplied, a liberal application of N tended to aggrevate the disorder and K content of leaves was lowered by increasing the amount of N supplied.

## Chemical Composition

*Nitrogen*—Foliage N increased as N levels increased, and K levels had no effect on foliage N.

*Phosphorus*—Plants receiving low N had more foliage P than medium or high N plants, and there was no difference between medium and high N levels. K levels did not affect P content of foliage.

*Potassium*—Neither K or N levels had any effect on foliage K. Generally, increasing K levels will increase K content of foliage and lower that of Mg and Ca, but for October 1 sampling date it did not (Tables 6, 7). However, there was no difference in foliage K at this sampling time, so possibly N was the main depressant for K, Mg and Ca in the foliage.

Table 6. Effect of 3 levels each of N and K on percent dry weight of Mg in 'Formosa' azalea foliage. Experiment 2.

| Nitrogen level | K level - ppa K | | |
|---|---|---|---|
| | $K_1$-0 | $K_2$-166 | $K_3$-332 |
| $N_1$ - 500 ppa | 0.67 | 0.96 | 0.97 |
| $N_2$ - 1000 ppa | 0.49 | 0.50 | 0.53 |
| $N_3$ - 1500 ppa | 0.43 | 0.40 | 0.56 |
| LSD | .05 | .01 | |
| Within table means | .15 | .21 | |

Table 7. Effect of 3 levels each of N and K on percent dry weight of Ca in foliage of 'Formosa' azalea. Experiment 2.

| Nitrogen level | K level - ppa K | | |
|---|---|---|---|
| | $K_1$-0 | $K_2$-166 | $K_3$-332 |
| $N_1$ - 500 ppa | 1.14 | 1.91 | 2.09 |
| $N_2$ - 1000 ppa | 0.59 | 0.83 | 1.00 |
| $N_3$ - 1500 ppa | 0.53 | 0.51 | 0.74 |
| LSD | | .05 | .01 |
| Within table means | | .33 | .44 |

Possibly, foliage samples taken in mid-summer before heavy abscission of leaves which had developed severe K deficiency symptoms, may have given an entirely different pattern of K, Mg and Ca content of the foliage.

*Magnesium*—Data of the significant NL-KL interaction are given in Table 6. At each K level, plants receiving low N had more foliage Mg than plants given medium and high N, and these 2 N levels were similar in foliage Mg content.

*Calcium*—Data for significant NL-KL interaction are given in Table 7. At low and medium N levels, plants receiving high K had more foliage Ca than plants given low K, but at high N there was no difference in foliage Ca at any K level.

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