differences between cultivars in shrinkage losses in normal storage. Total cultivar yield was negatively correlated with dry matter content of fleshy roots.

Literature Cited

1. Constantin, Roysell J., Lloyd G. Jones, and Travis P. Hernandez. 1975. Sweet potato quality as affected by soil reaction (pH) and fertilizer. *J. Amer. Soc. Hort. Sci.* 100:604-607.
2. Kushman, L. J., M. T. Deonier, J. M. Lutz, and W. Bolton. 1954. Effects of temperature and soil moisture at harvest and of delay in curing on keeping quality of Porto Rico sweet potatoes. *Proc. Amer. Soc. Hort. Sci.* 63:415-419.
3. ———, and ———. 1958. Effort of weather, date of harvest, and curing treatments on keeping qualities of Porto Rico sweet potatoes. *Proc. Amer. Soc. Hort. Sci.* 71:369-375.
4. ———, and ———. 1959. Relation of internal gas content and respiration to keeping quality of Porto Rico sweet potatoes. *Proc. Amer. Soc. Hort. Sci.* 74:622-641. 5.
5. Phills, B. R. 1972. Effect of ethephon, temperatures, water-submerged roots and cultivars on sweet potato plant production. MS Thesis. La. State Univ., Baton Rouge.

J. Amer. Soc. Hort. Sci. 103(5):603–605. 1978.

Nitrogen and Potassium Requirements of Rieger Begonia (*Begonia* x *hiemalis* Fotsch)[1]

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Abstract. **Optimum N and K rates were established for 'Schwabenland Red' Rieger begonia for weekly fertilization and for application with each watering. Weekly application of 400 ppm N or more and 150 ppm or less resulted in undesirable plant size reduction regardless of K level; 200 ppm was marginal and 250 and 300 ppm N were best. Weekly applications of 60 to 200 ppm K were best and equal when applied with 250 ppm N while levels of 250 ppm K and greater caused smaller final plant size. The best rates of N for application with each watering were 100 and 150 ppm; 75 ppm and lower and 200 ppm and higher had deleterious effects. K levels from 50 to 125 ppm were best for application with every watering while levels of 150 ppm and greater were undesirable.**

Rieger begonia has been grown since 1906 but only for the past decade in America. Most fertilization procedures were developed by commercial growers in Europe and few have been published. The few recommendations in the literature vary a great deal.

Rohde (4) indicated that a desirable fertilizer ratio was 2.0 N – 0.3 P – 1.2 K and recommended weekly alternation of 14–4.1–11.4 and 18–2.5–7.3 at a N concn ranging from 140–360 ppm. White et al. (5) reported good results from weekly application of 15–6.5–12.2 at a rate equivalent to 200 ppm N. Mikkelsen (3) recommended weekly application of 100 ppm each of N and K in the winter and 200 ppm each in the summer in addition to 5 g (1 teaspoon) of MagAmp or Osmocote slow release fertilizer applied to the surface of each 15 cm pot. Goldschmidt (1) based his recommendation of 280 to 420 ppm N on an application of 0.2 to 0.3% 14–4.1–11.4 fertilizer with every 2nd or 3rd application of water which could range from slightly less than a week to nearly 2 weeks depending on stage of growth and season. The recommended levels of N range in these reports from 100 to 420 ppm.

For application of fertilizer with every watering Goldschmidt (1) recommended a 0.05 to 0.1% solution of 14–4.1–11.4 (70–140 ppm N). Kiplinger (2) recommended 200 ppm each of N and K. White et al. (6) tested daily applications of 15–6.5–12.2 at concn providing 10, 50 and 150 ppm N. While not ideal, the 50 ppm rate was best. They suggested for trial purposes that 50 ppm N be used during the early stages of growth and 100 ppm later. Again the level of fertilizer recommended was variable and little attention was paid to the level of K.

The study reported here was conducted to determine optimum levels of N and K fertilization for weekly application and for application with each watering to Rieger begonia. Particular attention was paid to the relationship of N and K.

Materials and Methods

Several procedures were common to the whole study. Plants of 'Schwabenland Red' rooted from leaf cuttings were planted in standard 15 cm diam plastic pots in a root medium consisting of 10% sandy field soil: 45% horticultural grade vermiculite: 45% sphagnum peatmoss amended with 7 g/dm^3 of dolomitic limestone and 3.5 g/dm^3 of 20% superphosphate. They were grown in a greenhouse at 18^{o}C (night) and 24^o (day).

Nutrient solutions were formulated form KNO_3, NH_4NO_3 and $Ca(NO_3)_2$. One quarter of the N was applied in the ammoniacal form in all treatments. Long day conditions were established by lengthening the day to 14 hr with a min of 10 ft-c of light from an incandescent source. Short day conditions were established when day lengths were greater than 11 hr by covering plants with black cloth between 5 PM and 8 AM. The experimental design was a randomized complete block with 3 blocks and 4 plants per plot. Plant ht was measured at the marketable stage as the distance from the pot rim to the point of attachment of the leaf blade to the petiole of the highest leaf. Plant width consisted of the average of 2 measurements made at right angles to each other. Market stage was identified in this study by the presence of 15 open flowers on each of 80% of the plants in the control treatment of each

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experiment. Visual ratings from 0 – 10 estimated plant condition from death to the highest quality expected. The visual rating included total plant volume and the height to width balance. Quality increased as plant volume increased, as long as plant width exceeded height.

Four experiments (1 – 4) were conducted to determine the optimum levels of N and K for weekly application and an additional 2 experiments (5 – 6) to determine the optimum N and K levels for application with each watering. Cultural dates for each experiment appear in Table 1.

Results and Discussion

N levels of 200 and 400 ppm were compared in the first experiment at 4 ratios of N:K (1:1, 2:1, 3:1 and 4:1) (Table 2). Variance due to each main effect (N level and N:K ratio) was significant but that due to the interaction was not. The pooled height means for 200 and 400 ppm N were 12.7 and 15.1 cm, respectively, and had an LSD 5% of 1.6 cm. The taller plants associated with 400 ppm N were more desirable than the shorter ones at the lower N level. Among the 5 best treatments, the visual rating (Table 2) for the 200 ppm treatment rose faster than those for the 500 ppm N treatments between the 10th and 12th weeks indicating the greater suitability of 200 ppm N during this period. While 400 ppm N was superior for the overall culture of these plants and data indicated that neither level was ideal.

The pooled height means for N:K ratios of 1:1, 2:1, 3:1 and 4:1 were 12.4, 16.2, 13.8 and 13.3 cm respectively while the LSD 5% was 2.3 cm. More desirable plants resulted from the 2:1 ratio; however, it is interesting to note that this was due primarily to effects at the 200 ppm N level.

N levels of 300 to 700 ppm at multiple levels of K were tested in the second experiment since results of the first experiment indicated that a N level of 400 ppm was better than 200 ppm. Decreases in height and width were associated with increases in N level above 300 ppm (Table 3). The decline in quality could not be offset by adjustments in the K level. A level of 300 ppm N was superior to 400 ppm thus confirming the conclusion in the first experiment that neither 200 nor 400 ppm N was ideal.

N levels between 100 and 300 ppm were examined more closely in experiment 3 along with several N:K ratios at a fixed N level of 250 ppm. N levels of 100 and 150 ppm resulted in shorter and narrower plants while 200 ppm N resulted in narrower plants (Table 4). N levels of 250 and 300 ppm were best. Application of 60, 80, 100, and 125 ppm K in combination with 250 ppm N produced plants equal to and better than those given 250 ppm K as the latter were narrower.

The 4th experiment was designed to 1) further test N levels of 100 to 250 ppm; 2) test N:K ratios of 1:1, 1.5:1, and 3:1 at 250 ppm N; and 3) determine the N requirement for each of 2 stages of growth, i.e., the first 4 weeks of vegetative growth and the following 7.5 weeks which encompasses flower formation. (Table 5). N levels of 100 and 150 ppm throughout the crop resulted in shorter and narrower plants compared to all other treatments. Using steady N levels of 200 or 250 ppm

Table 2. Nutrient treatments applied weekly, visual observations after 10 and 12 weeks of growth and the final height of plants in expt. 1.

Treatment			Visual rating		Plant ht
N (ppm)	K (ppm)	N:K	10 wk	12 wk	(cm)
200	200	1:1	1.0	1.8	11.0
200	100	2:1	3.3	7.0	16.6
200	67	3:1	2.6	3.2	12.8
200	50	4:1	2.3	2.8	10.5
400	400	1:1	2.3	3.5	13.8
400	200	2:1	4.3	5.7	15.8
400	133	3:1	5.0	4.5	14.9
400	100	4:1	7.0	7.3	16.0
LSD 5%					3.2

Table 3. Nutrient treatments applied weekly and the final mean plant height and width in expt. 2.

Treatment		Plant ht	Plant width
N (ppm)	K (ppm)	(cm)	(cm)
300	133	15.8	20.6
400	133	14.4	17.9
400	200	13.0	18.3
400	400	13.2	18.1
500	133	11.5	14.9
500	167	11.8	16.3
500	250	13.4	17.5
700	133	8.6	13.8
700	175	10.5	14.7
700	233	9.6	15.4
700	350	8.9	12.6
LSD 5%		2.4	2.5

Table 4. Nutrient treatments applied weekly and final mean plant height and width in expt. 3.

Treatment		Plant ht	Plant width
N (ppm)	K (ppm)	(cm)	(cm)
100	125	13.3	24.5
150	125	14.2	24.9
200	125	16.2	26.5
250	125	18.3	29.5
300	125	18.1	29.7
250	60	18.3	29.4
250	80	18.1	29.0
250	100	18.4	31.0
250	150	15.8	26.9
250	250	15.3	24.8
LSD 5%		3.1	3.2

Table 1. Cultural dates for the 6 experiments conducted in this study.

Experiment	Planting date	Long-day treatment	Short-day treatment	Marketable date
1	Sept. 11, 1973	Sept. 11 to Oct. 12	Oct. 12 to Dec. 7	Dec. 7
2	Jan. 28, 1974	Jan. 28 to Mar. 4	Mar. 4 to April 26	April 26
3	Mar. 27, 1975	Mar. 27 to April 24	April 24 to June 5	June 5
4	May 16, 1974	May 16 to June 20	June 20 to Aug. 5	Aug. 5
5	Aug. 22, 1974	Aug. 22 to Sept. 19	Sept. 19 to Nov. 10	Nov. 10
6	May 8, 1975	May 8 to May 29	May 29 to July 8	July 8

Table 5. Nutrient treatments applied weekly and final mean plant height and width in expt. 4.

Treatment N (ppm)[z] 1-4 wk	5-11.5 wk	K (ppm)	Plant ht (cm)	Plant width (cm)
100	100	133	12.4	22.0
150	150	133	11.5	20.5
200	200	133	17.8	31.3
250	250	133	17.6	29.7
250	150	133	15.8	28.1
250	200	133	17.4	31.0
250	250	63	17.2	30.3
250	250	83	17.7	29.9
250	250	167	18.1	31.3
250	250	250	17.8	29.7
LSD 5%			2.0	2.1

[z]Initial levels of N were applied during the first 4 wk and final levels during the last 7.5 wk of the crop.

Table 6. Nutrient treatments applied with each watering and final mean plant height and width in expt. 5.

	Treatment N (ppm)	K (ppm)	Plant ht (cm)	Plant width (cm)
1	50	25	14.6	26.3
2	75	38	17.5	31.9
3	100	50	19.2	34.1
4	150	75	21.0	34.5
5	200	100	20.3	34.9
6	250	125	20.9	34.5
	LSD 5%		2.4	4.7

throughout the culture time of the crop as well as a split treatment of 250 initially and 200 or 150 ppm N later proved to be the best in this experiment. Application of 63 to 250 ppm K was equal and effective in plant response. These data indicated that different rates of N application during the early and later stages of growth are not necessary.

Collectively the 4 experiments showed that for weekly application, N levels of 250 and 300 ppm were better than levels of 400 ppm and greater and levels less than 200 ppm. A N level of 200 ppm was marginal since it was not adequate every time used. The optimum K level ranged from 60 to 200 ppm. A K level of 250 ppm was marginal causing growth reductions in some experiments.

The 5th experiment concerned fertilization at each watering and tested the effects of N levels from 50 to 250 ppm. K was applied at half the N level in each treatment. With applications of 50 ppm N plus 25 ppm K the plants were significantly shorter and narrower than those in all other treatments (Table 6). Plants fertilized with 75 ppm N plus 38 ppm K were

Table 7. Nutrient treatments applied with each watering and final mean plant height and width in expt. 6.

	Treatment N (ppm)	K (ppm)	Plant ht (cm)	Plant width (cm)
1	50	100	12.4	25.3
2	75	100	17.1	29.4
3	100	100	18.6	31.9
4	125	50	19.8	33.4
5	125	75	18.3	33.2
6	125	100	19.9	32.8
7	125	125	18.7	32.5
8	150	100	19.2	31.6
9	200	100	19.8	31.3
10	250	100	19.1	30.5
	LSD 5%		2.5	2.0

shorter than those in treatments 4, 5, and 6 but equal in width to those in treatments 3-6. Plants in the remaining treatments, given 100-250 ppm N, were best.

The 6th experiment again concerned fertilization with each watering. N levels from 50 to 250 ppm were restudied and 4 K levels from 50 to 125 ppm were tested with a constant N level of 125 ppm. Shorter and narrower plants developed in treatment 1 (50 N, 100 K) than in all other treatments (Table 7). Treatment 2 (75 N, 100 K) plants were shorter than those in treatments 4, 6 and 9 and narrower than plants in all treatments but 9 and 10. These effects were similar to those of experiment 5 for the same levels of N, even though K in this experiment was brought up to a level equal to the best treatments in experiment 5. The poor results were due to inadequate N. Plant ht in all other treatments was equal, however, small differences in width were found. Plants in treatments 3 through 8 (N levels of 100 to 150 ppm) attained the greatest width. Treatments with variable rates of K coupled with a constant rate of N (4 – 7) were among the group which did not vary significantly. Therefore, K levels of 50-125 ppm and N levels of 100 and 150 ppm were satisfactory for application at each watering.

Literature Cited

1. Goldschmidt, H. 1974. Marktwichtige Blutenbegonie. Gartnerischen Berufspraxis 41. Verlag Paul Parey, Berlin.
2. Kiplinger, D. C., H. K. Tayama and G. Staby. 1973. Tests and observations on Rieger begonias. *Ohio Florists' Assn. Bul.* 520. p. 2-3.
3. Mikkelsen, J. 1973. Simplified instructions for Rieger elatior begonia growth. *Flor. Rev.* 153(3957):36.
4. Rohde, J. 1971. Anban gesteuerter Begonia – Elatior – Hybriden der Rasse Rieger. *Der Erwerbsgartner* 25:53-58.
5. White, J. W., J. Holcomb and T. Maczko. 1973. Rieger elatior begonias progress report I. *Pa. Flower Growers Bul.* 263. p. 6-9.
6. ———, ——— and ———. 1973. Rieger elatior begonias research at Penn State progress report II. *Pa. Flower Growers Bul.* 264. p. 4-5.