Nutrition of Forced Tulips in Greenhouse and Hydroponic Culture

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GREENHOUSE FORCING

Calcium

Tulips have been forced under the concept that they do not require fertilization. The concept is somewhat faulty in that a pH recommendation for 6.5 is generally followed. This pH level insures a continuous calcium supply for the tulip. Although the tulip bulb contains calcium, most of it is locked in the bulb. A small amount moves to the developing leaves and scape. But, as the quantity of vegetation and the distance from the bulb to the newly developing tissue increases, the supply of calcium from the bulb decreases. A continuous supply of calcium from the soil throughout growth room and greenhouse stages is important. Generally, the higher the pH level of the soil, the higher is the level of available calcium.

We have conducted a series of experiments both in the greenhouse and in the field to determine the desirable range of pH levels. It turns out to be the same in both situations, 5.4 to 7.3. The lower limit is not easily identified and actually lies between 5.0 and 5.4. Below this level calcium deficiency occurs. The first symptoms are smaller leaves and a light green color. Later, topple will occur. Topple is a collapse of the scape such that the plant bends over with the flower bud hanging down. This generally, but not always, occurs along the internode below the flower or below the upper leaf at about the time the bud is opening. In more severe deficiencies the flower bud aborts before it emerges from the leaves. The upper pH limit is more precisely defined at 7.3 Above this point, leaves and scape are smaller and again there is a light green color of foliage.

Thus, we see that tulip forcers have inadvertently been fertilizing with calcium through pH adjustment of the root media. Are there other nutrients which need to be applied through a conventional fertilization program? This question is more difficult to answer. When a need is found it is usually for nitrogen.

Nitrogen

We have grown 'Paul Richter', 11-12 cm tulip bulbs under a variety of procedures including greenhouse forcing hydroponically, greenhouse forcing in solid root medium, and field production. The nitrogen contents of the various

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lots of parent bulbs were 0.73, 0.89, 0.98, 1.19, 1.42, and 1.45%. In each experiment nitrogen was applied at various rates and a control treatment without nitrogen was included. When bulbs contained 0.98% nitrogen and less, plants produced without nitrogen fertilization were lighter green and had smaller leaves. Although saleable, these plants were not as attractive as those receiving nitrogen. All plants from bulbs containing 1.19% nitrogen and more were of excellent quality. Addition of nitrogen had no beneficial effects.

The critical level of nitrogen in 'Paul Richter' bulbs lies between 1.0 and 1.2%. This is quite close to the minimum critical level of 1.0% reported for 'Apeldoorn' by Hoogeterp (1). When bulbs have a nitrogen content below the critical level they should be fertilized during forcing. If the level is above the critical level, no nitrogen fertilization is required.

Tulip bulbs are not customarily analyzed. Therefore, it is wise to fertilize all lots during forcing as an insurance against deficiency. We have had good success with the application of 2 lbs calcium nitrate per 100 gal (2.4 g calcium nitrate/l) at 3 times. The first is applied the day bulbs are potted. The second is applied half way through the growth room stage and the third when bulbs are moved to the greenhouse for forcing. It should be noted that excessive nitrogen application can cause a reduction in the scape length. We have seen this occur when 2 lbs calcium nitrate/100 gal was applied every other week during the growth room and greenhouse forcing stages.

Summary

Greenhouse forced tulips require calcium and occasionally nitrogen. We have not been able to demonstrate a need for any other nutrient. The calcium need can be met by maintenance of a root medium pH level between 5.4 and 7.3. The nitrogen requirement can be satisfied through the application of 2 lbs calcium nitrate/100 gal at the time of potting, half way through the growth room phase and at the start of greenhouse forcing.

HYDROPONIC FORCING

Product Description

A good market potential exists for a hydroponic tulip package to be forced into bloom in the home by the consumer. The package includes a plastic pot of 1 liter volume measuring about 16 cm (6.25 in) across and 7 cm (2.75 in) deep. The lid consists of 2 clear plastic plates which snap together to hold 5 tulip bulbs. The package is sold dry. Until now, the consumer has been instructed to add water to the point where the bottom of each bulb is wet, about 650 ml. The bulbs force into bloom in 20 to 35 days depending on temperature, cultivar and length of prior cold treatment. The shorter forcing times are associated with the later forcing dates and the higher temperatures.

Calcium Deficiency

A major problem has occurred. High percentages of plants topple and/or abort shortly before flowering. This is the result of calcium deficiency. Professor Klougart (2) in Denmark working with hydroponically forced 'Apeldoorn' found that calcium nitrate is the best source of calcium for correcting this problem. He found that the application of a complete fertilizer had deleterious effects.

It has further been established that calcium uptake is suppressed by increasing cold treatment time. This is probably due to the faster forcing time of the tulip and therefore shorter time for calcium uptake. Topple is a decidedly greater problem during the later forcing period. High relative

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humidities result in lower calcium uptake and more topple due to lower transpiration rates. Calcium is generally considered to be taken up passively in plants. It would thus flow in with water during transpiration. High temperatures again result in rapid growth and less time for calcium uptake. As would be expected, topple is greater at the higher temperatures.

Prevention of Calcium Deficiency

Our challenge was to find a rate of calcium nitrate which would prevent deficiency during hydroponic forcing over a range of cultivars, forcing dates and humidities. We chose the cultivars Abra, Christmas Marvel, Golden Melody, Jingle Bells, Oscar, and Prominence. Our flowering period extended from late January to early April. Relative humidities were 40% to simulate a dry room in a forced air heated home and 80% to represent a moist kitchen condition. The study was conducted in growth chambers at a temperature of 63°F (17°C) and a daylength of 14 hours at 400 foot candle light intensity from fluorescent lights.

Results from the first experiment were fairly typical of the 4 experiments. Listed in Table 1 are the percentages of plants which were impaired. When no calcium was applied, i.e., the plants were forced in deionized water alone, from 40 to 100% of the plants either toppled or aborted from calcium deficiency. When 100 ppm calcium was applied as calcium nitrate in deionized water, no problems occurred for 'Christmas Marvel' and 'Golden Melody'. Topple and abortion did occur in 'Abra' and 'Jingle Bells'. An application of 200 ppm calcium completely cured the problem. Concentrations of 400 and 800 ppm calcium brought on adverse effects in the form of floral abortion.

Table 1. Percent of tulip plants impaired by topple or abortion in Experiment 1. Forcing began on December 22, 1982.

Calcium	Abra		Christmas Marvel		Golden Melody		Jingle Bells	
(ppm)	42[z]	82	42	82	42	82	42	82
0	50	40	100	90	100	100	100	100
100	50	0	0	0	0	0	0	10
200	0	0	0	0	0	0	0	0
400	10	0	0	0	10	10	0	0
800	0	0	10	0	0	0	0	0

[z]relative humidity

These results are further supported by our dry weight measurements of the above bulb plant at bloom (Table 2). Highest weights were obtained when 100 and 200 ppm calcium were applied. Most notable decreases in plant size were noted when 0 and 800 ppm of calcium were applied

Table 2. Dry weight of the above bulb portion of plants in Experiment 1 (g per plant).

Calcium	Abra		Christmas Marvel		Golden Melody		Jingle Bells	
(ppm)	42[z]	82	42	82	42	82	42	82
0	2.50	2.24	3.17	3.08	3.47	3.37	2.95	2.74
100	3.38	3.02	3.32	3.10	3.46	3.59	3.09	3.03
200	3.48	3.06	3.08	3.10	3.51	3.57	2.89	2.74
400	3.17	2.72	2.93	2.91	3.35	3.21	3.16	2.88
800	3.07	2.36	3.06	2.76	3.25	3.07	3.02	2.78

[z]relative humidity

LSD .05 = 0.41, .01 = 0.55

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Our studies in earlier years with 'Jingle Bells' have indicated that the calcium content in tap water is insufficient. These studies have also demonstrated no beneficial effects from the addition of any other essential plant nutrient to the hydroponic solution. Only calcium presented a problem during forcing. It is conceivable that bulbs could be obtained which are abnormally low in nitrogen as was reported in the earlier greenhouse forcing section of this paper. In that event, the use of calcium nitrate as the calcium source for hydroponic forcing would prevent a nitrogen deficiency from occurring.

Solution to the Problem

Calcium deficiency can be prevented during hydroponic forcing by maintaining a root solution containing 200 ppm calcium as calcium nitrate at all times. The initial solution of 650 ml volume will last for about 2 weeks at which time its depth will have been reduced to about 1 inch (2 cm). The remaining solution should be discarded and a new calcium nitrate solution added. The second and subsequent solutions will last about 1 week due to the more rapid loss of water through plant transpiration. Each time the solution is lowered to 2 inch depth it should be replaced. A 200 ppm calcium solution is easy to make since it is approximately equal to 1 gram of solid calcium nitrate in 1 liter of water. One gram in a quart of water would be close enough. Any soluble grade of calcium nitrate as used in greenhouse fertilization programs, will work well.

The hydroponic tulip package should have considerable consumer appeal. Theoretically, cultivars suitable for greenhouse forcing in solid root media should work well in hydroponic forcing. We are currently testing such cultivars to determine their suitability for hydroponic forcing. The biggest problem in marketing this product will be the short shelf life of the bulbs after cooling and before forcing. Dr. Bob Herner in the Department of Horticulture at Michigan State University is working on special packaging to extend shelf life long enough to permit a reasonable sales time. He has met with considerable success already.

LITERATURE CITED

1. Hoogeterp, P. 1979. The effect of fertilizing with nitrogen on the plant and flower quality in the forcing of tulips. Bloembollencultuur 89:906.
2. Klougart, A. 1980. Acta Horticulturae 109:89-95.

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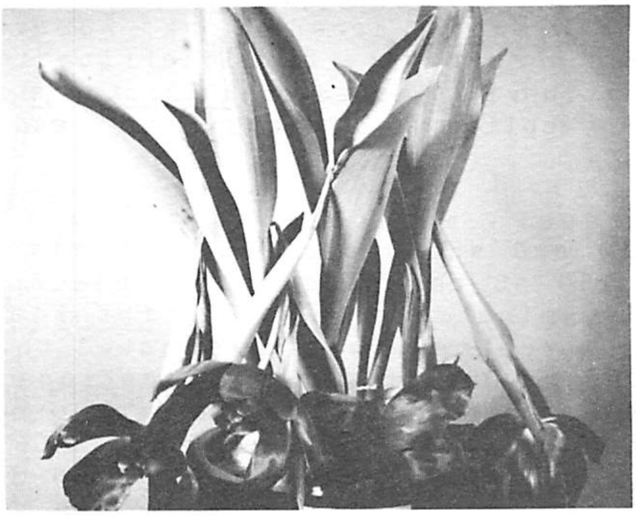
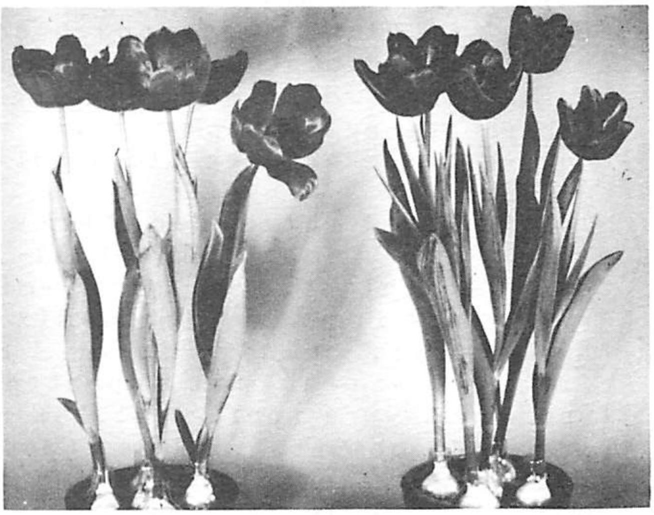


Tulips displaying the calcium deficiency symptom topple.



Pots of tulips forced hydroponically in a simulated home environment.