Gerbera Leaf Tissue Nutrient Sufficiency Ranges by Chronological Age

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Abstract

Gerbera liners of 'Festival Light Eye Yellow' were transplanted one plant per 5-inch pot. Plants were fertilized with one of six constant liquid fertilizer levels (50, 75, 100, 200, 300 or 400 mg·L^{-1} N) for 8 weeks. Plants were harvested at week 2, 5 and 8 after transplanting. Recently fully expanded leaves were sampled and analyzed for the concentration of 11 nutrients (N, P, K, Ca, Mg, S, B, Cu, Fe, Mn, and Zn). Upper and lower optimal nutritional limits were established for each element over time by analyzing the plant growth (plant height, diameter, dry weight and growth index (GI)). The sufficient tissue concentration of N, K, B, and Cu increased over 8 weeks. At 2 weeks, N and K ranged from 2.94 to 3.2% and 2.73 to 3.28% and increased to 3.33 to 4.16% and to 3.22 to 4.55% at 8 weeks, respectively. At 2 weeks, B and Cu ranged from 26.6 to 26.8 mg·kg^{-1} and 1.4 to 2.4 mg·kg^{-1} and increased to 32.0 to 35.8 mg·kg^{-1} and to 4.1 to 7.6 mg·kg^{-1} at 8 weeks, respectively. The range of other nutrients decreased over the 8 weeks. The optimal concentration ranges observed were narrower than previously published concentrations for gerberas for pot plant production. In addition, this study accounted for differences in concentrations over the entire crop cycle and reflected modern fertilization practices.

INTRODUCTION

Gerberas for pot plant production are considered moderate feeders. This moderate level of fertility produces a plant with a proportional leaf area to flower ratio. Sub-optimal fertility leads to lower leaf yellowing due to nitrogen deficiency. Excessive fertility can lead to lush growth and delayed flowering. The other common nutritional problems include iron deficiency induced by too high of a pH, iron/manganese toxicity induced by too low of a pH, and magnesium deficiency. Balancing the needs of the plant and periodic monitoring will help assure the nutritional requirements are being met. When growers are faced with visual symptoms indicating nutritional problems, accurate diagnosis can be done by plant tissue analysis. Therefore, the standards for leaf tissue nutrient concentrations are important to determine nutritional status of plants and potentially correct nutrition disorders.

The recommended fertilization concentration for gerbera production is 300 mg·L^{-1} nitrogen (N) and potassium (K) supplied using a constant liquid fertilizer (Erwin, 1991; Dole and Wilkins, 2005). This recommendation was geared towards cut gerbera production and growing large sized potted plants. As a result, the recommended leaf tissue concentration ranges (Mills and Jones, 1996; Dole and Wilkins, 2005) may reflect luxury uptake by the plant in excess of what is required for optimal plant growth. Although leaf tissue concentration changes according to plant growth stage, the tissue nutrient standards did not account for plant age. Therefore, the available standard is broad and general for gerbera pot plants. This research was undertaken to refine optimal tissue levels for pot gerbera over the production cycle.

MATERIALS AND METHODS

Gerbera liners (2.3 × 2.3 × 3.7 cm cell size) of 'Festival Light Eye Yellow' were transplanted one plant per 5-inch pot on 28 February, 2007. Plants were grown at 20°C

day and 18°C night temperatures in a glass greenhouse under ambient light conditions. Plants were fertilized with one of six constant liquid fertilizer levels based on N supply (50, 75, 100, 200, 300, or 400 mg·L^{-1}) using 1:1 N ratio of Excel® 13-2-13 and Champion WSF 20-2-20 (The Scotts Co., Marysville, Ohio), which contained 13N-0.86P-10.8K and 20N-0.86P-16.6K, respectively. Plants were irrigated as needed using a drip system utilizing sump-pumps (model 1A, Little Giant Pump Co., Oklahoma City, Oklahoma), and plants were harvested at three-week intervals for a total of three time points. At each harvest date, plant height (measured from the pot rim to the uppermost part of the plant) and plant diameter (measured at the widest dimension, turned 90°, and averaged) were used to calculate Growth Index (GI) according to Equation 1. Shoot dry weight was recorded. The experiment was a complete randomized block design with five single-plant replications and three sample times for the six levels of fertilization.

The youngest fully expanded leaves were sampled, the harvested tissue was washed in a solution of 0.5 N HCL for 1 min, and rinsed with deionized water before drying at 70°C for tissue analysis. Dried tissue was ground in a Foss Tecator Cyclotec™ 1093 sample mill (Analytical Instruments, LLC, Golden Valley, MN) to pass a ≤0.5 mm sieve. Tissue was then analyzed for macro- and micronutrient concentrations. Tissue analysis for N was performed with a C-H-N analyzer (Model 2400 series II, Perkin-Elmer, Norwalk, CT) by weighing 3.5 mg of dried tissue into tin cups and placed into the analyzer. Other nutrient concentrations were determined with inductively coupled plasma optical emission spectroscopy (ICP-OES; Model IRIS Intrepid II, Thermo Corp., Waltham, Mass.).

Data were tested by analysis of variance (ANOVA) using general linear model (SAS Institute, Cary, NC) and means were separated by least significant differences (LSD) at $P \leq 0.05$. Tissue concentrations of each fertilizer rate were regressed using the PROC REG to determine the best-fit, linear or quadratic model. Terms of the model were evaluated for significance based on a comparison of F values at $\alpha=0.05$.

Equation 1. Growth Index (GI) where height (ht) was measured from the pot rim to the uppermost part of the plant and diameter (dia_1) was measured from the widest dimension turned 90º to take second diameter (dia_2).

$$GI = \frac{ht + \frac{dia_1 + dia_2}{2}}{2}$$

RESULTS AND DISCUSSION

Upper and lower optimal nutritional limits were established for each element over time by analyzing plant height, diameter, dry weight, and GI (Equation 1). Plants fertilized with 50 and 75 mg·L^{-1} N had a significantly smaller plant height, diameter, dry weight, and growth index. Therefore, the values from the next highest fertilizer rate (100 mg·L^{-1}) were established as the lower range limit. The GI was statistically similar for the 100 to 200 mg·L^{-1} fertilizer concentrations, which established the upper sufficiency range. The GI was less for plants fertilized with 300 and 400 mg·L^{-1} N. In addition, drawing from experience concerning cost of fertilizer, common grower practices, and environmental impacts, it was concluded that with greater than 300 mg·L^{-1} N the plants would be entering a situation of luxury nutrient consumption and the additional fertilizer was not beneficial to quality.

Nitrogen

Published recommended tissue ranges for nitrogen are between 2.52 to 4.90% for pot gerberas (Table 1). Based on the research with 'Gerbera Festival Light Eye Yellow', the target ranges for plants grown with 100 to 200 mg·L^{-1} N increased over time from two weeks after transplanting until bloom, with the range being wider at bloom than just after transplanting (Fig. 1-A; Table 2). Nitrogen tissue levels were within a narrower band than the recommended published ranges (two weeks after transplanting with 2.94 to 3.20 and

at bloom 3.30 to 4.16%).

Phosphorus

The recommended range for phosphorus is between 0.25 to 0.7% for pot gerberas (Table 1). The lower optimal concentration was 0.24% at 2 weeks after transplant to 0.19% at bloom (Fig. 1-B; Table 2). This was slightly less than the lower published limit of 0.25%. For plants grown with 200 $mg \cdot L^{-1}$ N, the P levels increased from 0.33 to 0.44% by 5 weeks after transplanting, and then decreased to 0.31% at bloom. Phosphorus tissue levels were lower and within a narrower band than the recommended published ranges. Luxury uptake of phosphorus by the plant may account for the previously published upper recommendations of 0.7%, because 5 weeks after transplant, plants fertilized with 400 $mg \cdot L^{-1}$ N contained 0.73% P.

Potassium

The recommended range for potassium is between 3.1 to 5.0% for pot gerberas (Table 1). The lower measured concentration was 2.73% at 2 weeks after transplant, which increased to 3.93% five weeks after transplant, and then decreased to 3.22% at bloom (Fig. 1-C; Table 2). The initial value two weeks after transplant was slightly less than the lower published limit of 3.1%. For plants grown with 200 $mg \cdot L^{-1}$ N, the K levels increased from 3.28% to 4.87% by 5 weeks after transplanting, and then back down to 4.55% at bloom. Potassium tissue levels were within a narrower band than the recommended published ranges.

Calcium

Published recommended tissue ranges for calcium are between 0.4 to 4.2% for pot gerberas (Table 1). The optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N decreased over time from two weeks after transplanting until bloom, with the range being wider at bloom than just after transplanting (Fig. 1-D; Table 2). Calcium tissue levels were within a much narrower band than the recommended published ranges (two weeks after transplanting with 1.31 to 1.33% and at bloom 0.90 to 1.02%). The irrigation water used in the experiment did not contain Ca; therefore the only sources of Ca were from the initial lime charge provided in the substrate and the continual amount supplied from the fertilizer mixture containing 6% Ca.

Magnesium

The recommended range for magnesium is between 0.24 to 2.8% for pot gerberas (Table 1). The optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N decreased over time from two weeks after transplanting until bloom, with the widest range at bloom than just after transplanting (Fig. 1-E; Table 2). Tissue levels were higher in plants grown with 100 $mg \cdot L^{-1}$ N than 200 $mg \cdot L^{-1}$ N and may reflect the antagonistic competition of the corresponding increase in potassium being supplied in the fertilizer solution. Magnesium tissue levels were within a much narrower band than the recommended published ranges (two weeks after transplanting with 0.74 to 0.75 and at bloom 0.36 to 0.43%). The irrigation water used in the experiment did not contain Mg; therefore the only sources of Mg were from the initial lime charge provided in the substrate and the continual amount supplied from the fertilizer mixture containing 4.1% Mg.

Sulfur

There are limited recommendations for optimal sulfur levels. The only recommended range is for cut gerbera grown in tropical conditions of South America and is between 0.25 to 0.5% (Table 1). Based on the research with 'Gerbera Festival Light Eye Yellow', the optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N increased slightly from two to five weeks after transplant and then declined until bloom (Fig. 1-F; Table 2). Sulfur tissue levels were within a narrower band than the recommended published ranges (two weeks after transplanting with 0.26 to 0.31 and at bloom 0.24 to

0.26%). Sulfur deficiency is uncommon in greenhouse production.

Boron

The recommended range for boron is between 19 to 50 $mg \cdot kg^{-1}$ for pot gerberas (Table 1). The optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N increased over time from two weeks after transplanting until bloom (Fig. 2-A; Table 2). Boron tissue levels were within a narrower band than the recommended published ranges (two weeks after transplanting with 26.6 to 26.8 $mg \cdot kg^{-1}$ and at bloom 32.0 to 35.8 $mg \cdot kg^{-1}$).

Copper

The recommended range for copper is between 2 to 13 $mg \cdot kg^{-1}$ for pot gerberas (Table 1). The optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N increased over time from two weeks after transplanting until five weeks after transplant, but then declined with flowering (Fig. 2-B; Table 2). Copper tissue levels were within a narrower band than the recommended published ranges (two weeks after transplanting with 1.4 to 2.4 $mg \cdot kg^{-1}$, 8.5 to 12.9 $mg \cdot kg^{-1}$ five weeks after transplanting, and at bloom 4.1 to 7.6 mg/kg). At 2 weeks, tissue level of plants grown with 100 $mg \cdot L^{-1}$ N was below the published recommended ranges, but no deficiency symptoms were observed. Copper deficiency is uncommon in greenhouse production.

Iron

The recommended range for iron is between 56 to 130 $mg \cdot kg^{-1}$ for pot gerberas (Table 1). The optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N increased over time from two weeks after transplanting until five weeks after transplant, but then declined with flowering (Fig. 2-C; Table 2). Iron tissue concentrations were within a narrower band than the recommended published ranges (two weeks after transplanting with 74.5 to 79.5 $mg \cdot kg^{-1}$, 89.8 to 117.8 $mg \cdot kg^{-1}$five weeks after transplanting, and at bloom 37.3 to 57.4 $mg \cdot kg^{-1}$). Tissue levels at bloom were below the published recommended ranges of 56 $mg \cdot kg^{-1}$, but no deficiency symptoms were observed.

Manganese

The recommended range for manganese is between 30 to 260 $mg \cdot kg^{-1}$ for pot gerberas (Table 1). The upper optimal ranges for plants grown with 200 $mg \cdot L^{-1}$ N increased over time from two weeks after transplanting until five weeks after transplant, but then declined with flowering (Fig. 2-D; Table 2). The lower limit for plants grown with 100 $mg \cdot L^{-1}$ N steadily declined from two weeks after transplant until bloom. Manganese tissue levels were within a narrower band than the recommended published ranges (two weeks after transplanting with 61.4 to 63.9 $mg \cdot kg^{-1}$, 46.6 to 73.7 $mg \cdot kg^{-1}$ five weeks after transplanting, and at bloom 31.7 to 60.7 $mg \cdot kg^{-1}$).

Zinc

The recommended range for zinc is between 19 to 80 $mg \cdot kg^{-1}$ for pot gerberas (Table 1). The upper optimal ranges for plants grown with 100 to 200 $mg \cdot L^{-1}$ N increased over time from two weeks after transplanting until five weeks after transplant, but then declined with flowering (Fig. 2-E; Table 2). Zinc tissue levels were within a narrower band than the recommended published ranges (two weeks after transplanting with 33.4 to 36.7 $mg \cdot kg^{-1}$, 53.7 to 67.7 $mg \cdot kg^{-1}$ five weeks after transplanting, and at bloom 36.2 to 50.0 $mg \cdot kg^{-1}$).

CONCLUSIONS

This study updates the optimal tissue concentrations for pot gerbera production with lower fertility levels than 300 $mg \cdot L^{-1}$ N. Plants fertilized with 100 and 200 $mg \cdot L^{-1}$ N resulted in the maximum GI were used as the basis for optimal nutrient concentrations. Optimal concentration ranges for most nutrients were within a narrower band than the recommended ranges. Results will be suitable for interpreting values for other light-leafed

colored varieties.

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Literature Cited

Dole, J.M. and Wilkins, H.F. 2005. Floriculture Principles and Species, 2nd ed., Pearson-Prentice Hall, Upper Saddle River, New Jersey.

Erwin, J. 1991. Pot Gerbera Production. Minnesota Flower Growers Association. Bulletin 40(5).

Klossowski, W. and Strojny, Z. 1983. Chemical analysis of substrate and leaves as method of determining gerbera nitrogen and magnesium nutrition requirements. Prace Instytutu Sadownictwa i Kwiaciarstwa w Skierniewicach 8:111-121.

Mills, H.A. and Jones Jr., J.B. 1996. Plant analysis handbook II. MicroMacro Publ. Athens, Georgia.

Valenzuela de Ocampo, M. 2001. Gerbera. Ediciones Hortitecnia Ltda., Bogotá, Colombia.

Tables

Table 1. Recommended leaf tissue concentrations for pot and cut gerberas.

Nutrient	Pot gerbera		Cut gerbera			
				Valenzuela de Ocampo[1]		
	Dole and Wilkins	Mills and Jones	Klossowski and Strojny	Deficient	Low to Medium	Excessive
Nitrogen (% N)	2.7-4.1	2.52-4.90	2.7-3.1	1.2	1.5-3.5	6.0
Phosphorus (% P)	0.3-0.7	0.25-0.62	0.19-0.35	0.15	0.2-0.5	0.6
Potassium (% K)	3.1-3.9	3.91-5.00	3.06-3.64	2.0	2.5-4.5	6.0
Calcium (% Ca)	0.4-4.2	1.00-2.40	1.66-2.18	0.7	1.0-3.5	5.0
Magnesium (% Mg)	0.3-2.8	0.24-0.63	0.30-0.48	0.15	0.2-0.7	1.2
Sulfur (% S)	-	-	-	0.16	0.25-0.5	0.7
Boron ($mg \cdot kg^{-1}$ B)	19-50	30-40	-	15	20-60	100
Copper ($mg \cdot kg^{-1}$ Cu)	2-10	4-13	-	4	6-20	50
Iron ($mg \cdot kg^{-1}$ Fe)	60-130	56-112	-	40	50-200	500
Manganese ($mg \cdot kg^{-1}$ Mn)	30-260	38-148	-	30	40-250	700
Molybdenum ($mg \cdot kg^{-1}$ Mo)	0.2-0.6	-	-	-	-	-
Zinc ($mg \cdot kg^{-1}$ Zn)	19-80	33-52	-	20	25-100	200

[1] The target leaf tissue concentration for cut gerberas grown under tropical and subtropical conditions would be within the Low to Medium range, while nutrient deficiencies could be expected under Deficient levels, and toxicities under Excessive levels.

Table 2. Optimal leaf tissue concentrations for 'Gerbera Festival Light Eye Yellow' pot plants grown with 100 to 200 $mg \cdot L^{-1}$ N.

Nutrient	Weeks after transplanting		
	2 Weeks	5 Weeks	8 Weeks (bloom)
Nitrogen (% N)	2.94-3.20	3.36-3.94	3.33-4.16
Phosphorus (% P)	0.24-0.33	0.23-0.44	0.19-0.31
Potassium (% K)	2.73-3.28	3.93-4.87	3.22-4.55
Calcium (% Ca)	1.31-1.33	1.21-1.23	0.90-1.02
Magnesium (% Mg)	0.74-0.75	0.46-0.50	0.36-0.43
Sulfur (% S)	0.26-0.31	0.27-0.31	0.24-0.26
Boron ($mg \cdot kg^{-1}$ B)	26.6-26.8	25.4-29.0	32.0-35.8
Copper ($mg \cdot kg^{-1}$ Cu)	1.4-2.4	8.5-12.9	4.1-7.6
Iron ($mg \cdot kg^{-1}$ Fe)	74.5-79.5	89.8-117.8	37.3-57.4
Manganese ($mg \cdot kg^{-1}$ Mn)	61.4-63.9	46.6-73.7	31.7-60.7
Zinc ($mg \cdot kg^{-1}$ Zn)	33.4-36.7	53.7-67.7	36.2-50.0

Figures

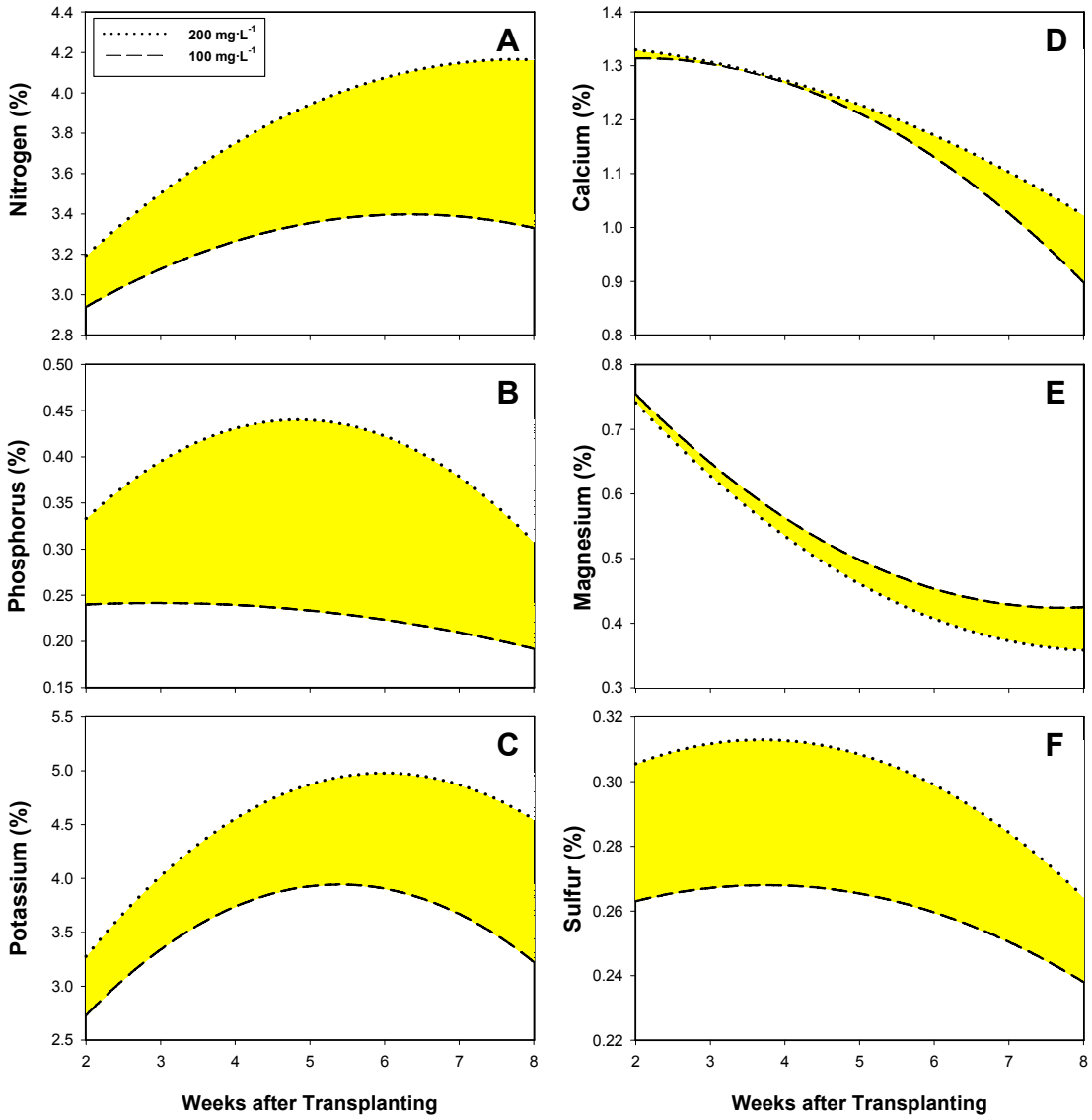

Fig. 1. Macro nutrients tissue concentration over time of 'Gerbera Festival Light Eye Yellow' plants grown with 100 and 200 mg·L^{-1} N.

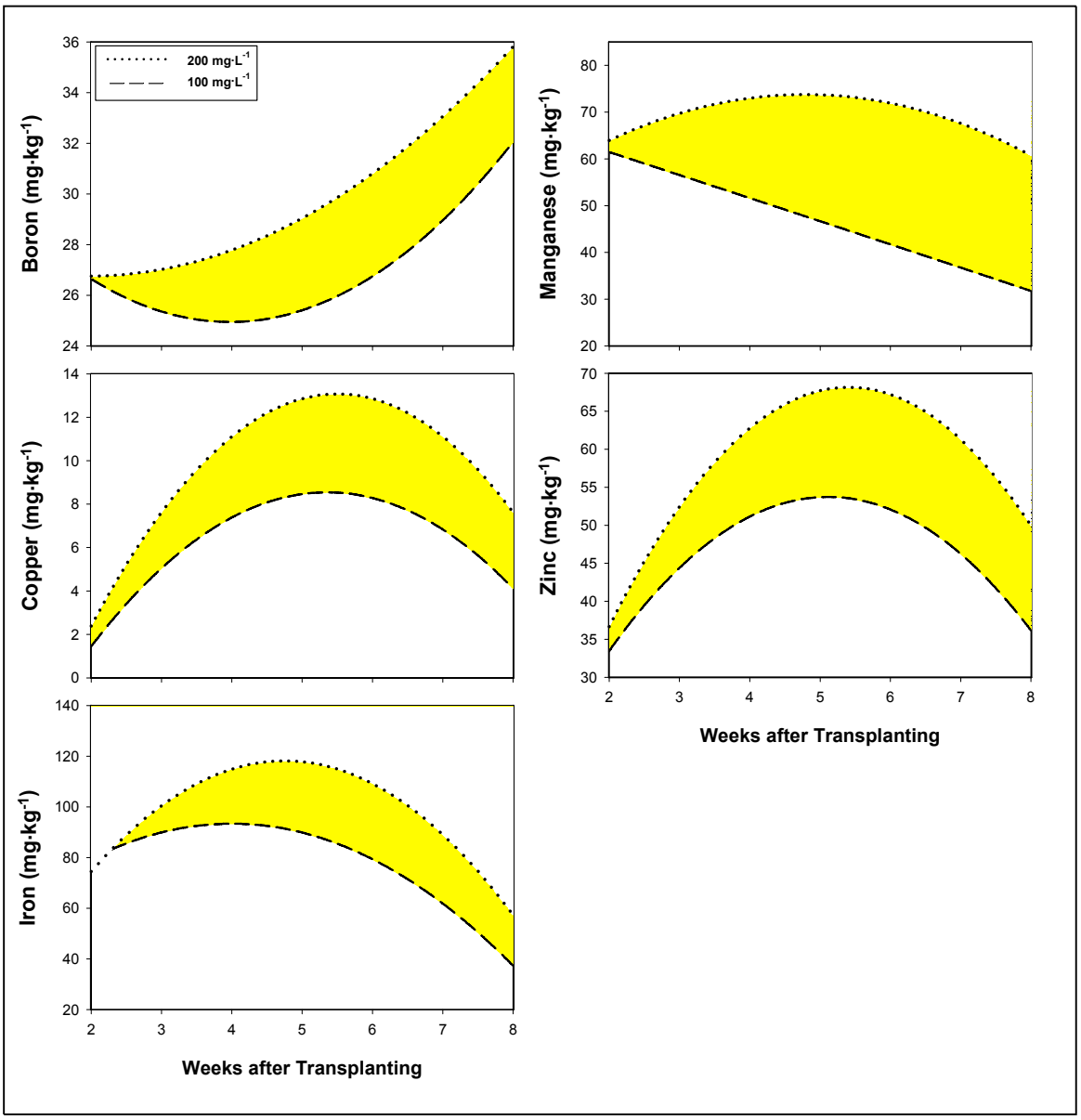

Fig. 2. Micro nutrients tissue concentration over time of 'Gerbera Festival Light Eye Yellow' plants grown with 100 and 200 mg·L^{-1} N.