

Effects of Various Mineral Deficiencies and Excess on Citrus Fruit Quality

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In the course of outdoor water-culture studies and field observations with bearing orange trees over a good many years, substantial information concerning nutritional effects on fruit quality has accumulated.

Fruit quality as used in this paper refers to any characteristic having to do with fruit (yield excepted). Mineral deficiency and excess are conceived of as any nutritional state in which there are visual or measureable effects on either growth, or fruit characteristics.

With some notable exceptions, the early stages of nutritional deficiencies and excesses produce little or no commercial effect on fruit quality. Growth abnormalities usually become apparent ahead of fruit quality effects, although in the case of phosphorus deficiency

we have noted that in the early stages of deficiency and before growth or appearance are visually affected, some fruit may show the kind of effects which become more general when the deficiency has become acute.

In the case of potassium, too, before there is any decrease in fruit set or yield and absolutely no growth or foliar effects, fruit size is reduced when potassium is on the low side.

In Tables 1 to 9, the qualitative effects or direction of effects of acute nutritional deficiencies and excesses, insofar as information is available, are recorded.

The results of these tables are self-explanatory and need no further elaboration.

TABLE 1. Fruit Size
Nutritional Factors Which Affected Fruit Size

Decrease Size		Increase Size	
Deficiencies	Excesses	Deficiencies	Excesses
B, Ca, Cu, Fe, Mg, Mn, K, S, Zn	B, N ?, P, Salinity	N (Yield); P (Yield)	F (Yield)

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TABLE 2. Fruit Color on Oranges

Nutritional Factors Which Affect Color			
Delays Coloring	Hastens Coloring	Modifies Color at Maturity	Little Effect
High N; High K	N - def; P - def; S - def;	B - def; less orange Ca - def; less orange Cu - def; less orange Fe - def; less orange Mg - def; less orange Mn - def; less orange N - def; less orange P - def; deepens orange P - exc; less orange S - def; less orange Zn - def; less orange Salinity; less orange	F - excess; K - def; Mild deficiencies in most cases have little or no effect

TABLE 3. Symmetry of Fruit
Nutritional Factors Which Modify Shape of Fruit

Modifies shape	No Appreciable Effect
B - def; misshapen Ca - def; (Esp. if K high) Cu - def; N - excess; (Sheeps neck) K - excess; (Sheeps neck) P - def; K - (Severe def). S - def;	Mild deficiencies or excesses have little or no effect

TABLE 4. Juice Percentage
Nutritional Factors Which Affect Juice Percentage

Increase	Decrease
N - def; High - P; K - (Mild def.)	B - def; Ca - def; Cu - def; N - excess; P - def; K - def. (Effect slight) K - excess; S - def; Zn - def;

TABLE 5. Internal Quality
Nutritional Factors which affect Internal Quality

Acid		Vitamin C		Total Solids	
Increase	Decrease	Increase	Decrease	Increase	Decrease
High-N;	B-excess;	P-def;	B-excess;	Ca-def;	B-def
P-def;	Cu-def;		Cu-def;		B-excess;
High-K;	N-def;sl.		N-def;sl.		Cu-def;
	P-excess;		P-excess;		N-def;sl.
	K-def;		K-excess		P-def;
	Zn-def;		Zn-def;		K-def;sl.
					Zn-def;

TABLE 6. Fruit Firmness
Nutritional Factors which affect Fruit Firmness

Increases Firmness	Decreases Firmness	Little or No Effect
B-def;	Mn-def.?	K-def;
Cu-def.?	N-excess?	Cu-def;
Fe-def.?	P-def;	Fe-def;
Mg-def.?		Mg-def;
N-def;		
P-excess		
K-excess		
S-def;		

TABLE 7. Rind Thickness
Nutritional Factors which affect Rind Thickness

Increases Rind Thickness	Decreases Rind Thickness	No or Little Effect
B-def;	Fe-def.?	Mild deficiencies
Ca-def;	Mg-def;	or excesses have
N-excess;	N-def;	little effect in
P-def;	P-excess;	general
K-excess;	K-def;	
S-def;	Salinity?	
Zn-def;		

TABLE 8. Rind Texture
Nutritional Factors which affect Rind Texture

Increases Coarseness	Increases Smoothness	No or Little Effect
Ca-def; (If K high)	Ca-def; (If Mg high	B-def.?
N-excess	and K low)	Cu-def; (Causes gum
K-excess;	Fe-def;	excrescence, some
P-def;	Mg-def;	scale and splitting)
	Mn-def;	F-excess;
	N-def;	Mild deficiencies and
	P-excess;	excesses have little
	K-def;	effect in general.
	S-def;	
	Zn-def;	

TABLE 9. Creasing
Nutritional Factors which affect creasing

Increase	Decrease
N-def. (In some years)	High N;
P-excess (In some years)	High K;
K-def. (In some years)	

REFERENCES

- BAHRT, G.M. and G.E. HUCHES. 1935. Recent developments in soil fertility investigations. *Proc. Fla. State Hort. Soc.* 48 : 31-37.
- BREWAR, R.F. 1965. Unpublished observations on file in Department of Soils and Plant Nutrition. University of California, Riverside.
- CHAPMAN, H.D., LIEBIG, F., Jr, and A.P. VAN-SELOW. 1940. Some nutritional relationships as revealed by a study of mineral deficiency and excess symptoms on citrus. *Soil Sci. Soc. Amer. Proc.* 4 : 196-200.
- CHAPMAN, H.D. and S.M. BROWN. 1941. The effects of sulphur deficiency on citrus. *Hilgardia* 14 : 185-201.
- CHAPMAN, H.D. and S.M. BROWN. 1941. The effects of phosphorus deficiency on citrus. *Hilgardia* 14 : 161-81.
- CHAPMAN, H.D. and W.P. KELLEY. 1943. The mineral nutrition of citrus. Chap. VII of *The Citrus Industry*. Vol. I. Edited by Webber and Batchelor. *Univ. Calif. Press, Berkeley, Calif.*

- CHAPMAN, H.D., S.M. BROWN and D.S. RAYNER. 1947. Effects of potash deficiency and excess on orange trees. *Hilgardia* 17: 619-50.
- CHAPMAN, H. D. and D. S. RAYNER. 1951. Effect of various maintained levels of phosphate on the growth, yield, composition, and quality of Washington Navel oranges. *Hilgardia* 20: 325-58.
- CHAPMAN, H.D. 1952. Studies of the nutrition of citrus. Report of the Thirteenth International Horticultural Congress. Vol. 2, pp. 1241-56. The Royal Horticultural Society, London, England.
- CHAPMAN, H. D., JOSEPH, HARRIETANN and D. S. RAYNER. 1965. Some effects of calcium deficiency on citrus. *Proc. Amer. Soc. Hort. Sci.* 86: 183-93.
- CHAPMAN, H. D. 1965. Unpublished data on file in Department of Soils and Plant Nutrition, University of California, Riverside.
- CHAPOT, HENRI and VITTORIO L. DELUCCHI. 1964. Maladies, troubles, et ravageurs des Agrumes au Maroc. Institut National de la Recherche Agronomique. *Rabat*. 339 p.
- DESZYCK, E. G., R. C. J. KOO and S. V. TING. 1958. Effect of potash on yield and quality of Hamlin and Valencia oranges. *Soil Crop Sci. Soc. Fla. Proc.* 18: 129-35.
- HAAS, A.R.C. 1945. Boron in citrus trees. *Plant Physiol.* 20: 323-43.
- JONES, WINSTON, W. and E.R. PARKER. 1947. Ascorbic acid-nitrogen relation in navel orange juice as affected by fertilizer applications. *Amer. Soc. Hort. Sci. Proc.* 50: 195-98.
- JONES, W. W. 1959. Nitrogen - yield - quality relations. *Calif. Citrograph* 45: 40, 56-58.
- JONES, W. W. and T. W. EMBLETON. 1959. The visual effect of nitrogen nutrition on fruit quality of Valencia oranges *Proc. Amer. Soc. Hort. Sci.* 73: 234-36.
- MORRIS, A. A. 1938. Some observations on the effects of boron treatment in the control of "Hard Fruit" in citrus. *Jour. Pom. and Hort. Sci.* 16: 167-81.
- PARKER, E.R. and W.W. JONES 1950. Orange fruit sizes in relation to potassium fertilization in a long-term experiment in California. *Amer. Soc. Hort. Sci. Proc.* 55: 101-13.
- REUTHER, W. and P.F. SMITH. 1952. Relation of nitrogen, potassium and magnesium fertilization to some fruit qualities of Valencia orange. *Proc. Amer. Soc. Hort. Sci.* 59: 1-12.
- ROY, W.R. 1937. The effect of soil applications of manganese on the mineral composition of foliage and maturity of fruit in citrus. *Proc. Fla. State Hort. Soc.* 50: 29-37.
- SITES, J.W. and E.J. DESZYCH. 1953. Effect of varying amounts of potash on the yield and quality of Valencia and Hamlin oranges *Proc. Fla. State Hort. Soc.* 65: 92-98.
- SKINNER, J.J., G.M. BAHRT and A.E. HUGHES. 1934. Influence of fertilizers and soil amendments on citrus trees, fruit production and quality of fruit. *Proc. Fla. State Hort. Soc.* 47: 9-17.
- SMITH, P. F. and W. REUTHER. 1950. The response of young valencia orange trees to differential boron supply in sand culture. *Plant Physiol.* 26: 110-14.
- SMITH, PAUL, F. and REUTHER, WALTER. 1951. Observations on boron deficiency in citrus. *The Citrus Industry*, Feb. 1950, pp. 5-7, 20.
- SITES, JOHN, W. 1947. Internal fruit quality as related to production practices. *Florida State Hort. Soc. Proc.* 60: 55-62.
- SMITH, P. F. 1955. Relation of boron level to production and fruit quality of grapefruit and oranges. *Proc. Fla. State Hort. Soc.* 68: 54-59.
- SMITH, P. F. 1959. Relation of potassium nutrition to size and quality of Valencia oranges *Proc. Amer. Soc. Hort. Sci.* 74: 261-65.
- SMITH, P. F. and G.K. RAMUSSEN. 1959. Relation of potassium nutrition to size and quality of Valencia oranges. *Proc. Amer. Soc. Hort. Sci.* 74: 261-65.
- SPENCER, W. F. and R. C. J. KOO. 1962. Calcium deficiency in field grown citrus trees. *Proc. Amer. Soc. Hort. Sci.* 81: 220-08.
- WALLIHAN, E. F. 1965. Unpublished observations on file in the Department of Soils and Plant nutrition, University of California, Riverside.