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DETERMINING MOST PROFITABLE LEVEL OF NITROGEN FERTILIZATION FOR CITRUS[1]

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Additional index words. yield response, marginal analysis, economics, Hamlin, Valencia, irrigation.

Abstract. **Applying nitrogen fertilizer to citrus groves has long been recognized as a way to increase fruit yields. However, applied research shows that as increasing increments of nitrogen fertilizer are added to a grove, fruit yield response becomes less and less until additional increments of nitrogen result in declining fruit yields. Therefore, the efficiency of utilizing nitrogen to increase yield decreases as maximum production is approached. The most profitable rate of nitrogen application will depend on the relationship among the price of nitrogen and value of fruit and the response of the grove to nitrogen fertilization. Nitrogen yield response data from recent research are used to evaluate most profitable nitrogen fertilization rates using both current nitrogen-fruit price relationships and anticipated future price increases.**

In the 1940's and 1950's nitrogen prices were low and rates applied were usually high with extreme cases of 400-500 lb. of nitrogen applied per acre per year (4). Research in the late 1950's and early 1960's demonstrated that nitrogen rates in excess of 200 lb. of N per acre per year in non-irrigated groves and 250 lb. of N per acre per year in irrigated groves could seldom be justified (3). Nitrogen fertilizer prices have increased dramatically since the early 1970's. Further increases will likely occur in the immediate future as current contracts for natural gas, a major feedstock in nitrogen fertilizer production, expire. Natural gas prices are expected to be several times higher under new contracts.

In the event of increasing nitrogen prices, citrus grove managers must decide what nitrogen fertilization rates will produce maximum profits, not necessarily maximum yields. Therefore, in this study, data from nitrogen fertilization experiments with Hamlin and Valencia orange groves were evaluated to find the most profitable nitrogen fertilization rates under differing nitrogen prices and fruit values.

Materials and Methods

Yield response of Hamlin and Valencia oranges to increasing rates of nitrogen fertilization formed the basis for this paper (1, 2). In one study (2) both varieties received normal grove care management including irrigation. The study began with 12-year-old Hamlin and Valencia trees in 1972-73 and continued for five years. Nitrogen rates of 70, 130, 190 and 250 lb. per acre annually were applied. In addition, data from an irrigation-nitrogen study using only Valencia orange was analyzed (1). The irrigation-nitrogen study began with 12-year-old trees in 1973-74 and continued for four years. Nitrogen rates of 80, 160 and 240 lb. per acre per year were used in this study. Three irrigation levels were also included: no irrigation (I-1), soil water level maintained at 35% of field capacity 0-60″ depth (I-2) and soil water level maintained at 65% of field capacity 0-60″ depth (I-3). Only the I-3 treatment is considered in this paper.

Yields in lb. solids per acre for each nitrogen rate were averaged over the period for each variety. Average yields from each nitrogen treatment were plotted on graph paper (Figs. 1, 2) and a smooth curve was fitted to the data points by graphic technique. Nitrogen rates beginning at 70 lb. per acre and in 30 lb. increments were plotted and corresponding yields in lb. solids per acre were read from the graph.

A marginal analysis of the data was performed by determining the additional yield from each 30 lb. increment of nitrogen. The most profitable nitrogen rate was determined by equating the cost of a 30 lb. increment of nitrogen fertilizer with the value of the corresponding yield *increase*. Maximum profit is realized when the cost of an increment of nitrogen is just equal to the corresponding *increase* in yield.

Results and Discussion

The yield response of both the Hamlin and Valencia oranges (Figs. 1, 2) clearly exhibits the law of diminishing

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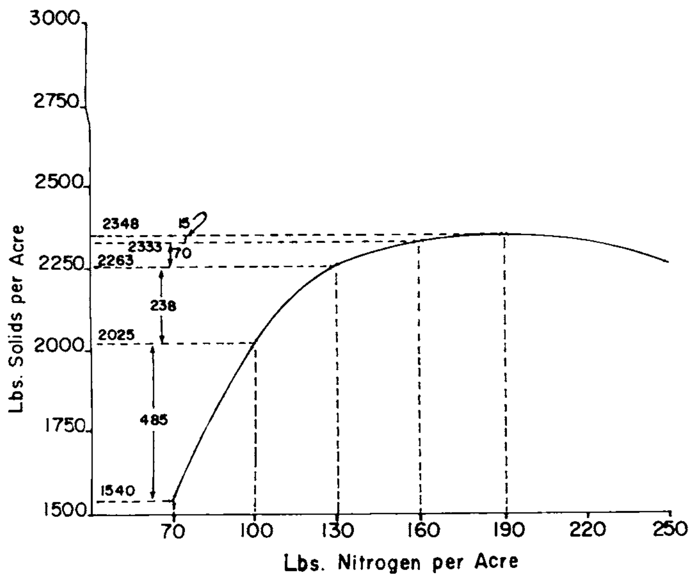

Fig. 1. Yield response of Valencia orange in lb. solids per acre to nitrogen fertilization 1972-73 to 1976-77 from research by Dr. R. C. J. Koo, IFAS Agricultural Research and Education Center, Lake Alfred.

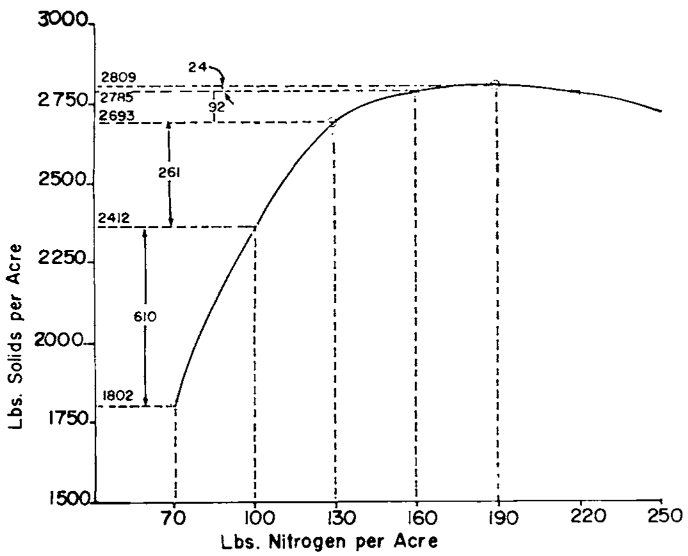

Fig. 2. Yield response of Hamlin orange in lb. solids per acre to nitrogen fertilization 1972-73 to 1976-77 from research by Dr. R. C. J. Koo, IFAS Agricultural Research and Education Center, Lake Alfred.

returns.[2] Large increases in yield are observed when 30 lb. increments of nitrogen are added to 70 or 100 lb. nitrogen rates. Response to further additions of 30 lb. increments of nitrogen becomes less and less until additional nitrogen causes a reduction in yield.

Maximum profit from applying nitrogen fertilizer is the point where the cost of adding an increment of nitrogen is just equal to the value of the corresponding increase in yield. In the case of Valencia oranges (Table 1), the *most profitable* nitrogen rate, with nitrogen at 25¢ per lb. and on tree fruit price at 85¢/lb. solids, is 190 lb. of nitrogen per acre per year. In this case, the 190 lb. nitrogen rate is also the rate that produces maximum yield (Fig. 1).

To determine the maximum profit level, note that adding 30 lb. of nitrogen to the 160 lb. rate results in a yield increase of 15 lb. solids per acre worth $12.75 (@ 85¢/lb. solids). The cost of 30 lb. of nitrogen @ 25¢/lb. was $7.50, leaving a net gain of $5.25. However, if 30 lb. of nitrogen are added to the 190 lb. rate, a reduction in yield of 38 lb. solids/acre occurs. Therefore, spending the additional $7.50 would result in a loss of $32.00 from reduced fruit yield or a total loss of $39.50 when the cost of the nitrogen is included. The prudent manager would not be willing to invest $7.50 if he were going to lose a total of $39.50.

Yield response of Hamlin orange to nitrogen fertilization (Fig. 2) was greater than Valencia orange. However, the maximum profit level was reached at the 190 lb. nitrogen rate (Table 2) with nitrogen costing 25¢/lb. and on-tree fruit value of 85¢/lb. solids. This is the same maximum nitrogen rate as the Valencia orange. Once again, the nitrogen rate producing the maximum profit also produced the maximum yield. If the price of nitrogen fertilizer increases in relation to the on-tree fruit value, the maximum profit nitrogen rate is likely to be less than the rate that produces maximum yield.

The most profitable nitrogen rate will vary depending on the price of nitrogen fertilizer, the value of the fruit and the response of the grove to nitrogen fertilizer. Tables 3 and 4 illustrate the most profitable nitrogen rate with various combinations of nitrogen cost and fruit values. Note that the most profitable nitrogen rate does not exceed 190 lb. Increasing nitrogen rates above this level will result in little or no increase in yield or an actual decrease in yield.

[2]The law of diminishing returns states that if one factor (input) of production (e.g. nitrogen fertilizer) is increased by small constant amounts while all other factors of production are held constant, the resulting increases in output will become smaller and smaller until output becomes constant and eventually declines.

Table 1. Marginal analysis of increasing nitrogen fertilization of Valencia orange.

Lb. elemental nitrogen			Yield—lb. solids/acre			
Total N	Addl. N	Cost of addl. N w/N @ $ .25	Total yield	Addl. yield from addl. N	Value of addl. yield @ $ .85/lb.	Net return from addl. N
lb.	lb.	$	lb.	lb.	$	$
70	—		1540			
100[z]	30	7.50	2025	485	412	404
130	30	7.50	2263	238	202	194
160[z]	30	7.50	2333	70	59	52
190[y]	30	7.50	2348	15	13	5
220[z]	30	7.50	2310	−38	(−32)	(−40)
250	30	7.50	2255	−55	(−47)	(−54)

[z]Interpolated from original data.
[y]Refer to example in text and Table 3.

Table 2. Marginal analysis of increasing nitrogen fertilization of Hamlin orange.

Lb. elemental nitrogen			Yield—lb. solids/acre			
Total N	Addl. N	Cost of addl. N w/N @ $ .25	Total yield	Addl. yield from addl. N	Value of addl. yield @ $ .85/lb.	Net return from addl. N
lb.	lb.	$	lb.	lb.	$	$
70	—		1802			
100z	30	7.50	2412	610	518	510
130	30	7.50	2693	281	239	232
160z	30	7.50	2785	92	78	70
190y	30	7.50	2809	24	20	12
220z	30	7.50	2775	—34	(—29)	(—36)
250	30	7.50	2721	—54	(—46)	(—54)

zInterpolated from original data.
yRefer to example in text and Table 4.

Table 3. Valencia orange—most profitable nitrogen rate.

Price of nitrogen	On-tree value of fruit/lb. solids	Total yield lb. solids/acre	Gross return/acre	Gross return/acre less N cost	Most profitable N rate lb./acre
$ .25	$ .85	2348	$1996	$1948	190z
.25	.95	2348	2231	2184	190z
$ .50	$ .95	2333	$2216	$2136	160
.50	1.05	2348	2465	2370	190
$ .75	$1.25	2333	$2916	$2796	160
.75	1.50	2348	3522	3402	190
$1.00	$1.75	2333	$4083	$3923	160
1.00	2.00	2348	4696	4506	190
$1.25	$2.25	2333	$5249	$5049	160
1.25	2.50	2348	5870	5632	190

zRefer to line 5 in Table 1.

Table 4. Hamlin orange—most profitable nitrogen rate.

Price of nitrogen	On-tree value of fruit/lb. solids	Total yield lb. solids/acre	Gross return/acre	Gross return/acre less N cost	Most profitable N rate lb./acre
$ .25	$ .85	2809	$2388	$2340	190z
.25	.95	2809	2669	2621	190z
$ .50	$ .85	2809	$2388	$2293	190
.50	.95	2809	2669	2574	190
$ .75	$ .95	2809	$2669	$2526	190
.75	1.05	2809	2949	2806	190
$1.00	$1.15	2785	$3203	$3043	160
1.00	1.25	2809	3511	3321	190
$1.25	$1.50	2785	$4178	$3978	160
1.25	1.60	2809	4494	3256	190

zRefer to line 5 in Table 2.

Valencia orange responded to higher rates of nitrogen fertilization with high irrigation (I-3) treatment (Fig. 3) than Valencia orange with normal irrigation. As a result, maximum profit level was not reached until the 220 lb. nitrogen rate (Table 5) with nitrogen costing 25¢/lb. and on-tree fruit value of 85¢/lb. solids. Table 6 illustrates the most profitable nitrogen rate with various combinations of nitrogen costs and fruit values.

Individual groves will respond differently to nitrogen depending on the age of the grove, tree spacing, soil, cultural practices and health of the trees, etc. Older groves in healthy condition on good soil will respond to higher nitrogen rates than groves on less desirable soil or groves with diseased, unthrifty trees.

The ultimate responsibility for deciding the most profitable nitrogen rate for an individual grove rests with the grove manager. The manager must judge the responsiveness of the grove to nitrogen while estimating the value of the fruit at harvest and then add in the price for nitrogen. The manager who makes the most accurate decisions is rewarded with the greatest return. Information in this paper and other research information can be used by the manager to guide his decisions and increase his chances of making more accurate decisions.

Table 5. Marginal analysis of increasing nitrogen fertilization of irrigated Valencia orange.

Lb. elemental nitrogen			Yield—lb. solids/acre			
Total N	Addl. N	Cost of addl. N w/N @ $ .25	Total yield	Addl. yield from addl. N	Value of addl. yield @ $ .85/lb.	Net return from addl. N
lb.	lb.	$	lb.	lb.	$	$
70z	—		1185			
100z	30	7.50	1410	225	191	184
130z	30	7.50	1600	190	162	154
160	30	7.50	1725	125	106	98
190z,y	30	7.50	1775	50	42	34
220z,y	30	7.50	1785	10	8	—
250z	30	7.50	1760	—15	—13	(—20)

zInterpolated from original data.
yRefer to Table 6.

Table 6. Valencia orange—irrigated study most profitable nitrogen rate.[z]

Price of nitrogen	On-tree value of fruit/lb. solids	Total yield lb. solids/acre	Gross return/acre	Gross return/acre less N cost	Most profitable N rate lb./acre[y]
$ .25	$ .85	1785	$1517	$1462	220
.25	.95	1785	1696	1641	220
.25	1.05	1785	1874	1819	220
.25	1.15	1785	2053	1998	220
$ .50	$ .85	1775	$1509	$1414	190
.50	.95	1775	1686	1591	190
.50	1.05	1775	1864	1769	190
.50	1.15	1775	2041	1946	190

[z]With nitrogen prices of $ .75, $1.00 and $1.25 per lb. on-tree fruit prices at least of $2.25, $3.00 and $3.75 respectively would be necessary before 220 lbs. of nitrogen per acre would be profitable.
[y]Refer to Table 5.

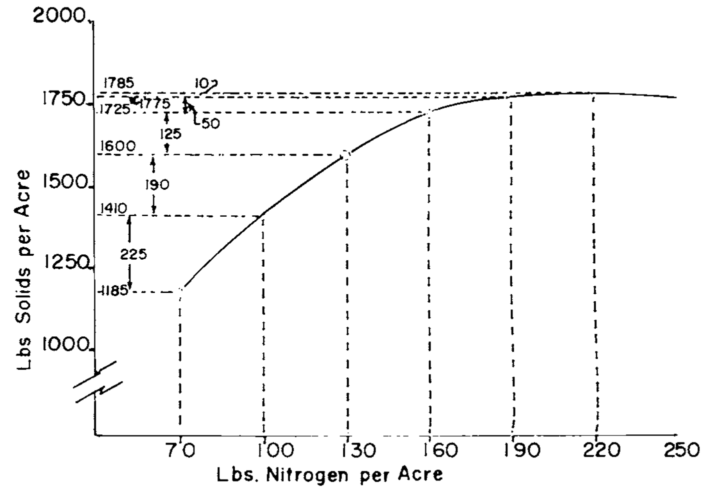

Fig. 3. Yield response of irrigated-nitrogen (irrigated to 65% of field capacity to 60") Valencia orange in lb. solids per acre to nitrogen fertilization 1973-74 to 1976-77 from research by Dr. R. C. J. Koo, IFAS Agricultural Research and Education Center, Lake Alfred.

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FRUIT SET AND DROP OF FLORIDA NAVEL ORANGES

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Abstract. **Fruit drop of navel oranges** [Citrus sinensis **(L.) Osbeck] following June drop was extensive in the 1978-1981 seasons. Blossom-end yellowing (BEY) during early summer, and stylar-end decay, fruit splitting and branch collapse during late summer and early fall all contributed to fruit drop. Sprays of 2,4-D alone or in combination with gibberellic acid suppressed BEY and reduced summer drop. However, these growth regulators did not affect summer-fall drop. Sprays of malathion and benomyl were ineffective in reducing summer or summer-fall drop.**

Inadequate fruit set and extensive fruit drop are major causes of low yields of navel oranges in Florida (8, 9). In addition to the postbloom and June drops, navels lose significant numbers of fruit during the period between the end of the June drop and legal maturity (13). Preharvest drop, defined as fruit drop after legal maturity, has not been extensive in recent years since many navels are harvested soon after reaching legal maturity.

Many attempts have been made to increase navel orange fruit set. Studies in Florida, however, have not resulted in practical solutions to the problem (1, 8, 9, 14). Girdling of the trunk during bloom was successful for increasing fruit set of 'Orlando' tangelo and navel orange (7). However, few growers currently girdle citrus trees in Florida because of unwilling or unreliable labor. Cross-pollination reportedly increases yields in Egypt (2) and South Africa (11); although, this practice has not been proven to increase yields in Florida (8, 15). Intermittent overhead misting or the application of an antitranspirant increased navel fruit set under experimental conditions (1). However, these methods have not been tested on a large scale.

Application of gibberellic acid (GA) to branches, inflorescences or individual fruits during bloom or shortly after consistently and significantly increased navel fruit set (9). Whole-tree sprays during the same period, however, produced inconclusive results. More recently, sprays of GA alone or in combination with 6-benzylaminopurine (BA) and/or $Ca(H_2PO_4)_2$ were found to increase navel fruit set through June drop (14). However, there is no evidence that GA increases yields of navel orange in Florida. As a result, not enough information is available to recommend GA sprays as a practical, reliable means of increasing navel fruit set and yields at the present time.

Factors involved with navel fruit drop after June drop have only been characterized recently (13). Two distinct waves of drop have been observed, the summer drop, which occurs mainly in June and July, and the summer-fall drop, which occurs from late August until October. Fruit abscission at these times is particularly disconcerting to growers and may be of more importance than previously realized (13).

The objectives of this work were to determine some possible causes of summer and summer-fall fruit drops, and to attempt to ameliorate these problems through the use of growth regulator, insecticide and fungicide sprays.

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