COMPARISON OF ALLIED CHEMICAL CORPORATIONS' REGISTERED NUTRIENT SPRAYS WITH CURRENTLY RECOMMENDED SPRAYS

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Abstract. **In a number of replicated field experiments NZN®, NMG™, and Folian® (NPK spray) were compared with the University of California's currently recommended observations were the sole means of evaluation. With the same amount of applied Zn, NZN® increased leaf Zn concentrations considerably more than recommended zinc sulfate sprays. None of the spray treatments significantly affected the carry-over effects on Zn concentrations in the next spring's growth. With equal amounts of applied Mg, NMG™ and the recommended Mg $(NO_3)_2$ spray were equally effective. There was very little carry-over effect into next spring's growth with either material. All Mg sprays increased the Zn concentrations in leaves. This may be due to the hygroscopic nature of the sprays which were applied upon a uniform grower application of Zn or the NO_3 in the spray which reacted with the residual Zn to make it more absorbable by the leaves. With equal amounts of applied N, Folian® and urea were equally effective. At recommended concentrations, KNO_3 was very effective. Folian® could not be applied at K amounts equal to recommended KNO_3 sprays.**

Introduction

For California citrus production, recommendations have been published for sprays to maintain nutrient levels or correct deficiencies of Zn and Mg[4,5]. Recommendations for Zn sprays include use of zinc sulfate. Evidence exists showing that supplying Zn in the spray solution is more effective in the NO_3 form than in other forms and certain additives increase Zn absorption[1,2,3,6].

This report compares some of the University of California's recommended nutritional sprays for citrus with registered sprays of Allied Chemical Corporation.

Field experiments were utilized with cooperation of a number of citrus growers. All field dilute-spray experiments were in a randomized block design with single-tree plots and 14 replications. The sprays were applied with conventional hand guns. Leaves were wetted to the point that the spray solution started dripping from them. With average mature trees, about 6545 liters of spray per ha was required. The sprays on the Christian property were applied with a concentrate sprayer calibrated to deliver 934 liters of spray per ha. Some delay occurred in dissolving the Epsom salts and calcium nitrate in the spray solution. There were 6 replications of 6 tree plots surrounded by border trees and border rows.

Spring flush leaves that emerged in March and April were sampled at various times during the current year, and the following year in some cases. Leaves were obtained from non-fruiting shoots from each of the 2 quadrants facing the row middles. Each leaf was hand washed in a 1% detergent (Joy) solution. All leaves in a sample were placed in an expanded aluminum basket, rinsed in tap water, then in a 1% HCl solution for 30 sec, and finally thoroughly rinsed in demineralized water. Drying was at 60°C in a forced-draft oven; the leaves were pulverized with a chromium-plated beater mill. Nutrient analyses were by conventional means. Evaluation was solely by comparisons of nutrient concentrations in the leaves and phytotoxicity observations.

The grades on an element basis of the registered liquid fertilizers used were: NZN® 15-0-0-Zn 5%; NMG™ 14-0-0-Mg 4%; Folian® 12-1.76-3.32-S 0.5% – Fe 0.1%. The $ZnSO_4$ used was 36% Zn. The dry $Na_2ZnEDTA$ contained 14.2% Zn. The grade of calcium nitrate was 15.5-0-0, and potassium nitrate was 13-0-38. Epsom salts contained 9.87% Mg.

Superior Farming Zn experiment (*Table 1*): In preliminary screening concentrations of NZN® above 0.17 g Zn per liter were toxic to young 'Valencia' orange leaves. With equal amounts of applied Zn, the NZN® increased Zn concentration in leaves considerably more than $ZnSO_4$. In October 1982, leaves sprayed with NZN® at 0.17 g Zn per liter, had considerably higher Zn concentrations than leaves sprayed with $ZnSO_4$ at 0.43 g Zn per liter. Including NMG™ with NZN® reduced the effectiveness of NZN® to supply Zn to the leaves. The $Na_2ZnEDTA$ at suggested rates appeared slightly less effective than $ZnSO_4$.

The NZN® sprays did not significantly increase the N concentrations in leaves, but when NMG™ was added to NZN®, there was a significant increase in N concentrations shortly after spraying; the effect did not carry over to the October 1982 sampling. Shortly after spraying, NZN® + NMG™ increased the leaf Mg concentration, but the effects did not carry over to the October 1982 sampling.

Chase and Bailey Zn experiment (*Table 2*): The treatments in this experiment were the same as in the Superior Farming experiment, and the results were similar, except that including NMG™ with NZN® significantly increased leaf Mg in the June 1982 and October 1982 samplings. None of the sprays applied in May 1982 had any significant carry-over effect on the concentrations of nutrients in young leaves in May 1983.

Rocky Hill Mg experiment (*Table 3*): In June 1982, NMG™ and the Epsom salts + calcium nitrate sprays at the same amount of applied Mg were equally effective, but the effects did not clearly carry-over into the Octover 1982 and May 1983 samples. In the second year, results were similar to the first year except the carry-over was clearly evident into the September 1983 sample.

In both years, the high rate of NMG™ increased N concentrations in leaves of the first sample after treatment. Inclusion of NZN® with NMG™ appeared to reduce the effectiveness of NMG™ in supplying N to the leaves.

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[2] Use of specific materials and trade names does not constitute endorsement of or preference for the product.

Table 1 Superior Farming 'Valencia' orange leaf composition as influenced by dilute Zn nutritional sprays (Bakersfield, CA)

Material and amount per 100 liters of spray[y]	Zn, g/liter of spray	Nutrients in dry leaves[z] Zn (ppm) 6/22/82	Zn (ppm) 10/11/82	N (%) 6/22/82	N (%) 10/11/82	Mg (%) 6/22/82	Mg (%) 10/11/82
0 (Control)	0	17.6 a	10.8 a	2.18 a	2.14	0.232 a	0.243 ab
0.12 liters NZN®	0.08	30.6 b	19.6 b	2.24 a	2.18	0.251 b	0.256 ab
0.25 liters NZN®	0.16	167.0 d	131.0 f	2.27 ab	2.16	0.248 ab	0.235 a
46 g $ZnSO_4$[x]	0.16	35.6 b	28.4 c	[illegible]	2.11	0.245 b	0.262 b
120 g $ZnSO_4$	0.43	72.2 c	44.7 d	2.26 ab	2.10	0.246 ab	0.266 b
210 g Na_2 ZnEDTA	0.30	38.0 b	17.1 ab	2.27 ab	2.19	0.249 ab	0.268 b
0.25 liters NZN® + 2.0 liters NMG™	0.16	77.6 c	55.9 e	2.39 b	2.15	0.280 c	0.268 b
Sig.[z]		*	**	*	NS	*	*
C.V. (%)[w]		16.1	17.0	7.2	6.6	8.7	11.8

[z] Mean separation in columns by Duncan's multiple range test; NS = not significant; * = ranked at the 5% level; ** = ranked at the 1% level.
[y] Sprays applied 5/2/82.
[x] Current University of California recommendation.
[w] Coefficient of variability in percent.

Table 2 Chase and Bailey navel orange leaf composition as influenced by dilute Zn nutritional sprays (Orange Cove, CA)

Material and amount per 100 liters of spray[y]	Zn, g/liter of spray	Nutrients in dry leaves[z] 12/23/81[x]	6/23/82	10/12/82	5/10/83
		Zn (ppm)			
0 (Control)	0	11.1 a	18.2 a	23.5 a	20.5
0.12 lites NZN®	0.08	11.6 ab	86.1 c	77.9 c	22.0
0.25 liters NZN®	0.16	11.5 ab	142.0 e	124.0 d	20.5
46 g $ZnSO_4$[w]	0.16	11.5 ab	41.5 b	48.3 b	20.8
120 g $ZnSO_4$	0.43	11.1 a	78.2 c	77.4 c	21.4
210 g Na_2 ZnEDTA	0.30	11.1 a	50.6 b	50.7 b	20.7
0.25 liters NZN® + 2.0 liters NMG™	0.16	11.9 b	112.0 d	106.0 d	21.8
Sig.[z]		*	*	**	NS
C.V. (%)[v]		7.6	35.3	29.6	15.6
		N (%)			
0 (Control)	0	2.62	2.32 a	2.62	2.68
0.12 liters NZN®	0.08	2.60	2.36 ab	2.66	2.60
0.25 liters NZN®	0.16	2.59	2.30 a	2.63	2.61
46 g $ZnSO_4$	0.16	2.64	2.34 a	2.70	2.60
120 g $ZnSO_4$[w]	0.43	2.60	2.32 a	2.63	2.60
210 g Na_2 ZnEDTA	0.30	2.63	2.32 a	2.64	2.64
0.25 liters NZN® + 2.0 liters NMG™	0.16	2.61	2.45 b	2.64	2.60
Sig.[z]		NS	*	NS	NS
C.V. (%)[v]		2.5	5.5	3.9	3.9
		Mg (%)			
0 (Control)	0	0.29	0.36 a	0.36 b	0.30
0.12 liters NZN®	0.08	0.28	0.37 a	0.34 ab	0.30
0.25 liters NZN®	0.16	0.28	0.35 a	0.34 ab	0.31
46 g $ZnSO_4$[w]	0.16	0.27	0.35 a	0.35 ab	0.29
120 g $ZnSO_4$	0.43	0.29	0.36 a	0.33 a	0.30
210 g Na_2 ZnEDTA	0.30	0.29	0.36 a	0.34 ab	0.29
0.25 liters NZN® + 2.0 liters NMG™	0.16	0.29	0.41 b	0.41 c	0.30
Sig.[z]		NS	**	**	NS
C.V. (%)[v]		8.6	9.8	8.3	6.6

[z] Mean separation in columns by Duncan's multiple range test; NS = not significant; * = ranked at the 5% level; ** = ranked at the 1% level.
[y] Sprays applied 5/25 and 5/26/82.
[x] Pretreatment sample.
[w] Current University of California recommendation.
[v] Coefficient of variability in percent.

There was a general Zn foliar application in this orchard shortly before the experimental treatments were applied. An increase in the Mg concentration in the spray solution increased the Zn concentration found in the leaves. This could have been due to the hygroscopic nature of the Mg sprays which have been observed to exist on leaves for at least a month if not washed off with rain or irrigation water. It could also have been due to the NO_3 in the Mg spray which reacted with the Zn deposits on the leaves and resulted in more absorption of Zn by the leaves. Inclusion of NZN® in the NMG™ treatment increased leaf Zn concentration even more. There was no clear carry-over effect on Zn concentration in young leaves of the following year.

Christian concentrate Mg spray experiment (Table 4): With equal amounts of applied Mg, NMG™ and Epsom salts + calcium nitrate were equally effective in increasing leaf Mg in the first sample after treatment. There were no significant effects in the fall sample after treatment, and the carry-over effects into the following spring's young leaves were not clear.

The high rate of NMG™ increased leaf N in June 1982 and Octover 1982 samples. Including NZN® spray reduced the effectiveness of NMG™ in supplying N to leaves. Carry-over effects into the next spring's leaves N content were not clear, but the Epsom salts + calcium nitrate appeared to be somewhat more effective.

Material and amount per 100 liters of spray[y]	Mg, g/liter of spray	Nutrients in dry leaves[z] 12/21/81[x]	6/23/82	10/11/82	5/9/83	7/11/83	9/14/83
		Mg (%)					
0 (Control)	0	0.26	0.315 a	0.34	0.237 a	0.31 a	0.31 a
0.43 liters NMG™	0.23	0.28	0.333 ab	0.34	0.250 ab	0.33 ab	0.33 b
0.86 liters NMG™	0.46	0.27	0.336 ab	0.34	0.249 ab	0.33 ab	0.33 b
2.0 liters NMG™	1.1	0.27	0.342 b	0.35	0.257 b	0.35 bc	0.37 c
2.0 liters NMG™ + 0.25 liters NZN®	1.1	0.27	0.344 b	0.35	0.245 ab	0.35 bc	0.36 c
1.11 kg ea. Epsom salts, $Ca(NO_3)_2$[w]	1.1	0.27	0.346 b	0.35	0.246 ab	0.36 c	0.37 c
Sig.[z]		NS	*	NS	**	*	*
C.V. (%)[v]		8.9	8.8	9.9	6.7	9.4	7.9
		N (%)					
0 (Control)	0	2.29	2.27 a	2.32	2.21 ab	2.31 a	2.38 a
0.43 liters NMG™	0.23	2.26	2.29 a	2.31	2.18 ab	2.32 a	2.35 a
0.86 liters NMG™	0.46	2.28	2.32 a	2.32	2.26 b	2.36 ab	2.38 a
2.0 liters NMG™	1.1	2.28	2.44 b	2.30	2.17 a	2.44 c	2.46 b
2.0 liters NMG™ + 0.25 liters NZN®	1.1	2.26	2.37 ab	2.27	2.22 ab	2.37 ab	2.41 ab
1.11 kg ea. Epsom salts, $Ca(NO_3)_2$[w]	1.1	2.28	2.28 a	2.32	2.18 ab	2.40 bc	2.40 ab
Sig.[z]		NS	*	NS	*	*	*
C.V. (%)[v]		2.2	5.6	4.5	4.4	3.7	3.8
		Zn (ppm)					
0 (Control)	0	79	71	41 a	22 a	41 a	45 a
0.43 liters NMG™	0.23	77	93	56 b	23 ab	64 b	66 b
0.86 liters NMG™	0.46	74	84	52 b	22 a	69 c	74 c
2.0 liters NMG™	1.1	81	96	75 c	23 ab	78 d	81 d
2.0 liters NMG™ + 0.25 liters NZN®	1.1	76	97	76 c	23 ab	117 e	[illegible] f
1.11 kg ea. Epsom salts, $Ca(NO_3)_2$[w]	1.1	78	83	68 c	24 b	76 d	87 e
Sig.[z]		NS	NS	*	**	*	*
C.V. (%)[v]		12.7	28.8	19.7	6.9	8.3	7.6

[z] Mean separation in columns by Duncan's multiple range test; NS = not significant; * = ranked at the 5% level; ** = ranked at the 1% level.
[y] Sprays applied 5/24-25/82; 5/31-6/1/83.
[x] Pretreatment sample.
[w] Current University of California recommendation.
[v] Coefficient of variability in percent.

ble 4 Christian navel orange leaf composition as influenced by concentrate Mg nutritional sprays (Ivanhoe, CA)

Material in 6545 liters spray/ha[y]	Mg (kg/ha)	Nutrients in dry leaves[z] 6/24/82	10/11/82	5/9/83
		Mg (%)		
0 (Control)	0	0.38 a	0.47	0.228 a
28 liters NMG™	1.5	0.42 ab	0.46	0.236 ab
56 liters NMG™	3.0	0.43 b	0.47	0.246 abc
56 liters NMG™ + 2 liters NZN®	3.0	0.45 bc	0.45	0.242 ab
31 kg ea. Epsom salts, $Ca(NO_3)_2$	3.1	0.43 b	0.48	0.258 bc
78 kg ea. Epsom salts, $Ca(NO_3)_2$[x]	7.7	0.48 c	0.47	0.266 c
Sig.[z]		*	NS	*
C.V. (%)[w]		6.8	6.8	6.6
		N (%)		
0 (Control)	0	2.37 a	2.53 a	2.34 a
28 liters NMG™	1.5	2.52 ab	2.66 bc	2.43 ab
56 liters NMG™	3.0	2.62 b	2.71 c	2.40 ab
56 liters NMG™ + 7 liters NZN®	3.0	2.50 ab	2.62 abc	2.42 ab
31 kg ea. Epsom salts, $Ca(NO_3)_2$	3.1	2.43 a	2.62 abc	2.48 b
78 kg ea. Epsom salts, $Ca(NO_3)_2$[x]	7.7	2.42 a	2.55 ab	2.46 b
Sig.[z]		*	*	*
C.V. (%)[w]		5.6	3.5	3.3
		Zn (ppm)		
0 (Control)	0	90 a	89 a	26 a
28 liters NMG™	1.5	129 b	102 ab	26 a
56 liters NMG™	3.0	139 b	105 b	24 a
56 liters NMG™ + 2 liters NZN®	3.0	205 c	134 c	24 a
31 kg ea. Epsom salts, $Ca(NO_3)_2$	3.1	129 b	92 ab	26 a
78 kg ea. Epsom salts, $Ca(NO_3)_2$[x]	7.7	139 b	106 b	31 b
Sig.[z]		*	**	**
C.V. (%)[w]		8.7	8.3	9.5

[z] Means separation in columns by Duncan's multiple range test, NS = not significant; * = ranked at the 5% level; ** = ranked at the 1% level.
[y] Sprays applied 6/3/82.
[x] Current University of California recommendation.
[w] Coefficient of variability in percent.

As in the Rocky Hill experiment, Mg sprays increased the concentration of leaf Zn. The only significant carry-over effect into the next spring's growth Zn content was associated with the high concentration of Epsom salts + calcium nitrate; the Mg concentration in that sprays was higher than in any of the NMG™ sprays.

Chase and Bailey NPK experiment (*Table 5*): At the low concentrations of applied N, the urea treatment appeared to have an initial favorable bias. However, at the higher N concentrations, both Folian® and urea treatments increased N leaf concentration in the June 1982 and the carry-over effects sample of May 1983. Why there were not more positive responses in October 1982 is open to question. In this experiment, KNO_3 sprays were effective in increasing the N leaf concentrations. Experience of the senior author has been that KNO_3 sprays are not consistently this effective.

The University of California does not have a recommended P spray for citrus. Data in Table 5 does not indicate a clear effect that Folian® increases leaf P concentrations adequately.

Published reports by the senior author and his colleagues are that KNO_3 dilute sprays should be about 3700 g/100 liters. The senior author and his colleagues have applied KNO_3 dilute sprays to oranges, lemons, and grapefruit at concentrations of 4800 g KNO_3 per 100 liters with effective results and no phytotoxicity. It was impractical to apply Folian® in concentrations to supply this amount of K to the trees. Samples in the calander year of spray strongly indicate that the high concentration of KNO_3 spray was the only treatment that resulted in a practical increase in the leaf K concentrations.

Conclusions

When equal amounts of Zn were applied, NZN® increased the concentrations of Zn in citrus leaves considerably more than the University of California's recommended $ZnSO_4$ sprays.

When equal amounts of Mg were applied, NMG™ and the University of California's recommended spray of Epsom salts plus calcium nitrate were equally effective in increasing the concentrations of leaf Mg. Applying Mg sprays over uniform in supplying Zn to the leaves. This could be because of the hygroscopic nature of the Mg sprays or because of the presence of NO_3 in the Mg sprays which, in the presence of Zn, resulted in the increased absorption of Zn by the leaves.

Table 5 Chase and Bailey navel orange leaf composition as influenced by dilute NPK nutritional sprays (Orange Cove, CA)

Material and amount per 100 liters of spray[y]	Nutrient, g/liter of spray	Nutrient in dry leaves[z] 12/22/81[x]	6/23/82	10/12/82	5/10/83
	N	N (%)			
0 (Control)	0	2.73 ab	2.34 a	2.72 a	2.52 a
1.43 liters Folian®	2.0	2.70 a	2.39 ab	2.71 a	2.61 ab
435 g urea	2.0	2.78 b	2.42 ab	2.78 ab	2.66 b
145 g KNO_3	0.2	2.72 ab	2.33 a	2.70 a	2.55 ab
359 g urea + 145 g KNO_3	2.0	2.74 ab	2.39 ab	2.77 ab	2.58 ab
1439 g urea[w]	6.6	2.73 ab	2.47 bc	2.78 ab	2.66 b
4797 g KNO_3[w]	6.2	2.74 ab	2.55 c	2.48 b	2.61 ab
4.30 liters Folian®	6.0	2.72 ab	2.56 c	2.72 a	2.63 b
Sig.[z]		*	*	*	*
C.V. (%)[v]		2.7	5.5	3.9	4.0
	P	P (%)			
0 (Control)	0	0.132	0.124 ab	0.140	0.215
1.43 liters Folian®	0.29	0.136	0.134 ab	0.138	0.217
435 g urea	0	0.139	0.130 ab	0.138	0.220
145 g KNO_3	0	0.133	0.122 a	0.134	0.217
359 g urea + 145 g KNO_3	0	0.134	0.129 ab	0.137	[illegible]
1439 g urea[w]	0	0.135	0.131 ab	0.136	[illegible]
4797 g KNO_3	0	0.133	0.130 ab	0.138	0.220
4.30 liters Folian®	0.88	0.134	0.139 b	0.138	0.220
Sig.[z]		NS	*	NS	NS
C.V. (%)[v]		7.8	13.4	4.8	5.9
	K	K (%)			
0 (Control)	0	0.25	1.08 a	0.92 a	1.42 a
1.43 liters Folian®	0.56	0.26	1.22 a	0.92 a	1.44 ab
435 g urea	0	0.24	1.26 a	0.99 a	1.47 abc
145 g KNO_3	0.56	0.29	1.13 a	0.98 a	[illegible]
359 g urea + 145 g KNO_3	0.56	0.27	1.27 a	0.94 a	1.48 abc
1439 g urea[w]	0	0.26	1.27 a	1.01 ab	1.49 abc
4797 g KNO_3[w]	18.6	0.26	1.73 b	1.14 b	1.46 abc
4.30 liters Folian®	1.67	0.24	1.17 a	0.95 a	1.50 bc
Sig.[z]		NS	*	**	*
C.V. (%)[v]		27.9	19	12.9	5.5

z Mean separation in columns by Duncan's multiple range test, NS = not significant; * = ranked at the 5% level; ** = ranked at the 1% level.
y Sprays applied 5/26/82.
x Pretreatment sample.
w Current University of California recommendation.
v Coefficient of variability in percent.

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