NITROGEN SOURCES AS RELATED TO YIELD AND QUALITY OF HAMLIN ORANGES

(A TEN YEAR SUMMARY)

JOHN W. SITES, I. W. WANDER AND
E. J. DESZYCK
Florida Citrus Experiment Station
Lake Alfred

Nitrogen sources used on citrus have varied considerably in the past. Fifty years ago, nitrogen was derived chiefly from organic sources. But increased use of these sources as protein supplements for feeding of livestock increased their value beyond the level economically practical for citrus fertilizer. Subsequently, use of less expensive and relatively pure inorganic fertilizer salts became common, but their use was soon associated with minor element deficiencies.

After deficiency symptoms were recognized and corrective procedures adopted, mixed fertilizers containing both major and minor elements were used. During World War II, solid nitrogen was in short supply, and much of the nitrogen used for citrus was derived from ammoniated superphosphate. After the War, ammonium nitrate became available and was extensively used. Even after this varied experience, growers are not in agreement as to the relative value of the nitrogen sources offered them commercially.

This report includes a summary of data collected over a period of ten years, wherein the effect of nitrogen sources on the quality and yield of Hamlin oranges has been studied.

PROCEDURE

Beginning with the spring application in 1944, the present nitrogen source experiment was started at the Citrus Experiment Station.

Table 1.

Summary of Nutritional Program - Block XI - 1944-45 thru 1953-54.
Hamlin Oranges*

Source of Nitrogen	Plot No.	Fertilizer Analysis - Percentage					
		N	P_2O_5	K_2O	MgO	MnO	CuO
1/2 Nitrogen (Ammonium sulfate and sodium nitrate)	1	2	6	8	4	1	1/2
1/3 Organic Nitrogen (1/3 castor pomace, 1/3 sodium nitrate, 1/3 ammonium sulfate)	6	4	6	8	4	1	1/2
Ammonium Nitrate	11	4	6	8	4	1	1/2
Ammonium Sulfate	3 & 8	4	6	8	4	1	1/2
Sodium & Potassium Nitrate	2 & 7	4	6	8	4	1	1/2
Uramon	5 & 10	4	6	8	4	1	1/2
Castor Pomace	4 & 9	4	6	8	4	1	1/2

Fertilizer applied February, June and October of each year at rates of 10 lbs. per tree during 1944 and the spring of 1945; 12 lbs. per tree during from the summer of 1945 thru 1949; from 1950 thru 1953, 20 pounds per tree was applied in the spring and 15 lbs. per tree for the summer and fall applications.
*All plots received 3 lbs. per 100 gals. of $ZnSO_4$ dormant spray and neutral copper as a melanose spray.

Florida Agricultural Experiment Station Journal Series, No. 454.

A block of Hamlin orange trees approximately 25 years old, budded on rough lemon rootstock was used. The treatments, presented in detail in Table 1, were applied to single rows five trees wide with each treatment separated by a buffer row. The trees have been handled uniformly in all other respects.

Data were taken on fruit juice quality, external fruit quality by U. S. Grade standards, leaf analysis for major elements, soil pH and nitrification.

Results

In Table 2 are presented 9-year summaries of juice-quality data. This table shows only overall differences resulting from nitrogen source. For replicated treatments, the mean values presented represent approximately 100 individual samples; while the means for single plot treatments represent approximately 50 individual samples.

Table 2.

Summary of 9 years results on juice quality of Hamlin oranges as affected by source of nitrogen.

Nitrogen Source	Percent soluble solids	percent titratable acid	Vitamin C mgm. per 100 Ml.	Ml. of juice per 10 fruit
Sodium - potassium nitrate	9.63	0.90	52.2	856
Ammonium sulfate	9.89	0.93	53.7	861
Castor pomace	9.57	0.89	52.5	842
Uramon	9.63	0.93	51.8	878
Ammonium nitrate	9.81	0.95	52.9	878
Mixture of 3 sources	9.67	0.92	51.6	875
1/2 standard nitrogen rate	9.51	0.88	54.3	810
$L.S.D._{.05}$	0.137	0.021	1.41	39.7
$L.S.D._{.01}$	0.183	0.028	1.88	-

The soluble-solids content of juice of fruit from Hamlin orange trees supplied with ammonium sulfate or ammonium nitrate as the nitrogen source in the fertilizer mixture was significantly higher than in fruit from trees receiving nitrogen from any of the other sources (Table 2). There were no significant differences in soluble-solids content of fruit from trees having received any of the other treatments. These results are similar to those reported at the end of the first five year period of the experiment (3).

Significant differences were found in the titratable-acid content of the fruit juice as affected by the source of nitrogen; these differences follow very closely the pattern previously discussed for soluble solids. Fruits from trees supplied with nitrogen from ammonium nitrate contained the highest average titratable acid content in the juice. This juice contained a significantly higher average percentage titratable acid than did juice of fruit from trees supplied with sodium and potassium nitrate, castor pomace, ⅓ castor — ⅓ ammonium sulfate —⅓ sodium nitrate, or ½ N treatments (Table 2). Differences in acid content of juice of fruits from trees supplied with ammonium nitrate, ammonium sulfate, and Uramon were not significant.

The vitamin C content of the juice also varied significantly as a result of the nitrogen-source treatments, with fruit from trees receiving the ½ N treatment having the highest vitamin C content. Fruit from trees supplied with nitrogen from sodium and ammonium nitrate, castor pomace, Uramon and ⅓ castor—

⅓ ammonium sulfate—⅓ sodium nitrate all contained significantly less vitamin C than did fruits from trees receiving the ½ N treatment (Table 2). Trees supplied with ammonium sulfate also produced fruit with a significantly higher vitamin C content than did those supplied with sodium and potassium nitrate, Uramon or ⅓ castor—⅓ ammonium sulfate—⅓ sodium nitrate.

There was no significant difference in juice content of the fruit, irrespective of the nitrogen source supplied to the trees, where 4 percent nitrogen was supplied in the fertilizer mixture. Fruit from trees which received only 2 percent nitrogen, (½ N), had significantly lower juice content than those produced by trees receiving any other treatment with the exception of those supplied with nitrogen from castor pomace (Table 2).

Data were collected for juice ratio and percentage of juice by weight. However, there were no significant differences due to treatment, and summaries of these data are therefore not presented.

External Fruit Quality—Each year the fruit was harvested, samples of not less than 30 percent of the entire production were run through the Citrus Experiment Station packinghouse so that grade and size information could be obtained. There have been no significant, measurable differences in grade of fruit produced regardless of the source of nitrogen supplied to the trees. A summary of the data showing the percentage U. S. No. 1 Grade fruit for the period from 1948-49 through 1953-54 is presented in Table 3. Similar data for U. S. No. 2 and U. S. No. 3 Grade fruit are available but are not presented in the interest of conserving space.

Table 3

Summary of grade and size distribution of fruit from Hamlin orange trees as affected by source of nitrogen over a 6-crop period 1948-1954.

Nitrogen Source	Percent U.S. No. 1 grade	Av. fruit diameter, inches
Sodium - potassium nitrate	70.36	2.89
Ammonium sulfate	71.69	2.84
Castor pomace	68.54	2.90
Uramon	72.13	2.87
Ammonium nitrate	70.69	2.83
Mixture of 3 sources	71.84	2.88
1/2 standard nitrogen rate	67.94	2.93
L.S.D..05	-	0.058
L.S.D..01	-	0.078

The size of fruit produced varied significantly in relation to the source and amount of nitrogen supplied. The fruit of largest average diameter was produced by those trees receiving the least total nitrogen (½ N) in the fertilizer. This fruit, as well as that produced on trees supplied castor pomace as a nitrogen source, was significantly larger than that produced by trees to which ammonium nitrate was used as a nitrogen source (Table 3). Trees receiving the latter source produced fruit of the smallest average size.

Production — Production records have been kept on an individual-tree basis throughout the history of the experiment; however, space does not permit presentation of all production data. A summary of these data is presented in Table 4, showing the average yields for each treatment for the 10-year period from 1944-45 to 1953-54.

These data indicate the production of oranges over this period was in no way significantly affected by the source of nitrogen supplied to the trees. The production was affected by the amount of nitrogen supplied; where only 2 percent total nitrogen (½ N) was supplied, the average yield was significantly reduced when compared to any other treatment. The yield figures for the 1944-45 season are comparatively low, due to the effects of the October 18-19, 1944 hurricane. A similar situation, though less severe, reduced the yields for the 1948-49 season. From a study of these data, it is apparent that the yields have been considerably greater during the second five years of the experiment, irrespective of the source of nitrogen supplied.

Discussion and Conclusions

The preferable forms of nitrogen for use in citrus production programs have been a subject of discussion among growers, fertilizer men, and research workers for many years. Why a general broad recommendation cannot be given is understandable only by those who have some knowledge of the varying conditions under which citrus fertilizers are applied and the effect of these conditions upon the ultimate utilization of nitrogen by the trees. The current market price, availability of the material, ease of application and the facility with which it may be compounded with other materials in a mixed fertilizer, the

Table 4.

Summary of Average Boxes of Fruit Produced per Tree per Year as Related to Nitrogen Sources. Block XI - 1944-45 to 1953-54.

Years	Sod.-Pot. Nitrate	Ammon. Sulfate	Nitrogen Sources Castor	Uramon	Ammon. Nitrate	1/3 N Mix.	1/2 N
1944-45	2.38	2.79	1.20	1.60	2.10	2.25	4.27
1945-46	5.84	6.85	4.92	5.84	4.12	4.45	2.06
1946-47	5.23	6.15	4.60	5.04	5.10	4.75	4.14
1947-48	5.82	7.60	6.20	7.40	7.12	6.40	1.45
1948-49	4.48	5.10	4.68	4.20	4.25	4.95	3.40
1949-50	5.22	4.20	4.19	5.70	5.45	4.55	3.50
1950-51	7.86	7.80	7.33	8.42	7.95	8.50	5.50
1951-52	9.44	8.80	9.44	8.80	9.20	10.00	8.60
1952-53	8.11	7.10	7.56	8.10	7.10	7.50	7.70
1953-54	10.83	9.12	10.19	10.98	9.35	11.90	8.20
10 Year Avg.	6.52	6.55	6.03	6.61	6.17	6.52	4.88

L.S.D. = 0.76 boxes per tree at 5% level.

L.S.D. = 1.00 boxes per tree at 1% level.

general physical condition of the trees to which it is to be applied, the soil pH, moisture and temperature, previous fertilizer practices, and the pest control program followed are but some of the factors which have a direct or indirect bearing on the source of nitrogen preferable for a specific condition.

Based on the analyses of the juice constituents of oranges produced during the period of this experiment, there is an indication that fruit produced by trees supplied largely with nitrogen from ammoniacal sources was of better internal quality than where nitrate nitrogen was supplied. Differences in percent soluble solids and titratable acid content of fruit produced by trees supplied with ammonium sulfate and those supplied with sodium and potassium nitrate were never great, but every year the differences were in favor of the ammonium sources. These results are difficult to explain physiologically because, under field conditions, one has no way of knowing whether the applied ammoniacal nitrogen was absorbed largely in that form or whether it was nitrified and absorbed as nitrate nitrogen. There is every reason to believe that where ammoniacal nitrogen is supplied it is taken up by the plant partially as ammoniacal and partially as nitrate nitrogen, and that the percentage absorption of these forms by the plant will vary considerably from season to season depending upon soil moisture, temperature, pH and other factors at that time or following the fertilizer application. It is logical to assume that the plant takes up more nitrogen in the ammonium form where source materials such as ammonium sulfate or ammonium nitrate are supplied. Under such conditions, the internal fruit quality is slightly better and fruit sizes tend to be smaller. In this experiment the small fruit size was not related to the higher soluble solids and acid content of the fruit since only sized fruit samples were used for analysis.

It was stated previously that production was not significantly affected by the source of nitrogen supplied to the trees. Based on analyses of the data for the entire ten-year period, this is true. A more detailed appraisal of these data indicates that during this ten-year period certain changes were taking place that must be considered. In the report concerned with the first five years of this experiment, it was pointed out that trees supplied with ammonium sulfate had produced substantially more fruit than trees supplied with any other source of nitrogen, although statistical differences existed only between the ammonium sulfate supplied trees, and those receiving castor pomace and the "½ N" treatments.

Beginning in 1949, it was observed that those trees which were supplied with ammonium sulfate were showing some signs of deterioration. This was manifested by abnormally small leaves, the presence of many leaves showing magnesium deficiency, and a general decline of the tops of the trees — this later resulted in some of the smaller twigs dying. These trees continued to show these symptoms in varying degrees through the spring of 1954; since then, the physical condition of the trees has improved. A comparison of the yields of trees supplied with ammonium sulfate and those supplied with sodium and potassium nitrate is presented in Fig. 1, showing the superior production of trees supplied with ammonium sulfate for the first five years, and the superior production of the trees supplied with sodium and potassium nitrate during the second five-year period. This is not presumed to be the result of either nitrogen source per se, but rather to associated conditions which prevailed during the ten-year period in which these sources were used.

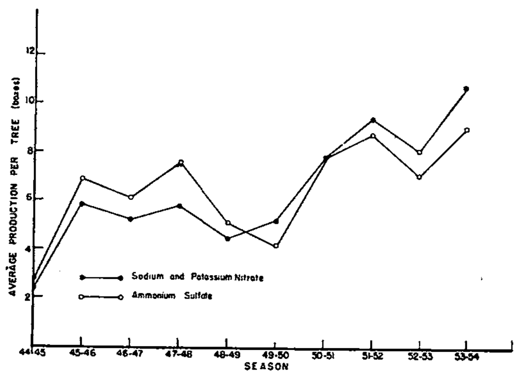

Fig. 1. Yearly variation in average production of trees supplied with ammonium sulfate and sodium-potassium nitrate as sources of nitrogen in the fertilizer mixture.

During the initial years of the experiment no dolomite was added to the soil, except when the experiment was started (Table 5). Sys-

Table 5.

Summary of Soil pH Values for Nitrogen Source Plots, Block XI, During Period from 1949-50 to 1954-55.*

Years	Sod.-Pot. Nitrate	Ammon. Sulfate	Nitrogen Sources Castor	Uramon	Ammon. Nitrate	1/3 N Mix.	1/2 N
			Soil pH[1]				
1944-45[2]	5.60	5.60	5.60	5.50	5.45	5.60	5.70
1949-50	4.85	4.50	4.70	4.80	4.70	4.70	4.90
1950-51	5.45	5.15	5.50	5.60	5.45	5.35	5.70
1951-52	5.00	4.20	4.80	4.80	4.55	4.45	5.20
1952-53	4.70	4.40	4.50	4.60	4.30	4.45	4.80
1953-54	5.45	5.10	5.20	5.30	5.25	5.10	5.45
1954-55	5.75	5.15	5.20	5.55	5.35	5.18	5.80

*Samples collected during latter part of January or early February of each year.

[1]Values represent arithmetical averages by treatments for 0" to 6" soil depth. Differential dolomite applications made April 1944 with no lime or dolomite applications made during following five-year period. Further dolomite applications made June 1949 at 10 pounds per tree, April 1950 at 15 pounds per tree, January 1952 at 30 pounds per tree and November 1953 at 40 pounds per tree.

[2]Samples collected March 14, 1944 and analyzed October 13, 1955.

tematic sampling of soil for pH measurement was started in February 1949 and continued each year for the balance of the period reported. It was observed at that time that the soil pH had dropped below pH 5.0 in all plots and as low as pH 4.5 where ammonium sulfate was supplied. During the following four-year period, from June 1949, a total of 95 pounds of dolomite per tree was applied; the corresponding effects on soil pH are presented. The soil pH has been slow to change and, with the exception of the nitrate and "½ N" plots, is still below the desired level. This has been the experience of many growers during past years. There have been innumerable cases where grove soils were allowed to become too acid – considerable difficulty was then experienced raising the soil pH again, and in getting the trees back in good condition. In most cases, favorable tree response was correlated with a correction of soil pH if the desired pH was then maintained.

In many of the problem commercial groves visited during the past several years, it has been established that the general decline of the trees was correlated with an increased use of nitrogen where at least half or more was derived from ammoniacal sources, and where insufficient liming materials had been added to maintain the soil pH in the 5.5 to 6.0 range. A situation of some concern is that it required four years to bring the trees in this experiment supplied with ammonium sulfate back to reasonably good physical appearance and that the yield is still affected after five years.

A completely satisfactory explanation accounting for these results is difficult, if not impossible, in light of present knowledge. However, the authors are agreed on certain aspects. Waksman (5) has shown the effect of pH on nitrification rate, and work reported by Eno (1) shows that nitrification is greatly reduced on acid, sandy soils when the pH of the soil is below 5.0.

A recent check of the nitrifying capacity of these soils, as shown in Table 6, indicates that where ammonium sulfate and ammonium nitrate have been supplied the nitrifying capacity of these soils is less than 60 percent of the soil receiving the other nitrogen sources. It is to be observed that the nitrifying capacity correlates rather closely with the pH of the samples. When such soil conditions exist –

Table 6.

Nitrifying Capacity of Soils Receiving Nitrogen from Different Sources. (Block XI - Hamlin Oranges 0" to 6" Depth)

Treatment	P.P.M. N as NO_3		Avg. P.P.M. N as NO_3	pH	Lbs./Acre Ca
Ammonium Sulfate	39	24	32	4.90	310
	39	24		5.00	280
Ammonium Nitrate	30	24	36	5.25	305
	48	42		5.10	325
Sodium Nitrate	66	60	62	5.70	390
	60	63		5.95	430
Uramon	66	54	62	5.75	450
	60	68		5.70	550
1/3 Ammon. Sulfate 1/3 Sod. Nitrate 1/3 Castor Pomace	48	60	54	5.25	400

Samples taken September 22, 1955, incubated 2 weeks and nitrates measured October 7, 1955.

and where nitrogen is supplied in the ammonium form – it is logical to assume that ammonium nitrogen as such is absorbed by the plant in larger quantities than where soil conditions are favorable for nitrification. The work of van der Merwe (4) and that recently reported by Wander and Sites (6) has shown that growth of citrus seedlings in water culture is greatly inhibited when constantly supplied with ammonium nitrogen in the solution. The growth of both roots and tops improved as the percentage of ammonium nitrogen decreased and nitrate nitrogen increased in the solutions.

Even though it is difficult under field conditions to ascertain if trees are actually absorbing ammonium or nitrate nitrogen, it is not inconceivable that the continued absorption of ammonium nitrogen present as a result of unfavorable nitrifying conditions in the soil might result in unsatisfactory growth response. It is not known whether the unsatisfactory growth condition associated with too much ammonium nitrogen results from the interference of physiological processes within the plant, at the root surfaces where

Table 7.

Analyses of Hamlin Orange Leaves where Nitrate, Ammoniacal and Nitrate and Ammoniacal Nitrogen were Supplied in the Fertilizer Mixture.

Source of Nitrogen	N	Percentage - Dry Leaf Basis P	K	Mg	Ca
Sodium-Potassium Nitrate	2.67	0.163	1.99	0.353	3.05
Ammonium Sulfate	2.52	0.134	2.00	0.249	2.52
Ammonium Nitrate	2.54	0.127	1.75	0.166	3.23

Leaves sampled May 31, 1954 - spring flush.

the ammonia cation may interfere with the absorption of other cations, or both. Some evidence that interference with absorption of other cations might be involved is evident in the data presented in Table 7. Magnesium deficiency symptoms have been very evident at times on the trees supplied with ammonium sulfate particularly, and to a lesser extent where ammonium nitrate was supplied as the nitrogen source. Leaves from trees receiving both of these sources of nitrogen were found to contain appreciably less magnesium by analysis than were leaves from trees supplied with nitrate nitrogen sources. The calcium content of the leaves was also found to be reduced where ammonium sulfate was supplied as the nitrogen source.

It might be inferred from the results thus far obtained that combinations of nitrate and ammoniacal nitrogen are preferable to the continued use of either source. At no time during the ten-year period did trees supplied with nitrogen wholly from nitrate sources produce fruit of the best quality or produce the highest yields. This suggests that nitrate nitrogen alone will not give optimum results.

Better results may be expected from nitrate sources if the soil is acid (pH 4.5 to 5.5 approximate range), where insufficient quantities of liming materials have been added in the past and may not be added in the future, and where trees have become in poor physcial condition through inadequate pH control and excessive use of ammoniacal nitrogen. Mixtures of nitrate and ammoniacal nitrogen would appear preferable as a maintenance nitrogen source where groves are in good physical condition and where sufficient dolomite is used to maintain the pH between 5.5 to 6.0 at all times. The most desirable ratio of one form to the other cannot be ascertained from these data. Pierre (2) has shown that a ratio of nitrate to ammoniacal of 80 to 20 resulted in no change in soil reaction. The results of this study would indicate that with the amount of dolomite supplied during the latter five-year period good results were obtained when as much as ⅓ of the nitrogen supplied was ammonium nitrogen, but that where as much as ½ of the total nitrogen was supplied directly as ammoniacal, optimum production was not maintained. This comparison is not strictly fair, however, because of the differences in organic and nitrate sources supplied in the comparisons made in this experiment.

The treatment consisting of nitrogen derived from ⅓ ammonium sulfate, ⅓ sodium nitrate and ⅓ organic resulted in satisfactory production and quality. But it is expensive, and any advantages over inorganic sources are not apparent at the present time.

Supplying all nitrogen from organic sources is impractical from a cost standpoint and fruit quality and production have been less satisfactory under this program, although differences in some cases have not been great enough for statistical significance.

Where nitrogen was supplied as urea, adequate fruit quality and satisfactory production has resulted.

Reducing the nitrogen supply to half the nitrogen supplied the other treatments resulted in a highly significant reduction in yield, and in the production of fruit of lower quality.

The most significant conclusion which may be drawn in the opinion of the authors is that maximum utilization of applied nitrogen depends largely on the soil conditions which prevail rather than upon the source of nitrogen per se, and that soil pH is probably the most important single factor with which the grower must be concerned.

Summary

Field trials were conducted on mature Hamlin orange trees to ascertain the effect of nitrogen, supplied from six different sources, on yield and fruit quality. Nitrogen was applied in mixed fertilizers derived from sodium, potassium and ammonium nitrate, ammonium sulfate, urea, and castor pomace. Also included in the experiment were mixtures of sodium nitrate, ammonium sulfate and castor pomace, and a single treatment where only ½ the amount of nitrogen supplied in the other treatments was applied.

From data accumulated over a period of ten years, it was found that fruit from trees supplied with nitrogen from ammonium sulfate and ammonium nitrate was of higher internal quality. Size of fruit and vitamin C content were affected positively when the total nitrogen supply was reduced one half, and a significant reduction in yield also resulted. Continued use of ammonium sulfate

where soil pH was allowed to go below pH 5.5 resulted in poor tree condition and decreased yields.

LITERATURE CITED

1. Eno, C. F. The effect of copper on nitrification in some Florida soils. Proc. Fla. State Hort. Soc. 66: 172-177. 1953.

2. Pierre, W. H. Nitrogenous fertilizers and soil acidity: I The effect of various nitrogenous fertilizers on soil reaction. Jour. Amer. Soc. Agron. 20: 254-269. 1928.

3. Sites, J. W. Present status of organic versus inorganic nitrogen as related to yield and fruit quality. Proc. Fla. Sta. Hort. Soc. 62: 65-72. 1949.

4. van der Merwe, A. J. Nitrogen nutrition of citrus in the nitrate and ammonium form. Sci. Bul. 299. Union of Sou. Africa, Dept. of Agr., Pretoria, S. A. 1949.

5. Waksman, Selman A., Soil microbiology. John Wiley and Sons, Inc. New York. 1952.

6. Wander, I. W. and John W. Sites. The effects of ammonium and nitrate nitrogen with and without pH control on the growth of rough lemon seedlings. In Press.

THE OBJECTIVE — A BETTER MITICIDE

C. O. Eddy

Niagara Chemical Division

Food Machinery and Chemical Corporation

Middleport, N. Y.

This paper is in response to a request from Mr. Arthur F. Mathias, your vice president, for a paper before your Society at this time on miticides. In his letter Mr. Mathias said: "More frequent applications of more expensive materials seem to be the direction that control of this pest has taken. In order to get all sides of the picture, I feel that a paper covering the following points would be very opportune at this time.

1. How miticides kill (both adults and eggs).
2. How miticides are selected.
3. How miticides are tested.
4. How miticides are manufactured.
5. How the above affects the final cost of the miticide to the grower.
6. What the outlook is for new and better miticides.
7. Any pertinent points the author wishes to make concerning the miticides, their use, cost, etc."

In a survey of recent literature, through talks with specialists on the subject, and in correspondence with technical people in Experiment Stations, in USDA laboratories, and in companies doing research and development in pesticides, it seems that the need, at present, is for a new, plant-safe miticide, or a combination of miticides that will kill all stages of mites economically, when applied occasionally. The objective of such a program is to bring back desirable biological balances that keep the mite populations low enough in numbers to be of no commercial importance.

By way of introduction it is desirable to say a few things about miticides and mites. I think we can agree that a miticide is a chemical that will control mites when properly formulated and applied. In general, mites differ from insects in that they have 4 pairs of legs instead of 3, the body consists of 2 parts instead of 3, a cephalothorax and abdomen. They lack antennae.

Generally speaking, mites are very small — many are microscopic in size. In fact, they are many times smaller than the insects with which we are more familiar. They are found in almost every habitat available to animal life. They are also internal and external parasites of man and other vertebrates. But, more important to us, mites also attack most plants and, in many cases become very serious economic pests. Like insects, some are also predatory, preying on other mites and even on small insects, and thus becoming one of the checks in nature.

The mouth parts of mites are difficult to describe as they are complex and variable between different groups but, essentially, are of a sucking or modified-sucking type. The skeleton of the mite is external as in the case of insects but is softer than that of insects. These characteristics, together with the fact that many of these pests are successful only in sheltered or concealed areas on plants, are important considerations in the control of mites by chemical sprays or dusts.

There are many studies going on now aimed at discovering more information relative to how miticides kill. This subject could well be discussed in a technical survey of the subject in a very lengthy paper. However, it