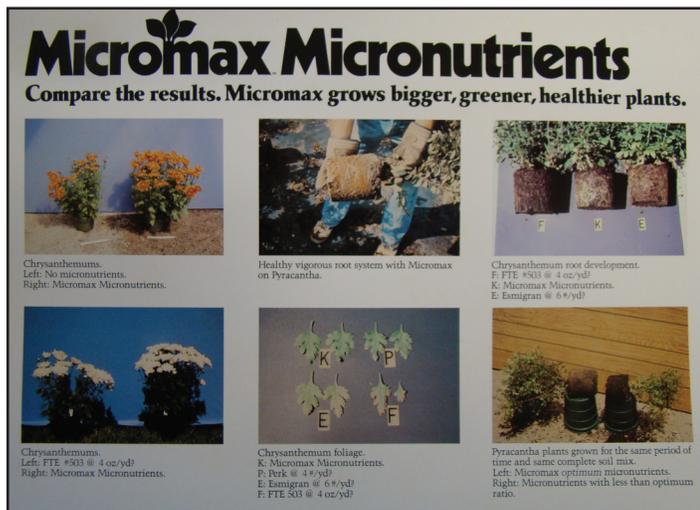


## The Micromax Fertilizer Story: An Adventure in Teamwork

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Progress is often the result of an accumulation of information from many sources. Sometimes team members are direct contributors. Other times, information contributed does not click in place until years later.

In 1982 I patented a micronutrient fertilizer formula (USA Patent #4,328,025). Micromax® became a world-wide success and it remains a major nutritional item used in growing plants in containers. Micromax® resulted from contributions from five key individuals.



My first position out of graduate school at Iowa State was at the U. of Florida, Gainesville. Growing plants in containers out-of-doors was in its infancy and nutritional problems were rampant. Chlorotic plants were the norm, not the exception in 1967 Florida. I began a series of experiments adding different micronutrient elements. Each experiment added to the accumulation of knowledge, but fell far short of solving the problem. Yet, each was a step forward. Fast forward to 1972 and I am now at Oklahoma State, Stillwater. Lots more experiments contributed to the growing pool of knowledge. By 1977 I was ready to conduct a huge experiment that might, just might, put all the pieces in place and finally solve the micronutrient problem plaguing plants growing in containers.

### The contributors.

David Jowett taught statistics and experimental design at Iowa State. After 15 credit hours of graduate level statistics, I knew considerable about the subject. But, there was more. Dr. Jowett was a master story teller in relating how various aspects of statistics could be applied to the real world. He made numbers come off pages and into the minds of his students, vivid and robust. From Dr. Jowett, I knew a factorial experimental design most likely to solve the micronutrient problem.

Joe Keely was a chemical engineer working for a large phosphate mining company in central Florida. I met Joe in 1968. I shared my challenge of trying to solve micronutrient problems relative to growing plants in containers. Joe shared information about the variety of micronutrient sources available. From Joe I learned that there were multiple commercial sources of each micronutrient element and they may behave differently in a container environment, and likely quite different from the laboratory formulations I had been using. For example, there were a variety of commercial sources of iron sulfate. On paper each show an identical analysis, FeSo<sub>4</sub>, but in practical application to plants they may vary widely. Joe provided four sources of iron sulfate. I placed them in experiments which revealed that one worked well, one not at all and two intermediate. We did similar studies with other micronutrient elements especially manganese and zinc. Without that knowledge my gamble on a huge factorial experiment could have been a complete bust.

My contribution was the accumulated knowledge from the many experiments with knowledge from Dr. Jowett and Joe Keely. My idea was to conduct a monster experiment with 243 treatments in factorial combination. This involved combining three levels of the best source of iron sulfate, with three levels of manganese = 9, times three levels of copper = 27, times three levels of zinc = 81, times three levels of boron = 243. Based on many preliminary studies, the three treatment levels were; my best estimate for each element, then doubled and reduced by half. Potentially a great idea, but, who and how to analyze the data? What I needed was a very knowledgeable statistician.

Dr. Bill Warde arrived in 1978 as a new hire in the statistics department at Oklahoma State, from the UK. When I presented my idea to him, his response was, "I would love to work on that". Dr. Warde suggested conducting the experiment as a fractional factorial which would reduce the number of physical treatments to 81 while still yielding data on the full 243. That made the monster experiment more manageable in size and number of plants involved. Still, 81 treatments with six replications and three species of plants = 1,458 containers. I chose to use full one-gallon size containers to better reflect growing conditions in a commercial nursery and not have plant growth restricted by limited container volume during a growing season. To fill that number of containers of that size required over seven cubic yards of a mixture of ground pine bark, peat and sand. My position at Oklahoma State on paper was 50% teaching and 50% research, but the teaching load dominated my time. What I needed was a bright young student to do the extensive leg work in weighing out the chemicals and putting the pieces in place.

Alan Storjohann was just starting on a masters degree and was looking for a topic for his thesis. I presented my monster experiment to him and he accepted the challenge with enthusiasm.

The experiment was a huge success. Analysis of the data by response surfaces looked like arcing lines on an upside down bowl. Dr. Warde cautioned that the analytical procedure was very new and untested and some data points could be false. But the fact that all three test species grew best with the same treatment, provided assurances.

Being cautious, I put exposing the choice formula on hold until further testing. My test procedure was to obtain enough raw materials to make 400 pounds. This was divided into 5 pound bags and shipped to cooperating nurseries across the country willing to follow the guidelines I had prepared. They could use their standard container growth medium and any species among the plants that they grow for the study at their location.

By mid-summer glowing reports of improved plant growth and color were arriving. Clearly the computer analysis of the data was valid. And best of all, the best micronutrient formula worked on all species used in the country wide test. I was required to assign the patent to Oklahoma State, which in turn licensed the new product to Sierra Chemical Co. in California. As part of the license agreement, Sierra Chemical required that I participate in informing potential customers about the product and how it worked. This led to speaking engagements around the world.

An adventure into solving a nutritional problem begun in 1968 was finally completed in 1982. Unfortunately by that time, Dr. Jowett, Joe Keely and Dr. Warde were deceased. But my thanks to them is clearly etched in my memory. Former student Alan Storjohann and I reminisce regularly on the topic. Anyone with chlorosis problems with any species should try adding 1.5 pounds of the original Micromax® formula per cubic yard of container growth medium. It is highly likely the chlorosis problem will be solved. Data from the monster experiment is still valid 40 years later.

