MicroSticker™ improves agronomic efficiencies in Brazil

Photos by courtesy of ARS

Many Brazilian farmers face limitations on yields and product quality as a result of the limited use of micronutrients.

ARR-MAZ do Brasil has developed a liquid additive that fixes powdered micronutrients on to the surface of bulk blended NPK fertilizers. This paves the way for the more widespread application of micronutrients in a crucial market, Brazil, as described by John Sinden in the paper he presented at British Sulphur's Fertilizantes Cono Sur Conference at Punta del Este Uruguay (21-23 November 2004).

Micronutrients have always been an important factor in efficient and sustainable agriculture. As agriculture has intensified during the past few decades, and as the need increases to harness old, nutrient-poor soils in such regions as the Cerrado in Brazil in order to increase food supplies to maintain the current world population in excess of 6 billion, micronutrient deficiencies have become ever more apparent.

There are many ways of correcting these deficiencies. In his paper, *Application of Micronutrients: Pros and Cons of the Different Application Strategies,* (IFA International Symposium on Micronutrients, New Delhi, February 2004), L. Pulschen of Kemira GrowHow outlined the following application systems:

- Broadcast
- Banded
- Foliar sprays.

The first two methods are limited to soil applications, while soluble compounds and/or chelates can be applied by means of foliar sprays or fertigation. In the case of soil applications, when using the same product to produce the same correction of a deficiency because of the low mobility of the micronutrients in the soil, the application of a banded product is normally less than 50% of a soil application. This is shown in Table 1 below.

It is clear that the costs and the practicality of applying solid bulk blends either by broadcast or banding are very much lower than any of the foliar products.

One aspect that may confuse growers is the plethora of different formulations recommended by agronomists, which lead suppliers to register thousands of different formulations of NPs, NKs and NPKs which have small but significant differences in the levels of micronutrients. A producer may typically have registered the following products in Table 2.

The only economically feasible way of producing this range of products is by bulk blending. It is neither practical nor profitable to have the granular bases with different ranges of micronutrients. In Brazil, there are a limited number of granulation

Table 1: **Rates of Mn fertilizer required for optimal soya bean yields on Mn deficient soils**

Mode of Mn fertilizer application	Requirements for optimal yield kg Mn/ha
Broadcast	14
Banded	3
Foliar sprays 2x	0.1

Source: *Marschner,* 1995

plants (approximately 28) and many hundreds of bulk blending units, so the logistics would not only be very difficult but extremely expensive.

The current practice of using a limited number of granulated products with high concentrations of several micronutrients is expensive, quite apart from having a reduced agronomic efficiency, as the NPKs are formulated to supply the lowest nutrient. This frequently means that other micronutrients are in excess. One major supplier has the following range of products shown in Table 3.

The guarantees for product "B" can be met by 25 kg/tonne of micronutrient mix No. 2. But at this level, a perfect homogeneous blend is very difficult to achieve. In the case of product "A", it requires 5 kg/tonne of micronutrient mix 1 and 15 kg/tonne of micronutrient mix 4. The difficulties of producing a homogenous blend with only 5 kg of granular products in 1,000 kg of material are very great, but the agronomic effects are even worse, since essentially only one granule in 200 will contain the micronutrient. This is not the case if 5 kg of a fine (100 mesh Tyler < 150 microns) is coated on to the surface of all the macronutrients. As an alternative, it is possible to use 15 kg of Mix 2, apart from giving away some boron for free, as the blend will contain 0.06% B. There will be 3 granules in 200 that will contain the micronutrients.

As long ago as 1965, the Tennessee Valley Authority (TVA) recommended adding the micronutrients as fine powders to the bulk blends and sticking them to the larger granules with a liquid additive. One major Brazilian producer decided to investigate this system as a possible solution for the various problems with current procedures. The work was done in conjunction with AAR-MAZ do Brasil, which supplied the "sticking agent", *MicroSticker*™.

Alternatives

For large-scale applications, such as on soya bean, corn, sugar and forestry, the most economically viable fertilizer applications are of solid NPs, NKs and NPKs. Micronutrients can be applied in the following different ways:

- Bulk blends with granular micronutrients.
- Incorporated in one of the raw materials used in the granulation plant.
- Coated with micronutrients.

The first-mentioned method is the most common system in use today. Its principal advantages are in the field of logistics, but there are serious disadvantages in terms of costs. In some cases, the supplier is forced to give an excess of one or more of the micronutrients. But these are less significant when compared to the loss in terms of agronomic efficiency. These can be shown in Table 4.

Table 4 clearly shows that the Zn sources with a small particle size (–100 mesh = 150μ) are the most effective, independently of their water solubility. ($ZnSO_4$ is water soluble, ZnO is not.) This water solubility partially offsets the effect of the larger granules, as shown by the difference between yields of the –10 and +14 applications. Comparable applications of manganese showed similar results. (*The Need for Controlled-Availability Micronutrient Fertilizers,* J. J. Mortvedt, Fertilizer Research 38: pp213-221 [1994].)

Table 5 from the same paper shows the other negative effect of using a concentrated source of micronutrients, namely that the reduction in the number of granules required to supply 1 kg/ha of Zn is very dramatic. It should always be noted that most micronutrients have limited mobility in the soil. The principal exception in this respect is boron when applied either as sodium borate or the double salt, ulexite.

Table 2

N	P_2O_5	K_2O	Zn	B
2.0	20.0	20.0	0.50	0.10
2.0	20.0	20.0	0.30	0.10
2.0	20.0	18.0	0.50	0.10
2.0	20.0	18.0	0.30	0.10
2.0	20.0	18.0	0.30	0.05

Table 3

Range	Zn	B	Cu	Mn
1	0	10.0	0	0
2	20.0	4.0	0	0
3	25.0	0	0	0
4	20	0	0	0
5	12.0	1.6	1.6	8.0
6	9.0	1.8	0.8	2.0+3.0 Fe+0.1 Mo

Table 4: **Forage yields and Zn uptake by corn as affected by fine and granular Zn sources**

Zn source	Granule mesh size	Zn rate lb/acre	Forage yield g/pot	Zn uptake mg/pot
–	–	0	3.4	0.03
$ZnSO_4$	-100	2	45.7	0.28
		4	59.9	0.38
$ZnSO_4$	-10/+14	2	14.7	0.14
		4	33.5	0.24
ZnO	-100	2	55.5	0.37
		4	60.8	0.45
ZnO	-10/+14	2	5.10	0.04
		4	5.20	0.04

Source: *J. J. Mortvelt*

With these types of numbers, plants need intelligent roots with sensors to detect the micronutrients if growers are to achieve satisfactory results from their fertilizer applications.

Incorporated applications

This refers to when the micronutrient is incorporated either in one of the raw materials used in the granulation plant, such as SSP, or added together with the other raw materials to the granulation plant's intake system. If the product is a stand-alone NP/NK/NPK, the distribution of the micronutrients is very good, being present in all the granules at uniform but low concentration. If the granular product is to be used as a base in bulk blends, then the distribution in the final product is not so uniform and the micronutrient concentration is not so low in the granules.

Several of the major fertilizer producers in Brazil have manufactured this type of base, for example 2-19-0+3.0% Zn or 0-19-0+3.0% Zn. Since this variant of the second route has many of the disadvantages of the granular micronutrient option, why is it used? The main disadvantage of the individual formulations with incorporated micronutrients is that there are too many different formulations which have to be handled as special products. Large tonnages of a particular grade containing one or more micronutrients must be made to justify the extra expense of producing and handling a special product. This is possible when large areas of a specific crop require one or more micronutrients for an optimum production in a given region.

In the United States in the 1960s, when there were several hundred regional granulation plants, some of the manufacturers turned to "premium" fertilizers, which supplied moderate quantities of several micronutrients. This is the same logic used by some manufacturers of granular micronutrients in Brazil today.

An ARS plant pathologist examines sweet orange plants for symptoms of a strain of Xylella fastidiosa that causes heavy citrus losses in Brazil – losses which could be reduced by the wider use of micronutrients.

Some agronomists object to this approach because the use of unneeded elements wastes the farmer's money and the indiscriminate use of micronutrients can have adverse effects. The biggest drawback to this method of application is the geographic size of Brazil and the fact that there are a very limited number of granulation plants that could produce this type of material compared with the hundreds of bulk blending plants.

Another problem is that during the granulation operation, chemical reactions can occur between the micronutrients and the other fertilizer components. In the case of many of the cations (Zn, Cu, Mn and Fe), these reactions can lead to changes in the water solubility of the micronutrients. This is particularly the case if the products are ammoniated. These changes in the solubility can affect the agronomic efficiencies, both for better and worse. For example, zinc sulphate – a water-soluble salt – may become insoluble when incorporated in ammoniated NPs or NPKs. Zinc oxide, which is not water-soluble, becomes soluble when incorporated in or coated on ammonium polyphosphate granules.

In the early 1980s, the author developed a product where the zinc source was added during the acidulation process for SSP. The results were as expected, the ZnO being a much stronger base than the phosphate rock

Table 5: **Number of fertilizer granules to provide 1 lb of Zn per acre**

Product	% Zn	Product applied lb/acre	Broadcast granules/sq. ft	Banded granules/ft of row
		–8 +9 mesh granules (20 mg)		
Zn in fertilizer	2	50	26	78
Granular $ZnSO_4$	36	2.8	1.4	4.3
		–12 +14 mesh granules (3 mg)		
Zn in fertilizer	2	50	173	520
Granular $ZnSO_4$	36	2.8	10	29

Source: *Mortvelt*

Table 6: **Solubility of Zn in various granular products**

Nutrient	SSP + Zn	SSG + Zn*	2-19-0+Zn*	SSG + Zn**	2-19-0+Zn**
N	0	0	2.1	0	2.3
P_2O_5 total %	18.7	20.8	19.2	20.0	19.2
APA %	17.2	19.1	14.4	18.6	17.4
Water soluble %	14.4	13.1	12.0	12.9	11.0
Zn total %	2.5	2.8	2.7	3.1	2.9
APA	2.4	2.7	2.5	2.6	2.4
Water soluble %	2.3	1.4	0.08	0.8	0.02
Conversion P_2O_5					
APA/total	92.0	91.8	90.6	93.0	90.6
W/S/total	77.7	63.0	62.5	64.5	57.3
Conversions Zn					
APA/total	96.0	96.4	92.6	83.9	82.8
W/S/total	95.8	50.0	3.0	25.8	0.7

* Granulated using ROP SSP + Zn
** The zinc source (nominally ZnO) is added during the granulation process

showed the higher conversion, since it was attacked preferentially. However, by increasing the amount of sulphuric acid, it was possible to obtain satisfactory conversions of both the Zn and the P_2O_5. The physical aspect of the product suffered a little, and this became significantly worse if the ZnO was contaminated with copper salts.

On granulation as a straight superphosphate, there was some decrease in the water-soluble Zn, but it maintained the ratio between available and water-soluble. When the ROP SSP plus Zn was granulated to form an NP compound, the water-soluble Zn was reduced to almost zero. Today, the procedure is to add the Zn source directly in the granulation plant, which results in lower levels of water-soluble zinc. The results are shown in Table 6. It was the reversion of the water-soluble Zn during the granulation process which was responsible for the abandonment of the addition of the micronutrients during the acidulation reaction.

Coating with micronutrients

The main advantage of coating micronutrients on to granular fertilizers is the flexibility. The micronutrients can be applied to existing stocks of mixed fertilizers in the proportions needed for specific fields. This method provides wider flexibility in the sources and proportions of micronutrients specified by agronomists and growers. There is no segregation of micronutrient sources from mixed fertilizer granules if the coating is done correctly.

For this coating to be done correctly, the micronutrients need to be supplied with a small particle size (i.e. < 100 mesh of –150μ). This has been shown to be agronomically effective. Originally, in the United States, one of the stated disadvantages of coating micronutrients was that it is a batch process which required additional handling, thus increasing costs. This is not a significant factor in Brazil, since bulk blending is the normal operational procedure.

The National Fertilizer Development Center (NFDC) of the TVA developed the coating procedure. The essential steps are:

- Add the granular fertilizer products and the powdered micronutrient(s) to the blend mixer unit. This is normally a rotary mixer but can be a ribbon mixer.
- Dry blend for the normal standard time for the mixer, which is normally one minute.
- Add a fluid binder, such as *MicroSticker*™, water, fluid fertilizer or oil.
- Continue blending for one more minute.
- Discharge the coated product.

To be effective, the fluid binders require that the micronutrients must be finely ground to adhere to granular fertilizers. The original work done in the United States showed that the following fluid binders proved to be effective: water, fluid fertilizers, and several types of oil. Water was not satisfactory for some coatings, particularly if the blend used urea or ammonium nitrate. Common light oils tended to bleed through the bags, and specifically in Brazil, fluid fertilizers were not readily available. For various reasons, coating with micronutrients has not been widely practised in Brazil.

The red clay soils typical of Brazil are fragile and require careful cultivation.

Table 7: **The effectiveness of oils as binders coating granular fertilizers with micronutrients**

Identification	Particle size	Addition	NPK binder	Immediate adherence*	Immediate adherence*
	Mesh	%	%	With binder	Without binder
No. 2 fuel oil					
Borate	– 48	7.0	18-20-0 (2%)	30	10
Borate	– 150	7.0	18-20-0 (2%)	90	40
ZnO/MnO	– 100	12.5	16-7-13 (3%)	98 (95)	40
Mixture	– 48	4.4	20-4-8 (3%)	92 (76)	0
Medium oil					
$MnSO_4$	–200	10.7	6-5-10 (3%)	99 (81)	7
$ZnSO_4$	– 100	5.6	14-6-12 (2%)	100	18
Frit	– 100	6.0	6-5-10 (3%)	99 (46)	21
Zn EDTA	– 100	1.4	17-7-14 (0.5%)	99	34
Zn EDTA	– 100	7.1	17-7-14 (1.5%)	99	–

* The values in parenthesis indicate percentage adherence after 2 weeks' storage.
Source: *Azotecon Ltd.*

Research has shown that the use of oil binders including *MicroSticker*™ did not influence the uptake of Zn or Mn from the zinc oxides or manganese oxides. Table 7 shows the effects of the size analysis of the micronutrients, the quantity of micronutrients, the quantity of binder and storage time on the adherence of the coatings.

In all major aspects – agronomic effectiveness, flexibility, logistics and costs – the preferred route for the addition of micronutrients to all granular fertilizers is by the process of coating with a liquid fertilizer. This is not a new process, but it has not been used to any significant extent in Brazil before, one of the reasons being the non-availability of a suitable binder. Today, this situation has been corrected as ARR-MAZ do Brasil has made available its product, *MicroSticker*™.