Enhancing Nutrient Availability for Maize with Surface Banding of Dry-Fertilizers

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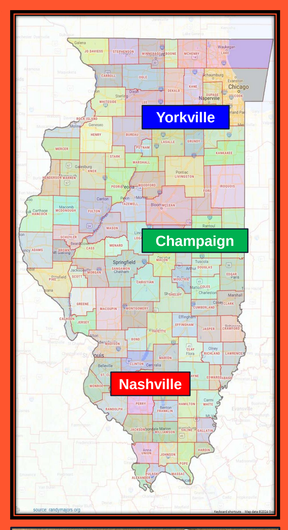
Introduction

Modern maize (*Zea mays* L.) hybrids are higher yielding and therefore have greater nutrient demand (Bender et al., 2013). Traditional preplant broadcast application of fertilizer can result in a low nutrient use efficiency and be insufficient to meet the nutritional demand of modern hybrids, especially for nutrients that have greater demand late in the season, such as sulfur.

Sulfur is an important nutrient for plant development. Due to reduced air pollutants, the supply of sulfur to the atmosphere, and consequently, the availability for plants, has decreased. Another factor that has decreased sulfur availability to crops is the switch to the use of more pure sources of mineral fertilizers.

Polyhalite is a 4-in-1 multi-nutrient organic fertilizer that has 19% of sulfur and 14% of K_2O and has potential as a suitable multi-nutrient source for maize (Figure 1).

Bender, R.R., J.W. Haegele, M.L.Ruffo, and F.E. Below. 2013. Nutrient uptake, partitioning, and remobilization in modern, transgenic insect-protected maize hybrids. Agron. J. 105:161-170.



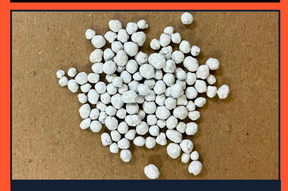


Figure 1. Polyhalite granules.

Research Approach

In the spring of 2023, maize hybrid DKC66-06 was planted at a density of 89,000 plants ha^{-1} at Nashville, IL and at 94,000 plants ha^{-1} at Champaign and Yorkville, IL. Five treatments were arranged in a randomized complete block design with six replications at all sites. Fertilizer was supplied as pre-plant broadcast or as in-season V6 surface dribbled band (Figure 2) and compared to an untreated control.

Fertilizer applications consisted of blends of monoammonium phosphate (MAP, 11-52-0) plus muriate of potash (MOP, 0-0-60), (NPK); with or without polyhalite (POLY4, 0-0-14-19S-11.4Ca, 3.6Mg) (Table 1).

Table 1. Total nutrients supplied to maize, either preplant broadcast or surface banded at V6. All plots received nitrogen (N) via UAN-32.

	Nutrients and Respective Fertilizer Sources Supplied						
	N	P_2O_5	K_2O	K_2O	S	Ca	Mg
Treatment	UAN-32	MAP	MOP	POLY4	POLY4	POLY4	POLY4
	kg ha^{-1}						
N-only control	200	-	-	-	-	-	-
NPK	200	90	67	-	-	-	-
NPK+POLY4	200	90	51	16	22	13	4

Soils were sampled 5 cm from the crop row at a depth of 0-15 cm at the V12-V15 growth stages to assess soil P, K, Ca, Mg, and S concentrations. These same nutrients were analyzed from leaf tissues at the R2 growth stage. Final grain yields were assessed at physiological maturity and yield components were determined using plot subsamples.

Figure 2. Manual surface-banding application (A) and final placement after application (B).

Objective: Increase nutrient availability and maize grain yield by supplying concentrated dry fertilizers adjacent to the crop row in-season.

Results

Soil and leaf analysis

- Soil nutrient levels of P, K, and S were all greater with the V6 surface fertilizer application when compared to the pre-plant broadcast applications. Additionally, supplying POLY4 at the V6 maize growth stage consistently increased soil sulfur concentration over NPK alone at V6 (Table 2).

- When averaged across the three sites, the surface banding treatment containing POLY4 increased the potassium level of the leaf when compared to the N-only control (Table 3).

Table 2. Soil nutrient concentrations at the V12-V15 maize plant growth stages as affected by fertilizer application placement and timing at Nashville, Champaign, and Yorkville, IL in 2023.

Treatment	Nashville			Champaign			Yorkville		
	P	K	S	P	K	S	P	K	S
	mg kg^{-1}								
Preplant broadcast									
N-only control	28	112	7	53	141	3	69	234	8
NPK	34	124	7	69	158	5	75	256	10
NPK+POLY4	38	128	13	68	164	11	82	254	14
V6 Surface Banded									
NPK	77	158	10	126	210	9	173	327	11
NPK+POLY4	86	179	26	97	200	22	130	289	30
LSD (α = 0.10)	26	28	7.3	22	33	5.75	31	47	6.7
(p-value)	*(p=<.0001)*	*(p=<.0001)*	*(p=<.0001)*	*(p=.0001)*	*(p=.0051)*	*(p=<.0001)*	*(p=<.0001)*	*(p=.0300)*	*(p=<.0001)*

Table 3. Effect of fertilizer treatments on macronutrient (P, K, Ca, Mg, S) concentrations of the leaf opposite and below the ear at the R2 growth stage in 2023. Presented values are averaged over three sites.

Treatment	Leaf Analysis				
	P	K	Ca	Mg	S
	g kg^{-1}				
Preplant broadcast					
N-only control	2.6	17.3	7.5	3.6	1.7
NPK	2.5	17.8	7.2	3.4	1.7
NPK+POLY4	2.5	17.7	7.4	3.6	1.7
V6 Surface Banded					
NPK	2.6	17.7	7.4	3.6	1.7
NPK+POLY4	2.6	18.2	7.3	3.5	1.7
LSD (α = 0.10)	NS	0.05	NS	NS	NS
(p-value)	*(p =.650)*	*(p =.054)*	*(p =.190)*	*(p =.230)*	*(p=.106)*

Yield and Yield Components

- When averaged over the three sites, all fertilized treatments increased grain yield over the N-only control. Numerically, the V6 surface-banded application of NPK + POLY4 produced the highest yield of 15.88 Mg ha^{-1} (Table 4).

- Fertilizing using surface-banding at V6 resulted in more kernels numerically than the control or the broadcast placements (Table 4). Adding POLY4 to the surface-banded NPK increased kernel weight over surface-banded NPK alone and maintained kernel weight compared to the broadcast applications despite numerically higher kernel numbers (Table 4).

Table 4. Effect of fertilizer application timing × placement on maize grain yield and yield components (kernel number and kernel weight) in 2023. Presented data is averaged over three sites. Grain yield is expressed at 15.5% moisture, while yield components were calculated at 0% moisture.

Treatment	Grain Yield	Kernel Number	Kernel Weight
	Mg ha^{-1}	kernel m^{-2}	mg $kernel^{-1}$
Preplant Broadcast			
N-only control	15.08	4096	291
NPK	15.68	4088	302
NPK + Poly4	15.61	4105	300
V6 Surface Banded			
NPK	15.41	4166	291
NPK + Poly4	15.88	4155	301
LSD (α = 0.10) *(p-value)*	0.31 *(p = 0.007)*	NS *(p = 0.150)*	5.53 *(p = 0.008)*

Conclusions

1. Grain yields of treatments containing POLY4 were comparable to pre-plant broadcasts of NPK, regardless of application method or timing. V6 surface-banded applications of NPK + POLY4 resulted in the highest observed yield, indicating a synergistic effect of a multi-nutrient granule supplied directly along the crop row.

2. Soil analysis during the late vegetative growth stage showed that supplying POLY4 increased soil sulfur concentrations, and surface banding placement improved the availability of P, K, and S when compared to broadcast placements.

3. These findings suggest that surface banding can be an effective placement of dry fertilizers, and that POLY4 can be a sustainable fertilizer source in both pre-plant or in-season nutrient management strategies.

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