COMPARISON OF COGRANULATED FERTILIZER TO BLENDS WITH S AND ZN IN CORN AND SOYBEANS

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INTRODUCTION AND OBJECTIVES

High yielding corn and soybean production systems in Missouri have renewed an interest in micronutrient management such as sulfur (S) which is essential for protein formation and zinc

(Zn) which is important for enzymes and metabolic reactions. Yield increases due to sulfur applications are more likely to occur during cool, wet springs when mineralization and crop growth are slow as a result of a decrease in atmospheric sulfur deposition. Soil tests in 2010 indicated that over 60% of the samples in upstate Missouri had low (<0.6 ppm) to medium (0.7 to 1.0 ppm) soil test Zn (Nathan, unpublished). Similarly, over 70% of the soil test samples were very low to medium for Bray 1P.

Fertilizer manufacturing has progressed to accommodate more uniform distribution of nutrients in an individual fertilizer granule (Anonymous, 2007). Each prill is formulated to contain Nitrogen (N), phosphorus (P), S, and/or Zn rather than a blended product that includes individual prills of individual nutrients. In a blend, there may be a certain amount of segregation that occurs which often affects the uniformity of distribution when the blended fertilizer is applied in the field. This poor distribution of applied blended dry fertilizer may be significant for recommendations of 5 to 10 lbs of Zn/acre. Typically, soluble S sources, such as ammonium sulfate (AMS) or ammonium thiosulfate, are recommended over elemental S (Janzen and Bettany, 1987) and $ZnSO_4$ is a common source of Zn (Boawn, 1973).

Cogranulated fertilizers, where S and Zn are added in layers to the monoammonium phosphate (MAP) prill, allows for a more uniform distribution of fertilizer which allows roots to have a higher probability of contact with the fertilizer granule and may enhance fertilizer efficiency. Mosaic has formulated MicroEssential sulfur 10 (MES10) (12-40-0-10S) and MicroEssential sulfur and zinc (MESZ) (12-40-0-10S-1Zn) with two forms of sulfur (50% sulfate and 50% elemental S). MESZ includes Zn as zinc oxide. These products were developed primarily for corn, soybean, wheat, and rice. This fertilizer combination has been promoted to increase P uptake up to 30%. The availability of Zn to the plant has been promoted as being 10 to 45% greater with the Mosaic product (Anonymous, 2007).

The objectives of this research were to:

1. Evaluate P rates of MES10 and MESZ formulations to equivalent blends of MAP, Zn, and S; and
2. Evaluate $ZnSO_4$ rates in a blend with MAP or DAP compared to MES10 and MESZ formulations on grain yields and uptake of micronutrients in a corn soybean rotation.

PROCEDURES

Field research was conducted at the Greenly Memorial Research Center near Novelty and Hundley-Whaley Center near Albany. Initial soil samples were taken each year, and the soil characteristics at 0-6 inches are reported in Table 1. A randomized complete block design was used at each site, with 4 replications at Albany and 5 replications at Novelty. Phosphorus, Zn,

and SO_4-S were analyzed from a soil samples from a 6-inch depth and a corn ear leaf tissue samples in 2013 and 2014 at both locations.

P rates of MES10 and MESZ compared to blends of MAP, Zn, and S

Soybeans followed corn plots established in 2014 and 2015. Fertilizer treatments for this experiment included MES10, MESZ, MAP, MAP+AMS, and MAP+$ZnSO_4$+AMS. All treatments were tested at 70 and 110 lbs P_2O_5 per acre (Table 4). Fertilizer was broadcast surface applied with a hand spreader. Table 2 reports field management information for corn sites at Albany in 2013 and 2014 and Novelty in 2011, 2012, 2013, and 2014. Soybean rotations are also listed for Novelty 2012, 2013, and 2014 in Table 2. The soybean plots received no additional fertilizer and were in the same location as the corn plots from the previous year.

ZnSO4 blended with MAP or DAP compared to MES10 and MESZ

Corn and soybean response was evaluated in 2014 (Table 5) and the subsequent soybean responses in 2015. Fertilizer treatments for this experiment included MES10, MESZ, MAP, MAP+AMS, MAP+$ZnSO_4$+AMS, MAP+SuperZn+AMS, diammonium phosphate (DAP), DAP+AMS, DAP+$ZnSO_4$+AMS, DAP+SuperZn+AMS. Zinc sources were tested at 2 and 5 lbs Zn per acre (Table 5). MAP or DAP were treated with a liquid formulation of Super Zinc (Helena Chemical Co., 2255 Schilling Blvd, Suite 300, Collierville, NT 38017) in 2013 and 2014. Field management information for the corn sites at Albany in 2013 and 2014(continuous corn and corn following soybean sites) and Novelty in 2011, 2012, 2013, and 2014 as well as the rotational crop (soybean) at Novelty in 2012, 2013, and 2014 is reported in Table 3. Soybean plots had no additional fertilizer application and were in the same location as the corn plots the previous year.

RESULTS

All of the sites had very low to medium soil test P, except for the corn-soybean rotation site at Albany for objective 2 (Table 1). Similarly, soil test SO_4-S was medium for all of the sites except for the corn-soybean rotation site at Albany for objective 2. Soil test Zn was low at all of the Novelty sites, but was medium to high at three of the Albany sites.

Corn P rates of MES10 and MESZ compared to blends of MAP, Zn, and S

Corn plant population was 27,000 to 32,000 plants/acre at Novelty (2011-2014) and no differences among treatments were observed at Albany in 2013 and 2014 (data not presented). There was no effect of fertilizer treatments on grain moisture at Albany or Novelty, while there was no difference in test weight at Novelty (data not presented).

Rainfall was above average in the spring of 2011 which was followed by moderately dry conditions during the summer. Corn grain yields were greatest with MESZ at 110 lbs P_2O_5/acre (151 bu/acre), MES10 at 110 lbs P_2O_5/acre (150 bu/acre), and MAP at 110 lbs P_2O_5/acre (150 bu/acre) at Novelty in 2011 (Table 4). All treatments were similar to MESZ at 110 lbs P_2O_5/acre except MAP at 70 lbs P_2O_5/acre, urea at 28 lbs N/acre, and urea at 46 lbs N/acre. No significant differences among treatments were observed at Novelty in 2012 or 2013, which was probably related to extremely dry conditions in 2012 and a flash drought in 2013. Grain yields at Albany in 2013 were greatest with MAP + $ZnSO_4$ + AMS at 110 lbs P_2O_5/acre (148 bu/acre), MAP at 110 lbs P_2O_5/acre (147 bu/acre), MAP + AMS at 110 lbs P_2O_5/acre (147 bu/acre), MES10 at 110lbs P_2O_5/acre (146 bu/acre), and MESZ at 110 lbs P_2O_5/acre (145 bu/acre). Reduced rates of

MAP (70 lbs P_2O_5/acre) were generally lower than MAP + $ZnSO_4$ + AMS at 110 lbs P_2O_5/acre. In 2014, the Novelty site experienced a high yield environment. At Novelty, treatments with the higher rate of P (110 lbs P_2O_5/acre) had higher yields compared to no additional P in 2014. All treatments increase corn yields compared to the P control at Albany in 2014. In general there was no significant difference between P applied at 70 and 110 lbs P_2O_5/acre, but yields were usually greater at 110 lbs P_2O_5/acre compared to 70 lbs P_2O_5/acre.

There was no difference in soil test P levels following corn at Novelty in 2013 (data not presented). All fertilizer treatments with Zn except MESZ at 110 lbs P_2O_5/acre increased soil test Zn concentration compared to treatments without Zn at Novelty in 2013. No differences among Zn rates were detected. Soil test SO_4-S was greatest with MES10 at 18 lbs S/acre, which was similar to MES 10 at 28 lbs S/acre, MESZ at 18 or 28 lbs S/acre, and MAP + AMS at 28 lbs S/acre. These treatments increased soil test SO_4-S concentrations compared to the other treatments. Soil samples at the Albany location were collected in the spring, 2014. At Novelty, ear leaf P concentration increased with MESZ at 110 lbs P_2O_5/acre, and all MAP treatments except MAP + $ZnSO_4$ + AMS at 70 lbs P_2O_5/acre compared to the non-treated control. MAP + AMS at 110 lbs P_2O_5/acre had the highest ear leaf P concentration (0.308 %) which was similar to MESZ and the other MAP treatments applied at 110 lbs P_2O_5/acre. In 2014, MAP at 70 lbs P_2O_5/acre, MAP at 110 lbs P_2O_5/acre + $ZnSO_4$, and all MES10 and MESZ treatments increased ear leaf P concentration compared to the non-treated control. However, no differences in Zn or S concentrations were detected in 2013 or 2014 on soils with medium S and low to medium Zn. Soil test Zn levels were greatest at Novelty (Table 1) compared to previous years.

No differences among soybean yields were detected in 2012 at Novelty following fertilizer treatments to corn in 2011 (Table 4). Soybean yields (35 to 36 bu/acre) were similar for MESZ at 110 lbs P2O5/acre, MAP + AMS at 110 lbs P2O5/acre, MAP + ZnSO4 + AMS at 75 or 110 lbs P2O5/acre, and urea at 46 lbs N/acre in 2013 (Table 4).

In summary, average corn grain yields were similar with MAP at 110 lbs P_2O_5/acre and MESZ at 110 lbs P_2O_5/acre (146 bu/acre) followed by MAP + $ZnSO_4$ + AMS at 110 lbs P_2O_5/acre (144 bu/acre). However, MESZ at 110 lbs P_2O_5/acre, MES10 at 110 lbs P_2O_5/acre, MAP at 110 lbs P_2O_5/acre + AMS, MAP at 110 lbs P_2O_5/acre + $ZnSO_4$ + AMS, and urea at 46 lbs N/acre had the highest average soybean yields (47 bu/acre) the following year.

<u>$ZnSO_4$ blend with MAP or DAP compared to MES10 and MESZ</u>

Grain moisture and plant populations were similar among treatments following corn or soybean at Albany and following soybean at Novelty (data not presented). Corn test weight was lowest in the non-treated, no N control at Novelty, but limited differences were observed among Zn treatments (data not presented).

At Novelty, corn grain yield was highest with MESZ and MAP + ZnSO4 + AMS in 2011; MESZ, non-treated and no N control, and N only in 2012; and MESZ, MAP + ZnSO4 (5 lbs Zn/acre) + AMS, MAP + SuperZn (5 lbs Zn/acre) + AMS, and DAP + AMS in 2013 (Table 6). Average corn yield for the 7 site-years evaluated to date were ranked, MAP + ZnSO4 (5 lbs Zn/acre) + AMS (133 bu/acre), MAP (131 bu/acre), MAP+$ZnSO_4$ (2 lbs Zn/acre) + AMS (130 bu/acre), DAP+$ZnSO_4$ (2 lbs Zn/acre)+AMS (130 bu/arce) data presented in Table 5. In 2014, several high yielding treatments including MAP + $ZnSO_4$ (5 lbs Zn/acre) + AMS and DAP + $ZnSO_4$ (2 lbs Zn/acre) + AMS had yields that were 10 bu/acre greater than MAP alone. Average soybean yields were 49 bu/acre with the N only control, MESZ, DAP, and DAP + $ZnSO_4$ (5 lbs

Zn/acre) + AMS, but there was no significant treatment effect on soybean yields within 2012, 2013, or 2014.

All treatments increased ear leaf P concentration compared to the non-treated, no N control at Novelty in 2013 (data not presented). The inclusion of MAP or DAP generally increased ear leaf P concentration compared to the N only treatment. There were limited differences in P concentration among P treatments at Novelty and no difference in 2014. In general, treatments increased ear leaf S and Zn concentration compared to the non-treated, no N control at Novelty in 2013 and ear leaf Zn concentration at Novelty in 2014, but treatments with S and Zn had ear leaf concentrations that were similar to the N only control.

MAP or DAP were treated with a liquid formulation of Super Zinc (Helena Chemical Co., 2255 Schilling Blvd, Suite 300, Collierville, NT 38017) in 2013 and 2014. At Novelty, all treatments increased soil test P compared to the non-treated, no N control (data not presented). MAP or DAP + $ZnSO_4$ (2 lbs Zn/acre) + AMS and MAP or DAP + Super Zn (5 lbs Zn/acre) + AMS increased soil test Zn 1.2 to 2.9 ppm compared to the non-treated controls. MES 10 and MESZ increased soil test S compared to the N only control, while blends of MAP +/- Zn at 2 lbs/acre + AMS and DAP + Super Zn (2 lbs Zn/acre) or $ZnSO_4$ + AMS significantly increased soil test S compared to the N only control.

There was no difference in ear leaf P, Zn, or S concentration among treatments at Albany with a corn-soybean rotation (data not presented), which was probably due to the high soil test P, Zn, and S at this location (Table 1). Similarly, no difference in soil test P or Zn was observed at the Albany site in a corn-soybean rotation (data not presented).

The continuous corn site at Albany had several treatments that increased soil test P concentration, but Zn treatments had no significant impact on soil test Zn concentration when compared to the non-treated controls (data not presented). When compared to the N only control, SO_4–S in the soil increased with all treatments that included a S additive. Soil test SO_4–S was similar between MES10 and MESZ when compared to the addition of AMS.

Average soybean yields were 47-49 bu/acre for all treatment in Novelty in 2012, 2013, and 2014 and Albany in 2013 and 2014 but there was no significant treatment effect on soybean yields within 2012, 2013, and 2014 (Table 5).

SUMMARY

<u>P rates of MES10 and MESZ compared to blends of MAP, Zn, and S</u>

- In corn, the effect of fertilizer yields from corn indicated MESZ and MAP at 110 lbs P2O5/acre had high average corn (6 site-years)
- In soybeans, the carry over effect of fertilizer treatments from corn to soybean indicated
- Urea at 46 lbs N/acre, MES10, MAP+AMS, MAP+$ZnSO_4$+AMS, MESZ at 110 lbs
- P2O5/acre had high average soybean (4 site- years) yields.
- Soil test Zn increased with all treatments that included Zn regardless of rate.
- Soil test SO_4-S increased with MES10 at 18 lbs S/acre, MES 10 at 28 lbs S/acre, MESZ at 18 or 28 lbs S/acre, and MAP + AMS at 28 lbs S/acre at Novelty in 2013.
- Ear leaf P concentration was greatest with MAP + AMS at 110 lbs P_2O_5/acre and was similar to the high rates of MAP or MESZ.

<u>ZnSO4 blends with MAP or DAP compared to MES10 and MESZ</u>

- Corn grain yields were ranked MAP + $ZnSO_4$ at 5 lbs/acre + AMS (133 bu/acre), MAP (131 bu/acre), and MAP + $ZnSO_4$ at 2 lbs/acre + AMS = DAP + $ZnSO_4$ at 2 lb/acre + AMS (130 bu/acre) for 7 site-years.

- The non-treated and no N control, N only control, MESZ, and DAP had similar soybean yields (4 site-years).
- At sites with low soil test P and S, selective fertilizer treatments significantly increased soil test P and S following corn in 2013.
- Soil test Zn increased with selective treatments at Novelty in 2013, but not at Albany with low or high initial soil test Zn.

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Table 1. Initial soil characteristics (average ± 1 standard deviation) 0-6 inches deep for Objectives 1 and 2 at Albany in 2013 & 2014 and Novelty from 2011-2014.

	Objective 1						Objective 2						
Soil characteristics	2011 Novelty	2012 Novelty	2013 Novelty	2013 Albany	2014 Novelty	2014 Albany	2011 Novelty	2012 Novelty	2013 Novelty	2013 Albany Rotation	2013 Albany C-C	2014 Novelty	2014 Albany
pH_s	6.2 ± 0.2	5.9 ± 0.2	5.7 ± 0.6	5.0 ± 0.8	5.8 ± 0.3	5.6 ± 0.2	6.0 ± 0.1	6.2 ± 0.2	5.1 ± 0.6	6.4 ± 0.4	5.1 ± 0.2	5.7 ± 0.2	5.9 ± 0.3
Neutralizable acidity (meq/100 g)	1.9 ± 0.4	1.7 ± 0.3	3.5 ± 2.5	6.9 ± 3.5	2.6 ± 0.1	3.3 ± 0.9	1.9 ± 0.2	1.1 ± 0.4	5.4 ± 5.5	1.9 ± 1.4	4.5 ± 1.1	2.5 ± 0.1	2.0 ± 0.9
Organic matter (%)	2.4 ± 0.2	2.7 ± 0.2	2.1 ± 0.2	2.2 ± 0.3	2.3 ± 0.6	2.9 ± 0.1	2.3 ± 0.1	2.9 ± 0.2	2.0 ± 0.2	4.4 ± 0.3	2.6 ± 0.3	2.2 ± 0.4	2.9 ± 0.1
Bray 1P (lb/acre)	22.6 ± 3.8 (L)[†]	16.8 ± 1.8 (VL)	32.8 ± 2.6 (M)	30.0 ± 17.0 (M)	24.6 ± 3.9 (L)	40.8 ± 8.9 (M)	14.0 ± 2.1 (VL)	14.0 ± 1.9 (VL)	19.6 ± 8.0 (L)	140 ± 5 (E)	22.0 ± 6.7 (L)	23.0 ± 2.3 (L)	31.5 ± 3.9 (M)
Ca (lb/acre)	4140 ± 160	4080 ± 340	3230 ± 580	3960 ± 600	4150 ± 400	5080 ± 820	4060 ± 210	4290 ± 280	3280 ± 340	5590 ± 670	3230 ± 380	4280 ± 370	5110 ± 210
Mg (lb/acre)	369 ± 25	305 ± 28	270 ± 30	493 ± 112	387 ± 56	896 ± 259	350 ± 33	310 ± 30	293 ± 44	650 25	410 ± 57	368 ± 46	639 ± 43
K (lb/acre)	176 ± 8	162 ± 11	162 ± 24	128 ± 20	181 ± 30	276 ± 56	144 ± 10	160 ± 20	114 ± 34	400 ± 30	209 ± 39	203 ± 27	184 ± 14
SO_4-S (ppm)	7.3 ± 1.2 (M)	7.3 ± 0.6 (M)	2.0 ± 0.2 (M)	0.9 ± 0.3 (M)	4.9 ± 0.7 (M)	5.7 ± 0.3 (M)	5.8 ± 1.1 (M)	6.4 ± 0.7 (M)	1.6 ± 0.3 (M)	8.6 ± 0.8 (H)	5.7 ± 0.4 (M)	4.5 ± 0.2 (M)	5.6 ± 0.6 (M)
Zn (ppm)	0.3 ± 0.1 (L)	0.4 ± 0.1 (L)	0.5 ± 0.1 (L)	3.9 ± 1.2 (H)	0.8 ± 0.3 (M)	2.6 ± 1.2 (H)	0.2 ± 0.1 (L)	0.5 ± 0.1 (L)	0.3 ± 0.1 (L)	1.8 ± 0.1 (H)	1.0± 0.3 (M)	0.8 ± 0.6 (M)	1.0± 0.6 (M)
Mn (ppm)	16.1 ± 0.6	20.8 ± 2.1	22.3 ± 2.7	---[‡]	19.3 ± 3.8	11.2 ± 0.9	16.7 ± 0.8	49.3 ± 7.4	17.2 ± 1.7	---[‡]	---	19.3 ± 3.2	9.8 ± 1.7
Fe (ppm)	45.0 ± 2.8	64.8 ± 8.2	64.2 ± 5.5	---	46.7 ± 9.3	54.4 ± 3.0	38 ± 1.0	49.3 ± 7.4	48.3 ± 12.4	---	---	40.3 ± 3.9	43.3 ± 11.8
Cu (ppm)	0.6 ± 0.1	0.7 ± 0.1	0.6 ± 0.1	---	0.7 ± 0.1	1.1 ± 0.2	0.6 ± 0.1	0.6 ± 0.1	0.4 ± 0.1	---	---	0.6 ± 0.1	0.8 ± 0.1
CEC (meq/100 g)	14.0 ± 0.7	13.4 ± 0.9	12.9 ± 2.5	20.2 ± 5.3	14.5 ± 1.3	20.1 ± 3.9	13.7 ± 0.8	13.3 ± 0.7	14.2 ± 3.2	19.1 ± 1.4	14.6 ± 1.1	14.7 ± 1.2	17.7 ± 0.7

[†]Abbreviations: E, excessive; VH, very high; H, high; M, medium; L, low; VL, very low; and C-Continuous corn (Missouri Soil and Plant Testing Lab).

[‡]Not determined at this sit

Table 2. Field and management information for the corn sites at Novelty in 2011, 2012, 2013 and 2014 as well as Albany in 2013 to evaluate phosphorus rates of MES10 and MESZ formulations compared to equivalent blends of MAP, Zn, and S and the subsequent effect on soybean the following year (Objective #1).

	2011	2012	2012	2013	2013	2014	2013	2014	2014	2014
Management information	Novelty Corn fb Soybean		Novelty Corn fb Soybean		Novelty Corn fb Soybean		Albany Corn fb Soybean		Albany	Novelty
Plot size (ft)	10 by 40	10 by 40	10 by 40	10 by 40	10 by 50	10 by 50	10 by 30	10 by 35	10 by 35	10 by 50
Hybrid or cultivar	DKC 63-84	Ag3730	DKC 63-84	Morsoy LL 3759N	DKC 63-25 VT3	Stine 38LE02	DK 61-89	AG 3731	DK 64-69	DKC 63-25
Planting date	12 Apr.	25 Apr.	2 Apr.	17 May	15 May	8 May	30 Apr.	15 May	5 May	18 Apr.
Row spacing (inches)	30	15	30	7.5	30	7.5	30	30	30	30
Seeding rate (seeds/acre)	31,000	180,000	33,000	160,000	33,000	180,000	29,000	156,000	30,000	33,000
Harvest date	22 Sep.	9 Oct.	28 Aug.	10 Oct.	7 Oct.	18 Oct.	5 Nov.	27 Oct.	16 Oct.	10 Oct.
Maintenance fertilizer	31 Mar. 2011	NA	18 Nov. 2011	NA	30 Nov. 2012	NA	NA	NA	NA	11 Nov. 2013
Nitrogen	180 lbs N/acre (AA)		190 lbs N/acre (AA) + N-serve at 1 qt/acre		180 lbs N/acre (AA)		180 lbs N/acre (AN)	NA	180 lbs N/acre (AN)	220 lbs N/acre
P-S-Zn application date	6 May	NA	28 Nov. 2011	NA	25 Apr.	NA	26 Apr.		5 May	25 Mar.
Tillage	No-till	No-till	No-till	No-till	No-till	No-till	Minimum	Minimum	Minimum	No-till
Weed management										
Burndown/PRE	5 Apr., Roundup Power MAX 32 oz/a + Verdict 5 oz/a + AMS 17 lb/100 gal	25 Apr., Sharpen 1 oz/a + 0.25% v/v NIS + UAN 1 qt/a + Roundup PowerMAX 32 oz/a	19 Mar., Verdict 5 oz/a + Roundup PowerMAX 32 oz/a + AMS 17 lb/100 gal	17 May, Sharpen 1 oz/a + Roundup PowerMAX 32 oz/a + UAN 1 qt/a + MSO 1% v/v	17 May, Lexar 3 qt/a + MSO 1% v/v + UAN 1 qt/a + Roundup PowerMAX 32 oz/a	23 May, Liberty 32 oz/a + AMS 17 lb/100 gal	30 Apr. Lexar 3.1 qt/a	15 May, Boundary 3 pt/A	Lumax 3 pt/a + atrazine 1 qt/a + Roundup PowerMAX 32 oz/a	13 Nov. 2013, Princep 1 qt/a + Roundup PowerMAX 16 oz/a + 2, 4-D 8 oz/a + COC 1 qt/a
Postemergence	17 May, Degree Xtra 3 qt/a	24 May, Reflex 1.25 pt/a + Roundup PowerMAX 32 oz/a + UAN 1 qt/a + 0.25% v/v NIS 22 June, Roundup PowerMAX 32 oz/a + AMS 17 lb/100 gal + 0.25% v/v NIS	10 May, Lexar 2.25 qt/a + Roundup PowerMAX 32 oz/a + 0.25% v/v NIS	4 June, Liberty 32 oz/a + AMS 17 lb/100 gal 1 July, Liberty 32 oz/a + Prefix 2.25 pt/a + AMS 17 lb/100 gal + 0.25% v/v NIS		25 May, Prefix 2.3 oz/a + AMS 17 lb/100 gal + 0.25% v/v NIS 9 July, Liberty 32 oz/a + Resource 4 pt/a + AMS 17 lb/100 gal + 0.25% v/v NIS	3 June Roundup PowerMAX 32 oz/a	3 June Roundup PowerMAX 32 oz/a		24 May, Lexar 3 qt/a + Touchdown Total 28 oz/a + 0.25% v/v NIS
Insect management	17 May, Warrior II 2 oz/a	NA	10 May, Warrior II 2 oz/a	NA	NA	NA	NA	NA	NA	NA
Disease management	NA	NA	NA	NA	NA	10 July, Quadris 9 oz/a	NA	NA	NA	10 July, Quadris 9 oz/a

†Abbreviations: AA, anhydrous ammonia; AN, ammonium nitrate; fb, followed by; COC, crop oil concentrate; MSO, methylated seed oil; NA, none applied; PRE, preemergence; and UAN, urea ammonium nitrate.

Table 3. Field and management information for the corn sites established at Albany in 2013 (corn-soybean rotation and continuous corn) and Novelty in 2011, 2012, 2013, and 2014 to evaluate Zn rates in a blend with MAP or DAP compared to MES10 and MESZ formulations (Objective #2).

	2011	2012	2012	2013	2013	2014	2013	2013		2014	2014
	Novelty Corn fb Soybean		Novelty Corn fb Soybean		Novelty Corn fb Soybean		Albany Rotation	Albany C-C fb Soybean		Albany	Novelty
Plot size (ft)	10 by 40	10 by 40	10 by 40	10 by 40	10 by 50	10 by 50	10 by 35	10 by 35	10 by 35	10 by 35	10 by 50
Hybrid or cultivar	DKC 63-84	Ag3730	DKC 63-84	Morsoy LL 3759N	DKC 63-25 VT3	Stine 38LE02	DK 64-69	DK64-69	AG 3731	DK 64-69	DKC 63-25
Planting date	12 Apr.	26 Apr.	2 Apr.	17 May	15 May	8 May	14 May	14 May	15 May	5 May	18 Apr.
Row spacing (inches)	30	17	30	7.5	30	7.5	30	30	30	30	30
Seeding rate (seeds/acre)	31,000	180,000	32,000	160,000	33,000	180,000	29,000	29,000	156,000	30,000	33,000
Harvest date	22 Sep.	9 Oct.	28 Aug.	10 Oct.	7 Oct.	18 Oct.	10 Oct.	10 Oct.	27 Oct.	16 Oct.	10 Oct.
Maintenance fertilizer	31 Mar. 2011	NA	18 Nov. 2011	NA		NA			NA	NA	11 Nov. 2013
Nitrogen	180 lbs N/acre (AA)		190 lbs N/acre (AA) + N-serve at 1 qt/acre		180 lbs N/acre (AA)		180 lbs N/acre (AN)	180 lbs N/acre (AN)	NA	180 lbs N/acre (AN)	220 lbs N/acre
P-S-Zn application date	6 May		28 Nov. 2011		29 Apr.	NA	10 May	7 May		5 May	25 Mar.
Tillage	No-till	No-till	No-till	No-till	No-till	No-till	Minimum	Minimum	Minimum	Minimum	No-till
Weed management											
Burndown/ Preemergence	5 Apr., Roundup Power MAX 32 oz/a + Verdict 5 oz/a + AMS 17 lb/100 gal	25 Apr., Sharpen 1 oz/a + 0.25% v/v NIS + UAN 1 qt/a + Roundup PowerMAX 32 oz/a	19 Mar., Verdict 5 oz/a + Roundup PowerMAX 32 oz/a + AMS 17 lb/100 gal	17 May, Sharpen 1 oz/a + Roundup PowerMAX 32 oz/a + UAN 1 qt/a + MSO 1% v/v	17 May, Lexar 3 qt/a + MSO 1% v/v + UAN 1 qt/a + Roundup PowerMAX 32 oz/a	23 May, Liberty 32 oz/a + AMS 17 lb/100 gal	14 May, Lexar 3 qt/a	14 May, Lexar3 qt/a	15 May, Boundary 3 pt/A	Lumax 3 pt/a + atrazine 1 qt/a + Roundup PowerMAX 32 oz/a	13 Nov. 2013, Princep 1 qt/a + Roundup PowerMAX 16 oz/a + 2, 4-D 8 oz/a + COC 1 qt/a
Postemergence	17 May, Degree Xtra 3 qt/a	24 May, Reflex 1.25 pt/a + Roundup PowerMAX 32 oz/a + UAN 1 qt/a + 0.25% v/v NIS 22 June, Roundup PowerMAX 32 oz/a + AMS 17 lb/100 gal + 0.25% v/v NIS	10 May, Lexar 2.25 qt/a + Roundup PowerMAX 32 oz/a + 0.25% v/v NIS	4 June, Liberty 32 oz/a + AMS 17 lb/100 gal 1 July, Liberty 32 oz/a + Prefix 2.25 pt/a + AMS 17 lb/100 gal + 0.25% v/v NIS		25 May, Prefix 2.3 oz/a + AMS 17 lb/100 gal + 0.25% v/v NIS 9 July, Liberty 32 oz/a + Resource 4 pt/a + AMS 17 lb/100 gal + 0.25% v/v NIS	11 June, Roundup PowerMAX (32 oz/a)	11 June, Roundup PowerMAX (32 oz/a)	3 June Roundup PowerMAX 32 oz/a		24 May, Lexar 3 qt/a + Touchdown Total 28 oz/a + 0.25% v/v NIS
Insect management	17 May, Warrior II 2 oz/a	NA	10 May, Warrior II 2 oz/a	NA	NA	NA	NA	NA	NA	NA	NA
Disease management	NA	NA	NA	NA	NA	10 July, Quadris 9 oz/a	NA	NA	NA	NA	10 July, Quadris 9 oz/a

†Abbreviations: AA, anhydrous ammonia; AN, ammonium nitrate; C-C, Continuous Corn; COC, crop oil concentrate; fb, followed by; MSO, methylated seed oil; NA, none applied; and UAN, urea ammonium nitrate.

Table 4. Grain yield response of corn (2011, 2012, 2013, and 2014) and the subsequent soybean crop (2012, 2013, and 2014) to phosphorus rates of MES10 and MESZ formulations compared to equivalent blends of MAP, Zn, and S (Objective #1).

Fertilizer				Corn fb 2011	Soybean 2012	Corn fb 2012	Soybean 2013	Corn fb 2013	Soybean 2014	Corn fb 2013	Soybean 2014	Corn 2014		Corn	Soybean
treatment	P_2O_5	Zn	S	Novelty		Novelty		Novelty		Albany		Novelty	Albany	Average[†]	Average[†]
	lbs/a	lbs/a	lbs/a	bu/acre											
Non-treated				37	37	26	32	123	64	117	42	231	127	100	44
MES10	70	0	18	144	38	23	34	117	65	142	46	247	161	139	46
MES10	110	0	28	150	39	21	34	118	69	146	44	251	172	143	47
MESZ	70	1.8	18	141	37	20	34	126	66	141	45	241	160	138	46
MESZ	110	2.8	28	151	40	29	35	126	69	145	43	252	172	146	47
MAP[‡]	70			130	38	24	33	118	69	141	42	236	162	135	46
MAP	110			150	36	29	33	129	68	147	42	244	179	146	45
MAP + AMS	70		18	142	39	22	34	120	66	136	43	239	181	140	46
MAP + AMS	110		28	144	40	23	36	120	67	147	43	243	170	141	47
MAP + $ZnSO_4$ + AMS	70	1.8	18	148	38	23	35	124	68	138	44	240	160	139	46
MAP + $ZnSO_4$ + AMS	110	2.8	28	146	38	22	36	129	70	148	43	244	177	144	47
Urea at 14 lbs N/acre[¶]				140	36	26	34	117	69	135	41	241	166	138	45
Urea at 21 lbs N/acre[¶]				142	38	22	34	123	66	135	42	232	167	137	45
Urea at 28 lbs N/acre[¶]				133	36	23	34	121	66	141	42	233	183	139	45
Urea at 33 lbs N/acre[¶]				144	38	24	33	121	69	138	42	229	174	138	46
Urea at 46 lbs N/acre[¶]				134	39	25	36	121	69	140	42	229	186	139	47
LSD (*P*=0.1)				13	NS	NS	2	NS	NS	9	NS	13	19		

[†]Grain yield averages were calculated for corn (Novelty 2011-2014, and Albany 2013 & 2014) and soybean (Novelty 2012-2014 and Albany in 2014).

[‡]Abbreviations: AMS, ammonium sulfate; C-C, continuous corn; DAP, diammonium phosphate; fb, followed by; MAP monoammonium phosphate.

[¶]Additional N was added to balance the N contribution from MAP and/or AMS N sources. All treatments had a base N application as denoted in Table 2

Table 5. Grain yield response of corn and the subsequent soybean crop to Zn rates in a blend with MAP or DAP compared to MES10 and MESZ formulations (Objective #2).

Fertilizer treatment[†]	P_2O_5	Zn	S	Corn 2011 fb[‡]	Soybean 2012	Corn 2012 fb	Soybean 2013	Corn 2013 fb	Soybean 2014	Corn 2013 fb	Soybean 2014	Corn 2013	Corn 2014		Corn[‡‡]	Soybean[‡‡]
										Albany		Albany				
		lbs/a		Novelty	Novelty	Novelty	Novelty	Novelty	Novelty	C-C	Albany	Rotation	Novelty	Albany	Average	Average
Non-treated, no N				36	42	26	37	101	60	97	47	104	189	108	94	47
Nitrogen only				135	42	26	38	135	67	104	49	113	241	133	127	49
MES10	80	0	20	147	41	21	37	141	67	98	48	118	248	131	129	48
MESZ	80	2	20	153	42	26	37	143	68	101	49	122	240	107	127	49
MAP	80			145	41	18	35	137	68	98	49	114	245	157	131	48
MAP + AMS	80		20[¶]	---[§]	---	---	---	139	69	99	48	120	240	129	---	---
MAP + $ZnSO_4$ + AMS	80	2	20[¶]	144	42	17	36	141	66	99	48	116	243	147	130	48
MAP + SuperZn[††] + AMS	80	2	20[¶]	---	---	---	---	141	71	108	48	116	242	152	---	---
MAP + $ZnSO_4$ + AMS	80	5	20[¶]	153	42	17	35	143	67	98	49	112	250	155	133	48
MAP + SuperZn[††] + AMS	80	5	20[¶]	---	---	---	---	143	74	99	47	118	249	152	---	---
DAP	80			140	43	21	36	140	68	103	48	116	237	137	128	49
DAP + AMS	80		20[¶]	---	---	---	---	143	72	99	50	117	245	141	---	---
DAP + $ZnSO_4$ + AMS	80	2	20[¶]	141	41	24	37	134	65	97	47	110	250	155	130	48
DAP + SuperZn[††] + AMS	80	2	20[¶]	---	---	---	---	141	66	99	47	112	223	152	---	---
DAP + $ZnSO_4$ + AMS	80	5	20[¶]	137	42	24	36	134	68	97	50	113	235	130	124	49
DAP + SuperZn[††] + AMS	80	5	20[¶]	---	---	---	---	140	68	103	47	109	247	127	---	---
LSD (*P*=0.1)				16	NS	7	NS	7	NS	NS	NS	NS	10	20		

[†]Nitrogen was balanced with urea to reach an equivalent N rate for all treatments except for the non-treated, no N control.

[‡]Abbreviations: AMS, ammonium sulfate; C-C, continuous corn; DAP, diammonium phosphate; fb, followed by; MAP monoammonium phosphate.

[¶]Balance of S with MES10.

[§]Treatments weren't applied these years.

[††]MAP or DAP were impregnated with Super Zinc (Helena Chemical Co., 2255 Schilling Blvd, Suite 300, Collierville, NT 38017) prior to application in 2013.

[‡‡]Grain yield averages were calculated for corn (Novelty 2011-2014 and Albany in 2013 & 2014) and soybean (Albany in 2013 and Novelty 2012-2014).

PROCEEDINGS OF THE

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