COMPARISON OF IMPREGNATED DRY FERTILIZER WITH S AND ZN BLENDS FOR CORN AND SOYBEANS

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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over 60% of the samples in upstate Missouri had low ($\leq$0.6 ppm) to medium (0.7 to 1.0 ppm) soil test Zn (Nathan, unpublished).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 N, 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 may occur 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).

Impregnated granules, 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 are 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 in 2014. This was the second year for corn plots to be established at both locations. Novelty's 2011 and 2012 research is reported. Initial soil samples were taken each year, the soil characteristics at 0-6 inches Table 1. A randomized complete block design was used at each site, with 4 replications at Albany and 5 replications at Novelty. P, Zn, and SO_4-S was analyzed from a soil test at a 6-inch depth and a corn ear leaf tissue sample in 2013 and will be analyzed in 2014 at both locations.

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

Soybeans will follow corn plots established in 2014. Fertilizer treatments for this comparison include 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 hand spreader. Table 2 reports field management information for corn sites at Albany in 2013 and Novelty in 2011, 2012, and 2013. Soybean rotations are also listed for Novelty 2012 and 2013 in Table 2. The soybean plots received no additional fertilizer and were in the same location as the corn plots from the previous year.

$ZnSO_4$ blended with MAP or DAP compared to MES10 and MESZ

Corn response will be evaluated in 2014 and subsequent soybean responses in 2014 and 2015. Fertilizer treatments for this comparison include 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. Field management information for the corn sites at Albany in 2013 (continuous corn and corn following soybean sites) and Novelty in 2011, 2012, and 2013 as well as the rotational crop (soybean) at Novelty in 2012 and 2013 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 the two Albany sites in 2013 for objective 2.

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 (2011-2013) and no differences among treatments were observed at Albany in 2013 (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 110 lbs P_2O_5/acre (146 bu/acre), and MESZ at 110 lbs P_2O_5/acre (145 bu/acre). Reduced rates of MAP (75 lbs P_2O_5/acre) were generally lower than MAP + $ZnSO_4$ + AMS at 110 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 summary, average corn grain yields were greatest (114 bu/acre) with MAP at 110 lbs P_2O_5/acre followed by MESZ at 110 lbs P_2O_5/acre (113 bu/acre) and MAP + $ZnSO_4$ + AMS at 110 lbs P_2O_5/acre (111 bu/acre).

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 P_2O_5/acre, MAP + AMS at 110 lbs P_2O_5/acre, MAP + $ZnSO_4$ + AMS at 75 or 110 lbs P_2O_5/acre, and urea at 46 lbs N/acre in 2013 (Table 4).

$ZnSO_4$ blend with MAP or DAP compared to MES10 and MESZ

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 + $ZnSO_4$ + AMS in 2011; MESZ, non-treated and no N control, and N only in 2012; and MESZ, MAP + $ZnSO_4$ (5 lbs Zn/acre) + AMS, MAP + SuperZn (5 lbs Zn/acre) + AMS, and DAP + AMS in 2013 (Table 6). Average corn yield for the 5 site-years evaluated to date were ranked MESZ (109 bu/acre), MES10 (105 bu/acre) = MAP + $ZnSO_4$ (5 lb Zn/acre) + AMS (105 bu/acre), and DAP (104 bu/acre).

All treatments increased ear leaf P concentration compared to the non-treated, no N control at Novelty in 2013 (Table 7). 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. All treatments increased ear leaf S and Zn concentration compared to the non-treated, no N control at Novelty, but treatments with S and

Zn had ear leaf concentrations that were similar to the N only control. Ear leaf Zn concentration was greatest with MESZ and DAP + AMS at Albany in continuous corn, but inconsistent differences among treatments were observed at this location. Ear leaf S was greatest with DAP + AMS, but differences among treatments were inconsistent.

At Novelty, all treatments increased soil test P compared to the non-treated, no N control (Table 8). MAP or DAP + $ZnSO_4$ + AMS at 2 lbs Zn/acre and MAP or DAP + Super Zn + AMS at 5 lbs Zn/acre 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/a + AMS and DAP + Super Zn at 2 lbs/a 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 (data not presented). 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 40 bu/acre with the non-treated and no N control, N only control, MESZ, and DAP for Novelty in 2012 and 2013, but there was no significant treatment effect on soybean yields within 2012 or 2013.

Summary

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

- In corn, the effect of fertilizer treatments from corn indicated MESZ at 110 lbs P_2O_5/acre had high average corn (4 site-years)
- In soybeans, the carry over effect of fertilizer treatments from corn to soybean indicated MESZ at 110 lbs P_2O_5/acre had high average soybean (2 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.

$ZnSO_4$ blends with MAP or DAP compared to MES10 and MESZ

- MESZ at 110 lbs P_2O_5/acre had the greatest yield average for corn (5 site-years).
- The non-treated and no N control, N only control, MESZ, and DAP had similar soybean yields (2 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.

References

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Table 1. Initial soil characteristics 0-6 inches deep for Objectives 1 and 2 at Albany in 2003 and Novelty in 2011, 2012, and 2013.

	Objective 1			Objective 2				
Soil characteristics	2011 Novelty	2012 Novelty	2013 Novelty	2011 Novelty	2012 Novelty	2013 Novelty	2013 Albany Rotation	2013 Albany Continuous corn
pH_s	6.2 ± 0.2	5.9 ± 0.2	5.7 ± 0.6	6.0 ± 0.1	6.2 ± 0.2	5.1 ± 0.6	6.4 ± 0.4	5.1 ± 0.2
Neutralizable acidity (meq/100 g)	1.9 ± 0.4	1.7 ± 0.3	3.5 ± 2.5	1.9 ± 0.2	1.1 ± 0.4	5.4 ± 5.5	1.9 ± 1.4	4.5 ± 1.1
Organic matter (%)	2.4 ± 0.2	2.7 ± 0.2	2.1 ± 0.2	2.3 ± 0.1	2.9 ± 0.2	2.0 ± 0.2	4.4 ± 0.3	2.6 ± 0.3
Bray 1P (lb/acre)	22.6 ± 3.8 (L)[†]	16.8 ± 1.8 (VL)	32.8 ± 2.6 (M)	14.0 ± 2.1 (VL)	14.0 ± 1.9 (VL)	19.6 ± 8.0 (L)	140 ± 5 (E)	22.0 ± 6.7 (L)
Ca (lb/acre)	4140 ± 160	4080 ± 340	3230 ± 580	4060 ± 210	4290 ± 280	3280 ± 340	5590 ± 670	3230 ± 380
Mg (lb/acre)	369 ± 25	305 ± 28	270 ± 30	350 ± 33	310 ± 30	293 ± 44	650 25	410 ± 57
K (lb/acre)	176 ± 8	162 ± 11	162 ± 24	144 ± 10	160 ± 20	114 ± 34	400 ± 30	209 ± 39
SO_4-S (ppm)	7.3 ± 1.2 (M)	7.3 ± 0.6 (M)	2.0 ± 0.2 (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)
Zn (ppm)	0.3 ± 0.1 (L)	0.4 ± 0.1 (L)	0.5 ± 0.1 (L)	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)
Mn (ppm)	16.1 ± 0.6	20.8 ± 2.1	22.3 ± 2.7	16.7 ± 0.8	49.3 ± 7.4	17.2 ± 1.7	---[‡]	---
Fe (ppm)	45.0 ± 2.8	64.8 ± 8.2	64.2 ± 5.5	38 ± 1.0	49.3 ± 7.4	48.3 ± 12.4	---	---
Cu (ppm)	0.6 ± 0.1	0.7 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	0.4 ± 0.1	---	---
CEC (meq/100 g)	14.0 ± 0.7	13.4 ± 0.9	12.9 ± 2.5	13.7 ± 0.8	13.3 ± 0.7	14.2 ± 3.2	19.1 ± 1.4	14.6 ± 1.1

[†]Abbreviations: E, excessive; VH, very high; H, high; M, medium; L, low; and VL, very low.

[‡]Not determined at this site

Table 2. Field and management information for the corn sites at Novelty in 2011, 2012, and 2013 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	
	Novelty		Novelty			
Management information	Corn fb Soybean		Corn fb Soybean		Novelty	Albany
Plot size (ft)	10 by 40	10 by 40	10 by 40	10 by 40	10 by 50	10 by 30
Hybrid or cultivar	DKC 63-84	Ag3730	DKC 63-84	Morsoy LL 3759N	DKC 63-25 VT3	DK 61-89
Planting date	12 Apr.	25 Apr.	2 Apr.	17 May	15 May	30 Apr.
Row spacing (inches)	30	15	30	7.5	30	30
Seeding rate (seeds/acre)	31,000	180,000	33,000	160,000	33,000	29,000
Harvest date	22 Sep.	9 Oct.	28 Aug.	10 Oct.	7 Oct.	5 Nov.
Maintenance fertilizer	31 Mar. 2011	NA	18 Nov. 2011	NA	30 Nov. 2012	
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)
P-S-Zn application date	6 May	NA	28 Nov. 2011	NA	25 Apr.	26 Apr.
Tillage	No-till	No-till	No-till	No-till	No-till	Minimum
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	30 Apr. Lexar 3.1 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		3 June Roundup PowerMAX 32 oz/a
Insect management	17 May, Warrior II 2 oz/a	NA	10 May, Warrior II 2 oz/a	NA	NA	NA
Disease management	NA	NA	NA	NA	NA	NA

[†]Abbreviations: AA, anhydrous ammonia; AN, ammonium nitrate; fb, followed by; MSO, methylated seed oil; NA, none applied; 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, and 2013 to evaluate Zn rates in a blend with MAP or DAP compared to MES10 and MESZ formulations (Objective #2).

	2011 Novelty	2012 Novelty	2011 Novelty	2012 Novelty	2013		
Management information	Corn fb Soybean		Corn fb Soybean		Novelty	Albany Rotation	Albany Continuous corn
Plot size (ft)	10 by 40	10 by 40	10 by 40	10 by 40	10 by 50	10 by 35	10 by 35
Hybrid or cultivar	DKC 63-84	Ag3730	DKC 63-84	Morsoy LL 3759N	DKC 63-25 VT3	DK 64-69	DK64-69
Planting date	12 Apr.	26 Apr.	2 Apr.	17 May	15 May	14 May	14 May
Row spacing (inches)	30	17	30	7.5	30	30	30
Seeding rate (seeds/acre)	31,000	180,000	32,000	160,000	33,000	29,000	29,000
Harvest date	22 Sep.	9 Oct.	28 Aug.	10 Oct.	7 Oct.	10 Oct.	10 Oct.
Maintenance fertilizer	31 Mar. 2011	NA	18 Nov. 2011	NA			
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)
P-S-Zn application date	6 May		28 Nov. 2011		29 Apr.	10 May	7 May
Tillage	No-till	No-till	No-till	No-till	No-till	Minimum	Minimum
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	14 May, Lexar 3 qt/a	14 May, Lexar3 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		11 June, Roundup PowerMAX (32 oz/a)	11 June, Roundup PowerMAX (32 oz/a)
Insect management	17 May, Warrior II 2 oz/a	NA	10 May, Warrior II 2 oz/a	NA	NA	NA	NA
Disease management	NA	NA	NA	NA	NA	NA	NA

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

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

				Corn fb Soybean		Corn fb Soybean					
				2011	2012	2012	2013	Corn 2013		Corn	Soybean
Fertilizer treatment	P_2O_5	Zn	S	Novelty		Novelty		Novelty	Albany	Average[†]	Average[†]
	lbs/a	lbs/a	lbs/a	---------- bu/acre ----------							
Non-treated				37	37	26	32	123	117	76	35
MES10	70	0	18	144	38	23	34	117	142	107	36
MES10	110	0	28	150	39	21	34	118	146	109	37
MESZ	70	1.8	18	141	37	20	34	126	141	107	36
MESZ	110	2.8	28	151	40	29	35	126	145	113	38
MAP[‡]	70			130	38	24	33	118	141	103	36
MAP	110			150	36	29	33	129	147	114	35
MAP + AMS	70		18	142	39	22	34	120	136	105	37
MAP + AMS	110		28	144	40	23	36	120	147	109	38
MAP + $ZnSO_4$ + AMS	70	1.8	18	148	38	23	35	124	138	108	37
MAP + $ZnSO_4$ + AMS	110	2.8	28	146	38	22	36	129	148	111	37
Urea at 14 lbs N/acre[¶]				140	36	26	34	117	135	105	35
Urea at 21 lbs N/acre[¶]				142	38	22	34	123	135	106	36
Urea at 28 lbs N/acre[¶]				133	36	23	34	121	141	105	35
Urea at 33 lbs N/acre[¶]				144	38	24	33	121	138	107	36
Urea at 46 lbs N/acre[¶]				134	39	25	36	121	140	105	38
LSD (*P*=0.1)				13	NS	NS	2	NS	9		

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

[‡]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

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).

				Corn 2011 fb[‡]	Soybean 2012	Corn 2012 fb	Soybean 2013	Corn 2013				
Fertilizer treatment[†]	P_2O_5	Zn	S	Novelty	Novelty	Novelty	Novelty	Novelty	Albany Rotation	Albany C-C	Corn[‡‡] Average	Soybean[‡‡] Average
		lbs/a		bu/acre								
Non-treated, no N				36	42	26	37	101	104	97	73	40
Nitrogen only				135	42	26	38	135	113	104	103	40
MES10	80	0	20	147	41	21	37	141	118	98	105	39
MESZ	80	2	20	153	42	26	37	143	122	101	109	40
MAP	80			145	41	18	35	137	114	98	102	38
MAP + AMS	80		20[¶]	---[§]	---	---	---	139	120	99	---	---
MAP + $ZnSO_4$ + AMS	80	2	20[¶]	144	42	17	36	141	116	99	103	39
MAP + SuperZn[††] + AMS	80	2	20[¶]	---	---	---	---	141	116	108	---	---
MAP + $ZnSO_4$ + AMS	80	5	20[¶]	153	42	17	35	143	112	98	105	39
MAP + SuperZn[††] + AMS	80	5	20[¶]	---	---	---	---	143	118	99	---	---
DAP	80			140	43	21	36	140	116	103	104	40
DAP + AMS	80		20[¶]	---	---	---	---	143	117	99	---	---
DAP + $ZnSO_4$ + AMS	80	2	20[¶]	141	41	24	37	134	110	97	101	39
DAP + SuperZn[††] + AMS	80	2	20[¶]	---	---	---	---	141	112	99	---	---
DAP + $ZnSO_4$ + AMS	80	5	20[¶]	137	42	24	36	134	113	97	101	39
DAP + SuperZn[††] + AMS	80	5	20[¶]	---	---	---	---	140	109	103	---	---
LSD (*P*=0.1)				16	NS	7	NS	7	NS	NS		

[†]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, 2012, 2013, and Albany 2013) and soybean (Novelty 2011 and 2012).