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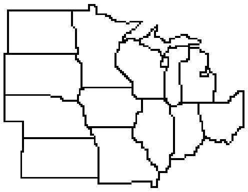

North Central Regional Extension Publication 103

Impact of “ACA” on Crop Yield in the North Central Region

George W. Rehm, editor

 

Various products are advertised and sold as fertilizer additives. ACA is one of those products. ACA is an acronym for “Agricultural Crop Additive.” This product is made by combining acetic acid, water, anhydrous ammonia, and zinc oxide. It has a guaranteed analysis of 15% nitrogen and 17% zinc by weight.

 

ACA has been evaluated in various trials with a variety of crops. Product literature reports that responses to the use of this product have been:

- more fibrous and extensive root systems;
- increase in the number and sugar content of brace roots;
- a more rapid and more vigorous

early plant growth;

- wider leaves which have a darker green color;
- heavier ear and kernel weights;
- increased crop yield.

Results of field trials conducted at Land Grant Universities which were designed to evaluate the importance of this product for crop production in a variety of production environments have been mixed. A summary of the yield response for several crops is provided in Table 1. This summary leads to the general conclusion that the use of this product has not consistently produced a measurable increase in crop yield. This is especially true for corn.

ACA has been added to a variety of nitrogen fertilizers. This product has been applied at various growth stages for a variety of crops. Yet, there has not been a consistent positive response to the use of this product. The information gathered from the majority of the individual evaluations is discussed and summarized in the sections that follow.

Table 1. Reported yield responses to the addition of ACA to a fertilizer program (1972–1996).

	Corn	**Soybean**	**Wheat**	**Grain Sorghum**
Number of experiments	25	2	2	1
Site years	43	4	6	1
Number of significant responses	7	0	1	0
Source: K.A. Kelling, Department of Soil Science, University of Wisconsin. Personal communication.				

A corn and alfalfa rotation, this one in southeast Minnesota, was one of the typical production situations evaluated in the ACA studies.

ACA With Anhydrous Ammonia

Early evaluations of this product were conducted in the mid 1970s in Michigan and Minnesota. At that time ACA was sold by the Amoco Oil Company, marketed as an addition to anhydrous ammonia.

In Minnesota, the evaluation was conducted for three years (1976–1978). Anhydrous ammonia, either with or without ACA, was applied to supply 100 and 150 lbs N per acre in 1976. The N rates were changed to 75 and 150 lbs N per acre for 1977 and 1978. Although yields were increased by the use of fertilizer nitrogen, neither total dry matter nor grain yields were significantly affected by the addition of ACA to the anhydrous ammonia (Table 2). The 1976 grain yields were reduced by moisture stress caused by dry weather; however, ACA use apparently did not help the crop overcome this stress. In addition, the use of the fertilizer additive had no significant effect on the concentration of N in corn tissue and grain (data not shown).

Table 2. The effect of the addition of ACA to anhydrous ammonia on total dry matter and grain yield of corn in Minnesota (1976–1978).

N Applied (lbs/acre)	ACA Used	Dry Matter Yield (tons/acre)			Grain Yield (bu/acre)		
		1976	1977	1978	1976	1977	1978
0	—	8.3	6.6	7.2	119	118	126
75 (100)*	no	8.1	6.6	8.4	138	145	159
75 (100)*	yes	8.4	7.4	8.1	137	151	156
150	no	7.9	7.8	8.4	133	149	164
150	yes	8.9	8.4	8.5	134	150	164
BLSD (.05)		ns	.9	.9	7	16	9
Source: G.W. Randall, 1978. * N rate in 1976 was 100 lbs per acre.							

The results reported in 1975 are averages for a three-year trial in Michigan (Table 3). Using a N rate of 120 lbs per acre, the ACA was applied at the recommended rate as well as 0.5 and 2.0 times this rate. The anhydrous ammonia/ACA mixture was applied either before planting or as a sidedress treatment. There was no increase in grain yield when ACA was used in 1973, 1974, and 1975.

Table 3. The effect of ACA applied with anhydrous ammonia on corn yield in Michigan (1973–1975).

Rate of ACA Used	Yield (bu/acre) When Applied at Planting	Yield (bu/acre) When Applied as Sidedress
none	112	111
recommended rate	113	113
0.5 times recommended rate	111	116
2.0 times recommended rate	115	113
LSD (.05)	ns	ns
Source: D.R. Christenson and C. Bricker, 1975		

In addition to the trials in Minnesota and Michigan, the effect of the combination of ACA and anhydrous ammonia was studied extensively in southern Illinois and reported in a private communication by G. Kapusta. The use of ACA increased grain yield in three of 65 comparisons over the period of 1973 through 1982. Yields were either not affected or were reduced by this product in the remainder of the trials (data not shown).

In the majority of the early trials where ACA was added to anhydrous ammonia, the evaluations focused on grain yield of corn. Although a more extensive, fibrous root system was one of the major advertising claims for this product, there had been no reported evaluation of ACA use on corn root systems. In 1988, trials in Nebraska were designed to measure the impact of ACA on the amount of pull required to lift the plants out of the soil, and on grain yield. In theory, more pull, measured in pounds, should be required to remove plants that have a more extensive root system from the soil. In this evaluation, the ACA was applied at several rates with anhydrous ammonia. (Table 4). Compared to the control, the application of N without ACA produced a substantial increase in the development of the root system as measured by the force required to pull the roots from the soil. The addition of ACA, however, had no effect on this measurement. Yield was also not affected by the use of ACA.

Table 4. The effect of rate of ACA applied with anhydrous ammonia on force required to pull corn roots and grain yield in Nebraska (1988).

ACA Applied (oz/acre)	N Applied (lbs/acre)	Force Needed to Pull Roots from Soil * (lbs)	Grain Yield * (bu/acre)
0	0	250 a	110 a
0	200	416 b	194 b
3	200	421 b	190 b
6	200	420 b	190 b
9	200	427 b	189 b

Source: G.W. Hergert, 1989.
* Treatment averages in each column followed by the same letter are not significantly different at the .05 confidence level

Research conducted in Iowa showed a positive response to the application of a combination of ACA and anhydrous ammonia (Table 5). This positive response, however, could not be predicted from measurement of soil properties. These results confirm the previously reported inconsistent response to the use of this product.

When the use of ACA had a positive impact on yield, the mode of action was not clearly identified. Some of the early research data and visual observations suggested that plant metabolism may have been altered or that ACA was functioning as a growth regulator. There was also some suggestion that it could act as a nitrification inhibitor or that the zinc could be responsible for the positive observations. A study conducted in Wisconsin in 1988 and 1989 was designed to evaluate the possibility that Zn could be responsible for the observed positive responses. Yields were limited by drought in 1988 and there was no response to the addition of ACA to anhydrous ammonia (Table 6).

Table 5. Corn grain yield as affected by the rate of ACA applied with anhydrous ammonia in Iowa (1980).

ACA Applied (lbs/acre)	Grain Yield (bu/acre) *
.0	150 b
0.14	155 ab
0.28	161 a
0.56	162 a
1.12	147 b

Source: I.C. Anderson.
* Treatment averages followed by the same letter are not significantly different at the .05 confidence level

Table 6. The effect of ACA on the yield of field corn in Wisconsin (1988).

Treatment	ACA Rate (oz/acre)	Grain Yield ** (bu/acre)
control	—	117 a
NH_3 only	—	116 a
NH_3 + 6-24-24 + ACA	3	113 a
NH_3 + 6-24-24 + ACA	6	116 a
NH_3 + 6-24-24 + ACA	9	118 a
NH_3 + 6-24-24 + Zn	—	123 a

Source: E.S. Oplinger, 1990.
* The rate of 6-24-24 was 200 lbs per acre for all treatments.
** Treatment averages followed by the same letter are not significantly different at the .05 confidence level.

In 1989, ACA was applied either to 33-0-0 and broadcast before planting or with the 6-24-24 and applied as a starter fertilizer (Table 7). Yields were higher in 1989 and increased with the application of the nitrogen fertilizer. There was, however, no response to either the use of ACA or the addition of Zn in a starter fertilizer.

Table 7. The effect of ACA and use of starter fertilizer on the yield of corn in Wisconsin (1989).

Treatment	Yield (bu/acre)
control	142 a
33-0-0 only*	164 b
33-0-0 + 6-24-24*	162 b
33-0-0 + 6-24-24 + Zn	162 b
33-0-0 + 6-24-24 w 10.7 oz ACA per acre	169 b
33-0-0 + 6-24-24 w 5.3 oz ACA per acre	167 b
Source: E.S. Oplinger, 1990. * 33-0-0 applied to supply 100 lbs N per acre; 6-24-24 applied at a rate of 200 lbs per acre.	

In both years, the soil at the sites selected for study were apparently not deficient in Zn. Since there were no yield increases when ACA or Zn was applied, these trials could not identify whether the mode of action of this product is related to Zn metabolism.

ACA With Fluid Fertilizers For Corn

During the early 1980s the emphasis on the marketing of ACA decreased considerably and field evaluations were minimal. In the late 1980s, the initiation of a marketing effort by United Agri-Products stimulated further efforts to document the potential benefits and identify the cause of any growth response. There was also one substantial change in the procedures used in the evaluation process. The product was either applied with a fluid fertilizer or used undiluted.

ACA was evaluated for corn at one irrigated site in Minnesota.

When applied with 28-0-0, trials in Kansas showed no positive response to the use of ACA for either corn or grain sorghum production (Table 8). All treatments in the corn trial received a N rate of 200 lbs per acre. This N rate was reduced to 100 lbs per acre for grain sorghum production. In both studies, the combination of ACA and 28-0-0 was broadcast and incorporated before planting.

Table 8. The effect of ACA in combination with 28-0-0 on the yield of corn and grain sorghum in Kansas (1987).

Rate of ACA Applied (oz/acre)	Corn (bu/acre)	Grain Sorghum (bu/acre)
.0	159	131
3.25	164	134
6.50	156	145
LSD (.05)	ns	ns
Source: D.A. Whitney et al., 1987		

More recently, ACA has been evaluated for corn production in several trials when applied with a starter fertilizer near the seed at planting. The analysis of the starter and placement varied with each evaluation trial. This variability in use, however, did not affect the conclusions. In the trials reported, the use of ACA in a band at planting had no positive, significant effect on corn yield.

In Illinois, the evaluation of ACA with a starter fertilizer was completed in a field where minimum tillage production practices were used (Table 9). The starter fertilizer was placed 2 inches to the side of and 2 inches below the seed. This trial was conducted at five locations in either a continuous corn or a corn-soybean cropping sequence. Since the use of ACA did not have a positive effect on yield at any of the locations, treatment averages for the five locations are listed in Table 9.

Table 9. The effect of ACA applied with a starter on the average corn yields at five locations in Illinois where minimum tillage planting systems were used.

Fertilizer Applied (lbs/acre)			Yield * (bu/acre)
N	P_2O_5	K_2O	
0	0	0	171a
25	30	0	176 a
25	30	0+.5 pint ACA/acre	179 a
Source: K.B. Ritchie, et al., 1977. * Treatment averages followed by the same letter are not significantly different at the .05 confidence level.			

In corn evaluations in South Dakota, some of the starter containing ACA was applied with the seed and the remainder was placed in a band near the seed (Table 10). Consistent with the results from Illinois, the measured yields of corn showed that the use of ACA applied in this manner had no positive effect on yield.

Table 10. The effect of ACA applied with fertilizer in a band on corn yield.

Treatment	Yield (bu/acre) *
no starter, N only	150 a
starter plus N **	157 a
starter with ACA plus N	157 a
Source: A. Bly, et al., 1997. * Treatment averages followed by the same letter are not significantly different at the .05 confidence level. ** 7-21-7 starter used; 6 gallons per acre with the seed plus 7 gallons per acre in a band 4 inches to the side of and 2 inches below the seed.	

The effect of ACA on corn production has also been evaluated by private research organizations. Results of this work have also been mixed. For example, Ag Resource Inc., Arkansas, Wisc., found a significant yield increase from the use of this product in three of four years (1991–1994). The average yield increase for the years in which there was a positive response was 10 bushels per acre. This research, however, did not identify an optimum rate. The rate of ACA applied varied each year in a range of 5.3 to 10 oz per acre.

Results of trials conducted by Agri-Growth Research Inc., were also mixed. In 1993, corn growth was stressed by cool temperatures and excessive moisture and the use of ACA had no positive effect on yield (Table 11). In another year, when weather was more conducive to higher yields, there was a curvilinear response to the rate of applied product. The yield produced by the use of 10 ounces of product per acre was significantly higher than the yield of the control. Increases in rate above this amount, however, did not produce increases in yield.

Table 11. The effect of ACA applied in a band 2 inches to the side of and 2 inches below the seed on corn yield, under stressed and non-stressed growing conditions.

ACA Applied (oz/acre)	Stressed * (bu/acre)	Non-Stressed * (bu/acre)
0	91 a	186 b
5	92 a	191 ab
10	96 a	193 a
20	91 a	193 a
40	91 a	190 ab
Source: Agri Growth Research, Inc. * Treatment averages in each column followed by the same letter are not significantly different at the .05 confidence level.		

Evaluation For Sweet Corn Production

ACA has also been evaluated for sweet corn production (Table 12). In trials conducted in Wisconsin, the ACA was applied with 28-0-0 through a spoke injector to supply 100 lbs N per acre. The trials were conducted at Arlington (silt loam) and Hancock (loamy sand) in 1990 and 1991.

For the Wisconsin sweet corn trial, the nitrogen with and without ACA was applied to six sweet corn hybrids. The yields measured at both sites each year showed that the use of ACA had no positive effect on production of the six hybrids that were used in the study.

Table 12. The effect of ACA applied with liquid nitrogen on the yield of sweet corn at two locations for two years.

	Arlington Yield (tons/acre) *		Hancock Yield (tons/acre) *	
Treatment	1990	1991	1990	1991
no N	10.3 a	4.4 a	7.1 a	2.3 a
100 lbs N/acre	10.6 a	6.7 b	9.1 b	8.0 b
100 lbs N/acre +				

ACA	10.3 a	7.1 b	8.7 b	7.1 b
Source: K.A. Kelling, et al., 1997. * Treatment averages in each column followed by the same letter are not significantly different at the .05 confidence level.				

Corn at harvest in one ACA evaluation, where no significant yield improvements were found.

Evaluation For Sugarbeet Production

Nearly all of the trials conducted with ACA in the North Central region have used field corn or sweet corn as the test crop. Evaluations using other crops are limited. One exception is work with sugarbeets in the Red River Valley of North Dakota and Minnesota. In these trials, ACA was applied with 10-34-0. Results for these locations were averaged and are summarized in Table 13.

Table 13. The effect of ACA applied with 10-34-0 on sugarbeet yield and the amount of sugar produced.

Variety	Treatment *	Root Yield (tons/acre)	Sugar Produced (lbs/acre)
VDH 66140	control	26.0	7,065
	10-34-0	25.8	7,050
	10-34-0 + ACA	27.6	7,533
Monohikari	control	24.4	6,579
	10-34-0	25.4	6,862
	10-34-0 + ACA	25.6	7,063
ACH	control	24.3	6,423
	10-34-0	25.5	6,911
	10-34-0 + ACA	26.1	6,910
LSD (.05)		1.4	455
Source: R.E. Watkins, et al., 1994. * 10-34-0 rate = 3 gal./acre; ACA rate = ½ pint/acre.			

Except for the VDH 66140 variety, the use of ACA added to the 10-34-0 had no significant effect on both sugarbeet yield and the amount of sugar produced. These results do not provide an explanation for the response of the one variety.

Evaluation For Potato Production

Use of ACA has been evaluated for potato production in Wisconsin. The ACA was added to a starter fertilizer. The evaluation was conducted for three years and the yield results are summarized in Table 14.

Table 14. The effect of ACA on potato yield and grade (1994 – 1996).

Year	Treatment	Total Yield (cwt/acre)	Grade A Tubers (percent)	US1A Yield (cwt/acre)
1994	control	383	87	170
	8 oz ACA/acre band	389	89	187
	8 oz ACA/acre foliar	377	87	163
	8 oz ACA/acre band +	378	91	185
	8 oz ACA/acre foliar	—	—	—
	Pr > F	0.94	0.71	0.47
1995	control	347	48	62
	starter + 0 oz ACA/acre	398	42	69
	starter + 4 oz ACA/acre	370	40	56
	starter + 8 oz ACA/acre	438	57	99
	starter + 16 oz ACA/acre	406	47	82
	starter + 24 oz ACA/acre	391	48	75
	Pr > F	0.03	0.09	0.07
1996	control	354	75	54
	starter + 0 ACA	445	77	88
	starter + 4 oz ACA/acre	502	82	141
	starter + 8 oz ACA/acre	491	80	113
	starter + 16 oz ACA/acre	471	80	106
	starter + 24 oz ACA/acre	504	81	121
	Pr > F	0.01	0.18	0.01
Source: K.A. Kelling, et al., 1997.				

The use of ACA did not consistently improve yield or grade in 1994. However, in 1995 and 1996, the use of a starter fertilizer increased potato yield and quality. It appears that the addition of ACA at a rate of 8 ounces per acre in 1995, and 4 or more ounces per acre in 1996 may have had some benefit on yield.

Because of encouraging results in 1995, several parameters of potato production were measured in 1996 (Table 15). These results show that while more tubers were harvested, neither the numbers of tubers set nor vegetative growth were affected by the use of ACA.

Table 15. Effect of ACA on potato tuber set, stem number, and harvested tuber number (1996).

Treatment	Stems per 3 plants	Tubers per 3 plants	Harvested Tubers in 40 feet of Row
control	11.3	24.3	285
starter + 0 ACA	11.3	35.3	345
starter + 4 oz ACA/acre	14.0	31.2	378
starter + 8 oz ACA/acre	13.7	43.3	362
starter + 16 oz ACA/acre	13.5	41.5	365
starter + 24 oz ACA/acre	11.7	34.5	394
PR > F	0.31	0.08	0.01
Source: K.A. Kelling, et al., 1997.			

Summary

The fertilizer additive, ACA (Agricultural Crop Additive) has been marketed for nearly three decades. It has a guaranteed analysis of 15% nitrogen and 17% zinc by weight and is recommended to be applied at rates which range from a few ounces per acre to ½ pint per acre with various fertilizers. There have been several advertising claims made for this product.

Field trials designed to document the effect of the use of this product for crop production have been conducted since the mid-1970s. Although there have been some exceptions, the addition of this product to a recommended fertilizer program has rarely increased crop yields. This lack of response has been observed when crops were growing under stress as well as when there were no environmental limitations to production.

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