EFFECT OF NUTRIENT COMBINATIONS AND NITRAPYRIN IN STARTERS ON CORN[1]

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ABSTRACT

Experiments were conducted from 1994 to 1996 at the Belleville Research Center of Southern Illinois Univerity and the Dixon Springs Agricultural Center of the University of Illinois to evaluate the effect of starter fertilizers, nitrapyrin (N-Serve) amendment of the starters, and tillage on corn. The soil at the Belleville site was an Iva silt loam, a low organic matter soil with relatively high P and K soil test levels. At Dixon Springs a Bonnie silt loam (bottomland) soil was used and the soil test levels for P and K were in the medium range. Responses to combinations of N, P, K and Cl in the starters, amended with and without N-Serve, were mixed at the two locations. Starters increased the nutrient composition of young plant tissue, increased the dry matter weights of V-6 growth stage corn, and increased grain yield. Nutrient combinations that contributed the most at Belleville to early growth were those starters that contained only N or N and P. Greatest yield benefit was acheived with only N in the starter. At Dixon Springs the largest early growth increases and yield increases were obtained from starter combinations that contained N + P, N +K + Cl, or N + P + K + Cl.

N-Serve inclusion with the starters resulted in increased N and P levels in the tissue of immature plants but increased the early plant growth only at Belleville. N-Serve had no effect on early corn growth at Dixon Springs. Grain yield was significantly increased in only one of the six site-years of study with N-Serve addition to the starters. The responses observed with the starters and N-Serve were similar across the two tillage methods (no-till and chisel till), and no significant interactions between tillage, starters and N-Serve were noted.

INTRODUCTION

Starter fertilizers have been shown to enhance early nutrient uptake, growth, and yield of corn. In Indiana studies, Mengel (1990) observed 5 to 10 bu/Ac yield increases from the use of starters across a wide range of soils using conservation tillage practices. Schulte and Bundy (1994) reported that consistent responses to starter fertilizers were usually observed in the cool, wet soils of Wisconsin even under high-testing environments. Recently Ritchie et al. (1996) in Illinois reported that starter fertilizers applied to no-till corn and banded 2 X 2 at planting increased corn yields in 8 of 9 site-years, regardless of the previous crop. Average yield increases were 8 bu/Ac for N alone (25-0-0), 13 bu/Ac for N and P (25-30-0), and 14 bu/Ac for

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N, P, and K (25-30-20) in the starter. Yield benefits were usually greater in northern Illinois than southern Illinois soils.

Providing an enhanced level of ammonium in starters for a longer duration through the use of a nitrification inhibitor has been shown to improve plant N utilization in the early growth stages of corn (Francis et al., 1994). In a review by Huffman (1994), it was suggested that an enhanced ammonium nutrition (provided by the use of a nitrification inhibitor with starters) may result in a stimulation of the uptake of both N and P in the early stages of corn growth. In other research, chloride additions to the nutrient solution, especially under enhanced ammonium environments, were shown to increase the harvest index of corn (Teyker et al., 1993) and the dry matter yield of wheat (Koening and Pan, 1993). Chloride application to corn has been reported by Heckman (1993) to increase the water content of immature corn tissue and enhance the grain yield even under high yielding field conditions.

The objectives of this research were:

(i) To evaluate the influence of phosphorus, potassium, and chloride under a fixed nitrogen component included with starter fertilizers on corn nutrient uptake and yield.

(ii) To determine the effect of nitrapyrin (N-Serve) inclusion to retain a high level of ammonium-N in starter fertilizers on nutrient uptake relationships in corn and on corn yield.

(iii) To evaluate the influence of starter fertilizer treatments on corn under both reduced (chisel) till and no-tillage management systems.

METHODS

Experiments were conducted for three years from 1994 to 1996 at the Dixon Springs Agricultural Center of the University of Illinois and the Belleville Research Center of Southern Illinois University. The experimental sites at both locations were the same for all three years of the studies. The soil at the Dixon Springs experimental site was classified as a Fluvaquent (bottomland soil) while the soil at Belleville was an Alfisol that had a moderately well developed soil profile (a weak claypan). Both soils had an organic matter content that ranged from 1.5 to 2.0 percent.

Selected information relating to site details, treatments, hybrids used, and other experimental details is given in Table 1. As shown, starter treatments were applied that included a fixed application of N (30 lb N/Ac) with variable amounts of phosphorus, potassium, and chloride added as companion nutrients. The nitrogen component in the starter was from UAN (28-0-0), phosphorus (and part of the N) was from ammonium polyphosphate (10-34-0), potassium was from suspension grade muriate of potash (0-0-62), and chloride was from 0-0-62 or added as calcium chloride (Treatments 5 and 6). One treatment (No. 10) included potassium but no chloride (the K source was potassium nitrate). Each starter treatment was duplicated, one

without nitrapyrin and the other with nitrapyrin added at 0.25 lb a.i. per acre as N-Serve 24E. The starters were applied in a band, 2 inches to the side and 2 inches below the seed, at planting.

A control treatment (0-0-0-0) was included. Thirty (30) lb N/Ac as 28-0-0 was sprayed as a "weed and feed" application to the control treatment at planting to balance the N applied in the starter treatments. An additional 150 lb N/Ac was applied as a knife-injected UAN source at the sidedressing stage to give a total of 180 lb N/Ac applied to the corn crop.

The starter treatments were evaluated under both no-tillage and reduced (chisel) tillage management conditions at each locations. However, at Belleville in 1994 and 1996, treatment effects were evaluated only using chisel till management because the final stand of corn under no-tillage was too uneven to be satisfactory for a valid yield comparison. A split plot design was used at both locations with tillage as main plots and starter treatments without and with N-Serve as subplots. However, at Belleville no main plot comparisons or interactions of tillage with fertilizers were possible for 1994 or 1996. Four replications of all treatments were employed at each location.

RESULTS AND DISCUSSION

General Comments

Excessive April and May rainfall during all three years of the study caused delays in corn planting at both locations (Figure 1). Dixon Springs was planted during the third or fourth week in May each year but at Belleville planting did not occur until the last week in May or into June. Cool soils were not a problem for good corn emergence at these later planting dates but soil wetness may have been a contributing factor for the early growth response that was observed with starters, especially at Belleville. This early growth response to starter treatments at Belleville was observed even though soil test levels for P and K were relatively high and a starter response was less probable.

Excellent yields were obtained for all three years at both locations, except Belleville in 1995. That year, wetness caused delayed planting until June 19 followed by severe dryness in July and August in which only 41 percent of normal rainfall was received. Those factors likely contributed to the lower yields at Belleville that year.

Effect of Starters, N-Serve, and Tillage on N, P, and K Composition of V-6 Growth Stage Corn Plants

Data on the nutrient composition of V-6 growth stage corn plants sampled in 1995 and 1996 is given in Tables 2 and 3. At both locations in 1995, the different nutrient combinations in the starters resulted in significant differences in N, P, and K composition in the corn tissue (Table 2). Adding N alone in the starter or with other nutrient combinations resulted in significantly higher tissue N composition than the control, which received the same amount of N but as a "weed and feed" application at planting. Similarly, adding P or K with N in the starter resulted in significantly higher levels of P and K in the tissue compared to the starter containing only N.

Adding chloride with N in the starter (as calcium chloride) had no impact on the levels of N, P, or K in the tissue compared to the starter that contained only N. At both locations, inclusion of N-Serve with the starter significantly increased levels of both N and P in the immature corn tissue. Potassium composition was not affected by N-Serve. Levels of N, P, and K in the tissue were generally higher in no-till plots than those which were chisel tilled.

The N, P, and K nutrient level patterns observed with the different starter combinations in 1996 (Table 3) were very similar to these found in the 1995 studies. Adding specific nutrients in the starter (ex. P or K) resulted in their significant increase in the tissue compared to their omission. The only exception was that N in the tissue at Belleville was not affected by its addition in starters. As was found in 1995, N-Serve addition to the starters resulted in significantly higher levels of N and P in the young corn plants but did not have any effect on K composition. These results were in agreement with findings reported by Huffman (1994). Tillage method used did not affect N or K composition at Dixon Springs but P levels were significantly higher with no-tillage compared to chisel till.

Nutrient composition differences in the tissue of young corn plants (that resulted from starter use) largely disappeared by the time the corn reached the silking stage. Corn ear leaf sample analyses essentially showed no differences in nutrient levels regardless of starter application or nutrient combination that was used.

Effect of Starters, N-Serve, and Tillage on Dry Matter Weights of V-6 Growth Stage Corn

Early growth of corn was stimulated by starter fertilizer application but the nutrient combinations that gave the greatest increase in dry matter were different at the two locations (Table 4). At Dixon Springs early growth was enhanced to the greatest extent by N + P or N + P +K + Cl (16 percent and 11 percent increases over the control, respectively). Nitrogen alone, N + K + Cl, and N + Cl starter combinations had no influence on early growth. Apparently the P and P + K combinations with N were important in augmenting the modest levels of soil test P and K that were present. At Belleville, where soils were more poorly drained but higher in soil test P and K, the greatest dry matter increase was obtained with N only in the starter (30 percent increase over the control). A slight increase, to 34 percent dry matter increase over the control, was achieved with the N + P nutrient combination in the starter. Other nutrient combinations resulted in a lower dry matter increases compared to the control.

N-Serve inclusion with starters had no effect on the dry matter weights of 10 plants at the V-6 growth stage at Dixon Springs for any of the years of study (Table 4). However, at Belleville, N-Serve addition to the starters resulted in significantly enhanced early growth compared to its non-inclusion each year of the study. Use of N-Serve resulted in about an 11 percent dry matter increase over the three years of this study.

Early corn plant growth was significantly greater with no-till compared to chisel tillage at Dixon Springs each year of the study (Table 4). At Belleville, in 1995, tillage method had no effect on early corn growth.

Effects of Starters, N-Serve, and Tillage on Corn Grain Yield

Significant yield increases were obtained with starter fertilizers in five of six site-years of this study (Table 5). The largest yield increase was obtained from a different nutrient combination at Dixon Springs compared to Belleville. At Dixon Springs, over the three years, a modest yield increase (8 bu/Ac) was obtained with only N in the starter but the largest increases were obtained with N + P (11 bu/Ac), N + K + Cl (12 bu/Ac), and N + P + K + Cl (12 bu/Ac). It was clear that P and/or K inclusion in the starters was important in maximizing the starter responses at Dixon Springs where the soil test P and K levels were in the medium range. At Belleville, over the three years, the largest yield increase was obtained with only N in the starter. All other starter combinations resulted in a much smaller yield increase (1-2 bu/Ac) compared to the control. Apparently, the addition of P or K in the starters at Belleville was not crucial because of the relatively high soil test P and K levels present.

N-Serve inclusion with starters had no effect on grain yield in five of the six site-years (Table 5). Only in 1995 at Dixon Springs did N-Serve addition result in a significant yield increase (4 bu/Ac). It was apparent that the higher N and P nutrient levels in immature corn, enhanced by N-Serve, had little influence on the final grain yield that was obtained. Tillage practices used (no-till vs. chisel till) likewise had no significant effect on the overall grain yields.

SUMMARY AND CONCLUSIONS

Use of starter fertilizers was found (I) to increase easily growth of corn, (ii) increase the nutrient composition in the issue, especially those nutrients that were included in the starter, and (iii) increase corn grain yield. At each location, nutrient combinations which were different at each location resulted in the largest increases in early growth and yield. At Dixon Springs, the greatest dry weight increases, compared to the control, for corn tissue at the V-6 stage were obtained with N + P (16%) or N + P + K + Cl (11%) in the starter. At Belleville the largest early growth increase was obtained with only N in the starter or N + P in the starter (31% and 34% increases over the control). The greatest yield increase at Dixon Springs over the three years was obtained with starters containing N + P, N + K + Cl, or N + P + K + Cl (11, 12, and 12 bu/Ac, respectively). At Belleville, the largest yield increase was obtained with only N in the starter and average 7 bu/Ac.

N-Serve addition to the starters resulted in significant increases in N and P composition of young plant tissue. Also it resulted in greater plant weights at the V-6 stage for all three years at Belleville but had no effect on plant dry weight at Dixon Springs. A significant yield increase with N-Serve in the starters was obtained in only one of the six site-years of study.

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Table 1. Experimental Conditions and Details at the Dixon Springs Agricultural Center and the Belleville Research Center for Starter Fertilizer Studies on Corn (1994-1996).

Parameter	Dixon Springs	Belleville
Soil Type:	Bonnie silt loam (Fine-silty, mixed, acid, mesic Typic Fluvaquents)	Iva silt loam (Fine-silty, mixed, mesic Aeric Endoaqualfs)
Soil Test Data:		
pHw	5.8	6.6
Bray P_1	32 lb P/Ac	57 lb P/Ac
Exch K	198 lb K/Ac	257 lb K/Ac
Corn Hybrid Planted:		
1994	Pioneer 3394	Pioneer 3394
1995	Pioneer 3394	Pioneer 3394
1996	Mycogin NG 7959	Pioneer 3394
Treatments: (lb N-P_2O_5-K_2O-Cl/Ac, without and with N-Serve at 0.25 lb a.i./Ac)	1. 0-0-0-0 2. 30-0-0-0 3. 30-0-20-15 4. 30-0-40-30 5. 30-0-0-15 6. 30-0-0-30 7. 30-30-0-0 8. 30-30-20-15 9. 30-30-40-30 10. 30-30-40-0	1. 0-0-0-0 2. 30-0-0-0 3. 30-0-20-15 4. 30-0-40-30 5. 30-0-0-15 6. 30-0-0-30 7. 30-30-0-0 8. 30-30-20-15 9. 30-30-40-30 10. 30-30-40-0
Experimental Design:	Randomized Complete block with tillage as main plots and starter treatment (without and with N-Serve) as subplots. Four replications.	Randomized Complete block with tillage as main plots and starter treatments(without and with N-Serve) as subplots. Four replications.
Plot size:	4 Rows X 35 ft. (subplots)	4 Rows X 35 ft. (subplots)

Figure 1. Rainfall amd normal rainfall for DSAC and BRC, 1994-96.

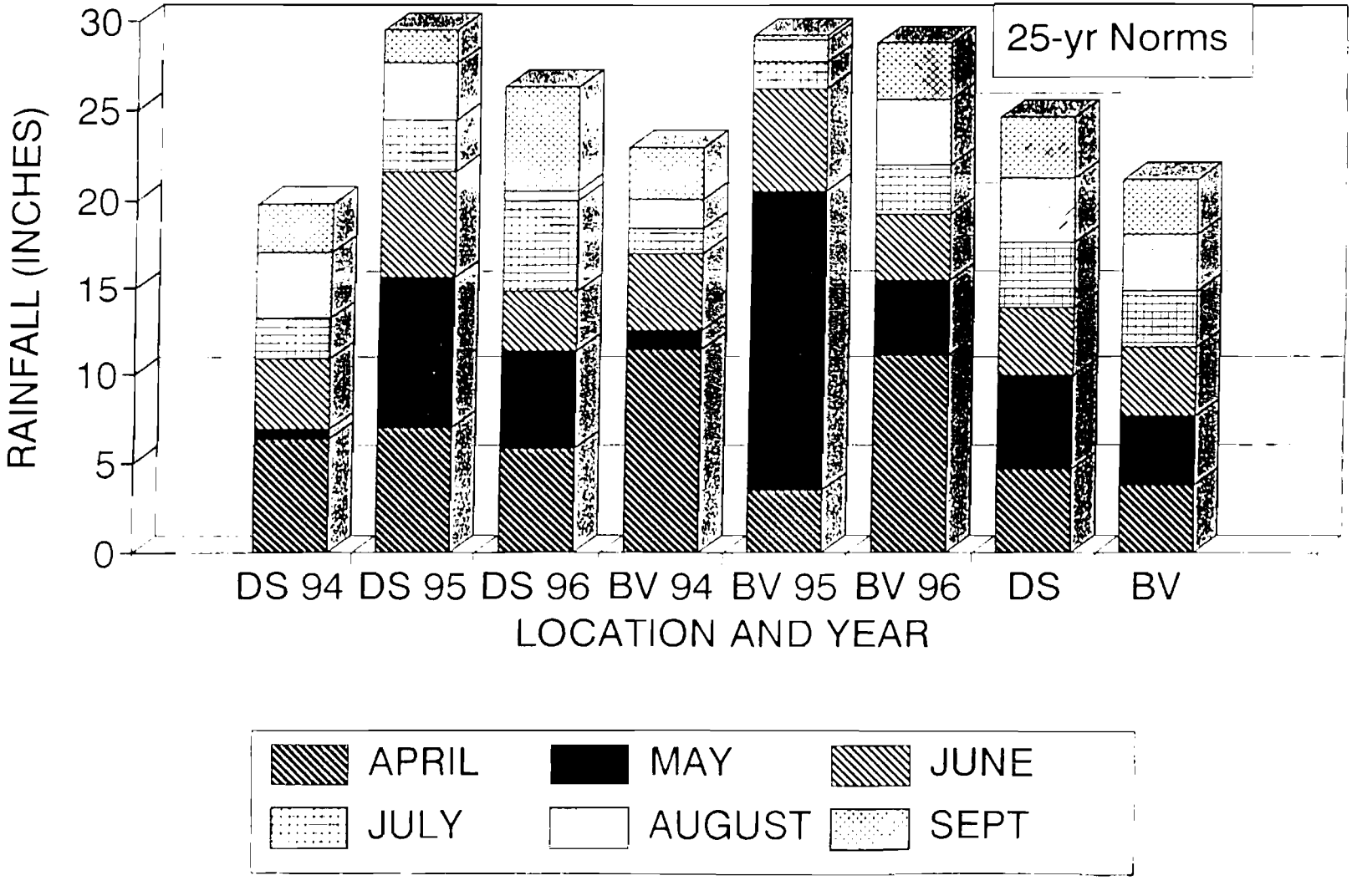

Table 2. Effect of Starter Fertilizers, N-Serve, and Tillage on the N, P, and K Nutrient Composition of Whole Corn Plant Tissue at the V-6 Growth Stage at Dixon Springs and Belleville in 1995.

Starter Treatment[1]	Dixon Springs N	Dixon Springs P	Dixon Springs K	Belleville N	Belleville P	Belleville K
	----------%			----------%		
Control	3.39	0.34	4.62	2.89	0.45	4.34
N	3.55	0.34	4.62	3.65	0.41	4.35
N + P	3.77	0.38	4.54	3.63	0.44	4.31
N + K + Cl	3.60	0.35	4.97	3.49	0.42	4.79
N + Cl	3.69	0.35	4.62	3.54	0.42	4.48
N + P + K + Cl	3.66	0.38	4.98	3.33	0.46	4.76
$LSD_{0.05}$	0.15	0.02	0.24	0.19	0.02	0.18
- N-Serve	3.60b	0.35b	4.81a	3.36b	0.43b	4.55a
+ N-Serve	3.67a	0.36a	4.83a	3.53a	0.44a	4.55a
No-Till	3.58a	0.39a	4.87a	3.58a	0.50a	4.69a
Chisel Till	3.68a	0.33b	4.77a	3.30b	0.37b	4.42b

[1] N = 30 lb N/Ac; P = 30 lb P_2O_5/Ac; K = Mean of 20 and 40 lb K_2O/Ac; Cl = Mean of 15 and 30 lb Cl/Ac.

Table 3. Effect of Starter Fertilizers, N-Serve, and Tillage on the N, P, and K Nutrient Composition of Whole Corn Plant Tissue at the V-6 Growth Stage at Dixon Springs and Belleville in 1996.

Starter Treatment[1]	Dixon Springs N	P	K	Belleville N	P	K
	----------%----------			----------%----------		
Control	2.88	0.34	4.54	3.71	0.41	4.50
N	3.26	0.34	4.32	3.86	0.40	4.51
N + P	3.25	0.36	4.31	3.79	0.45	4.49
N + K + Cl	3.22	0.35	4.76	3.76	0.42	5.10
N + Cl	3.29	0.35	4.55	3.84	0.42	4.62
N + P + K + Cl	3.24	0.37	4.90	3.79	0.44	4.98
$LSD_{0.05}$	0.10	0.02	0.23	NS	0.03	0.41
- N-Serve	3.16b	0.35b	4.65a	3.73b	0.42b	4.84a
+ N-Serve	3.25a	0.36a	4.63a	3.83a	0.44a	4.79a
No-Till	3.15a	0.37a	4.57a	------	------	------
Chisel Till	3.26a	0.34b	4.70a	------	------	------

[1] N = 30 lb N/Ac; P = 30 lb P_2O_5/Ac; K = Mean of 20 and 40 lb K_2O/Ac; Cl = Mean of 15 and 30 lb Cl/Ac.

Table 4. Effect of Starter Nutrient Combinations, N-Serve, and Tillage on the Dry Weights of Ten Immature Whole Corn Plants at Dixon Springs and Belleville, 1994-96.

Starter Treatment[1]	Weight of 10 plants at the V-6 stage (grams)								
	Dixon Springs				Belleville				
	1994	1995	1996	Mean (% incr.)[2]	1994	1995	1996	Mean (% incr.)[2]	
Control	33.9	35.2	42.5	37.2	24.4	15.9	41.9	27.1	
N	29.7	36.5	43.2	36.5 (-2)	31.5	20.3	54.3	35.4	(+31)
N + P	35.5	40.3	53.4	43.1 (+16)	31.6	23.9	53.3	36.3	(+34)
N + K + Cl	34.0	36.1	42.3	37.5 (+1)	29.7	19.6	48.3	32.5	(+20)
N + Cl	32.2	36.1	44.9	37.8 (+2)	28.8	19.4	49.0	32.4	(+20)
N + P + K + Cl	34.9	39.8	49.3	41.3 (+11)	30.0	18.5	49.4	32.6	(+20)
$LSD_{0.05}$	4.7	3.6	6.9		4.0	3.9	5.4		
- N-Serve	33.9a	37.1a	46.1a	39.0	28.2b	19.1b	46.0b	31.1	
+ N-Serve	33.9a	38.2a	45.0a	39.0	30.5a	20.4a	53.2a	34.7	
No-Till	35.7a	42.2a	52.5a	43.5	-----	19.6a	-----	-----	
Chisel Till	32.1b	33.1b	38.7b	34.6	-----	20.6a	-----	-----	

[1] N = 30 lb N/Ac; P = 30 lb P_2O_5/Ac; K = Mean of 20 and 40 lb K_2O/Ac; Cl = Mean of 15 and 30 lb Cl/Ac.
[2] Percent increase in dry weight compared to the non-fertilized control.

Table 5. Effect of Starter Nutrient Combinations, N-Serve, and Tillage on the Yield of Corn at Dixon Springs and Belleville, 1994-96.

Starter Treatment[1]	Grain Yield (bu/Ac) Dixon Springs 1994	1995	1996	bu/Ac Mean (incr.)[2]	Belleville 1994	1995	1996	bu/Ac Mean (incr.)[2]
Control	151	165	131	149	187	105	165	152
N	160	168	143	157 (+8)	199	112	165	159 (+7)
N + P	161	174	144	160 (+11)	192	113	157	154 (+2)
N + K + Cl	163	173	147	161 (+12)	190	112	155	153 (+1)
N + Cl	162	173	142	159 (+10)	192	112	158	154 (+2)
N + P + K + Cl	161	174	148	161 (+12)	191	111	156	153 (+1)
$LSD_{0.05}$	6.5	8.0	8.9		7.6	7.4	NS	
- N-Serve	161a	169b	143a	158	192a	112a	159a	155
+ N-Serve	161a	173a	144a	160	192a	112a	160a	155
No-Till	162a	172a	143a	159	-----	114a	-----	-----
Chisel Till	160a	171a	144a	158	-----	110a	-----	-----

[1] N = 30 lb N/Ac; P = 30 lb P_2O_5/Ac; K = Mean of 20 and 40 lb K_2O/Ac; Cl = Mean of 15 and 30 lb Cl/Ac.
[2] Increase in grain yield compared to the non-fertilized control.

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