NITROGEN FERTILIZATION FOR CORN PRODUCTION WHEN USING LEPA CENTER PIVOT SPRINKLERS

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ABSTRACT

A four year study was conducted with LEPA (Low Energy Precision Application) sprinkler-irrigated field corn in western Kansas on a deep, well-drained, loessial silt loam to compare nitrogen (N) fertilization using preplant broadcast or in-season LEPA fertigation for five different applied-N amounts (0, 90, 145, 200 or 260 kg/ha).

Residual soil N levels in the soil profile, corn yields, apparent nitrogen uptake (ANU), water use, and water use efficiency (WUE) were utilized as criteria for evaluating treatment differences. In general, results were similar for both application methods, indicating that either method is acceptable for corn production. Corn yield, ANU, and WUE all plateaued at approximately the same level of total applied N, 180 kg/ha (145 kg/ha with either primary method plus a 35 kg/ha starter application). Average yields at this level was 13.8 Mg/ha. Soil nitrate concentrations to a depth of 2.4 m for this same treatment were below 5 mg/kg at the conclusion of the study. The results emphasize that high-yielding corn production also can be efficient in nutrient and water use.

KEYWORDS. Sprinkler irrigation, nutrient management, nitrogen application, water use efficiency

INTRODUCTION

Low energy precision application (LEPA) sprinkler irrigation is a fast-growing irrigation technology in the U.S. Great Plains. This system applies water as a line source (1.5 m spacing applied between two 0.76 m corn rows) at a height of approximately 0.45-0.6 m above the soil surface. This can be very advantageous from a water conservation standpoint, reducing both evaporation due to wind and also reduced evaporation from wetting less of the soil surface. However, it has the potential to be an advantage or disadvantage when used in combination with fertigation (fertilizer applied with the irrigation water). Using proper management it could result in reduction of fertilizer use similar to reductions applied to traditional banding of fertilizers. Used with inappropriate management, it could increase the chances for groundwater contamination, because as fertilizer would be applied in a smaller zone and then "pushed downward" by the "slug" of irrigation water. Irrigators are already investing heavily in LEPA sprinklers. Fertigation in combination with LEPA also is likely to be a widely utilized technology, but some producers will continue to apply N fertilizer through traditional methods. This study compared N fertigation with LEPA sprinklers to a more conventional preplant-broadcast application method.

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PROCEDURES

The project was conducted with field corn from 1993-1996 at the KSU Northwest Research-Extension Center at Colby, Kansas on a deep, well-drained, medium-textured loessial silt loam. The continental climate was semi-arid with an average annual precipitation of 474 mm and annual lake evaporation of 1400 mm. Irrigation was scheduled using a climatic water budget.

The study area accommodated 30 plots in a randomized complete block design of 2 whole-plot treatments (preplant broadcast or LEPA fertigation) and 5 sub-plot treatments (0, 90, 145, 200 or 260 kg/ha of N) with 3 replications. The experimental treatments were applied during the 1993 corn-growing season to develop approximately equilibrium nitrogen levels in the soil profile and crop residue before the 1994 season. No further discussion of the 1993 season will be made. Each plot was approximately 12 m wide and 20 m long with circular row direction running parallel to direction of center pivot sprinkler travel. Each LEPA sprinkler effectively irrigated 2 corn rows. All N in the study was applied as an experimental variable except for the small amounts supplied by the spring starter fertilizer application (approximately 35 kg/ha of N and phosphorus (P) each). The N source, urea-ammonium-nitrate (UAN, 32-0-0) was either preplant broadcast in one application prior to corn planting or injected in weekly increments into the center pivot lateral for LEPA fertigation. Weekly fractional amounts to be applied were estimated from a N-use curve developed at Iowa State University (Ritchie, et al., 1989). Fertigation was begun about mid-June with the final fractional amount of N (usually around 20%) applied in mid-August.

Water use was calculated as the sum of seasonal changes in soil water between the first and last sampling dates, irrigation, and rainfall. Furrow dams restricted runoff. Available soil N (ammonium and nitrate N) was determined for each plot at the initiation and conclusion of each cropping season to a depth of 2.4 m. The apparent nitrogen uptake (ANU) was calculated from the field biomass levels and the whole-plant N content at physiological maturity. Grain yield was determined from a hand-harvested sample at physiological maturity. Water use efficiency (WUE) was obtained by dividing crop yield by water use.

RESULTS AND DISCUSSION

Climatic Conditions

Precipitation during the crop period was 277, 280 and 518 mm in the respective years 1994, 1996 and 1996 compared to the 25-year mean of 315 mm. The cumulative calculated ET was slightly above the 25-year mean of 577 mm in 1994 (628 mm) and 1995 (590 mm) but significantly below the mean in 1996 (494 mm). In this study, seasonal irrigation amounts were 373, 394 and 152 mm in 1994-96, respectively, compared to a long-term normal net irrigation requirement of 391 mm. Although the climatic conditions for the three years varied, they did represent a good range of conditions.

Residual Nitrate-N in the Soil Profile

After four years (1993-1996, with 1993 not included in analysis) of continuous application of the fertilizer treatments, nitrate-N levels in the soil increased with increasing rates of applied N under both preplant broadcast application and LEPA fertigation (Figure 1). In general, the nitrate concentrations were less than 10 mg/kg. An exception for the preplant broadcast application was a 17 mg/kg concentration near the soil surface for the 260 kg/ha applied N rate. Elevated soil nitrate concentrations (15 mg/kg) also occurred for the 200 and 260 kg/ha LEPA fertigation treatments at the 0.6 to 0.9 m depth. This actually may indicate fewer volatilization losses with this application method which resulted in more N available to move to the deeper depth. The nitrate concentration at the end of the study did not exceed 5 mg/kg for N rates 145 kg/ha or less for either application method. In terms of nitrate concentrations, a best management practice (BMP) would be to apply not more than 180 kg/ha of N (145 kg/ha preplant broadcast or LEPA fertigation and additional 35 kg/ha of N as part of a starter fertilizer program). The soil profiles for the 260 kg/ha N rate for the six different sampling periods indicates that leaching did not occur in every year even for the higher N rate (Figure 2). If N runoff is a concern, these data indicate that LEPA fertigation with incremental applications can reduce the pool of N available for runoff.

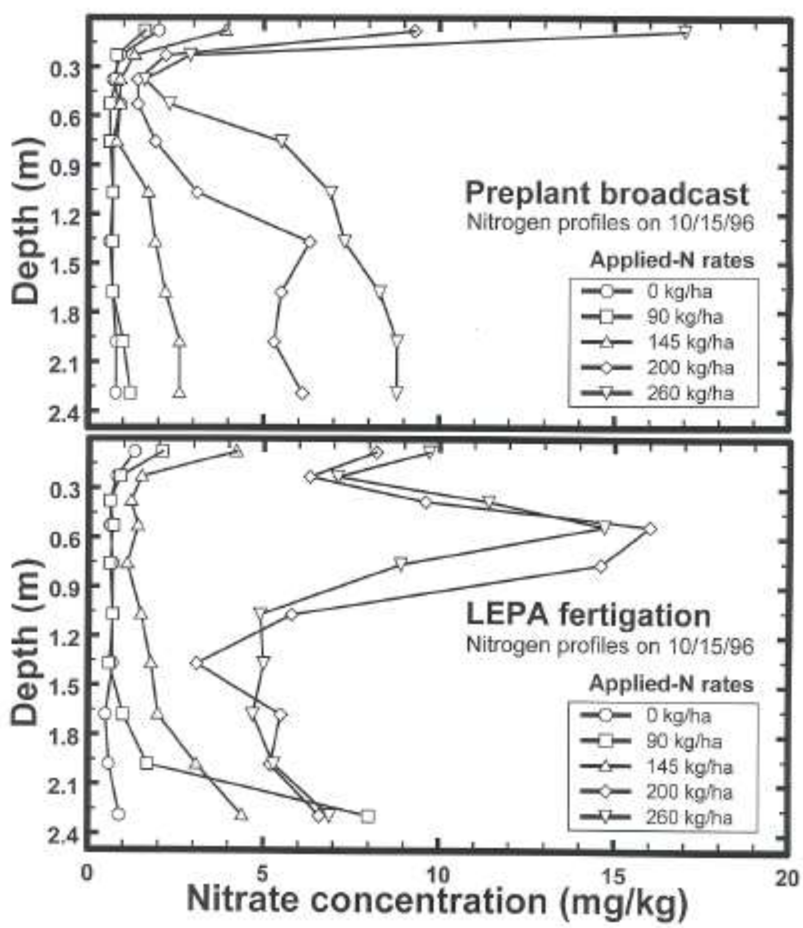

Figure 1. Soil nitrate-N concentrations as a function of depth for the five applied-N rates for preplant broadcast and LEPA fertigation application methods. Total applied N exceeded fertilization level shown in graph by N starter application of 35 kg/ha.

Corn Yields

No significant differences (P=0.05 significance level) in corn yields occurred in any year as affected by application method (Table 1). However, corn yields were significantly (P=0.05 significance level) different among N rates in all three years but generally were similar at and above the 145 kg/ha applied N rate (Table 1 and Figure 3). Overall yields were high (13-14 Mg/ha) even when including 1995 yields that were lowered by hail and poor growing conditions. This data would continue to support the BMP of 180 kg/ha (primary plus starter application) of N to optimize corn yields.

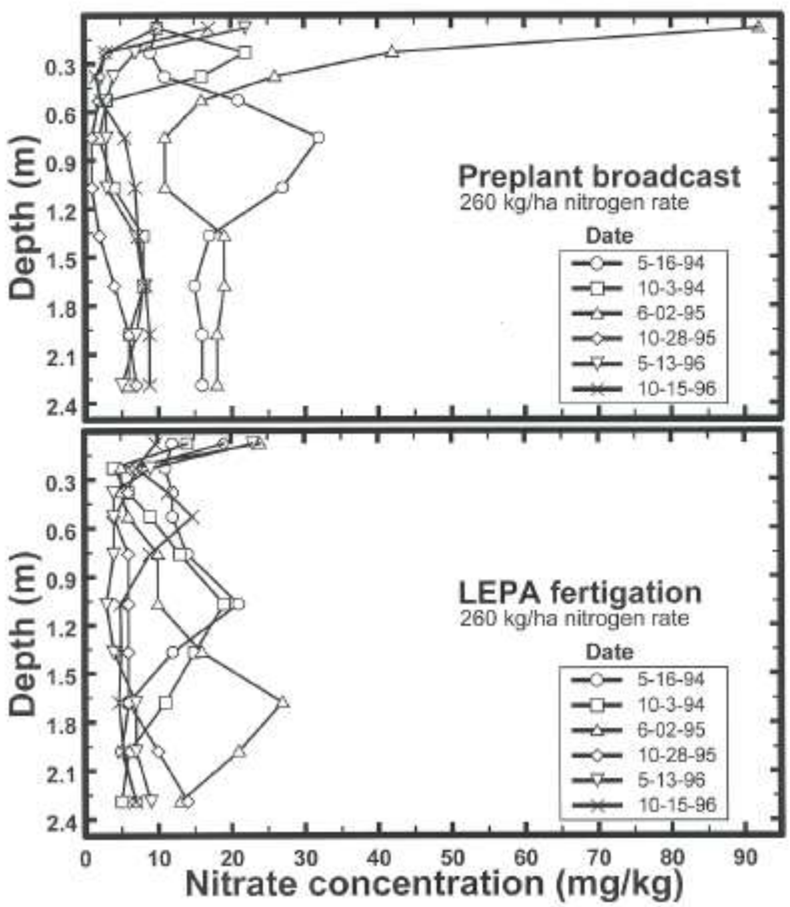

Figure 2. Soil nitrate-N concentrations as a function of depth for six sampling dates for the 260 kg/ha N rate applied preplant broadcast or with LEPA fertigation. Total applied N exceeded fertilization level shown in graph by N starter application of 35 kg/ha.

Apparent Nitrogen Uptake

The amount of N in the aboveground biomass was significantly different (P=0.05) between application methods in only one year, being higher for the LEPA fertigation method in 1994 (Table 1). Applied-N rate affected ANU in all three years with higher applied-N increasing ANU. The three year average ANU exceeded the total amount of applied N for both application methods up to 235 kg/ha N rate (200 + 35 kg/ha primary and starter application), indicating good use of the applied N (Figure 3).

Water Use and Water Use Efficiency

Water use was affected by application method only in 1995 with LEPA fertigation requiring less water (Table 1). Water use differed significantly (P=0.05) among N rates only in 1996 but tended to be higher for applied-N rates greater than 0 kg/ha in all three years. Irrigation amounts were identical among treatments so it can be concluded that adequate levels of fertilization can help better utilize available soil water. WUE was not affected by application method in any year. WUE was significantly different (P=0.05) among N rates (Table 1) with a trend toward WUE maximization at a total applied-N rate of 180 kg/ha (Figure 3). The plateauing of WUE coincided with plateauing of corn yield and ANU at approximately 180 kg/ha of total applied-N.

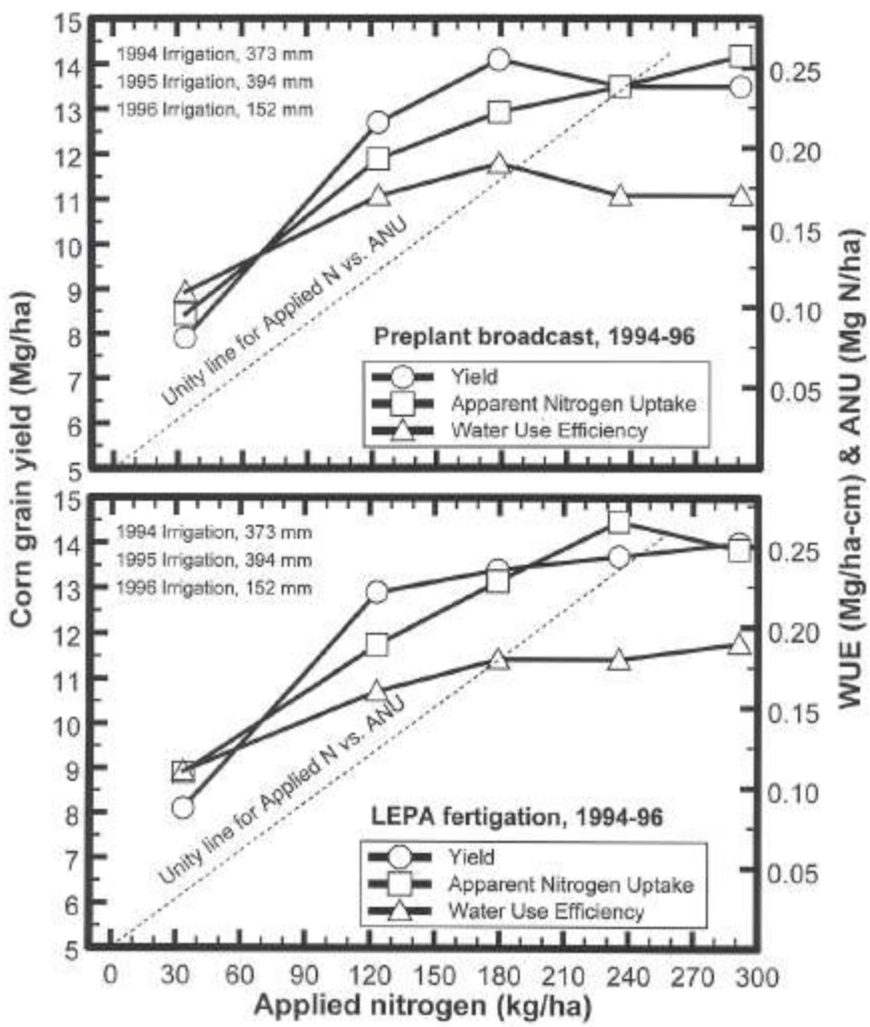

Figure 3. Average (1994-96) corn yield, apparent nitrogen uptake in the above-ground biomass, and water use efficiency as related to the total applied N (nitrogen amount applied by preplant broadcast or LEPA fertigation and starter fertilizer application of 35 kg/ha).

CONCLUSIONS

In general, no appreciable differences occurred between preplant broadcast and LEPA N fertigation methods for corn production in terms of grain yields, nutrient uptake, residual soil N, water use or water use efficiency.

Increasing the applied-N rate to 200 kg/ha with an additional 35 kg/ha of starter N tended to increase nitrate concentrations in the soil profile above 5 mg/kg. The lower 145 kg/ha N application rate was not appreciably different from the control treatment with no primary N application. A primary application of 145 kg/ha of N using either application method with the addition of a 35 kg/ha N starter application optimized grain yields at approximately 13.8 Mg/ha. Similarly, apparent nitrogen uptake and water use efficiency tended to plateau at the 145 kg/ha N level. This emphasizes that high-yielding corn production also can be efficient in nutrient and water use.

REFERENCES

Ritchie, S. W., J. J. Hanway, and G. O. Benson. 1989. How a corn plant develops? Iowa State University, Cooperative Extension Service, Ames, Iowa. Special Report No. 48. 21 pp.

Table 1. Summary of corn yield, nutrient uptake, and water use data from a nitrogen fertilization study using LEPA sprinkler irrigation, 1994-96.

Nitrogen application method	N-rate[1] kg/ha	Yield Mg/ha				Apparent N uptake kg/ha				Water use[2] mm				Water use efficiency[3] Mg/ha-mm			
		1994	1995	1996	Mean	1994	1995	1996	Mean	1994	1995	1996	Mean	1994	1995	1996	Mean
Preplant broadcast	0 + 35	10.2	5.5	7.9	7.9	122	84	81	96	759	732	704	732	0.014	0.008	0.011	0.011
	90 + 35	13.6	10.7	13.9	12.7	258	165	155	193	833	717	742	764	0.016	0.015	0.019	0.017
	145 + 35	15.1	12.3	15.1	14.1	245	191	230	222	780	804	714	766	0.019	0.015	0.021	0.019
	200 + 35	14.0	11.8	14.9	13.5	242	221	251	238	848	814	762	808	0.017	0.014	0.020	0.017
	260 + 35	14.5	11.4	14.8	13.5	258	234	278	257	820	801	739	787	0.018	0.014	0.020	0.017
LEPA fertigation	0 + 35	10.6	5.6	8.3	8.1	175	75	77	109	795	689	681	722	0.014	0.008	0.012	0.011
	90 + 35	13.8	10.9	14.1	12.9	257	156	154	189	831	765	767	787	0.017	0.014	0.018	0.016
	145 + 35	13.7	11.5	15.1	13.4	280	204	200	228	823	714	726	755	0.017	0.016	0.021	0.018
	200 + 35	14.1	12.1	15.0	13.7	303	238	254	265	818	782	711	770	0.017	0.016	0.021	0.018
	260 + 35	14.9	11.8	15.1	14.0	291	214	239	248	815	683	737	745	0.018	0.017	0.020	0.019
Mean																	
Preplant broadcast		13.5	10.3	13.3	12.4	225	179	199	201	808	774	732	771	0.017	0.013	0.018	0.016
LEPA fertigation		13.4	10.4	13.5	12.4	261	177	185	208	816	727	724	756	0.017	0.014	0.019	0.016
N rate	0 + 35	10.4	5.5	8.1	8.0	149	80	79	103	777	710	692	727	0.014	0.008	0.012	0.011
	90 + 35	13.7	10.8	14.0	12.8	257	160	155	191	832	741	754	776	0.017	0.015	0.019	0.017
	145 + 35	14.4	11.9	15.1	13.8	263	197	215	225	801	759	720	760	0.018	0.016	0.021	0.018
	200 + 35	14.0	12.0	14.9	13.6	272	229	253	252	833	798	737	789	0.017	0.015	0.020	0.017
	260 + 35	14.7	11.6	14.9	13.7	275	224	258	252	818	742	738	766	0.018	0.016	0.020	0.018
LSD 0.05																	
Application method		NS	NS	NS	NS	25	NS	NS	6	NS	46	NS	NS	NS	NS	NS	NS
N-rate		1.2	0.9	1.0	0.8	36	41	31	24	NS	NS	41	38	0.002	0.001	0.002	0.001

N-rate with same method	1.7	1.3	1.4	1.1	50	59	44	34	NS	NS	58	25	0.003	0.002	0.003	0.002
Method with same N-rate	NS	NS	NS	NS	25	NS	NS	16	NS	41	NS	NS	NS	NS	NS	NS

[1] Applied nitrogen rate with preplant broadcast or LEPA fertigation method plus the 35 kg/ha nitrogen starter application.

[2] Water use is defined as sum of irrigation, rainfall, and change in seasonal soil water in the 2.4 m soil profile.

[3] Water use efficiency is defined as yield divided by water use.