NITROGEN PLACEMENT, ROW SPACING, AND WATER MANAGEMENT FOR FURROW-IRRIGATED FIELD CORN

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ABSTRACT

Banding and sidedressing nitrogen (N) fertilizer on a never-irrigated side of a row of corn (*Zea mays* L.) were hypothesized to maintain yield and decrease nitrate leaching. In a two-year field study on a Portneuf silt loam (Durinodic Xeric Haplocalcid) in southern Idaho, we evaluated effects on yield and N uptake of 1) urea placement (broadcast pre-plant vs. band at planting), 2) row spacings (30-in vs. an offset 22-in spacing in which every pair of 22-in rows was positioned close to a furrow rather than each row on a bed center), and 3) water management. Our water management, termed irrigated furrow positioning, consisted of every-second furrow irrigation in which we applied water to either a) the same or b) the opposite side of the row with successive irrigations, the latter called alternating furrow irrigation. At season's end, we harvested 20 ft of row at three locations in each plot for silage and at three other locations for grain. Grain yield was not affected by the positioning of the irrigated furrow. However, averaged across years, grain yield from 22-in rows was 113 bu acre^{-1} from banded plots, 5% greater ($P<0.05$) than broadcast plots. Two-year average grain yield from 30-in rows was 107 bu acre^{-1}, with no difference between banding and broadcasting. In the second year, N uptake in grain averaged across row spacings was 72.3 lb acre^{-1} from banded plots and 65.5 lb acre^{-1} from broadcast plots ($P<0.01$). Silage yield increased up to 26% and N uptake in silage increased up to 21% from banding, compared to broadcasting, where we irrigated the same furrow in the study's second year. In both years, grain and silage yield and N uptake in grain and silage were similar or greater where urea was banded on one side of a row rather than broadcast.

INTRODUCTION

Minimizing fertilizer N contact with water moving downward from irrigation furrows should keep nitrate in the surface horizons of the soil profile, allowing the fertilizer N to be more available for crop uptake and less susceptible to leaching from the root zone. This goal may be achieved by banding and sidedressing N fertilizer on one side of a corn row and irrigating the other. However, fertilizer N may be positionally unavailable if the soil in contact with the fertilizer granules is too dry for root growth or extension, thereby reducing crop N uptake and yield. If one periodically wets this dry soil by irrigating the furrow near the N fertilizer, nitrate may be leached from the root zone or transported horizontally and upward to or near the surface into drier soil where uptake is less.

The research objective was to evaluate effects of N placement, row spacing, and irrigated furrow positioning on the yield of field corn grain and silage and on N uptake in grain and silage.

METHODS

The experiment was a split-split plot design with four replications. The main plot effect was irrigated-furrow positioning. In one treatment, we irrigated the same furrow all season (Furrow A in Fig. 1). In the other treatment, we irrigated alternating furrows (Furrow A, then B, then A, etc.) with successive irrigations. The subplot treatments were the row spacings shown in Fig. 2. The sub-subplot treatments (N fertilizer placements) were: 1) half of the N requirement broadcast pre-plant then half sidedressed 6 wks after planting, 2) half of the N banded at planting then half sidedressed, or 3) no N fertilizer applied. Placement of N (always as urea, 46% N) is shown in Fig. 1. Each plot was four rows wide and 335 ft long.

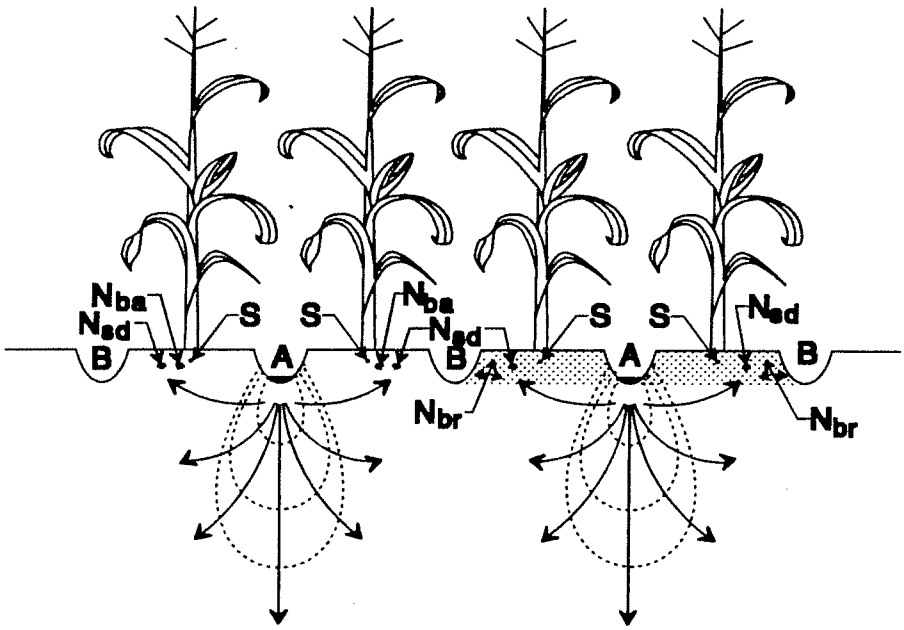

Figure 1. Positioning of seed (S), banded N (N_{ba}), sidedressed N (N_{sd}), and broadcast N (N_{br}) for 30-in rows where we irrigated the same furrow (A). Where we irrigated alternating furrows, we irrigated Furrow A first, then B, then A, etc. Equipotential and flow lines are conceptually shown.

Each spring prior to planting, we incorporated P and, into selected plots, broadcast-applied N according to University of Idaho soil test recommendations. In mid-May, "Pioneer 3901" corn was planted at the 2-in depth at a population of 26,900 plants acre^{-1}. At planting, N was banded 2 inches to the side and 1 inch below the seed, thus placing the N about 2 inches above the water surface when irrigating. Six weeks after planting, the sidedressed N was knifed into bed shoulders as a band 3 in beneath the soil surface and 5 in to the dry furrow side of the emerged corn (Fig. 1). Each year, we applied equal volumes of water to every other furrow of all plots with irrigations that were 12 hours long for the 30-in rows and 8.8 h for the 22-in rows. In 1988, we used an inflow of 4 gal min^{-1} to irrigate 9 times, each time applying 2.8 in of water (in gross). In 1989, we used an inflow of 5 gal min^{-1} to irrigate 7 times, applying 3.5 in of water each time. From each plot, we harvested 20 ft of row at each of three locations for silage yield and, later, at three other locations for grain yield.

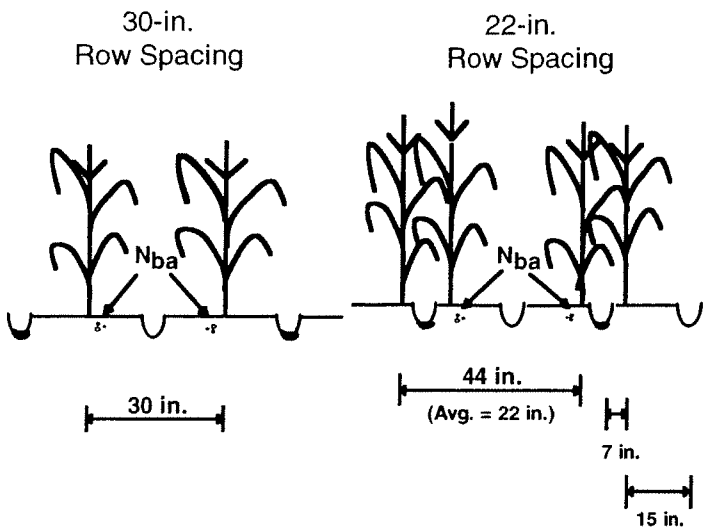

Figure 2. Row spacings were standard 30 in and an offset 22 in. Offset rows were positioned close to the irrigated furrow to increase water availability and decrease furrow erosion.

RESULTS AND DISCUSSION

Grain yield

Averaged across years, grain yield was not affected by irrigated-furrow positioning (data not shown). Repeatedly irrigating the same furrow yielded 99 bu acre^{-1} versus 98 bu acre^{-1} (not significant, NS) when irrigating alternating furrows. Two-year average yield revealed an interaction between row spacing and N placement (Table 1). When averaged across years, grain yield from 22-in rows was 5% greater (P=0.051) from banded than broadcast N. Grain yield from banded N was similar to or greater than was seen from broadcast N, regardless of row spacing. Two-year average grain yield from 30-in rows was similar, whether urea was banded or broadcast. When averaged across years and irrigated furrow positionings, grain yields did not differ from one row spacing to the other at any N placement (Table 1).

Table 1. Row spacing and N placement effects on corn grain yield, averaged across years and irrigated furrow positioning.

	Corn grain yield†		
	N placement		
Row spacing	Banded & sidedressed	Broadcast & sidedressed	Unfertilized
in	------- bu acre^{-1} -------		
22	113	107	77
30	107	107	81

†Yields adjusted to 15.5% moisture. $LSD_{0.05}$ = 5.9 bu acre^{-1} to separate placement means at either row spacing. Row spacing effects were not significant at 5%.

When grain yield was averaged across irrigated furrow positioning and N placement, however, row spacing was important. In 1988, corn in 22-in rows yielded 128 bu acre^{-1}, 6% more (P<0.029) than the 120 bu acre^{-1} from 30-in rows. In 1989, the trend reversed with 77 bu acre^{-1} from 30-in rows vs. 70 bu acre^{-1} from 22-in rows, significantly different at P<0.033. In 1988, residual soil N concentrations were relatively high, not likely growth- or yield-limiting. In 1989, with much less residual N in the soil, N was likely scavenged more efficiently by roots that were more evenly distributed under 30-in than 22-in rows. Also, irrigation water was closer to the banded and sidedressed N fertilizer with 22-in than 30-in rows (Fig. 2), likely leaching more fertilizer N and soil N from the corn's root zone under narrower than wider rows, particularly in 1989 (Lehrsch et al., 2001).

Nitrogen placement effects on grain yield depended upon the year (Table 2). In 1988, grain yield was statistically equal where N was banded and later sidedressed and where N was broadcast, then sidedressed. In 1989, yield was 11% greater (P<0.002) from banded N than broadcast N. Again, banding maintained or increased yield, especially in 1989 with much less residual N in the spring soil profile (soil N data not shown). Also in 1989, soil nitrate nitrogen (NO_3-N) was likely leached from corn root zones by two relatively large, early-season irrigations (Lehrsch et al., 2000 and 2001).

Table 2. Nitrogen placement effects on grain yield in 1988 and 1989.

	Grain yield†	
N placement	1988	1989
	-- bu acre^{-1} --	
Banded & sidedressed	123	96
Broadcast & sidedressed	128	86
Unfertilized	121	37

†Yields adjusted to 15.5% moisture. $LSD_{0.05}$ = 5.9 bu acre^{-1} to separate placement means in either year.

Nitrogen uptake in grain

Nitrogen uptake in grain averaged 90.9 lb acre^{-1} in 1988, but only 55.0 lb acre^{-1} in 1989, due in part to low uptake and yield in unfertilized plots in 1989 (Table 2). Irrigated-furrow positioning did not affect N uptake either year (data not shown). Row spacing effects were only significant in 1989 when N uptake was 14% greater (P<0.005) from 30-in than 22-in rows (Table 3). Equal spacing between 30-in rows compared to unequal spacing between 22-in rows (Fig. 2) likely led to more uniform root distribution in and more efficient N removal from the N-depleted profile.

Table 3. Row spacing effects on N uptake in corn grain in 1988 and 1989.

	N uptake in corn grain	
Row spacing	1988	1989
in	– lb acre^{-1} –	
22	93.9	51.4
30	88.0	58.6
$LSD_{0.05}$	NS	4.1

Nitrogen placement effects on N uptake in grain depended upon the year (Fig. 3). Nitrogen uptake in grain was similar for banded and broadcast N placement in 1988. In 1989, in contrast, banding compared to broadcasting increased N uptake more than 10% (P<0.01).

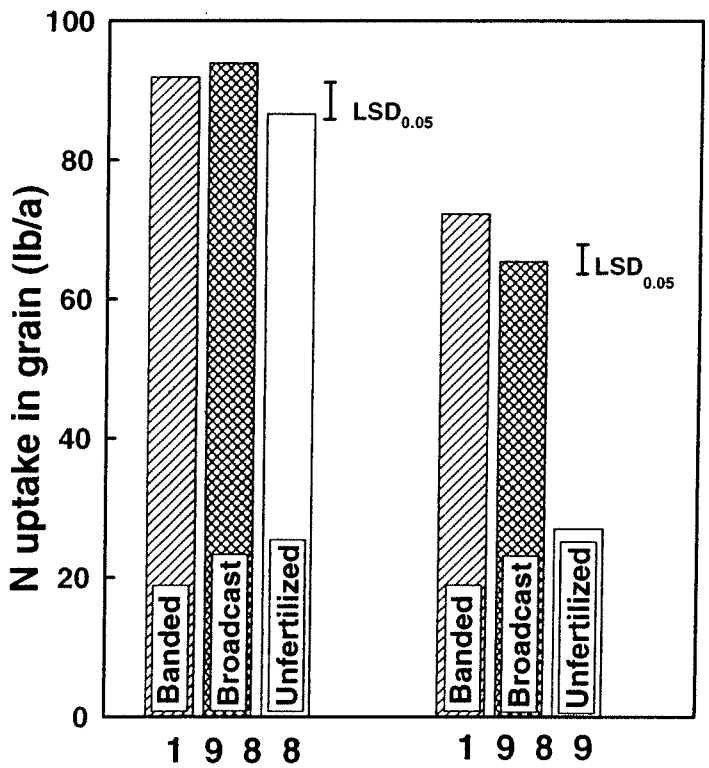

Figure 3. N placement effects on N uptake in corn grain, averaged across row spacings, in 1988 and 1989.

Silage yield

Silage yield averaged 9.0 ton acre^{-1} in 1988 and 9.1 ton acre^{-1} from N-fertilized plots in 1989. Yields were marginal because the corn cultivar was better adapted to produce grain than silage and plant populations were less than optimum for silage production. Research findings (Lehrsch et al., 2000) suggested two recommendations for silage producers. First, when growing silage in 22-in rows and irrigating the same furrow, a producer should apply N in a band rather than broadcast pre-plant to increase yield, potentially by 26%. Second, in soil profiles with little

residual N, producers who grow silage in 22-in rows should irrigate the same rather than alternating furrows to avoid silage yield losses that may approach 18%. When averaged across furrow positioning, 1988 silage yields were similar among row spacings. From fertilized plots in 1989, however, silage yields were 4.5% greater from 30-in than 22-in rows, 9.2 versus 8.8 ton acre^{-1}, respectively, not significant at P=0.05.

Nitrogen uptake in silage

When averaged across years and irrigated furrow positioning, N uptake in silage was consistently greater with 30-in than 22-in rows at every placement, although the differences were seldom significant at the 5% level (data not shown).

Irrigated furrow positioning did not affect silage N at any placement in 1988 or 1989 (Table 4). However, where water was applied all season to the same furrow, N uptake from banding was similar to that from broadcasting in the first year but was 21% greater (P<0.001) in the second year. From an N deficient soil profile, fertilizer N was used more efficiently from banding than broadcasting when the same furrow was irrigated throughout the season.

Table 4. Irrigated furrow positioning and N placement effects on N uptake in corn silage in 1988 and 1989. Data have been averaged across row spacings.

	N uptake in silage		
	N placement		
Irrigated furrow positioning†	Banded & sidedressed	Broadcast & sidedressed	Unfert.
	------ lb acre^{-1} ------		
		1988	
Alternating furrow	144 a‡	135 ab	121 b
Same furrow	133 a	137 a	130 a
		1989	
Alternating furrow	117 a	114 a	54 b
Same furrow	125 a	104 b	54 c

†Irrigated furrow positioning did not affect N uptake at any placement in either year.

‡Within a row for each year, means followed by the same letter are not significantly different at P=0.05.

CONCLUSIONS

Corn grain yield and N uptake in grain were similar or greater where urea was banded on one side of a row, rather than broadcast pre-plant. In Portneuf silt loam relatively deficient in N at planting, wider row spacings increased both grain yield and N uptake in grain. Silage yield and N uptake in silage were either maintained or increased where we banded N on one side of a row and repeatedly irrigated the other side. Where we irrigated the same furrow, silage yield increased up to 26% and N uptake in silage increased up to 21% from banding, compared to

broadcasting, in the study's second year. Irrigating the same furrow throughout the season neither reduced the yield of corn grain or silage nor the N uptake in grain or silage. In addition, as reported in Lehrsch et al. (2001), positioning irrigation water away from banded and sidedressed N fertilizer also minimized profile NO_3-N without sacrificing yield.

REFERENCES

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