Nitrogen Management for High Population Corn Production in Wide and Narrow Rows

By Carl R. Crozier, Ronald J. Gehl, David H. Hardy and Ronnie W. Heiniger

A 3-year study of corn planted in wide and narrow rows in North Carolina found grain yields were significantly higher with narrow rows and side-dress N application than with other row width and timing combinations. The 19% grain yield increase in response to applications of N fertilizer could be attributed to changes in ear yield components: kernels per row increased by 17%, mean kernel weight increased by 8%, and rows per ear increased by 3% due to N application.

While corn plant population guidelines published in 1988 suggested 20,250/A rainfed or 24,300/A if irrigated (Olson and Sander, 1988), more recent studies have found advantages with higher populations up to 37,700/A (Novacek et al., 2013). Transitions to higher plant populations are sometimes associated with narrower row spacings in an effort to minimize intra-row competition. Planting in narrower rows complicates field accessibility and thus side-dress N application. The objectives of our research were to determine the optimum N timing and rate in high population corn production systems. Corn yield response and yield components (rows per ear, kernels per row, and kernel size) were compared among wide row (30- to 40-in.) and narrow row (15- to 20-in.) corn.

A series of 13 N fertilizer response experiments with corn for grain were conducted on Tidewater, Coastal Plain, Piedmont, and Mountain region sites in North Carolina. A starter band application of 6 lb N/A (5 gpa of 11-37-0) was applied to all plots in all experiments except the site in Perquimans Co 2011, which had already received 50 lb N/A broadcast uniformly. Check plots (0 N) and a range of N fertilizer rates (40, 80, 120, 160, and 200 lb N/A) were applied either at planting or at side-dress (between V-5 and V-7 stage) to both wide- and narrow-row corn plots. Seed densities and row spacings are shown in **Table 1**. Optimum populations vary across the state, and our "high population" targets represent 1.5 times the previous density recommended in North Carolina (Heiniger, 2004).

A split-plot experimental design was used, with row width as the main plot. Planters were adjusted to achieve approximately the same target population in both wide and narrow row

Abbreviations and notes: N = nitrogen; gpa = gallons per acre. IPNI Project #NC-21.

Table 1. Sites, target populations and row width/seed spacing alternatives.

Region (No. of sites)	County (year)	Target population/A	Narrow row: Row width	Narrow row: Seed spacing	Wide row: Row width	Wide row: Seed spacing
			- - - - - - - - - - - inches		- - - - - - - - - - -	
Tidewater (5)	Pamlico ('10,'11,'12) Tyrrell ('11) Pasquotank ('12)	37,500	20	8.4	40, 36	4.2, 4.6
Coastal Plain (3)	Perquimans ('10, '11,'12)	33,750	20	9.3	40	4.6
Piedmont (2)	Union ('10, '11)	30,000	15	13.9	30	7.0
Mountain (3)	Henderson ('10,'11,'12)	34,500	20	9.1	36	5.0

Corn was planted in wide (40-inch) and narrow (20-inch) row configurations at a Tidewater region experiment.

configuration. The subplot factor was N management (rate and timing). Plot sizes varied depending on the planter arrangement, but subplots measured 3 to 4 wide-rows or 6 to 8 narrow rows in width, and at least 30 ft. in length. Corn grain yield was measured by hand harvesting 20 row ft. for wide rows and 40 row ft. for narrow rows, with shelling and adjustment to 15.5% moisture. Yield components were determined from plant and ear counts of the entire harvested segments, and from 5-ear samples for which rows per ear, kernels per row, and mean kernel weight were determined. For pooling across environments (site-years), relative grain yield was calculated based on the highest mean yield found at each environment. For each individual site, analysis of variance (ANOVA) was performed using SAS Proc GLM to calculate $LSD_{0.05}$ (or as noted $LSD_{0.1}$) for treatment mean grain yield comparisons. For assessment of factorial N rate x timing effects, check plots were excluded and SAS Proc Mixed was used, with row width, N timing, N rate, and their interactions considered fixed effects; and environment and its interactions considered as random effects.

Grain yields are shown in **Figures 1, 2 and 3** (2010, 2011 and 2012). Substantial differences in residual N levels and degrees of response to N fertilization were noted among sites. **Table 2** identifies experimental treatments that were found to have significant effects on corn yield components or overall grain yields. These include simple main effects, such as response to N rate summarized in **Table 3**, or as interaction effects such as the interaction between row spacing and timing of N application shown in **Table 4**. Additional interaction effects were noted, many with the "environment", which indicates that there were differences in response to the management variables among the different experimental sites and years.

The N rate response data indicate that when

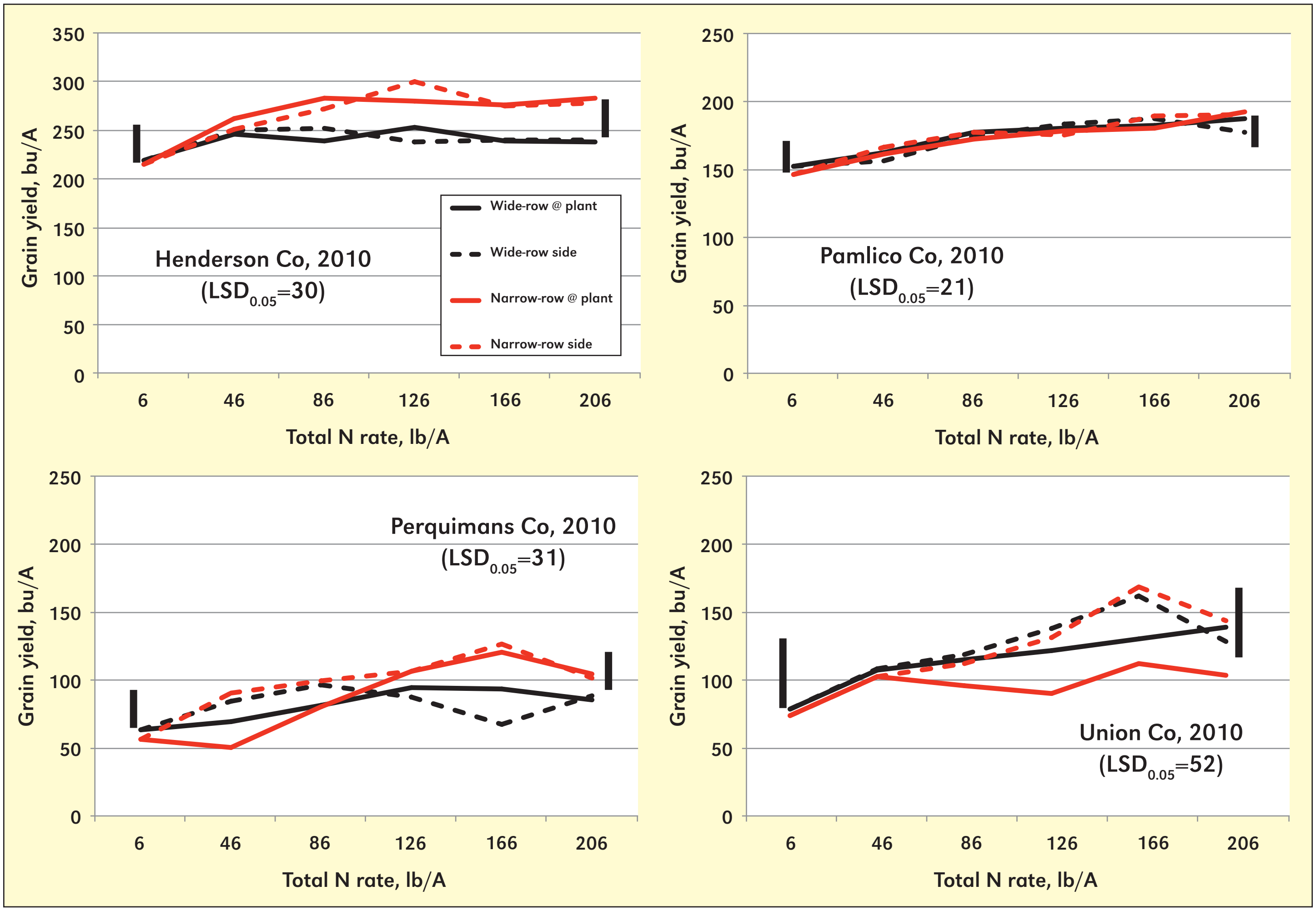


Figure 1. Corn grain yield response to N fertilization in 2010 experiments. Vertical bars represent the least significant difference ($p<0.05$) for comparison of treatment means.

averaged across sites, row spacings, and application timings, grain yield increased 19% above yields with the lowest N rate (**Table 3**). Comparing this yield increase to changes in individual yield components found no contribution by changes in plant density or mean numbers of ears per plant. However, mean numbers of rows per ear increased 3%, mean numbers of kernels per row increased 17%, and mean kernel weight increased 8%. Thus, the yield components determined earliest in

Table 2. Overall analysis of variance (ANOVA) results.

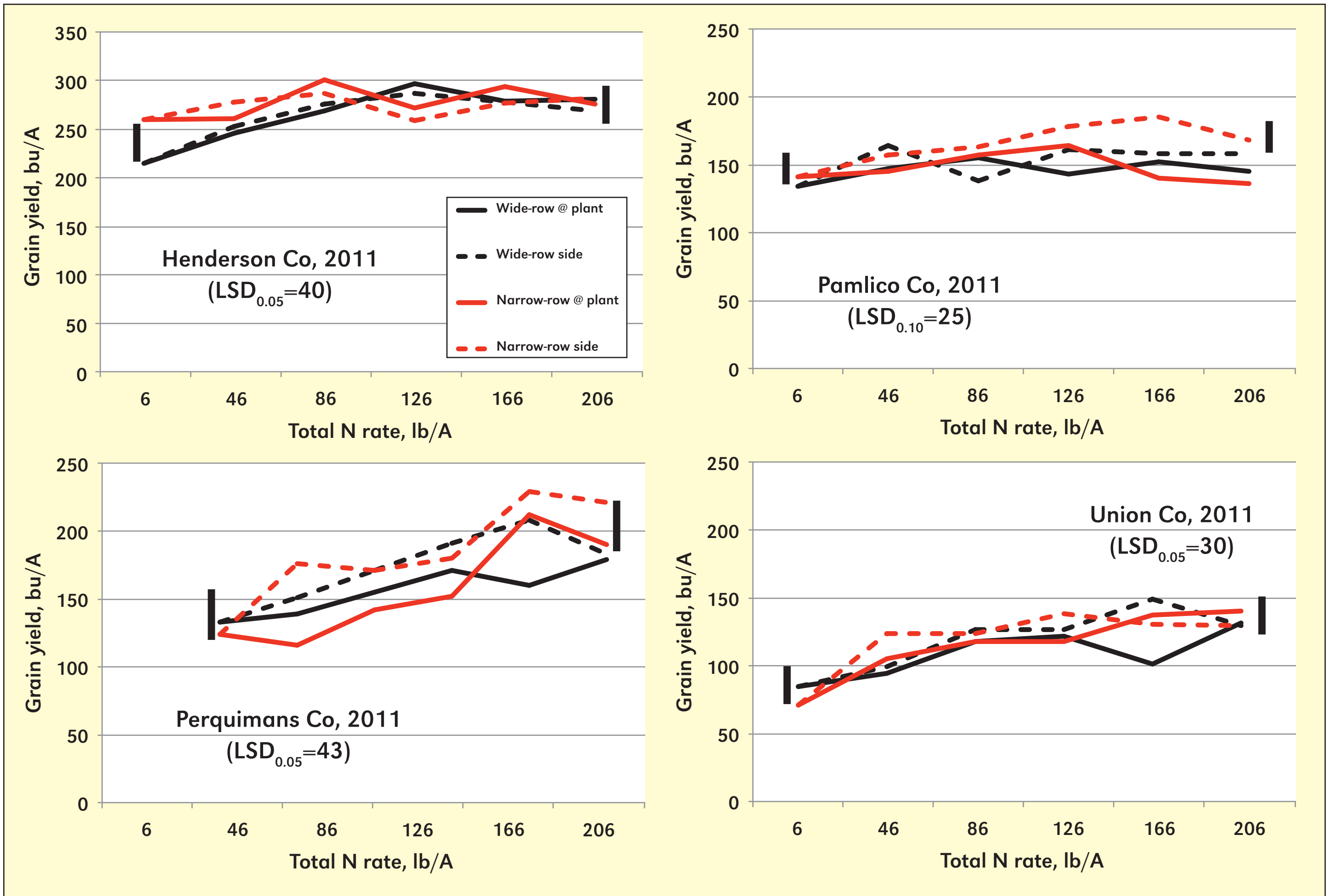
Effect	Plant density	Ear density	Rows per ear	Kernels per row	Kernel weight	Relative yield
Row width (RW)			+			
Timing of N application (Time)				*	*	*
N rate (N)			**	***	***	***
RW x Time				*		*
RW x N						
Time x N		*				
RW x Time x N						
Environment (Env)			***	***	***	**
Env x RW		***		***	**	**
Env x Time		*		+		**
Env x N						*
Env x RW x T			**		*	
Env x RW x N						
Env x T x N			**	+		*
Env x RW x T x N	*					

Statistical significance of each effect is indicated by symbols: +, $p<0.1$; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$. Absence of symbol indicates no statistical significance, i.e. $p>0.1$.

Table 3. Main effect of N when averaged across row widths, application timing, and all environments[1].

N rate, lb/A	Relative yield, % of max	Rows/ ear	Kernels/ row	Kernel weight, g
6	68	15.46	27.6	0.236
46	72 c	15.59 c	29.6 c	0.236 c
86	79 b	15.72 bc	31.2 b	0.243 b
126	83 ab	15.91 ab	32.0 ab	0.246 b
166	86 a	15.93 a	32.4 a	0.254 a
206	87 a	15.89 ab	32.1 ab	0.255 a
% increase[2]	+19%	+3%	+17%	+8%

[1]The N rate effect was significant for relative yield and all three ear yield components, with means (except for the lowest N rate) within a column not followed by the same letter differing significantly, $p<0.05$. The lowest N rate was not included in the statistical evaluation, which also considered factorial rate x timing effects.
[2]Maximum % increase in comparison with values of the lowest N rate treatment (6 lb N/A).



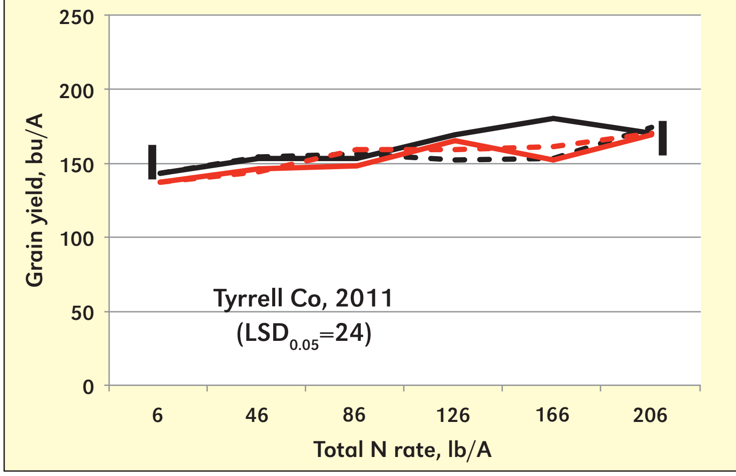


Figure 2. Corn grain yield response to N fertilization in 2011 experiments. Vertical bars represent the least significant difference for comparison of treatment means.

Side-dress N application to corn planted in 20-inch rows.

the season (plant density, ear density, rows per ear) did not appear to vary as much as did the yield components whose value became fixed later in the season (kernels per row and kernel weight).

The row spacing x N timing interaction data demonstrate the importance of later-season N, at least for the narrow row corn (**Table 4**). For narrow row corn, both grain yields and the numbers of kernels per row were greater with side-dress application than with all N at planting; while no such timing effect was evident with the wide rows. When averaged across all sites and N rates, relative grain yields were significantly higher with narrow rows and side-dress N. This is an important interaction to note, since side-dress application is more complicated with narrow row systems and would probably be discouraged without such evidence of increased yield potential.

Table 4. Effect of row width x timing interaction averaged across all environments and N rates[1].

Row width	Timing of N application	Relative yield, % of max	Kernels/ row
Narrow	At plant	79 b[2]	30.3 b
	Side-dress	86 a	31.9 a
Wide	At plant	78 b	31.6 a
	Side-dress	81 b	32.1 a

[1]Lowest N rate excluded to permit evaluation of factorial effects.
[2]Means within a column not followed by the same letter differed significantly, $p<0.05$.

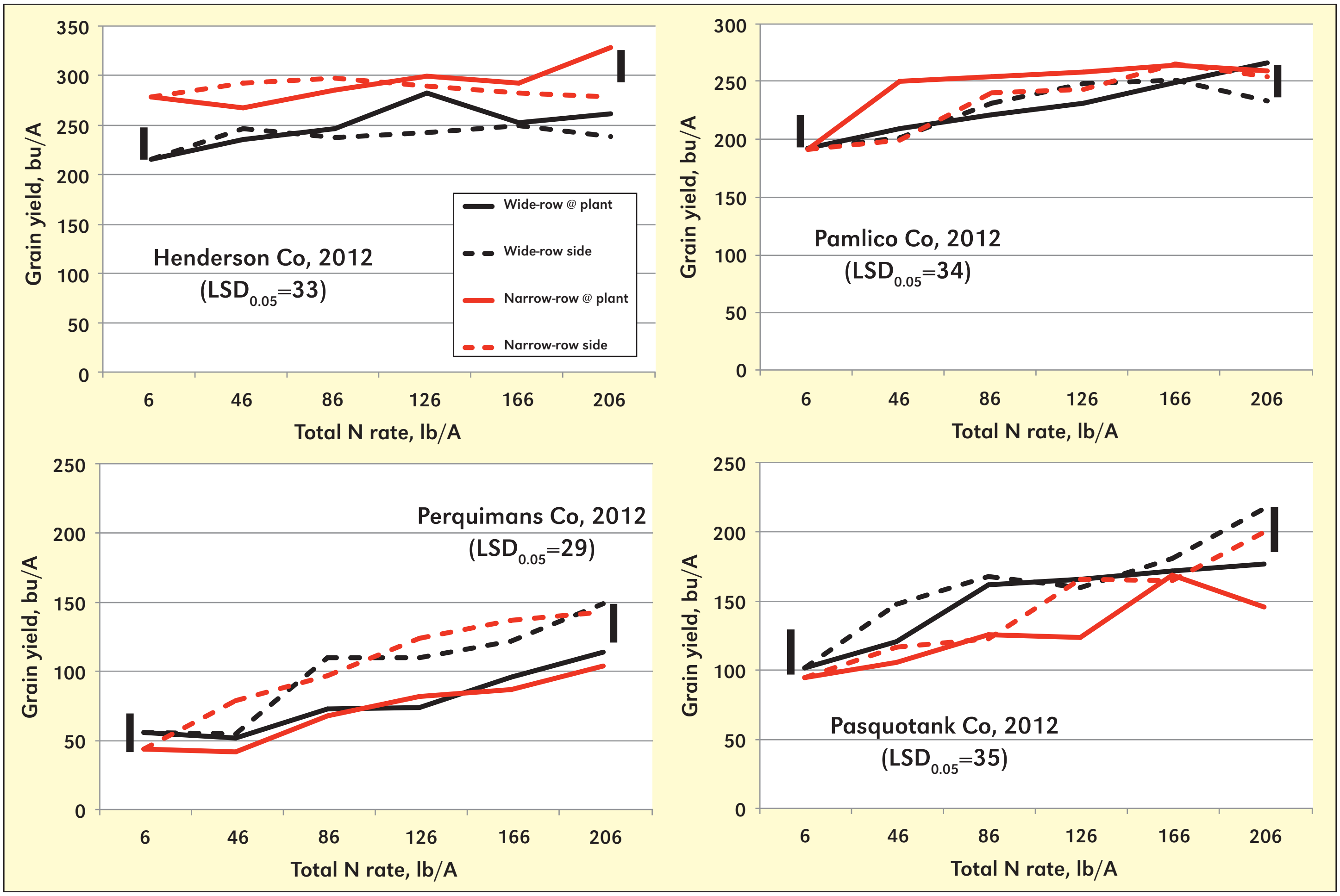


Figure 3. Corn grain yield response to N fertilization in 2012 experiments. Vertical bars represent the least significant difference ($p<0.05$) for comparison of treatment means.

Visually evident N status differences at the 2012 Pasquotank Co. site prior to V-5 side-dress.

Where significant N timing differences were noted (**Table 2**), relative grain yield, kernels/row, and mean kernel weight were all greater with side-dress application than with all N at planting. Current North Carolina recommendations call for 1/4 to 1/3 of the N to be applied at planting, with the remainder at side-dress. This ideal split scenario was not utilized in our experiments due to the already large number of experimental plots and since timing-related effects should be easier to measure given more extreme differences in management.

Summary

Highest grain yields were found with narrow rows and side-dress N applications. For these high population corn production systems, it appears to be critical to maintain sufficient N supply later in the season to contribute to the formation of the later-season ear yield components. Additional N timing and/or N source experiments should lead to the design of improved overall N management programs that reduce stress at all stages of the crop. BC

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Dr. Crozier (e-mail: carl_crozier@ncsu.edu) is Professor located in Plymouth, NC and Dr. Gehl is Assistant Professor located in Mills River, NC, Dept. of Soil Science, North Carolina State University. Dr. Heiniger is Professor located in Plymouth, NC, Dept. of Crop Science, North Carolina State University. Dr. Hardy is Chief of the Soil Testing Section of the Agronomic Services Division, North Carolina Dept. of Agriculture and Consumer Services, Raleigh, NC.

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