EFFECTS OF RESIDUE DENSITY LEVELS ON THE RESPONSE OF NO-TILL CORN TO N FERTILIZERS AND INHIBITORS[1]

E.C. Varsa and Stephen Hnetkovsky[2]

ABSTRACT

Experiments were conducted from 1989-91 at two southern Illinois locations (Belleville and Carbondale) to evaluate the effect of residue levels on the performance of N fertilizers, urease inhibitors, and placement on the response of no-till corn. Levels of 0, 50, 100, and 200 percent of existing (pre-plant) amounts were established in the crop residues of previous corn. Nitrogen fertilizers were urea-ammonium nitrate (UAN) solution (dribble, injection, and split-applied) and urea (broadcast-applied). Nitrogen was applied at 150 lbs/acre. Urease inhibitors were N-(n-butyl) thiophosphoric triamide (NBPT) and ammonium thiosulfate (ATS). The highest level of residues resulted in soil temperatures averaging about 4°F cooler than bare soils during the initial six weeks of corn growth. Temperature differences became smaller between residue levels as crop development advanced. Significantly higher soil moisture was determined in soils with increasing levels of residues at mid-season crop development.

Ear leaf N composition decreased slightly as levels of residues increased, probably due to N immobilization. Corn yield decreased or remained unaffected by increasing levels of residues in 1989 and 1991, but in 1990 significant yield increases were obtained with higher residue levels. At Belleville, highest yields and ear leaf N percentages were observed with UAN that was injection-applied. The corn yield from injected UAN was some 20 bu/acre greater than that obtained with dribble-placed UAN and over 40 bu/acre greater than those obtained from broadcast urea. ATS inclusion with UAN had no effect on yield but NBPT addition to UAN resulted in about a 4 bu/acre increase over nonamended UAN. Split application of UAN resulted in corn yields similar to those obtained with dribbled UAN. At Carbondale, droughty conditions in 1989 and 1991 resulted in mostly nonsignificant responses to N sources and inhibitors. However, the split UAN application resulted in significantly higher yields than those obtained from any other N treatment when evaluated at the 100% residue level.

INTRODUCTION AND OBJECTIVES

Crop residues occurring at the soil surface in a no-till system have a significant impact on the physical, chemical, and biological properties of the soil. Perhaps the single, most important effect is that of protection of the soil from water and wind erosion. Other notable effects include enhanced water infiltration, reduced rates of moisture evaporation, and generally an increased supply of plant-available water for crops. A residue cover also results in cooler soil temperatures below the mulch which can delay planting

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[2]Associate Professor and former Graduate Assistant, Plant and Soil Science Dept., Southern Illinois University, Carbondale, IL.

and increase the time for seedling emergence. Leaching losses of soluble anionic nutrients, such as nitrates, are also enhanced in a no-till system.

Crop residues are known to play an important role in the efficiency with which fertilizers, especially nitrogen, are used by crops. The microbially rich zone at or near the soil surface (induced by the residues) can cause increased N immobilization of surface applied N fertilizers. Furthermore, if soil moisture is excessive, high N losses from denitrification are known to occur in this zone. Reduced crop use efficiency from the surface application of urea in no-till systems is an outgrowth of high urease activity in the surface soil and the concomitantly high ammonia volatilization losses that occur.

The objectives of this research were to study the effects of different residue density levels on the performance of urea-ammonium nitrate (UAN) solution, urea, and urease inhibitor additives on no-till corn. Urease inhibitors studied were N-(n-butyl) thiophosphoric triamide (NBPT) and ammonium thiosulfate (ATS). The treatment comparisons also included placement and timing strategies.

MATERIALS AND METHODS

Experiments were conducted from 1989-1991 to evaluate the effects of residue levels on the performance of N fertilizers on no-till corn. The study sites were the Belleville Research Center (BRC) and the Carbondale Agronomy Research Center (ARC) on Iva silt loam (fine-silty, mixed mesic, Aeric Ochraqualfs) and Stoy silt loam (fine-silty, mixed, mesic, Aquic Hapludalfs) soils, respectively. The previous crop was no-till corn at each location for each year of the study.

Four residue levels were established each year of the study by removing residues from selected plots (designated as 0% level of residues) and adding those to the existing residues on other plots to give a 200% residue level. Other plots had about one-half of the residues removed to give plots designated as 50% residue cover. Remaining plots, designated as 100% residue cover, were left undisturbed with respect to existing residues. Therefore, residue levels of 0, 50, 100, and 200 percent were in place approximately one month prior to corn planting. Over the 3-year period of study, amounts of dry matter per acre that were present following redistribution ranged as follows:

Residue Level	Belleville	Carbondale
	--------------pounds/acre--------------	
0%	negligible	negligible
50%	2,900-3,600	2,800-3,800
100%	4,900-6,600	4,500-6,300
200%	9,800-13,200	9,000-12,600

Fertilizer treatments were applied following planting and, except for the "weed and feed" treatment, were applied at approximately the 2-3 corn leaf stage. A complete listing of the fertilizer treatments included in this report is given in Table 1. Ammonium sulfate at 50 pounds per acre was broadcast as a blanket application over all treatments to minimize a possible sulfur response that may be elicited by ATS.

All N fertilizer treatments occurred in factorial combinations with residue levels, except for treatment number 7 which occurred only at the 100% residue level. A randomized complete block design was employed with six replications. The corn hybrid planted at each location was Pioneer 3471 in 1989 and 1990 and Pioneer 3394 in 1991.

RESULTS AND DISCUSSION

Effect of Residues on Soil Moisture, Soil Strength, and Temperature

Soil moisture was determined during mid-growing season at Carbondale in both 1990 (Table 2) and 1991 (Table 3). For both years higher amounts of soil moisture were found with increasing levels of residues. The differences were greatest at the 0-4 inch soil depth with smaller differences found at the 4-8 inch depth (Table 3). Reduced rates of moisture evaporation from the soil, resulting from greater amounts of residues, were likely responsible for the differences.

Soil strength as measured by penetrometer resistance in the 0-2 inch depth was also significantly influenced by residue level in 1990 measurements at Carbondale (Table 2). Higher resistances were found with lower amounts of residue on the surface. The high resistance found in the 0% residue level plots was likely the consequence of heavy rainfall following redistribution of residues which caused compaction of the bare soil. However, bulk density was not influenced by these factors (Table 2).

Residue level had a significant impact on soil temperature. As shown in Figure 1, the greatest difference in temperature imparted by residues was observed early in the growing season (mid-May) and was followed by more narrow differences as crop development and shading of the soil became apparent. During the period of temperature measurement, the 200% residue level averaged nearly 4°F cooler than residue-free plots (Table 3). The lower temperature would delay germination, emergence, and early root development. Additionally, rates of microbial activity would be reduced and may impact such processes as nitrification, denitrification and N immobilization.

Effects of Residues, N Fertilizers, and Inhibitors on Leaf N Composition and Grain Yields.

Generally lower leaf N compositions were found to occur with increasing levels of residues at both locations when averaged over the 3-year study (Figure 2). The reduction in leaf N was about 0.1 percent when the 0% and 200% levels were compared. Immobilization of N associated with higher amounts of substrate carbon and decomposition (microbial) activity probably accounted the reduced leaf N in plants growing in the high residue environment.

Grain yield as affected by residue levels showed considerable variation among years (Figure 3). At Belleville, increasing levels of residues resulted in significant yield decreases in 1989. However, in 1990 significant increases in grain yield occurred at the higher residue levels at both locations. The 1990 growing season was very unusual in that planting was delayed until mid-June because of excessive rainfall. Additionally, heavy rains in May caused considerable compaction of the surface soil (that was bare of residues) as evidenced by the penetrometer results given in Table 2. The beneficial effects of the 200% residue level resulted in nearly a 20 bu/acre yield increase over the 0% residue level at Carbondale. At Belleville, the same comparison revealed a 10 bu/acre yield increase in favor of the highest residue level. An inverse relationship was observe at Carbondale in 1990, in that, N in ear leaves was found to decrease with higher residue levels but grain yields tended to increase. The leaf N composition was not lowered below the "Critical Level" even at highest residue level and greater yields were observed at each successively higher level of residues.

The behavior of N fertilizers, inhibitors, and placements in relation to residue levels is shown in Figure 4 for Belleville and Figure 5 at Carbondale for the 3-year studies. At Belleville, (Figure 4) clearly the injection method of UAN placement was superior to dribble placement, regardless of the use of NBPT or ATS. Also, urea that was broadcast was clearly inferior to all other N sources or placements.

The higher levels of residues had a more negative effect on yields for the urea and the control treatments than all others at Belleville (Figure 4). This was probably the result of higher immobilization of N for the urea (broadcast-applied) and 0-N treatments as well as higher ammonia volatilization losses with the urea N source in the presence of higher residues. Inclusion of ATS with UAN had no effect on yield but NBPT addition to UAN resulted in an average increase of 4 bu/acre (Figure 6). The split UAN application (applied at the 100% residue level only) was not any different than a dribble application of UAN at planting time. Ear leaf N results as affected by N sources and inhibitors followed the same general pattern as yields at Belleville (Figure 7).

Effects of residue levels on N fertilizers, inhibitors and placements at Carbondale are shown in Figure 5. Yields were greatly reduced in both 1989 and 1991 by severe summer dryness. Consequently, yield differences due to inhibitors and placements were small, regardless of the level of residue evaluated. Of special note was the split UAN application (applied at the 100% residue level only) being the highest yielding treatment. As seen in Figure 6, urea that was broadcast resulted in the lowest relative yields. A similar pattern of leaf N composition was observed at Carbondale as was observed at Belleville with respect to N sources, inhibitors, and placements (Figure 7).

ACKNOWLEDGEMENTS

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REFERENCE

Benjamin, J.G., R.M. Cruse, A.D. Blaylock, and L.V. Vogl. 1988. A small plot point injector for liquid fertilizer application. Soil Sci. Soc. Amer. J. 56:1194-1195.

Table 1. Fertilizer treatments applied over 0, 50, 100, and 200 percent residue levels at Belleville and Carbondale in 1989-1991 experiments.

Treatment No.	N Rate[1]	N Source/Inhibitor/(Placement)[2]
1	0	--
2	150	UAN (Dribble)
3	150	UAN + NBPT (Dribble)
4	150	UAN + ATS (Dribble)
5	150	UAN (Inject)
6	150	Urea (Broadcast)
7	150	UAN (Split: 1/2 Weed & Feed and 1/2 Sidedress-dribble)

[1]Includes N from 50 lbs of ammonium sulfate per acre applied over all treatments.

[2]UAN source was 28-0-0 obtained from Tri-County Chemical Co., Eldorado, IL. NBPT was applied at 1.0 lb per acre as a mixture with UAN. ATS was applied at a 10 percent volume: volume basis with the N solution. Dribble placement was approximately 6 inches from 30-inch spaced corn rows. Injection was to about 5 inches depth at about 6 inches from corn rows using an apparatus similar to that described by Benjamin et al.. (1988). Treatment No. 7 also included 7-21-7 as a "starter" at planting and was applied only to the 100% residue level.

Table 2. The effect of residue density levels on soil moisture, bulk density, and penetrometer resistance in no-till corn at Carbondale on July 16, 1990.

Residue Level[1]	Soil Property[2]		
	Soil Moisture by weight (0-4")	Bulk Density (0-4")	Pentrometer Resistance (0-2")
%	%	gm/cm^3	lbs/ft^2
0	18.9 c	1.44 a	293 a
50	21.7 b	1.40 a	233 b
100	22.5 a	1.41 a	222 b
200	23.1 a	1.42 a	186 c

[1]Residue level: 0% = residues removed; 50% = ~50% removal of existing residues; 100% = pre-plant amount (no modification); 200% = double existing residues (taken from 0% plots).

[2]Means in columns followed by letters in common are not significantly different at the 5 percent level by the Duncan's Multiple Range Test.

Table 3. The effect of residue density levels on average soil temperature (May 13-June 20, 1991) and soil moisture at different depths on July 25, 1991 in no-till corn at Carbondale.

Residue Level[1]	Soil Temperature (at 4" depth, noon)	Soil Moisture by weight[2] (0-4")	(4-8")
%	°F	%	%
0	79.8 a	16.9 c	17.8 c
50	78.0 b	20.4 b	19.9 b
100	77.2 b	21.5 b	21.2 b
200	75.9 c	24.4 a	22.8 a

[1]Residue level: 0% = residues removed; 50% = ~50% removal of existing residues; 100% = pre-plant amount (no modification); 200% = double existing residues (taken from 0% plots).

[2]Means in columns followed by letters in common are not significantly different at the 5 percent level by the Duncan's Multiple Range Test.

Figure 1. The Influence of Residue Levels on Noon-day Soil Temperature at the four-inch Depth, May 13 to June 20, 1991.

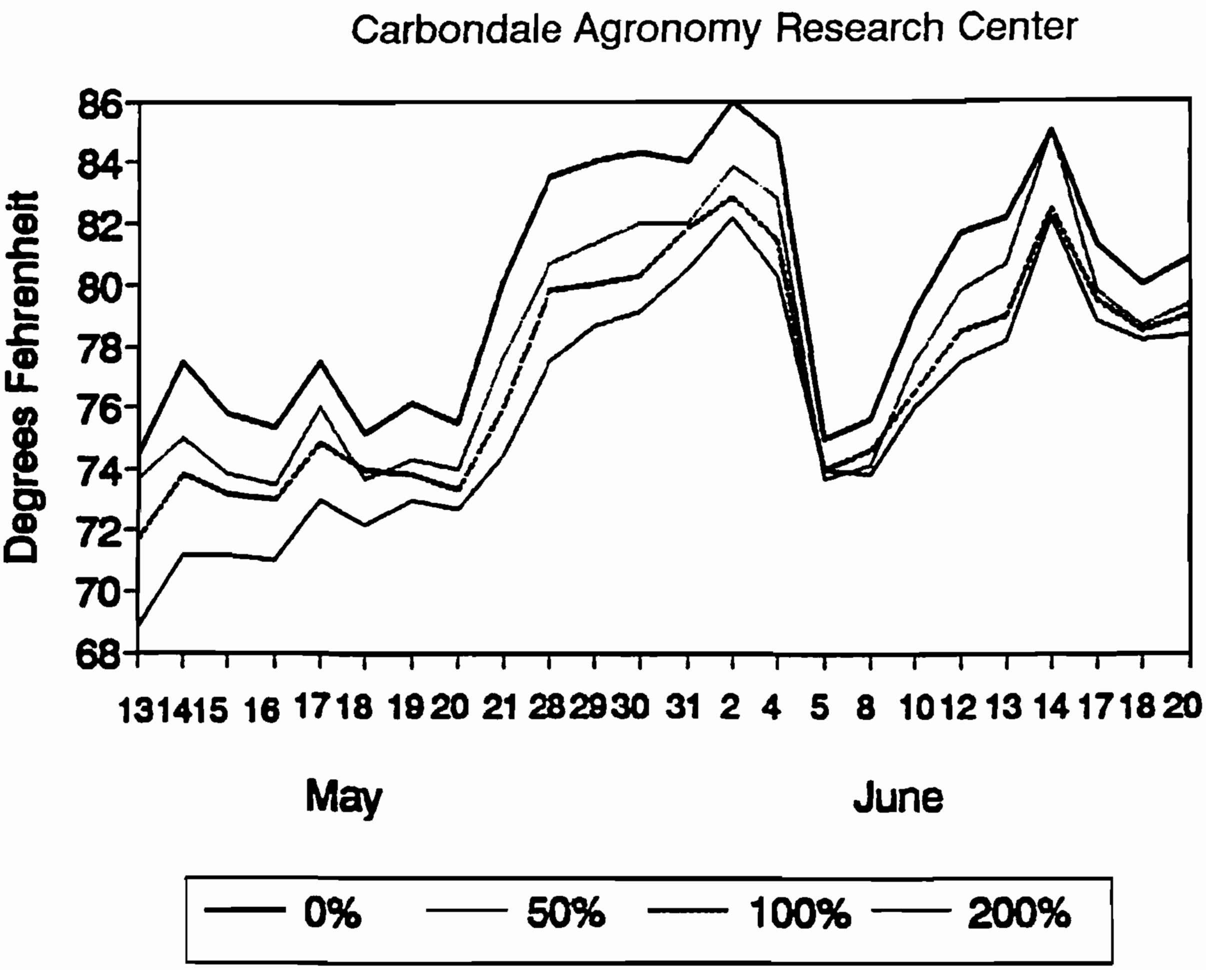


Figure 2. Effect of Residue Density Levels on Ear Leaf N Composition

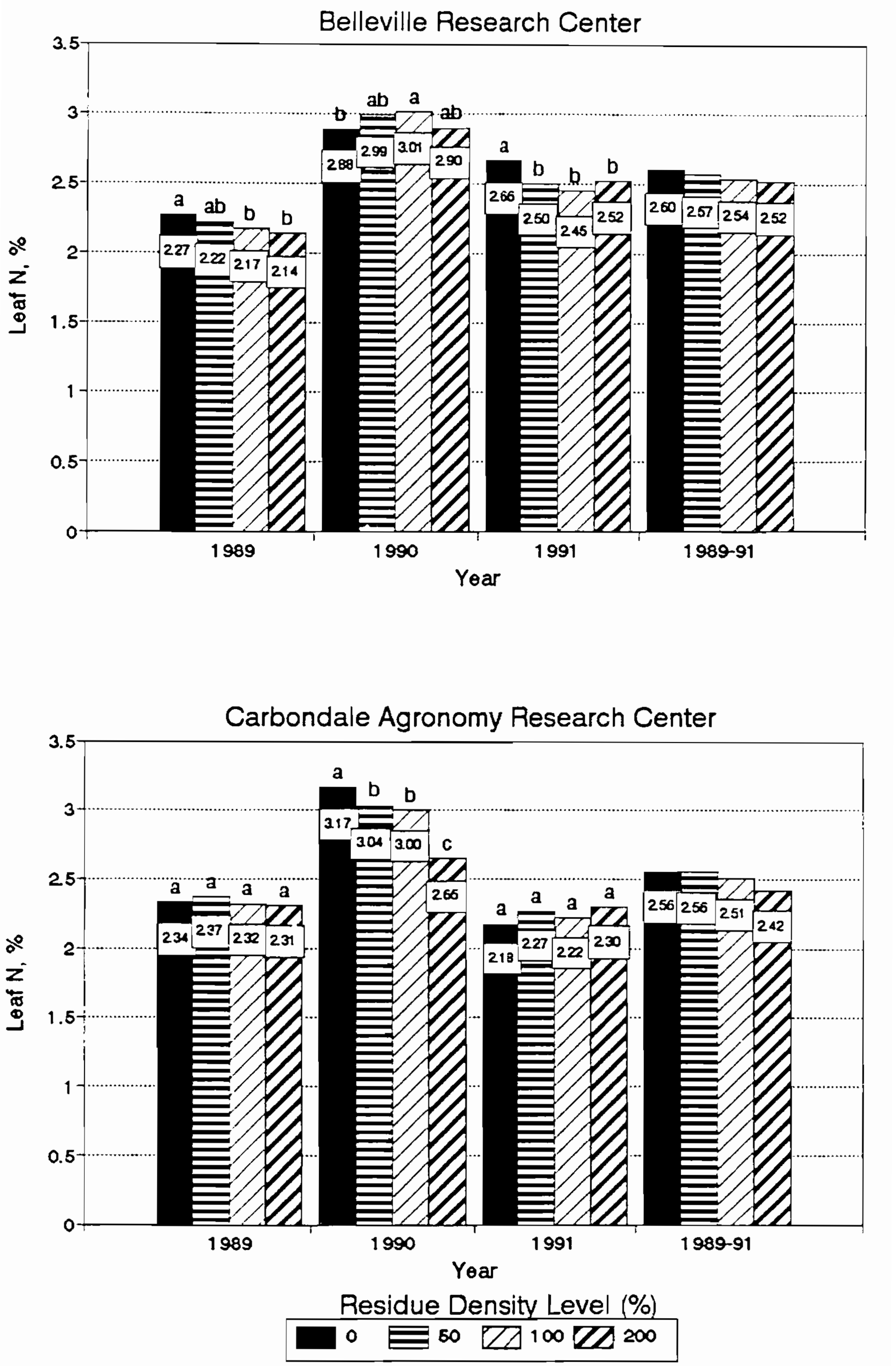


Figure 3. Effect of Residue Density Levels on Corn Grain Yields

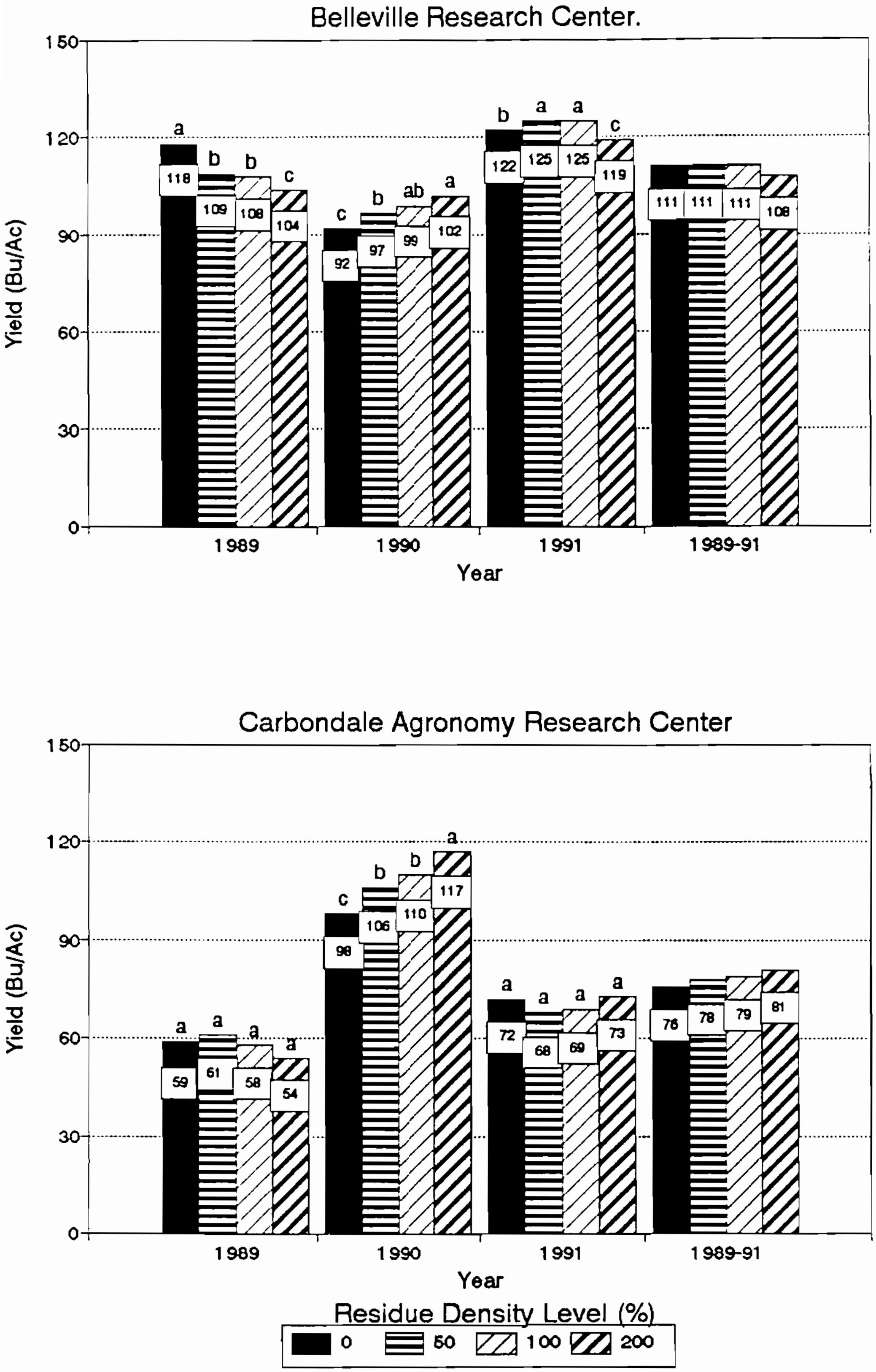


Figure 4. Effect of N Fertilizers and Inhibitors on No-Till Corn Yields at Different Residue Levels, Belleville Research Center, 3 year (1989-1991) Averages.

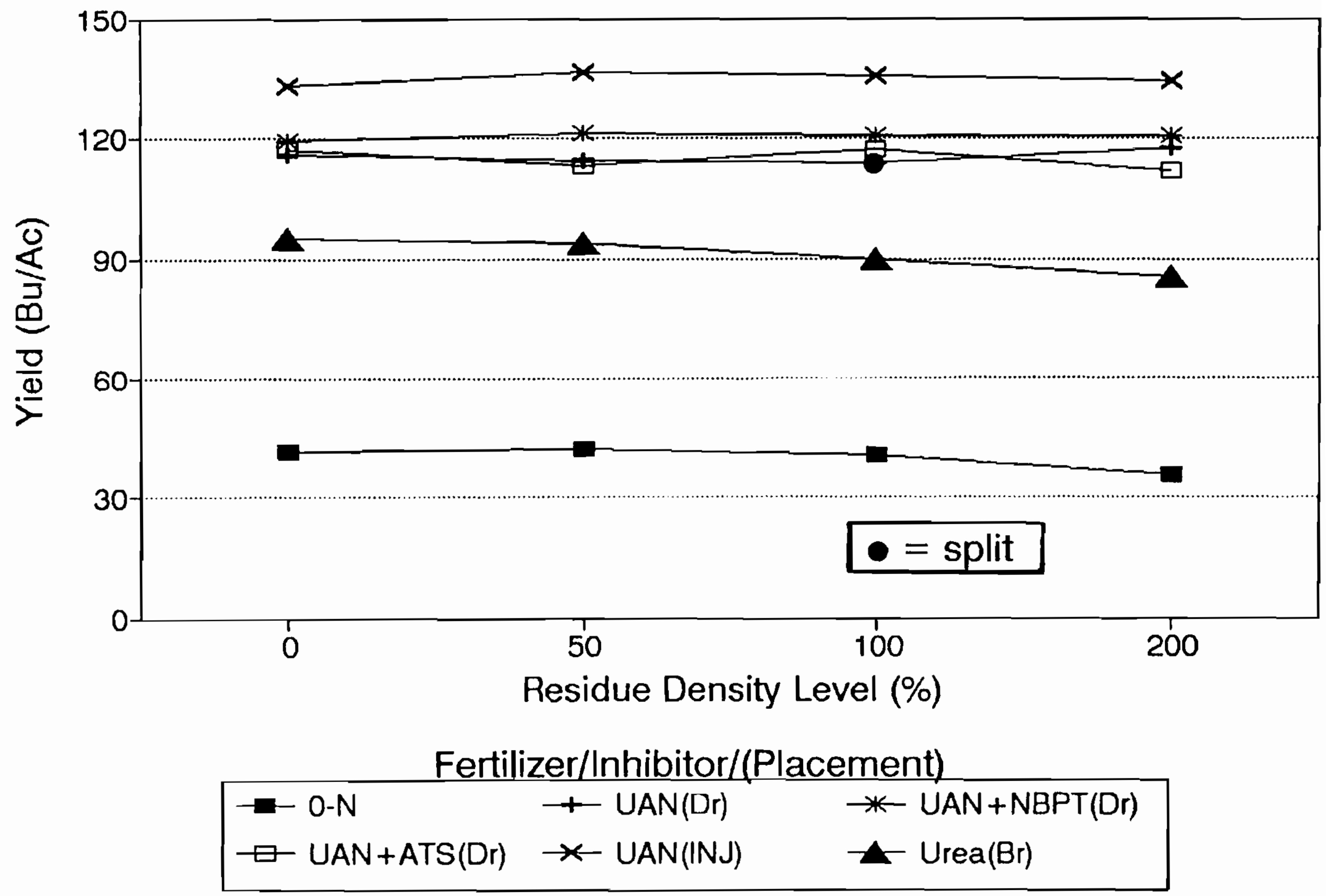


Figure 5. Effect of N Fertilizers and Inhibitors on No-Till Corn Yields at Different Residue Levels, Carbondale Agronomy Research Center, 3 year (1989-1991) Averages.

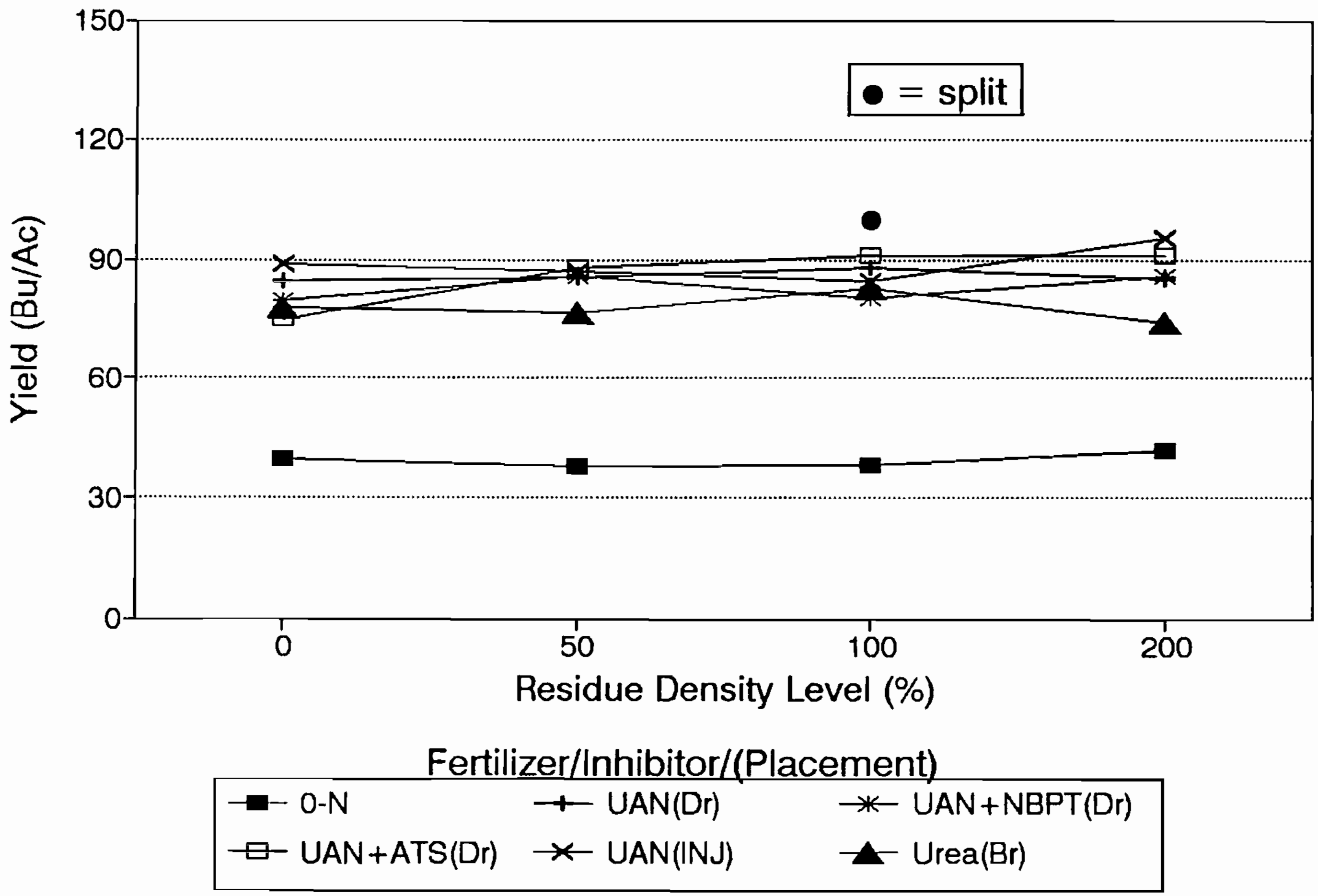


Figure 6. Effect of N Fertilizers and Inhibitors on No-Till Corn Yields over all Residue Levels at Belleville and Carbondale, 3yr (1989-91)Average

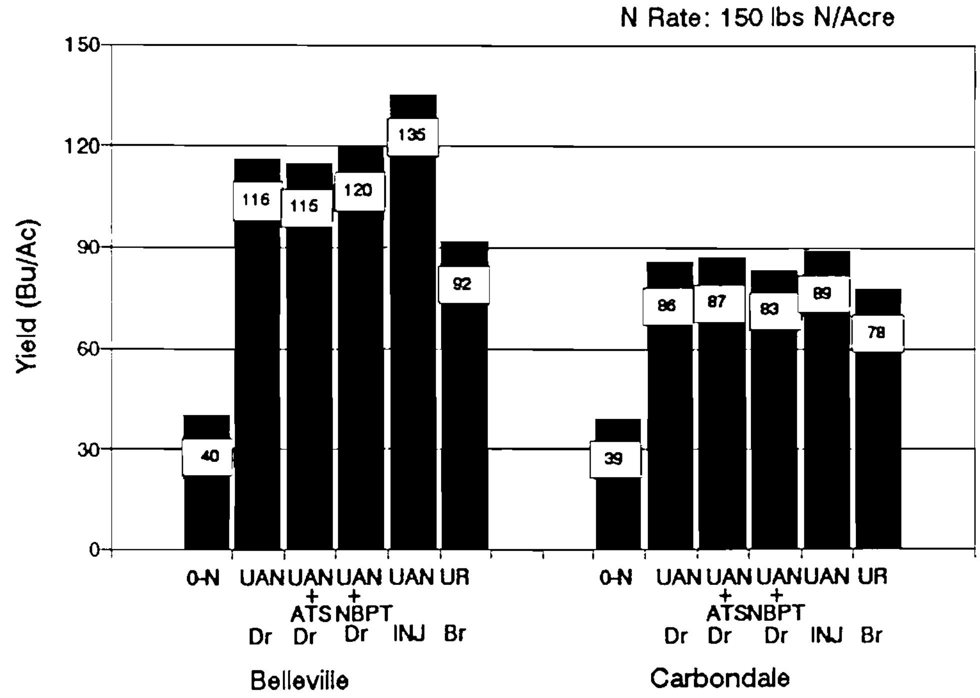
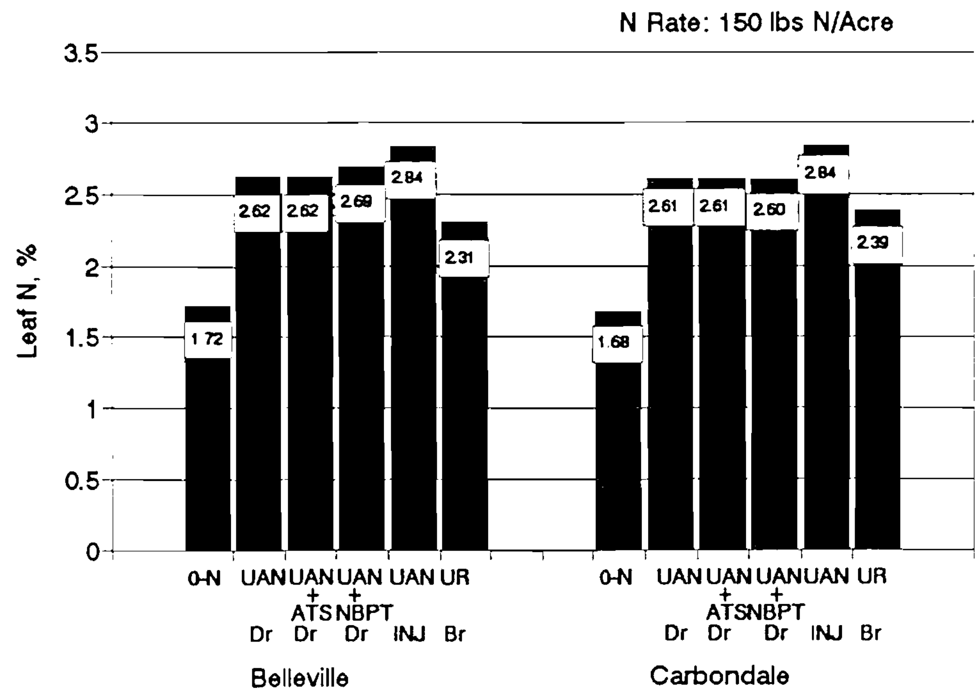


Figure 7. Effect of N Fertilizers and Inhibitors on Ear Leaf N Composition over Residue Levels at Belleville and Carbondale, 3yr (1989-91)Average



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Program Chairman and Editor:

Ray Lamond
Department of Agronomy
Throckmorton Hall
Kansas State University
Manhattan, KS 66506