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Improved yields improve environment

Tests made on grain sorghum and winter wheat to determine optimum recovery and minimize N leaching.

Summary: *Minimizing environmental impact of fertilizer use requires nutrient management technologies that maximize crop yield and recovery of applied nutrients. The studies described here demonstrate that adequate fertilization to correct nutrient* stress, *combined with the appropriate fertilizer placement method, will maximize fertilizer nitrogen recovery and minimize profile nitrate after harvest.*

Responses to applications of N and P on experimental fields in Ford County, KS, produced yield increases as high as 34 bu/A for grain sorghum and 24 bu/A for winter wheat (Table 1). At the same time, apparent N recovery (ANR) decreased with increasing N rate. However, ANR with subsurface-applied N and P was significantly greater than surface applied N and P (Table 2).

Grain sorghum. Averaged over P rates, ANR with N applied at 40 lbs/A was approximately 40 percent with broadcast N compared to 57 percent with subsurface and surface band-applied N and P. ANR improved by increasing P rate from 20 to 40 lbs/A of P_2O_5, but the increases were only 2 to 10 percent, depending on placement method and N rate.

N response data indicate that optimum N rate was slightly less than 80 lbs/A N and optimum P rate was between 20 and 40 lbs/A P_2O_5. Increasing N and P rate increased both grain N and P concentra-tion. Subsurface and surface band (dribble) placement of N and P significantly increased grain yield and N concentration, compared to broadcast placement.

Increasing N rate generally increased profile N content concentration after harvest, although profile N was slightly lower with subsurface and surface band applied N than with broadcast N (Table 1). More importantly, P fertilization increased grain yield and recovery of N, which decreased profile N content after harvest.

Winter wheat. Averaged over P rates, ANR was approximately 49 percent with N broadcast-applied at 40 lbs/A compared with 72 percent using subsurface application and 58 percent applying N and P in a surface band. Apparent N recovery at 40 lbs/A N improved by increasing P rate from 20 to 40 lbs/A of P_2O_5. However, increases were only 5 to 12 percent, depending on placement method. Apparent N recovery was not affected by increasing P to 40 lbs/A P_2O_5 at the 80-lb/A N rate.

N response data indicate that optimum N and P rates were slightly greater than 40 lbs/A N and 20 lbs/A P_2O_5, respectively. Subsurface and surface band placement of N and P significantly increased grain yield compared to broadcast placement. Grain yield with subsurface N and P placement was greater than with surface band placement, which was probably not related to N immobilization by the surface crop residues.

Increasing N rate generally increased profile N concentration after harvest, although no differences in profile N were observed between placement methods, despite greater N recovery with band-applied N (Table 2). This was probably related to greater N immobilization by surface crop residues with broadcast N than with either subsurface or surface band-applied N. More importantly, P fertilization increased grain yield and recovery of N, which decreased profile N concentration after harvest.

Fluids selected

Treatments in both studies included 0, 40 and 80 lbs/A of N as hAN and 0, 20 and 40 lbs/A as ammonium polyphosphate. Treatments were broadcast, dribbled on the surface behind a press wheel and knifed two inches below the seed. All placement methods were applied at planting. Treatments were arranged in a randomized complete block design with four replications.

Grain sorghum was established in 1992 on Ulysses silt loam soil (Table 3). The field had been conventional-till fallowed following wheat harvest in 1991 and also in the spring of 1992, prior to planting sorghum. The winter wheat experiment was established in September of 1991 on a Harney sil soil (Table 3). The site had been no-till fallowed in the fall of 1990 and summer of 1991, prior to planting wheat.

A four, 30-inch row JD Maxemerge planter was used to plant DeKalb DK 41 Y in the sorghum plots on May 27 at 52,000 seeds/A. Plots were 10 by 30 feet. The middle two rows of each plot were hand harvested on October 20. A six-row (12-inch row spacing) no-till drill was used to plant Tam 107 in the winter wheat plots at

Table 1. Fertilizer management effect on grain sorghum yeild and grain N and P content.

Rate		Placement Method	Grain Sorgum			Winter Wheat		
			Grain Yeild	Grain		Grain Yeild	Grain	
N	P_2O_5			N	P		N	P
lbs/A			bu/A	%		bu/A	%	
0	0		37	1.10	0.29	32	1.80	0.27
40	0	Broadcast	49	1.12	0.26	37	2.11	0.24
40	20	“	56	1.14	0.33	41	2.12	0.32
40	40	“	59	1.16	0.36	44	2.13	0.35
80	0	“	57	1.32	0.26	42	2.19	0.26
80	20	“	63	1.26	0.32	45	2.22	0.34
80	40	“	67	1.27	0.34	47	2.17	0.35
40	0	Knife	55	1.17	0.25	41	2.15	0.23
40	20	“	63	1.20	0.34	48	2.12	.034
40	40	“	67	1.19	0.36	52	2.11	0.37
80	0	“	62	1.31	0.24	46	2.25	0.25
80	20	“	68	1.29	0.33	56	2.21	0.33
80	40	“	71	1.27	0.37	55	2.23	0.37
40	0	Dribble	55	1.15	0.27	40	2.16	0.24
40	20	“	62	1.19	0.33	44	2.14	0.33
40	40	“	67	1.20	0.36	46	2.12	0.36
80	0	“	61	1.29	0.26	44	2.21	0.25
80	20	“	67	1.27	0.32	50	2.19	0.34
80	40	“	69	1.30	0.35	49	2.22	0.35

Table 2. Fertilizer management effect on ANR and soil N content after harvest.						
			Grain Sorgum		Winter Wheat	
Rate (lbs/A) N	P_2O_5	Placement Method	ANR* %	Soil N* lbs/A	ANR* %	Soil N* lbs/A
0	0		-	41	-	25
40	0	Broadcast	22	70	31	44
40	20	"	36	59	44	40
40	40	"	43	52	54	36
80	0	"	26	86	26	57
80	20	"	30	66	32	50
80	40	"	34	64	33	48
40	0	Knife	37	61	46	41
40	20	"	53	50	66	39
40	40	"	60	48	78	33
80	0	"	31	76	35	49
80	20	"	36	58	50	43
80	40	"	38	57	49	40
40	0	Dribble	35	64	43	45
40	20	"	51	48	55	41
40	40	"	61	50	60	35
80	0	"	29	79	42	54
80	20	"	34	55	51	41
80	40	"	37	51	50	40

*ANR = apparent N recovery; Soil N = inorganic N content, 0 to 4-foot depth

75 lbs/A. Plots were 6 by 30 feet. A plot combine was used for harvesting on June 24.

After harvest, grain samples were weighed and moisture and test weight were determined. Samples were dried in a forced-air oven at 60 degrees C for 48 hours. Subsamples were ground to 0.1 mm, digested in sulfuric acid/peroxide and the digests analyzed for total N and P. Soils were sampled to 4- to 6-inch increments. Samples were air dried, extracted with 2M KCl and the extracts analyzed for inorganic N (NO_3- and NH_4+) on an autoanalyzer.

Ecological considerations

The experiments described were conducted to quantify the N and P rate and placement interaction effects on dryland winter wheat and grain sorghum yield, apparent nutrient recovery and soil profile NO_3- content after harvest.

The impact of nitrogen fertilizer use on groundwater and environmental quality has become a major concern for the public and the fertilizer industry. Adoption of fertilizer "best management practices" is essential for I) conserving limited resources used to produce agricultural inputs, 2) reducing the environmental impact of chemical inputs applied to agroecosystems, 3) increasing input efficiency and agricultural profitability and 4) ensuring long-term sustainability.

The most important factor in reducing the quantity of N remaining in the soil after harvest is to apply the "correct" fertilizer N rate. Fertilizer N rates are determined by models generally represented by:

N recommendation = abc

In the model, a = yeild goal, b = soil test N and c = factors. The term "factors" includes adjustments or corrections for previous crop (i.e., legume), manure applications or other soil/crop management factors. "Soil test N" represents extractable inorganic N determined prior to planting. Soil profile NO_3- is highly correlated to yield response to fertilizer N and is routinely used in making N recommendations in the Great Plains. This test quantifies the NO_3- content at sampling time and is subject to considerable error in fields where NO_3- is lost by leaching plant uptake. In the above model, "yield goal" influences the quantity of fertilizer N recommended more than any other term. Thus, accurate determination of optimum fertilizer N rates requires realistic yield goals for each field. Yield goal estimates that are too low will underestimate N needs and reduce yield potential and profit. Yield goals that are too high will result in above-optimum N applications and will, in addition to reducing profitability, greatly reduce crop recovery of applied N and increase the probability of N leaching.

Among other management factors, N placement can greatly influence crop recovery of applied N and reduce the quantity of fertilizer N in the soil profile after harvest. In Kansas studies on no-till dryland sorghum, ANR was 40 and 70 with broadcast and knife applications of 75 lbs/A of N, respectively. On P responsive soils, positive interaction of N and P fertilization on grain yield and fertilizer N recovery has been observed. In long-term N and P studies with irrigated sorghum, yields increased 30 to 40 percent with 40 lbs/A P_2O_5 compared to no P on a low-P soil fertilized with 160 lbs/A of N. In studies with winter wheat, ANR increased from 25 to 50 per-cent by increasing P rate from 20 to 40 lbs/A of P_2O_5, respectively. In other Kansas studies, ANR in winter wheat was 40 and 50 percent with 32 lbs/A of P_2O_5, applied broadcast and with the seed, respectively. These studies demonstrate that both P rate and placement greatly influence recovery of fertilizer N and reduce quantity of N remaining in the soil profile after harvest.

Conclusions

Adoption of N management practices that optimize yield and recovery of fertilizer N will reduce the quantity of potentially leachable fertilizer N in the soil after harvest. Our studies show that subsurface and surface band application of N and P increased grain yield and ANR, compared to broadcast N and P. At the no-till wheat site, grain yield with surface band N was greater than broadcast N, but was less than subsurface N. On P responsive soils, P fertilization increased grain yield and ANR. In general, increasing ANR decreased soil profile N concentration after harvest.

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Table 3. Soil Characteristics and selected soil properties at the Ford County sites in 1992.		
Parameter*	Grain Sorghum	Winter Wheat
Soil Type	Ulysses sil	Harney sil
Soil Class	Aridic Hapulstoll	Typic Argiustol
pH (1:1)	7.4	7.2
Bray 1-P (lbs/A)	14.0	11.0
NH4OAc-K (lbs/A)	1,152.0	865.0
OM%	2.2	2.1
DTPA-Fe (lbs/A)	12.4	8.4
DTPA-Zn (lbs/A)	2.8	2.1
Soil N** (lbs/A)	45.0	29.0

* Soil analyses: 0 to 6 inches **NO3- + NH4+, 0 to 4 feet