Research Report of Progress - 1978
Grant-in-Aid Program
The Potash/Phosphate Institute

POTASSIUM AND PHOSPHORUS RESEARCH ON ALFALFA, WHEAT, CORN AND GRAIN SORGHUM

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MANAGEMENT OF IRRIGATED ALFALFA

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An irrigated alfalfa management study was designed during 1974-1975 by several people including R. L. Vanderlip, D. Whitney, E. Sorensen and the authors.

The objectives are to determine (1) the forage yield and nutrient removal of alfalfa to several levels of P_2O_5 applied preplant, annually and split during the growing season; to three levels of K_2O; and to one level of sulfur; (2) the forage yield, forage quality and stand persistence to three cutting management systems, and (3) whether an additional late fall cutting will reduce stand persistence under different fertility rates. This study is located on sandy soil. The soil types are Pratt loamy fine sand and Naron loamy fine sand.

Two varieties, Kanze and Marathon, were seeded September 4, 1975 following wheat.

Five cuttings were made in 1977 and 1978 with the additional late fall cutting being made only on the bud stage management in 1977 and on the bud and 1/10 bloom managements in 1978. Only four cuttings were harvested in 1976 and are not included in Table 90. The cutting managements are as follows: cutting each time at bud stage, cutting each time at 1/10 bloom, and cutting alternately at bud and full bloom stages.

The results as shown in Table 90 indicate that forage yield can be increased more than 2 Ton per acre per year by addition of 80 pounds per acre P_2O_5 annually. Rates higher than 80 pounds per acre of P_2O_5 have tended to show yield increases in the range of .5 Ton per acre. To date, there has been no yield increase to the addition of K_2O. The addition of 40 pounds per acre sulfur has shown a slight yield response.

The variety Kanza in 1978 increased in yield over what it was in 1977 while Marathon remained the same. Following this same trend, Kanza had larger amounts of K removed in 1978 than in 1977 while Marathon remained nearly the same in both years. The opposite was true with the P content. Both Kanza and Marathon removed less P in 1978 than in 1977.

In summary, alfalfa forage yield can be significantly increased by addition of phosphate fertilizers. The optimum level is between 80 and 120 pounds per acre. The forage yields where P rates are below 80 pounds per acre annually are decreasing, evidently the native phosphate levels have been reduced below optimum. Forage yields have not been increased significantly by additions of potassium or sulfur. Cutting managements have varied between years so more data is needed to determine if stage of cutting has an effect on yield or quality.

This study will be continued at the Sandyland Experiment Field.

Table 90. MANAGEMENT OF IRRIGATED ALFALFA

Fertilizer Treatment lbs/A			Yield T/A @ 15% Moisture		Crude Protein lbs/A		Nutrient Removal			
							lbs P/A		lbs K/A	
Preplant P_2O_5	Annual P_2O_5	Annual K_2O	1977	1977	1977	1978	1977	1977	1978	1978
0	0	0	7.89	7.37	2989	2589	32	25	352	323
0	40	80	9.05	9.00	3467	3205	43	34	420	407
0	80	80	9.41	9.53	3637	3409	50	42	435	445
0	120	80	9.41	9.96	3648	3658	53	46	442	450
320	0	80	9.09	9.36	3512	3426	45	37	421	438
320	40	80	9.58	10.01	3635	3585	52	43	436	450
320	80	80	9.40	9.97	3584	3612	54	46	431	445
320	120	80	9.52	10.10	3639	3605	56	50	441	460
0	120	0	9.41	9.99	3689	3655	53	49	421	434
0	120	160	9.63	9.99	3630	3585	52	46	439	466
0	80 1/	80	9.38	9.71	3638	3509	49	42	433	443
0	120	80 2/	9.70	9.90	3687	3524	53	45	433	443
320	120	80 3/	9.74	10.97	3627	3907	56	53	430	472
0	0	80 3/	7.97	8.03	2931	2818	32	27	350	362
LSD (.05) 4/			0.46 T		271 lbs		N.S.		19 lbs	

1/ Split P_2O_5 application -- 40 lbs/A early spring, 40 lbs/A after third cut.
2/ Also includes 40 lbs/A sulfur -- applied in 1976 and 1978.
3/ Includes additional late cutting in fall about time of killing frost to the alfalfa.
4/ The LSD is for comparing the same or different treatments in different years.

Fertilization of Irrigated Alfalfa on the Kansas River Valley Field

Larry Maddux, Superintendent, Kansas River Valley Field

A study was initiated in 1976 at the Topeka Unit to examine effects of plowdown phosphorus and annual topdress applications of N, P, and K on irrigated alfalfa. Kanza alfalfa was planted April 13, 1976 and yield data was first collected in 1977. Results are given in Table 14.

There was no alfalfa yield response to any fertilizer treatments in 1977. This would be expected due to the good initial soil levels of phosphorus and potassium (37 lb available P per acre and 495 lb exchangeable K per acre). Soil test results for 1977 and 1978 are shown in Table 14a. Soil test levels of P and K have declined where no fertilizer was applied. Even with the annual treatment of 80 pounds K_2O/a the K level seems to be declining.

In 1978, there was a significant yield increase in alfalfa with annual topdress applications of 0-40-0, 0-40-80, 0-80-80 at the first and fourth cuttings and with 0-40-80 and 0-80-80 at the fifth cutting. There was no significant yield response to the plowdown phosphorus treatments even though there was a trend to higher yields on the plots which received plowdown phosphorus. Plant tissue analyses shows higher P content in the plant as the annual P treatment increased to 40 and 80 lbs P_2O_5/a. There was a trend to higher P content in plant tissue with the plowdown phosphorus although this was only significant for the fourth cutting. Potassium in the plant increase significantly with 80 lbs K_2O on all but the third cutting. Nitrogen fertilization had no effect on forage yield or plant composition. Neither was there any fertilizer effect on protein content.

Application of annual phosphorus increased total crop removal of phosphate in 1978 from 27.9 pounds P/a (0-0-80) to 32.8 pounds P/a (0-40-80) to 35.1 pounds P/a (0-80-80) average across preplant phosphate applications. Potash removal by the crop increased from 439 pounds K/a to 462 pounds K/a with annual treatments of 0-40-0 and 0-40-80 respectively.

Table 14. Effect of N, P, K on Yield[1] of Irrigated Alfalfa, Topeka Unit, 1978.

Fertilizers, lb/a				Cut 1				Cut 2				Cut 3				Cut 4				Cut 5				
PRE	Annual																							
P_2O_5	N	P_2O_5	K_2O	Forage Yield	Protein %	%P	%K	Forage Yield	Protein %	%P	%K	Forage Yield	Protein %	%P	%K	Forage Yield	Protein %	%P	%K	Forage Yield	Protein %	%P	%K	Total Yield
0	0	0	80	1.21	19.34	.219	3.65	1.35	16.58	.193	3.33	1.30	13.38	.171	3.58	1.19	19.22	.224	3.64	1.09	17.34	.193	3.00	6.20
0	0	40	0	1.44	19.94	.275	3.29	1.33	16.20	.216	3.19	1.36	14.42	.245	3.74	1.26	18.77	.260	3.48	1.14	16.94	.226	2.85	6.56
0	0	40	80	1.44	19.06	.268	3.55	1.30	16.50	.217	3.41	1.40	14.08	.216	3.68	1.26	17.41	.249	3.67	1.21	17.41	.231	2.94	6.72
0	0	80	80[2]	1.42	19.36	.284	3.65	1.33	16.09	.233	3.27	1.29	14.52	.251	3.65	1.26	19.14	.286	3.74	1.19	16.44	.236	2.98	6.54
0	100	40	80[2]	1.34	18.85	.264	3.63	1.38	16.27	.212	3.25	1.38	13.68	.257	4.43	1.24	18.81	.248	3.57	1.14	16.16	.205	2.87	6.50
80	0	0	80	1.35	17.66	.236	3.66	1.38	16.45	.201	3.38	1.31	14.37	.221	3.68	1.21	17.88	.242	3.81	1.18	17.39	.188	3.04	6.45
80	0	40	0	1.42	18.75	.277	3.77	1.38	17.69	.230	3.25	1.34	13.92	.225	3.79	1.30	18.70	.262	3.59	1.15	16.44	.224	2.94	6.56
80	0	40	80	1.43	18.95	.291	3.98	1.35	16.63	.223	3.30	1.32	14.85	.250	3.64	1.30	20.28	.271	3.67	1.19	16.31	.228	2.98	6.59
80	0	80	80[2]	1.42	18.25	.307	4.05	1.33	16.97	.237	3.30	1.45	13.85	.263	3.91	1.28	18.58	.275	3.73	1.23	16.94	.231	2.98	6.73
80	100	40	80[2]	1.42	18.66	.275	3.79	1.39	16.60	.217	3.40	1.38	14.50	.259	3.83	1.26	17.75	.250	3.54	1.17	17.47	.222	3.00	6.69
160	0	0	80	1.43	19.08	.261	3.64	1.38	16.20	.205	3.24	1.48	15.71	.232	3.42	1.17	18.31	.265	3.79	1.12	17.22	.207	3.07	6.65
160	0	40	0	1.39	19.46	.288	3.42	1.41	15.28	.215	3.00	1.28	14.58	.253	3.68	1.20	19.28	.287	3.48	1.16	17.81	.241	2.84	6.58
160	0	40	80	1.45	19.25	.287	3.68	1.37	16.61	.225	3.23	1.36	14.69	.250	3.63	1.28	19.61	.272	3.74	1.24	16.83	.218	2.93	6.75
160	0	80	80[2]	1.43	19.47	.320	3.92	1.44	16.55	.235	3.29	1.41	14.48	.241	3.50	1.27	18.81	.290	3.63	1.25	17.99	.255	3.03	6.89
160	100	40	80[2]	1.37	19.36	.293	3.88	1.35	16.40	.215	3.24	1.42	14.46	.226	3.62	1.22	17.94	.261	3.64	1.19	17.16	.225	2.94	6.63
																								NS
Preplant P_2O_5 Means																								
0				1.37	19.31	.266	3.55	1.34	16.33	.214	3.29	1.34	14.06	.228	3.82	1.24	18.67	.253	3.62	1.15	16.86	.218	2.93	6.51
80				1.41	18.45	.277	3.85	1.36	16.87	.222	3.33	1.36	14.30	.244	3.77	1.27	18.64	.260	3.67	1.18	16.91	.218	2.99	6.61
160				1.41	19.32	.290	3.71	1.39	16.21	.219	3.20	1.39	14.78	.240	3.57	1.23	18.79	.275	3.66	1.19	17.40	.229	2.96	6.70
LSD .05				NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	.013	NS	NS	NS	NS	NS	NS
Annual Fertilizer Means																								
0-0-80				1.33	18.69	.245	3.65	1.37	16.41	.208	3.32	1.36	14.49	.208	3.56	1.19	18.47	.243	3.74	1.13	17.32	.196	3.03	6.44
0-40-0				1.42	19.38	.280	3.49	1.37	16.39	.241	3.15	1.33	14.31	.241	3.74	1.25	18.92	.270	3.51	1.15	17.06	.230	2.88	6.57
0-40-80				1.44	19.09	.282	3.74	1.34	16.58	.239	3.31	1.36	14.54	.239	3.65	1.28	19.10	.264	3.69	1.21	16.84	.224	2.95	6.69
0-80-80				1.42	19.03	.303	3.87	1.37	16.54	.252	3.29	1.38	14.29	.252	3.69	1.27	18.85	.284	3.70	1.22	17.12	.241	3.00	6.72
100-40-80				1.38	18.96	.277	3.76	1.37	16.42	.248	3.30	1.39	14.28	.248	3.96	1.24	18.17	.253	3.58	1.17	16.93	.217	2.93	6.61
LSD .05				.07	NS	.020	0.19	NS	NS	.024	0.11	NS	NS	.024	NS	.06	NS	.011	0.11	.05	NS	.010	0.08	NS

[1] Machine harvested yields corrected to 15% moisture, Tons/acre.
[2] 100# N/a applied as ammonium nitrate after second cutting.

Table 14a. Effect of plowdown phosphorus and annual treatments of N, P, and K on pH and phosphorus and potassium content of soil, 1977 and 1978.

Fertilizer annual N	P	K	Trts, lb/a plowdown P	pH 11/77	pH 11/78	P 11/77	P 11/78	K 11/77	K 11/78
0	0	80	0	7.5	7.2	20	18	366	304
0	40	0	0	7.4	7.1	27	34	283	293
0	40	80	0	7.4	7.1	21	26	322	292
0	80	80	0	7.5	7.1	26	45	262	350
100	40	80	0	7.6	7.1	24	24	305	285
0	0	80	80	7.4	7.1	26	22	371	349
0	40	0	80	7.4	7.2	37	35	298	269
0	40	80	80	7.4	7.1	32	27	347	336
0	80	80	80	7.5	7.1	40	48	328	281
100	40	80	80	7.5	7.1	30	34	320	318
0	0	80	160	7.4	7.1	37	26	323	295
0	40	0	160	7.4	7.1	46	69	289	270
0	40	80	160	7.5	7.2	34	32	304	292
0	80	80	160	7.5	7.2	58	63	317	291
100	40	80	160	7.6	7.3	37	34	314	246
			0	7.5	7.1	24	29	308	305
			80	7.4	7.1	33	33	333	311
			160	7.5	7.2	42	45	309	279
0	0	80		7.4	7.1	28	22	353	316
0	40	0		7.4	7.1	37	46	290	277
0	40	80		7.4	7.1	29	28	324	307
0	80	80		7.5	7.1	41	52	302	307
100	40	80		7.6	7.2	30	31	313	283
Initial Soil Test Spring 1976				7.5		37		495	

Table 14b. Nutrient removal in the 1978 irrigated alfalfa crop at the Kansas River Valley Field, Topeka Unit.

Pre P_2O_5	Topdress $N-P_2O_5-K_2O$	Nutrient Removal: Protein lb/a	P (P_2O_5) lb/a	K (K_2O) lb/a	Total Yield Tons/a
0	0-0-80	2095.2	25.3 (57.98)	423.4 (512.3)	6.20
0	0-40-0	2256.6	32.0 (73.36)	434.0 (525.2)	6.56
0	0-40-80	2232.2	31.3 (71.62)	457.6 (553.7)	6.72
0	0-80-80	2226.0	33.6 (76.86)	450.0 (544.5)	6.54
0	100-40-80	2166.7	30.7 (70.40)	463.2 (560.5)	6.50
80	0-0-80	2143.8	28.0 (64.13)	452.5 (547.5)	6.45
80	0-40-0	2258.1	32.2 (73.76)	459.3 (555.8)	6.56
80	0-40-80	2298.5	33.3 (76.25)	464.8 (562.4)	6.59
80	0-80-80	2263.7	35.4 (81.0)	485.0 (586.8)	6.73
80	100-40-80	2247.7	32.5 (74.39)	467.3 (565.4)	6.69
160	0-0-80	2272.0	30.8 (70.6)	452.2 (547.2)	6.65
160	0-40-0	2221.0	33.2 (75.9)	423.3 (512.2)	6.58
160	0-40-80	2332.3	33.7 (77.1)	462.4 (559.5)	6.75
160	0-80-80	2369.3	36.5 (83.5)	459.0 (555.4)	6.89
160	100-40-80	2230.1	32.0 (73.3)	455.4 (551.0)	6.63

EFFECT OF POTASH APPLICATIONS ON WHEAT YIELD AND GRAIN PROTEIN ON A SOIL HAVING A HIGH POTASH SOIL TEST LEVEL

M. C. Lundquist

Treatments in this study consisted of variable potash application rates from zero to 160 pounds K_2O per acre. All treatments received uniform applications of N and P. There was no significant effect of treatment on either the yield or grain protein in this study. Results are given in Table 17.

Table 17. Effect of Potash Applications on a Soil having a High Potash Soil Test level. Wheat Yield and Grain Protein.

M. C. Lundquist — Southwest Expt. Field

Edwin Griffith Farm, Ford Co.

K_2O Rate(lb/A)	Yield(bu/A)	Protein(%)
0	29.3	12.0
20	31.9	11.7
40	28.4	11.8
80	29.6	12.4
160	30.3	11.8
$LSD_{.05}$	NS	NS

RATE, SOURCE AND FREQUENCY OF PHOSPHORUS APPLICATION

Two studies were started in 1974 to evaluate the phosphorus needs in eastern and southeastern Kansas. The studies at the Eastcentral Kansas Experiment Field and the Parsons field of the Southeast Branch Experiment Station were established on land just broken out of native sod which is very deficient in available P. The question is frequently asked concerning the possibility of applying enough P in one application to meet the crop needs for several seasons. These studies were designed to apply the annual recommendation for sorghum of 50 lb/A of P_2O_5, to apply initially twice the recommended (100 lb/A of P_2O_5) with application of P only made every two years, and to apply four times the recommended (200 lb/A of P_2O_5) with application of P only made every four years. Thus in a period of four years all plots receiving P would have applied 200 lb/A of P_2O_5. The studies include two P sources - ammonium orthophosphate (18-46-0) and ammonium polyphosphate (10-34-0). For the first four years the studies were planted to grain sorghum with N and K applied as a blanket treatment. The four year cycle was completed in 1977 and in 1978 the Parsons study was planted to soybeans to start the second four year cycle. The other location remained in sorghum.

An excellent response to P has been found at both locations with no significant difference between P sources. For the first four years (1974-77), the four year average yields for the frequency of P application showed no difference, however, if individual years are considered the yields in 1974 were superior for the heavier P rates applied in that year, but the yields in 1977 were superior for the 50 lb/A of P_2O_5 annual as the 200 lb/A of P_2O_5 applied only in 1974 was not adequate to hold the yield comparable to the annual application. The yields in 1978 showed no difference among the P frequency treatments but does show a response to P. Soil samples pulled in the spring of 1978 show a moderate increase due to the P application over the four year period when compared to the no phosphorus treatment. Results to date would suggest that a four year P supply applied in one application would not be as good as a more frequent application with perhaps a heavier application in the first season.

Soybean's Response to Fertilizer Applied to a Previous Crop, Wheat, in a Double-cropping Rotation. K. W. Kelley (Table 50)

Double-cropping wheat and soybeans is common in southeastern Kansas. However, additional phosphorus and potassium often are not applied to the wheat crop (so as to be available for the soybeans that follow the same year) nor are the soybeans fertilized directly.

In 1976 we established a study to determine how applying additional phosphorus and potassium to the wheat crop would influence soybeans that follow. Lime also was included as a variable. Soil site selected for the study was medium in available phosphorus and low in exchangeable potassium; pH was moderately low.

Wheat yields in 1977-78 at the Columbus field were significantly increased by the phosphate applications. There was very little yield response above the 60 pound P_2O_5 rate. Potash and lime did not increase wheat yields.

However, for the double-cropped soybeans that followed the wheat, lime has increased yields an average of 5 bushels per acre. Applying additional phosphorus and potassium did not affect the soybean yields significantly, although there was a slight increase in yield at the higher fertilizer rates.

Effect of Rate, Source and Frequency of Phosphorus Application on Soybean Yields (Study started in 1974).

Southeast Kansas Experiment Station (Parsons)

P_2O_5 Application Frequency	P Source	1978 Yield	1974 thru 1977 Sorghum Yield	Soil Test P[1]
lb/A		bu/A	bu/A	ppm
None	--	22	42	4
50 annual	AOP	25	58	6
100 1974, 1975 and 1978	AOP	25	57	5
200 1974 and 1978	AOP	26	57	5
50 annual	APP	24	58	7
100 1974, 1976 and 1978	APP	27	60	5
200 1974 and 1978	APP	28	58	6

[1]Samples taken in spring of 1978 prior to P application.

Effect of Rate, Source and Frequency of Phosphorus Application on Grain Sorghum Yields. (Study started in 1974)

Eastcentral Kansas Experiment Field

P_2O_5 Rate and Application Frequency	P Source	Soil Test P[1]	1978 Yield	5 Year Average
lb/A		ppm	bu/A	bu/A
None	--	5	37	38
50 annual	AOP	14	48	52
100 1974, 1976 and 1978	AOP	11	51	52
200 1974 and 1978	AOP	9	49	53
50 annual	APP	12	47	55
100 1974, 1976 and 1978	APP	9	47	53
200 1974 and 1978	APP	9	39	49

[1]Samples taken in spring of 1978 prior to P application. Initial soil P test - 4 ppm P.

SOYBEAN'S RESPONSE TO FERTILIZERS APPLIED TO A PREVIOUS CROP, WHEAT, IN A DOUBLE-CROPPING ROTATION, 1977-78

Kenneth W. Kelley
Columbus Field, Southeast Kansas Branch Experiment Station

Table 50.

Fertilizer 1/			Wheat yield, 2-yr. av.			Soybean yield, 2 yr. av.		
N	P_2O_5	K_2O	No lime	Lime 2/	Mean	No lime	Lime	Mean
---lbs/A----			-----bu/A-----			-----bu/A-----		
70	0	0	35.5	36.9	36.2	16.3	21.7	19.0
70	0	100	36.0	36.6	36.3	18.0	22.8	20.4
70	30	100	40.8	40.6	40.7	17.4	22.7	20.1
70	60	100	44.5	44.0	44.3	17.7	22.9	20.3
70	90	100	45.4	45.9	45.7	18.0	24.5	21.3
70	120	100	46.3	44.8	45.6	16.6	23.5	20.1
70	150	100	46.9	45.8	46.4	18.7	23.6	21.2
70	60	0	44.9	42.5	43.7	17.6	24.3	21.0
70	60	50	43.9	42.8	43.4	17.0	23.7	20.4
70	60	100	44.0	44.0	44.0	17.8	23.9	20.9
70	60	150	43.2	42.9	43.1	18.4	24.4	21.4
70	60	200	42.3	43.9	43.1	19.9	23.8	21.9
70	60	250	45.1	45.0	45.1	18.5	23.7	21.1
Mean			43.0	42.8	--	17.8	23.5	--

1/ Fertilizer applied to the wheat crop before planting.

2/ Lime applied in the fall of 1975.

Initial Soil Test

ph = 5.5
ECC = 2000 lbs/A
O.M. = 1.1

Avail. P = 19 lbs/A
Exch. K = 137 lbs/A

EFFECT OF PHOSPHORUS AND POTASSIUM FERTILIZATION ON LONG-TERM IRRIGATED CORN YIELDS

Several long-term irrigated corn studies are ongoing in Kansas which involve rates of nitrogen, phosphorus and potassium. These studies have been very useful in establishment of fertilizer recommendations.

A summerization of the P and K effects for 1978 and long-term averages for four locations are presented in the following table. The P and K effect are shown at the optimum N rate in the study. The Sandyland, Garden City and Tribune locations now test low in available phosphorus on the no phosphorus treatments and are showing an excellent response to P. The Kansas River Valley study has a P test in the medium to high range and is not showing a P response. The response on these sites confirms the interpretation limits now being used by the KSU Soil Testing Lab.

There has been no K response at any of the locations. The Kansas River Valley, Tribune and Garden City locations have K soil tests that are interpretated as very high and the Sandyland location has a medium K soil test. The abundant soil K supply coupled with only grain removal has not drawn the soil K level down to a responsive level. Continuation of these studies with soil tests to monitor the change in the soil fertility level will be valuable molding future to KSU fertilizer recommendations.

Summarization of the P and K fertilization effect on long-term irrigated corn studies in Kansas.

Fertilizer Rate N	P_2O_5	K_2O	1978 Yield	Long-term Average
——lb/A——			bu/A	bu/A
Sandyland Experiment Field, St. John (Carwile sandy loam)				
0	0	0	26	21 (11 yr. ave.)
225	0	50	66	113
225	50	0	104	146
225	50	50	116	145
Garden City Experiment Station (Richfield silt loam)				
0	0	0	82	86 (10 yr. ave.)
180	0	0	98	132
180	40	0	130	155
180	40	40	132	155
Tribune Experiment Station (Ulysses silt loam)				
0	0	0	85	62 (18 yr. ave.)
160	0	0	137	139
160	40	0	185	163
160	40	40	178	163
Kansas River Valley Experiment Field, Silver Lake (Eudora loam)				
0	0	0	103	85 (7 yr. ave.)
150	0	0	178	145
150	30	0	182	150
150	30	60	180	157

COMPARISONS OF METHODS OF N AND P APPLICATION FOR WINTER WHEAT

D. F. Leikam, L. S. Murphy, R. E. Lamond, T. Fairweather and D. D. Buchholz

The results of the studies reported in Table 7 through Table 9 are an outgrowth of work begun in 1975. Since 1975, results of these studies have indicated definite superiority for the technique involving dual knife applications of anhydrous ammonia or urea ammonium nitrate solution (UAN) in combination with liquid ammonium polyphosphate (APP). This technique placed both fertilizer materials in the same soil retention zone. These dual knife applications were effected by equipping each ammonia shank with two lines, one to deliver ammonia and the other to deliver liquid APP. Dual knife applications of UAN and APP were made by simply mixing the two fertilizer materials and injecting through the liquid line. Treatments were injected on 18 inch centers to a depth of six inches.

These treatments were compared to a variety of methods of N and P application methods. At Ellsworth and Reno counties, the comparisons were made to treatments involving separation of the N and P fertilizers. The ammonia and UAN was knifed in while the APP was sprayed on the soil surface and incorporated by disking. In addition one treatment involved knifing of UAN on 18 inch centers and the knifing APP *between* the bands of UAN. This resulted in the APP and UAN being separated and *not* in the same soil retention zone. All of these treatments were conducted both with and without the nitrification inhibitor, N-SERVE. N-SERVE is a product of Dow Chemical Company.

The studies conducted at Dickinson and Osage counties were slightly different. The dual knifed treatments were compared to dribble and broadcast applications of APP and UAN. In each case the APP and UAN were mixed together and then applied. There were also treatments involving knife, broadcast and dribble applications of N only. Each of the treatments in these studies were also carried out with the addition of 0.5 pounds active ingredient per acre of N-SERVE.

The Reno and Ellsworth county locations were conducted on the same sites as were the 1977 studies. With this year's applications, the studies receiving N and P received a total of 80 pounds of P_2O_5 for the two years. The location in Dickinson County had just come out of established alfalfa. Although the soil P was low by weak-Bray P extraction, more than adequate amounts of soil nitrogen were present. The Osage County location was in forage sorghum in the summer of 1977 and resulted in a low soil test of available N while the P level was medium.

At each location, growth differences were apparent in April. Knifed, preplant applications of ammonia and APP, as well as knifed, preplant applications of UAN and APP produced much more vegetative growth than other methods of nitrogen and phosphorus application. Although differences were apparent at the Reno and Ellsworth county locations they were not nearly as evident as the differences found at Dickinson and Osage counties. Dribble applications of UAN-APP combinations generally appeared to produce more early plant growth than broadcast applications, but did not produce near as much vegetative growth as the dual knifed applications.

Tissue samples were collected from each of the four locations and analyzed for nitrogen and phosphorus concentrations in the leaf tissue. The results of those analyses are reported in Tables 7 and 8.

Rains continued through May and the prospects of excellent wheat yield continued through harvesting. The differences that were apparent earlier were still striking at Dickinson and Osage county at maturity. The differences at Ellsworth and Reno county tended to diminish as the crop matured, although the differences were still apparent at Ellsworth county at heading.

Looking at the data from the Dickinson and Osage county locations (Table 8) dual knifed, preplant applications of nitrogen and phosphorus produced the highest yields at both locations. Surface applications, either broadcast or dribble, were inferior to dual knife, preplant applications of either UAN and APP or ammonia and APP. The increase in yield due to dual knife applications of nitrogen and phosphorus, compared to surface applications, was 10 bushels at Dickinson county for both UAN and ammonia. At Osage county the increase was about 30 bushel for ammonia and 14 bushel for UAN. It might be noted that at the Osage County location, ammonia without phosphorus was 15 bushel better than UAN without phosphorus.

At this time we have no explanation for this large yield difference between ammonia and UAN. Past data indicates no difference between these two materials for sources of nitrogen. However, there are two possible explanations that may have been involved in the yield difference. Between planting and harvesting of the Osage County study there were extended periods of wet weather. Part of the UAN may have been denitrified and lost from the soil as nitrogen gases. Another possibility may be that some of the urea from the UAN solution may have been leached away from the application zone.

Also included in these studies were the addition of N-SERVE, a nitrification inhibitor produced by Dow Chemical Company. During the spring the plots receiving N-SERVE were judged to be visibly superior to treatments receiving no N-SERVE . However, there was no advantage of N-SERVE, in terms of grain yield, at three of the four locations. The exception was Osage County, where some interesting results were noted. N-SERVE increased grain yields when nitrogen and phosphorus were dual knifed or dribble applied, while N-SERVE applied with broadcast nitrogen and phosphorus had no effect. This indicates that the nitrogen and phosphorus must be in the same soil zone to get a yield increase from N-SERVE. No response due to N-SERVE was recorded at Dickinson County due to the high soil nitrogen levels present in the soil.

Plant tissue nitrogen and phosphorus concentrations indicated the same trends as did yields. Dual knifed treatments were generally higher in nitrogen and phosphorus than other treatments. The addition of N-SERVE resulted in an increase in plant tissue nitrogen and phosphorus content at all locations, although not significantly higher in all cases.

The results of the 1977-1978 studies are consistant with the results obtained since 1975. The locations used, varied in both soil nitrogen and phosphorus levels and the same type of results were obtained from these locations, despite the difference in fertility levels. Prior to the 1976-1977 crop year we had concluded that the differences obtained in yield were due to the fact that the fertilizer was placed deeper in the soil where more moisture was available.

Since 1977 the results lead us to believe that these differences are not only due to the deeper position in moist soil but also are due to an interaction between ammonium-nitrogen and phosphorus. When relatively high levels of ammonia-nitrogen are present in the same soil retention zone, it results, we believe, in some change in the reactions affecting soil phosphorus. This idea is substantiated by yield and tissue concentrations of nitrogen and phosphorus. In addition, yields and tissue concentrations are increased in some cases when N-SERVE is added to the soil retention zone. Delaying nitrification of the ammonium-nitrogen results in a longer period of high ammonium levels in the retention zone. This results in further benefits of dual knifed nitrogen and phosphorus.

More research is planned in the future to answer questions about this technique. During 1978-1979, studies utilizing different nitrogen and phosphorus sources and rates, nitrification inhibitors, different application methods and varying knife spacings will be carried out across the state.

Table 7.

EFFECTS OF METHODS OF N AND P APPLICATION ON WINTER WHEAT

(Ellsworth and Reno Co., 1978)

D. F. Leikam, R. E. Lamond, T. Fairweather, D. D. Buchholz,
W. A. Moore, and L. S. Murphy

Rate lb/A N	Rate lb/A P	N Source	Method of Application		N-Serve	Ellsworth Co. Grain Yield	Ellsworth Co. Grain Protein	Ellsworth Co. Tissue % N	Ellsworth Co. Tissue % P	South Central Expt. Field Grain Yield	South Central Expt. Field Grain Protein	South Central Expt. Field Tissue % N	South Central Expt. Field Tissue % P
75	0	NH_3	Knife	---	Yes	47.2	11.6	3.76	.20	24.6	15.6	3.53	.18
75	0	NH_3	Knife	---	No	36.8	11.2	3.50	.18	24.3	15.2	3.52	.18
75	0	UAN	Knife	---	Yes	37.8	11.2	3.76	.21	34.4	15.0	3.43	.21
75	0	UAN	Knife	---	No	39.0	11.3	3.70	.20	23.8	15.2	3.46	.18
75	0	UAN	B'cast	---	No	37.2	10.8	3.69	.20	27.9	15.1	3.63	.18
75	40	NH_3	Knife	Knife	Yes	62.8	10.2	3.97	.28	49.6	14.2	3.92	.24
75	40	NH_3	Knife	Knife	No	60.0	10.5	3.91	.26	55.2	13.8	3.98	.25
75	40	UAN	Knife	Knife	Yes	58.4	9.8	3.65	.25	50.0	14.3	3.73	.23
75	40	UAN	Knife	Knife	No	57.9	9.6	3.48	.26	50.2	13.8	3.80	.24
75	40	NH_3	Knife	B'cast	Yes	60.3	10.6	3.82	.22	55.9	13.8	3.70	.23
75	40	NH_3	Knife	B'cast	No	54.6	11.1	3.63	.21	54.5	14.3	3.84	.24
75	40	UAN	Knife	B'cast	Yes	43.4	10.3	3.40	.19	58.2	14.0	4.00	.27
75	40	UAN	Knife	B'cast	No	62.8	10.4	3.37	.20	47.2	14.0	3.68	.23
75	40	UAN	B'cast	B'cast	No	45.3	9.7	3.21	.20	53.0	13.8	3.67	.23
75	40	NH_3	Knife[1/]	Knife	Yes	59.4	9.9	3.91	.24	54.8	14.1	3.80	.24
75	40	NH_3	Knife[1/]	Knife	No	51.4	10.6	3.62	.22	47.8	14.1	3.60	.21
			Treatment	$LSD_{(.05)}$		10.7	0.8	0.28	.03	9.2	0.6	0.23	.03
			N-Serve			51.7	10.6	3.73	.23	45.4	14.5	3.72	.23
			No N-Serve			51.8	10.7	3.60	.22	42.5	14.4	3.71	.22
				$LSD_{(.05)}$		NS	NS	0.12	NS	NS	NS	NS	NS
			NH_3			53.6	10.8	3.77	.22	44.0	14.5	3.75	.22
			UAN			49.9	10.4	3.56	.22	44.0	14.4	3.68	.23
				$LSD_{(.05)}$		NS	0.4	0.12	NS	NS	NS	NS	NS
			0 P			40.2	11.3	3.68	.20	26.8	15.2	3.48	.19
			Knife P			59.8	10.0	3.75	.26	51.2	14.0	3.86	.24
			B;cast P			55.3	10.6	3.56	.20	53.9	14.0	3.80	.24
				$LSD_{(.05)}$		5.9	0.5	0.15	.02	4.8	0.3	0.11	.02

1/ Split applications of N and P.

Table 8.

EFFECTS OF METHODS OF N AND P APPLICATION ON WINTER WHEAT
(Osage and Dickinson Co., 1978)

D. F. Leikam, L. S. Murphy, R. E. Lamond, T. Fairweather and D. D. Buchholz

Rate lb/A N	Rate lb/A P	N Source	Method of Application N	Method of Application P	N-Serve	Osage Co. Grain Yield	Osage Co. Grain Protein	Osage Co. Tissue % N	Osage Co. Tissue % P	Dickinson Co. Grain Yield	Dickinson Co. Grain Protein	Dickinson Co. Tissue % N	Dickinson Co. Tissue % P
75	0	NH_3	Knife	---	Yes	59.1	10.0	3.39	.21	42.2	14.6	3.95	.18
75	0	NH_3	Knife	---	No	59.4	10.0	3.42	.21	50.2	14.3	4.12	.18
75	0	UAN	Knife	---	Yes	46.3	10.1	3.20	.21	44.3	15.0	3.89	.16
75	0	UAN	Knife	---	No	44.0	9.8	3.09	.20	46.8	14.5	3.80	.16
75	0	UAN	Drib.	---	Yes	37.3	9.5	2.88	.23	43.9	14.2	3.70	.16
75	0	UAN	Drib.	---	No	44.0	10.4	2.82	.20	47.6	14.0	3.57	.17
75	0	UAN	B'cast	---	Yes	37.1	9.6	3.13	.21	44.0	14.6	3.57	.16
75	0	UAN	B'cast	---	No	50.6	9.8	3.30	.20	46.8	14.4	3.62	.16
75	40	NH_3	Knife	Knife	Yes	75.5	10.1	3.84	.32	73.0	13.3	4.38	.28
75	40	NH_3	Knife	Knife	No	62.6	9.6	3.54	.26	72.3	13.7	4.31	.24
75	40	UAN	Knife	Knife	Yes	63.5	9.8	3.15	.29	70.0	13.6	4.07	.24
75	40	UAN	Knife	Knife	No	49.4	9.7	2.90	.25	71.6	12.8	4.14	.23
75	40	UAN	Drib.	Drib.	Yes	48.1	9.4	2.98	.24	62.6	13.2	3.82	.21
75	40	UAN	Drib.	Drib.	No	29.8	9.3	2.68	.25	60.2	13.7	3.50	.20
75	40	UAN	B'cast	B'cast	Yes	42.9	9.8	2.78	.22	58.0	13.2	3.75	.19
75	40	UAN	B'cast	B'cast	No	48.9	10.0	2.98	.23	60.0	14.0	3.52	.18
0	0	---	---	---	---	12.7	10.2	2.40	.24	44.4	14.3	3.54	.16
			Treatment $LSD_{(.05)}$			13.5	NS	0.17	.02	8.3	0.9	0.15	.02
Mean Values for the treatments receiving N only and N and P			NH_3 Knifed			65.4	9.9	3.55	.25	60.2	14.0	4.19	.22
			UAN Knifed			50.8	9.8	3.08	.24	58.2	14.0	3.97	.20
			UAN Drib.			38.8	9.6	2.84	.23	53.6	13.8	3.65	.18
			UAN B'cast			44.9	9.8	3.05	.21	52.2	14.1	3.62	.17
			$LSD_{(.05)}$			6.7	NS	0.17	.02	4.2	NS	0.16	.01
			0 P			47.2	9.9	3.15	.21	46.1	14.4	3.78	.17
			40 P			53.2	9.7	3.10	.26	66.0	13.4	3.94	.22
			$LSD_{(.05)}$			4.8	NS	NS	.01	3.0	0.3	0.11	.01
			N-Serve			51.2	9.8	3.17	.24	55.1	14.0	3.89	.20
			No N-Serve			49.2	9.8	3.09	.22	56.9	13.9	3.82	.19
			$LSD_{(.05)}$			NS	NS	NS	.01	NS	NS	NS	NS
Mean values for the treatments receiving N and P only			NH_3+P Knife - Knife			71.5	9.9	3.69	.29	72.6	13.5	4.34	.26
			UAN+P Knife - Knife			56.5	9.7	3.02	.27	70.8	13.2	4.10	.23
			UAN+P Drib. - Drib.			38.7	9.4	2.82	.25	61.4	13.4	3.66	.20
			UAN+P B'Cast - B'cast			45.9	9.9	2.88	.22	59.0	13.6	3.64	.18
			$LSD_{(.05)}$			10.0	NS	0.31	.04	5.6	NS	0.23	.02
			N - P + N-Serve			57.5	9.8	3.18	.27	65.9	13.3	4.01	.23
			N - P w/o N-Serve			48.9	9.7	3.02	.25	66.0	13.5	3.87	.21
			$LSD_{(.05)}$			7.1	NS	NS	NS	NS	NS	NS	.01

EFFECTS OF METHODS OF N AND P APPLICATION AND P RATE ON WINTER WHEAT

D. F. Leikam, K. Winter, D. D. Scott, D. A. Whitney, M. Blocker and L. S. Murphy

These studies were conducted to determine if higher phosphorus efficiency is achieved when the phosphorus is dual knifed with anhydrous ammonia. Previous work has shown that increased phosphorus utilization results from the dual knife application technique. These studies were conducted in Dickinson and Reno counties. Phosphorus was applied at 20, 30, 40 and 50 pounds P_2O_5 per acre. Methods of phosphorus application were broadcast, banded and dual knifed with anhydrous ammonia. Banded phosphorus was applied in direct seed contact at drilling time. Broadcast and dual knifed applications were made preplant. Liquid ammonium polyphosphate (APP;10-34-0) was the phosphorus source and anhydrous ammonia was used as the nitrogen source. All ammonia was knifed preplant and applied at rates which balanced the nitrogen application to a total of 75 pounds of N per acre.

Results of the investigations reported in Table 9 indicates a 5 bushel advantage of dual knifed nitrogen and phosphorus when compared to banded phosphorus and 8 bushel above broadcast treatments at Dickinson County. Yields were also increased with increasing phosphorus application rates. Tissue concentrations of nitrogen and phosphorus also increased as the phosphorus application rates increased. As with yields, dual knife treatments were also higher in leaf tissue nitrogen and phosphorus concentrations when compared to banded or broadcast phosphorus applications.

Plots receiving dual knife applications of nitrogen and phosphorus were visibly superior to plots receiving the same phosphorus rates but banded or broadcast . Also, plots receiving 20 pounds P_2O_5 per acre; dual knifed, were as good or superior to treatments involving 40 pound P_2O_5 per acre broadcast or banded at the Dickinson County site.

At Reno County, there was no yield response due to phosphorus applications and consequently there were no differences noted between methods of phosphorus application. However, tissue concentrations of phosphorus increased as phosphorus application rates increased. Dual knifed phosphorus applications also resulted in higher leaf tissue concentrations of phosphorus when compared to broadcast and band fertilizer applications.

The results of these investigations suggest lower phosphorus application rates are possible when dual knifed with ammoniacal nitrogen. Additional work in this area is planned for the next crop year with lower application rates.

Table 9. EFFECTS OF METHODS OF N AND P APPLICATION AND P — RATE ON WINTER WHEAT

(Dickinson and Reno Co., 1978)

D. F. Leikam, K. Winter, D. D. Scott, D. A. Whitney, M. Blocker,
W. A. Moore, and L. S. Murphy

Rate		Method of Application		Dickinson Co.				South Central Expt. Field			
				Grain		Tissue		Grain		Tissue	
N	P	N	P	Yield	Protein	% N	% P	Yield	Protein	% N	% P
75	0	Knife	---	35.4	15.1	3.67	.16	46.6	12.4	2.99	.24
75	20	Knife	Knife	53.4	14.3	3.69	.18	51.1	12.2	3.37	.27
75	30	Knife	Knife	59.8	14.4	3.70	.19	47.5	12.4	3.05	.27
75	40	Knife	Knife	69.7	14.2	3.97	.22	45.7	12.6	3.33	.28
75	50	Knife	Knife	68.6	14.1	3.98	.23	47.0	12.4	3.15	.30
75	20	Knife	B'cast	54.1	14.6	3.49	.17	47.6	12.7	3.25	.25
75	30	Knife	B'cast	48.7	14.4	3.34	.16	49.8	12.3	3.26	.25
75	40	Knife	B'cast	57.3	14.3	3.53	.17	48.4	12.5	3.22	.26
75	50	Knife	B'cast	57.0	14.4	3.45	.18	53.2	12.0	3.40	.27
75	20	Knife	Band	45.2	14.8	3.50	.16	47.2	12.0	3.02	.25
75	30	Knife	Band	60.8	14.5	3.61	.17	48.6	12.8	3.20	.27
75	40	Knife	Band	56.8	14.5	3.85	.19	54.2	12.4	3.18	.28
75	50	Knife	Band	67.6	13.6	3.75	.20	49.5	12.0	3.40	.29
Treatment LSD$_{(.05)}$				9.5	NS	NS	.03	NS	NS	NS	.02
20# P_2O_5				50.9	14.6	3.56	.17	48.6	12.3	3.21	.26
30# P_2O_5				56.4	14.4	3.55	.17	48.6	12.5	3.17	.26
40# P_2O_5				61.3	14.3	3.78	.19	49.4	12.5	3.24	.28
50# P_2O_5				64.4	14.0	3.73	.20	49.9	12.2	3.32	.29
LSD$_{(.05)}$				5.7	0.4	0.21	.02	NS	NS	NS	.01
Knife P				62.8	14.2	3.84	.21	47.8	12.4	3.23	.28
B'cast P				54.3	14.4	3.45	.17	49.8	12.4	3.28	.26
Band P				57.6	14.3	3.68	.18	49.9	12.3	3.20	.27
LSD$_{(.05)}$				4.9	NS	0.18	.01	NS	NS	NS	.01