EFFECTS OF SHANK SPACINGS OF DUALLY INJECTED NITROGEN AND PHOSPHORUS ON WINTER WHEAT

By

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ON WINTER WHEAT

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CHAPTER I

INTRODUCTION

Oklahoma depends heavily on winter wheat to provide stimulus to the state's economy. In the future, with the world's population booming and essential resources becoming more scarce, this will become more so. Reports of once plentiful phosphate fertilizer reserves dwindling have given agricultural researchers an important task of finding more efficient ways of using fertilizers.

The concept of banding fertilizers is not new, but with today's technology and fluid fertilizers, placement has become much easier to accomplish. Dual injection of nitrogen and phosphorus fertilizers is a relatively new fertilization scheme and should be evaluated for use on wheat producing soils of the Great Plains. Once this type of fertilization is adequately evaluated, recommendations can be made at the appropriate level and resource conservation can be realized if the procedure is widely adopted. Time, energy, and money can be saved if nitrogen and phosphorus are applied in combination in one trip across the field.

Most previous research done on the dual injection concept has been with a shank spacing distance of approximately 45 cm. Wider and narrower spacings need to be investigated to determine if spacings of bands have significant effects on yield, nutrient composition and fertilizer recovery of winter wheat.

CHAPTER II

REVIEW OF LITERATURE

Physiological, Morphological, and Chemical Effects

Grunes (1959) made a thorough review of the literature on nitrogen and its effect on phosphorus availability. It can be highlighted as follows:

1. Biological effects:

   A. Root area and absorbing capacity - He states that banding N and P fertilizers together in deficient soils would increase root growth as well as fertilizer uptake.

   B. Root efficiency - When fertilizer materials are banded in the soil, this results in a high concentration of the available nutrient. Thus the P supplying power of a band would be greater than the soil. The diffusion of P toward root surfaces would increase, the amount of P in solution would increase, thus root uptake due to this could increase.

   C. Ammonium ion effects - The ammonium ion may physiologically affect plant absorption of P especially if the N and P are placed close together.

   D. Stage of growth--Plant nutrient uptake functions - Data shows that when 50 percent of total P uptake has occurred, only 20 percent of total growth has occurred. During early plant growth, if N is present, absorbed P should be higher than if N is not present.

   E. Effect of nitrogen on plant metabolism and ability of roots to absorb phosphorus - N absorption may affect P absorption by increasing root cation exchange capacity. It can also affect phytohormonal levels in roots.

2. Chemical effects:

   A. Salt effects - Nitrogen salts may tend to increase availability of soil or fertilizer phosphorus, or decrease them. Salts may also prevent phosphate reversion.

B. pH effects - Ammoniacal fertilizers release acid upon nitrification. The decrease in microarea pH may favor certain ionic species of P such as H_2PO_4 over HPO_4.

Many scientists have described effects of ammoniacal nitrogen on phosphate absorption by plants. Physiologically acid fertilizers, according to Chapman (1963), have in some cases increased availability of soil and fertilizer phosphorus. Ammonium sulfate, ammonium nitrate and urea were found to increase availability of native P in two of three California calcareous soils. He claims that acid formation due to nitrification of ammoniacal N played a role in increased solubility of soil P.

Lorenz and Johnson (1953) working with high pH soils grew several crops in a greenhouse study. They concluded that ammonium fertilizers increased solubility of native soil P considerably over nitrate fertilizers.

Mixing ammonium sulfate, potassium chloride and superphosphate all in one band was most effective for early P uptake for Robertson et al. (1954). These workers reported significant increases in plant height, and higher fertilizer recovery through the rest of the growing season. They stated that both physiological and chemical interactions of plants and soil were due to ammonium sulfate. The field study was on a Vigo silt loam with a pH of 6.4. The crop grown was corn.

Miller and Ohlrogge (1958) using labelled superphosphate and ammonium sulfate as fertilizers for corn seedlings found that nitrogen in the phosphorus band increased root proliferation in the band, as well as P uptake. This effect was noted at various soil P concentrations of a Fincastle silt loam with a pH of 5.2. Nitrogen supplied in an independent band only increased banded P uptake at soil P levels of less than 112 kg per hectare.

Subsequent research by Duncan and Ohlrogge (1958) using ammonium nitrate and ammonium sulfate as N sources, treblephosphate as the P source, and growing corn seedlings, found that in the presence of both ammonium N and P roots developed as silklike masses. This characteristic was not present in the ammonium nitrate or ammonium sulfate bands, although something similar, but less pronounced was observed in the phosphate bands.

Duncan and Ohlrogge (1959) noticed that corn seedling root distribution was greater in the area of soil with the highest fertilizer P concentration. They concluded that when N and P are placed together in a small volume of soil, nitrogen will increase phosphorus uptake in part by increasing root growth.

The mechanisms involved in soybean root proliferation in N and P bands were checked by Wilkinson and Ohlrogge (1962). These researchers hypothesized that perhaps higher root respiration in the N and P band was due to a greater growth hormone level. By using bioassays on Avena coleoptiles and chromatography, they discovered that an unknown precursor appeared to be increasing the level of a nitrogen induced growth hormone. Willis and Yemm (1955) stated that both ammonium and nitrate fertilized, excised barley roots exhibited an increase in respiration. The ammonium fertilized roots exhibited the peak respiration level first although later the respiration decreased.

A four year study by Olson and Drier (1956) was conducted using various tagged P fertilizers and several nitrogen sources in both greenhouse and field studies. Nitrogen effects on phosphate uptake and yield of small grains were determined. Their data shows that N and P complement one another and that this is especially true if ammonium and P are placed together. A greater P yield on a per hectare basis was found, thus indicating enhancement of fertilizer P uptake by ammonium N. They also state that this occurred in a wide range of soil types. Oat grain yields were increased significantly by banding P and broadcasting ammonium nitrate.

Grunes et al. (1958a) grew barley in a growth chamber experiment. Uptake of fertilizer P was found to be increased by the presence of ammonium sulfate in the concentrated superphosphate bands. There was little difference in P uptake between placement methods of sodium nitrate. In a continuation of this research, Grunes et al. (1958b) looked at various effects of fertilizer sources and placement on potatoes and sugarbeets. Finding that additions of ammonium nitrate in contact with phosphorus bands increased early season uptake of fertilizer P in sugarbeets,they postulated that ammonium in the presence of P may stimulate root growth, or due to the acid forming ammonium nitrate, the fertilizer P was more available.

Miller (1965) conducted greenhouse studies using radioactive concentrated superphosphate and reagent grade ammonium sulfate in banded treatments with corn seedlings. He determined that the uptake of P as influenced by ammonium was not dependent on extra root growth, but was instead caused by a physiological mechanism turned on by the presence of high concentrations of ammonium. Probing into this question further, Leonce and Miller (1966) decided that the ammonium ion has an influence on P movement into the symplast. Mamaril and Miller (1970) designed a study to ascertain if ammonium had any effects on uptake of other nutrients besides P. Sulfate and rubidium uptake appeared not to be affected by ammonium. They also determined that concentration of P in the soil was the most important factor of ammonium affected P uptake by corn. Factors ruled out were 1) the proportion of soil fertilized and 2) the proportion of the root system exposed to fertilized soil. Miller et al. (1970) discovered by using electron microprobe scans and autoradiographic techniques that in the presence of ammonium sulfate, monocalcium phosphate was not precipitated at the soil-root interface. A lower pH was found in this area, due to ammonium sulfate, which gave a greater H_2PO_4/HPO_4 ratio. This microarea pH change was thought to cause increased availability of the fertilizer P. Continuing this research, Blair et al. (1971) found that in soils of a basic reaction, calcium and phosphorus were precipitated at the soil-root interface with ammonium absent. In a soil with a pH of 5.5, calcium, iron, and phosphorus were precipitated and with a soil with a pH of 4.2 no precipitation was found. Phosphorus uptake was greatest in the presence of ammonium and lowest with nitrate present. The data suggests that ammonium prevents P precipitation near the interface.

Riley and Barber (1971) found that ammonium decreased soybean rhizocylinder pH, and that the opposite was true for nitrate. A soil with an initial pH of 5.2 was affected by ammonium and nitrate treatment differences as much as 1.9 pH units in the rhizosphere. They concluded that with ammonium in the P band, fertilizer P will remain in a soluble form, thus increasing fertilizer P uptake.

By utilizing a continuously aerated one-fifth strength Hoagland's solution, Thien and McFee (1970) grew corn seedlings and measured tagged

P uptake. They suggested that two mechanisms were responsible for P uptake. The N treated plants took up more of the labbelled P than the P singular treatments. No differences were found in P uptake between N supplied as either ammonium chloride or sodium nitrate. Because this study utilized nutrient solutions, this may lend credence to the hypothesis of P precipitation at the soil-root interface by Miller et al. (1970).

Hagen and Hopkins (1955) using excised barley roots found that roots absorb more P at lower pH values. At pH 5 almost all phosphate ions are in the H_2PO_4 form. At pH 7, hydroxyl ions compete with absorption of both HPO_4 and H_2PO_4.

Caldwell (1960) grew corn in Nicolett silty clay loam and Waukegan silt loam. Various N sources were used that contained ammonium and nitrate. Radioactive labelled P was supplied in several P forms, and potassium chloride was the only potash source. He found that ammoniacal N forms increased P uptake from superphosphate when the two materials were mixed together. The ammonium in monoammonium phosphate and in ammoniated superphosphate also increased P uptake. He suggests that this is probably due to a salt effect rather than physiological changes in the root caused by ammonium.

Lutz et al. (1961) studied the effects of a 10-8.7-16.7 blend of high phosphate solubility and a 7.6-11.7 mixture, of low phosphate solubility. In 13 experiments on low P soils, broadcasting was only 42 percent and topdressing 33 percent as effective for dry forage production as banding the fertilizer with the seed. Ninety kg per hectare of P with the seed produced the highest P content in forage.

The placement of ammonium N and P in the same fertilizer band appears to have its merits. Regardless of the various and controversial mechanisms of influence involved, placing ammoniacal N and P together seems to be sound reasoning.

Field Evaluations of Dual Placement

Most of the research into dual placement by injecting both N and P has been conducted by researchers at Kansas State University. Little information has been published in scientific literature although Murphy et al. (1978a, 1978b) and Leikam et al. (1979b) have published some initial findings in trade journals. Almost all of the phosphate sources used in dual injection studies are various grades of liquid ammonium polyphosphate (10-15-0 and 15-27-0). According to Miner and Kamprath (1971) ammonium polyphosphate (APP) is very similar to orthophosphate sources once it has undergone hydrolysis. Gaseous anhydrous ammonia (82-0-0) and liquid urea ammonium nitrate (28-0-0 and 32-0-0) are the main nitrogen sources used with liquid ammonium polyphosphate.

Hall et al. (1976) when comparing several methods of N and P placement found that dually knifed treatments yielded about 540 kilograms of wheat more per hectare than surface applied treatments. Statistically significant P levels increases in forage were also seen with this type of placement. Anhydrous ammonia and APP were used in the knifed treatments.

Liekam et al. (1977) continued this work and found that dual placement gave consistently higher yields than either P broadcast or P singularly banded. Striking differences in the forage growth of dually injected applications as compared to other treatments were seen. Effects of a nitrification inhibitor, nitrapyrin, were also evident.

Leikam et al. (1978) found dually knifed N and P treatments to have higher leaf P concentrations, higher leaf N levels at one of two sites and higher grain yields at the one location where a P response was noted. Leikam et al. (1979a) found that dually knifed N and P produced more protein per hectare than other treatments and total P removal per hectare was also higher. A significant increase in grain yields was also seen in the dually injected N and P applications. They also found that treatments including injected P were generally better, regardless of N method of placement. Dually knifed treatments by Kissel et al. (1980) also showed that higher grain yields can be obtained with this type of fertilization.

Edlund (1980) found that dual injection increased P levels in forage but did not significantly increase grain yields over injected P and broadcast N. He did conclude, however that this type of placement was as good as any other and could possibly save time and fuel.

Work conducted by Maxwell et al. (1979) and Maxwell et al. (1980) included dual injection at several band spacings, rather than the usual 45-50 cm spacing. Variation in wheat growth on the conventional spacings has been seen previously. Wheat forage growth on or near the band was visually superior to growth further from the band. This erratic growth has been termed "ribboning". In 1979 a P response was noted at only one of three locations and no significant differences in treatments were seen, these effects did not manifest themselves in increased grain yield or nutrient content. The 1980 data showed no significant increases in grain yields, due to shank spacings, even though a fertilizer P response was noted at all three locations. The researchers report that the 1980 data was severely affected by adverse weather conditions.

CHAPTER III

METHODS AND MATERIALS

An experimental procedure was designed to determine the effects of four dual injection band widths and four phosphorus fertilizer levels on winter wheat (Triticum aestivum L.)

The four band spacings used were 15, 30, 45, and 60 cm. Phosphorus fertilizer rates included 0, 9.6, 19.2, and 28.8 kg P per hectare. Ammonium polyphosphate (APP), 10-15-0 (elemental form) was the single P source. A constant rate of nitrogen, 84 kg per hectare was applied as anhydrous ammonia, (NH_3), 82-0-0. Phosphorus rates were applied via dual injection of APP with NH_3. Due to the varying N levels contained in differing rates of APP, liquid urea ammonium nitrate, (UAN), 28-0-0 was applied as a boom spray application to give a constant N rate of 104 kg per hectare. All combinations of P rates and shank spacings plus an unfertilized control gave seventeen treatments (Table I). The treatments were replicated four times in a randomized complete block design.

Four locations were selected for experimental areas. The Seventh Approximation classification of the soils used in this study are reported in Table II. Two of the sites were at branch stations of the Oklahoma Agricultural Experiment Station System. The other two areas were on farms owned by Mr. Ron Voth, a farmer residing near Orienta, Oklahoma. Initial soil test indexes are reported in Table III. Other location information is provided in Tables IV and V. The Tipton

TABLE I

FERTILIZER SOURCES, RATES, AND SHANK SPACINGS

N				P	
NH3	UAN	APP	Total	APP	Spacing
kg/ha					cm
0	0	0	0	0	--
84	19.8	0	104	0	15
84	13.2	6.6	104	9.6	15
84	6.6	13.2	104	19.2	15
84	0	19.8	104	28.8	15
84	19.8	0	104	0	30
84	13.2	6.6	104	9.6	30
84	6.6	13.2	104	19.2	30
84	0	19.8	104	28.8	30
84	19.8	0	104	0	45
84	13.2	6.6	104	9.6	45
84	6.6	13.2	104	19.2	45
84	0	19.8	104	28.8	45
84	19.8	0	104	0	60
84	13.2	6.6	104	9.6	60
84	6.6	13.2	104	19.2	60
84	0	19.8	104	28.8	60

TABLE II

SEVENTH APPROXIMATION CLASSIFICATIONS OF SOILS

Location	Description
Haskell	Taloka silt loam, fine, mixed, thermic, Mollic Albaqualfs
Orienta East	Reinach very fine sandy loam, coarse, silty, mixed, thermic, Pachic Haplustolls
Orienta West	McLain silty clay loam, fine, mixed, calcareous, thermic, Pachic Argiustolls
Tipton	Tipton fine sandy loam, fine-loamy, mixed, thermic, Pachic Argiustolls

TABLE III

INITIAL SOIL TEST RESULTS

Location	pH	B.I.	NO_3-N	P	K
			kg/ha		
Haskell	4.6	6.5	62	46	101
Orienta East	7.3	--	21	63	242
Orienta West	7.1	--	40	100	725
Tipton	7.4	--	95	148	601

TABLE IV

FERTILIZATION, SEEDING DATES, WHEAT VARIETIES AND SEEDING RATES

Location	Date Fertilized	Variety	Seeding Rate	Seeding Date
			kg/ha	
Haskell	10/30/80	TAM 101	101	11/05/80
Orienta East	9/18/80	TAM 101	67	10/03/80
Orienta West	9/30/80	Payne	101	12/18/80
Tipton	10/10/80	TAM 101	67	11/04/80

TABLE V

PLOT SIZES, HARVEST AREAS, AND HARVEST DATES

Location	Plot Size	Yield Area		Harvest Date	
		Grain	Forage	Forage	Grain
	m	m^2			
Haskell	5.2 X 15.2	45.6	11.6	4/02/81	6/23/81
Orienta East	4.9 X 9.1	27.3	----	-------	6/08/81
Orienta West	6.1 X 12.2	36.6	----	-------	6/23/81
Tipton	5.2 X 12.2	36.6	2.8	3/13/81	6/19/81

location was on the Southwest Agronomy Research Station, south of Tipton, Oklahoma. The soil was a Tipton very fine sandy loam having very good structure and moisture during the growing season. The Tipton study was pre-irrigated prior to fertilizer application and was irrigated once during the first week of December and again during the last week of February. Due to spring rainfall, subsequent irrigation was not necessary.

The Haskell location was on the Eastern Research Station south of Haskell, Oklahoma. The soil at this location is classified as a Taloka silt loam. The soil moisture conditions at the time of fertilizer application were good. Planting conditions were excellent and as a result a good stand of wheat was obtained. Rainfall in the late fall and spring was at such levels that high grain yields were produced.

The Orienta locations were north of Fairview, Oklahoma, situated west of the Cimarron River. The Orienta East site is a Reinach very fine sandy loam. This area had considerable crop residue present from the previous year's wheat crop. The shortage of precipitation during the summer prevented residue decomposition. This location lacked sufficient rainfall for good forage growth, although late winter and early spring rains produced enough forage to enable the cooperator to use the area for cattle pasture. Cattle grazing of the experimental area was ceased in early March, 1981. Later precipitation was adequate for the location to produce moderate yields.

The Orienta West experiment was conducted on a McLain silty clay loam soil. The area had been mouldboarded deeply after the previous wheat harvest, and due to insufficient rain there were large soil aggregates still present at fertilizer application and planting times. The soil was dry to the depth of plowing. In an effort to firm the seedbed, the field was disked prior to fertilizer application. This location was originally sown witha 67 kg per hectare rate of TAM 101 variety wheat on October 23, 1980. Due to poor moisture and growing conditions during that time period, it was decided to replant the study on December 18, 1980. Payne variety was sown at a 101 kg per hectare rate. Moisture remained critical and a partial stand was attained by March, 1981. Due to the thin stand, weed encroachment was inevitable and by May, competition from Kochia (*Kochia scoparia*) became critical. 2,4-D was applied but did not do a thorough job of controlling the weeds. Because of the weed problem, the fourth replicate was not harvested for grain. The other three replicates were weed infested to some extent, but were deemed harvestable.

The dual injection treatments were placed pre-plant using a three tool bar anhydrous ammonia rig. This was fitted with a stainless steel tank to serve as the APP reservoir, a Bloomhart flow divider manifold for the APP and a John Blue nitrolator to regulate the ammonia flow. The pressure to drive the APP delivery system was provided by a PTO driven roller pump. The three parallel tool bars were spaced 45 cm apart. The front tool bar had five springtooth shanks mounted on it at 45 cm intervals. The rear two tool bars had four each of the same type shanks mounted in the same fashion. The shanks were spaced so that the plow points were staggered in a diagonal, from front tool bar to back, with a 15 cm difference from bar to bar. The reason for this arrangement scheme was to facilitate crop residue flow between shanks. Ultimately, in effect there were thirteen shanks spaced 15 cm apart. Fifteen cm wide cultivator sweeps were bolted to the front of the shanks and the dual injection delivery tubes were bolted to the back side. The dual injection tube assembly consisted of two stainless steel tubes with a 2.5 cm gap between them (to prevent freeze up of APP tube by ammonia) welded to a piece of angle iron with holes drilled in appropriate places. To achieve the respective band widths, delivery lines were turned on or off depending upon the desired spacing. The treatments were placed approximately 18 cm deep. The experimental areas were disked prior to planting.

The plots were sown to respective wheat varieties using a John Deere LZ minimum tillage type hoe drill. The wheat drill hoes were spaced 25 cm apart.

Determination of forage yield at the Tipton location was accomplished by using a gasoline engine powered flail type mower mounted on a small International Cub tractor. A 0.9 m by three m area was harvested from the end of each plot. The effectiveness of the machine for determination of wheat forage yield was not without question. Treatment fourteen replicate three and treatment eight replicate four had considerable amounts of soil contamination in the harvested forage. Because of this, those values were dropped from forage yield and related statistical analyses. The dry matter conversion samples were used for laboratory analyses. The samples used in the laboratory were sufficiently cleaned by a series of screening and blowing them through a density air column (seed separator).

Forage yield at Haskell was determined by using another type of machine. A Kincaid Equipment Manufacturing Company forage harvester was used. This machine performed better than the flail type mower described perviously. This forage harvester utilizes a horizontal sickle bar for cutting and a belt for elevating forage into a bin. At the time forage yield was taken at this location, it was noticed by visual inspection that the plots had fertilizer bands running perpendicular to them. It was ascertained that 504 kg per hectare of 12-5.2-10 had been banded with the previous sorghum crop in 0.9 m rows that ran perpendicular to the plots. Because of drought the sorghum crop failed and considerable residual fertilizer remained. The crop was then plowed under and fallowed until the wheat experiment was initiated. The soil at this location is considered low in native P, but the initial soil test reported 46 kg P/hectare present. It is possible that when the area was soil sampled, cores were taken in previous fertilizer bands. Therefore, the soil test results reported in Table III may not be indicative of the actual nutrient status of this experimental area. Due to this problem, forage yield and resulting data could possible be confounded to some extent. In an effort to discern differences in nutrient content of the forage growing between previous bands of fertilizer, tissue samples were taken for laboratory analysis. Forage yield was taken by harvesting a strip 0.75 m wide by the length of the plot. The dry matter conversion sample was also used for tissue analysis. It was discovered by visual inspection that treatment five replicate three did not receive phosphorus fertilizer during the treatment applications. Because of this problem the plot was not considered for statistical determinations. Treatment fourteen replicate four laboratory analysis sample was not found when laboratory work was begun. Therefore appropriate statistical measures were taken for missing values.

Grain yield was determined at all four locations by using a Gleaner Model A, self-propelled combine with a three m header. The center three meters of each plot were harvested and plot yield measured. A laboratory analysis sample was then taken from the grain. The Tipton location received rain and wind storms in May, 1981. This resulted in severe lodging of most plots. Lifter fingers were installed on the combine header and extreme care was taken to harvest all grain in the plots.

Percentage compositions of N, P, and K in both forage and grain were determined using standard Oklahoma State University Soil Fertility Research Laboratory procedures. N percentage was determined by using a sulfuric acid digestion on the plant materials and a micro-Kjeldahl procedure. Percent total P was determined by nitric-perchloric digestion of the plant material and a colorimetric determination. A Brinkman dipping probe colorimeter was then utilized to measure color and thus concentration. The same nitric-perchloric extract was analyzed for K using a Perkin Elmer model 403 atomic absorption spectrophotometer. Percentage composition of respective nutrients was multipled by forage yield and grain yield to measure nutrient removal on a per hectare basis.

All data were analyzed using the statistical analysis system (SAS). Analysis of variance procedures were followed for both Orienta locations. Because of missing values from Haskell and Tipton, the general linear models procedure was used for these locations. All computer work was performed through the Oklahoma State University Computer Center. All calculated least significant difference (LSD) values are a result of "F" values of significance of at least the 0.05 level for the treatment parameter in question.

CHAPTER IV

RESULTS AND DISCUSSION

Grain yield, percentage nutrient composition and grain nutrient uptake values for the Orienta East location are reported in Table VI. Nitrogen and potassium in grain and nitrogen uptake were the only parameters that were significant (0.05). Grain nitrogen content and total protein production on a per hectare basis were significantly increased by fertilizer N. There were no significant differences for these characteristics among fertilizer treatments. The initial soil test results from this location indicated the soil was about 90 percent sufficient for phosphorus, so little phosphorus response could be expected. Although not significant in terms of grain yield, the application of nitrogen did increase the quality of the harvested grain. Percent grain potassium was significantly different at the 0.05 level, although no definite treatment response pattern emerged. The bulk of the treatments were not different from the check. Due to lack of precipitation, ideal conditions for experimentation were not present.

Data for the Orienta West location are reported in Table VII. The only significant difference recorded was in percent grain phosphorus. No treatments however, were significantly different from the control. Grain yield was unaffected by treatments, again probably due to late planting and poor growing conditions. Although not significant, the control did produce the least amount of grain.

TABLE VI

GRAIN YIELD, NUTRIENT COMPOSITION, AND GRAIN NUTRIENT UPTAKE, ORIENTA EAST, 1981

Treatment									
N	P	Spacing	Yield	N	P	K	GNU*	GPU	GKU
kg/ha		cm	kg/ha		%			kg/ha	
0	0	--	1683	2.10	0.39	0.35	36	7	6
104		15	2057	2.84	0.38	0.32	58	8	7
104	+9.6	15	2143	2.94	0.37	0.33	63	8	7
104	+19.2	15	2017	2.88	0.39	0.33	58	8	7
104	+28.8	15	1903	3.00	0.36	0.31	57	7	6
104		30	2118	2.99	0.36	0.31	63	8	7
104	+9.6	30	2134	2.94	0.38	0.32	63	8	7
104	+19.2	30	2049	3.02	0.37	0.32	61	8	7
104	+28.8	30	2057	2.94	0.39	0.33	60	8	7
104		45	2130	2.97	0.37	0.32	63	8	7
104	+9.6	45	2199	2.90	0.36	0.32	64	8	7
104	+19.2	45	1891	2.96	0.39	0.31	56	7	6
104	+29.8	45	2000	2.81	0.41	0.34	56	8	7
104		60	2053	2.94	0.39	0.34	60	8	7
104	+9.6	60	2057	3.07	0.39	0.32	63	8	7
104	+19.2	60	2094	2.97	0.39	0.34	62	8	7
104	+28.8	60	2159	2.85	0.40	0.35	61	9	8
	LSD (.05)		N.S.	0.21	N.S.	0.03	8.0	N.S.	N.S.

*GNU, GPU, GKU represent uptake values of respective nutrients, calculated by multiplying yield times percent compostion of nutrient.

TABLE VII

GRAIN YIELD, NUTRIENT COMPOSITION AND GRAIN NUTRIENT UPTAKE, ORIENTA WEST, 1981

Treatment									
N	P	Spacing	Yield	N	P	K	GNU*	GPU	GKU
kg/ha		cm	kg/ha		%			kg/ha	
0	0	--	1419	3.05	0.54	0.53	43	8	8
104		15	2179	3.22	0.54	0.53	70	12	12
104	+9.6	15	1769	3.08	0.53	0.54	55	9	10
104	+19.2	15	1748	3.10	0.52	0.52	54	9	9
104	+28.8	15	1992	3.16	0.52	0.49	63	10	10
104		30	1468	3.15	0.55	0.56	46	8	8
104	+9.6	30	1683	3.09	0.55	0.54	52	9	9
104	+19.2	30	1496	3.19	0.54	0.54	48	8	8
104	+28.8	30	1516	3.20	0.55	0.59	49	8	9
104		45	1834	3.09	0.51	0.50	57	9	9
104	+9.6	45	1468	3.08	0.53	0.56	45	8	8
104	+19.2	45	2029	3.17	0.56	0.56	64	11	11
104	+28.8	45	1777	3.03	0.52	0.55	54	9	10
104		60	1659	3.05	0.53	0.58	51	9	10
104	+9.6	60	1573	3.04	0.54	0.56	48	8	9
104	+19.2	60	1683	3.06	0.54	0.57	51	9	9
104	+28.8	60	1748	3.23	0.54	0.54	57	9	9
	LSD (.05)		N.S.	N.S.	0.03	N.S.	N.S.	N.S.	N.S.

*GNU, GPU, GKU represent uptake values of respective nutrients calculated by multiplying yield times percent composition of nutrient.

At the Tipton location, both forage and grain data were taken, At no time during the growing season could differences in forage growth be visibly detected. The soil test values were such that all effects due to fertilizer application were negligible (Tables VIII and IX). The check contained the lowest amount of nitrogen in the forage, although this was not significantly different from fertilizer treatments. Forage potassium percent as well as forage potassium uptake was considerably higher for the Tipton location as compared to Haskell. This is most likely due to differences in soil potassium levels. The grain yields at this site were the highest of the four locations. Severe lodging of the wheat plants occurred during May, due to rain and wind storms. As compared to other locations, the protein content of the grain at Tipton appeared to be lower.

The Haskell location produced the most striking differences, as compared to the other locations (Tables X and XI). Forage growth differences were noted early in the growing season. Even with the 0.9 m bands of 504 kg per hectare 12-5.2-10 running perpendicular to the plots, significant differences in forage production were recorded. The 15 and 30 cm band spacings at high P rates produced greater amounts of forage than the same rates injected at 45 and 60 cm band widths. There were no statistical differences between medium and high P rates at the 15 cm spacing or at the 30 cm spacing. The wider spacing of 45 cm and the 28.8 kg P per hectare treatment did not produce more forage yield than the 30 cm spacing with 19.2 kg P per hectare. The low rates of dually injected fertilizer P at 15 and 30 cm shank spacings produced the same amount of forage dry matter as the high rate of P injected at 60 cm spacing. There was no difference between the check and the 60 cm

TABLE VIII

FORAGE DRY MATTER YIELD, NUTRIENT COMPOSITION AND FORAGE NUTRIENT UPTAKE, TIPTON, 1981

Treatment N	Treatment P	Spacing	D.M.	Dry Matter Yield	N	P	K	FNU	FPU	FKU
— kg/ha —		cm	%	kg/ha	——— % ———			—— kg/ha ——		
0	0	--	21.1	2257	3.57	0.52	4.29	81	12	97
104		15	17.7	1941	3.77	0.49	4.58	70	9	88
104	+9.6	15	17.3	1721	4.05	0.52	4.76	70	9	82
104	+19.2	15	15.4	1521	3.98	0.49	4.57	61	8	69
104	+28.8	15	16.0	1638	4.10	0.49	4.62	67	8	75
104		30	15.1	1608	4.14	0.49	4.83	67	8	78
104	+9.6	30	16.1	1612	4.13	0.55	4.89	64	9	77
104	+19.2	30	19.4	2249	4.26	0.52	4.57	94	12	103
104	+28.8	30	17.6	1980	3.87	0.50	4.63	74	10	89
104		45	16.7	1890	4.06	0.48	4.77	76	9	88
104	+9.6	45	14.9	1430	4.11	0.52	4.96	59	7	70
104	+19.2	45	14.4	1456	4.08	0.49	4.77	59	7	70
104	+28.8	45	16.8	1608	4.21	0.50	4.71	67	8	75
104		60	16.8	1469	4.22	0.50	4.55	61	7	70
104	+9.6	60	19.0	1775	4.01	0.49	4.57	70	9	80
104	+19.2	60	18.9	1942	3.76	0.46	4.45	72	9	86
104	+28.8	60	17.3	1887	4.03	0.52	4.49	75	10	83

No Significant Differences (.05)

*FNU, FPU, FKU represent uptake values of respective nutrients calculated by multiplying yield times percent composition of nutrient.

TABLE IX

GRAIN YIELD, NUTRIENT COMPOSITION AND GRAIN NUTRIENT UPTAKE, TIPTON, 1981

Treatment									
N	P	Spacing	Yield	N	P	K	GNU*	GPU	GKU
kg/ha		cm	kg/ha		%			kg/ha	
0	0	--	4168	2.58	0.41	0.34	108	17	14
104		15	3772	2.56	0.40	0.36	97	15	14
104	+9.6	15	4409	2.60	0.39	0.36	115	17	16
104	+19.2	15	3729	2.60	0.39	0.36	97	14	13
104	+28.8	15	3168	2.67	0.37	0.34	85	12	11
104		30	3619	2.67	0.40	0.36	96	14	13
104	+9.6	30	3382	2.62	0.39	0.35	89	13	12
104	+19.2	30	3537	2.59	0.40	0.36	92	14	13
104	+28.8	30	3375	2.63	0.38	0.35	89	13	12
104		45	3379	2.64	0.36	0.34	89	12	12
104	+9.6	45	3446	2.57	0.37	0.35	89	13	12
104	+19.2	45	3531	2.68	0.38	0.36	95	14	13
104	+28.8	45	3308	2.62	0.38	0.36	87	13	12
104		60	3500	2.69	0.38	0.34	94	13	12
014	+9.6	60	3421	2.56	0.38	0.34	87	13	12
104	+19.2	60	3229	2.64	0.38	0.34	85	12	11
104	+28.8	60	3199	2.62	0.39	0.35	84	13	11

No Significant Differences (.05)

*GNU, GPU, GKU represent uptake values of respective nutrients calculated by multiplying yield times percent composition of nutrient.

TABLE X

FORAGE DRY MATTER YIELD, NUTRIENT COMPOSITION AND FORAGE NUTRIENT UPTAKE, HASKELL, 1981

Treatment N	Treatment P	Spacing	D.M.	Dry Matter Yield	N	P	K	FNU*	FPU	FKU
— kg/ha —		cm	%	kg/ha	———	% ———		——	kg/ha	——
0	0	--	21.8	324	4.41	0.24	3.42	14	1	11
104		15	20.0	237	5.17	0.23	3.43	12	1	8
104	+9.6	15	20.1	723	4.75	0.27	3.09	34	2	22
104	+19.2	15	19.0	1330	5.16	0.35	2.44	69	5	32
104	+28.8	15	18.6	1320	4.99	0.38	2.48	66	5	33
104		30	20.4	286	4.87	0.24	3.38	14	1	10
104	+9.6	30	20.0	544	4.79	0.27	3.02	26	2	16
104	+19.2	30	18.8	991	5.12	0.34	2.67	51	3	26
104	+28.8	30	18.1	1155	5.31	0.43	2.54	61	5	29
104		45	20.8	281	4.73	0.23	3.40	13	1	10
104	+9.6	45	19.3	680	4.94	0.29	3.01	34	2	20
104	+19.2	45	18.3	693	5.18	0.35	2.85	36	3	20
104	+28.8	45	18.5	806	5.30	0.38	2.68	42	3	22
104		60	21.4	269	4.69	0.23	3.34	8	1	6
104	+9.6	60	19.3	502	4.99	0.30	3.13	25	2	16
104	+19.2	60	19.0	665	4.99	0.35	2.86	33	2	19
104	+28.8	60	19.1	711	5.01	0.34	2.97	35	2	21
	LSD (.05)		0.7	218	0.36	0.04	0.33	11	1	6

*FNU, FPU, FKU represent uptake values of respective nutrients calculated by multiplying yield times percent composition of nutrient.

TABLE XI

GRAIN YIELD, NUTRIENT COMPOSITION AND GRAIN NUTRIENT UPTAKE, HASKELL, 1981

Treament N	P	Spacing	Yield	N	P	K	GNU*	GPU	GKU
— kg/ha —		cm	kg/ha		%			kg/ha	
104	0	--	2964	2.76	0.29	0.33	82	8	10
104		15	2830	3.18	0.26	0.31	90	7	9
104	+9.6	15	2952	3.25	0.23	0.28	96	7	8
104	+19.2	15	2817	3.12	0.26	0.28	88	7	8
104	+28.8	15	2797	3.07	0.27	0.31	86	8	9
104		30	2769	3.07	0.26	0.31	85	7	9
104	+9.6	30	3135	3.23	0.24	0.30	101	8	9
104	+19.2	30	2891	3.10	0.25	0.29	89	7	8
104	+28.8	30	2305	3.09	0.28	0.31	71	7	7
104		45	2866	3.10	0.25	0.30	89	7	9
104	+9.6	45	2854	3.22	0.25	0.29	92	7	8
104	+19.2	45	2610	3.10	0.26	0.30	81	7	8
104	+28.8	45	2342	3.28	0.27	0.30	77	6	7
104		60	2805	3.22	0.26	0.30	91	7	8
104	+9.6	60	3074	3.15	0.25	0.29	97	8	9
104	+19.2	60	2635	3.22	0.26	0.30	85	7	8
104	+28.8	60	2695	3.12	0.27	0.30	84	7	8
	LSD (.05)		342	0.18	N.S.	0.02	10	1	1

*GNU, GPU, GKU represent uptake values of respective nutrients calculated by multiplying yield times percent composition of nutrient.

spacing of 9.6 kg P per hectare in forage production. The treatments with N only injected at the four spacings were statistically similar to the check plot. Dry matter percent was affected by treatments. The high P rate treatments produced the least amount of dry matter, and the check and the N only treatments had the greatest dry matter percentage. This is indicative of greater water content by the treatments with high P levels. This could mean that the high P rates may help produce more efficient forage growth as far as water absorption is concerned.

Nutrient percentages contained by the forage were found to be statistically different also. The forage N percentage did not appear to follow any distinct treatment trends, although the check was statistically lower in N content than fertilizer treatments receiving phosphorus. Percent forage P was found to be highest in the treatment with the high P rate at the 30 cm spacing. The high and medium P rates at 15 and 45 cm band widths were not significantly different. Potassium content was found to have an approximately inverse relationship to forage production. The treatments producing greater forage growth probably contained less K because of dilution.

As mentioned earlier, samples for laboratory analysis were taken between the fertilizer bands running perpendicular to the plots. The results from laboratory analyses of these tissue samples are reported in Table XII. The two sampling types were considered subunit factors with the whole plot being considered the main unit and a split-plot statistical analysis was performed. Sampling type data for nutrient composition percentage, reported in Tables X and XII were found to be significant at the 0.05 level for percent N, although no statistical differences were found between P and K percentages. The significant differences

TABLE XII

NUTRIENT COMPOSITION OF FORAGE GROWING
BETWEEN BANDS, HASKELL, 1981

Treatment			N	P	K
				%	
Check			3.95	0.22	3.38
104 kg N/ha		15 cm Spacing	4.33	0.20	3.41
"	+9.6 kg P/ha	"	4.43	0.27	2.99
"	+19.2 kg P/ha	"	4.55	0.32	2.80
"	+28.8 kg P/ha	"	4.68	0.34	2.51
"		30 cm Spacing	4.49	0.23	3.46
"	+9.6 kg P/ha	"	4.63	0.26	3.14
"	+19.2 kg P/ha	"	4.75	0.35	2.53
"	+28.8 kg P/ha	"	4.69	0.41	2.61
"		45 cm Spacing	4.30	0.22	3.41
"	+9.6 kg P/ha	"	4.79	0.31	2.85
"	+19.2 kg P/ha	"	4.81	0.37	2.47
"	+28.8 kg P/ha	"	4.99	0.40	2.77
"		60 cm Spacing	4.40	0.22	3.36
"	+9.6 kg P/ha	"	4.80	0.30	2.97
"	+19.2 kg P/ha	"	4.72	0.35	2.51
"	+28.8 kg P/ha	"	4.76	0.38	2.48
	LSD (.05)		0.24	0.04	0.34

sample types could be due to the fertilizer in the previous bands.

The N content of the samples taken between the previous bands had a general tendency to increase as phosphorus fertilizer rates increased, although this was not statistically significant. The high dually injected P rates at the 30 and 45 cm spacings produced greater P content than did the same rate with the 15 cm spacing. Potassium percentage tended to decrease with increasing P fertilizer level. The same general trends were detected by both methods of sampling for P and K, however N percentages were in some cases markedly different.

Forage nitrogen uptake, (FNU), a measure of nutrient removal on a per hectare basis, was found to have statistically different treatment effects. The two narrow spacings at the medium and high P fertilizer rates produced more protein than the other spacings and rates. The low P rate at the 15 cm band width produced as much protein as the high P rate at the 45 and 60 cm spacings. The check produced statistically the same amount as the low P level with the 60 cm spacing. The treatments with N fertilizer only did not produce any more than the control. Forage phosphorus uptake (FPU) results show that the 15 cm spacing at the medium and high rates of P fertilizer and the 30 cm spacing at the high P level had a significantly higher P removal than all other treatments. As the spacings get wider and as P fertilizer rates decrease, the phosphorus uptake on a per hectare basis decreases. Again, there were no differences between the treatments that received N only and the check. Forage potassium uptake (FKU) results show that on a per hectare basis K uptake was significantly greater for the higher yielding treatments. This is another indication that K was undergoing dilution.

Even though striking differences were recorded in forage growth, this did not carry over into grain yields (Table XI). Grain yields did not tend to follow any distinct trends. Most treatments were not significantly different from the control. No treatments produced greater amounts of grain than the check, although several produced lower. This cannot be readily explained. The residual fertilizer in the previous bands probably had the most profound effect on grain yield. The initial soil test P indicated a 90 percent sufficiency of this soil for grain production.

Grain nitrogen uptake (GNU), grain phosphorus uptake (GPU) and grain potassium uptake (GKU) were found to be significantly different with respect to treatment. However, these parameters are defined as yield times percent of the respective nutrient, and due to the grain yield and nutrient composition not following any discernable trends, neither do these parameters.

CHAPTER V

SUMMARY AND CONCLUSIONS

A constant nitrogen fertilizer rate, four phosphorus fertilizer rates and four shank spacings of dually injected N and P were tested at four locations in Oklahoma. During active spring growth, forage yield was measured and nutrient composition was subsequently determined. Grain yield determinations were made and nutrient composition determined for the grain. Statistical analyses were performed on forage and grain parameters for each location. A split plot design was then utilized to compare the effects of fertilizer treatments over the four locations. The following conclusions can be made from the experimentation.

Statistically different levels of all parameters were found when compared over locations. Significant location by treatment interactions were present for 1) forage: percent nitrogen, percent phosphorus, percent potassium; 2) grain: percent nitrogen, percent potassium, nitrogen uptake, and phosphorus uptake.

The shank spacings and fertilizer applications had no positive effect on grain yields at any location. Response to nitrogen fertilizer was indicated by increased grain nitrogen percentage in grain samples from the Orienta East and Haskell locations. Response to nitrogen fertilizer was also noted in grain nitrogen uptake at Orienta East and Haskell. Forage parameters were not significantly affected by dual application at Tipton, although several characteristics were affected at the Haskell site. Forage yield as measured by dry matter production, forage nitrogen uptake, forage phosphorus uptake, and forage potassium uptake were greatly affected by phosphorus fertilizer rate and shank spacing. At the 15 cm spacing and the 19.2 kg P per hectare rate, statistically similar values for the above named characteristics were produced as compared to the 30 cm spacing and 28.8 kg P per hectare rate. For low pH, low phosphorus soils, narrower shank spacings of dually injected N and P and lower P fertilizer rates could be utilized by growers to optimize forage production for cattle grazing. With the Haskell data in mind, a net savings of 9.6 kg P fertilizer pre hectare could be realized by using the 15 cm spacing as compared to the wider spacings, while producing the same amount of forage.

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