EFFECT OF VARIOUS FERTILITY TREATMENTS, WHEAT STRAW ADDITIONS, AND SOIL STERILIZATION UPON THE YIELD OF WHEAT AND SUDAN GRASS

By

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I. INTRODUCTION

Proper fertilization of wheat in the western part of Oklahoma is one of the more important problems of the farmers in that area. Most farmers in this area grow only wheat for a cash crop and are vitally concerned with obtaining high yields and maintaining good soil productivity.

Most farmers leave the straw on the ground when they combine wheat. Therefore, it is desirable to determine the effects of large additions of straw, with and without nitrogen, on following wheat yields. The breakdown of wheat straw into humus is a complex procedure involving the activities of soil microorganisms and their utilization, "tie up", and release of available nitrogen in the soil. Factors affecting activities of soil organisms and resulting influence on available plant nutrients, particularly nitrogen, greatly influence crop growth and grain yield.

This study was undertaken with the objective of determining effects of various fertility treatments and wheat straw additions, with and without soil sterilization, on yields of wheat under field and greenhouse conditions and sudan grass in greenhouse experiments.

II. REVIEW OF LITERATURE

The literature concerning fertilization of wheat is voluminous. This review is primarily concerned only with portions of this information that may be directly related to this study.

The influence of residual straw remaining on the ground after harvest has received much attention. Jongedyk and Hickock (9)* reported that wheat grown under low rates of fertilization in a three year rotation of corn, wheat, and mixed meadow had the following quantities of the main fertilizer components per ton of straw: Nitrogen as N, 12.4 pounds; phosphorus as P_2O_5, 26.0 pounds; potassium as K_2O, 19.2 pounds. But when wheat was grown under high rates of fertilization and with the same rotation as above, the straw contained the following quantities of the main fertilizer components per ton of straw: Nitrogen as N, 19.4 pounds; phosphorus as P_2O_5, 34.4 pounds; potassium as K_2O, 38.8 pounds.

Smith, et al. (19) reported that by the additions of nitrogen in 0, 30, 60, and 90 pound rates, the forage yield of wheat was increased by approximately 500 pounds for each 30 pound increment over the range from 0 to 90 pounds of nitrogen. Applications of P_2O_5 at a rate of 50 pounds per acre also increased the forage yields of wheat. Applications of K_2O had no effect on the forage yields.

Bartholomew and Hiltbold (2) applied corn fodder and alfalfa to soils. They reported that plant yields and nitrogen uptake were lower in the soils to which corn fodder had been applied than in the soils which had no residue or alfalfa added. Plant absorption of nitrogen

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*Figures in parenthesis refer to "Literature Cited".

from the fertilizer increased in direct proportion to the rate of application. Recoveries in the total crop ranged from 27 to 54 percent of the nitrogen applied. The lower percentage recoveries were generally associated with the lower rates of nitrogen applications and with the addition of plant residue to the soil.

According to Dalton, et al. (5) soil organic matter is beneficial in making soil phosphorus more available. Easily decomposable organic matter is more effective for increasing the availability of soil phosphorus than are organic substances that decompose slowly.

Verma and Kohnke (22) reported in their findings that by the additions of wheat straw and corn stover as mulches, the organic matter content of the top five inches was increased slightly over a year's period.

Working with the yields of wheat, Williams and Smith (24) reported that the yield of wheat was increased a greater percentage when 25 pounds of nitrogen was applied per acre than when the rate was 50 and 100 pounds of nitrogen per acre. Although they found a small increase in the yield with applications of 50 and 100 pounds of nitrogen, the 100 pound rate resulted in the greatest increase in percent of protein in the grain. Their highest yields were obtained from 50 and 100 pound rates of nitrogen combined with 50 pounds of phosphorus (P_2O_5) per acre.

According to Broadbent (4), additions of nitrogen to oat straw residue will decrease the weight loss during decomposition compared to straw receiving no additions of nitrogen. With the addition of nitrogen the cation exchange capacity (m.e. per 100 grams) of the residue was increased during the initial period of decomposition (0-135 days), but the cation exchange capacity of the untreated residue was higher in

the following period from 135 to 452 days.

Allison (1) writing on the question of "Does nitrogen added to crop residues produce more humus?" stated that the addition of nitrogen to crop residues does not necessarily help hold extra carbon in the crop residue, but the extra nitrogen may result in better crop growth and thereby add more residue to the soil for the formation of organic matter. In most farm crops heavy fertilization will not only increase yields but will also contribute toward solving the problem of maintenance of adequate soil organic matter.

Reporting on twenty years of research on wheat fertilization in Oklahoma, Murphy (10) stated that phosphorus fertilization increased wheat yields but decreased the protein content of the grain. Nitrogen fertilization increased the protein content of wheat. Many of the soils of Oklahoma need phosphorus fertilizer to increase yields, and more will need it in the future. When phosphate is used to obtain better yields of wheat, the soil must have a good supply of nitrogen to maintain the percentage of protein in the grain. This means that the use of legumes, organic residues, and nitrogen fertilizers is becoming increasingly important in the management of Oklahoma wheat soils. Murphy reported that the highest yields were obtained with a fertilizer mixture of three-fourths phosphorus and one-fourth nitrogen. This treatment gave higher yields than the superphosphate alone. He also found that the residual effect of superphosphate was pronounced in maintaining yields, although high rates of application of phosphate with limited or no nitrogen showed definite nitrogen deficiency of the wheat plant. The residual effects of nitrogen were less than those of phosphorus.

Smith (17), reporting on the yield of wheat on Geary silt loam soil of Kansas, stated that the best yields were obtained when 25 pounds of P_2O_5 per acre were applied with the seed plus 25 pounds of N per acre as a spring top-dressing. Different rates and times of application of fertilizers did not increase significantly the protein content of the wheat.

Pesek and Dumenil (12) stated that grain crops do not remove more than half of the nitrogen and a fourth of the phosphorus and potassium from applied fertilizer, provided that the stover or straw remains in the field. Residual effects of nitrogen will vary from one area to another, and from season to season within a given area. Residual effects of phosphorus are very good if it was applied in large quantities. The risks connected with fertilizer use and cropping are reduced materially by the residual effects. All the fertilizer is not lost, even though drouth, poor stand, insects, and other factors prevent good returns in the year of application.

Patterson (11) reported on a three course rotation experiment on the use of wheat straw and fertilizers which have been in progress at Rothamsted Experiment Station since 1933. The experiment was conducted to provide information on the use of wheat straw (plowed under or composted) in the maintenance of fertility. The treatments used were additions of fertilizer without straw and additions of fertilizer with straw and compost made of straw. The mean yield of potatoes, grown under these conditions, were higher during the period of 1933-1951 for the plots which received applications of straw with fertilizer than for those which received no straw.

Working on the theory that growth and nitrogen uptake by soybeans

are depressed by incorporation of substantial rates of straw in the soil, Englehorn, et al. (6) reported on a field experiment which had additions of straw and cornstalks with and without additions of nitrogen. They found no decrease in yield of threshed soybeans as a result of plowing under straw or cornstalk residues. They believed that incorporation of straw at time of plowing would have its main effect on the amount of nitrogen available early, but unless the straw was added in excessive amounts it would not be likely to reduce the supply of nitrogen during the critical growth stage of the soybeans.

Where Englehorn, et al. (6) reported that the additions of straw to the field had no effect on the yield of soybeans, Pinck, et al. (14), working under greenhouse conditions, found that the additions of large amounts of straw decreased the yield of soybeans when no nitrogen was applied. When four tons of straw and 25 pounds of nitrogen per acre were applied they found a slight decrease in yields as compared to their check pots. But when the same amount of straw was applied with higher rates of nitrogen there was an increase in yield.

Pinck, et al. (13), conducted an experiment to determine the quantity of nitrogen that must be applied to a growing crop to counteract the effect of the added carbon applied as straw. In order to increase the growth of sudan grass when two and four tons of straw were applied, it was necessary to add nitrogen at the rate of 50 pounds or more per acre.

Investigating the effects of organic residues and nitrogen fertilizers under two cropping systems on a Palouse silt loam soil in Washington, Smith and Vandecaveye (18) reached the following conclusions. Nitrogen was the principal factor which determined the crop yields, for

continuous wheat and wheat after fallow. Application of straw without supplemental nitrogen resulted in a decrease of yields.

III. EXPERIMENTAL PROCEDURE

Soil Description

The field plots were located in Township 22 N, Range 7 W, SW 4th of the SE 4th of Section 13, Garfield County, Oklahoma.

The soil was a youthful soil and appeared to have been developed in young alluvium. The soil does not have any strongly developed horizons. A sandy layer found at 30 inches indicates stratified layering of the soil. A similar soil was used for the greenhouse studies. A summary of the physical and chemical properties of the soils used are presented in table 1. These soils are classified according to mechanical analysis as loam soils.

The following is a description of the soil profile: From 0-12 inches, brown loam, friable, weak granular, grades to layer below, pH of 6.0 to 6.2. From 12-15 inches, dark grayish brown, silty clay loam, friable, weak medium subangular blocky, breaks to medium granular, grades to layer below. From 15-30 inches, reddish brown, silty clay loam, weak subangular blocky, breaks to medium granular, many worm cast, grades to layer below. Below 30 inches, yellowish red, fine sandy loam, mottled with darker splotches.

Greenhouse Studies

The objective of this study was to determine the effect of the various fertilizer treatments and wheat straw additions, with and without soil sterilization, upon the forage yield of wheat and sudan grass under greenhouse conditions.

Table 1. Physical and chemical characteristics of soil used in the greenhouse and field experiments.

Soil	Soil Texture[1]			Soil pH[2]	Nitrogen %[3]	Digestible Carbon %[4]	Extractable K_2O lbs/A[5]	Extractable P_2O_5 lbs/A[6]	Cation Exchange Capacity in m.e./100 Grams[3]
	% Sand	% Clay	% Silt						
Greenhouse	46.75	12.00	41.25	6.0	.078	1.59	228	71.36	11.49
Field Plot 0-12"	48.50	8.50	43.00	6.2	0.85	1.54	316	80.96	11.01

1. Determined essentially by method of Bouyoucos (3).
2. Determined by Beckman glass electrode pH meter, using soil-water ratio of 1:1.
3. Determined by method of Piper, C. S. (15).
4. Determined by method of Walkley and Black (23).
5. Determined by method of Harper (8).
6. Determined by method of Harper (7).

Ammonium nitrate, monobasic calcium phosphate, and wheat straw were used in combinations that enabled the potted soils to be fertilized at rates equivalent to 160 pounds of elemental N, 120 pounds of P_2O_5, two and six tons of air dry wheat straw calculated on an acre basis. Sixteen pounds of soil were weighed into a sufficient number of two gallon glazed earthenware pots to enable all treatments to be made in triplicate. On January 15, 1955, the wheat straw was added to all the pots and on January 19, 1955, half of the pots were sterilized under steam pressure for approximately 12 hours at 120° - 130° C. On January 21, 1955, the fertilizer treatments were added as solutions. On this same day the pots were planted to wheat, Ponca variety. The seedlings were thinned to a uniform stand of 10 plants per pot.

On May 18, 1955, the above ground portions of the plant were harvested. The relative growth of this crop was measured by the dry weight of the plant tissue. A sample of soil was taken from each pot and carbon and nitrogen content was determined on these samples. Analyses of the harvested wheat plant tissue were made for nitrogen, phosphorus, and potassium.

Iahoma Sweet Sudan was planted on May 23, 1955 in the same pots from which wheat forage was harvested. No further fertility treatments were made. This crop was harvested on July 6, 1955. The relative growth was measured by the dry weight of plant tissue. Analyses of harvested sudan grass forage were made for nitrogen.

Wheat and sudan grass forage was analyzed by the following methods: potassium by methods of Toth, et al. (21); phosphorus by methods of Shelton, et al. (16); and nitrogen by methods of Piper (15). Soil nitrogen was determined by methods of Piper (15) and soil carbon was

determined by methods of Walkley and Black (23).

Field Studies

In order to study the effects of the various fertility treatments and additions of wheat straw under field conditions, an experiment was established on a field with, as nearly as possible, the same soil characteristics as the field from which the greenhouse soil sample was taken.

Wheat straw additions, in the rates of one and three tons per acre, were plowed under on December 21, 1954. Ponca variety of wheat was planted at the rate of approximately two bushels per acre on December 22, 1954. The seed were planted with a grain drill with a spacing of approximately seven inches between rows. The wheat was planted in the field as a split-split plot design, each treatment plot measuring 16 feet by 32 feet.

On February 22, 1955, the plots which received fertility treatments were top-dressed by hand. The kinds and rates of fertilizers used were as follows: Nitrogen as NH_4NO_3 supplying elemental N at the rate of 100 pounds per acre; phosphorus as 0-45-0 supplying P_2O_5 at the rate of 60 pounds per acre.

The wheat was harvested on June 30 and July 1, 1955, by selecting at random three four-foot square areas within each plot and compositing these three subsamples for determination of forage and grain yield of the individual plot. Grain and straw yields are reported as pounds per acre.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

Greenhouse Studies

Yields of wheat forage grown under greenhouse conditions are reported in table 2. The sterilized pots outyielded the unsterilized pots in all cases. The largest difference in yields for sterilized pots over unsterilized pots was produced by applications of phosphorus alone and in combinations with the straw additions. The next largest difference was produced by the pots which received no fertilizer treatment.

Within the unsterilized series the highest wheat forage was produced in the pots which received treatments of nitrogen and phosphorus only. Lowest yields in this series were obtained when phosphorus was combined with the high rate of straw addition. Low yields were also obtained when phosphorus was applied to the pots receiving the low rate of straw addition. All pots which received applications of straw benefited by the addition of nitrogen alone (Figures 1 & 2).

The highest forage yield for sterilized pots was produced by the pots which received treatments of three tons of straw with applications of nitrogen and phosphorus. Pots which received straw applications alone produced less forage than pots which received no fertilizer or straw treatment in the sterilized series. Applications of six tons of straw with phosphorus reduced the yield of forage, while applications of three tons of straw with phosphorus gave a small increase of yield over the untreated pots. Applications of nitrogen and nitrogen plus phosphorus increased the yields in all cases over the pots receiving no

Table 2. The effects of various fertilizer and wheat straw additions, with and without soil sterilization, on yield of wheat forage under greenhouse conditions.

Treatments*	Air Dry Forage Yield in Grams** Unsterilized	Sterilized
0	3.93	10.17
N	9.30	14.56
P	3.67	11.18
NP	14.53	15.33
S_1 0	2.54	8.09
S_1 N	7.79	14.25
S_1 P	2.21	10.84
S_1 NP	12.90	17.92
S_2 0	2.97	6.04
S_2 N	10.30	13.31
S_2 P	1.62	5.78
S_2 NP	8.40	15.51

* 0 = No treatment.
N = 160 pounds N per acre.
P = 120 pounds P_2O_5 per acre.
S_1 = 3 tons straw per acre.
S_2 = 6 tons straw per acre.

** Yields represent the mean of three replicates.

Crop planted January 21, 1955, and harvested May 18, 1955.

Analysis of Variance

Source	df	M.S.	F Value
Total	71		
Reps	2	291.03	86.20
Treatments	11	97.49	28.88*
Unst. vs. St.	1	89.03	26.37*
Error	57	3.38	

* F values significant at the 1% level (20).

Figure 1. Effect of various fertilizer and soil sterilization treatments on growth of wheat. A. N-sterilized, B. N-unsterilized, C. P-sterilized, D. P-unsterilized. (See table 2 for treatments and yields).

Figure 2. Effect of various fertilizer and soil sterilization treatments on growth of wheat. A. S_2 N-sterilized, B. S_2 N-unsterilized, C. S_2 P-sterilized, D. S_2 P-unsterilized. (See table 2 for treatments and yields).

treatment.

The reduced yields obtained from pots within the sterilized and unsterilized series, which received no nitrogen fertilizer with additions of wheat straw, gave an indication of the effect of soil microorganisms in the assimilation of available soil nitrogen. Additions of phosphorus only generally decreased yields of wheat forage and gives an indication of the need for nitrogen fertilizer when the available soil nitrogen is "tied up" by soil microorganisms utilizing the straw as a source of energy and carbon.

Sterilization of the soil seemed to decrease the activities of soil microorganisms which "tie up" available soil nitrogen. The increased nitrogen availability following soil sterilization may have resulted from reduced competition for activities of desirable ammonifiers and nitrifiers.

Analyses of variance were calculated for the yield of wheat forage. The F values for fertilizer, straw additions, and soil sterilization treatments were highly significant at the 1% level.

Wheat forage was analyzed for total nitrogen, phosphorus, and potassium content and results are reported in table 3. Nitrogen content, in general, was higher when nitrogen was applied alone within the unsterilized series. The highest nitrogen content was found when combined in nitrogen plus phosphorus treated pots of the sterilized series. Phosphorus content was higher when phosphorus was applied alone in unsterilized and sterilized series except on the high straw sterilized treatment. Analyses of variance were calculated and the F value was not significant at the 1% or 5% level.

Samples of soil were removed from the pots after the wheat crop

Table 3. The effect of various fertilizers and wheat straw additions, with and without soil sterilization, on the total nitrogen, phosphorus, and potassium contents of wheat forage grown under greenhouse conditions.*

	Unsterilized***			Sterilized***		
Treatments**	% N	% P	% K	% N	% P	% K
0	1.69	.688	0.90	1.54	.234	1.04
N	2.58	.310	1.13	2.11	.272	1.14
P	1.59	.817	1.01	1.72	.607	1.21
NP	2.36	.465	1.09	2.26	.536	0.98
S_1 0	1.91	.641	0.95	1.44	.348	0.97
S_1 N	2.49	.276	0.69	1.98	.192	1.13
S_1 P	1.90	.742	0.88	1.51	.590	0.93
S_1 NP	1.91	.428	1.20	2.24	.478	1.05
S_2 0	1.66	.674	0.68	1.35	.337	0.81
S_2 N	2.10	.273	1.10	1.63	.351	1.09
S_2 P	1.90	.654	0.78	1.32	.393	0.72
S_2 NP	1.83	.440	1.07	1.69	.523	1.06

* All forage analyses performed in duplicate by the following methods: N by methods of Piper (15), P by methods of Shelton, et al. (16), and K by methods of Toth, et al. (21).

** 0 = No treatments.
N = 160 pounds N per acre.
P = 120 pounds P_2O_5 per acre.
S_1 = 3 tons straw per acre.
S_2 = 6 tons straw per acre.

*** Average of three replicates.

Analysis of Variance

Source	df	M.S.	F Value
Total	23		
Treatments N	11	0.1557	1.76*
Error N	12	0.0896	
Treatments P	11	0.0393	1.65*
Error P	12	0.0238	
Treatments K	11	0.033	2.53*
Error K	12	0.013	

* F values are not significant (20).

was harvested and analyzed for percent nitrogen and carbon. The results are shown in table 4. Although limitations in the procedures for determining soil nitrogen and carbon are recognized, the additions of straw would be expected to influence the carbon percentages significantly. Total soil nitrogen is not related directly to available soil nitrogen. Analyses of variance were calculated and the F values were not significant for nitrogen but were significant at the 1% level for carbon.

The sudan grass followed wheat with no additional soil treatments applied. Differences in soil micro organism populations should be less marked and pots producing the high yields of wheat would be expected to produce lower yields of sudan grass as a result of soil depletion in available plant nutrients.

Sudan grass yields grown under greenhouse conditions are reported in table 5. Sudan grass forage showed less differences between the unsterilized and sterilized pots than wheat forage (Figures 3 & 4). The unsterilized pots outyielded the sterilized pots in nearly all treatments. The only treatments of the sterilized pots which outyielded the unsterilized pots were the ones which received the following treatments: phosphorus, nitrogen plus phosphorus, and three tons of straw plus nitrogen and phosphorus.

Unsterilized pots showed the same trend in yields of sudan grass forage and wheat forage. Treatments which produced less forage than untreated pots were phosphorus, 3 tons straw, 3 tons straw plus phosphorus, 6 tons straw, and 6 tons straw plus phosphorus. Applications of nitrogen and nitrogen plus phosphorus benefited the yield of forage.

Pots which were sterilized did not produce the same results for

Table 4. Chemical analysis of greenhouse soil following the wheat crop.*

	Unsterilized***		Sterilized***	
Treatments**	% N	% C	% N	% C
0	.030	1.43	.030	1.33
N	.027	1.67	.049	1.79
P	.037	1.61	.049	1.61
NP	.037	1.70	.049	1.73
S_1 0	.041	1.67	.062	1.85
S_1 N	.022	1.52	.057	1.73
S_1 P	.053	1.73	.049	1.70
S_1 NP	.026	1.73	.044	1.64
S_2 0	.055	1.73	.055	1.76
S_2 N	.046	1.79	.051	1.94
S_2 P	.033	1.73	.053	1.64
S_2 NP	.055	1.94	.053	1.89

* All analyses performed in duplicate by the following methods: N by methods of Piper (15), C by methods of Walkley and Black (23).

** 0 = No treatment.
N = 160 pounds N per acre.
P = 120 pounds P_2O_5 per acre.
S_1 = 3 tons straw per acre.
S_2 = 6 tons straw per acre.

*** Average of three replicates.

Analysis of Variance

Source	df	M.S.	F Value
Total	23		
Treatment N	11	.00013	1.00*
Error N	12	.00013	
Treatment C	11	.036	6.00**
Error C	12	.006	

* F value not significant (20).

** Significant at 1% level (20).

Table 5. The effects of various fertilizers and wheat straw additions, with and without soil sterilization, on growth of sudan grass following the wheat crop under greenhouse conditions.

Treatments*	Air Dry Forage Yield in Grams** Unsterilized	Sterilized
0	6.00	5.38
N	8.56	7.36
P	4.69	6.07
NP	6.53	9.21
S_1 0	4.92	4.85
S_1 N	7.62	5.20
S_1 P	5.06	4.09
S_1 NP	7.46	9.38
S_2 0	3.81	2.63
S_2 N	7.11	6.47
S_2 P	5.42	2.52
S_2 NP	7.30	7.06

* 0 = No treatment.
N = 160 pounds N per acre.
P = 120 pounds P_2O_5 per acre.
S_1 = 3 tons straw per acre.
S_2 = 6 tons straw per acre.

** Yields represent the mean of three replicates.

Crop planted May 23, 1955, and harvested July 6, 1955.

Analysis of Variance

Source	df	M.S.	F Value
Total	71		
Reps	2	13.38	6.33
Treatments	11	16.83	7.96*
Unst. vs. St.	1	24.57	11.62*
Error	57	2.11	

* F values are significant at the 1% level (20).

Figure 3. Effect of various fertilizer and soil sterilization treatments on growth of sudan grass. A. N-sterilized, B. N-unsterilized, C. P-sterilized, D. P-unsterilized. (See table 5 for treatments and yields).

Figure 4. Effect of various fertilizer and soil sterilization treatments on growth of sudan grass. A. S_2 N-sterilized, B. S_2 N-unsterilized, C. S_2 P-sterilized, D. S_2 P-unsterilized. (See table 5 for treatments and yields).

sudan grass forage as for wheat forage. The pots with the greatest yield were the ones which received treatment of 3 tons of straw plus nitrogen and phosphorus. The lowest yields were produced on the pots which received treatments of 6 tons of straw with phosphorus.

Analyses of variance were calculated and an F value for treatments and unsterilized vs. sterilized was found to be significant at the 1% level.

The sudan grass forage was analyzed for total nitrogen and the results are reported in table 6. Treatments were statistically significant for nitrogen content of sudan grass at the 1% level. In general, treatments which received nitrogen fertilizer produced forage having a higher nitrogen content.

Field Studies

Grain yields of wheat grown under field conditions are reported in table 7. The average of three replicates showed that there was a slight increase of yield for some of the treatments. The highest yielding plot received phosphorus alone. The plots which received phosphorus with nitrogen and one ton of straw gave an increased yield over the untreated plots. Additions of three tons of straw alone gave an increase over the check plot, but with added fertilizers the yields decreased.

Analyses of variance were calculated and the F value for treatments was not significant.

Straw yields of wheat grown under field conditions are reported in table 8. The addition of one ton of straw plus nitrogen gave the most marked reduction in straw yields. The highest yield of straw occurred on the plot treated with three tons of straw plus nitrogen and

Table 6. The effect of various fertilizers and wheat straw additions, with and without soil sterilization, on the total nitrogen content of sudan grass forage following wheat grown under greenhouse conditions.*

Treatments	Unsterilized** % N	Sterilized** % N
0	0.93	0.93
N	1.77	1.93
P	1.02	0.86
NP	1.36	1.43
S_1 0	0.92	1.23
S_1 N	1.83	1.47
S_1 P	0.93	1.11
S_1 NP	1.03	1.05
S_2 0	1.18	1.13
S_2 N	1.14	0.75
S_2 P	0.98	1.56
S_2 NP	1.20	1.15

* All analyses performed in duplicate by methods of Piper (15).

** Average of three replicates.

0 = No treatment.
N = 160 pounds N per acre.
P = 120 pounds P_2O_5 per acre.
S_1 = 3 tons straw per acre.
S_2 = 6 tons straw per acre.

Analysis of Variance

Source	df	M.S.	F Value
Total	23		
Treatments	11	0.173	5.09*
Error	12	0.034	

* F value significant at the 1% level (20).

Table 7. Grain yields in pounds per acre for wheat grown under field conditions.

Treatments	Replications* I	II	III	Mean
0	691.52	549.04	578.08	606.21
N	766.84	610.75	578.08	651.89
P	704.22	692.42	740.52	712.39
NP	524.54	607.12	711.48	614.38
S_1 0	722.37	507.29	503.66	577.77
S_1 N	500.03	548.13	638.88	562.35
S_1 P	713.30	622.55	547.22	627.69
S_1 NP	735.98	563.56	609.84	636.46
S_2 0	832.18	528.17	538.15	632.83
S_2 N	558.11	439.23	543.59	513.64
S_2 P	549.95	668.83	598.95	605.91
S_2 NP	571.73	541.78	539.06	550.86

* Reported as pounds per acre; yields represent the mean of three subsamples taken from each plot.

0 = No treatment.
N = 100 pounds N per acre as 33-0-0.
P = 60 pounds P_2O_5 per acre as 0-45-0.
S_1 = 1 ton straw per acre.
S_2 = 3 tons straw per acre.

Analysis of Variance

Source	df	M.S.	F Value
Total	35		
Reps	2	22196.15	3.19
Treatments	11	8141.15	1.17*
Error	22	6956.55	

* F value is not significant (20).

Table 8. Straw yields in pounds per acre for wheat grown under field conditions.

Treatments	Replications* I	II	III	Mean
0	3630.00	2904.00	2722.50	3085.50
N	3176.25	2994.75	3267.00	3146.00
P	3448.50	2994.75	2994.75	3146.00
NP	3085.50	3720.75	3176.25	3327.50
S_1 0	3176.25	2359.50	2450.25	2662.00
S_1 N	2904.00	2359.50	2631.75	2631.75
S_1 P	2994.75	2450.25	2813.25	2752.75
S_1 NP	4265.25	2631.75	3811.50	3569.50
S_2 0	3267.00	3448.50	2450.25	3055.25
S_2 N	2813.25	3357.75	2722.50	2964.50
S_2 P	2450.25	3176.25	2450.25	2692.25
S_2 NP	3630.00	3811.50	3902.25	3781.25

* Reported as pounds per acre; yields represent the mean of three subsamples taken from each plot.

0 = No treatment.
N = 100 pounds N per acre as 33-0-0.
P = 60 pounds P_2O_5 per acre as 0-45-0.
S_1 = 1 ton straw per acre.
S_2 = 3 tons straw per acre.

Analysis of Variance

Source	df	M.S.	F Value
Total	35		
Reps	2	270,629.74	1.63
Treatments	11	394,537.52	2.38*
Error	22	165,813.48	

*F value is significant at the 5% level (20).

phosphorus. When nitrogen plus phosphorus fertilizers were applied, the yield of straw was increased in all cases. Decreased yields were obtained with all straw treatments except where both nitrogen and phosphorus were also used.

Analysis of variance shows an F value for treatments which is significant at the 5% level.

The grain-straw ratio is reported in table 9. The highest ratio was found on the plots which received three tons of straw plus nitrogen and phosphorus. The lowest ratio occurred on plots which received one ton of straw with phosphorus.

A two factor differential correlation was made between yields of straw and grain, by methods of Snedecor (20). The correlation coefficient was found to be 0.280 and is assumed to be an unreliable indication of correlation.

Climatic conditions during crop growth were not favorable for the activities of soil microorganisms. Decomposition of the added straw and nitrogen release were slow. A very dry fall and winter was followed by a cool spring and early summer with soil moisture limiting until the late spring months. These conditions undoubtedly influenced the experimental results to a large extent.

Table 9. Straw-Grain ratio of wheat grown under field conditions.

Treatments	Ratios*
0	5.09:1
N	4.87:1
P	4.46:1
NP	5.47:1
S_1 0	4.55:1
S_1 N	4.68:1
S_1 P	4.34:1
S_1 NP	5.56:1
S_2 0	4.88:1
S_2 N	5.83:1
S_2 P	4.49:1
S_2 NP	6.92:1

* Average of three replications, each replication value representing the mean of three subsamples taken from each plot.

0 = No treatment.
N = 100 pounds N per acre as 33-0-0.
P = 60 pounds P_2O_5 per acre as 0-45-0.
S_1 = 1 ton straw per acre.
S_2 = 3 tons straw per acre.

V. SUMMARY AND CONCLUSIONS

Greenhouse studies were used to evaluate the effect that different fertilizers, wheat straw additions, and soil sterilization have on the growth of wheat and sudan grass. Field experiments were carried out to determine the effect of different fertilizers and wheat straw additions on the wheat yields.

The greenhouse studies on wheat included partial soil sterilization with steam for 12 hours at 120° - 130° C., nitrogen fertilization (160 lbs. N/acre), phosphorus fertilization (120 lbs. P_2O_5/acre), and wheat straw additions at three and six tons per acre. After the wheat was harvested Lahoma sweet sudan grass was planted in the pots without further soil treatment.

Field studies were carried out to determine the grain and straw yields of wheat as a result of various treatments including nitrogen fertilization (100 lbs. N/acre), phosphorus fertilization (60 lbs. P_2O_5 /acre), and wheat straw additions applied at rates of one and three tons per acre.

The following conclusions are indicated from the experimental results of these studies.

1. Partial soil sterilization resulted in higher yields of wheat forage for all fertilizer treatments as compared to the same treatments on unsterilized soil.

2. Nitrogen fertilization increased yields of wheat forage for both sterilized and unsterilized treatments. Additions of phosphorus fertilizer depressed the vegetative growth of wheat in the unsterilized series.

3. Additions of straw at both rates used, when combined with nitrogen or nitrogen plus phosphorus, resulted in increased yields for both sterilized and unsterilized treatments.

4. No significant differences were found in the composition of the wheat forage as a result of the various soil treatments.

5. Analyses of the soil following growth of the wheat crop indicated significance in the percent of organic carbon in the soil as a result of the straw additions.

6. Sudan grass yields were higher for unsterilized pots than for sterilized pots receiving various fertilizer treatments plus six tons of straw per acre.

7. Analyses of variance gave F values that were significant for fertilizer treatments, straw additions, and soil sterilization for both the wheat and sudan grass forage.

8. The greenhouse experiment indicated the need for nitrogen and phosphorus fertilization when straw is returned to the soil.

9. No significant difference was found for the grain yield as a result of the various fertilizers and straw treatments under field conditions.

10. Differences in straw yields were significantly different as a result of various soil treatments.

11. Climatic conditions may have had a governing influence on the effects of the various soil treatments on the wheat yields in the field experiment.

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