# A FORAGE AND PROTEIN YIELD STUDY OF SORGHUM GROWN ALONE AND IN COMBINATIONS WITH FOUR SUMMER LEGUMES -- COWPEAS, GUAR, MUNGBEANS, AND SOYBEANS

By

BILL CARL JONES

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1957

Submitted to the faculty of the Graduate School of the Oklahoma State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE May, 1959

# A FORAGE AND PROTEIN YIELD STUDY OF SORGHUM GROWN ALONE AND IN COMBINATIONS WITH FOUR SUMMER LEGUMES — COWPEAS, GUAR, MUNGBEANS, AND SOYBEANS

Thesis Approved

Frank F. Davies
Thesis Adviser

Luther V. Reed

Lowell Mansfield
Dean of the Graduate School

## ACKNOWLEDGEMENTS

The author wishes to express his gratitude to the staff of the Agronomy Department of Oklahoma State University for their co-operation in making this thesis problem possible.

He wishes to express sincere appreciation to his major adviser, Mr. Frank F. Davies, for encouragement, advice, and helpful criticisms throughout this study. Thanks are extended to Dr. Ralph S. Matlock for helping to select the legumes used in the study, to Dr. Lester W. Reed for his assistance with the chemical analysis, to Dr. Robert D. Morrison for help in outlining the statistical analysis, and to all others who assisted in some way with this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

# INTRODUCTION

There has been much interest in the possibility of planting a legume with forage sorghums to increase the protein per cent of the forage. Many growers are of the opinion that it would be more convenient, and possibly more economical to increase the protein per cent of a forage than to supplement the forage with a high-protein supplement.

The primary purpose of this study was to provide information leading to the optimum production of a forage with a higher protein percentage. More specifically, the aim was to determine what effect summer legumes, interplanted with a forage sorghum, would have on the yield and protein content of the forage.

Information on forage sorghums grown with a legume is limited. Most experimental work has been done on each crop separately. More information on the competing ability of the two crops when grown together would be of value to the grower.

## LITERATURE REVIEW

Slate and Brown (11)[1/] of Connecticut reported three years' work with soybeans and corn as a combination crop for silage. The corn was planted at one rate in both checked and drilled rows and the soybeans were interplanted at five different rates with both the checked and drilled rows of corn. They found that the combination of one stalk of corn and three of soybeans produced more dry matter and more pounds of protein per acre than corn alone. Odland (10) found no significant increase in air-dry forage or total digestible nutrients by growing corn and soybeans in combination as compared to growing corn alone.

Borst and Park (1) stated that growing soybeans and corn together for silage had little advantage over growing corn alone. Generally there were enough soybeans lost in harvest to offset the increase in protein. McClelland in Arkansas (6) found that planting legumes with corn reduced the yields in most cases. The loss in yield was greater from velvet bean than from cowpeas and soybeans.

Nevens (7) found that seeding 1.5 bushels of soybeans per acre with the usual amount of sudan seed would increase the yield and improve the feeding value of the forage.

Nevens et al. (9) reported that the variety of each crop used was an important factor in the yields obtained when sorghum and soybeans were interplanted. They also found that the quality of silage made

---

1/ Numbers in parentheses refer to Literature Cited

from sorghum could be improved when combined with green soybean forage. Also the yield and quality of silage was improved in some seasons by growing adapted sorghums and soybeans together. Ellington (4) observed that forage type sorghums grown alone at a heavy seeding rate produced more tonnage than sorghum grown in combination with soybeans. However, the feeding value of the straight sorghum silage was somewhat lower than that of the combination silage.

Hopkins (5) compared cowpea and soybean silage with clover hay. The composition of the cowpea silage corresponded closely to that of the hay, while the soybean silage was equal to the hay in protein, higher in fat, and lower in net energy.

Zahnley (13) reported that the practice of planting soybeans with corn was used in Kansas. He stated that soybeans could be planted at the same time and in the same row with corn by using a bean and pea attachment on the corn planter. The corn was planted at the usual rate and the soybean rates ranged from four to eight pounds per acre. He found that planting corn at the usual rate with eight pounds of soybeans per acre in the same row gave more pounds of protein per acre than corn planted alone. Dvorachek et al. (3) observed that silage made from corn and cowpeas was more palatable than silage made from corn alone, and that the combination silage was more valuable, pound for pound, than the corn silage.

## MATERIALS AND METHODS

A forage and protein yield study of sorghum planted alone and in combination with four summer legumes was conducted on the Oklahoma State University Agricultural Experiment Station near Perkins in the summer of 1958 on a Vanoss fine sandy loam soil.

The objective of the study was to determine the effects on yield and protein content of the forage when a legume was planted with sorghum as compared to sorghum planted alone with 21 and 42 inch row spacing.

The field layout consisted of one main plot which was subdivided into four replications in a randomized block design. Each 50 foot replication consisted of 13 treatments in rows 21 inches apart and 13 treatments in rows 42 inches apart. Each treatment included a four row plot from which the two center rows were harvested. The 26 treatments were placed in each replication at random. The crops used were Sumac 1712 sorghum, Iron K-329 cowpeas, Groehler guar, Jumbo mungbeans, and Dorman soybeans.

The treatments were composed of: each of the five crops planted alone in solid stands; each of the legumes planted in alternate rows with the sorghum; and each of the legumes interplanted within the same row with the sorghum. Each combination was planted in 21 and 42 inch rows. The field layout plan is shown in Figure I.

A V-belt planter was used to seed the plots so that the different sized seeds could be planted within the same rows. The following rates

FIELD PLAN

Rep. I

12 21 6 20 4 8 10 7 1 3 11

25 13 15 14 2 23 17 19 24 18 5 26 22 16 9

Rep. II

1 17 13 21 26 8 9 24 11 14 3 2 23

22 4 6 5 19 18 10 25 12 20 7 16 15

Rep. III

11 20 21 3 4 22 14 9 5 12 25 15 16

19 23 22 26 10 24 17 8 18 7 13 6 1

Rep. IV

5 4 19 14 23 1 2 25 18 21 15 13 6

11 10 7 12 20 16 24 8 3 22 17 26 9

Treatments

| 42 inch rows | | 21 inch rows | |
|---|---|---|---|
| 1. | Solid cowpeas | 14. | Solid cowpeas |
| 2. | Solid mungbeans | 15. | Solid mungbeans |
| 3. | Solid guar | 16. | Solid guar |
| 4. | Solid soybeans | 17. | Solid soybeans |
| 5. | Solid sorghum | 18. | Solid sorghum |
| 6. | Mixed cowpeas and sorghum | 19. | Mixed cowpeas and sorghum |
| 7. | Mixed mungbeans and sorghum | 20. | Mixed mungbeans and sorghum |
| 8. | Mixed guar and sorghum | 21. | Mixed guar and sorghum |
| 9. | Mixed soybeans and sorghum | 22. | Mixed soybeans and sorghum |
| 10. | Alt. cowpeas and sorghum | 23. | Alt. cowpeas and sorghum |
| 11. | Alt. mungbeans and sorghum | 24. | Alt. mungbeans and sorghum |
| 12. | Alt. guar and sorghum | 25. | Alt. guar and sorghum |
| 13. | Alt. soybeans and sorghum | 26. | Alt. soybeans and sorghum |

Figure 1. Field plan

were used when each crop was seeded alone:

| | | | | | | |
|---|---|---|---|---|---|---|
| Soybeans | - | 10 | viable | seeds | per | foot |
| Guar | - | 4 | " | " | " | " |
| Cowpeas | - | 4 | " | " | " | " |
| Mungbeans | - | 5 | " | " | " | " |
| Sorghum | - | 6 | " | " | " | " |

Where two crops were planted within the same row, one-half the recommended seeding rate for both crops was used. A comparable stand was obtained and no thinning was required.

The seeding date was July 1, which is later than the May 10 to June 10 date recommended for seeding these crops in Oklahoma. This late seeding date was necessary because the first planting, on May 21, was seriously injured by an attack of the chinch bug on the sorghum and the jackrabbit on the soybean plants.

General cultural practices common to this area were used on the plots during the growing season. The 42 inch spacings were cultivated twice and the 21 inch spacings were not cultivated.

The rainfall for the growing season was above average. However, a supplemental irrigation of three inches of water was applied on June 23 to pack the soil after the first crop had been destroyed with a field cultivator and to give adequate surface moisture to germinate the seed. The rainfall from January 1 to October 1 was 30.41 inches (Table I).

The initial plan was to harvest all plots at the same date, however the legumes and sorghum did not reach the desired maturity stage simultaneously; therefore, it was necessary to make two separate harvests. The first harvest was September 5, when the legumes were estimated to be at their maximum forage yield stage. At this date, a few mungbean pods had turned black, the guar had lost some leaves due to Alternaria Leaf Spot, and a few cowpea pods had turned brown, but the plants were

TABLE I

DAILY RAINFALL AT PERKINS, OKLAHOMA, JANUARY 1, 1958 TO SEPTEMBER 30, 1958

| Day | Months | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. |
| 1 | | | | | | | | .49 | |
| 2 | | | | .06 | .13 | | | | |
| 3 | | | | | .91 | | | | |
| 4 | | | .01 | | | | | | |
| 5 | | .39 | .03 | | | | | | |
| 6 | | .01 | .80 | | | | .02 | | .01 |
| 7 | | | | .32 | | .06 | .16 | | .01 |
| 8 | | | .66 | | | | | .08 | |
| 9 | | .27 | | .01 | .06 | | | | |
| 10 | | | .24 | | .08 | | | 1.06 | .02 |
| 11 | .18 | | | | | | | | |
| 12 | .03 | | .58 | .13 | | | 1.88 | .10 | |
| 13 | | | | .49 | | | | | |
| 14 | | | | .01 | .06 | | .13 | | .12 |
| 15 | | | .05 | | .31 | .85 | | | .13 |
| 16 | | | .06 | | | 1.84 | | | 2.49 |
| 17 | | | .34 | .03 | .02 | | | .65 | |
| 18 | | | | | | .04 | | | |
| 19 | 1.09 | | | .92 | | .02 | | | |
| 20 | .11 | | | | | 1.29 | | 2.36 | .03 |
| 21 | | | | .14 | | 1.33 | .11 | .02 | |
| 22 | | | | | | .05 | .03 | | |
| 23 | | .01 | .72 | | | | | .07 | .02 |
| 24 | | | | | | | | | |
| 25 | | | | | | 2.04 | | | |
| 26 | | .22 | | | | | .38 | | |
| 27 | | | | | | | 1.42 | | |
| 28 | | | 1.20 | .03 | .06 | | | | |
| 29 | | | .02 | | | | | | .16 |
| 30 | | | | | .07 | | | | .08 |
| 31 | | | | | | | | | |
| Totals | 1.41 | .90 | 4.71 | 2.14 | 1.70 | 7.52 | 4.13 | 4.83 | 3.07 |

considered to be at their maximum stage for forage production. At this date the sorghum was in the bloom stage, which is considered immature for best forage production. The plots of soybeans were not harvested because of heavy rabbit damage in the early stage of growth.

The sorghum was in the hard dough seed stage at the second harvest on October 1. Since the cowpea has an indeterminate growth habit, it was still in good condition for forage production. The guar had lost all leaves, but the seeds were still somewhat soft. The mungbeans had shattered much of the seed and had lost most of the leaves.

In harvesting each plot, 1/500th of an acre was taken at each date. A moisture sample was taken from each treatment and dried at 160° F. and the dry matter content was determined. The samples were then ground in a Wiley mill and divided into approximately 75 gram samples. The nitrogen content of each sample was determined by the Kjeldahl method and converted into per cent protein by using 6.25 as the conversion factor.

The yields were recorded in pounds per plot and then converted to pounds of dry matter per acre. The protein percentage of each sample was multiplied by the dry matter to give pounds of protein per acre.

The data was statistically analyzed following methods used by Snedecor (12) and Duncan (2). The analysis of variance and the multiple range tests were calculated on total dry matter weight, per cent of protein, and pounds of protein per acre.

## RESULTS AND DISCUSSION

Significant differences among treatments for pounds of dry matter per acre, pounds of protein per acre, and per cent protein were obtained for each harvest (Tables II, IV, V, VI, VII) with the exception of the pounds of dry matter per acre in the second harvest (Table III). Sorghum in the 21 inch rows yielded more dry weight in the first and second harvest than any other treatment. In all treatments except guar planted alone, the 21 inch row spacings produced more pounds of dry matter per acre than the 42 inch rows (Tables VIII, IX). In the one exception, the 42 inch rows of guar produced 245 more pounds dry matter than did the 21 inch rows. However, the difference was not significant.

The multiple range tests (Table VIII) showed that the 21 inch rows of interplanted guar and sorghum produced significantly more dry weight than the 42 inch rows of interplanted guar and sorghum. The multiple range tests (Table IX) did not show a significant difference in dry weight in the second harvest between sorghum in 21 inch rows and sorghum in 42 inch rows. However, the orthogonal comparison test showed a significant advantage of sorghum in the 21 inch rows. This can be accounted for because individual orthogonal comparisons are more sensitive comparisons than the multiple range tests. This was the only instance that the two tests differed.

In all but two cases, the 21 inch row spacings produced more pounds of protein per acre than the 42 inch spacings in both the first and

TABLE II

ANALYSIS OF VARIANCE OF THE POUNDS OF DRY MATTER PER ACRE PRODUCED IN THE FIRST HARVEST

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Total | 79 | 159274160. | 2016128.6 | |
| Reps. | 3 | 10640418. | 3546806.0 | |
| Treat. | 19 | 71866053. | 3782423.8 | 2.81* |
| Error | 57 | 76767689. | 1346801.5 | |

* Significance at 5% level
Coefficient of Variation = 17%

TABLE III

ANALYSIS OF VARIANCE OF THE POUNDS OF DRY MATTER PER ACRE PRODUCED IN THE SECOND HARVEST

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Total | 55 | 183350706. | 3333649.2 | |
| Reps. | 3 | 1330956. | 443652.0 | |
| Treat. | 13 | 43098015. | 3315231.9 | .93 |
| Error | 39 | 138921735. | 3562095.7 | |

Coefficient of Variation = 23%

TABLE IV

ANALYSIS OF VARIANCE OF THE POUNDS OF PROTEIN PER ACRE PRODUCED IN THE FIRST HARVEST

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Total | 79 | 5340239.51 | 67597.96 | |
| Reps. | 3 | 1328495.68 | 442831.89 | |
| Treat. | 19 | 4688883.49 | 246783.34 | 43.57* |
| Error | 57 | 322860.36 | 5664.21 | |

* Significance at 5% level
Coefficient of Variation = 12%

TABLE V

ANALYSIS OF VARIANCE OF THE POUNDS OF PROTEIN PER ACRE PRODUCED IN THE SECOND HARVEST

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Total | 55 | 1147931.86 | 20871.488 | |
| Reps. | 3 | 122976.50 | 40992.166 | |
| Treat. | 13 | 426644.49 | 32818.806 | 2.13* |
| Error | 39 | 598310.87 | 15341.304 | |

* Significance at 5% level
Coefficient of Variation = 22%

TABLE VI

ANALYSIS OF VARIANCE OF THE PER CENT OF PROTEIN PRODUCED IN THE FIRST HARVEST

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Total | 79 | 776.65 | 9.831 | |
| Reps. | 3 | 9.76 | 3.253 | |
| Treat. | 19 | 717.77 | 37.777 | 31.17* |
| Error | 57 | 69.12 | 1.212 | |

* Significance at 5% level
Coefficient of Variation = 12%

TABLE VII

ANALYSIS OF VARIANCE OF THE PER CENT OF PROTEIN PRODUCED IN THE SECOND HARVEST

| Source of Variation | d.f. | Sum of Squares | Mean Square | F |
|---|---|---|---|---|
| Total | 55 | 70.17 | 1.275 | |
| Reps. | 3 | 7.49 | 2.496 | |
| Treat. | 13 | 29.69 | 2.283 | 2.69* |
| Error | 39 | 32.99 | .8458 | |

* Significance at 5% level
Coefficient of Variation = 13%

second harvests (Tables X, XI). The two exceptions, both in the first harvest, were guar planted alone and guar in alternate rows with sorghum. There was no significant difference between the two spacings of guar grown alone. Both cowpea spacings, 21 inch mungbean spacings, and 42 inch guar spacings were significantly higher in pounds of protein per acre than any sorghum plot or any combination.

In the first harvest, guar interplanted with sorghum in 21 inch rows produced more protein per acre than any combination planting (Table X). However, this treatment was not statistically higher than the 21 inch rows of cowpeas in alternate rows with sorghum. In the second harvest, the cowpeas in alternate 21 inch rows with sorghum produced more pounds of protein per acre than any other combination, and was significantly higher than the guar interplanted with sorghum, which was the better yielder in the first harvest.

The cowpeas in alternate rows with sorghum produced more pounds of protein per acre than the cowpeas and sorghum interplanted within the same row in comparable spacings in the first and second harvest.

There was no significant difference in row spacings in the first harvest when comparing the cowpea and sorghum combinations (Table X), but there was a significant difference between 21 inch rows and 42 inch rows of the cowpea combinations in the second harvest. The 21 inch rows yielded significantly more pounds of protein than the 42 inch rows.

With one exception, the alternate legume and sorghum plantings were higher in per cent protein than the legume sorghum planting within the same row (Table XII). The one exception (Table XIII), the 21 inch rows of mungbeans interplanted with sorghum, was higher in per cent protein than the 21 inch rows of alternate mungbeans and sorghum.

TABLE VIII

MULTIPLE RANGE TEST OF THE MEANS OF THE POUNDS OF DRY MATTER PER ACRE FOR THE FIRST HARVEST

| Row Spacing in inches | Treatments | Mean | Multiple Range $\angle x$ 5% |
|---|---|---|---|
| 21 | Sorghum | 9995.77 | |
| 21 | Mixed guar and sorghum | 9390.33 | |
| 21 | Alt. mungbeans and sorghum | 7701.14 | |
| 21 | Mixed cowpeas and sorghum | 7609.49 | |
| 21 | Alt. cowpeas and sorghum | 7545.42 | |
| 21 | Cowpeas | 7393.95 | |
| 21 | Mixed mungbeans and sorghum | 7379.57 | |
| 42 | Sorghum | 7332.76 | |
| 21 | Mungbeans | 7230.88 | |
| 42 | Cowpeas | 6944.22 | |
| 42 | Alt. cowpeas and sorghum | 6849.08 | |
| 42 | Guar | 6494.10 | |
| 21 | Alt. guar and sorghum | 6472.60 | |
| 42 | Mixed guar and sorghum | 6295.97 | |
| 21 | Guar | 6245.01 | |
| 42 | Mixed cowpeas and sorghum | 6005.37 | |
| 42 | Alt. guar and sorghum | 5917.63 | |
| 42 | Mixed mungbeans and sorghum | 5819.81 | |
| 42 | Mungbeans | 5486.33 | |
| 42 | Alt. mungbeans and sorghum | 4837.62 | |

TABLE IX

MULTIPLE RANGE TEST OF THE MEANS OF THE POUNDS OF DRY MATTER PER ACRE FOR THE SECOND HARVEST

| Row Spacing in inches | Treatments | Mean | Multiple Range $\angle x$ 5% |
|---|---|---|---|
| 21 | Sorghum | 11987.58 | |
| 21 | Alt. cowpeas and sorghum | 9247.31 | |
| 42 | Sorghum | 9235.92 | |
| 21 | Mixed guar and sorghum | 8879.12 | |
| 21 | Mixed cowpeas and sorghum | 8810.98 | |
| 21 | Alt. guar and sorghum | 8669.10 | |
| 21 | Mixed mungbeans and sorghum | 8288.72 | |
| 21 | Alt. mungbeans and sorghum | 7818.10 | |
| 42 | Mixed guar and sorghum | 7570.09 | |
| 42 | Mixed mungbeans and sorghum | 7395.17 | |
| 42 | Alt. cowpeas and sorghum | 6771.31 | |
| 42 | Alt. mungbeans and sorghum | 6306.81 | |
| 42 | Mixed cowpeas and sorghum | 6266.35 | |
| 42 | Alt. guar and sorghum | 6024.49 | |

TABLE X

MULTIPLE RANGE TEST OF THE MEANS OF THE POUNDS OF PROTEIN PER ACRE FOR THE FIRST HARVEST

| Row Spacing in inches | Treatments | Mean | Multiple Range /x 5% |
|---|---|---|---|
| 21 | Cowpeas | 1123.14 | |
| 42 | Cowpeas | 1082.60 | |
| 42 | Guar | 934.22 | |
| 21 | Mungbeans | 861.92 | |
| 21 | Guar | 760.01 | |
| 42 | Mungbeans | 668.23 | |
| 21 | Mixed guar and sorghum | 655.44 | |
| 21 | Sorghum | 620.73 | |
| 21 | Alt. cowpeas and sorghum | 603.63 | |
| 21 | Alt, mungbeans and sorghum | 601.45 | |
| 42 | Alt, cowpeas and sorghum | 596.55 | |
| 42 | Alt. guar and sorghum | 530.21 | |
| 42 | Sorghum | 523.55 | |
| 21 | Mixed mungbeans and sorghum | 523.21 | |
| 21 | Mixed cowpeas and sorghum | 518.96 | |
| 21 | Alt. guar and sorghum | 468.61 | |
| 42 | Mixed cowpeas and sorghum | 460.01 | |
| 42 | Mixed guar and sorghum | 452.68 | |
| 42 | Alt. mungbeans and sorghum | 435.38 | |
| 42 | Mixed mungbeans and sorghum | 414.37 | |

TABLE XI

MULTIPLE RANGE TEST OF THE MEANS OF THE POUNDS OF PROTEIN PER ACRE FOR THE SECOND HARVEST

| Row Spacing in inches | Treatments | Mean | Multiple Range $\angle x$ 5% |
|---|---|---|---|
| 21 | Alt. cowpeas and sorghum | 790.64 | |
| 21 | Sorghum | 755.21 | |
| 21 | Mixed cowpeas and sorghum | 674.03 | |
| 21 | Alt. guar and sorghum | 625.04 | |
| 42 | Sorghum | 582.78 | |
| 21 | Mixed mungbeans and sorghum | 580.21 | |
| 21 | Mixed guar and sorghum | 570.92 | |
| 42 | Mixed mungbeans and sorghum | 502.13 | |
| 42 | Alt. cowpeas and sorghum | 501.07 | |
| 42 | Mixed guar and sorghum | 497.35 | |
| 21 | Alt. mungbeans and sorghum | 495.66 | |
| 42 | Alt. mungbeans and sorghum | 469.22 | |
| 42 | Alt. guar and sorghum | 440.99 | |
| 42 | Mixed cowpeas and sorghum | 436.76 | |

TABLE XII

MULTIPLE RANGE TEST OF THE MEANS OF THE PER CENT OF PROTEIN FOR THE FIRST HARVEST

| Row Spacing in inches | Treatments | Mean | Multiple Range $\angle x$ 5% |
|---|---|---|---|
| 42 | Cowpeas | 15.59 | |
| 21 | Cowpeas | 15.19 | |
| 42 | Guar | 14.26 | |
| 21 | Mungbeans | 12.92 | |
| 42 | Mungbeans | 12.18 | |
| 21 | Guar | 12.17 | |
| 42 | Alt. mungbeans and sorghum | 9.00 | |
| 42 | Alt. guar and sorghum | 8.96 | |
| 42 | Alt. cowpeas and sorghum | 8.71 | |
| 21 | Alt. cowpeas and sorghum | 8.00 | |
| 21 | Alt. mungbeans and sorghum | 7.81 | |
| 42 | Mixed cowpeas and sorghum | 7.66 | |
| 21 | Alt. guar and sorghum | 7.24 | |
| 42 | Mixed guar and sorghum | 7.19 | |
| 42 | Sorghum | 7.14 | |
| 42 | Mixed mungbeans and sorghum | 7.12 | |
| 21 | Mixed mungbeans and sorghum | 7.09 | |
| 21 | Mixed guar and sorghum | 6.98 | |
| 21 | Mixed cowpeas and sorghum | 6.82 | |
| 21 | Sorghum | 6.21 | |

TABLE XIII

MULTIPLE RANGE TEST OF THE MEANS OF THE PER CENT OF PROTEIN FOR THE SECOND HARVEST

| Row Spacing in inches | Treatments | Mean | Multiple Range /x 5% |
|---|---|---|---|
| 21 | Alt. cowpeas and sorghum | 8.55 | |
| 21 | Mixed cowpeas and sorghum | 7.65 | |
| 42 | Alt. mungbeans and sorghum | 7.44 | |
| 42 | Alt. cowpeas and sorghum | 7.40 | |
| 42 | Alt. guar and sorghum | 7.32 | |
| 21 | Alt. guar and sorghum | 7.21 | |
| 21 | Mixed mungbeans and sorghum | 7.00 | |
| 42 | Mixed cowpeas and sorghum | 6.97 | |
| 42 | Mixed mungbeans and sorghum | 6.79 | |
| 42 | Mixed guar and sorghum | 6.57 | |
| 21 | Mixed guar and sorghum | 6.43 | |
| 21 | Alt. mungbeans and sorghum | 6.34 | |
| 42 | Sorghum | 6.31 | |
| 21 | Sorghum | 6.30 | |

In considering all combinations of sorghum and a legume, the 21 inch spacing of cowpeas and sorghum in alternate rows was consistently among the higher producing combinations. This one combination was not statisticially lower in dry matter weight, per cent protein, or pounds of protein per acre than any combination of legume and sorghum.

The yield advantage of the 21 inch row spacing may have been a seasonal effect, due to adequate moisture. The 30 year average rainfall, from 1926 - 1955, during the months of June, July, August, and September was 13.26 inches. The 1958 rainfall for the same period was 19.55 inches, or 6.29 inches above the 30 year average.

It appears from this study that it would be advisable to grow the sorghum and legume crops separately to get the maximum tonnage and protein from each crop. At harvest, the forage from the two crops could be mixed in any ratio, depending on the protein per cent desired. For example, to obtain a ten per cent protein forage three parts of sorghum could be combined with two parts of cowpeas. In this ratio, the tonnage of the two crops grown separately in 21 inch rows is similar to that obtained from the sorghum and cowpeas grown in 21 inch alternate rows. However, the protein per cent is increased by two per cent when the two crops are grown separately. This conclusion is based on the data from the first harvest of the two crops, since the legumes grown separately were not included in the second harvest.

If further studies are made on this problem, it would seem advisable to place more emphasis on maturity of the varieties of the crops grown in the combinations. In order to have the sorghum and legumes reach maturity at the same date, either select later maturing varieties of legumes or plant the two crops at different dates. The sorghum could

be planted early in rows followed by planting the legume after the sorghum had been cultivated.

Fertility trials were not included in this study, but they might offer valuable information in increasing dry matter weight as well as protein content of the forage.

## SUMMARY AND CONCLUSIONS

A forage and protein yield study of sorghum planted alone and in combination with four summer legumes was conducted on the Oklahoma State University Agricultural Experiment Station near Perkins in the summer of 1958 on a Vanoss fine sandy loam soil.

The field design was a randomized block with four replications. Each replication consisted of 13 treatments in rows 21 inches apart and 13 treatments in rows 42 inches apart planted in two 50 foot ranges.

A statistical analysis was made of the total dry matter weight, pounds of protein per acre, and protein per cent. The multiple range test showed that the 21 inch row spacings produced more dry matter weight and more pounds of protein than the 42 inch spacings in all but three entries.

No legume and sorghum combination raised the total pounds of protein per acre enough to be significantly higher than sorghum planted alone in 21 inch row spacings. The statistical analysis showed a trend indicating that the cowpea combinations in 21 inch row spacings would be the better yielder of dry matter weight and pounds of protein per acre than any other combination. In the first harvest, the cowpeas and sorghum planted in alternate rows produced more pounds of protein per acre than the cowpeas and sorghum planted within the same row.

## LITERATURE CITED


1. Borst, H. L., and J. B. Park. Experiments with growing corn and soybeans in combination. Ohio Agri. Expt. Sta. Bull. 513. 1932.

2. Duncan, D. B. Multiple range and multiple F test. Biometrics 11:1-42. 1955.

3. Dvorachek, H. E., F. H. Herzer, R. H. Mason, H. E. Reed, and Edgar Martin. Legume forage with corn and cane for silage. Univ. of Ark. Agri. Expt. Sta. Bull. 196. 1925.

4. Ellington, Charles P. Try soybeans and sorghums for silage. Hoard's Dairyman. March 10, 1957.

5. Hopkins, Cyril G. Composition and digestibility of corn ensilage, cowpea ensilage, soja bean ensilage, and corn-fodder. Ill. Agri. Expt. Sta. Bull. 43. 1896.

6. McClelland, C. K. The effect of interplanted legumes on the yield of corn. Univ. of Ark. Agri. Expt. Sta. Bull. 229. 1928.

7. Nevens, W. B. Making high quality silage for dairy cattle. Ill. Agri. Expt. Sta. Circ. 686. 1951.

8. Nevens, W. B., K. E. Harshbarger, and K. A. Kendall. Grass and legume silage for dairy cattle. Ill. Agri. Expt. Sta. Circ. 605. 1946.

9. Nevens, W. B., K. E. Harshbarger, and K. A. Kendall. Legumes and grasses for silage. Ill. Agri. Expt. Sta. Bull. 529. 1948.

10. Odland, T. E. Soybeans for silage and for hay. W. Va. Agri. Expt. Sta. Bull. 227. 1930.

11. Slate, W. L., Jr., and B. A. Brown. Soybeans and corn as a combination crop for silage. Conn. Agri. Expt. Sta. Bull. 133. 1925.

12. Snedecor, G. W. Statistical methods, 5th ed. Ames, Iowa: Iowa State College Press. 1956.

13. Zahnley, J. W. Soybean production in Kansas. Kans. Agri. Expt. Sta. Bull. 249. 1930.

VITA

Bill Carl Jones

Candidate for the Degree of

Master of Science

Thesis: A FORAGE AND PROTEIN YIELD STUDY OF SORGHUM GROWN ALONE AND IN COMBINATIONS WITH FOUR SUMMER LEGUMES -- COWPEAS, GUAR, MUNGBEANS, AND SOYBEANS

Major Field: Field Crops

Biographical:

Personal data: Born near Hennessey, Oklahoma, April 21, 1935, the son of Alva A. and Ethel E. Jones.

Education: Attended elementary and graduated from Hennessey High School, Hennessey, Oklahoma in 1953; received the Bachelor of Science degree from Oklahoma State University, with a major in agriculture, in May, 1957; attended Graduate School at Oklahoma State University 1957 - 1959.

Experience: Farming 1953 - 1956; employed by Oklahoma Foundation Seed Stocks 1956 - 1958.

Date of Final Examination: December, 1958