TRENDS IN THE CHEMICAL COMPOSITION AND YIELD OF ATLAS FORAGE SORGHUM AS AFFECTED BY STAGE OF MATURITY, PLANT POPULATION, AND ROW WIDTH

by

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INTRODUCTION

The use of forage sorghum as livestock feed in the Great Plains is widespread. Forage sorghum is more tolerant to drought than corn, and yields are greater than those of corn. Atlas forage sorghum is probably more widely grown than any other variety. It is particularly adapted to ensilage production because of its sweet, juicy stalk and its high yields.

Stage of maturity, row width, plant population, palatibility, digestibility, and yield influence feeding value and the production of forage sorghums. Many farmers have suggested that forage sorghum be cut at the early dough stage for maximum livestock utilization. Others are of the opinion that harvesting at the hard dough stage is best. Still others have said that harvesting in the late dough stage produced highest yields but that a reduction in palatibility and digestibility result. Protein, carbohydrate, and fiber content influence palatibility and digestibility. Modern ensilage machinery has been designed to harvest the 40-inch row widths which have been regarded as the standard width. Some farmers have contended that a row width of 20-inches produces greater yields than 40-inch rows. It may be that one row width has more merit under certain conditions than does the other, or there may be no difference between the two. Although sorghum can adjust for population differences, more information is needed on the effect of plant population in forage sorghums.

This investigation was undertaken to determine the trends in accumulation of protein, fiber, carbohydrates, and dry matter and their relation to row width, plant population, and stage of maturity.

REVIEW OF LITERATURE

Many studies have shown that protein percentage of the total sorghum plant changes very little after heading and may even decrease slightly (6, 9, 10, 11, 12, 13, 14). Thurman et al. (6) have shown that the percent of protein of the leaf blade is about four times greater than the leaf sheath, about two times greater than the heads, and about six times greater than the stalks. These investigators further point out that protein content may decrease due to the accumulation of carbohydrates in the stalk and to the deterioration of leaf blades. Studies by Webster and Davies (9) have shown that protein content is higher in dry years than in wet years. As leaf growth is constant under most conditions (6), the protein percent of the plant would increase in dry years due to a decrease in stalk growth. This probably accounts for the increase in protein content shown by Webster and Davies (9).

There are varying points of view about the accumulation of fiber in sorghums. Willaman et al. (14) found that the percent of fiber increased slightly until heading, when there was a slight, consistent decrease. Investigations be Webster and Davies (9) indicate that the percent of fiber accumulation usually reached a minimum about the time of grain maturation and that there was a slow, steady increase until frost.

Several studies have shown that nitrogen-free extract (which is positively correlated with carbohydrates) increases greatly until heading, when there is a slower increase (9, 12, 14). Urich (6) found that the amount of nitrogen-free extract in the culm increased significantly after physiological maturity of the grain. As maturity progresses, total sugar percent increases consistently, particularly until the grain matures (2, 8, 10, 13). Ventre, Byall, and Catlett (8) have shown that total sugars are an ever-increasing proportion of the increase in carbohydrates.

Collier (2) has suggested that harvesting the crop after the grain is dry will result in sugar of the highest quality and in greatest quantity. According to Ramsey _et al_. (4), digestibility of cellulose is greater when sorghum is harvested at an early stage, and they suggest that the crop be harvested when the grain in the upper one-third of the head begins to turn to mature grain color. Thurman _et al_. (6) also believe that earlier harvest increases digestibility of the sorghum, but they state that early harvest may decrease the amount of nutrients produced and the value of the grain in digestion. The time of maximum forage yield varies with the season, but Webster and Davies (9) suggest that the hard dough stage of the grain is probably the best time to harvest the crop.

MATERIALS AND METHODS

Atlas forage sorghum was planted May 26, 1962, at the Kansas State University Agronomy Farm. The soil was an unnamed, alluvial, silt loam which had been fall-plowed. Eighty pounds of nitrogen per acre were broadcast in the spring and worked in. The season was an excellent one for sorghum as 28.09 inches of precipitation fell during the growing season (May 1-October 31). All cultivation was done by hand.

The seed was thickly planted in 20 and 40 inch rows with a hand planter. Eight 20-inch rows or four 40-inch rows constituted a plot. When the plants were about six inches tall, they were accurately thinned to leave 60, 240, and 480 square inches per plant. These spacings represented, respectively, approximately 104,500, 26,100, and 13,100 plants per acre. These spacings were chosen to represent populations that were high, medium, and low, respectively, in stand density. The six treatments were placed in a randomized block design with four replications.

Data were expressed on the basis of pounds per acre and pounds per three plants. It was thought that three plants would reduce sampling error as compared with a single-plant sample.

Sampling was begun on July 27, 62 days after planting, and continued at weekly intervals thereafter, except the last sampling which was taken two weeks after the previous sampling. The last sample was taken about two weeks before a killing frost. The second sampling was accomplished when the plants were in 40 percent bloom, which was 69 days after planting.

Three plants, including the three main culms and their tillers, were cut about one-inch above the ground. The plants were taken from rows which did not border an adjacent plot. Several plants were always left in the row between weekly cuttings to provide normal competition between plants. The three-plant samples were weighed and their tillers counted. A sub-sample composed of one main culm and sufficient tillers to make a complete plant (based on tiller counts) was taken. This sub-sample was then separated into its component parts: culm, leaf sheath and blade, and head (which until the fourth week after bloom was considered as part of the culm). The component parts were then weighed, placed in separate containers, and taken to the laboratory where the samples were autoclaved for ten minutes at five pounds pressure to stop enzyme action.

The samples were dried for one week at 70° C and again weighed. Samples were then ground with a Christy-Norris mill. In order to reduce the number of samples for chemical analysis, equal amounts of material from replications I and III and from replications II and IV were compositted.

Total sugars and acid-hydrolyzable carbohydrates were determined by the method outlined by Kersting et al. (3). The sum of these two components will, hereafter, be called total carbohydrates. Protein content was determined using the modified Gunning-Kjeldahl method (1). Crude fiber was determined by the Kansas State University Chemical Service Laboratory. All determinations were based on dry weight. All statistical analyses were made using procedures outlined by Snedecor (5).

RESULTS AND DISCUSSION

Dry Matter

Accumulation of dry matter in the leaves of three plants is shown in Fig. 1, and in appendix Table 1. During the sampling period, there was a slight increase in dry matter content in the high population, with little variability. The medium population showed a greater increase and also greater variability than the low population. Noticable decreases were observed in the medium population the week following bloom and the seventh week after bloom and were attributed to environmental influence on plant growth. The greatest increase in dry matter during the sampling period occurred in the low population. This accounts for the highly significant (1 percent level) differences among the populations. Noticable decreases were also observed at the fifth and at the seventh weeks after bloom, and particularly the week following bloom. A highly significant (1 percent level) population x date interaction was found, which was due to the relatively greater increase in dry matter content in the low population than in either of the other populations.

Dry matter content of the leaves in the two row widths increased greatly over the sampling period. Since each width showed a great deal of variability

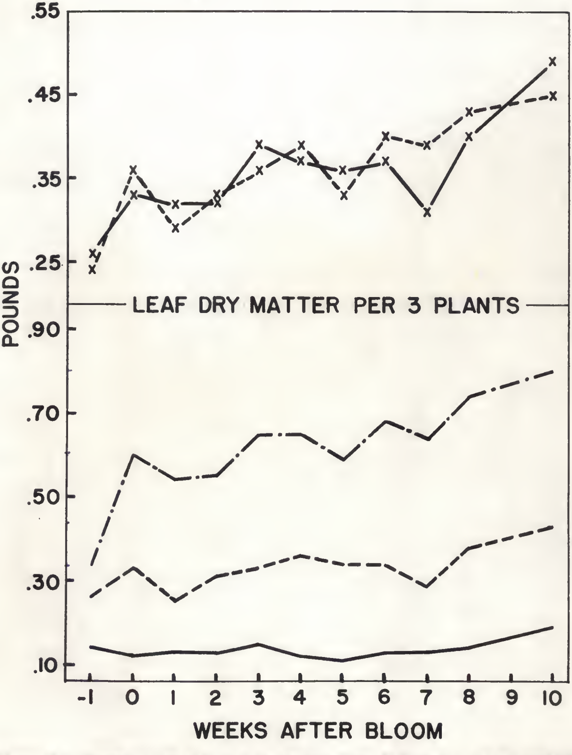

Figure 1. Accumulation of leaf dry matter (lbs./3 plants). High population, ________; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = .77; population L.S.D. .05 level = .40.

in its dry matter accumulation pattern, significant differences between row widths were not found. The 20-inch rows showed a sharp decrease in dry matter content the week following bloom and again the fifth week after bloom. There was a sharp decrease the week following bloom and the seventh week after bloom in the 40-inch rows. Highly significant differences in dry matter accumulation were found among the dates. Evidently, as the plant matured, the leaves served more as storage organs, rather than being drained of their dry matter to fill up the stem. Most of the increase in dry matter content was attributed to carbohydrates.

Figure 2 and appendix Tables 2 and 3 present the accumulation of dry matter in the stems of three plants. The accumulation in the different populations followed the same general pattern as did that of leaves in that the lower the population, the greater the relative increase in dry matter content. However, there was a much greater accumulation of dry matter in stems than in leaves. Differences among populations were sufficiently great to make them highly significant. A highly significant population x date interaction was found when the immature heads were combined with the stems, but was not found when the data for more mature heads were separated from the stems. Evidently, the interaction was due to the presence of the heads and would probably have been found in the later stages had the heads been combined with the stems. A slight decrease in dry matter content was noted in all populations the fifth week after bloom. Slight decreases were also found in the medium and low populations the seventh week after bloom.

Differences between row widths were not significant. A sharp increase in dry matter in the early weeks following bloom was due to the increase in dry matter in the heads that were combined with the stems. The 20-inch rows

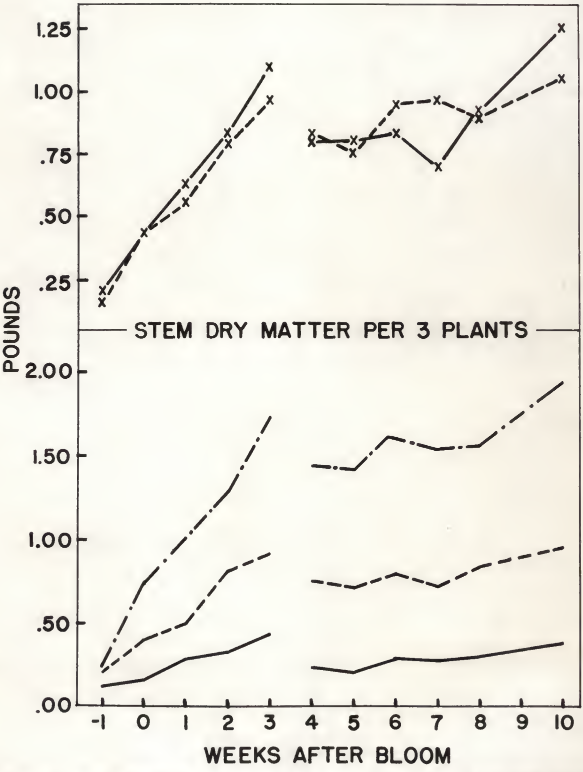

Figure 2. Accumulation of stem dry matter (lbs./3 plants). High population, ______; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ x _ _. Width x date L.S.D. .05 level = .14, .23; population L.S.D. .05 level = .08, .04.

showed a slight decrease at the fifth and eighth weeks following bloom, while the 40-inch rows showed a greater decrease in dry matter content the seventh week after bloom. A consistent increase in dry matter was found throughout the sampling period; thus, differences among dates were highly significant.

There was a gradual increase in dry matter in the heads of three plants (Fig. 3 and appendix Table 4). The lower the population, the greater was the relative increase in dry matter content. Thus, significant differences (10 percent level) were found among populations. Greater differences among dates might have been observed had the heads and stems been separated earlier when the heads were greatly increasing their dry matter content. Slight decreases in dry matter content were noted within the high and low populations at five and seven weeks after bloom. The medium population showed a much greater decrease at seven weeks after bloom.

Differences between row widths were significant at the 10 percent level. This was due in part to the sharp decrease in dry matter content in the 40-inch row width at seven weeks after bloom. The 20-inch rows showed a lesser decrease at five weeks after bloom. The overall trend was an increase in dry matter content over the sampling period.

Total dry matter per three plants is shown in Fig. 4 and appendix Table 5. As with the separate plant components, the low plant population produced the greatest increase in dry matter while the high population produced the lowest. Because of this relatively greater increase by the lower populations, a highly significant population x date interaction and highly significant differences among dates were found.

Total dry matter also increased greatly in the two row widths over the sampling period. Significant differences were not found between widths. A

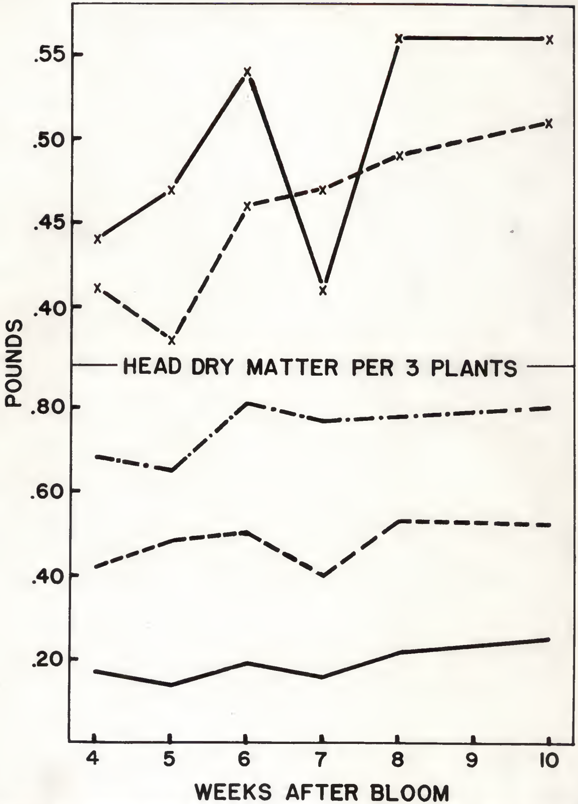

Figure 3. Accumulation of head dry matter (lbs./3 plants). High population, ______; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = .12; population L.S.D. .05 level = .06.

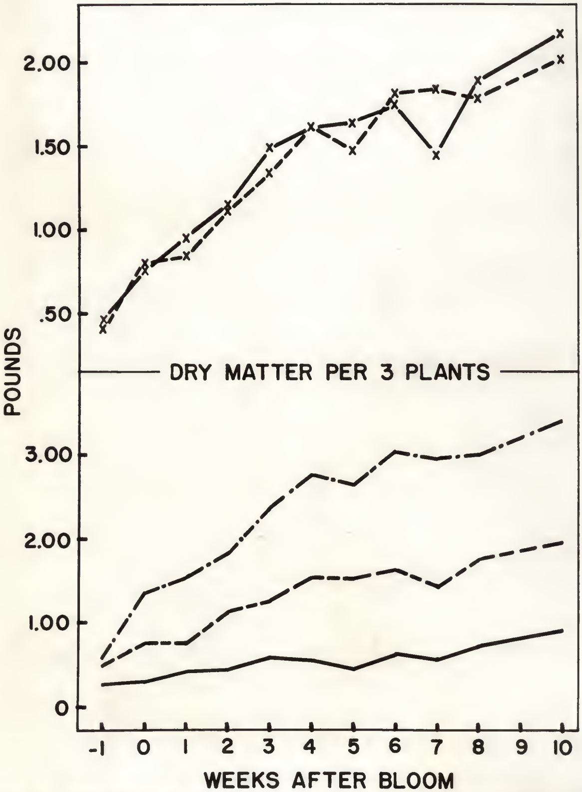

Figure 4. Accumulation of dry matter (lbs./3 plants). High population, ______; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x_ _ _. Width x date L.S.D. .05 level = .32; population L.S.D. .05 level = .52.

sharp decrease in dry matter was observed five weeks after bloom in the 20-inch rows and at seven weeks after bloom in the 40-inch rows. Differences among dates were highly significant in all cases since the plants continued to increase in dry matter content throughout the sampling period.

When the accumulation per acre was considered, it was found that the results differed from those shown above. These data are presented in Table 1. The high population produced the largest dry matter per acre yield, while the lowest yield was produced by the low population.

From these data it would appear that forage sorghum plants will continue to increase in dry matter content until frost stops growth. It was found that while the low population produced the greatest relative increase in dry matter on a three plant basis, the high population produced the greatest yield of dry matter per acre. Thus, the greater relative increase could not offset the effect of the low population.

Protein

The percent of protein per plant part is presented in Fig. 5 and appendix Table 6. Protein content of the leaves decreased consistently during the sampling period. The protein content of the stems decreased sharply until bloom, at which time protein content decreased slightly for a few weeks and then began increasing slightly at the eighth week following bloom. The protein percent of the heads increased from the fourth to sixth week after bloom, at which time the content leveled off until sampling was discontinued. From the time that head sampling was started and until sampling was discontinued, the heads contained the largest percent of protein. Leaves contained somewhat less protein than the heads, but the content in the stems was very

Table 1. Accumulation of dry matter (lbs./A.) in Atlas forage sorghum as affected by stage of maturity, plant population and row width.

Date Weeks after bloom	Population			Row width	
	High	Med.	Low	40	20
-1	9,010	4,059	2,530	5,879	4,519
0	9,706	6,387	5,811	6,960	7,642
1	14,146	6,442	6,720	9,619	8,585
2	15,974	9,837	7,944	11,672	10,830
3	20,239	10,947	10,355	15,030	12,662
4	18,629	13,428	12,025	15,038	14,349
5	16,061	13,362	11,590	13,424	13,917
6	20,848	14,189	13,500	16,032	16,325
7	19,282	12,285	12,814	13,300	16,286
8	23,242	15,266	13,360	17,762	16,815
10	28,814	16,822	15,388	21,113	19,568

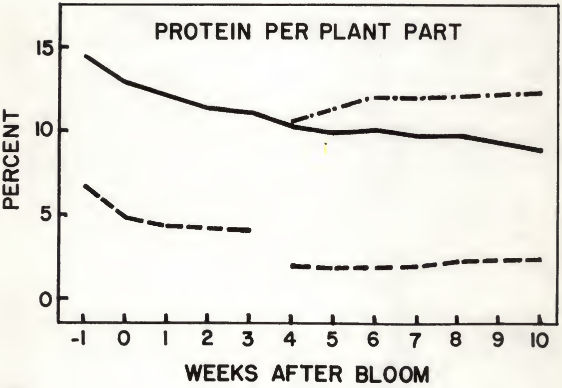

Figure 5. Accumulation of protein (%/plant part). Leaves, ______; stem, _ _ _ _; head, ___.___.___. Date L.S.D. .05 level: leaves, .26; stems, .34, .12; head, .48.

low. This was attributed to the increase in carbohydrate in the stems. In all plant parts, differences among dates were highly significant.

Figure 6 and appendix Table 7 show the pounds of protein per three plants. A great increase was noted for the low population. Plants in the high population showed the smallest increase of the three populations. Because of the greater relative increase in pounds of protein by the low population, a highly significant population x date interaction was found, along with highly significant differences among dates and among populations. Slight decreases in protein content were noted at one, five, and seven weeks after bloom in the low population, while slight decreases were observed at one and seven weeks after bloom in the medium population. The high population was subject to a decrease in content at bloom and at five and seven weeks after bloom.

Differences between row widths were not significant. The protein content in the 40-inch rows increased greatly over the sampling period, but showed a sharp decrease seven weeks after bloom.

Highly significant differences among populations and among dates were found when the pounds of protein per acre were considered (Figure 7 and appendix Table 8). The general trend was an increase in protein yield throughout the sampling period. The high population showed the greatest relative increase and yielded the most protein per acre. Sharp decreases were noted in protein content at bloom and at five and seven weeks after bloom in the high population. The medium and low population increased in protein throughout the sampling period, but differences among populations were never large. A significant (5 percent level) population x date interaction was found and was attributed to the relatively greater increase in protein content in the high population.

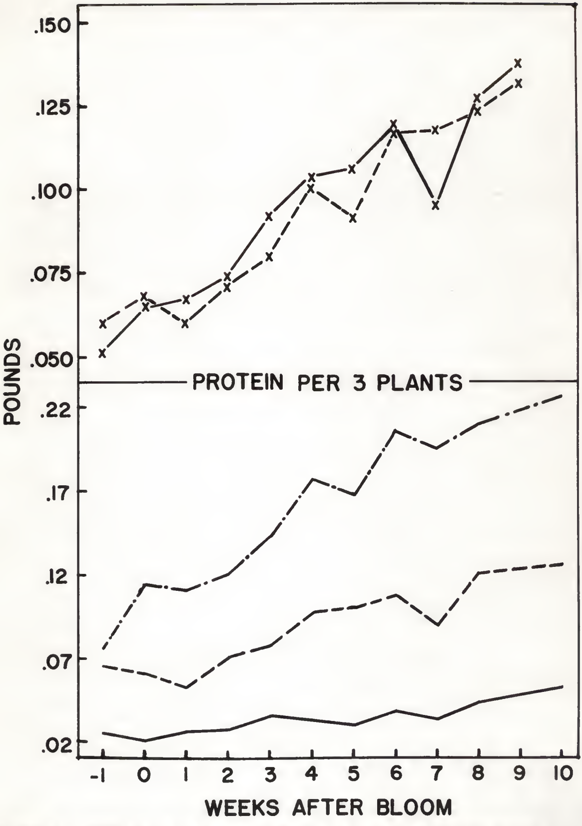

Figure 6. Accumulation of protein (lbs./3 plants). High population, ______; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ____x____; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = .0229; population L.S.D. .05 level = .0084.

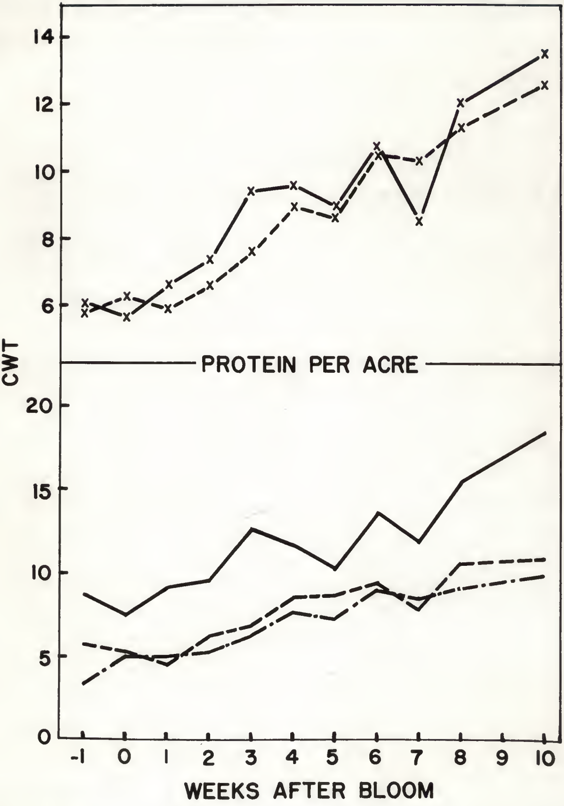

Figure 7. Accumulation of protein (cwt./A.). High population, ____; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = 1.64; population L.S.D. .05 level = .60.

Differences between row widths were not significant, although the 40-inch width showed a sharp decrease seven weeks after bloom. The overall trend for both row widths was to increase greatly in protein throughout the sampling period.

Although the low population accumulated the largest amount of protein on a three plant basis, the high population produced the greatest total amount of protein per acre. This was due entirely to the effect of population. Percent of protein content of the leaves decreased over the sampling period. This may have been due both to deterioration of leaves and to accumulation of carbohydrates as the plants matured. The stems contained the lowest percent of protein because of carbohydrate accumulation, and the heads contained the highest percent of protein.

Crude Fiber

The percent of crude fiber per plant part is shown in Fig. 8 and appendix Table 9. The content of the leaves fluctuated slightly until three weeks after bloom; then it began to decrease slightly and continued to decrease throughout the sampling period. Differences among the dates were highly significant. When the immature heads were combined with the stems, the content decreased sharply after bloom. This was attributed to accumulation of carbohydrates in the heads. Here again, differences among dates were highly significant. After the heads and stems were separated, each decreased slightly in percent of crude fiber until sampling was discontinued. The leaves contained the greatest percent of crude fiber. The content of the stems was less than that of the leaves because of carbohydrate accumulation in the stems. The heads contained a large amount of carbohydrates; hence, less crude fiber was present.

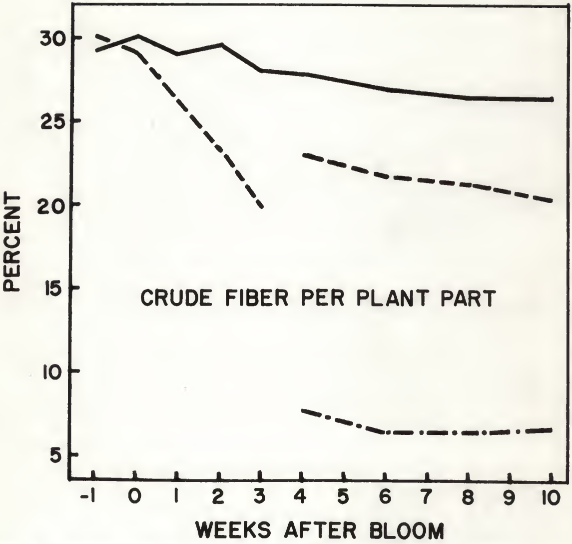

Figure 8. Accumulation of crude fiber (percent/plant part). Leaves, ____; stem, _ _ _ _; head, ___.___.___. Date L.S.D. .05 level: leaves, .82; stems, .95, 1.55; head, 1.21.

As was shown with dry matter and protein, the low population made the largest relative increase in crude fiber per three plants (Figure 9 and appendix Table 10). This accounted for the highly significant population x date interaction. Differences in the crude fiber content among dates were highly significant. The high population fluctuated little while increasing slightly in content. Slight decreases were noted one and three weeks after bloom in the medium population.

Differences between widths were not significant. Slight fluctuations were noted in each width, but the general trend was to increase greatly in crude fiber content.

Accumulation of crude fiber per acre is shown in Figure 10 and appendix Table 11. Very little difference was observed between the medium and low populations at any one date, although they increased in crude fiber throughout the sampling period. Slight decreases were noted in the medium population at one, three, and six weeks after bloom. The high population produced the greatest amount of fiber at all dates, and this accounted for the highly significant differences among dates and among populations. In the high population, the crude fiber content dropped sharply at four weeks after bloom and did not regain its previous maximum until about the ninth week following bloom.

Crude fiber content in the two row widths increased greatly over the sampling period. Though differences between the widths were not significant, each width fluctuated somewhat, with the greatest variation shown by the 40-inch rows. Here again, a sharp decrease was observed the fifth and sixth weeks after bloom in the 40-inch rows. The 40-inch rows overcame this decrease at about the ninth week following bloom.

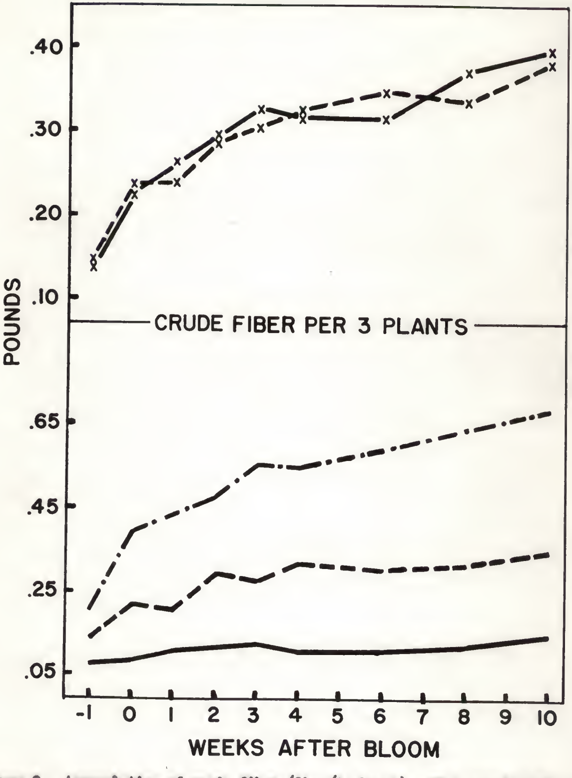

Figure 9. Accumulation of crude fiber (lbs./3 plants). High population, ____; med. population, _ _ _ _; low population, ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = .0833; population L.S.D. .05 level = .0341.

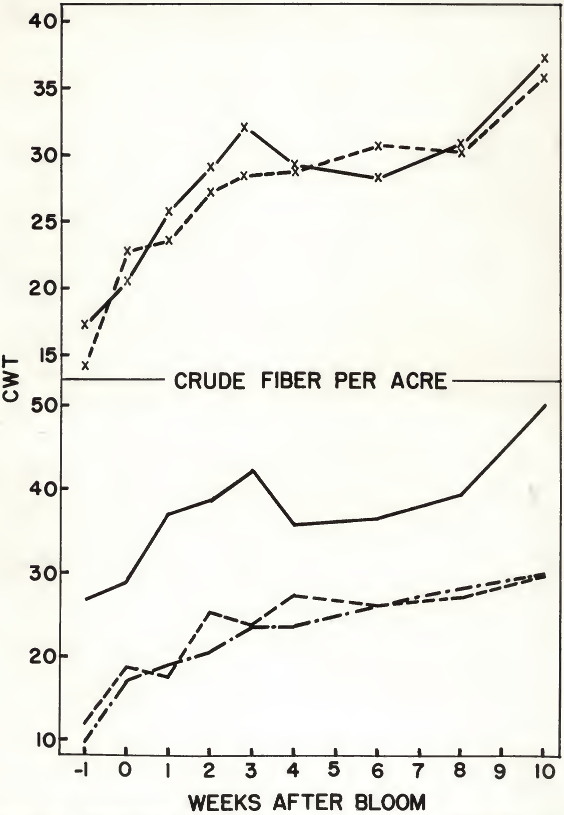

Figure 10. Accumulation of crude fiber (cwt./A.). High population, ____; med. population, _ _ _ _; low population, ____.____.____.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = 5.55; population L.S.D. .05 level = 2.26.

The leaves contained the largest amount of crude fiber, while the heads contained the least amount due to their high carbohydrate content. The percent of crude fiber decreased in the stems and leaves because of the accumulation of carbohydrates. On a three plant basis the low population produced the largest amount of crude fiber, but the high population produced the greatest amount on a per acre basis. Similar amounts of crude fiber were produced by both the low and the medium populations on a per acre basis. The general trend was for an increase in fiber over the sampling period.

Acid Hydrolyzable Carbohydrates

Figure 11 and appendix Table 12 present the accumulation of acid hydrolyzable carbohydrates on a percent basis. The content in the leaves decreased slightly in the early sampling periods and decreased very sharply the sixth week after bloom. This decrease occurred about the time of physiological maturity and when dry matter increased in the total plant. The acid hydrolyzable carbohydrates were transformed into chemical compounds which were not picked up in the analyses. The decrease was made up by the tenth week after bloom. When the heads and stems were combined, the acid hydrolyzable carbohydrates increased. This was due to the large accumulation of carbohydrate substances in the heads. When the heads and stems were separated, there was a sharp decrease in content at the sixth week after bloom in both. Following that decrease, they increased sharply in content. As was expected, the heads contained the largest percent of acid hydrolyzable carbohydrates during the later sampling periods. During these later sampling periods, it was noted that the leaves and stems contained about the same percent of acid hydrolyzable carbohydrates.

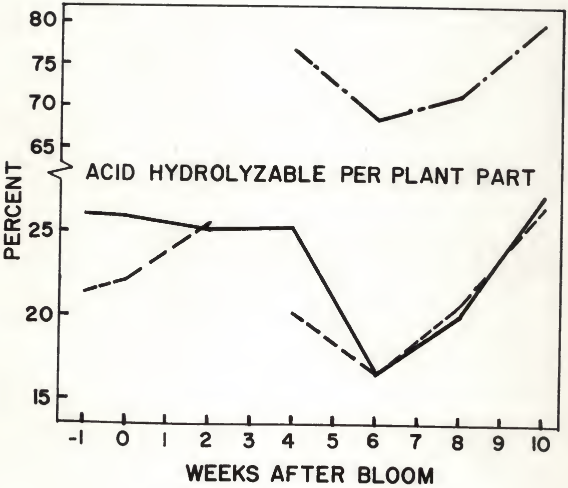

Figure 11. Accumulation of acid hydrolyzable carbohydrates (percent/plant part). Leaves, ____; stem, _ _ _ _; head, ___.___.___. Date L.S.D. .05 level: leaves, 2.32; stems, .25, 2.02; head, 12.29.

Total Sugars

The leaves greatly increased in percent of total sugars over the sampling period (Fig. 12 and appendix Table 13). The greatest increase occurred the third and fourth weeks after bloom, with a slight decrease the sixth week after bloom. The stems increased slightly in percent of total sugars at six weeks after bloom and then decreased slightly until sampling was discontinued. A sharp decrease was noted in the heads the fifth and sixth weeks after bloom and then decreased slightly until sampling was discontinued. A sharp decrease was noted in the heads the fifth and sixth weeks after bloom, at which time the percentage leveled off. This decrease was expected as the grain reached physiologic maturity at about five and one-half weeks after bloom because by this time the sugars would have been converted to starch.

As sugar formation took place in the leaves, it was expected that they would contain a larger percent of total sugars than any other plant part. However, the sudden increase in percent total sugars present in the leaves could not be explained by any known concepts. It was postulated that transfer of the sugars to the heads was very rapid and that, as the sugars accumulated in the heads, the rapidity at which the transfer was taking place was decreased, thus allowing the total sugars to build up in the leaves. However, it was also thought that as the heads filled up with carbohydrates, more of the total sugars would be transferred to the stem where they would accumulate. If this were true, it was difficult to ascertain why transfer to the stems would be slower than to the heads.

Environmental conditions may have caused the rate of respiration to be increased at about the fifth to seventh weeks after bloom. As sugars are used in respiration, it was possible that respiration caused the acid hydrolyzable

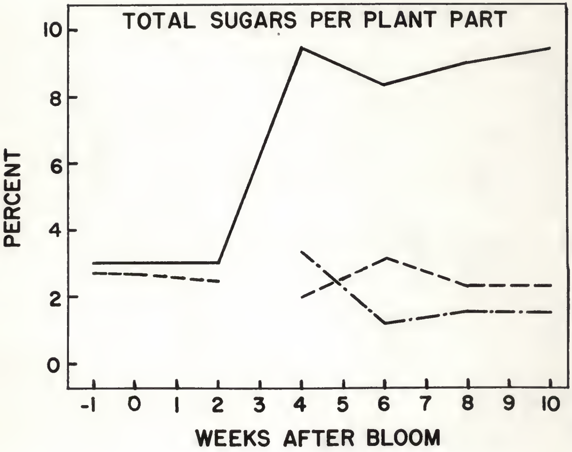

Figure 12. Accumulation of total sugars (percent/plant part). Leaves, ______; stem, _ _ _ _; head, ____.____.____. Date L.S.D. .05 level: leaves, .95; stems, .21, .18; head, 1.25.

carbohydrates to be degraded into sugars which could then be used in respiration. This may account for the slight increase in the percent of total sugars in the stems at that time.

Total Carbohydrates

The sum of acid hydrolyzable carbohydrates and total sugars is referred to as total carbohydrates. Figure 13 and appendix Table 14 present the percent of total carbohydrates per plant part. The content of the leaves decreased slightly until two weeks after bloom, but it increased greatly between the second and the fourth week after bloom. This increase was followed by a sharp decrease to the sixth week after bloom when the content began increasing sharply again. The stem and head combination showed an increase in the early sampling periods due to the large increase in carbohydrates in the heads. The stems alone decreased somewhat the sixth week after bloom and increased sharply thereafter. The heads also showed a sharp decrease the sixth week after bloom, at which time they began increasing in percent of total carbohydrates again.

The heads contained the greatest percent of total carbohydrates, as was expected. It was surprising to note, however, that the leaves contained a larger percent than did the stems.

Pounds of total carbohydrates per three plants are shown in Fig. 14 and appendix Table 15. The low population produced the greatest relative increase, while the high population made the least; thus, a highly significant population x date interaction was observed. A slight decrease in content was shown by all populations the sixth week after bloom. Differences in total carbohydrate content among the populations were highly significant.

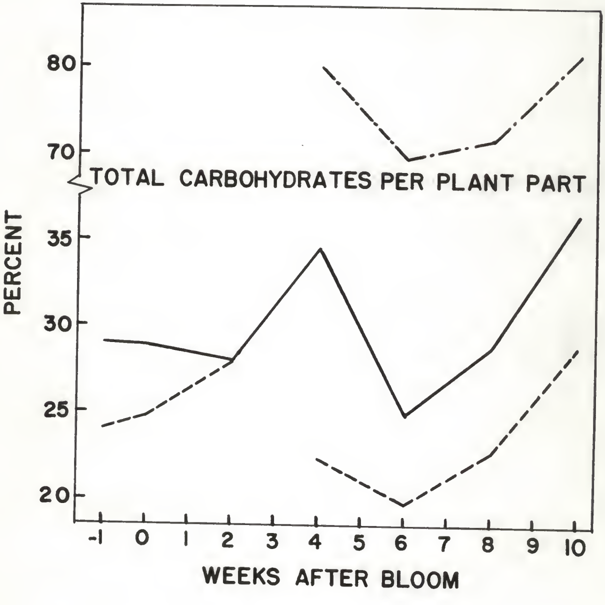

Figure 13. Accumulation of total carbohydrates (percent/plant part). Leaves, ______; stem, _ _ _ _; head, ___.___.___. Date L.S.D. .05 level: leaves, 2.81; stems, .84, 2.11; heads, 12.15.

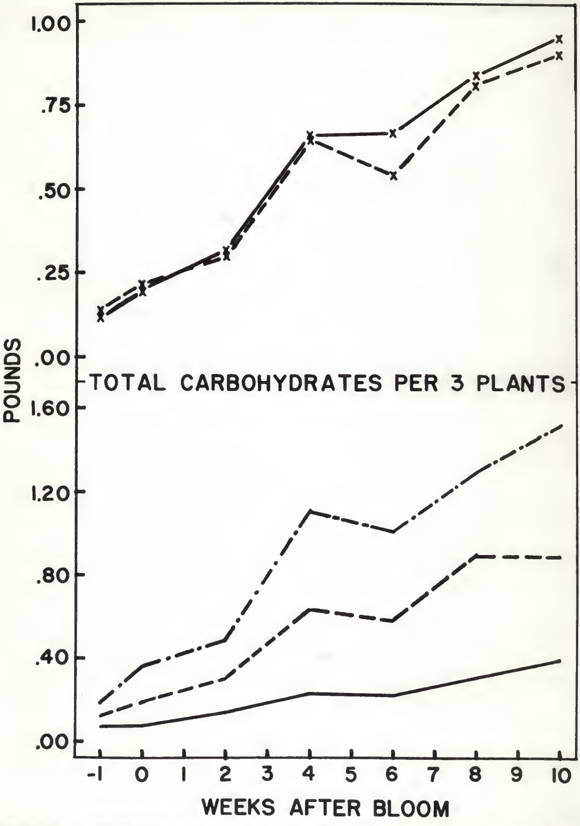

Figure 14. Accumulation of total carbohydrates (lbs./3 plants). High population, ____; med. population, _ _ _; low population ___.___.___.; 40-inch row width, __x__; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = .0901; population L.S.D. .05 level = .0417.

Total carbohydrate content of the row widths increased greatly over the sampling period. The 40-inch width produced slightly more total carbohydrates than did the 20-inch width, and differences between the two widths were significant at the 5 percent level. This was probably due in part to the moderate decrease in content of the 20-inch rows at six weeks after bloom. Highly significant differences among the dates were found.

The largest yield of total carbohydrates per acre was produced by the high population (Fig. 15 and appendix Table 16). The largest relative increase over the sampling period was also produced by the high population, and the low population made the smallest increase. Slight decreases in content were observed the sixth week after bloom in all populations. Highly significant differences were noted among dates and among populations. Because of the great relative increase in total carbohydrates in the high populations, a highly significant population x date interaction was found.

Differences in total carbohydrate content between widths became increasingly larger after the second week following bloom. A significantly higher yield of total carbohydrates was produced by the 40-inch row width. The significant (5 percent level) population x row width interaction was probably due to the interaction between the high population and the 40-inch row width to produce the highest yields. The population x row width x date second order interaction was also found to be highly significant.

It was shown that acid hydrolyzable carbohydrates made up the greatest part of total carbohydrates. The leaves contained a larger percent of acid hydrolyzable carbohydrates and total sugars than did the stems. The heads contained very large amounts of acid hydrolyzable carbohydrates but only small amounts of total sugars. Total carbohydrates per three plants and per acre increased greatly over the sampling period. The 40-inch row width yielded

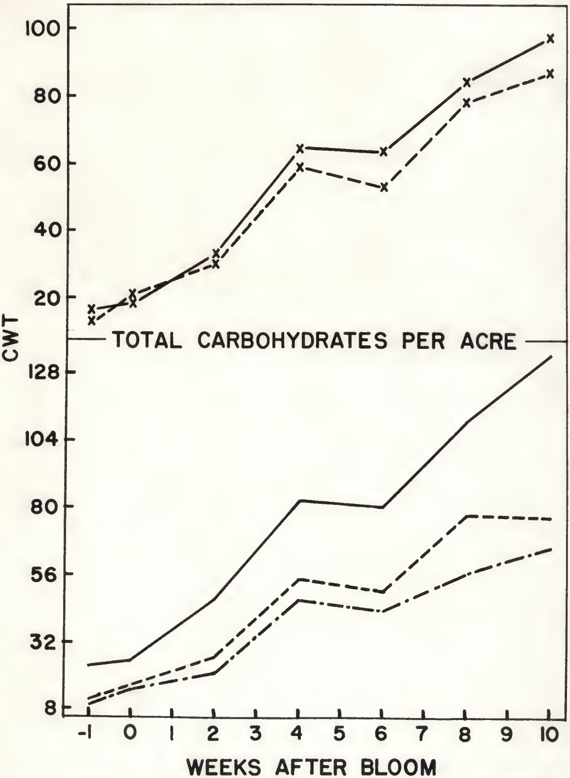

Figure 15. Accumulation of total carbohydrates (cwt./A.). High population, ____; med. population, _ _ _ _; low population ___.___.___.; 40-inch row width, ___x___; 20-inch row width, _ _ _ x _ _ _. Width x date L.S.D. .05 level = 9.30; population L.S.D. .05 level= 4.30.

significantly more total carbohydrates per acre than did the 20-inch row width. Maximum yield of total carbohydrates per acre was produced by the high population. It seemed logical that total carbohydrates would increase until a killing frost occurred.

Harvest at Eleven Weeks after Bloom

Table 2 and appendix Table 17 present the results of harvesting the plots 11 weeks after bloom, on October 19. The 20-inch row width produced slightly higher silage yields (70 percent moisture) than did the 40-inch rows. The difference between the widths was significant at the 10 percent level. Highly significant differences were noted among populations as the high population (in 20-inch row widths) produced significantly higher yields than the low population but not significantly higher than the medium population. The high population produced significantly greater yields than the low and medium populations in the 40-inch widths.

Stover:grain ratio differences were significant (5 percent level) among populations. Differences between widths were not significant. Overall, the low population produced significantly larger ratios than the high population.

The high population produced significantly higher grain yields than did the low or medium populations. Differences between the row widths were not significant.

The high population produced a significantly higher head threshing percentage than the low population. Differences between the high and medium populations were not significant. Also, differences between row widths were not significant.

It was thus found that the high population produced a greater threshing percentage and higher silage and grain yields than the low population.

Table 2. Silage yield, stover:grain ratio, grain yield and threshing percentage in Atlas forage sorghum as affected by plant population and row width when harvested 11 weeks after bloom.

Population	Row width 20	40	ave.
SILAGE YIELD (TONS/A.); 70% MOISTURE			
High	30.36	29.14	29.75
Med.	27.49	23.34	25.42
Low	23.81	22.10	22.96
Ave.	27.22	24.86	26.04
Population L.S.D. .05 level = 2.95			
STOVER:GRAIN RATIO			
High	3.15	3.26	3.20
Med.	4.19	3.17	3.68
Low	4.47	4.26	4.36
Ave.	3.94	3.56	3.75
Population L.S.D. .05 level = .86			
GRAIN YIELD (cwt/A); OVEN DRY			
High	44.47	41.24	42.86
Med.	32.12	34.50	33.31
Low	26.92	25.61	26.26
Ave.	34.50	33.78	34.14
Population L.S.D. .05 level = 6.38			
HEAD THRESHING PERCENTAGE			
High	78.7	79.7	79.2
Med.	75.7	77.2	76.4
Low	74.5	75.2	74.8
Ave.	76.3	77.4	76.8
Population L.S.D. .05 level = 3.3			

Differences between the high and medium populations were significant only with respect to grain yield. Because of the greater number of plants per acre, more grain was produced, which lowered the stover:grain ratio in the high population. The low population produced the largest stover:grain ratio. Generally, very small differences were observed between row widths.

Tillering and Plant Part Contribution to Dry Weight

Average tiller counts over the sampling period showed that the high population produced essentially no tillers, the medium population approximately 1.6 tillers per plant, and the low population almost 3 tillers per main culm. The previously noted greater relative increase in dry matter per three plants and in chemical constituents per three plants by the low population was thus due largely to the number of tillers produced.

In reference to Table 3, it was noted that the leaves made up a greater percent of the plant dry weight than did the stems when the first sample was taken. The increase in the contribution by stems to total dry weight until the fourth week after bloom was partly due to the increase in the weight of the heads which were combined with the stems. After that time, it was observed that the percent of the plant dry weight produced by the respective plant parts changed little. Stems made up about 50 percent of the plant dry weight, while the leaves contributed about 20 percent and the heads about 30 percent. It was evident that the various plant parts were increasing in weight and in total carbohydrate accumulation at about the same rate during the later sampling periods.

Table 3. Percent contributed by the plant parts to total dry weight of Atlas forage sorghum.

Date of harvest	Leaves*	Stems	Heads
-1	56.6	43.4	
0	44.1	55.9	
1	34.1	65.9	
2	28.9	71.1	
3	26.8	73.2	
4	23.5	50.1	26.4
5	22.4	50.2	27.4
6	21.7	50.3	28.0
7	18.5	50.2	31.3
8	22.8	49.2	28.0
10	22.5	52.0	25.5

*Leaves included both leaf blade and sheath.

SUMMARY AND CONCLUSIONS

A study was conducted in 1961 to determine the trends in carbohydrate, fiber, protein, and dry matter accumulation in Atlas forage sorghum as affected by stage of maturity, plant population, and row width. Forty-inch and 20-inch row widths were used. The populations were 104,500 plants per acre (high), 26,100 plants per acre (medium), and 13,100 plants per acre (low).

All plant parts tended to increase in dry matter (pounds per three plants) during the sampling period. The low population made the greatest relative increase while the high population made the smallest. Physiologic maturity of the grain occurred at about five and one-half weeks after bloom, at which time all plant parts showed an increase in dry matter accumulation. Differences between row widths in dry matter accumulation were not significant. The high population produced the highest yield per acre.

Percent of protein in the leaves decreased consistently over the sampling period. The percent in the stems decreased slightly and levelled off, while that of the heads increased slightly. During the later portion of the sampling period, the heads contained the highest percent protein. Pounds of protein per three plants and per acre tended to increase throughout the sampling period. The high population produced the smallest relative increase in protein per three plants but produced the highest yield per acre. Significant differences between row widths were not found.

The leaves contained the greatest percent of crude fiber. All plant parts decreased in percent of crude fiber during the sampling period. The pounds of crude fiber per three plants and per acre increased throughout the sampling period. The greatest relative increase per three plants was made by the low population, while the high population produced the highest yield of fiber per acre. Differences between row widths were not significant.

The trend in the accumulation of percent of acid hydrolyzable carbohydrates per plant part was to decrease and then increase. This decrease, which was noticed in all plant parts between four and six weeks after bloom, was attributed to transformation of the acid hydrolyzable carbohydrates into chemical compounds which were not determined by the methods of analysis employed. The stems and leaves contained about the same percent of acid hydrolyzable carbohydrates, while the heads contained much more.

The leaves increased greatly in percent of total sugars over the sampling period and also contained the highest percent of total sugars. The content in the stems and heads did not change much over the sampling period.

Percent of total carbohydrates in each plant part tended to increase throughout the sampling period. Pounds of total carbohydrates per acre and per three plants also increased. The low population produced the greatest relative increase per three plants while the high population produced the highest yield per acre. Pounds per acre yields between row widths were highly significant as the 40-inch row width outproduced the 20-inch width.

A final harvest 11 weeks after bloom showed that the high population produced the highest silage yield, grain yield, threshing percentage, and the lowest stover:grain ratio. Differences between the row widths were not significant at the 5 percent level.

Little tillering was observed in the high population, while the medium population had about 1.6 tillers and the low population about 3 tillers per main culm. The stems made up about 50 percent of the dry weight of the plant, while the leaves and heads contributed about 20 percent and 30 percent, respectively.

It was concluded that:

1. the high population was superior to either the medium or low population in production of total yield,
2. differences between row widths were generally not significant, and
3. highest yields per acre were obtained at the last sampling period.

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APPENDIX

Table 1. Accumulation of dry matter (lbs./3 plants) in leaves of Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population High	 Med.	 Low	Row width 40	 20
-1	.14	.26	.34	.26	.24
0	.12	.33	.60	.33	.36
1	.13	.25	.54	.32	.29
2	.13	.31	.55	.32	.33
3	.15	.33	.65	.39	.36
4	.12	.36	.65	.37	.39
5	.11	.34	.59	.36	.33
6	.13	.34	.68	.37	.40
7	.13	.29	.64	.31	.39
8	.14	.38	.74	.40	.43
10	.19	.43	.80	.49	.45

Width x date L.S.D. .05 level = .77
Population L.S.D. .05 level = .40

Analysis of variance

Source of variation	D.F.	Mean Squares
Date	10	.083**
Replication	3	.004
Date x replication	30	.006
Population	2	5.158**
Row width	1	.001
Population x row width	2	.051**
Population x date	20	.027**
Row width x date	10	.007
Population x row width x date	20	.010
Error	165	.009
TOTAL	263	

**Exceeds the .01 level.

Table 2. Accumulation of dry matter (lbs./3 plants) in stems of Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population			Row width	
	High	Med.	Low	40	20
-1	.12	.21	.24	.21	.17
0	.16	.41	.74	.43	.44
1	.28	.50	1.00	.63	.56
2	.33	.82	1.28	.83	.79
3	.44	.92	1.73	1.09	.97

Width x date L.S.D. .05 level = .14
Population L.S.D. .05 level = .08

Analysis of variance

Source of variation	D.F.	Mean Squares
Date	4	2.535**
Replication	3	.027
Date x replication	12	.031
Population	2	5.345**
Row width	1	.070
Population x row width	2	.035
Population x date	8	.411**
Row width x date	4	.018
Population x row width x date	8	.036
Error	75	.030
TOTAL	119	

**Exceeds the .01 level.

Table 3. Accumulation of dry matter (lbs./3 plants) in stems of Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population			Row width	
	High	Med.	Low	40	20
4	.24	.75	1.44	.80	.82
5	.21	.71	1.42	.80	.76
6	.28	.79	1.61	.83	.95
7	.27	.72	1.54	.71	.97
8	.30	.83	1.56	.92	.88
10	.38	.95	1.94	1.26	1.06

Width x date L.S.D. .05 level = .23
Population L.S.D. .05 level = .04

Analysis of variance

Source of variation	D.F.	Mean Squares
Date	5	.292**
Replication	3	.047
Date x replication	15	.052
Population	2	20.680**
Row width	1	.050
Population x row width	2	.020
Population x date	10	.042
Row width x date	5	.096
Population x row width x date	10	.093
Error	90	.078
TOTAL	143	

**Exceeds the .01 level.

Table 4. Accumulation of dry matter (lbs./3 plants) in heads of Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population High	Population Med.	Population Low	Row width 40	Row width 20
4	.17	.42	.68	.44	.41
5	.14	.48	.65	.47	.38
6	.19	.50	.81	.54	.46
7	.16	.40	.77	.41	.47
8	.22	.57	.78	.56	.49
10	.25	.56	.80	.56	.51

Width x date L.S.D. .05 level = .12
Population L.S.D. .05 level = .06

Analysis of variance

Source of variation	D.F.	Mean squares
Date	5	.060+
Replication	3	.047
Date x replication	15	.023
Population	2	3.765**
Row width	1	.070+
Population x row width	2	.015
Population x date	10	.013
Row width x date	5	.018
Population x row width x date	10	.014
Error	90	.024
TOTAL	143	

**Exceeds the .01 level.

+Exceeds the .10 level.

Table 5. Accumulation of dry matter (lbs./3 plants) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date	Population			Row width	
Weeks after bloom	High	Med.	Low	40	20
-1	.26	.47	.58	.46	.41
0	.28	.73	1.34	.76	.80
1	.41	.74	1.54	.95	.84
2	.46	1.13	1.82	1.15	1.12
3	.58	1.26	2.38	1.48	1.33
4	.54	1.54	2.76	1.61	1.61
5	.46	1.54	2.66	1.64	1.47
6	.60	1.63	3.10	1.74	1.81
7	.55	1.41	2.94	1.44	1.83
8	.67	1.75	3.07	1.88	1.78
10	.83	1.93	3.54	2.17	2.02

Width x date L.S.D. .05 level = .32
Population L.S.D. .05 level = .52

Analysis of variance

Source of variation	D.F.	Mean squares
Date	10	6.163**
Replication	3	.093
Date x replication	30	.093
Population	2	74.115**
Row width	1	.040
Population x row width	2	.000
Population x date	20	1.183**
Row width x date	10	.151
Population x row width x date	20	.187
Error	165	.154
TOTAL	263	

**Exceeds the .01 level.

Table 6. Accumulation of protein (%/plant part) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Plant Part: Leaves	Stem	Stem	Head
-1	14.46	6.64		
0	12.79	4.76		
1	12.02	4.39		
2	11.39	4.23		
3	11.04	4.04		
4	10.21		1.94	10.53
5	9.85		1.88	11.37
6	10.04		1.88	11.92
7	9.67		1.94	11.92
8	9.66		2.09	12.03
10	8.83		2.28	12.08
Date L.S.D. .05 level	.26	.34	.12	.48

Analysis of variance

Source of variation	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.
Date	10	32.91**	4	12.03**	5	.296**	5	4.34**
Composite	1	3.47**	1	.78*	1	.980**	1	1.48*
Date x composite	10	.08	4	.09	5	.010	5	.21
Population	2	18.47	2	1.71**	2	1.915**	2	4.80**
Row width	1	1.15	1	.01	1	.010	1	2.11**
Population x row width	2	.40	2	.02	2	.030	2	2.75**
Population x date	20	.26	8	1.57**	10	.035	10	.26
Row width x date	10	.20	4	.26	5	.018	5	.37
Population x row width x date	20	.06	8	.13	10	.033	10	.14
Error	55	.11	25	.18	30	.029	30	.25
TOTAL	131		59		71		71	

**Exceeds the .01 level. *Exceeds the .05 level.

Table 7. Accumulation of protein (lbs./3 plants) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population High	Population Med.	Population Low	Row width 40	Row width 20
-1	.0249	.0656	.0764	.0513	.0599
0	.0215	.0615	.1146	.0640	.0678
1	.0263	.0532	.1108	.0672	.0597
2	.0273	.0711	.1195	.0741	.0711
3	.0360	.0783	.1432	.0920	.0797
4	.0335	.0974	.1762	.1038	.1010
5	.0296	.0999	.1673	.1065	.0914
6	.0388	.1078	.2052	.1181	.1165
7	.0341	.0898	.1947	.0952	.1172
8	.0441	.1208	.2097	.1268	.1230
10	.0527	.1248	.2260	.1372	.1318

Width x date L.S.D. .05 level = .0229
Population L.S.D. .05 level = .0084

Analysis of variance

Source of variation	D.F.	Mean squares
Date	10	.008514**
Composite	1	.000024
Date x composite	10	.000244
Population	2	.172722**
Row width	1	.000080
Population x row width	2	.000034
Population x date	20	.001831**
Row width x date	10	.000315
Population x row width x date	20	.000388
Error	55	.000392
TOTAL	131	

**Exceeds the .01 level.

Table 8. Accumulation of protein (lbs./A.) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date	Population			Row width	
Weeks after bloom	High	Med.	Low	40	20
-1	867	571	333	595	585
0	748	536	499	568	621
1	917	464	483	656	587
2	951	619	521	732	663
3	1,254	682	624	941	766
4	1,167	848	768	964	891
5	1,030	870	728	890	863
6	1,354	938	894	1,070	1,055
7	1,189	782	848	850	1,030
8	1,537	1,053	913	1,206	1,130
10	1,835	1,087	984	1,351	1,254

Width x date L.S.D. .05 level = 164
Population L.S.D. .05 level = 60

Analysis of variance

Source of variation	D.F.	Mean squares
Date	10	679,853**
Composite	1	6,468
Date x composite	10	8,749
Population	2	2,891,372**
Row width	1	38,762
Population x row width	2	32,366
Population x date	20	42,948*
Row width x date	10	25,362
Population x row width x date	20	21,919
Error	55	20,111
TOTAL	131	

**Exceeds the .01 level.

*Exceeds the .05 level.

Table 9. Accumulation of crude fiber (%/plant part) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Plant part: Leaves	Stem	Stem	Head
-1	29.20	30.14		
0	30.08	28.96		
1	29.04	26.18		
2	29.53	23.39		
3	27.92	19.70		
4	27.87		23.00	7.65
6	26.80		21.74	6.35
8	26.45		21.38	6.35
10	26.31		20.69	6.60
Date L.S.D. .05 level	.82	.95	1.55	1.21

Analysis of variance

Source of variation	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.
Date	8	23.64**	4	215.74**	3	11.29+	3	4.66
Composite	1	.06	1	1.51	1	2.94	1	.07
Date x composite	8	.75	4	.70	3	1.42	3	.87
Population	2	17.50**	2	15.86**	2	2.15*	2	21.58**
Row width	1	2.59*	1	.01	1	1.82	1	5.62**
Population x row width	2	2.71**	2	6.80**	2	2.62*	2	.72
Population x date	16	1.17*	8	2.33*	6	2.84**	6	.41
Row width x date	8	.34	4	.43	3	1.11	3	.12
Population x row width x date	16	.77	8	.27	6	.33	6	.19
Error	45	.52	25	.71	20	.51	20	.43
TOTAL	107		59		47		47	

**Exceeds the .01 level. *Exceeds the .05 level. +Exceeds the .10 level.

Table 10. Accumulation of crude fiber (lbs./3 plants) in Atlas forage sorghum as affected by stage of maturity, plant population and row width.

Date	Population			Row width	
Weeks after bloom	High	Med.	Low	40	20
-1	.0755	.1361	.2058	.1379	.1405
0	.0826	.2141	.3924	.2246	.2349
1	.1060	.2031	.4368	.2606	.2367
2	.1110	.2884	.4722	.2942	.2869
3	.1213	.2728	.5495	.3270	.3021
	.1027	.3140	.5446	.3167	.3243
6	.1049	.2996	.5862	.3145	.3461
8	.1133	.3124	.6312	.3709	.3338
10	.1435	.3412	.6809	.3962	.3810

Width x date L.S.D. .05 level = .0833
Population L.S.D. .05 level = .0341

Analysis of variance

Source of variation	D.F.	Mean squares
Date	8	.067255**
Composite	1	.000049
Date x composite	8	.002384
Population	2	1.409616**
Row width	1	.001052
Population x row width	2	.000230
Population x date	16	.017168**
Row width x date	8	.001373
Population x row width x date	16	.002506
Error	45	.005132
TOTAL	107	

**Exceeds the .01 level.

Table 11. Accumulation of crude fiber (lbs./A.) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date	Population			Row width	
Weeks after bloom	High	Med.	Low	40	20
-1	2,631	1,185	897	1,737	1,405
0	2,879	1,865	1,709	2,042	2,261
1	3,694	1,769	1,903	2,563	2,348
2	3,868	2,512	2,056	2,913	2,712
3	4,226	2,376	2,394	3,175	2,822
4	3,578	2,735	2,372	2,916	2,875
6	3,655	2,610	2,554	2,810	3,070
8	3,952	2,721	2,750	3,082	3,034
10	4,999	2,972	2,966	3,720	3,572

Width x date L.S.D. .05 level = 555
Population L.S.D. .05 level = 226

Analysis of variance

Source of variation	D.F.	Mean squares
Date	8	4,366,920**
Composite	1	0
Date x composite	8	88,545
Population	2	26,386,946**
Row width	1	350,208
Population x row width	2	131,392
Population x date	16	238,770
Row width x date	8	145,998
Population x row width x date	16	183,588
Error	45	227,749
TOTAL	107	

**Exceeds the .01 level.

Table 12. Accumulation of acid hydrolyzable carbohydrates (%/plant part) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Plant part Leaves	Stem	Stem	Head
-1	26.05	21.42		
0	25.93	22.13		
2	25.03	25.50		
4	25.11		20.10	76.64
6	16.61		16.63	68.31
8	19.92		20.48	71.08
10	27.10		26.50	79.78
Date L.S.D. .05 level	2.32	.25	2.07	12.29

Analysis of variance

Source of variation	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.
Date	6	180.83**	2	57.01**	3	201.53**	3	325.26
Composite	1	.60	1	.02	1	24.66*	1	381.32
Date x composite	6	5.63	2	.22	3	2.53	3	89.45
Population	2	4.62	2	2.83**	2	28.17**	2	453.18**
Row width	1	51.98**	1	.12	1	.03	1	.87
Population x row width	2	.28	2	.32	2	11.70*	2	19.64
Population x date	12	9.01+	4	7.68**	6	4.58+	6	82.58
Row width x date	6	26.33**	2	.57	3	6.11+	3	174.26*
Population x row width x date	12	1.30	4	1.18+	6	7.55*	6	62.14
Error	35	4.81	15	.43	20	2.09	20	41.94
TOTAL	83		35		47		47	

**Exceeds the .01 level. *Exceeds the .05 level. +Exceeds the .10 level.

Table 13. Accumulation of total sugars (%/plant part) in Atlas forage sorghum as affected by stage of maturity, plant population and row width.

Date Weeks after bloom	Plant part Leaves	Stem	Stem	Head
-1	2.98	2.68		
0	3.02	2.63		
2	3.03	2.44		
4	9.38		2.26	3.30
6	8.35		3.12	1.20
8	9.01		2.30	1.55
10	9.37		2.29	1.52
Date L.S.D. .05 level	.95	.21	.18	1.25

Analysis of variance

Source of variation	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.
Date	6	125.53**	2	.195*	3	2.10**	3	10.89*
Composite	1	1.37	1	.000	1	0.00	1	.85
Date x composite	6	.90	2	.010	3	0.02	3	.93
Population	2	6.28**	2	.015	2	2.18**	2	2.92**
Row width	1	2.86**	1	.000	1	2.37**	1	.02
Population x row width	2	2.51**	2	.015	2	2.12**	2	.44*
Population x date	12	4.35**	4	.012	6	2.16**	6	.89**
Row width x date	6	5.50**	2	.020+	3	2.46**	3	.12
Population x row width x date	12	2.37**	4	.002	6	2.50**	6	.17
Error	35	.35	15	.007	20	.02	20	.09
TOTAL	83		35		47		47	

**Exceeds the .01 level. *Exceeds the .05 level. +Exceeds the .10 level.

Table 14. Accumulation of total carbohydrates (%/plant part) in Atlas forage sorghum as affected by stage of maturity, plant population and row width.

Date Weeks after bloom	Plant part Leaves	Stem	Stem	Head
-1	29.03	24.10		
0	28.94	24.76		
2	28.06	27.94		
4	34.49		22.36	79.94
6	24.96		19.75	69.51
8	28.92		22.77	72.63
10	36.47		28.79	81.30
Date L.S.D. .05 level	2.81	.84	2.11	12.15

Analysis of variance

Source of variation	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.	D.F.	M.s.
Date	6	188.82**	2	50.54**	3	175.46**	3	388.35
Composite	1	3.80	1	.03	1	25.09+	1	346.21
Date x composite	6	7.93	2	.23	3	2.65	3	87.55
Population	2	9.84	2	2.70*	2	45.27**	2	384.19**
Row width	1	30.41*	1	.13	1	1.89	1	1.10
Population x row width	2	2.36	2	.44	2	5.42+	2	14.46
Population x date	12	14.87**	4	8.16**	6	6.21*	6	82.70
Row width x date	6	33.91**	2	.78	3	15.18**	3	171.27*
Population x row width x date	12	3.40	4	1.17+	6	11.75**	6	60.92
Error	35	4.99	15	.46	20	1.99	20	41.56
TOTAL	82		35		47		47	

**Exceeds the .01 level. *Exceeds the .05 level. +Exceeds the .10 level.

Table 15. Accumulation of total carbohydrates (lbs./3 plants) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population			Row width	
	High	Med.	Low	40	20
-1	.0683	.1234	.1862	.1244	.1276
0	.0730	.1929	.3590	.1998	.2169
2	.1367	.3084	.4888	.3205	.3023
4	.2365	.6279	1.0963	.6606	.6468
6	.2325	.5774	1.0074	.6733	.5385
8	.3182	.8858	1.2918	.8444	.8198
10	.3850	.8815	1.5113	.9510	.9012

Width x date L.S.D. .05 level = .0901
Population L.S.D. .05 level = .0417

Analysis of variance

Source of variation	D.F.	Mean squares
Date	6	1.16633**
Composite	1	.00780
Date x composite	6	.00410
Population	2	2.88255**
Row width	1	.02090+
Population x row width	2	.01155
Population x date	12	.15218**
Row width x date	6	.00755
Population x row width x date	12	.00563
Error	35	.00591
TOTAL	83	

**Exceeds the .01 level.

+Exceeds the .10 level.

Table 16. Accumulation of total carbohydrates (lbs./A.) in Atlas forage sorghum as affected by stage of maturity, plant population, and row width.

Date Weeks after bloom	Population			Row width	
	High	Med.	Low	40	20
-1	2,381	1,075	811	1,550	1,295
0	2,544	1,680	1,564	1,831	2,028
2	4,764	2,686	2,129	3,344	3,044
4	8,240	5,470	4,775	6,452	5,874
6	8,102	5,029	4,388	6,375	5,307
8	11,089	7,716	5,627	8,471	7,820
10	13,414	7,679	6,582	9,727	8,727

Width x date L.S.D. .05 level = 930
Population L.S.D. .05 level = 430

Analysis of variance

Source of variation	D.F.	Mean squares
Date	6	110,333,410**
Composite	1	36,088
Date x composite	6	284,589
Population	2	95,844,094**
Row width	1	5,721,646**
Population x row width	2	1,757,780+
Population x date	12	4,879,329**
Row width x date	6	591,191
Population x row width x date	12	4,867,390**
Error	35	629,313
TOTAL	83	

**Exceeds the .01 level.

+Exceeds the .10 level.

Table 17. Silage yield, stover:grain ratio, grain yield and threshing percentage in Atlas forage sorghum as affected by plant population and row width when harvested 11 weeks after bloom.

Analysis of variance

Source of variation	Silage yield D.F.	Silage yield M.S.	Stover:grain ratio D.F.	Stover:grain ratio M.S.
Replication	3	7.23	3	.05
Row width	1	33.35+	1	.83
Population	2	94.70**	2	2.70*
Population x row width	2	4.90	2	.68
Error	15	7.66	15	.65
TOTAL	23		23	

Source of variation	Grain yield D.F.	Grain yield M.S.	Threshing percentage D.F.	Threshing percentage M.S.
Replication	3	2.58	3	3.72
Row width	1	3.11	1	6.40
Population	2	554.53**	2	38.92*
Population x row width	2	16.34	2	.35
Error	15	35.83	15	9.84
TOTAL	23		23	

**Exceeds the .01 level.
*Exceeds the .05 level.
+Exceeds the .10 level.

TRENDS IN THE CHEMICAL COMPOSITION AND YIELD OF ATLAS FORAGE SORGHUM AS AFFECTED BY STAGE OF MATURITY, PLANT POPULATION, AND ROW WIDTH

by

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Forage sorghums are very important in the Great Plains. Stage of maturity at harvest, plant population and row width have influenced palatibility, digestibility, and yields of sorghum silage.

The present investigation was conducted to determine the trends in accumulation of dry matter, protein, crude fiber and carbohydrates as affected by plant population, stage of maturity, and row width.

Atlas forage sorghum was grown in 1961 in a randomized block design with three plant populations (high, 104,500 plants per acre; medium, 26,100; and low, 13,100) and two row widths (40 and 20 inches). Samples were taken at weekly intervals, beginning one week before bloom and continuing until ten weeks after bloom. Plants were divided into leaves (blade and sheath), stems, and heads. Chemical determinations were made for nitrogen, fiber and carbohydrates.

Total dry matter increased throughout the sampling period. The high population produced the highest yield per acre. There was little difference in yield between the medium and low populations. Differences between the widths were not significant.

Protein yields per acre increased during the sampling period. The highest yield per acre was produced by the high population. Little difference was noted between row widths. The heads contained a higher percent of protein during the late sampling periods than did the leaves or stems.

Total pounds of crude fiber increased throughout the sampling period. Percent of crude fiber of all the plant parts decreased during this time. The leaves contained the highest percent of crude fiber. The high population produced the highest yield per acre, but no significant differences were noted between row widths.

Percent of acid hydrolyzable carbohydrates and percent of total sugars increased over the sampling period. The leaves and stems contained about the same percent of acid hydrolyzable carbohydrates, while the heads contained a much larger percent. Leaves contained the highest percent of total sugars.

Percent of total carbohydrates (total sugars plus acid hydrolyzable carbohydrates) per plant part increased over the sampling period. Pounds of total carbohydrates per acre also increased. The high population produced higher yields than did the other populations. The 40-inch width significantly outproduced the 20-inch width.

The high population produced the highest silage yield, grain yield, threshing percentage and the lowest stover:grain ratio when a final harvest was taken 11 weeks after bloom. Little difference was observed between row widths.

Although the low population produced about three tillers per main culm, this was an insufficient stand density compared with the high population, even though the high population produced no tillers.

At the final harvest, about 50 percent of the plant dry weight was contributed by the stems, while the leaves contributed about 20 percent and the heads 30 percent.