TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 204 FEBRUARY, 1917

DIVISION OF AGRONOMY

# The Recurving of Milo and Some Factors Influencing It.

POSTOFFICE:
COLLEGE STATION, BRAZOS COUNTY, TEXAS

AUSTIN, TEXAS:
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1917

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## DIVISION OF AGRONOMY

# The Recurving of Milo and Some Factors Influencing It.

BY

A. B. CONNER, Agronomist,

AND

R. E. KARPER, Suprintendent, Substation No. 8.

POSTOFFICE:

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1917

# AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

W. B. Bizzell, A. M., D. C. L., President

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*As of February 1, 1917.
**In cooperation with United States Department of Agriculture.

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# THE RECURVING OF MILO AND SOME FACTORS INFLUENCING IT.

BY A. B. CONNER AND R. E. KARPER.

## INTRODUCTORY.

During the season of 1916 experiments were conducted by the writers at the Experiment Station at Lubbock, Texas, pertaining to the recurving or "goosenecking" of milo. The season proved exceptionally favorable for the study of this problem, inasmuch as plats were matured under favorable and unfavorable growing conditions. This gave opportunity for comparison of a large number of individual plants grown under widely varying environmental conditions. Some conclusive data pertaining to the anatomy of the milo plant and the variation in anatomy of both milo and kafir plants under different environmental conditions have been obtained, which it is believed should be presented at this time. This study is being continued, with the hope that another year's observations and data will develop the fundamental cause, or causes, of recurving.

## THE PROBLEM.

Milo and certain other grain sorghums show varying percentages of recurved heads. It has been observed that this percentage of recurved heads varies greatly with different conditions of plant growth. Hence it is probable that while recurving may be a heritable character, a number of factors influence it. This recurving causes considerable loss of heads during periods of high wind velocity, especially when these periods occur a short time after the head has emerged.* It also makes the harvesting of the heads with machinery impracticable. Therefore, a study of the causes of recurving in milo and factors influencing it may have a practical value, in that it may furnish a basis for the selection of strains having erect heads.

## PREVIOUS WORK.

The available literature indicates that practically nothing has been done toward determining the cause of recurving in milo and the factors influencing it Ball and Leidigh** refer to an attempt to select for erect-headed strains of milo, and state:

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*An instance of this kind was noted, in which a plat of milo 1/22 acre in size having approximately 50 per cent. of young recurved heads exposed to a wind and rain storm showed, by actual count, a loss of sixty-three heads, or approximately 25 per cent. loss of the heads exposed. Assuming that 50 per cent. of the plants in the field were at the critical stage, this would mean a loss of 12 1/2 per cent. of the entire crop due to recurving and consequent liability to snapping of the peduncle at its weak point. Not a single emerged erect head on this plat was recorded as injured.

**Farmers Bulletin No. 322, United States Department of Agriculture, Washington, D. C.

"Through selection and thicker seeding the heads have been changed from mostly pendant to mostly erect. All heads not leaning over more than 30 degrees from the perpendicular are classed as erect, since for all practical purposes they are erect. From 75 to 90 per cent. have been brought to this position in different strains. A large part of the remaining 10 to 25 per cent. are merely inclined, i. e., bent over more than 30 degrees and less than 90 degrees, or the horizontal position."

It is evident that while an attempt has been made to establish erect-headed strains, the work was of a general character and based on the position of the head selected without regard for characters of the plant which might influence or be associated with erectness of stem.

Ball* states:

"Pendant heads seem to be the result of deep-seated habit in the plant. Because the largest, heaviest heads are most likely to be pendant, some persons believe that the bending is caused by the weight of the head. This is not true. The peduncle, or stem bearing the head, often begins to turn down as soon as the head comes out from the boot and before it is at all heavy with seed. Strong, vigorous stalks are most likely to produce pendant heads. Enough desirable stalks bearing erect heads can usually be found, however, to allow selections for erectness.

"Our experiments show that the planting of these crops rather thickly in drills tends to prevent too great a vigor of growth and therefore checks the production of pendant heads without decreasing the yield. With the same number of plants per acre, those planted in drills appear to produce more pendant heads than those spaced evenly in drills."

Ball further says:

"A strain of white durra has been perfected in which 100 per cent. of the heads are erect under all conditions. Improvement in the milos has not progressed so far. The percentage of erect heads varies from 50 to 95, depending, perhaps, more upon the character of the season than on the particular strain. This character does not yield readily to selection. It doubtless can be entirely eliminated, however, by long-continued selections."

The work cited above theorizes as to the causes of recurving and gives some information as to the factors influencing it. The author seems convinced that recurving is associated with vigor in the plant, and, perhaps, with the distribution of the plants on the land. It appears that while marked progress was made in securing a strain of durra with erect heads, no statement follows as to the stability of the selection under environmental conditions favorable to recurving.

## GENERAL STATEMENT.

The data presented in this publication show rather conclusively the relation between certain environmental conditions and recurving. Much

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*Farmers Bulletin No. 448, United States Department of Agriculture, Washington, D. C.

of the material is quite suggestive, but no definite conclusions are drawn as to the fundamental causes of recurving. The material contained herein, however, eliminates as fundamental causes a number of the factors which have heretofore been considered largely responsible for recurving, and indicates that *recurving is due to structure and development of the upper leaf sheath.*

## THE EXPERIMENT.

### *Location.*

The work presented in this paper has been conducted wholly at Texas Substation No. 8, located at Lubbock, Texas, and includes one season's results. The conditions are ideal for the study of this problem, inasmuch as the section is well adapted to the production of grain sorghums.

### *Personnel.*

The authors have personally conducted all the detail work in connection with this study and have compiled all the results presented herein. Both men have been closely associated with grain sorghum work for the past several years and had at the beginning of this investigation a good working knowledge of the anatomy of the grain sorghums and of the characteristic growths of the different groups and varieties, a circumstance which, it is believed, has made it possible for them to secure the results presented herein.

### *Methods.*

While much of the data presented in this paper has been obtained from records and measurements on a limited number of plants, care has been exercised to select plants that were uniformly representative of the plats from which they were taken; in fact, the tall and dwarf groups referred to have been uniformly tall or dwarf. Furthermore, the plats from which material was taken were in all cases 1/22 acre or more in size and had the necessary guard rows to provide comparable conditions.

### *Distribution of Rainfall.*

A knowledge of the rainfall and its distribution throughout the growing period is necessary for a full understanding of the conditions affecting the results herein reported. A table is presented showing the distribution of rainfall for a period of one year preceding the maturity of the plants referred to. It will be observed that the precipitation for the twelve-month period was 18.85 inches as compared to a normal rainfall of approximately 21 inches.

**TABLE 1.**

**DISTRIBUTION OF RAINFALL.**

**Substation No. 8, Lubbock, September 1, 1915, to August 31, 1916.**

| Day. | 1915 Sept. | 1915 Oct. | 1915 Nov. | 1915 Dec. | 1916 Jan. | 1916 Feb. | 1916 Mar. | 1916 April | 1916 May | 1916 June | 1916 July | 1916 Aug. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | T | T | .04 | .01 | | | |
| 2 | | | | | | | | | | | T | |
| 3 | | | | | | | | | T | | | |
| 4 | | | | | .005 | | | .30 | | | | |
| 5 | | | | | | | | | | | T | |
| 6 | | | | .52 | | | | .01 | | | .12 | |
| 7 | | | | .21 | T | | | .01 | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | .09 | |
| 13 | | .13 | | | | | | .10 | | .27 | | |
| 14 | .09 | | | | | | | 1.25 | | | | |
| 15 | .44 | 1.14 | | | | | | .03 | | .61 | | |
| 16 | .13 | | | | T | | | | | .06 | | |
| 17 | T | .25 | T | | .03 | | | | | .21 | | .01 |
| 18 | T | | | | | | | | .38 | | | .01 |
| 19 | 1.33 | | | | | | | | T | T | | .24 |
| 20 | | | | | .12 | | | | | .02 | | 1.22 |
| 21 | .43 | | | | | T | | | | T | | |
| 22 | 2.75 | | | | | | | | | | | |
| 23 | .45 | | | | | | .11 | | | .35 | | |
| 24 | 1.17 | | | | | | | | | | | |
| 25 | .50 | | .04 | | T | | | | | | | |
| 26 | .02 | | | | T | | | .89 | | | | |
| 27 | | | | | | | | | | | .15 | T |
| 28 | | | | .02 | T | | | | | | | |
| 29 | | | | | | | | | | | | |
| 30 | .55 | | | | .015 | | | | | | | |
| 31 | | | | .01 | | | 1.04 | | | | | .97 |
| Total | 7.86 | 1.52 | .04 | .76 | .17 | T | 1.15 | 2.63 | .39 | 1.52 | .36 | 2.45 |

It will be observed that of the total precipitation of 18.85 inches for the period, approximately one-half occurred during September and October. The months of November, December, January, February, and March show practically no rainfall. May and June also were very dry.

The dwarf plants headed during the first part of June, and, therefore, were subjected to very limited moisture conditions throughout their period of growth. These plants were enabled to produce grain only because of the previous September and October rainfall. The tall plants headed during the first part of September, and, therefore, had the advantage of the two good rains occurring in the latter part of August, which materially supplemented the September and October moisture stored up during the previous fall.

## EXPERIMENT DATA.

### *Variation in Stature of Plants.*

It has been observed and recorded that in the case of many different crops a lengthening or shortening of the internode takes place when the plants are grown under varying conditions of climate and soil. To what extent this variation in stature is due to light, heat, moisture supply, etc., little information is at hand. The available literature shows that great variation in stature does exist when plants are grown under different conditions. Tallness or dwarfness, due to such causes, seems to be the result of the lengthening or shortening of the internodes.

Cook,* in discussing "Brachysm; a Hereditary Deformity of Cotton and Other Plants," states:

"The internodes are always longer under conditions that favor luxuriant growth of the plants than where growth is restricted by drouth. Though this relation is general, some varieties shorten their internodes much more than others. The susceptibility to shortening is sometimes so great that the same variety may be short-jointed like a cluster cotton in some places, while under other conditions it behaves as a normal long-jointed variety. Attention was called some years ago to a case of this kind in a variety called the Parker that had been grown in Texas for several seasons as a long-jointed variety, but behaved as a short-jointed or semi-cluster variety at Del Rio in the season of 1907."

Ness† shows in a paper on "Variation in Indian Corn When Brought from New York to Texas" that the average height of fourteen varieties of corn grown at Ithaca, New York, was seventy-seven inches, and that the average height of the same varieties grown at College Station, Texas, was fifty-six and one-half inches. Ness charges this correspondingly dwarf growth at College Station to light conditions, and cites literature‡ showing that highly refrangible rays of light have a retarding or stunting effect on growing plants, and that plants grown under light of high intensity are short-jointed dwarfs as compared to plants grown under less intense light.

Marked variation in the stature of milo plants was found at the Lubbock station during 1916, this variation in stature being due, presumably to difference in environmental conditions present during the growing period of different plats. The height of milo in one case was recorded as 121 centimeters, as against 77 centimeters in another case, and in each instance the heights recorded were uniformly representative of the whole plat.

*Physical Characters.*

Careful notes on the anatomy of the milo plant showed it to be much more slender than kafir. Like most other crops, the number of nodes seems to be more or less constant regardless of height. The length of the internode, however, varies greatly when the plant is grown under varying conditions of moisture and food supply. The peduncle is quite tender in the early stages of development and possesses a considerable degree of flexibility, but later becomes somewhat hardened. The flexibility of the young peduncle is such that when the supporting leaf sheath is removed, or the peduncle is freed from the sheath, the head falls outward ond downward of its own weight, and consequently either breaks at the tender point or assumes a pendant position. The same behavior was recorded in kafir plants receiving

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*Journal of Agricultural Research, Volume 3, No. 5, page 391.

†"Variation in Indian Corn When Brought from New York to Texas"—paper read before the Texas Academy of Science, December 28, 1898, pages 75-77.

‡Vine's Lectures on Plant Physiology, pages 380, 396, 441.

similar treatment. No appreciable difference was noted in the tenderness of the peduncle of milo and kafir during the early stages of development. In every case noted the normal inclination of the peduncle was toward the side of the leaf sheath opening. On removal of a vertical section of the back of the sheath, in either kafir or milo, however, the peduncle recurved in that direction as readily as untreated plants recurved in the opposite direction (see Figure 1), this fact indicating that the support from the leaf sheath alone controlled the direction in which the head inclined.

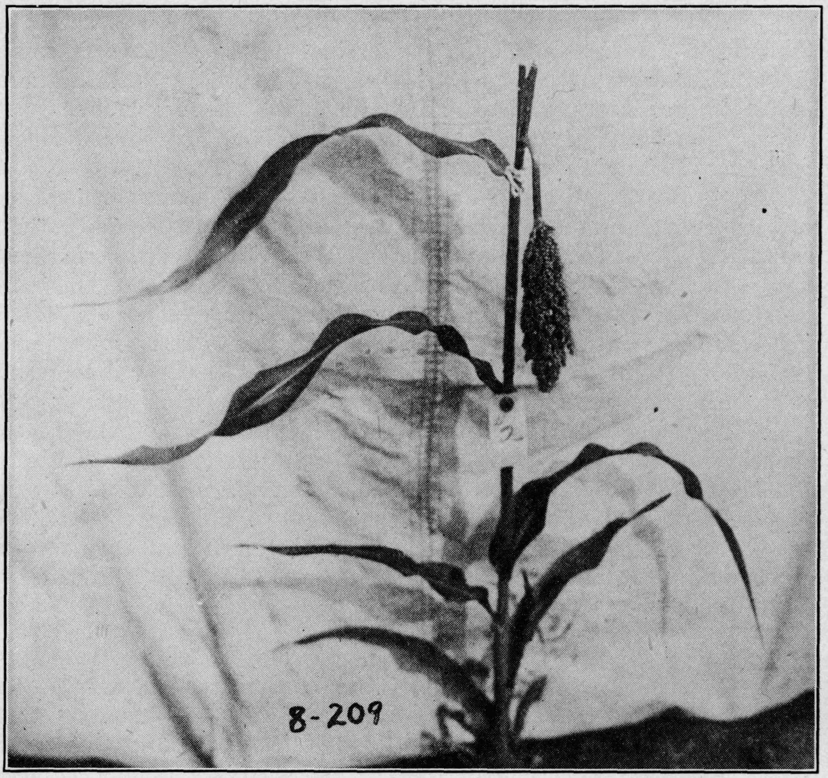


Figure 1—Milo plant No. 2, with a vertical section on back of upper leaf sheath removed. Note that the peduncle is completely recurved and in the opposite direction to the normal recurving through the leaf sheath opening.

Examination of a number of leaf sheaths showed a much thinner and apparently more flexible sheath in milo than is found in kafir. In point of attachment of upper leaf to sheath, no individual cases were noted in which the leaf joined the sheath at right angles. The angle of attachment (see Figure 2), however, appeared to be quite variable, normally being approximately 45 degrees. The angle of attachment seemed to affect the extent of inrolling of the upper leaf sheath after the head is fully emerged, a wide angle of attachment always being accompanied by a long inroll of the sheath and vice versa. This inrolling after the emergence of the head seems to be a return of the sheath approximately to its original infolded position. It was noted that the unfolding of the upper leaf sheath due to head emergence caused the

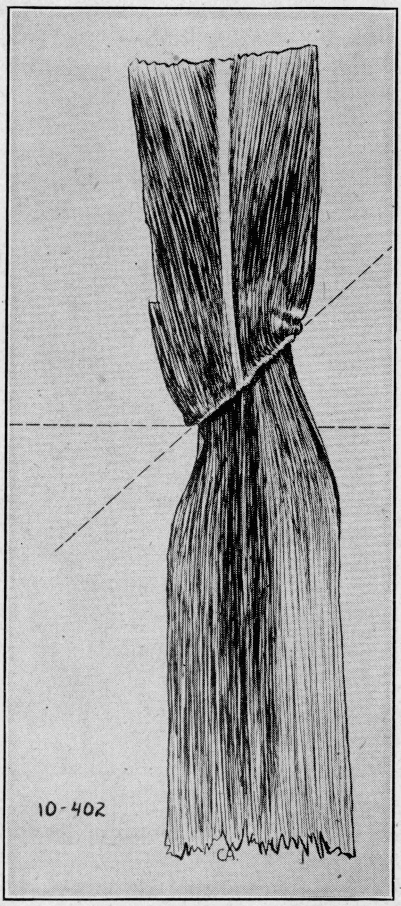


Figure 2—Note the ligule where the leaf joins the sheath at an angle of approximately 45 degrees. This angle varies in different plants.

upper leaf to describe almost a complete circle in a horizontal plane, and on the complete emergence of the head the leaf returns to approximately its original position by describing another circle in the opposite direction. (See Figure 3.) Observation of a large number of plants indicates that about one-half of the plants inroll in one direction and one-half in the other direction, the controlling factor being the angle of attachment. It has been observed, further, that the longer side of the sheath is always the thinner, and that the longer side of the sheath is the last to unfold and the first to begin inrolling. The inroll or twisted sheath tip appears to be so constricted that on the upward advance of the head the sheath opens at the side instead of completely unfolding as it does normally in kafir (see Figure 4) and in some other grain sorghums. Individual plants have been observed in which the upward advance of the head almost completely unfolded the sheath. In every instance noted, however, there seemed to be a part of the tip of the sheath not completely unfolded. In case the head is forced out at the side and receives little support from the short overlapping of the sheath, an inrolling takes place.

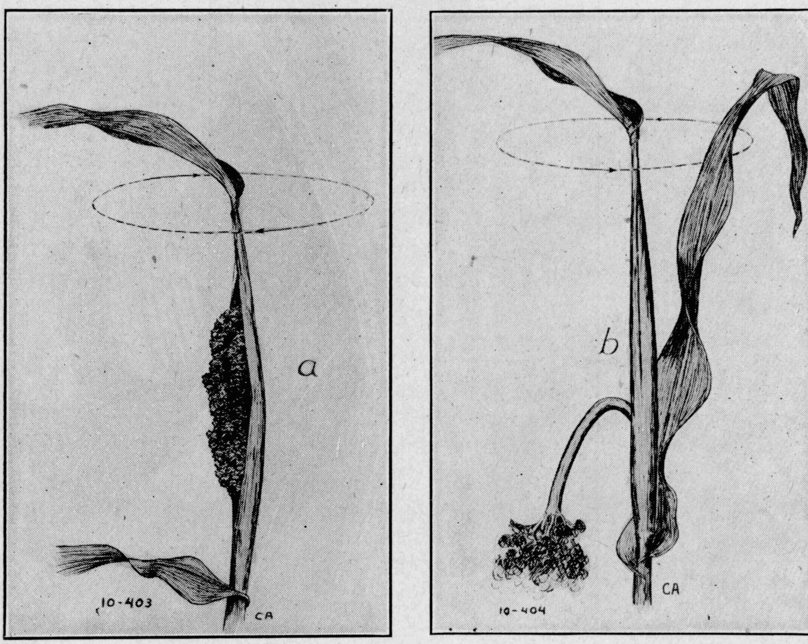


Figure 3—The above sketch illustrates (a) the change in position of upper leaf due to unfolding of sheath; (b) the return of the leaf to its original position because of inrolling of sheath after side emergence of head.

### *Relation of Height of Plant to Position of Head.**

It was observed that dwarf groups of milo, as compared to tall groups within the same strain but grown under different conditions, show varying proportions of erect, inclined, and recurved heads. In the following table it is shown that the dwarf group contained a larger percentage of

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*Erect heads as referred to in this paper include heads that are inclined less than 15 degrees. Inclined heads include all heads inclined between 15 degrees and the horizontal position. Recurved heads include all horizontal heads or heads below a horizontal position.

erect heads and a smaller percentage of recurved heads than the tall group.


Figure 4—Showing manner of emergence of milo head on the right and kafir head on the left in comparison. Note that the kafir head is emerging through the throat of the upper leaf sheath and has completely unfolded upper sheath, whereas the milo head is emerging through the side of the sheath without having completely unfolded it.

**TABLE 2.**

**Relation of Height of Plant to Position of Head.**

| T. S. No. | Plant. | Stature of plant. | Average height in cm. | Number plants counted. | Position of Head. Per cent erect. | Per cent inclined. | Per cent pendant. |
|---|---|---|---|---|---|---|---|
| 670 | Dwarf milo.... | Dwarf | 77.2 | 10 | 60 | 40 | 0 |
| 670 | Dwarf milo.... | Tall | 121.6 | 10 | 0 | 10 | 90 |

It is seen that dwarfness in milo is associated with a high percentage of erect heads, while tallness is attended by a high percentage of pendant heads. It is subsequently shown in Figure 8 that the dwarf group showed an average overlap of sheath of 9.04 centimeters, and the tall group an average of 4.27 centimeters.

*Effect of Rate of Growth on Stature of Plant.*

The average daily rate of growth in milo is shown in the following table, together with figures as to height and growing period of dwarf and tall groups:

**TABLE 3.**

**Effect of Rate of Growth on Stature of Plant.**

| T. S. No | Plant. | Period of growth. Days.* | Average daily growth. cm. | Average height. cm. |
|---|---|---|---|---|
| 670 | Dwarf milo.................... | 73 | 1.05 | 77.2 |
| 670 | Dwarf milo...................... | 62 | 1.95 | 121.6 |

*Refers to period required for reaching maximum height.

It seems that when the daily rate of growth in the tall is practically double that in the dwarf, the height of the plant is practically double that of the dwarf. These data show that the rapid-growing tall plants had an average sheath overlap of 4.27 centimeters, whereas the slow-growing dwarf plants had a sheath overlap of 9.07 centimeters.

*Root-pruning of Milo and Its Effect on Position of the Head.*

A plat of milo grown under rather favorable moisture conditions was included in an experiment to determine the effect of root-pruning on position of the head. Accordingly, one-half of a plat was cultivated deep, with pointed four-inch cultivator shovels. (See Figure 5.) This cultivation destroyed a great many surface feeding roots, and, therefore, limited the feeding area of the plant to some extent. Subsequent heavy rainfall counteracted to a certain degree the effect of this root-pruning and a second and more severe treatment was given with the hoe. The treatment resorted to was the removal of soil from the base of the plant and the cutting of many of the lateral feeding roots, leaving the plant attached only by the deeper roots. The other half of the plat was given ordinary cultivation at the time of the first root pruning. It later received no cultivation. Stands were equal in all cases. A count of one hundred consecutive plants, in both the treated and untreated plats, showed the following results:

**TABLE 4.**

**Root-pruning of Milo and its Effect on Position of the Head.**

| T. S. No. | Plant. | Treatment. | No. plants. | Position of Head | | |
|---|---|---|---|---|---|---|
| | | | | Erect. | Inclined. | Pendant. |
| 670 | Dwarf milo...... | Roots pruned.......... | 100 | 61 | 27 | 12 |
| 670 | Dwarf milo...... | Roots not pruned....... | 100 | 28 | 23 | 49 |

It is seen from the above table that root-pruning and a consequent limitation of food supply increased the number of erect heads and decreased the number of pendant heads, as compared to the plat with no treatment.

The treated and untreated plats showed practically no difference in height on casual observation. Unfortunately, no height or sheath measurements were secured on these plats.


Figure 5—Showing method of pruning surface roots of milo plat, by the use of pointed 4-inch shovels. This pruning was later followed by a supplementary pruning with a hoe.

### *Feeding Area of the Plant and Its Effect on the Position of Head.*

An experiment was conducted including six plats of drawf milo, planted at the same time and otherwise receiving similar treatment except in the seeding rate, which varied from 775 to 2545 plants per plat. The area per plant ranged from 112 to 368 square inches. A count of one hundred consecutive main plants in each of the several plats showed the following results in regard to the position of the head:

TABLE 5.

**Feeding Area of the Plant and Its Effect on the Position of Head.**

| T. S. No. | Plant. | Area per plant. Sq. In. | Number plants counted. | Average height of plant. cm. | Position of Head. | | |
|---|---|---|---|---|---|---|---|
| | | | | | Erect. | Inclined. | Pendant. |
| 670 | Dwarf milo.... | 112 | 100 | 70.3 | 100 | 0 | 0 |
| 670 | Dwarf milo.... | 185 | 100 | 70.0 | 93 | 7 | 0 |
| 670 | Dwarf milo.... | 226 | 100 | 71.7 | 85 | 15 | 0 |
| 670 | Dwarf milo.... | 262 | 100 | 77.1 | 61 | 39 | 0 |
| 670 | Dwarf milo.... | 274 | 100 | 80.7 | 53 | 47 | 0 |
| 670 | Dwarf milo.... | 368 | 100 | 82.5 | 36 | 61 | 3 |

The data presented above show a marked decrease in the percentage of erect heads as the area per plant increases, and as the moisture and food per plant decreases, and a corresponding increase in the number of inclined heads as the area per plant increases. Only three pendant heads were shown in the entire count and these were found on the plat with the largest area per plant. It seems conclusive that thick seeding


Figure 6—Showing representative tall and dwarf milo plants grown from the same seed. Note the sheath and internode lengths of each.

induces the production of erect heads, while thin seeding induces the production of pendant heads. The above data show a gradual increase in the height of the plant as the number of plants per acre decreases and the area per plant increases. It has previously been shown that dwarf stature is accompanied by a long overlapping of leaf sheath and a high percentage of erect heads. While leaf sheath measurements were not taken for the plants represented in Table 5, it will be observed that the number of erect heads decreased as the stature of the plant increased, further substantiating the results presented in Table 2.

*Overlapping of Leaf Sheath.*

The lengthening or shortening of the internode is very common in milo when widely different growing conditions are encountered. The authors have observed in many different cases that the shortening of the internode, when grown under unfavorable conditions, is apparently not attended by a corresponding shortening of the leaf sheath. This seemingly causes a much longer overlapping of leaf sheath to ex-

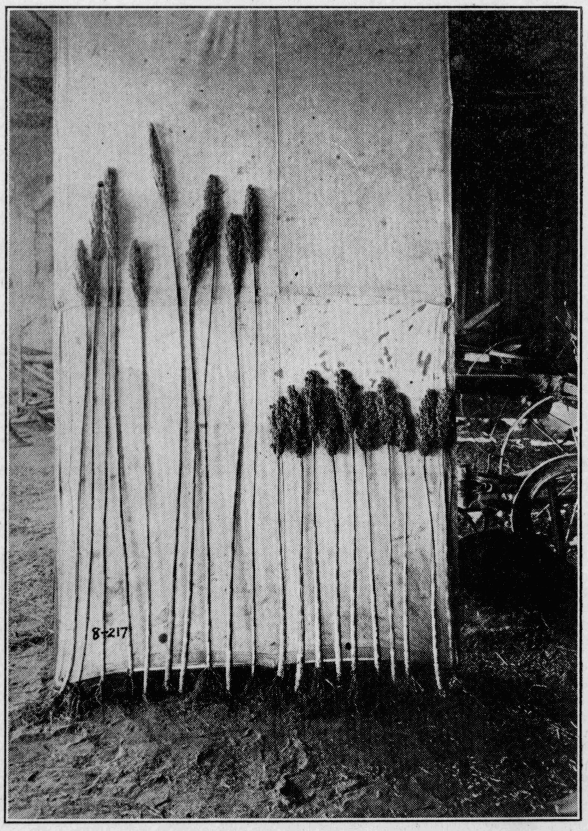


Figure 7—Representative tall and dwarf plants of kafir grown from the same seed.

ist in dwarf plants than in tall plants when the dwarfness or tallness is due to environmental conditions. To determine the extent of overlapping of the leaf sheath in tall and dwarf plants possessing the same inherent qualities, measurements were taken from a group of tall plants and a group of dwarf plants, both grown from the same lot of seed, but under favorable and unfavorable moisture conditions. The plants were quite uniformly tall and dwarf, respectively (see Figures 6 and 7), and the individual plants selected for measurement were secured from single rows by taking consecutive main plants. Ten individual main plants were taken in each case and measurements were secured from each internode and sheath on each of these ten plants. Additional data were tabulated showing height, position of the head, etc., and are presented in the following table:

**TABLE NO. 6.**

**Comparative Length of Internode and Leaf Sheath in Tall and Dwarf Milo Plants.**

Length: Centimeters. All Measurements Beginning at Base of Plants.

T. S. No. 670.—Dwarf Milo.

**DWARF PLANTS.**

| Plant No. | Height plant. cm. | 1st Internode. | 1st Sheath. | 2nd Internode. | 2nd Sheath. | 3rd Internode. | 3rd Sheath. | 4th Internode. | 4th Sheath. | 5th Internode. | 5th Sheath. | 6th Internode. | 6th Sheath. | 7th Internode. | 7th Sheath. | 8th Internode. | 8th Sheath. | 9th Internode. | 9th Sheath. | 10th Internode. | 10th Sheath. | 11th Internode. | 11th Sheath. | 12th Internode. | 12th Sheath. | Length of inroll. | Position of the Head. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 73 | 20 | 24 | 6.5 | 16 | 8 | 14 | 4.5 | 14 | 4.8 | 14.2 | 5 | 15 | 5.5 | 14 | 3.5 | 15.5 | 1 | 14 | .... | 11 | ..... | 7 | .... | 6 | 7 | Inclined 20° |
| 2 | 85 | 28 | 26 | 8.7 | 16.6 | 6.7 | 15.2 | 5 | 15.2 | 4 | 15.5 | 6.7 | 15.7 | 6 | 15.6 | 3.8 | 13.5 | 1 | 11.2 | .... | .... | ..... | ...... | .... | .... | 1 | Erect. |
| 3 | 67 | 18 | 26 | 5.5 | 17 | 5 | 14.5 | 3.5 | 13 | 3 | 13 | 3.4 | 12.5 | 3 | 14 | 2.8 | 14.5 | 3.4 | 15 | 3.5 | 15.5 | 2.2 | 14 | .... | .... | 15 | Inclined 20° |
| 4 | 89 | 31 | 28 | 9 | 18 | 7 | 17 | 5 | 17.5 | 8.4 | 15.5 | 7.5 | 15 | 3 | 13 | ...... | ....... | .... | ...... | .... | .... | ..... | ...... | .... | .... | 1.5 | Erect. |
| 5 | 79 | 25.5 | 27 | 7.7 | 16 | 5 | 15 | 5.5 | 15.5 | 6 | 16 | 5 | 15 | 5 | 15 | 2.5 | 13 | .8 | 10.2 | .... | .... | ..... | ...... | .... | .... | 1.5 | Erect. |
| 6 | 80 | 29 | 25 | 8.4 | 17 | 5.6 | 15 | 5.5 | 15.7 | 6.5 | 15.5 | 6 | 15 | 2.7 | 12 | ...... | ....... | .... | ...... | .... | .... | ..... | ...... | .... | .... | 0 | Erect. |
| 7 | 84 | 27.5 | 27 | 8 | 16 | 5 | 16.2 | 6 | 15.5 | 6.5 | 15.7 | 7 | 15 | 4.4 | 14 | 1 | 12 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 2 | Erect. |
| 8 | 68 | 18 | 24.5 | 5 | 17.5 | 4 | 14.5 | 4 | 13.5 | 4 | 12.5 | 4.5 | 13 | 4.5 | 14.5 | 3.5 | 15 | 4.5 | 16 | 2.2 | 14 | .. .. | 11.5 | .... | .... | 8.5 | Inclined 20° |
| 9 | 68.5 | 20 | 22.5 | 7.5 | 15 | 4 | 12.5 | 2.5 | 11 | 3.5 | 12.5 | 3.5 | 14 | 3.3 | 15.5 | 3.4 | 15.5 | 4.1 | 15.5 | 2.7 | 13.5 | 1. | 12 | .... | .... | 5 | Erect. |
| 10 | 79 | 21 | 24.5 | 7.6 | 18.5 | 6 | 15 | 5 | 14.5 | 4.6 | 14 | 5 | 15.4 | 5.4 | 16.5 | 5.6 | 15.3 | 4.8 | 13.6 | .8 | 11.5 | ..... | ...... | .... | .... | 9 | Inclined 25° |
| Average | 77.25 | 23.8 | 25.45 | 7.39 | 16.76 | 5.63 | 14.89 | 4.65 | 14.54 | 5.13 | 14.44 | 5.36 | 14.56 | 4.28 | 14.41 | 3.2625 | 14.2875 | 2.8 | 13.643 | 2.3 | 13.1 | 1.33– | 11.125 | .... | 6 | 5.05 | |

**TALL PLANTS.**

| Plant No. | Height plant. cm. | 1st Internode. | 1st Sheath. | 2nd Internode. | 2nd Sheath. | 3rd Internode. | 3rd Sheath. | 4th Internode. | 4th Sheath. | 5th Internode. | 5th Sheath. | 6th Internode. | 6th Sheath. | 7th Internode. | 7th Sheath. | 8th Internode. | 8th Sheath. | 9th Internode. | 9th Sheath. | 10th Internode. | 10th Sheath. | 11th Internode. | 11th Sheath. | 12th Internode. | 12th Sheath. | Length of inroll. | Position of the Head. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 132 | 24 | 32 | 12 | 21 | 17 | 16 | 17.5 | 16 | 16.7 | 18 | 12 | 17 | 10.8 | 12 | 4 | 11 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 25 | Recurved. |
| 2 | 129 | 34 | 32 | 17 | 20 | 14.8 | 17.5 | 13.5 | 17 | 12.3 | 16 | 10.3 | 14.5 | 6.1 | 11 | 1.1 | 5 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 21 | Recurved. |
| 3 | 115 | 32 | 33 | 14 | 20 | 11 | 17.4 | 11.6 | 16.4 | 12.3 | 14.5 | 10.5 | 13 | 4 | 11 | ...... | ....... | .... | ...... | .... | .... | ..... | ...... | .... | .... | 21 | Recurved. |
| 4 | 120 | 28 | 32 | 14.6 | 20 | 14.2 | 18.3 | 14.1 | 17 | 12.5 | 15.7 | 11.2 | 14.5 | 5.4 | 12.5 | 1.4 | 10 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 20 | Recurved. |
| 5 | 136.5 | 32 | 27 | 13.2 | 21.5 | 15.5 | 18 | 18 | 15.8 | 18 | 17.3 | 11.2 | 17.2 | 9.2 | 13.7 | 3.4 | 12 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 17 | Inclined 45° |
| 6 | 118.5 | 31.4 | 32 | 17 | 20 | 10.7 | 18 | 12.6 | 17.5 | 11.7 | 15.3 | 10.8 | 13 | 5.4 | 12.5 | 1.2 | 9 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 20 | Recurved. |
| 7 | 118 | 28 | 32 | 14.7 | 18.5 | 12.5 | 16.8 | 12.8 | 16.2 | 12.2 | 16 | 10.3 | 14.5 | 7 | 12.5 | 1.6 | 11 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 20 | Recurved. |
| 8 | 121 | 33.5 | 32.5 | 18.6 | 19.5 | 13.2 | 18 | 13.9 | 16.4 | 12 | 14 | 8 | 13.5 | 3 | 13 | 1 | 10 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 20 | Recurved. |
| 9 | 114 | 22 | 31.5 | 12.2 | 19.6 | 16 | 17 | 18 | 14.4 | 16.7 | 15 | 8.8 | 15.5 | 4.6 | 12.5 | ...... | ....... | .... | ...... | .... | .... | ..... | ...... | .... | .... | 21 | Recurved. |
| 10 | 112 | 28 | 32 | 15.8 | 18 | 13.5 | 17.6 | 13 | 16.3 | 12.6 | 15 | 8 | 14.5 | 1.7 | 11 | 1 | 9 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 19 | Recurved. |
| Average | 121.6 | 29.29 | 31.6 | 14.91 | 19.81 | 13.84 | 17.46 | 14.5 | 16.3 | 13.7 | 15.68 | 10.11 | 14.72 | 5.72 | 12.17 | 1.8375 | 9.625 | .... | ...... | .... | .... | ..... | ...... | .... | .... | 20.4 | |

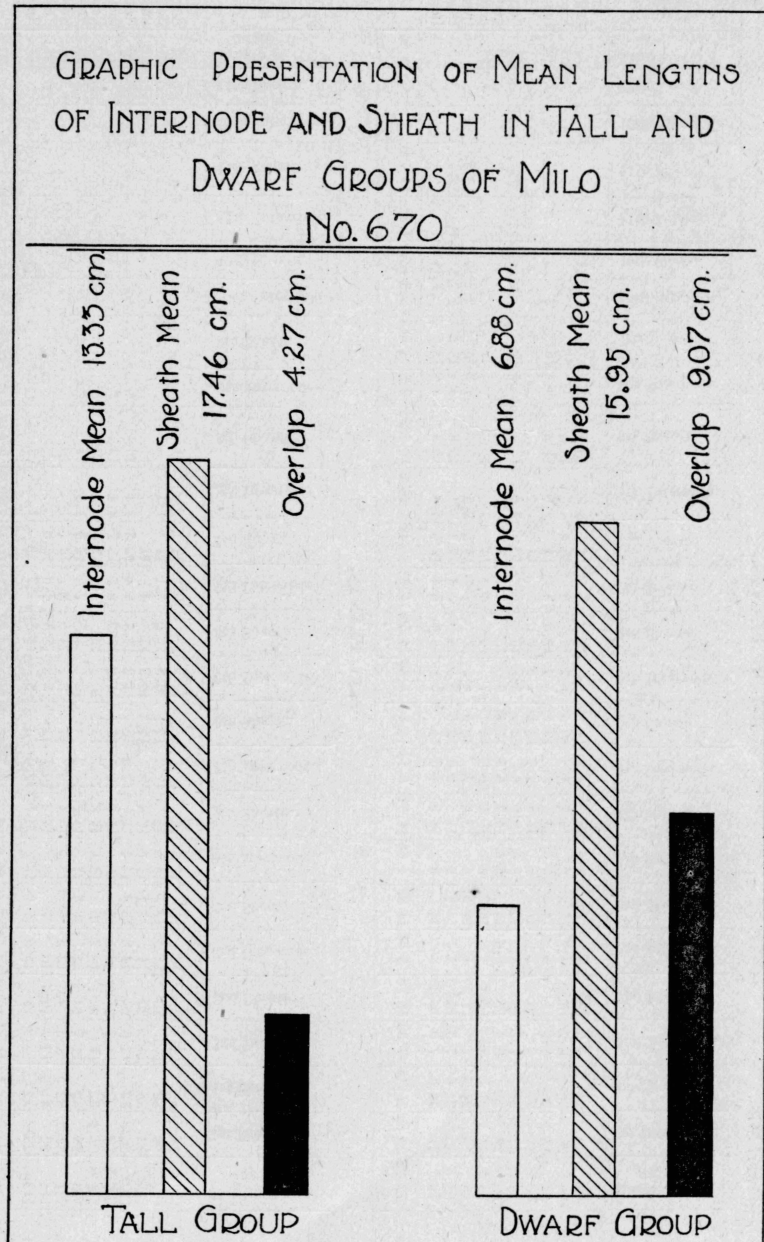
GRAPHIC PRESENTATION OF MEAN LENGTNS OF INTERNODE AND SHEATH IN TALL AND DWARF GROUPS OF MILO
No. 670
Internode Mean 13.35 cm.
Sheath Mean 17.46 cm.
Overlap 4.27 cm.
Internode Mean 6.88 cm.
Sheath Mean 15.95 cm.
Overlap 9.07 cm.
TALL GROUP
DWARF GROUP

Figure 8

The data given above showing internode and sheath measurements, numbering 78 in the case of tall plants and 93 in the case of dwarf plants, furnish fairly good material for determining the mean length of internode and sheath in each of the two groups.

The foregoing measurements show an internode mean of 13.95±.061, and a sheath mean of 17.46±.050 for the tall group, as compared to an internode mean of 6.88±.048, and a sheath mean of 15.95±.026 for the dwarf group. It will be observed that in the dwarf where a shortening of internode has taken place a corresponding shortening of the sheath has not occurred. It is observed from these figures that the extent of overlapping in the dwarf group is strikingly greater than in the tall group. The overlapping in the tall amounts to 4.27 centimeters and in the dwarf to 9.07 centimeters. This is shown very clearly and forcibly in Figure 8.

Such overlapping as shown above in the dwarf group must undoubtedly lend considerable support to the stem, inasmuch as the sheath is more than twice as long as the internode, and, therefore, the stem would be braced by more than two sheaths at any one point, whereas the overlapping in the tall group is such that the stem would have the support of only one sheath at a given point except on the lower part of each internode. (See Figure 6.) There can be no doubt that structural development of the tall group is such as to favor the recurving of the head, whereas the structural development in the dwarf group would tend to discourage any tendency on the part of the plant to produce recurved heads.

Since kafir has never been known to produce recurved heads, a series of measurements of internodes and sheaths was secured from dwarf and tall groups grown from the same seed, but under different environmental conditions, and corresponding to the tall and dwarf groups of milo previously discussed. Ten individual consecutive main plants were measured in each case. The data secured are shown in the following table:

## TABLE 7.

**Comparative Length of Internode and Leaf Sheaths in Tall and Dwarf Kafir Plants.**

Length: Centimeters. All Measurements Beginning at Base of Plants.

T. S. No. 673.—Dwarf Kafir.

### DWARF PLANTS.

| Plant No. | Height plant. cm. | 1st Internode | 1st Sheath | 2nd Internode | 2nd Sheath | 3rd Internode | 3rd Sheath | 4th Internode | 4th Sheath | 5th Internode | 5th Sheath | 6th Internode | 6th Sheath | 7th Internode | 7th Sheath | 8th Internode | 8th Sheath | 9th Internode | 9th Sheath | 10th Internode | 10th Sheath | 11th Internode | 11th Sheath | 12th Internode | 12th Sheath | Length of inroll. | Position of the head |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 85.5 | 24.5 | 27.5 | 4.25 | 19. | 4. | 17.5 | 4. | 17.5 | 3.75 | 17. | 4.5 | 16. | 4. | 15.5 | 3.75 | 15.25 | 3. | 15.5 | 3.5 | 15.5 | 2 5 | 16. | ..... | ..... | 0 | Erect |
| 2 | 90.5 | 27. | 28.25 | 5. | 24.25 | 5.5 | 18.5 | 3.5 | 17.5 | 4. | 16.5 | 4.75 | 15.75 | 4.5 | 15.5 | 4. | 15.5 | 3. | 15.5 | 3. | 16. | 2.75 | 15.5 | 2. | 15. | 0 | Erect |
| 3 | 90.5 | 26.5 | 28.5 | 6. | 19. | 6. | 18.75 | 5.5 | 18.25 | 5.5 | 18.5 | 5.75 | 16. | 4.75 | 15.75 | 3.25 | 15.5 | 3. | 15.5 | 1.5 | 13. | ..... | ..... | ..... | ..... | 0 | Erect |
| 4 | 87.5 | 27. | 27. | 5.5 | 19.25 | 4.75 | 18.5 | 5. | 18. | 5.5 | 17. | 5. | 16.5 | 4. | 17. | 3.5 | 16.5 | 2.25 | 16. | 2. | 15. | ..... | ..... | ..... | ..... | 0 | Erect |
| 5 | 91. | 28.5 | 29.5 | 4.75 | 20. | 4.5 | 18.5 | 4.5 | 18.5 | 4.5 | 18. | 4.75 | 16 5 | 4.75 | 16.5 | 4. | 16.5 | 3.25 | 16.5 | 2.5 | 16.5 | ..... | ..... | ..... | ..... | 0 | Erect |
| 6 | 86. | 27.5 | 26. | 5. | 17. | 5. | 16.5 | 5.5 | 15.5 | 5.5 | 14.5 | 5. | 14.5 | 4.25 | 14.5 | 3.5 | 14.5 | 2.5 | 14. | 2. | 12.5 | .... | ..... | ..... | ..... | 0 | Erect |
| 7 | 97. | 35. | 29.5 | 7. | 21. | 5.5 | 19. | 7. | 17.5 | 7.5 | 16.5 | 5. | 17. | 4 25 | 16.5 | 3. | 15.5 | 2.5 | 15. | 2.5 | ..... | ..... | ..... | ..... | ..... | 0 | Erect |
| 8 | 85. | 26.5 | 27.5 | 6. | 18.5 | 4.5 | 17. | 4.5 | 17. | 4.5 | 15.75 | 3.75 | 16. | 3. | 17. | .3.5 | 16. | 3. | 14.5 | 2.7 | 14.5 | 2. | 14. | ..... | ..... | 0 | Erect |
| 8 | 92. | 32. | 26.5 | 6 5 | 17.75 | 6.5 | 16. | 7.75 | 16.5 | 5. | 15.5 | 4. | 14.5 | 3.5 | 14. | 2.5 | ..... | ..... | ..... | ..... | 11. | ..... | ..... | ..... | ..... | 0 | Erect |
| 10 | 39.5 | 30. | 29. | 6. | 20.5 | 4.5 | 18.5 | 4. | 18. | 4.75 | 17.5 | 5. | 16. | 4.25 | 15. | 4. | 17. | 2 5 | 17. | 3. | 10. | ..... | ..... | ..... | ..... | 0 | Erect |
| Average | 84.45 | 28.45 | 27.9 | 5.6 | 19.6 | 4.8 | 17.8 | 5.1 | 17.4 | 5. | 16.6 | 4.7 | 15.8 | 4.1 | 15.7 | 3.5 | 15.8 | 2.7 | 15.5 | 2.5 | 13.7 | 2.4 | 15.1 | 2. | 15. | | |

### TALL PLANTS.

| Plant No. | Height plant. cm. | 1st Internode | 1st Sheath | 2nd Internode | 2nd Sheath | 3rd Internode | 3rd Sheath | 4th Internode | 4th Sheath | 5th Internode | 5th Sheath | 6th Internode | 6th Sheath | 7th Internode | 7th Sheath | 8th Internode | 8th Sheath | 9th Internode | 9th Sheath | 10th Internode | 10th Sheath | 11th Internode | 11th Sheath | 12th Internode | 12th Sheath | Length of inroll. | Position of the head |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 138. | 38. | 30.5 | 12.5 | 21.75 | 11.5 | 17.5 | 11. | 16.5 | 13. | 15. | 8.5 | 15. | 4.5 | 14.5 | 3.25 | 12. | 3. | 13.5 | 3.25 | 14. | 3. | 15.5 | ..... | ..... | 0 | Erect |
| 2 | 151. | 40.5 | 33.5 | 12.5 | 21.5 | 12. | 19.5 | 8.5 | 18.5 | 10. | 18. | 12.25 | 17. | 13.25 | 18. | 6. | 17.5 | 4.5 | 14.5 | 4.5 | 14. | 2.5 | 12.5 | ..... | ..... | 0 | Erect |
| 3 | 158. | 51.5 | 33. | 12.5 | 22. | 12. | 19.5 | 11.5 | 17. | 14.5 | 15.5 | 13.25 | 17. | 5.5 | 17.5 | 4.5 | 14.5 | 4.5 | 14.5 | 3. | 11.5 | ..... | ..... | ..... | ..... | 0 | Erect |
| 4 | 149. | 44. | 33. | 13. | 24. | 9.5 | 19.5 | 10. | 19. | 11.75 | 17. | 14.5 | 16.5 | 8.5 | 17. | 4.5 | 17. | 4. | 15.5 | 2.5 | 13.5 | ..... | ..... | ..... | ..... | 0 | Erect |
| 5 | 139. | 40. | 31. | 12. | 20.25 | 9. | 19.5 | 11. | 16. | 15.5 | 15.5 | 8.5 | 16. | 5. | 17. | 3.5 | 15.5 | 3.5 | 15.5 | 2.5 | 12.5 | 2. | 12. | ..... | ..... | 0 | Erect |
| 6 | 149. | 41. | 32.5 | 9.5 | 22. | 9.5 | 18.5 | 11. | 18. | 11.5 | 18. | 10. | 17 5 | 8. | 18.5 | 6.5 | 17 5 | 5.5 | 17.5 | 4.5 | 16. | 3. | 15. | 2. | 12. | 0 | Erect |
| 7 | 175. | 48. | 36.5 | 15.5 | 25. | 14.5 | 22. | 13. | 21.5 | 11.5 | 21.5 | 11.5 | 21.5 | 12. | 20. | 11. | 19.5 | 5.5 | 19. | 2.5 | 15.5 | ..... | ..... | ..... | ..... | 0 | Erect |
| 8 | 152.5 | 48.5 | 31.5 | 14.5 | 22. | 11. | 19. | 10.5 | 17.5 | 13.25 | 16.5 | 13. | 16.75 | 6.5 | 16.5 | 4.5 | 14. | 3.75 | 12.5 | 2.5 | 10. | ..... | ..... | ..... | ..... | 0 | Erect |
| 9 | 147. | 44. | 33. | 14. | 23. | 10. | 19.5 | 10.5 | 17. | 11.5 | 16. | 11.5 | 16. | 7. | 17. | 4. | 16. | 4. | 13.5 | 3. | 13. | 1.5 | 10.5 | ..... | ..... | 0 | Erect |
| 10 | 151. | 50.5 | 33.5 | 14. | 21. | 15. | 18. | 15.5 | 17. | 9.75 | 16.5 | 7.25 | 17. | 5.25 | 17. | 3. | 16.5 | 3. | 14. | 2.5 | 13. | ..... | ..... | ..... | ..... | 0 | Erect |
| Average | 150.95 | 44.7 | 32.8 | 13. | 22.2 | 11.4 | 19.2 | 11.2 | 17.8 | 12.2 | 16.9 | 11. | 17. | 7.5 | 17.3 | 5. | 16. | 4. | 15. | 3. | 13.3 | 2.4 | 12.7 | 2. | 12 | | |

The above data show internode and sheath measurements, numbering 106 in the case of the tall group and 100 in the case of the dwarf. From these data the mean internode and sheath lengths from tall and dwarf groups have been figured, as follows:

The results show an internode mean of 12.00±3.599 centimeters and a sheath mean of 18.01±.3814 centimeters for the tall group, as compared to an internode mean of 6.89±.532 centimeters and a sheath mean of 18.02±.322 centimeters for the dwarf group. It will be seen that as in the case of milo a shortening of the internode due to environmental conditions has not been attended by a corresponding shortening of the leaf sheath. The relative mean lengths of internode and sheath in the two groups, together with the average overlap, is shown in Figure 9.

While in the case of milo a shortening of the internode has also been attended by a slight shortening of the sheath it is observed that in the case of kafir, where practically the same proportionate shortening of internode has occurred, the mean shows an actual lengthening, rather than a shortening, of the sheath. It is further observed that the overlap in the tall kafir is approximately 50 per cent. greater than in the tall milo, which would tend to cause less favorable conditions for recurving in tall kafir than in the tall milo.

It is seen that the dwarf plants of milo showing an overlap of 9.07 centimeters developed 40 per cent. inclined heads, whereas the tall kafir plants, with a shorter overlap of 6.01 centimeters, showed no tendency toward recurving.

The controlling factor in the recurving of the head evidently does not exert an equal influence on milo and kafir when the overlap is equal. It has been pointed out in a preceding discussion that the removal of a vertical section of supporting leaf sheath did produce recurved heads in kafir, as well as in milo, and since this is a fact, it is evident that some factor other than the early flexibility of the peduncle governs the position of the head. It seems likely, therefore, that while overlapping may exert great influence on the position of the head in certain varieties, such as milo, the controlling factor lies somewhere in the shape or structure of the upper leaf sheath.

### *Angle of Attachment of Upper Leaf Sheath.*

As previously stated, the upper leaf of milo is attached to its sheath at an angle, and consequently one side of the upper leaf sheath is longer than the other. This angle of attachment in milo is very pronounced. At booting time the angle is tightly infolded and in the further development of the plant the unfolding of the upper sheath seems slow as compared to that of kafir. It very frequently happens that as the head advances the sheath opens normally at the side, but opens downward rather than upward. It is uncertain whether this downward opening of the sheath is due to varying width of the sheath, or to the close infolding of the leaf attachment above. The head, however, instead of advancing upward through the sheath, very often emerges at the side. When side

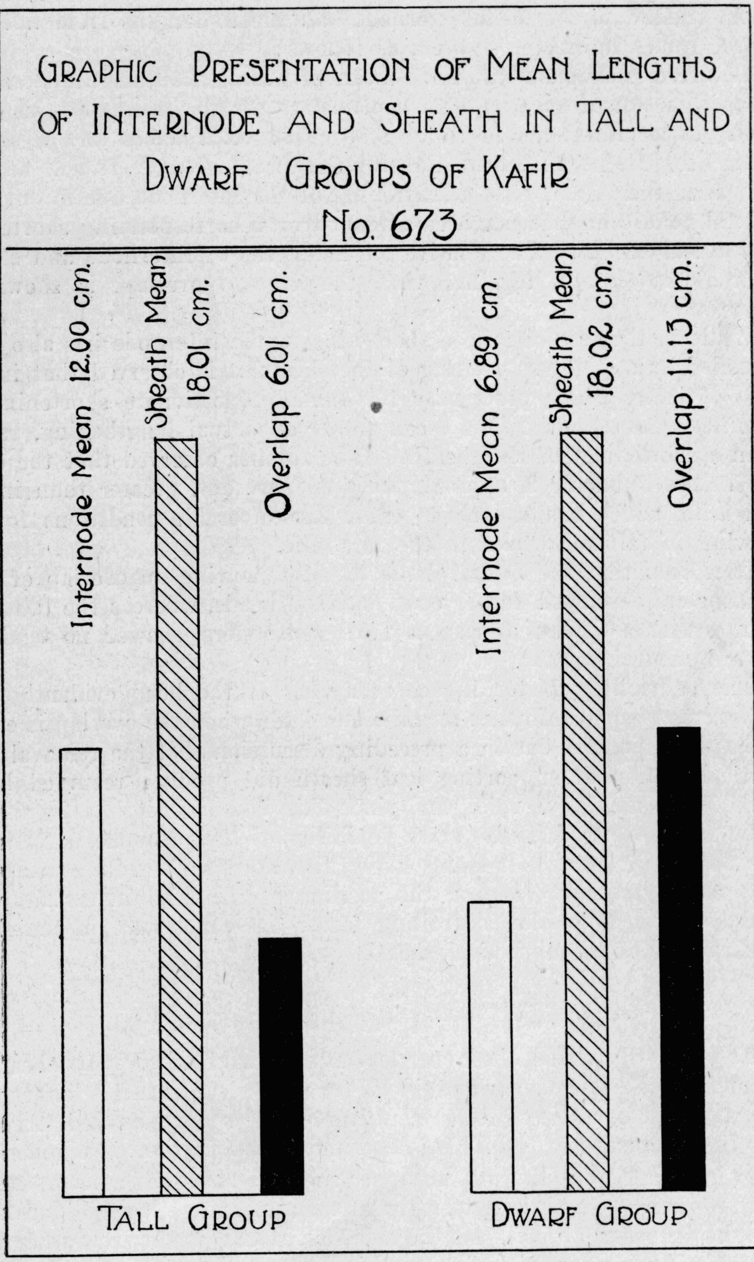
GRAPHIC PRESENTATION OF MEAN LENGTHS OF INTERNODE AND SHEATH IN TALL AND DWARF GROUPS OF KAFIR
No. 673
Internode Mean 12.00 cm.
Sheath Mean 18.01 cm.
Overlap 6.01 cm.
Internode Mean 6.89 cm
Sheath Mean 18.02 cm.
Overlap 11.13 cm.
TALL GROUP
DWARF GROUP

Figure 9

emergence takes place the peduncle receives no support from the upper part of the last leaf sheath, which is yet not entirely unfolded, and when the side emergence of the head relieves the upward pressure tending to unfold the sheath, the sheath begins to inroll, rather than unfold, and, therefore, if effective at all, tends to force the peduncle to incline. The extent of inclination, of course, will depend upon the extent of overlapping of the lower sheaths, and the consequent support from below before the peduncle has hardened.


Figure 10—Showing untreated plant No. 27. Note the normal emergence of the head on the side and the upper leaf sheath beginning to inroll.

That the tightly inrolled tip of the upper leaf sheath in milo exerts some influence on the position of the head is shown by an experiment in which ten plants in the same plat, without treatment, were compared to ten treated plants. The treatment consisted of the removal of five centimeters of the upper leaf sheath, including all of the angle of attachment. This treatment seemed to allow more rapid upward advance of the head through the throat of the sheath. (Compare Figures 10 and 11.) The results of this preliminary test are shown in the following table:

TABLE 8.

**Removal of Upper Leaf Sheath Tip and Its Effect on Position of the Head.**

| T. S. No. | Plant. | Treatment. | Number plants treated. | Position of Head. Per cent Erect. | Per cent Inclined. | Per cent Pendant. |
|---|---|---|---|---|---|---|
| 670 | Dwarf milo...... | Tip removed....... | 10 | 100 | 0 | 0 |
| 670 | Dwarf milo...... | Tip not removed... | 10 | 20 | 0 | 80 |

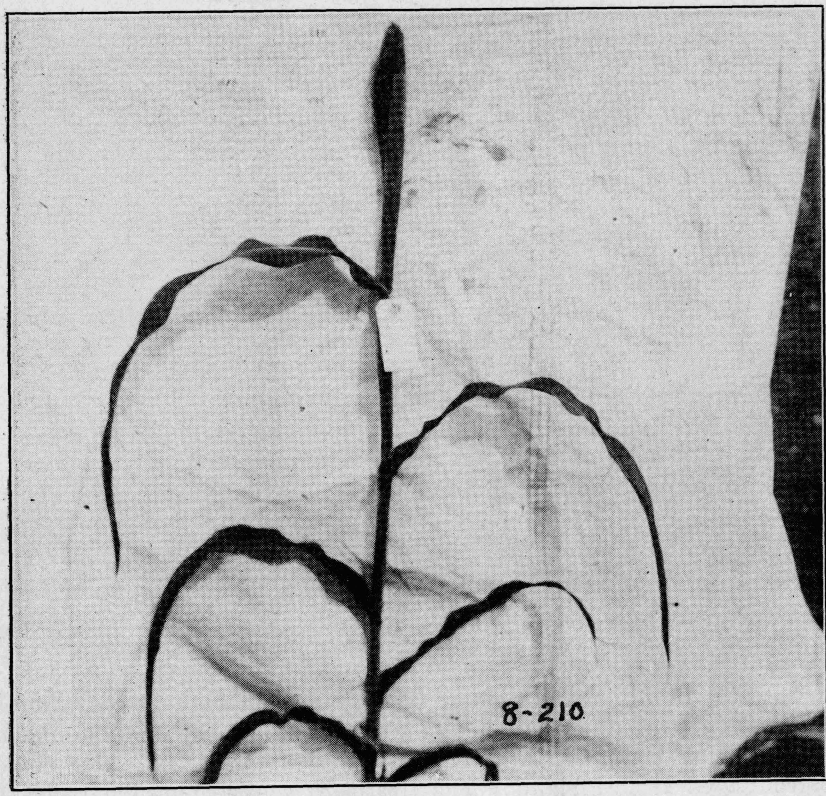


Figure 11—Showing treated milo plant No. 8. Note that the tip of the upper leaf sheath has been removed and observe the advance of the head upward through the sheath in contrast to the side emergence and the inrolling of sheath in plant No. 27.

It should be borne in mind that the test referred to above was conducted under very favorable conditions. The treated plants showed 100 per cent. erect heads, as against 20 per cent. erect heads for the untreated plants. (See Figure 12.

A final test was conducted in which alternate rows of milo in a single plat were treated by removing five centimeters of upper leaf sheath, leaving the remaining rows without treatment for comparison. The

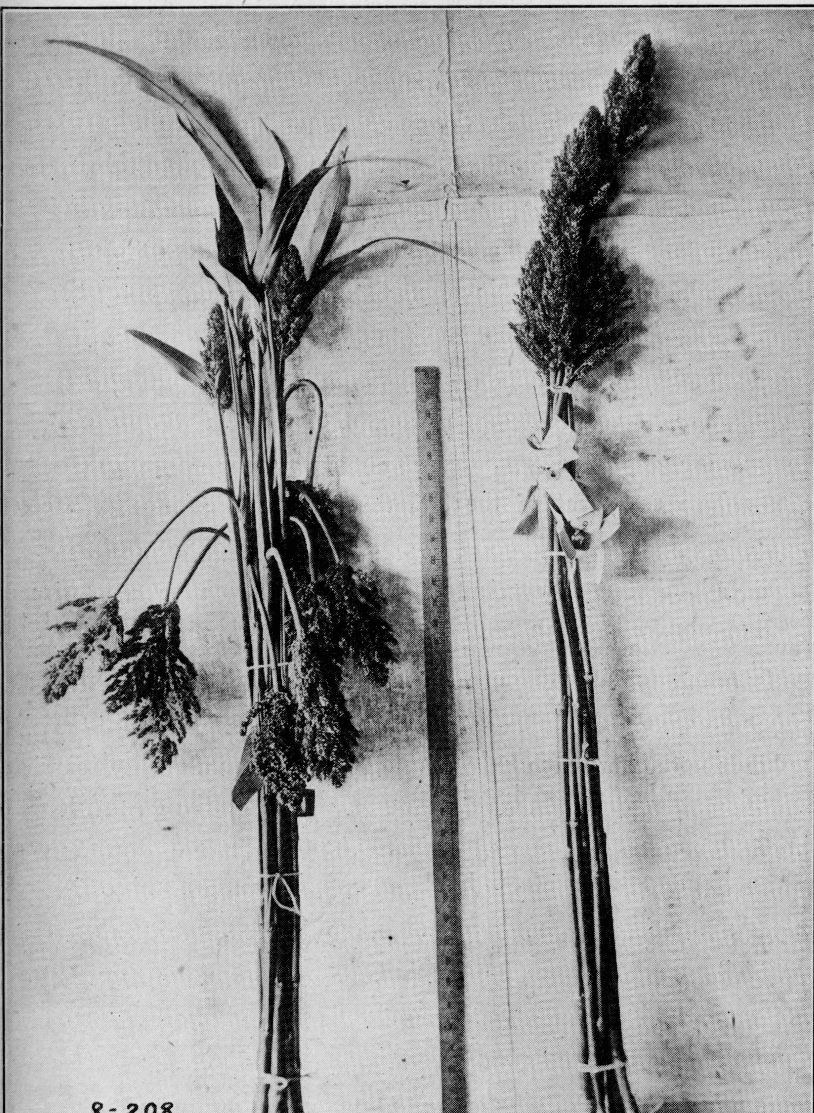


Figure 12—Showing a bundle of 10 untreated plants on the left and a bundle of 10 treated plants on the right. Note the number of pendant heads in the untreated bundle and the number of erect heads in the treated bundle.

treated and untreated plants in the same plat had otherwise identical treatment. When all the plants had headed, a count of 100 consecutive main plants was made in each row and a record made as to the position of the heads. The results are shown in the following table:

**TABLE 9.**

**Effect of Removal of Upper Leaf Sheath Tip on Position of the Head.**

| T. S. No. | Plant. | Treatment. | Row No. | No. plants. | Position of Heads. | | |
|---|---|---|---|---|---|---|---|
| | | | | | No. erect. | No. inclined. | No. pendant. |
| 670 | Dwarf milo.... | Tip removed..... | 1 | 100 | 89 | 2 | 9 |
| 670 | Dwarf milo.... | No treatment.... | 2 | 100 | 75 | 4 | 21 |
| 670 | Dwarf milo.... | Tip removed..... | 3 | 100 | 91 | 2 | 7 |
| 670 | Dwarf milo.... | No treatment.... | 4 | 100 | 79 | 7 | 14 |
| 670 | Dwarf milo.... | Tip removed..... | 5 | 100 | 87 | 1 | 12 |
| 670 | Dwarf milo.... | No treatment.... | 6 | 100 | 60 | 7 | 33 |
| | Total treated........................... | | | 300 | 267 | 5 | 28 |
| | Total not treated....................... | | | 300 | 214 | 18 | 68 |

It will be seen that of the 300 treated plants counted, 267 erect, 5 inclined, and 28 pendant heads were produced, as compared to a count of 300 plants without treatment, showing 214 erect, 18 inclined, and 68 pendant heads. The results here are not nearly so conclusive as those in the preliminary test. It should be stated, however, that the growing conditions for the plants included in this final test were much less favorable for production of pendant heads than in the preliminary test. Moreover, both the treated and untreated plants in the final test were subjected to frequent high wind velocity, and in several instances the heads were blown free from the sheath. In a number of cases where the tip of the leaf sheath had been removed a splitting of the back had occurred, thus weakening the support given the peduncle.

It seems conclusive that in milo a tightly inrolled upper sheath tip influences the position of the head.

*The Relation of Stature to Length of Sheath Inroll and Position of the Head.*

It was observed that a difference in the length of the sheath inroll (see Figure 6) existed between dwarf and tall groups where the difference in stature was due to environmental conditions. Measurements were recorded as to length of inroll on the dwarf and tall groups shown in Table 6. The average length of sheath inroll for the groups of ten dwarf plants and ten tall plants, together with the percentages of erect, inclined, and pendant heads, is shown in the following table:

TABLE 10.

**Relation of Stature to Length of Sheath Inroll and Position of the Head. Average of 25 Counts.**

| T. S. No. | Plant. | Stature of plants. | Average length of inroll. Cm. | Position of Head. | | |
|---|---|---|---|---|---|---|
| | | | | Per cent erect. | Per cent. inclined. | Per cent pendant. |
| 670 | Dwarf milo.............. | Dwarf | 5.0 | 60 | 40 | 0 |
| 670 | Dwarf milo.............. | Tall | 20.4 | | 10 | 90 |

The data submitted above show an average length of inroll of 5.0 centimeters for the dwarf group and 20.4 centimeters for the tall group, or an inroll practically four times longer in the tall group.

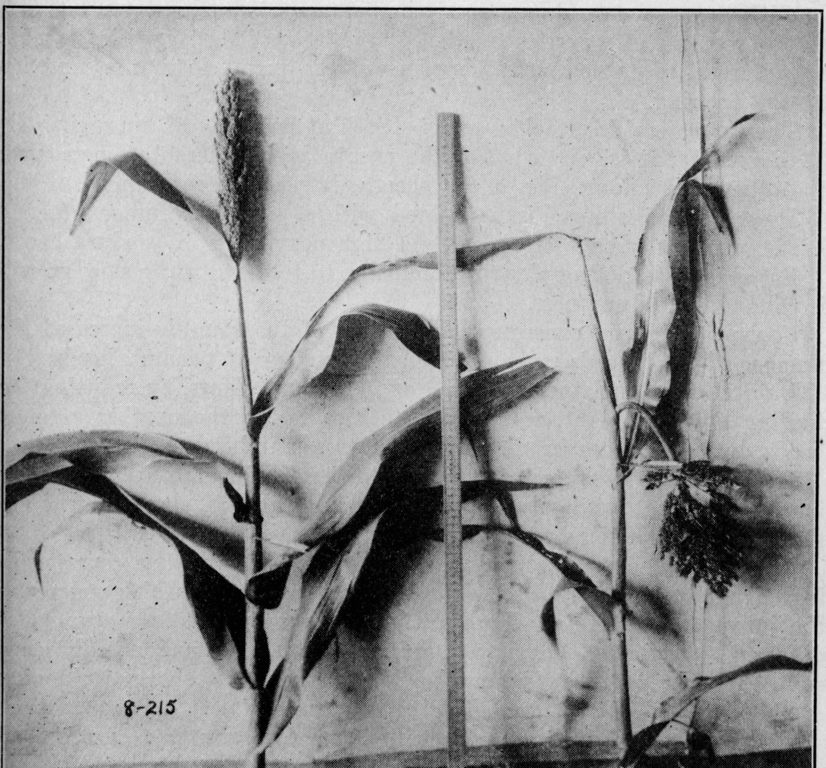


Figure 13—Showing long inrolling of the sheath of milo plant, in contrast to the lack of any inrolling in the sheath of kafir plant. Note the long inroll and complete closing of sheath behind peduncle as compared to the lack of inrolling and the normal enclosing of peduncle in sheath in kafir plant. Note the knives sticking into the stems of plants, indicating the lower peduncle node in each case.

## SUMMARY.

Recurving in milo and certain other grain sorghums is undesirable on account of impracticability of harvesting the crop with machinery, and the probable reduction in yield by loss of heads during the early stage of development.

A study of the fundamental cause, or causes, of recurving and the factors influencing it will be conducive to progress in developing erect-headed strains.

Climatic conditions at the Lubbock station, where experiments were conducted, were very favorable to the study of the problem.

Tallness or dwarfness in the same strain is the result of lengthening or shortening of the internode.

No apparent difference was observed in the tenderness of the peduncle of different grain sorghums at similar stages of development.

The removal of a vertical section of the back of the upper leaf sheath always resulted in complete recurving of the peduncle in the direction of the opening.

The upper leaf is attached to its sheath at an angle of approximately 45 degrees, that is, one edge of the sheath is considerably longer than the other. The long side of the sheath first begins inrolling.

Dwarfness in stature is associated with a high percentage of erect heads, while tallness is attended by a high percentage of pendant heads.

Rapid growth of the plant is conducive to tallness, while slow growth is conducive to dwarfness.

Root-pruning and consequent limitation of food supply increased the number of erect heads and decreased the number of pendant heads.

Limitation of moisture and food of individual plants, by reducing the feeding area per plant, resulted in an increase in the number of erect heads and a decrease in the number of pendant heads.

Measurements of internode and sheath lengths in both milo and kafir have shown that while the internode varies widely under different environmental conditions, the sheath length remains quite stable.

A shortening or a lengthening of the internode without a corresponding change in the length of the sheath results in the sheath's overlapping the internode in varying degrees when the same plant is grown under different conditions. Long overlapping of the sheath undoubtedly lends support to the stem, including the peduncle, while a short overlapping of the sheath lends correspondingly little support.

The removal of the inrolled sheath tip before any part of the head appeared resulted in increasing the percentage of erect heads. It seems conclusive that in milo a tightly inrolled upper leaf sheath tip influences the position of the head.

Plants of tall stature showed a long inroll, as compared to dwarf plants, and long inroll of the upper sheath seems to be associated with a large number of pendant heads.