EFFECTS OF ROW SPACINGS AND SEEDING RATES ON YIELD IN GRAIN SORGHUMS

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INTRODUCTION

It is a matter of common observation that the growth habits of plants are modified by the space available for their development. Numerous experiments have been conducted to determine the effect of spacing on the development and yield of cotton, corn, grain sorghums, and small grains plants.

Some of the earliest spacing work with sorghums for the Great Plains area was conducted at Manhattan, Kansas (12)[1]. The need for information regarding varietal response was imperative as new varieties were introduced or developed by agronomic research. Growers in the area previously unacquainted with grain sorghum production were also interested in rate of planting and seeding methods for the new crop.

Previous literature contains adequate information regarding performance of standard sorghum varieties, the seeding rates recommended and an indication of yields that might be expected when certain seeding rates are adopted (26).

Sorghum varieties carrying the genetic factor for short internodes have been developed in recent years. Dwarf-type varieties were the result of plant breeders interested in developing varieties which would be suitable for combine harvesting.

Sufficient information is not available regarding the response of dwarf-type grain varieties, or combine-type sorghums when subjected to a practical range of seeding rate-row spacing combinations.

Grain sorghums are generally planted in rows spaced 3 1/2 feet apart,

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[1] Figures in parenthesis refer to "Literature Cited", p. 41.

permitting the use of row cultivators during the growing season. A seeding rate commonly recommended is 4 to 6 pounds per acre (1). In order to reduce time and labor required by cultivation, a widespread practice of sowing grain sorghums with small grain drills has been followed. Labor costs are not only reduced, but time required by drilling permits seeding to be completed while optimum planting conditions prevail. Weed growth is somewhat reduced on well-prepared seed beds by the planting of grain sorghums in closely drilled rows.

The major objective of this investigation was to obtain information on yields of 4 grain sorghum varieties when subjected to a combination of various row spacings and seeding rates.

REVIEW OF LITERATURE

History of Spacing Studies

Grain sorghums are of great economic importance in the Central and Southern Great Plains area due mainly to their ability to adapt themselves to the prevailing climatic conditions. The physiological nature of sorghums provides an endurance to the extremes in drought and heat so injurious to most forms of plant life in the Southwestern United States. The ability of the crop to withstand droughty conditions common to that area labels the crop as a feed source not to be overlooked in long-range agricultural operations.

Following the introduction of Red kafir to Manhattan, Kansas, where it was first planted in 1889, a seeding rate-row spacing study was conducted by Georgeson (13) in 1892 and 1893. A similar experiment was begun at Stillwater, Oklahoma, in 1897. Morrow and Bone (27), by using a small grain drill, made seeding rate and row spacing studies with White-Hulled kafir. More recent spacing work with sorghums was performed by Karper (16) of Texas, Sieglinger (33, 34) and Klages (21) of Oklahoma, and Martin, et al (25) of the Southern Great Plains area.

Climate

The prominence of climate as a factor in controlling grain yields of sorghums was extensively discussed throughout the literature.

After summarizing studies at the Woodward, Oklahoma Station, Sieglinger (33) maintained that five principal climatic factors were very influential in regulating grain sorghum production in that area. Those factors listed by the author are:

1. Limited and variable annual precipitation of irregular seasonal distribution.
2. Relatively low atmospheric humidity.
3. High evaporation rate during summer months.
4. Wide daily temperature range.
5. High average wind velocity.

Extremely high temperatures during the period of flowering and fruiting in grain sorghum have been shown to decrease grain yields. Vinall (39) of Texas recommended that a planting date be selected in order for germination and early plant growth to proceed during the period of high temperatures and flowering would occur when more moderate temperatures prevailed. Seasonal temperature during the heading period was believed to be an important factor in determining the yields of grain sorghums by Martin and coworkers (25). Mean temperatures higher than 80°F during heading resulted in shorter stalks, smaller heads, and lower yields than when mean temperatures were slightly below 80°F.

Seeding rates for forage production were influenced by annual rainfall as the area of production extended westward into arid regions of the Great Plains. Martin and Stephens (26) recommended 60 to 75 pounds per acre for the area east of the 98th Meridian and 30 pounds per acre for the area west of the 100th Meridian.

Seasonal conditions are strongly correlated with sorghum webworm damage in grain sorghums. Losses are usually more extensive during seasons of abundant rainfall and of no importance during droughty years (29).

Soil differences as well as climate may vary the quantity of seed to be used. Sections with rich soil and more abundant moisture can be sown to sorghums, particularly milo, more thickly in the row than sections having thin sandy soils and lighter rainfall (1).

Width of Row

In areas where available moisture is the controlling factor in grain sorghum production, soil area per plant may be increased by increasing distance between rows. With climatic conditions common to the Texas Panhandle, Rothgeb (30) believed a higher total crop yield could be obtained by planting sorghums in rows 3 1/2 feet apart, while a grain crop was more certain when row spacing was extended to 7 feet.

At the Oklahoma station, Kiltz and coworkers (20) found alternate rows or wide row spacing seldom profitable. Under most conditions, satisfactory results could be obtained from rows spaced 40 to 44 inches apart.

In the Oklahoma Panhandle, Finnell (10) observed 23 sorghum varieties in rows 3 1/2 feet and 7 feet apart. As a group, the milos showed nearly equal results in grain yields from the two spacings. A marked preference for wider spacing was shown by Yellow Straight-neck milo, Dwarf Blackhull kafir, and Reed kafir.

On average Oklahoma upland soils, grain sorghums should be planted in rows 3 feet apart with 1 stalk each 3 to 5 inches, according to Fields (9).

The use of wide rows were considered to be uneconomical by Karper because of losses in grain yields (16, 18), unless the use of wide rows was more desirable in conjunction with some other farm practice.

At Hays, Kansas, Swanson (36) showed 40-inch row spacing was most advantageous for both grain and forage yields during normal years. In seasons of drought, a row spacing of 80 inches produced slightly more grain.

By the use of a grain drill, Georgeson (13) of Kansas varied distance between rows of Red kafir from 16 to 24 and 32 inches. Grain yields indicated the 32-inch spacing with plants spaced 4 inches apart in the row was the best. A comparable test was conducted by Morrow and Bone (27) of Oklahoma, in which distances between rows were 6, 12, 18, 30, 36, and 44 inches apart. Row spacings of 30 and 44 inches were regarded as less desirable than the 36 inch spacing.

Edward (7) of Texas called attention to the greater reliability of wide row planting in withstanding drouth and regarded it as a good reason for discarding the thicker method except as a catch crop under unusually favorable conditions. Lister planting was advised by Helder (15) of Kansas as a preventive measure for wind erosion and root protection against summer heat and drought.

Georgeson (12) prescribed drill seeding of kafir in preference to lister planting. Danger of heavy rain damage from soil washing was reduced by surface planting. The use of close-drilled methods of seeding were advised only for the production of hay by Martin and Stephens (26). In Nebraska, Kiesselbach (19) recommended the use of a small grain drill as a means of improving the quality of Black Amber forage.

Seeding Rate

Planting rates of cultivated crops usually appear in the literature as pounds of seed per acre. In many instances, the distance between plants is given in order that the reader unfamiliar with seeding rates can obtain a better understanding of the spacing between plants.

Profitable yields of grain sorghums are dependent largely upon two cultural practices: an optimum spacing of the plants and proper time of planting (25).

Bennett (4) emphasized the rate of seeding as a most effective factor in changing grain yields during droughty seasons and of minor significance during seasons of adequate rainfall. For the Texas Panhandle, Rothgeb (31) regarded seeding rates as being important, but concluded that no stand or rate would produce the highest yield under all seasonal conditions. Thick stands usually yielded higher than thin ones when adequate rainfall was available, but in dry seasons, thin stands were more likely to yield a crop.

A spacing study favored by abundant rainfall was conducted by Karper (16) in 1914. Three varieties, Dwarf milo, Dwarf kafir, and Feterita were planted in rows 3 feet apart, with space between plants ranging from 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6, 6 to 7, 7 to 8 inches. Higher yields were consistently produced by the thicker rates for all 3 varieties tested. By having adequate rainfall, it was possible to mature plants in a thicker stand on a given area than would be the case during an average season.

Blackhull kafir studies by Klages (20) in Oklahoma demonstrated the affect on grain and forage yields of space between plants in 42-inch rows. Plant spacings of 6, 12, 18, 24, and 30 inches within the row were observed. The obtained yields indicated that both grain and forage yields decreased materially from the thicker to the thinner stands.

From data collected at 9 field stations throughout the Southern Great Plains, Martin and coworkers (24) demonstrated the consistency of grain yields of sorghum varieties when subjected to extensive seeding rate studies. On Dwarf Yellow milo, the author states:

> At no station were the average yields of best spacing more than 4 bushels from the poor spacing except at Lawton where the 1 year's results under poor conditions could be significant.

The average for 43 station years indicated an 18-inch plant spacing for Dwarf Yellow milo in 42-inch rows to be most profitable. A 6-inch spacing of Dawn kafir gave the highest yields at 5 of 6 stations. From data obtained at 4 stations it appeared that Feterita would produce the highest yields when spaced 8 to 9 inches apart.

The greatest yields of both forage and grain were reported by Edwards (7) of Texas when distance between plants ranged from 4 to 8 inches apart. Similar observations were made by Karper (17).

Correlation studies were conducted by Martin (24) on grain sorghums to determine the plant characters responsible for grain yields. Measurements of head size and stalks per acre were obtained on fields of milo and kafir. The yields of grain sorghums were found to be more closely correlated with the number of heads per acre than with the size of head or weight of grain per head.

When grain sorghums are to be harvested by hand, Edwards (8) proposed the production of comparatively large sorghum heads, the results of a light seeding rate.

Conner and Karper (6) of Texas varied the soil area of milo plants to determine the effect on position of the seed head. As distance between plants was increased, an increase in number of pendant heads was observed.

Tillering

Grain sorghum varieties responded individually when planted at different seeding rates and subjected to climatic conditions quite normal for the Southern Great Plains area. Martin and Sieglinger (25) found that some grain sorghum varieties are more capable of utilizing available nutrients, moisture, and additional space than others. The kafirs, particularly, were not seeded to an advantage when widely spaced within the row. Some varieties produced additional plant stalks, commonly referred to as tillers, when more than adequate row space was provided for each plant.

A number of investigators, (8, 14, 17, 25), reported Dwarf Yellow milo as prominent in producing additional seed heads when low seeding rates were used. Sieglinger (34), after 4 years of spacing studies with sorghums at Woodward, Oklahoma, classified the varieties by their capacity to sucker profusely; the milos, Common feterita, Shallu, and Sunrise kafir produced similar yields by additional stalks regardless of distance between plants. Those varieties which produced few tillers and showed a progressive reduction in yields as the distance between plants was increased included: Spur feterita, Kaoliangs, and probably all kafirs other than Sunrise.

Swanson and Laude (36) called attention to the undesirability of tillering in sorghums which caused uneven ripening.

Vinall (37) noted tillering in feterita and regarded the reaction as so undesirable that -

> With a row space in excess of 12 inches, some varieties especially feterita were inclined to produce numerous sucker stalks, which matured late and had poorly filled heads. Lack of uniformity interferes with machine harvesting which results in a poor quality grain high in moisture content.

Ball and Leidigh (1) showed that in sowing milo thinly, a "larger number of objectionable pendant heads" were produced. Letteer (23) and Martin (25) proposed a proper spacing of feterita, and kafir as well as milo in order to obtain a more uniform crop with an earlier maturity date.

Extensive plant studies by Martin (24) at Woodward, Oklahoma, demonstrated that the number of heads was increased as space within the row was increased from 6, 12, 18, 24 and 30 inches. An increase in average number of heads per plant continued up to 24 inches where a decrease of .04 was shown with a 30-inch spacing.

Edwards (8) showed a stabilization of yields by tillering. Grain yields were measured on 5 varieties for a 4-year period where plants were spaced 4, 8, 12, and 16 inches apart in 40-inch rows. In all varieties except Dwarf milo, the thinnest rate produced the lowest yield.

Insect Control

The lack of uniformity produced by tillers was regarded by Gable (11) as very undesirable in areas infested with the sorghum midge, *Contarinia sorghicola* Coquillet. Prolonged flowering of host plants, either by the presence of 2 or more varieties or extensive tillering was considered a major factor in midge control. An increase in number of midges resulted from successive generations developing where a long blooming season was present. Successful production of sorghums in midge-infested regions depended upon the crop completing flowering before the insect appeared. From spacing studies by Hastings (14) of Texas, plots containing closely spaced plants matured about 1 week earlier than the wide spaced plants. Plant counts taken on May 15 indicated that less tillering occurred with thick planting and that a more uniform crop regarding maturity could be obtained. In the San Antonio district of Texas, milo plants should be planted 3 to 4 inches apart to reduce tillering. Gable (11) pointed to a sturdy crop uniformly developed as a major control for midges and suggested that farming measures which would produce a uniform crop be used, particularly those which would reduce the length of blooming season. Martin (25) proposed thick planting of all varieties in areas where the sorghum midge is abundant.

Late maturing varieties are also subject to damage from sorghum webworm, Celama Sorghiella Riley. Sieglinger and Davies (35) reported grain losses from the sorghum webworm at the Oklahoma Experiment Station. Individual variety loss of grain was found to be somewhat proportional to date of seed formation. The grain of Sugar Drip and African Millet, both late forage varieties, was completely destroyed by the worms.

Physical Features

Maturity, as observed by Martin (25), was altered somewhat by plant spacing, a 6-inch spacing maturing 3 days earlier than the 24 and 30-inch spacings when planted in 42-inch rows.

Plant response to seeding rates, with exception of maturity, usually results in a change of plant height, stalk size, size or weight of head. Time of heading may also be influenced by rate of seeding.

Distance between plants not only affected yield but height of stalk and length of head as well. Length of head was shown by Georgeson (13), to change somewhat progressively from broadcast length of 5 inches to 13.5 inches for heads from rows grown 32 inches apart.

Conner and Karper (5) conducted spacing experiments over a 6-year period to determine the effects of plant spacing on shelling percentage. Yellow milo showed a lower shelling percentage than Blackhull kafir, but no relation was shown between thickness of seeding and the threshing percent.

Distance between sorghum plants was varied to determine the affect on number of heads per plant. An increase in number of heads by tillering was not in proportion to a greater distance between plants. Martin and Sieglinger (25) demonstrated a reduction in number of heads per acre with increased plant spacing.

According to Swanson and Laude (37) of Kansas, lodging in sorghums was influenced principally by height of plant, thickness of stand and variety. In most instances, lodging tended to occur more frequently and to be more severe for taller than for shorter plants and in thicker rather than thinner stands.

Several workers (8, 14, 24), reported a decrease in sorghum head size as seeding rate per acre was increased.

MATERIALS AND METHODS

A seeding rate-row spacing study in sorghums was conducted at the Oklahoma Experiment Station near Perkins in 1950.

Four grain sorghum varieties adapted to the Southern Great Plains, and developed particularly for combine harvesting were selected for study. Certified planting seed was provided by the Oklahoma Crop Improvement Association. Experimental data and results from previous yield tests indicated that the 4 selected varieties would be grown extensively in the immediate future. The four varieties were: Dwarf kafir Woodward 44-14, Redlan kafir Woodward 3-3, Martin milo Sorghum Accession 5330, and Resistant Wheatland milo Garden City 38228.

An International Harvester small-grain drill equipped with press wheels was used for planting. Thirteen separate compartments, each being 7 inches apart, constituted the seed box of this particular drill. A specific row spacing resulted from placing seed in compartments above the selected drill cups. For example, seed was placed in every other compartment in order to obtain rows 14 inches apart. A 42-inch row spacing resulted from placing seed in cup Nos. 1, 7, and 13. In order to space the rows 21 inches apart, seed was added to compartment Nos. 4 and 10 in addition to Nos. 1, 7, and 13. A 7-inch row spacing was obtained by allowing all cups to distribute seed.

In order to establish a standard from which to vary, 3 seeding rates based on a 42-inch row spacing were used. Four, 6, and 8 pounds per acre, termed light, medium and heavy, respectively, seemed most suitable to cover the range of planting rates used by farmers. With this approach in mind, a "low" rate of 4 pounds per acre required the properly calibrated drill to sow 1.33 pounds from each of the 3 cups while planting 1 acre. To sow 6 pounds per acre, 2 pounds must be seeded from each of the 3 cups. A "high" rate of 8 pounds per acre required 2.66 pounds to be sown from each cup.

The seeding rates were combined with 4 different row spacings: 42-inch, 21-inch, 14-inch, and 7-inch. The resulting 12 combinations of seeding rates and row spacings composed the treatments to which all varieties were subjected. Capital letters, L, M, and H, are used as abbreviations for light, medium and heavy seeding rates. The 12 combinations of rates and spacings are: 42L, 21L, 14L, 7L, 42M, 21M, 14M, 7M, 42H, 21H, 14H, and 7H.

Planting rates gradually increased as distance between rows was reduced. Drill settings previously determined for sowing rows 42 inches apart were adopted for seeding rows 21 inches, 14 inches, and 7 inches apart. Plants seeded at the light rate in 42-inch rows were the same distance apart with the row as those sown in 21-inch rows at the light rate.

Instead of obtaining the desired 4, 6, and 8 pound rates per acre, restrictions in drill calibration permitted rates of 4.35, 6.09 and 7.80 pounds to be sown. As space between rows was reduced from 42 to 21, 14, and 7 inches, the following seeding rates resulted (Table 1):

Table 1.--Seeding rates in pounds per acre for seeding rate-row spacing study on grain sorghums at Perkins, Oklahoma in 1950.

	Seeding Rates		
Spacing	Light	Medium	Heavy
42	4.35	6.09	7.80
21	8.70	12.15	15.65
14	13.09	18.27	23.45
7	26.13	36.53	46.93

Detailed procedure of drill calibration and additional information on planting rates as influenced by distance between rows is included in the appendix.

In order to gain a greater degree of accuracy in measuring treatment affects, particularly row spacing-seeding rate interaction, a split plot design was selected. The varieties, their differences previously measured by yield tests, were assigned to whole plots where a critical comparison was not of major importance. By assigning the 12 treatments to subdivisions of the whole plots, a more precise measurement was obtained of spacing-seeding rate interaction due mainly to the larger number of replications of the small plots, a larger number of degrees of freedom for error, and reduction in soil variation and treatment interaction.

All varieties and treatments of the four replications were placed at random. The first replication is shown in Figure 1 to examplify the order of field layout. Each main plot was composed of 12 subplots, each 9 by 70 feet in size. Alley ways 22 feet wide separated the main plots. Uniform soil treatment for the experiment was obtained by seeding the alley ways to Dwarf kafir or Martin milo. Inadequate seed necessitated the use of the second variety, Martin milo, in some alleys.

All plantings were made on May 30 with the exception of Resistant Wheatland milo which was planted on May 25. Rainfall and mechanical trouble prevented the sowing of all varieties on the same day. General cultural methods common to the area were practiced during the growing season. Reseeding of short distances, particularly the ends of 24 plots, was completed on June 10.

Physical features of the plants were observed throughout the growing season. Time of heading, height of plants, maturity dates, and test weight

REDLAN	MARTIN	RES. WHEATLAND	DWARF KAFIR
1 14-inch Heavy	13 7-inch Light	25 14-inch Medium	37 21-inch Light
2 21-inch Medium	14 21-inch Medium	26 14-inch Heavy	38 21-inch Medium
3 14-inch Light	15 14-inch Medium	27 42-inch Light	39 7-inch Light
4 42-inch Light	16 14-inch Heavy	28 42-inch Heavy	40 14-inch Heavy
5 21-inch Light	17 42-inch Medium	29 7-inch Light	41 14-inch Medium
6 21-inch Heavy	18 21-inch Heavy	30 7-inch Medium	42 14-inch Light
7 42-inch Heavy	19 21-inch Light	31 21-inch Heavy	43 42-inch Medium
8 14-inch Medium	20 42-inch Light	32 7-inch Heavy	44 21-inch Heavy
9 7-inch Medium	21 14-inch Light	33 42-inch Medium	45 42-inch Heavy
10 7-inch Light	22 7-inch Medium	34 14-inch Light	46 7-inch Medium
11 42-inch Medium	23 42-inch Heavy	35 21-inch Light	47 42-inch Light
12 7-inch Heavy	24 7-inch Heavy	36 21-inch Medium	48 7-inch Heavy

Fig. 1.--Field lay-out showing randomization of treatments within main plots and location of varieties within replication 1.

were recorded for each variety and for all treatments to determine the effect resulting from increased intra-plot competition.

An equal land area was harvested from each plot. By heading 62.5 feet of the center row on 42-inch spacings, 1/199.13 acre was harvested. To obtain the same area on 21-inch spacings, 2 of the 3 inside rows were harvested. Three rows were harvested from 14-inch plots while 6 rows were harvested from 7-inch spacings (Fig. 2). Hand harvesting proceeded immediately after maturity when moisture content had decreased sufficiently to assure safe storage of the heads. Grain yields per acre were not corrected to a standard moisture percentage.

A Vogel plot thresher designed as a self-cleaning machine was used for the threshing of all plots.

Grain yields were subjected to analysis of variance.

RESULTS AND DISCUSSION

Although a dry spring preceded the growing season at Perkins, Oklahoma, in 1950, frequent rainfall through the summer was conducive to the production of grain sorghums (Table 2). After planting was completed on May 30, a heavy rain was received on June 2. With frequent use of a rotary hoe, moisture was conserved until additional precipitation was received on June 29. In July, an abnormal rainfall of 10.13 inches was recorded. Adequate distribution of the moisture through August and September, as well as July, provided an optimum condition for plant development.

The seasonal rainfall was also affective in reducing mean temperature for the months of July and August. From data collected at Stillwater, the mean temperature for July was 76.8°F in comparison to 81.4°F for a 20-year average (1931-1950 incl.), while the August mean temperature was 75.9°F as compared to 81.3°F for the same period[2]. The maximum temperature for the growing season was 99°F.

The field appearance of the 4 row spacings, 42, 21, 14, and 7 inches between rows, is shown in Fig. 2. Distance between plants within the row is shown in Fig. 3, where the results of the 3 seeding rates, light, medium, and heavy (high) can be observed. Distance between plants varied from approximately 2 inches for the light rate to 1 1/2 inches between plants for the medium rate to 1 inch between plants at the high rate.

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[2] Temperature data were made available by Frank Davies, Associate Professor of Agronomy, Oklahoma A. & M. College, Stillwater, Oklahoma.

Table 2.--Daily moisture precipitation at Perkins, Oklahoma, January 1, 1950 to September 30, 1950.

Day	Months								
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.
1					.02			0.90	
2			.05	1.72		1.42			
3	.48						.09		
4					.03		.14	.02	.44
5									
6									
7		.01			.03		.78	.01	
8					.02		.04		
9				.01	.98		2.11		
10					1.18	.25	.08		
11	.13	.50	.17		.01				
12	.66	.24	.02				.26		.92
13									.70
14									.26
15			.26					.06	.33
16				.14					.04
17							.52	.04	
18	.03			.12	.43		.09		
19							2.49		
20					.40	.06		.02	
21							1.98		
22									
23								.41	
24									
25							.37		
26					2.10				.26
27		.48			.25				
28						.60			
29							.60	.42	
30									
31							.58		
Totals	1.30	1.23	.50	1.99	5.45	2.33	10.13	1.88	2.95

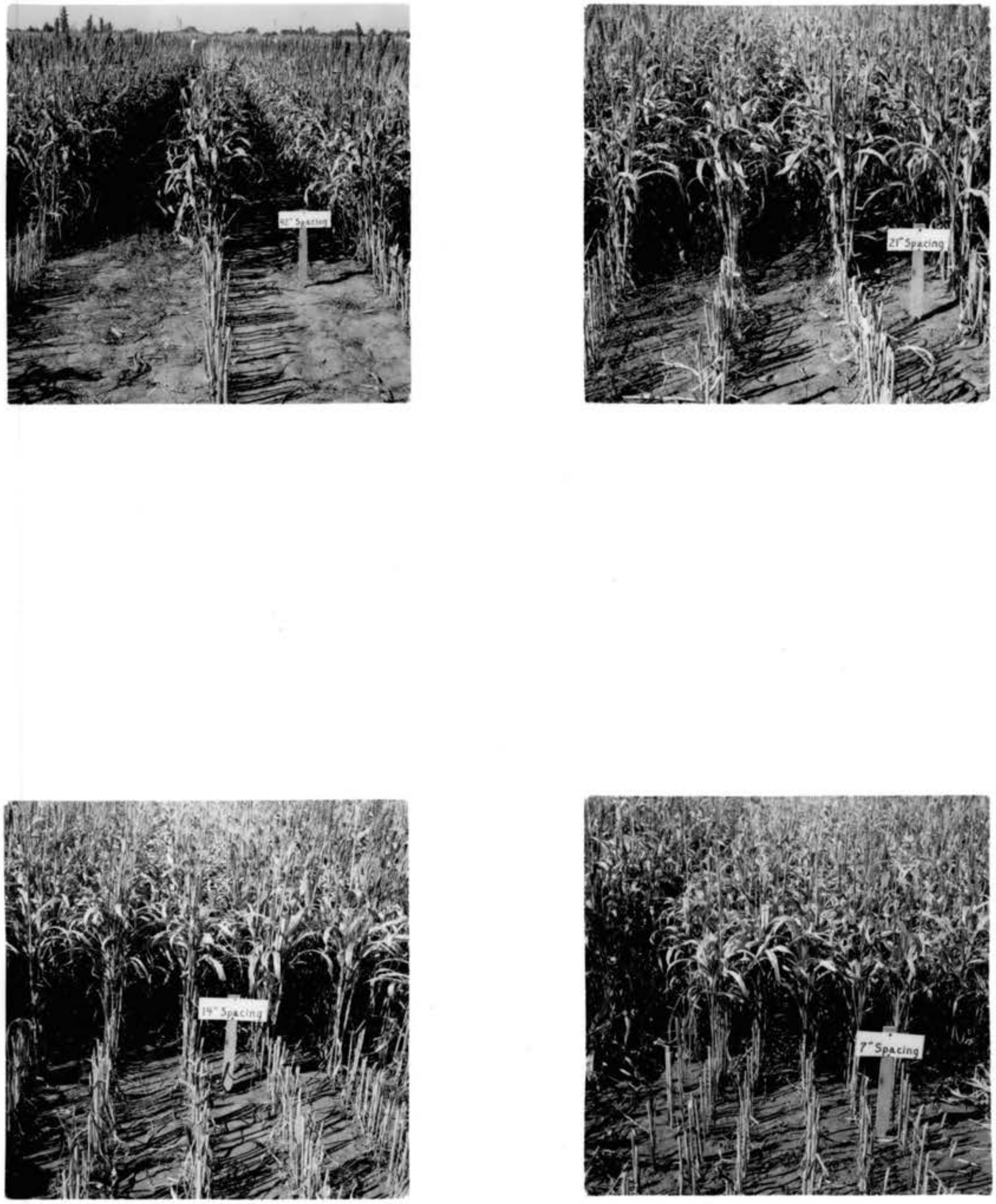

Fig. 2.--Field plots of Redlan kafir showing 4 row spacings used in the seeding rate-row spacing study.

Fig. 3.--Field plots of Redlan kafir showing three seeding rates and their affect on distance between plants within the row.

Grain Yields

Grain losses from bird damage resulted in the loss of data from the first replication.

Grain yields as compared by treatment averages presented a range from 40.25 bushels for 21-Medium plots to 30.34 bushels for 7-Medium spacings, with all treatments except 7-Medium and 7-Heavy plots producing within 4 bushels of the highest yielder (Table 3).

Variety averages indicated Resistant Wheatland produced the greatest yield with 39.02 bushels per acre, followed by 36.08 for Redlan kafir, 36.53 for Martin milo and 35.49 bushels for Dwarf kafir. The difference in yields between Resistant Wheatland and Dwarf kafir was not enough for significance.

The analysis of variance for grain yields is given in Table 4.

A highly significant difference due to spacings was found. The 21-inch spacings averaged 39.11 bushels per acre in comparison to 38.19 for 14-inch plots, 37.82 for 42-inch plots, and 32.98 for 7-inch spacings. The least significant difference at the 1% level was .99 bushel and the difference between the 21-inch spacing and 7-inch spacing was 6.13 bushels.

No significance was obtained for rate differences, indicating the varieties responded to the three rates to produce similar grain yields.

Significant interaction of spacing and rate indicated different rates are required for maximum yields at the different row spacings. Forty-two inch plots yielded highest when sown at the heavy rate. The 4 varieties produced significantly lower yields when subjected to the 7-inch spacing and planted at the medium or heavy rate.

Table 3.--Average grain yields in bushels per acre of 4 grain sorghum varieties as affected by seeding rate-row spacing treatments at Perkins, Oklahoma in 1950.

Treatment	Varieties				Spacing Average	Treatment Average
	Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo		
42L	36.77	36.77	32.91	38.55		36.25
42M	41.05	32.91	37.48	36.77		37.05
42H	36.77	40.34	38.55	44.98	37.82	40.16
21L	41.05	38.55	37.84	35.70		38.28
21M	37.48	39.62	42.84	41.05		40.25
21H	41.05	36.05	34.98	43.19	39.11	38.81
14L	37.84	39.62	34.98	41.05		38.37
14M	39.62	37.84	38.55	39.27		38.82
14H	40.34	35.70	37.84	35.70	38.19	37.39
7L	33.20	42.12	32.48	44.62		38.10
7M	25.34	34.27	29.63	32.13		30.34
7H	27.84	32.13	27.84	34.27	32.98	30.52
Average	36.53	37.08	35.49	39.02		

Table 4.--Analysis of variance of the grain yield data from 4 grain sorghum varieties, grown at Perkins, Oklahoma in 1950.

Source of Variation	D. F.	Sum of squares	Mean square	F value
Total	143	461.00		
Replications	2	13.89	6.95	3.61
Varieties	3	16.71	5.57	2.89
R x V (Error a)	6	11.57	1.93	
Spacing	3	64.29	21.43	8.00**
Rate	2	3.14	1.57	
S x R	6	43.95	7.33	2.74*
V x S	9	29.00	3.22	1.20
V x R	6	10.82	1.80	
V x S x R	18	31.92	1.77	
Error	88	235.71	2.68	

*Indicates significance at the 5% level.

**Indicates significance at the 1% level.

An absence of significance for the interaction, variety x spacing, indicated no variety responded to a particular spacing to produce a significantly different yield.

The interaction, variety x rate, failed to show significance, indicating that no variety produce a significantly difference yield when subjected to a particular seeding rate.

A relatively low mean square for second-order interaction is indicative of no particular variety showing a very favorable response when subjected to a specific rate and row spacing.

Date of Heading

Time required for the varieties to reach the heading stage is recorded in Table 5. Date of heading was largely influenced by prevailing climatic conditions during the flowering period. The rainfall data in Table 2 indicate the amount of moisture which was received during the period of flowering.

Martin milo, Redlan and Dwarf kafir completed heading during the first 3 weeks of August when rainfall was relatively light. Martin milo headed with little effect from the treatments. Ideal weather helped the variety to complete flowering with a difference of 3 days between the first and last plots. Seven-inch spacings bloomed at the later date.

Redlan kafir completed heading within a 2-day range, the 7-Heavy treatments averaging 74 for the latest.

Dwarf kafir showed a range of 5 days with 7-Heavy plots heading last for the variety.

Resistant Wheatland began flowering July 26 during a period of intermittent rainfall. High humidity tended to fuse the glumes which

Table 5.--Average number of days from planting date until time of heading on 4 grain sorghum varieties when subjected to 12 row spacing-seeding rate treatments at Perkins, Oklahoma in 1950.

	Varieties					
Treatment	Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo	Spacing Average	Treatment Average
42L	69	74	75	70		72
42M	69	73	76	70		72
42H	68	72	75	69	72	71
21L	69	73	74	69		71
21M	69	73	74	70		72
21H	69	73	74	69	71	71
14L	69	74	76	71		72
14M	69	74	75	72		73
14H	69	74	75	72	73	73
7L	71	74	77	72		74
7M	71	74	78	74		74
7H	71	74	79	74	74	75
Average	69	74	76	71		

prolonged date of flowering and reduced the degree of pollination on individual heads. Forty-two Heavy, 21-Light, and 21-Heavy plots headed 69 days after seeding while 7-Heavy and 7-Medium completed heading in 74 days.

Spacing averages for the 4 varieties indicate that increased seeding rates retard the date of heading.

Date of Maturity

Date of maturity, strongly favored by ideal weather conditions during the 1950 growing season, was generally unaffected when subjected to a wide range of seeding rates. With an absence of drought periods following head formation, the 7-inch plots matured 1 to 2 days later than plots sown to 42, 21 or 14-inch spacings.

Maturity averages in Table 6 indicate a 3-day range for Martin milo, a 1-day range for Redlan and a 2-day range for Dwarf kafir.

The 21-Medium and 21-Heavy plots of Resistant Wheatland milo matured 104 days after seeding while 7-Medium and 7-Heavy plots matured 5 days later, presenting the widest range for any 1 variety in the experiment.

Plant Heights

Plant heights varied depending upon the variety when subjected to the treatment combinations (Table 7).

Martin milo ranged from 56 inches to 42 inches for the 12 treatments. Although the 42-Heavy and 42-Medium plots were the tallest with the 7-Heavy plots as the shortest, reduction was erratic and failed to follow any system of gradual decline.

Redlan kafir, which has averaged 42 inches over a 4-year period

Table 6.--Average number of days from planting date until maturity on 4 grain sorghum varieties when subjected to 12 row spacing-seeding rate treatments at Perkins, Oklahoma in 1950.

	Varieties					
Treatment	Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo	Spacing Average	Treatment Average
42L	103	118	118	107		112
42M	102	117	118	106		111
42H	103	118	118	107	112	112
21L	103	118	118	106		111
21M	103	117	118	104		111
21H	103	118	118	104	111	111
14L	103	117	118	106		111
14M	103	118	118	107		112
14H	103	118	118	107	112	112
7L	104	118	119	108		112
7M	104	118	120	109		113
7H	105	118	119	109	113	113
Average	103	118	118	107		

(1945 to 1948 incl.) and 52 inches in 1950 when planted in 42-inch rows, showed an uneven trend in plant height from 60 inches for 42-Medium plots to 37 inches for 7-Heavy plots[3].

Dwarf kafir, averaging 44 inches over the same 4-year period and 46 inches in 1950 when planted in 42-inch rows, responded to increased seeding rates and close row spacing by an elongation of internodes. The 1950 season permitted plant response in height to occur without restrictions from climatic factors. A range of height extended from 54 inches for 7-Heavy plots to 64 inches for the 42-inch spacings. All 42-inch, 21-inch, and 14-Light treatments averaged 60 inches or more in height.

Resistant Wheatland declined somewhat irregularly from 41 inches at 42-Light, to 26 inches for the 7-Heavy plots, a 37% reduction from the highest average. Eight treatments averaged within 7 inches of the tallest height, with the remaining 4 treatments, 14-Heavy, 7-Light, 7-Medium, and 7-Heavy, centering around 31 inches in height.

Treatment averages, as well as spacing averages showed reduction of plant height as distance between rows was reduced and seeding rates were increased. Treatment averages on the 4 varieties showed 42-Light plots to have the highest average with 56 inches and 7-Heavy plots to have the lowest with a height of 40 inches. Spacing averages ranged from 55 inches for the 42-inch plots to 43 inches for the 7-inch spacings.

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[3] Plant heights for the 4-year period 1945 to 1948, and for the 1950 season were made available by J. B. Sieglinger, and Frank Davies, Agronomist and Associate Professor of Agronomy, respectively, Oklahoma A. & M. College, Stillwater, Oklahoma.

Table 7.--Average plant heights in inches for 4 grain sorghum varieties when subjected to 12 row spacing-seeding rate treatments at Perkins, Oklahoma in 1950.

Treatment	Varieties				Spacing Average	Treatment Average
	Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo		
42L	54	58	64	41		56
42M	56	60	64	40		55
42H	56	58	64	40	55	55
21L	51	55	60	40		52
21M	53	54	62	37		52
21H	51	53	62	34	51	50
14L	49	51	61	36		49
14M	50	51	59	37		49
14H	48	48	54	31	48	45
7L	47	44	55	33		45
7M	45	39	59	31		44
7H	42	37	54	26	43	40
Average	50	51	60	36		

Head Size

Seed heads of representative size were selected from all treatments. Data on head size are presented in Table 8. Average head length for 42-Light plots was 8.4 inches while heads from 7-Heavy plots averaged 3.6 inches, a reduction of 57% (Fig. 4). A reduction in length was observed for treatment averages, and for individual varieties, but with less consistency, as seeding rates were increased from 4.35 pounds per acre to 46.93 pounds per acre.

Heads from the 42-inch plots were greatest in length averaging 7.9 inches while 7-inch spacings produced the smallest heads with an average of 4.2 inches.

Test Weights

Average weights from Martin milo on all treatments failed to fall below 58 pounds per bushel. The 42-inch spacings were the best averaging 59 pounds per bushel (Table 9).

Redlan kafir, threshing relatively free of glumes, was more consistent in test weights than the other varieties. Weights ranged from 59.5 for 42-Medium to 57.2 for the 7-Medium treatment.

Averages for Dwarf kafir ranged from 57.2 pounds for 42-Heavy to 58.6 for 21-Light and 21-Medium treatments.

The test weight per bushel of Resistant Wheatland was unaffected by treatments. Seven-Heavy and 42-Medium were both 58.2 while 14-Heavy was 58.3, and 21-Heavy was 58 pounds per bushel.

Presence of trash was more influential in changing test weights than treatments, particularly during a season of adequate rainfall for ideal seed development. This was shown by the minor differences in spacing averages and treatment averages.

Table 8.--Length in inches of representative seed heads from 4 grain sorghum varieties when subjected to seeding rate-row spacing treatments at Perkins, Oklahoma, in 1950.

	Varieties					
Treatment	Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo	Spacing Average	Treatment Average
42L	9.5	7.0	8.0	9.0		8.4
42M	9.0	6.5	7.5	8.5		7.9
42H	9.0	6.5	7.0	8.0	7.9	7.6
21L	9.0	6.0	6.5	7.5		7.2
21M	8.0	5.5	5.5	7.0		6.5
21H	7.5	6.0	5.0	6.5	6.6	6.2
14L	7.5	5.0	5.5	7.0		6.2
14M	6.0	5.0	5.0	6.5		5.6
14H	5.5	4.5	4.5	6.0	5.8	5.1
7L	5.0	4.5	4.5	5.5		4.8
7M	4.5	4.0	4.0	4.5		4.2
7H	4.0	3.0	3.5	4.0	4.2	3.6
Average	7.0	5.3	5.6	6.6		

Fig. 4.--Representative heads from 4 grain sorghum varieties when subjected to 12 seeding rate-row spacing treatments.

Table 9.--Average pounds per bushel of 4 grain sorghum varieties when subjected to 12 row spacing-seeding rate treatments at Perkins, Oklahoma in 1950.

	Varieties					
Treatment	Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo	Spacing Average	Treatment Average
42L	59.3	59.4	58.0	58.4		58.8
42M	59.1	59.5	58.3	58.2		58.8
42H	59.4	59.0	57.2	58.1	58.7	58.4
21L	58.8	58.6	58.6	57.6		58.4
21M	58.2	58.7	58.6	57.7		58.5
21H	59.0	58.4	58.1	58.0	58.4	58.4
14L	58.5	58.1	57.9	58.5		58.3
14M	58.7	58.2	57.7	58.0		58.2
14H	58.6	58.3	57.5	58.3	58.2	58.2
7L	58.6	57.4	58.2	57.6		58.0
7M	58.7	57.2	57.8	58.0		57.7
7H	58.5	57.3	57.6	58.2	57.9	57.9
Average	58.8	58.3	58.0	58.1		

Threshing Percentages

Threshed grain weights were divided by dry head weights to obtain threshing percentages. Three plots of each treatment for each variety were averaged to obtain the data presented in Table 10.

All varieties tended to center around a mean indicating an absence of correlation between threshing percentages and treatments for the experiment.

Martin milo averaged 70% for 12 treatments showing percentages from 67 to 76%. Redlan kafir threshed an average of 67% grain with an overall range of 64 to 70%. Dwarf kafir which was more difficult to thresh than the other varieties produced less grain per pound of dry head weight with an average percentage of 66%. A range from 56 to 64% was shown for the variety. Resistant Wheatland milo averaged 64% for the 12 treatments with a range from 62 to 68%.

Spacing averages and treatment averages indicated the threshing percent of the 4 varieties was not affected by the treatments of the study.

Weed Control

An observation was made of weed growth, particularly crab grass (*Digitaria sanguinalis* L. Scop.) when subjected to various spacings of sorghum plants. As seeding rates were increased and distance between rows was reduced from 42 inches to 7 inches, a pronounced reduction in weed growth was observed. All 42-inch spacings required cultivation in order to control weeds while the sorghum plants were small. When the three taller varieties reached a height of 3 feet, crab grass had reached

Table 10.--Average threshing percentages from 4 grain sorghum varieties when subjected to seeding rate-row spacing treatments at Perkins, Oklahoma in 1950.

Treatment	Varieties: Martin milo	Redlan kafir	Dwarf kafir	Resistant Wheatland milo	Spacing Average	Treatment Average
42L	72	66	57	64		65
42M	72	66	61	62		65
42H	67	68	60	63	65	65
21L	68	66	56	62		63
21M	71	69	61	65		66
21H	72	70	58	64	64	62
14L	68	66	56	65		64
14M	70	68	60	63		65
14H	73	66	59	64	65	66
7L	68	70	58	65		65
7M	76	66	56	62		65
7H	73	64	64	68	64	63
Average	70	67	66	64		

its climax in growth.

Twenty one-inch spacings did not receive cultivation and were infested with weed growth. A thick mat of grass emerging shortly after planting, but was short-lived and practically disappeared after the plants reached a height of 2 feet.

When space between rows was reduced to 14 inches, competition from crab grass was practically eliminated. Light and space appeared to be limiting factors for crab grass development when sorghums were planted in rows 14-inches apart.

A complete absence of crab grass was shown in the presence of 7-inch row spacings and only in exposed areas was the weed able to thrive. Light could be regarded as the limiting factor for growth, as the soil was completely shaded after the plants reached a height of 8 to 12 inches.

Bird Damage

Grain losses from sparrow damage occurred on 2 varieties in Replication 1, which necessitated discarding the grain yield data for the replication from the study. The varieties receiving the most damage were Redlan kafir and Martin milo. Stage of maturity and field location of the Redlan block were particularly favorable toward bird infestation. Trees and shrubbery adjacent to the Redlan block provided protection and a roost for bird concentrations.

Evidence of initial damage was noted the first week of September when the varieties had reached the milk stage of seed development.

Size of head was positively correlated with degree of seed loss. The largest heads as produced by 42-inch spacings were completely destroyed, 21-inch and 14-inch receiving intermediate damage, while the small heads of the 7-inch spacings received only minor losses. The weak stems of the thicker plantings were of inadequate size to permit bird perching and feeding at the same time. In wooded areas where sorghums might be menaced by birds, controlling head size by seeding rate might be of significance in reducing grain losses from bird damage. The results showed the 7-inch spacings to yield quite profitably while 42-inch spacings after undergoing bird damage were a complete loss.

SUMMARY

This experiment was conducted in 1950 on the Oklahoma Agricultural Experiment Station near Perkins, Oklahoma, in order to study the effects of row spacing and seeding rate on yield in grain sorghums.

In addition to grain yields, the following physical features were also studied: date of heading, date of maturity, plant height, test weight, threshing percent and head size.

Without additional data, only limited conclusions, which may be modified by future results can be drawn.

1. A highly significant difference for spacing, indicated a difference in yield for the 4 spacings tested.

2. No significant difference was observed for rate, which showed all three rates produced similar yields.

3. The interaction, spacing x rate, showed significance at the 5% level, indicating spacing yields were significantly affected by seeding rate.

4. The interaction, variety x spacing, showed no significance indicating an absence of varietal response to a particular row spacing.

5. No significant difference was obtained for variety x rate interaction, signifying that all varieties reacted alike when sown at the 3 rates.

6. An absence of a significant difference with the interaction, variety x spacing x rate, indicated no variety was an outstanding yielder when subjected to a specific spacing and seeding rate.

7. Increased seeding rates were effective in prolonging the date of heading from 3 to 5 days.

8. The date of maturity was not affected by seeding rate or distance between rows.

9. Plant height was reduced as seeding rates were increased; the 42-Light plots averaged 56 inches as compared to 7-Heavy plots which averaged 40 inches in height.

10. Length of seed head decreased gradually as seeding rate per acre was increased.

11. Test weights and threshing percentages of the 4 varieties were not affected by the treatments of the study.

12. Growth of crab grass was somewhat restricted by the 21-inch spacing, with a greater degree of control on plots planted to 14 and 7-inch spacings.

13. Small seed heads resulting from high rates of seeding received only minor damage when attacked by birds.

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A P P E N D I X

Drill Calibration

The calibration of seeding equipment is dependent upon the effective width of the implement. By using the 13-hole drill to seed rows 42 inches apart (cup Nos. 1, 7, and 13 sowing), the effective width was determined by adding an additional 42 inches to the seeded width. Twenty-one inches on each side of the drill would extend half way to the next row, producing an effective width of 126 inches or 10.5 feet. To sow an acre, the drill would have to travel 4,150 feet (43,560 sq. ft./10.5 ft. = 4,150 ft.). Effective width, influenced by distance between rows, was decreased as row spacing was reduced to 21 inches, 14 inches and 7 inches. The resulting widths obtained from adding the distance between rows to the seeded width (84 inches) increased linear distance required for sowing an acre (Table 11).

Table 11.--Affect of row spacing on effective width and linear distance necessary for sowing an acre.

Row Spacing (inches)	Effective Width (feet)	Linear Distance/A. (feet)
42	10.50	4,148.57
21	8.75	4,978.20
14	8.17	5,331.70
7	7.58	5,746.70

Ground wheel revolutions per acre were determined by dividing linear distance for each row spacing by the outside circumference of the ground wheel, 7.15 feet. Revolutions traveled per acre were 580.2 in sowing rows 42 inches apart, 696.25 for 21-inch spacing, 745.69 for 14-inch spacing, and 803.73 for 7-inch spacing.

Simple ratios were used to trace the transfer of ground wheel movement through a series of gears and to the seed box containing the distributors.

Number one gear, mounted directly to the ground wheel, revolved once every 7.15 feet. A chain from No. 1 transferred the power to No. 2. The No. 3 gear was connected directly to No. 2 by a shaft, completing a revolution for each complete turn of No. 2. No. 3, a conical-shaped gear, consisted of 10 separate rings of teeth. The first ring located nearest the shaft upon which the gear was mounted contained 20 teeth in which a sliding gear would mesh. The number of teeth increased by four with each setting until the ring on the edge of the cone or setting No. 10 contained 56 teeth. When the sliding gear was adjusted upon the cone, a change toward ten would increase the seeding rate from a previous seeding, or a move toward No. 1 would decrease the seeding rate. No. 4 gear, sliding on a keyed shaft and meshing in No. 3, was fixed to a shaft connected to No. 5. The speed of No. 5 was reduced by meshing with No. 6, a gear containing over three times as many teeth as No. 5. No. 7 sprocket was mounted on the opposite end of a shaft connected to No. 6. A chain connected No. 7 to No. 8. Both sprockets had the same number of teeth, producing neither an increase or reduction in revolutions. Sprocket No. 8 was mounted upon the seed cup shaft. Odd-numbered gears were considered as drivers while the even-numbered ones were those being "driven" (Table 12).

One rev. of No. 1 equals 9/15 revolution of No. 2.

One rev. of No. 3 equals 20-56/20 rev. of No. 4.

One rev. of No. 5 equals 10/35 rev. of No. 6.

One rev. of No. 7 equals 1 rev. of No. 8.

Table 12.--Gear data from small grain drill.

Gear Number	Function	Number of teeth
1	Driver	9
2	Driven	15
3	Driver	20-56*
4	Driven	20
5	Driver	10
6	Driven	35
7	Driver	8
8	Driven	8

*Conical gear with 20, 24, 28, 32, 36, 40, 44, 48, 52, and 56 teeth.

To find the revolutions made by the seed distributor at setting No. 1 (per revolution of ground wheel):

9/15 x 20/20 x 10/35 x 8/8 equals 0.171 revolution.

To find the revolutions made by the seed distributor at setting No. 10 (per revolution of ground wheel):

9/15 x 56/20 x 10/35 x 8/8 equals 0.480 revolutions (Table 13).

A similar table could be prepared by substituting ground wheel revolutions traveled when sowing an acre with 21, 14, or 7-inch row spacing in place of 580.2 where rows are spaced 42 inches apart.

Redlan kafir was used to determine the amount seeded per revolution of the distributor. Individual containers were placed beneath each seed cup. After turning the seed cup shaft 75 revolutions, the amount of grain in each container was weighed, and the weight divided by 75. Each revolution was found to distribute 0.0146 pounds per row.

Table 13.--Range of distributor speeds available by manual adjustment of No. 3 gear.

Setting	Distributor Rev./ground Wheel Rev.			Distributor Rev./Acre
1	0.171	x	580.2*	99.5
2	0.206			119.5
3	0.240			139.2
4	0.274			159.0
5	0.308			178.7
6	0.342			199.0
7	0.376			218.5
8	0.412			239.0
9	0.446			259.0
10	0.480			278.0

*Revolutions of ground wheel per acre (42-inch row spacing).

To determine rate of seeding at setting No. 1 with 42-inch row spacing:

99.5 (A) x 0.0146 lbs. (B) x 3(C) equals 4.35 lbs./A.

A - revolutions of seed cup distributor per acre.

B - amount of seed sown per revolution of seed cup.

C - number of rows sown per 126 inches (effective width).

By adjusting the drill to setting No. 3, distributor* revolutions per acre were increased to 139.2. Substituting this value for 99.5 in the formula raised the planting rate to 6.09 lbs. per acre. In setting No. 5, distributor revolutions was advanced to 178.7 per acre. The calculated seeding rate was increased to 7.8 pounds. By using setting No. 10, a maximum of 12.18 pounds per acre could be planted in rows 42 inches apart (Table 14).

Table 14.--Minimum and maximum seeding rates for Redlan kafir as determined by drill calibration when 4 row spacings were used.

	Distance between Rows			
Setting	42"	21"	14"	7"
1	4.35	8.70	13.09	26.13
2	5.20	10.50	15.70	31.40
3	6.09	12.15	18.27	36.53
4	6.95	13.90	20.90	41.70
5	7.80	15.65	23.45	46.93
6	8.7	17.40	26.10	52.20
7	9.6	19.10	28.70	57.40
8	10.5	21.00	31.40	62.80
9	11.3	22.70	34.00	68.00
10	12.18	24.40	36.50	73.00

*Note: The term "distributor" is used synonymously with "seed cup".

Table 15.—Collected data, measured and computed, used in calibration of the small grain drill.

Row Spacing (inches)	Seeding Rate	Effective Width (feet)	Linear Distance/A. (feet)	Ground Wheel Rev. /A.	Seed Cup Rev./Ground Wheel Rev.	Seed Cup Rev./A	Seed Sown per Seed Cup Rev. (lbs.)	No. of Rows	Seeding Rate/A. (lbs.)
42	L	10.5	4,148.5	580.2	0.172	99.79	0.0146	3	4.35
	M	10.5	4,148.5	580.2	0.240	139.24	0.0146	3	6.09
	H	10.5	4,148.5	580.2	0.308	178.70	0.0146	3	7.80
21	L	8.75	4,978.2	696.25	0.172	119.75	0.0146	5	8.7
	M	8.75	4,978.2	696.25	0.240	167.10	0.0146	5	12.15
	H	8.75	4,978.2	696.25	0.308	214.44	0.0146	5	15.65
14	L	8.17	5,331.7	745.69	0.172	128.25	0.0146	7	13.09
	M	8.17	5,331.7	745.69	0.240	178.96	0.0146	7	18.27
	H	8.17	5,331.7	745.69	0.308	229.67	0.0146	7	23.45
7	L	7.58	5,746.7	803.73	0.172	138.24	0.0146	13	26.13
	M	7.58	5,746.7	803.73	0.240	192.89	0.0146	13	36.53
	H	7.58	5,746.7	803.73	0.308	247.54	0.0146	13	46.93

Table 16.--Basic grain data in pounds from 4 grain sorghum varieties when subjected to 12 seeding rate-row spacing treatments at Perkins, Oklahoma in 1950.

Treatment	Martin milo			Redlan kafir		
Reps.	2	3	4	2	3	4
42L	11.5	8.5	11.0	10.5	10.0	10.5
42M	11.0	11.0	12.5	10.5	7.5	10.5
42H	9.5	11.0	10.5	11.5	11.0	11.5
21L	11.5	14.5	8.5	11.0	11.0	10.5
21M	10.5	12.0	9.0	11.0	11.0	11.5
21H	11.0	12.0	11.5	12.0	11.0	7.5
14L	10.5	11.0	10.5	11.0	11.5	11.0
14M	11.0	10.0	12.5	10.5	10.5	11.0
14H	11.5	13.0	9.5	10.5	9.5	10.0
7L	8.5	10.0	9.5	12.0	12.0	11.5
7M	6.5	6.0	9.0	8.5	11.0	9.5
7H	9.0	9.0	5.5	9.5	8.5	9.0

Treatment	Dwarf kafir			Resistant Wheatland milo		
Reps.	2	3	4	2	3	4
42L	9.5	9.0	10.0	11.5	12.5	8.5
42M	13.0	9.5	9.0	13.5	7.5	10.0
42H	10.0	11.0	11.5	13.0	13.0	12.0
21L	8.0	12.0	12.0	12.5	4.5	13.0
21M	13.5	11.5	11.0	12.5	12.0	10.0
21H	10.5	8.0	11.0	13.0	15.0	8.5
14L	9.5	10.5	9.5	13.5	11.0	10.0
14M	11.0	11.5	10.0	12.5	9.5	11.0
14H	12.5	10.0	9.5	7.5	10.0	12.5
7L	10.0	10.0	7.5	13.0	12.5	12.0
7M	8.5	9.0	7.5	11.0	10.0	6.0
7H	9.0	8.0	6.5	9.0	10.5	9.5

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