COMPARISON BETWEEN THE PERFORMANCE OF F_1 AND F_2 SEEDS FOR YIELD AND OTHER AGRONOMIC CHARACTERISTICS IN GRAIN SORGHUM

By

Hikmat George Nasr

A Thesis Submitted to the Faculty
of Agricultural Sciences in Partial Fulfillment of
The Requirments for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Major: Agronomy
Minor: Plant Pathology

Approved:

W. W. Worzella
In Charge of Major Work

D. W. Bray

Fram Nicolaisen

R. S. Jamoney

Wallace W. Worzella
Chairman, Graduate Committee

American University of Beirut
1965

Comparison of F_1 and F_2 Sorghum

Nasr

ACKNOWLEDGEMENTS

The critical guidance, encouragement and assistance offered by Dr. W.W. Worzella and Dr. D.W. Bray are here recognized and greatly appreciated. Many thanks are due to Mr. Sami Saad who helped with the field work.

A special thank you is due to Miss Yeran Kaledjian and Miss Julia Saad for moral support and encouragement.

ABSTRACT

A two-year study was carried out at the Agricultural Research and Education Center, Beqa'a, Lebanon, to make a comparison between the performance of F_1 and F_2 seeds in grain sorghum. The plant characters studied were grain and stover yield, test weight, number of days to flowering, plant height, head length, head weight and one-hundred kernel weight. This study was conducted under irrigated conditions.

The results indicate that there was a reduction in the grain yielding capacity from the F_1 to the F_2 generation of grain sorghum hybrids. The stover yield and test weight, however, were not influenced by planting either F_1 or F_2 generation seeds.

The average date of flowering of the F_2 sorghum plants was delayed a few days and the heads were a few grams lighter than those of the F_1 plants. In some grain sorghum hybrids the F_1 plants were taller and their heads were larger than were those of the F_2 plants. However, the seeds of F_2 sorghum plants were heavier than were those of the F_1 plants.

Less variation was observed between plants in each F_1 population than between the plants of the corresponding F_2 population for the following characteristics of six grain sorghum hybrids: number of days to flowering, plant height, head length, head weight, and 100 kernel weight.

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INTRODUCTION

In the early 1930's, the development of corn hybrids caused a great rise in corn production in the United States. This was due to the utilization of hybrid vigor in corn which resulted in higher yields per acre when compared with that of the open-pollinated varieties. The practical use of heterosis that was started in the breeding of hybrid corn now has been applied in other field and vegetable crops such as sugar beets, onions, cucumbers, tomatoes and sorghums. In sorghum, hybrids were not utilized commercially until after 1954 when cytoplasmic male sterile lines became available.

In the 1930's and 1940's, when hybrid seed was used extensively in the production of corn, the problem of using F_2 seeds arose. This was because, by tradition, the farmer saved his own seed supply from the open-pollinated varieties. Also, the superior performance of the adapted hybrids increased the temptation for the farmer to save F_2 seeds. Farmers have been generally advised against planting second generation seed from corn hybrids. This advice has been based upon the need of using specific genotypes as hybrids, the demonstrated reduction in the yielding capacity of the F_2 population and the increased variability in the agronomic characteristics from the F_1 to the F_2 in the corn hybrids.

Yield and the uniformity of other agronomic characteristics are the two criteria for the superiority of hybrids over open-pollinated varieties. In addition to the decline in the yield, corn fields planted with F_2 seeds segregate and produce plants that vary widely in height, maturity and other agronomic characteristics. Therefore, it is important to find out what happens when F_2 seeds of sorghum are grown so that sound advice can be given to the farmers as to the purchasing of seeds. The purpose of this study, therefore, was to make a comparison between the performance of F_1 and F_2 seeds for yield and other agronomic characteristics in grain sorghum.

This study was conducted at the Agricultural Research and Education Center, Beqa'a, Lebanon, during the period 1963-1964.

REVIEW OF LITERATURE

Limited data are available on the performance of grain sorghum produced from F_1 and F_2 seed stocks because of the fact that hybrid sorghum was not commercially known until after 1954 when cytoplasmic male sterility was discovered. The purpose of this survey of literature is to review the available information pertaining to the comparison between F_1 and F_2 seeds used for yield and other agronomic characteristics in grain sorghum and corn.

Sorghum

Webster (14) reported that F_2 generation seeds of the grain sorghum RS 501 yielded 18 percent less grain than did the F_1 hybrid of the same cross, whereas the F_1 and F_2 generation seeds of the hybrid RS 650 had the same yielding capacity. It was found by Wing (15) that the average grain yield from the F_2 seed stocks of sorghum was 12 percent less than that of the F_1 hybrids. This difference was mainly due to fewer seeds per head in the sorghum plants produced from the F_2 seed.

As to other agronomic characteristics Wing (15) found that the bushel weight of the F_1 hybrids of grain sorghum exceeded their respective F_2 plants by one-half pound.

It was observed by Webster (14) that the date of blooming was one to three days later and the plants were a few inches shorter from the F_2 seed plots than were those from the F_1 hybrid plots. Wing (15) reported that the heights of the F_2 sorghum plants averaged four to five inches less than those of the F_1 plants.

Corn - Grain Yield

The research work involving comparative studies of the F_1 and F_2 generations in corn has been conducted extensively. Because both corn and sorghum are row crops and are used primarily for feed, it would be pertinent to review some of the important results concerning corn.

Kiesselbach (3) found that F_2 and F_3 corn plants yielded 68 and 66 percent respectively as much grain yield as did the F_1 plants of the same crosses. Richy et al. (11) reported that F_1 hybrids yielded an average of 15.2 percent more grain than did the F_2 plants, and that a larger decrease occurred among the higher yielding F_1 crosses.

It was determined by Neal (10) that grain yields of F_2 and F_3 generations of single cross corn hybrids averaged 70.5 and 75.7 percent, respectively, of those of the F_1 generation of the same hybrids. However, the grain yield of the F_2 generations of double crosses averaged 84.2 percent of that of the F_1 hybrids. In the case of three-way hybrids, the F_2 and F_3 generations yielded an average of 76.6 and 75.8

percent of the grain yield of the F_1 hybrids. Data presented by Rosbaco (12) show that the F_2 plants of double cross corn hybrids averaged a loss of 27 to 42 percent in grain yielding capacity as compared with their F_1 hybrids. It was found by Gologan et al. (2) that the grain yield of the F_2 of intervarietal hybrids was 92.5 percent of that of the F_1 hybrids, but in the case of a much higher yielding double interline hybrid, Pioneer 352, the grain yield of the F_2 was 69.4 percent of that of the F_1 hybrid.

Kiesselbach (4) in a two-year study of controlled self-pollinations, reported that the reduction in grain yielding ability through selfing and sibbing of the F_2 plants of a corn single cross averaged 35.4 and 35.2 percent respectively. No further reduction occurred in F_3 from continued random sibbing, whereas the reduction was 51 percent when selfing was practiced. The selfing of double crosses resulted in reductions in the F_2 and F_3 of 33.3 and 48.2 percent, respectively, whereas the reduction was 18.5 and 19.9 percent in the case of sibbing.

Caputa and Popow (1) in a six-year study in Switzerland reported that the grain yield from F_1 seeds of the hybrid, Wisconsin 270, was 10 percent higher than that obtained from F_2 plants.

Salanov (13) in a fifteen-year study in Russia found that the yielding capacity of the F_1 intervarietal hybrids can be maintained and can even be improved upon in the F_2

and later generations, provided adequate selection methods are practiced.

Corn - Forage Yield

Lanza (6) observed that F_2 seeds sown for forage production yielded slightly less green material than did the open-pollinated varieties. Kiesselbach (4) reported in a two-year study that the fodder yielding capacity of the F_2 of single crosses was 22 percent less than that of the F_1 hybrids, but for the F_2 of double crosses, the yielding capacity was only 13 percent less. Caputa and Popow (1) also found in a six-year study in Switzerland that the dry matter yields of silage corn obtained from F_1 plants of three United States hybrids were 17.8 percent more than were those of the F_2 plants of the same crosses.

Kiesselbach et al. (5) determined that the relative moisture free fodder weights of selfed lines, F_1 hybrids and F_2 plants of corn were 100, 215 and 164, respectively.

Corn - Other Agronomic Characteristics

It was reported by Kiesselbach et al. (5) that the relative stalk heights of selfed lines, F_1 hybrids and F_2 plants of corn were 100, 128 and 114, and the relative leaf areas per plant were 100, 143 and 116, respectively. In root development the depth of penetration, the combined length of

all main roots per plant, and the diameter of main roots increased materially in the F_1 hybrids, while in the F_2 plants it was intermediate as compared with those of selfed lines.

Malinowski et al. (8) found that the plants in the F_1 plots of three crosses of corn surpassed the taller parents in plant height, and were early to intermediate in flowering time. However, the F_2 generation of the same three crosses, had a number of individual plants taller than the tallest F_1 plants and flowering time was later. Nakamura and Tate (9), in Japan, observed that the vegetative cycle was shorter in F_1 hybrids than in F_2 plants, but the silking date did not differ between the generations. In the case of the tasseling date the variance of the F_2 plants was greater than that in the F_1 hybrid.

MATERIALS AND METHODS

The study was carried out for two years, 1963 and 1964, at the Agricultural Research and Education Center in the Beqa'a, Lebanon. This area is located in the Northern Central Beqa'a plain between Zahle and Baalback. The soil is clayey, calcareous, high in potassium and low in nitrogen, phosphorous and organic matter. It is well drained with a pH of about 8.0.

The land was plowed and harrowed in the fall. Ammonium sulfo-nitrate and simple super-phosphate, at the rate of 12 kilograms of nitrogen and 20 kilograms of P_2O_5 per dunum, were applied on the surface and disked into the soil prior to planting. As a supplementary amount two side dressings, each at the rate of four kilograms of nitrogen per dunum, were added during the 1963 growing season. Three side dressings were applied in 1964.

F_2 hybrid seeds were produced each year by controlled self pollination of the following six F_1 hybrids: RS 610, RS 630, RS 650, Tx 620, Tx 660, and NK 222. In May F_1 and F_2 generation seeds were planted thickly by a V-belt seed drill in plots consisting of two rows, each five meters long and 0.75 meters apart. About four weeks after planting, the plants were thinned to 5 to 10 centimeters apart within the

row. Irrigation was done by sprinklers in the early stages and later through furrows at weekly intervals throughout the growing season. Weeding was done regularly but discontinued at the boot stage when the sorghum plants suppressed the weeds by competition. The crops were sprayed with Metasystox to control aphids and leafhoppers.

The field layout was a randomized complete block with four replicates. Forty plants (ten from each replicate) were selected at random from the first row of each plot, when the plants were about 0.50 meters tall, and used to obtain specific data on individual plants. Data were recorded on grain and stover yield, test weight, days to flowering, plant height, head length, head weight and 100 kernel weight.

Grain and stover yield as well as test weight were obtained from the central four meters of the two rows, leaving one-half meter on each end of the row as border. The heads harvested from each plot were put in a cloth sack, air dried for three to four weeks, and then threshed. The weight of the seeds was recorded in grams and converted to kilograms per dunum. The green weight of stover was recorded at the time of harvest. A one kilogram sample was taken from each plot for moisture determination and air dried for four to five weeks. The stover yields were calculated on an air-dry basis and reported in kilograms per dunum. The test weight of each plot was determined in pounds per bushel by following standard procedures.

Measurements of days to flowering, plant height, head length, head weight and 100 kernel weight were made on each of the forty selected plants. The number of days to flowering was reported as the number of days from planting to flowering. Plant height was measured in centimeters from ground level to the top of the head. Head length was measured in centimeters from the lowest node of the head to the tip. Head weight was recorded in grams of seeds per head, and the weight of 100 kernels was recorded in grams.

Frequency distributions were constructed in tabular form for each of the following characters: days to flowering, plant height, head length, head weight and 100 kernel weight. Means, standard deviations, and averages of all the sorghum varieties for the two generations were calculated. The "t" test and the F-test were used as tests of significance. Data measured for grain and stover yield and test weight were subjected to an analysis of variance (7) and Duncan's Multiple Range Test (7) was used to determine whether differences between the entries were significant.

RESULTS AND DISCUSSION

A two-year study was conducted to determine the difference between the performance of F_1 and F_2 generation seed for yield and other agronomic characteristics in grain sorghum.

The results are summarized and reported in tables[+] 1 to 8. Statistical analysis of yield and head weight are given in the Appendix[++] tables 9 to 14. On the basis of Duncan's Multiple Range Test asteriks are placed close to the treatments that are statistically significant.

Grain Yield

The data for grain yield in kilograms per dunum of grain sorghums produced from F_1 and F_2 seeds are summarized in table 1. In both years, 1963 and 1964, the F_1 of the hybrid RS 610 yielded significantly more grain than did its F_2. Under the same conditions, however, the grain yields obtained from the F_1 and the F_2 seeds of Tx 620 showed the same trend, but the differences were not statistically significant. In the other four hybrids (RS 630, RS 650, Tx 660, and NK 222) the F_1 generation seed produced more grain than the respective F_2 generation seed in one year, but the yield

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[+] All comparisons are made between F_1 and F_2 generations.

[++] Only yield and head weight are reported as representative samples of the statistical analysis used in the thesis.

Table 1 - Grain yields in kilograms per dunum of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	Grain yield in kilograms per dunum			
	F_1		F_2	
	1963	1964	1963	1964
RS 610	1072**	904*	882	711
RS 630	938**	810	690	682
RS 650	858	862*	824	691
Tx 620	926	835	893	683
Tx 660	981	948**	850	727
NK 222	879	895**	756	649
Average	942.3*	875.6**	815.8	690.3

* Significant at 5% level.
** Significant at 1% level.

differences obtained in the second year were not significant.

It should be noted that, from the 12 possible comparisons, higher yields were obtained in each case from plots planted with F_1 seeds than from those planted with F_2 seeds.

The highest yielding hybrids, RS 610 and Tx 660, for both years 1963 and 1964, had a greater reduction in yielding capacity from the F_1 to the F_2 generation than did the lower yielding hybrids (RS 650 and Tx 620). This difference is probably due to the fact that in the process of hybridization higher yielding hybrids reflect more heterosis than the lower yielding ones. In the random recombination of the yield genes in the F_2 generation greater losses would result in the hybrids depending upon more genes for yield.

The average grain yields of all six grain sorghums grown from F_1 seeds was 942.3 kilograms per dunum in 1963 and 875.6 kilograms in 1964. These yields were higher than those of the grain sorghums grown from F_2 seeds which yielded 815.8 and 690.3 kilograms per dunum in 1963 and 1964 respectively. These results are in agreement with the work of Webster (14) and Wing (15).

Stover Yield

As can be seen from the data in table 2, stover yields in sorghum hybrids were not influenced greatly by planting F_1 or F_2 generation seeds. Only in the hybrid, Tx 620, were the stover yields higher for the plots planted with

Table 2 - Dry stover yields in kilograms per dunum of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	Dry stover yield in kilograms per dunum			
	F_1		F_2	
	1963	1964	1963	1964
RS 610	907	741	830	803
RS 630	852	680	762	737
RS 650	845	747	934	771
Tx 620	833	769	1168**	684
Tx 660	828	848	875	757
NK 222	734	703	749	681
Average	833.2	748.0	886.3	738.8

** Significant at 1% level.

F_2 seeds as compared to those planted with the F_1 seeds. This difference was probably due to the increase in the plant height (table 5) of the F_2 generation of this particular hybrid.

Test Weight

The test weights of the grain of the sorghum hybrids are reported in table 3. Data were obtained only for the year 1963. It will be noted from the data that for the hybrid RS 610 only, the test weight was significantly higher for the grain from plants originating from F_1 seeds as compared to that obtained from F_2 seeds. The test weight obtained for the grain of the other five hybrids was not affected by planting either F_1 or F_2 generation seeds.

Number of Days from Planting to Flowering

The time of flowering of the sorghum was materially affected by the use of different generation seeds as shown in table 4.

In 1963 the grain sorghums grown from F_1 seeds of the hybrid RS 610, RS 630, Tx 620, and Tx 660 bloomed earlier than did their respective F_2's, and the differences are highly significant. F_1 hybrids of RS 650 and NK 222 were about one day earlier than the F_2 plants. In 1964, all of the F_1 hybrids were significantly earlier in blooming than

Table 3 - Test weights in pounds per bushel of six grain sorghums grown from F_1 and F_2 seeds during 1963.

Hybrids	F_1	F_2
RS 610	59.0**	57.5
RS 630	56.4	56.0
RS 650	56.1	56.5
Tx 620	57.4	57.8
Tx 660	57.2	56.5
NK 222	58.2	58.0
Average	57.4	57.0

** Significant at 1% level.

Table 4 - Days from planting[+] to flowering and standard deviations of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	F_1				F_2			
	Planting to flowering (days)		Standard deviation (days)		Planting to flowering (days)		Standard deviation (days)	
	1963	1964	1963	1964	1963	1964	1963	1964
RS 610	82.4**	90.5**	1.4	4.1	86.8	94.2	2.9**	5.1
RS 630	86.1**	95.1*	2.1	3.8	88.8	97.3	3.4**	5.2*
RS 650	87.5	92.2**	2.6	3.5	88.4	95.8	5.0**	5.1*
Tx 620	85.2**	93.7**	2.8	4.5	88.5	96.5	5.6**	5.3
Tx 660	87.3**	92.4**	2.3	3.0	89.6	97.9	5.0**	6.7**
NK 222	84.8	96.1*	2.7	4.7	85.7	98.4	3.4	6.0
Average	85.5**	93.3**	2.32	3.93	88.0	96.7	4.22**	5.57*

+ May 9 and May 4 were the planting dates for years 1963 and 1964, respectively.
* Significant at 5% level.
** Significant at 1% level.

their respective F_2's. This is in agreement with the work of Webster (14).

The data in table 4 shows higher standard deviations for the grain sorghums grown from the F_2 generation seeds than those from the F_1 seeds. The results are consistant and in most comparisons the differences are statistically significant. This indicates that greater variation in the time of flowering of sorghum plants can be expected when F_2 generation seeds are used instead of F_1. Since the time of flowering and the date of maturity are correlated, one would expect a wide spread in plant maturity from using F_2 seeds of most sorghum hybrids. This is regarded as an undesirable character for harvesting and processing the sorghum crop.

Plant Height

The average plant heights of sorghum plants are reported in table 5. In 1963 the plants grown from F_1 seeds of the hybrid RS 610 and RS 630 were, on the average, 9 and 12 centimeters taller than those grown from F_2 seeds of the same hybrids. Similar results for these two hybrids were obtained in 1964 when the differences found were 15 and 17 centimeters, respectively. These data are in agreement with the work of Wing (15). No difference in plant height was found between F_1 and F_2 plants of the hybrids RS 650 and Tx 660. In the hybrid Tx 620, the F_2 plants were 17 centimeters

Table 5 - Plant heights and standard deviations in centimeters, of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	F_1				F_2			
	Plant height (cms.)		Standard deviation (cms.)		Plant height (cms.)		Standard deviation (cms.)	
	1963	1964	1963	1964	1963	1964	1963	1964
RS 610	140**	142**	10.7	10.8	131	127	13.9	19.1**
RS 630	142**	140**	6.9	8.6	130	123	13.9**	13.8**
RS 650	122	129	8.3	12.6	125	126	16.7**	21.6**
Tx 620	143	140**	10.0	9.7	160**	129	35.3**	15.4**
Tx 660	131	130	8.7	9.0	130	125	15.5**	17.7**
NK 222	121**	120	4.9	7.3	114	121	13.8**	22.9**
Average	133	133*	8.2	9.7	132	125	18.2*	18.4**

* Significant at 5% level.
** Significant at 1% level.

taller in 1963 than those of the F_1 plants and 11 centimeters shorter in the 1964 crop. For the hybrid NK 222 the F_1 plants were seven centimeters taller than those of F_2 plants in 1963, whereas small differences in plant height were obtained in 1964.

The F_2 plants of all six hybrids studied showed a larger standard deviation in plant height than that of the F_1 plants. The differences in the standard deviation were highly significant except for the hybrid RS 610 when grown in 1963. The high standard deviation indicates that large variations in plant height will be obtained when F_2 generation seeds are used in the production of grain sorghum. This is an undesirable character as it makes sorghum harvesting more difficult.

Head Length

The summary of the data concerning head length of the F_1 and F_2 sorghum plants is given in table 6. No significant difference was found in the average head length between the F_1 and the F_2 sorghum plants of the hybrids RS 610 and Tx 620. The increase in the average head length of the F_1 over that of the F_2 sorghum plants was significant in the hybrids RS 650 and NK 222 in 1963 and in the hybrids RS 630 and Tx 660 in 1963 and 1964.

The difference in the degree of variation between plants in the F_1 population and those of the corresponding F_2

Table 6 - Head lengths and standard deviations in centimeters, of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	F_1				F_2			
	Head length (cms.)		Standard deviation (cms.)		Head length (cms.)		Standard deviation (cms.)	
	1963	1964	1963	1964	1963	1964	1963	1964
RS 610	22.9	20.6	1.6	2.3	22.2	21.0	3.4**	3.4*
RS 630	24.1*	22.2**	1.7	1.8	23.0	20.0	3.2**	2.7**
RS 650	25.3*	20.8	1.5	1.3	23.8	21.3	3.7**	2.1**
Tx 620	24.6	22.1	2.2	2.7	24.4	21.8	2.8	2.3
Tx 660	26.8*	23.1**	2.4	2.3	25.6	21.6	2.8	2.8
NK 222	27.0**	25.5	2.3	2.6	25.2	24.6	2.9	4.0**
Average	25.1**	22.4	1.9	2.2	24.0	21.7	3.1*	2.9*

* Significant at 5% level.
** Significant at 1% level.

population for the character head length was not similar in all hybrids. Plants in the F_2 generation of the hybrids RS 610, RS 630, and RS 650 showed a higher standard deviation for head length than did those of the respective F_1 generation for the years 1963 and 1964. The plants of the other hybrids tested showed no differences between the F_1 and F_2 generation in the standard deviation for head length, with the exception of NK 222, where in 1964, a larger standard deviation was found.

Head Weight

The data on head weights in sorghum hybrids are summarized in table 7. The decrease in head weight of the F_2 as compared to those of the F_1 sorghum plants was 23.5 grams in 1963 and 9.5 grams in 1964 for hybrid RS 630, and 8.8 and 11 grams for hybrid Tx 660. However, in one of the two years the F_1 plants of hybrids RS 610, Tx 620, and NK 222 gave higher head weights than did the F_2 plants of the same hybrids. It should be noted that in all of the 12 possible comparisons higher head weights were obtained from fields planted with F_1 seeds than those planted with F_2 seeds.

The variations within the F_1 populations were not different from those of their respective F_2 populations in the hybrids RS 610, RS 630 and RS 650. The variability in the head weights of the three hybrids, Tx 620, Tx 660, and NK 222 was found to be greater in the F_2 population than in the

Table 7 - Head weights and standard deviations in grams of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	F_1				F_2			
	Head weight (gms.)		Standard deviation (gms.)		Head weight (gms.)		Standard deviation (gms.)	
	1963	1964	1963	1964	1963	1964	1963	1964
RS 610	68.0*	47.7	17.2	14.0	58.7	42.7	19.8	17.7
RS 630	72.7**	51.2**	19.6	13.2	49.2	40.7	17.9	13.8
RS 650	58.2	42.7	18.4	12.0	51.7	42.0	22.8	9.9
Tx 620	56.0	47.7*	15.8	14.9	54.5	40.7	27.0**	14.4
Tx 660	60.0*	50.5**	17.1	13.6	51.2	39.5	23.3*	17.4
NK 222	51.7	49.7**	14.2	13.7	44.7	40.2	19.9*	18.3
Average	61.1*	48.3**	17.1	13.6	51.7	41.0	21.8*	15.3

* Significant at 5% level.
** Significant at 1% level.

corresponding F_1 population only in 1963.

100 Kernel Weight

The weights of 100 seeds of six grain sorghum hybrids are reported in table 8. In both years, 1963 and 1964, the F_2 plants of the hybrids Tx 660 and NK 222 produced heavier seeds than did the F_1 plants of the same hybrids.

For the hybrids RS 630, RS 650 and Tx 620, the kernel weights of F_2 plants were higher than those of the F_1 plants only in one year. The weight of 100 kernels was not affected by planting either the F_1 or the F_2 seeds of the hybrid RS 610.

The difference in the degree of variation between the F_1 population and the related F_2 populations for 100 kernel weight was not consistent in all of the hybrids. Plants of the F_2 generation of the sorghum hybrids RS 610 and NK 222 had a higher standard deviation for 100 kernel weight than did those of the corresponding F_1 generation for the years 1963 and 1964. The variability in 100 kernel weight of the two hybrids, RS 630 and Tx 660, was greater in the F_2 plants than in the F_1 plants only in 1963. The variation in the 100 kernel weight was found not to be affected by using either F_1 or F_2 seeds in the two hybrids RS 650 and Tx 620.

Table 8 - One hundred kernel weights and standard deviations of six grain sorghums grown from F_1 and F_2 seeds during 1963 and 1964.

Hybrids	F_1				F_2			
	100 kernel weight (gms.)		Standard deviation (gms.)		100 kernel weight (gms.)		Standard deviation (gms.)	
	1963	1964	1963	1964	1963	1964	1963	1964
RS 610	3.10	2.88	0.30	0.38	3.07	2.94	0.53**	0.54*
RS 630	3.11	2.65	0.33	0.37	3.39	2.92**	0.52**	0.35
RS 650	2.50	2.59	0.41	0.36	2.83**	2.69	0.47	0.46
Tx 620	2.75	2.72	0.44	0.50	3.03**	2.68	0.48	0.40
Tx 660	2.53	2.68	0.30	0.36	2.72*	2.86*	0.53**	0.47
NK 222	3.07	2.86	0.37	0.43	3.42**	3.12**	0.70**	0.63*
Average	2.84	2.73	0.36	0.40	3.08*	2.87*	0.54**	0.48

* Significant at 5% level.
** Significant at 1% level.

SUMMARY AND CONCLUSIONS

The experiment was conducted to determine the effect of F_1 and F_2 generation seeds on yield and other agronomic characteristics in grain sorghum. F_1 and F_2 plants of six hybrids were grown under irrigated conditions at the Agricultural Research and Education Center, Beqa'a, Lebanon, during 1963 and 1964.

The average grain yields from the F_2 seed stocks of sorghum were 13.3 and 20.8 percent less than those of the F_1 hybrids, for the years 1963 and 1964, respectively. This reduction in grain yielding capacity of the F_2 sorghum plants was observed to be greater in the higher yielding hybrids than in the lower yielding ones.

The stover yields of sorghum hybrids were not affected by planting either F_1 or F_2 seeds.

It was found that the grains of the F_1 plants of hybrid RS 610 gave higher test weights than those of the F_2 plants. Under the same conditions, however, the test weights obtained from the grains of the F_1 and F_2 plants of the other five hybrids showed no significant differences.

F_1 sorghum plants of all of the six hybrids bloomed a few days earlier than did their respective F_2's. More variation in days to flowering was observed in the plants in the

F_2 population than in the F_1 population of sorghum hybrids, except for the hybrid NK 222.

The effect of planting either F_1 or F_2 generation seeds of sorghum on the character plant height was not consistent. In 1963 and 1964, F_1 seeds of hybrids RS 610 and RS 630 produced taller plants than did F_2 seeds of the same hybrids. However, no difference in plant height was found between the F_1 and the F_2 plants of the hybrids RS 650 and Tx 660. In the hybrid Tx 620, the F_2 plants on the average were taller than the F_1 plants in 1963 and shorter in 1964. Whereas, in the hybrid NK 222, the F_1 plants were taller than the F_2 plants in 1963 and the same in height in 1964. In all six hybrids the plants in the F_2 generation showed more variation for height than did the plants in the corresponding F_1 generation.

In both years the increase in the head length of the F_1 over those of the F_2 sorghum plants were significant in the hybrids RS 630 and Tx 660. In the other four hybrids either no differences were observed in plant height between the F_1 and F_2 generations or the differences were not consistent. The increases in variation in head length of the plants of the F_2 generation as compared to those of the corresponding F_1 generation, were significant at the 5 percent level for all six hybrids.

Greater head weights were obtained from sorghum plots planted with F_1 seeds than from those planted with F_2 seeds, except for the hybrid RS 650. Planting F_1 or F_2 seeds showed

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little influence on the variation obtained in the average head weight in most comparisons except for the hybrids Tx 620, Tx 660, and NK 222, where in 1963 larger standard deviations were observed.

Kernels produced by the F_2 plants were heavier than those produced by the F_1 plants, except for the hybrid RS 610 which showed no significant difference in this respect. With the exception of hybrids RS 650 and Tx 620, higher variability in kernel weight was observed in the F_2 generation plants as compared to those of the F_1 generation.

It appears from the present study that the F_2 seeds of grain sorghum hybrids are inferior in their yielding capacity to the F_1 seed. In addition to the loss in yield F_2 seeds of grain sorghum hybrids produce plants that vary in maturity, height and other agronomic characteristics, making sorghum harvesting and processing very difficult.

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A P P E N D I X

Table 9 - Analysis of variance for grain yields of six grain sorghums grown from F_1 and F_2 seeds during 1963.

Source	D.F.	M.S.	F.
Replications	3	20442.70	5.228**
Treatments	11	39434.13	10.086**
Error	33	3909.77	

** Denotes F value significant at the 1% level.

Table 10 - Analysis of variance for grain yields of six grain sorghums grown from F_1 and F_2 seeds during 1964.

Source	D.F.	M.S.	F.
Replications	3	8750.40	1.53
Treatments	11	43267.83	7.58**
Error	33	5704.94	

** Denotes F value significant at the 1% level.

Table 11 - The "significant studentized range" (r_p) values and the "shortest significant range" (R_p) values for the treatment yields in 1963.

P		2	3	4	5	6	7	8	9	10	11	12
r_p:	5%	2.88	3.47	3.82	4.08	4.28	4.42	4.58	4.69	4.80	4.89	4.97
	1%	3.87	4.43	4.77	5.01	5.20	5.36	5.50	5.61	5.71	5.80	5.89
R_p:	5%	90.03	108.47	119.41	127.54	133.79	138.17	143.17	146.61	150.05	152.86	155.36
	1%	120.98	138.48	149.11	156.61	162.55	167.55	171.93	175.37	178.49	181.31	184.12

5% level

RS 630S+	NK 222S	RS 650S	Tx 660S	RS 650	NK 222	RS 610S	Tx 620S	Tx 620	RS 630	Tx 660	RS 610
690	756	824	850	858	878	882	894	926	938	981	1072

1% level

Treatments underlined are not significantly different.

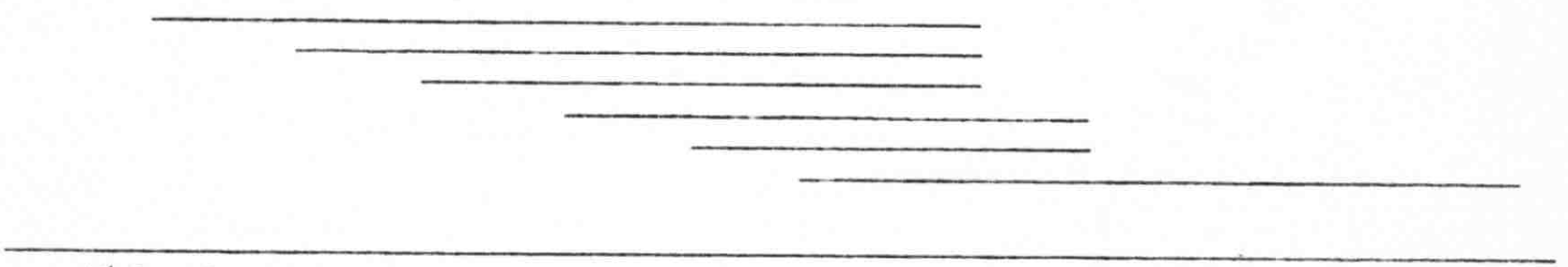
+ S denotes F_2.

Table 12 - The "significant studentized range" (r_p) values and the "shortest significant range" (R_p) values for the treatment yields in 1964.

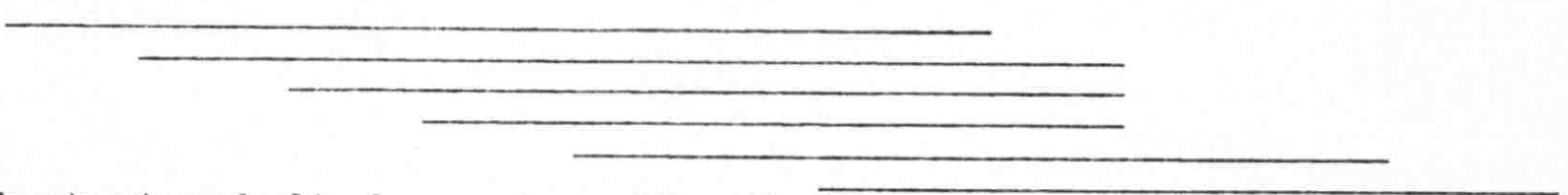
P		2	3	4	5	6	7	8	9	10	11	12
r_p:	5%	2.88	3.47	3.82	4.08	4.28	4.42	4.58	4.69	4.80	4.89	4.97
	1%	3.87	4.43	4.77	5.01	5.20	5.36	5.50	5.61	5.71	5.80	5.89
R_p:	5%	108.78	131.06	144.28	154.10	161.66	166.94	172.98	177.14	181.30	184.69	187.72
	1%	146.17	167.32	180.16	189.23	196.39	202.45	207.73	211.89	215.67	219.07	222.44

5% level

NK 222S+	RS 630S	Tx 620S	RS 650S	RS 610S	Tx 660S	RS 630	Tx 620	RS 650	NK 222	RS 610	Tx 660
649	682	683	691	711	726	810	835	862	895	904	948



1% level



Treatments underlined are not significantly different.

+ S denotes F_2.

Table 13 - Frequency table for head weight in grams of forty plants of grain sorghum RS 610 grown from F_1 and F_2 seeds in 1963.

Class range (gms.)	Class value (gms.)	Number of plants per class									
		RS 610 (F_1)					RS 610 (F_2)				
		Rep. 1	Rep. 2	Rep. 3	Rep. 4	Total	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Total
16-25	20									1	1
26-35	30						1		2	1	4
36-45	40		1	2		3	1	1	2		4
46-55	50		2		5	7	1	4	2	3	10
56-65	60		4	2	3	9	1	2	2	2	7
66-75	70	3		2	2	7	2	2	1	1	6
76-85	80	3	2	3		8	2				2
86-95	90	1	1	1		3	2	1	1	1	5
96-105	100	2				2				1	1
106-115	110	1				1					
Total						40					40
Mean						68.00*					58.75
Stand. dev.						17.27					19.76

* Significant at 5% level.

Table 14 - Frequency table for head weight in grams of forty plants of grain sorghum RS 610 grown from F_1 and F_2 seeds in 1964.

Class range (gms.)	Class value (gms.)	Number of plants per class									
		RS 610 (F_1)					RS 610 (F_2)				
		Rep. 1	Rep. 2	Rep. 3	Rep. 4	Total	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Total
6-15	10				1	1			1		1
16-25	20				1	1	3	1	2	1	7
26-35	30	1	1	1	3	6	3	1	1		5
36-45	40	1	2	2	1	6	2	4	1	4	11
46-55	50	3	4	2	4	13	1	2	1	1	5
56-65	60	4	3	4		11		2	3	2	7
66-75	70			1		1			1	1	2
76-85	80	1				1	1			1	2
Total						40					40
Mean						47.75					42.75
Stand. dev.						14.03					17.68