DETERMINATION OF GENE-CHROMOSOME RELATIONSHIPS ON *SORGHUM BICOLOR* (L.) MOENCH

by

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DETERMINATION OF GENE-CHROMOSOME RELATIONSHIPS ON *Sorghum bicolor* (L.) Moench

INTRODUCTION

Sorghum is economically important for grain, forage, syrup, and other products. Many cultivars and types of this grass have been described. Genetic studies, especially chromosome mapping, however, are not comparable to other important crops, such as maize, wheat, tomato, and barley; among the ten possible linkage groups in *Sorghum bicolor*, only six linkage groups with three or more genes have been identified by crossing over analysis (28, 11). A few other groups are represented by only two genes (17). In addition, these identified linkage groups have neither been determined for their relationship with trisomics or interchanged stocks nor associated with specific chromosome or chromosome segments in this species except very few individual genes: gene for stalk texture (D) and gene for seedcoat color (r) (12).

Reciprocal translocations, which are valuable cytogenetics tools, can be used to associate genes and linkage groups with chromosomes and chromosome segments. The chromosomal interchange method is based upon the F_3 performance of the homozygous normal (no chromosome interchange) as compared to homozygous interchange from the same cross

(Fig 3 and Fig 4). These homozygous lines from the crosses with the interchanged stocks facilitate analyses and comparisons for differences between the two parents (1), Burnham (1) believes that "the chromosomal interchange method of locating genes can be applied to simply or complexly inherited characters, and that this method should be superior to the gene marker method, because the interchange itself usually does not affect the expression of the character under study, whereas the gene marker method may."

Kasha and Burnham (10) had performed the diallel crosses between interchanged stocks in barley to study the chromosome pairing and to locate breakpoints of interchanges. Johnson (9) located genes for malting quality and some agronomic characters in barley (Hordeum vulgare L.) by using interchanged chromosomes. Moreover, interchange method had also been applied in maize to locate genes for smut resistance (2, 20, 21), resistance to European corn borer (7), fertility resteration (5, 14), resistance to leaf blight (8), mesocotyl length (27), ear number (13), earworm resistance (19), oil content (15), pericarp tenderness (16), date of silking and pollen shedding, and tillering (16).

The objectives of this research were twofold: (1) to determine

the relationships of some linkage groups with interchange stocks, and (2) to test the effectiveness of using interchanged stocks in locating genes.

MATERIALS AND METHODS

Two groups of materials were used: (A) A set of homozygous translocation stocks in sorghum developed from "Combine 7078" by Schertz (22) were used as female parents. The 11 stocks represent at least two translocations involving each of the 10 chromosomes. Twelve chromosome arms are represented among the 11 stocks. Their stock numbers, temporary chromosome designations and relation with primary trisomics are shown in Table 1. "Combine 7078" is a 3-dwarf type (dw_1 Dw_2 dw_3 dw_4) with red seeds, awned, compact head, juicy midrib, liguled, and fertile; (B) Normal stocks carrying the contrast characters to group (A) were chosen as male parents. They are Combine Kafir 60, PL-1 (26), male-sterile$_1$ (ms_1), Blackhull Kafir, midribless (mrl) (3), liguless (24), Martin 2 dwarf (dw_1 Dw_2 Dw_3 dw_4), and awnless stock. One exception is that when crosses were made between male-sterile$_1$ and translocation stocks, the latter were used as male and ms_1 was used as female.

Crosses between plants of group A and B were made in 1978 spring. Due to the limited stocks and timing of flowering, only certain crosses were performed (Table 2). The F_1 seeds were planted for each cross to obtain F_2 seeds during the summer of 1978.

F_2 seeds were harvested separately from individual semisterile F_1 plants. In 1978 summer, the F_2 seeds were grown for each cross (Table 2); also planted were Combine Kafir 60 plants to cross and distinguish normal F_2 plants from translocation plants. The testcross was made using Combine Kafir 60 as female and those F_2 plants as male. All F_2 heads were bagged and only fertile ones were saved.

One difficulty was encountered while performing testcross in the field. The F_2 panicles were bagged one or two days ahead of dehiscence. It was found, however, that anther dehiscence within a paper pollinating bag was delayed beyond normal, and the humidity in the bag was so high that the minimum amount of pollen essential for cross pollinations could not be collected. This always resulted in failure or low percentages of seed set of testcross hybrids. Schertz and Clark (23) had the same result in their study. Therefore, to cut the Gordian Knot, the F_2 heads would not be bagged until the very first anther dehiscenced. The mature F_2 heads were observed and collected only from the lower half although their upper portion might have been contaminated.

Testcross hybrids were grown in a greenhouse in the winter of 1978. As these hybrids reached dehiscence stage, pollen stainability

was recorded for each plant by using acetocarmin as the normal plants should have all stainable pollen and translocation plants should have half stainable pollen and half aborted pollen (Fig. 1 and Fig. 2).

In May of 1979, seed of those fertile F_2 plants were planted in Manhattan field at the number of 30 to 50 plants each. Performance of the normal and homozygous translocation were compared for expression of characters, such as awness, pericarp color, liguleness, seed weight and plant height.

The F_3 plants grown in the summer of 1979 were planted at two defferent locations of North Agronomy Farm, Manhattan, Kansas. The plants at the first location suffered serious damage by chinch bugs in spite of intensive insecticide (Sevin) sprays.

RESULTS AND DISCUSSION

Normal F_2 plants were distinguished from translocations upon the stainability of pollen from testcross plants (Fig. 5). According to the data obtained, we may compare the performance of F_3 plants to associate gene and linkage groups with chromosomes and chromosomal segments.

Data collected from F_3 generations of each fertile F_2 plants from which testcrosses were made are shown in Table 3 to 7. Among the 20 successful F_2 intercross hybrids, as shown in Table 2, three of them were lost owing to the low fertility of testcross, and low self-compatibility. They are: T10 X mr1, T19 X mr1, and T42 X m2d.

Plant Height

The short-stalked varieties, except for Double Dwarf milo 38, in the United States result from combining dwarfness from more than one source. Four such recessive, non-linked, brachytic-dwarfing genes are known (18). Liguless is a variant from the treated seeds of the cultivar Rox Orange (RO). RO has the genotype, dw_1 Dw_2 Dw_3 dw_4 (4). If "T1 X liguless", "T10 X liguless", T15 X liguless", and "T25 X liguless"

were critical crosses, the F_3 homozygous normal stocks should be 2-dwarf type, and 3-dwarf type be the homozygous translocation ones. Data in Table 3a showed that those crosses were non-critical ones.

Martin 2-dwarf (m2d) has the genotype for height -- dw_1 Dw_2 Dw_3 dw_4, so both crosses, "T28 X m2d" and "T29 X m2d", had one gene (dw_3) in segregation. Data in Table 3b also indicated that these two were non-critical crosses.

When translocation stocks were crossed with Blackhull Kafir of which genotype is Dw_1 Dw_2 dw_3 dw_4, there will be one gene, (dw_1) in segregation. Data from both crosses, "T25 X Blackhull Kafir" and "T26 X Blackhull Kafir" (Table 3b, 3c) suggested that they were non-critical crosses.

Cultivar PL-1, an introduction from Ethiopia converted to combine height, is an 3-dwarf type with genotype -- dw_1 dw_2 Dw_3 dw_4. Thus, in the cross of "T26 X PL-1", there should be 2 genes (dw_2, dw_3) in segregation. Data in Table 3c revealed that this was also a non-critical cross.

For the cultivars "CK60" and "awnless", height genes were the

same (dw_1 Dw_2 dw_3 dw_4) as "Combine 7078". Therefore, no comparison on the height character is made.

Pericarp Color

From 1909 though 1914, Graham (6) recorded the seedcoat colors in segregating populations of natural hybrids of sorghum. He accounted for the monogenic and digenic segregations and two kinds of whites by assuming two factors, R (red) and Y (yellow), both of which must be present for the development of red seed color. Then, the genotypes for red would be RRYY; yellow, rrYY; and white, RRyy and rryy. In this scheme it is the heterozygous condition of Y rather than R that gives simple segregations of red and white seed.

"CK60" and "Blackhull Kafir" are both white in pericarp color. If the crosses with interchanged stocks are critical cross, the F_3 homozygous normal progenies should be all white and the homozygous interchanged plants be all red. However, the data for these crosses in Table 4a, 4b and 4c showed that they were non-critical crosses.

"PL-1" has yellow pericarp (26). The cross, "T26 X PL-1", showed segregations in F_3 progenies (Table 4d), such as, the appearance

of white pericarp, so this cross is non-critical.

Because "liguless", "awnless", and "Martin 2 dwarf" have the same pericarp color as "Combine 7078", no comparison of F_3 performance on this character are discussed.

Awness

Both strong-awned and weak-awned are considered "awned" in this study. The data in Table 5a and 5b showed that among several crosses of "translocation X CK60", none of them was a critical cross. If any, the homozygous normal F_3 stocks should be all awnless as CK60 is and the homozygous interchanged plants should be all awned. The rest of the data in Table 5b - d also revealed the fact that these crosses are non-critical crosses. No comparison was made for "translocation X liguless" because "liguless" stock is also awned as is the "Combine 7078".

Liguleness

Liguless is controlled by single recessive gene, lg. If the crosses are critical, the normal F_3 should be all liguless and the

homozygous translocation stocks should be all liguled. The five crosses between translocation stocks and "liguless" were very easily identified as non-critical crosses because of the F_3 segregations (Table 6).

Seed Weight

This character was measured on the cross of "T26 X PL-1" only. PL-1 possesses large yellow seeds which averaged 56 grams per 1,000 seeds (25). Only the main head on each F_3 plant in full competition was harvest and threshed. Data in Table 7 represented the average of seed weight from 3 or 4 plants within the same line. By comparing the weights between "normal" and "homozygous translocation" stocks in Table 7, "T26 X PL-1" is not a critical cross.

CONCLUSION

Data in Table 3a - 7, show that total number of F_3 homozygous translocation lines is far less than that of the F_3 normal lines. This might be caused by the fewer seed set obtained from testcross of F_2 translocation plants as compared to F_2 normal plants. An understanding achieved in this study was that there is no critical cross in those intercrosses performed and no positive answers were found. For further studies, other researchers could at least not repeat the same crosses as done in this study.

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Fig. 1: The normal and aborted pollen from the hybrid of a cross, "CK60 X ($F_2$24-T1 X liguless)", are shown in dark and transparent respectively. (400X)

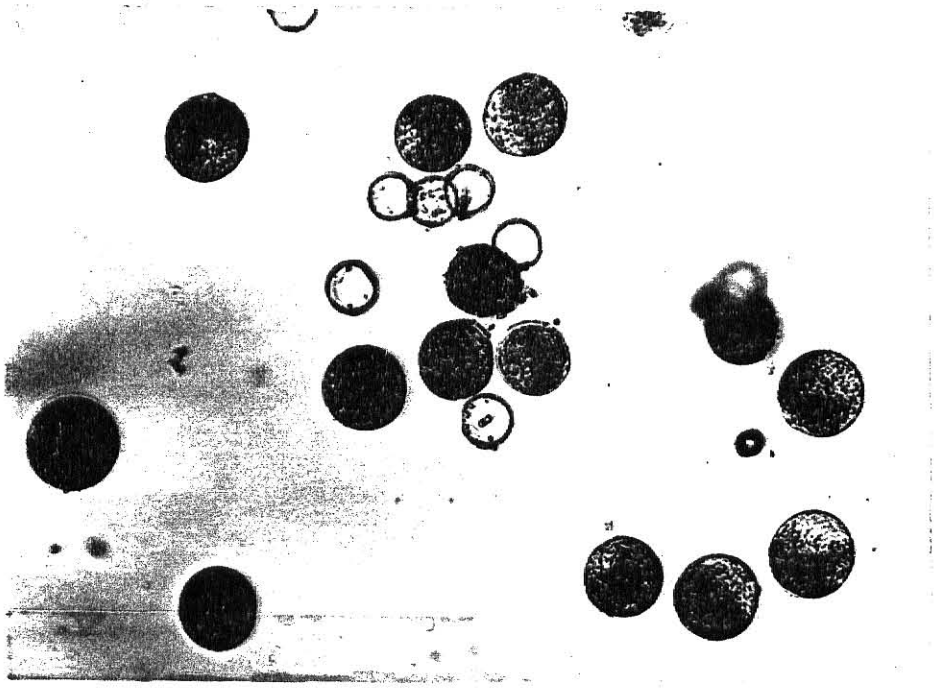

Fig. 2: The normal and aborted pollens from the hybrid of a test-cross, "CK60 X ($F_2$5-ms_3 X T25)". (400X)

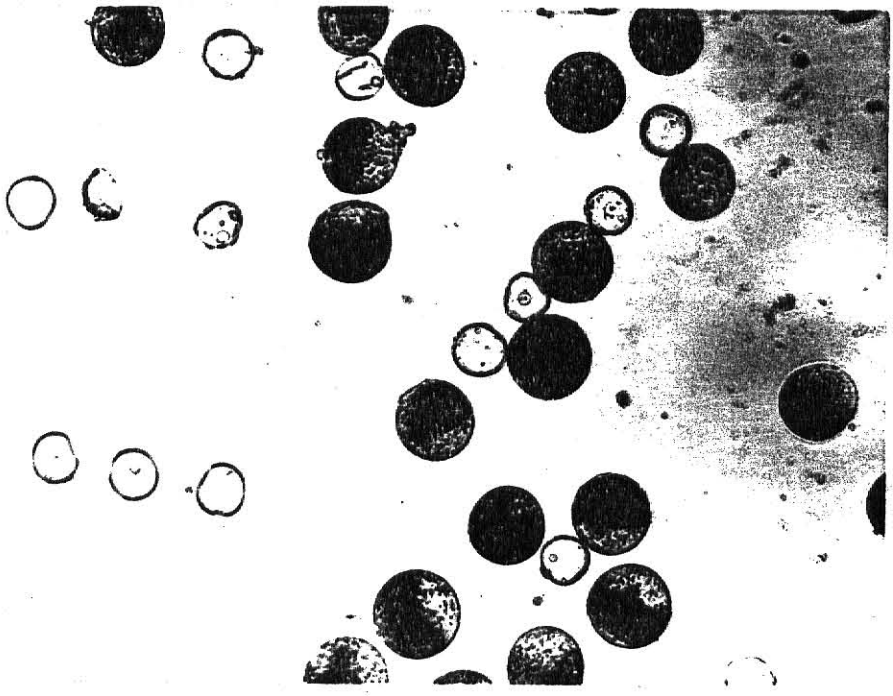

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Fig. 3 CRITICAL CROSS

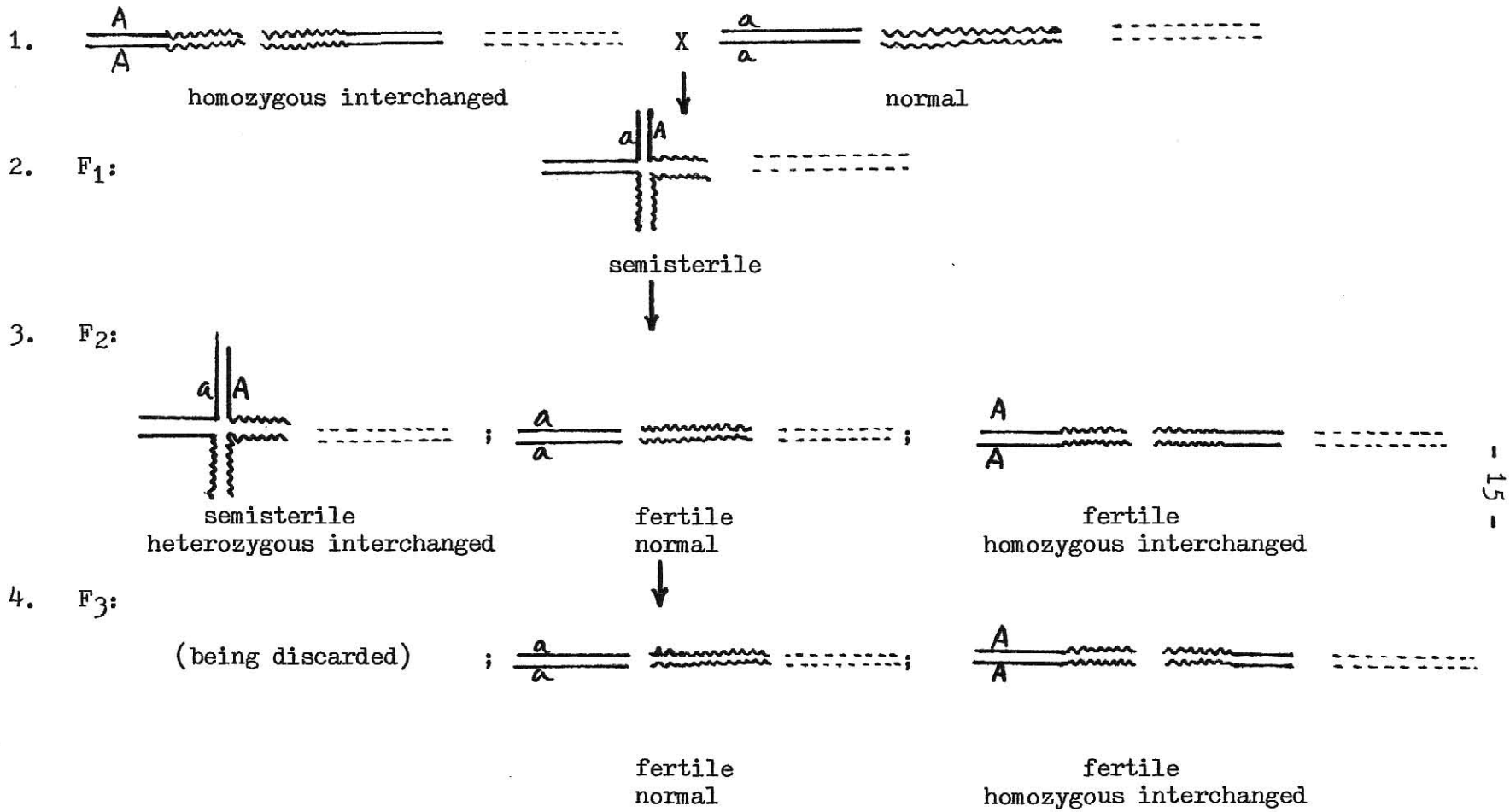

Fig. 4 NON-CRITICAL CROSS

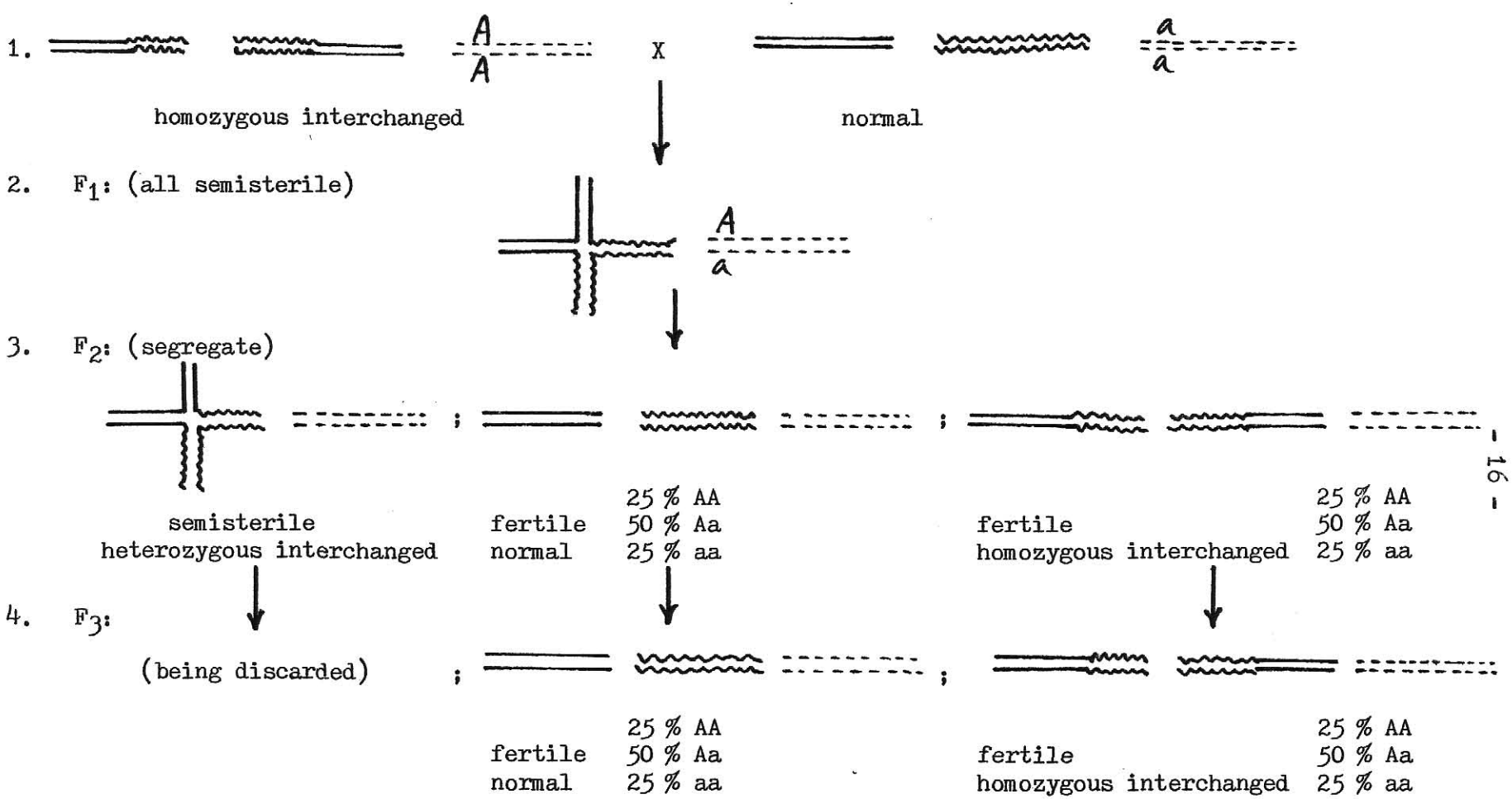

Fig. 5 Identification of homozygous normal and homozygous translocation

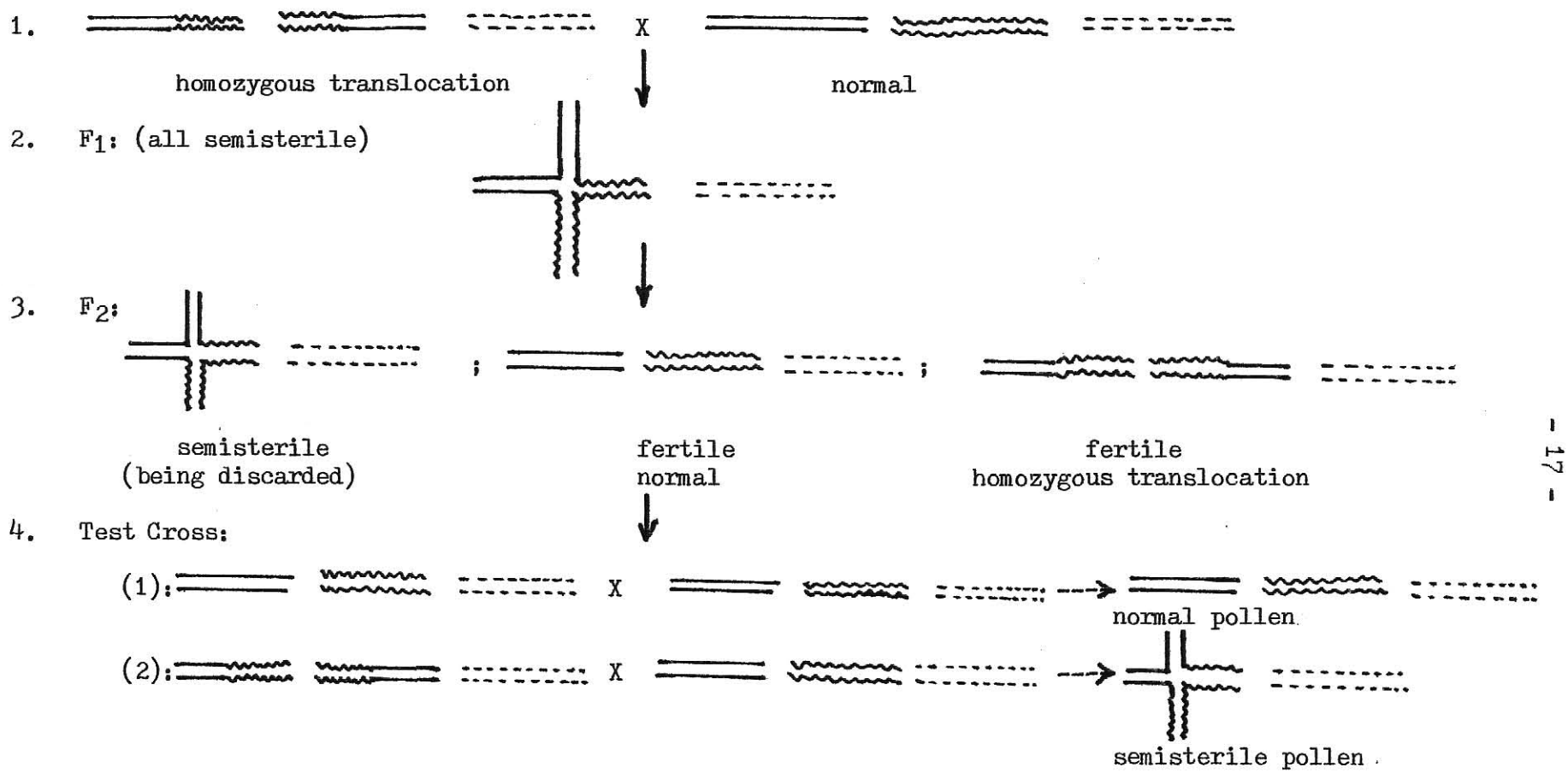

Table 1. A set of homozygous translocation stocks in Sorghum bicolor (L.) Moench and their chromosome designation and relation with primary trisomics for these translocations.

STOCK NO.	CHROMOSOME DESIGNATION	TRISOMIC IDENTIFICATION
T 1	DA	Stiff Branch -- D
T10	CB	Compact -- C
T15	AE	Bottle Brush -- A
T19	JD	Spear -- J
T24	FJ	Asymmetric -- F
T25	DG	---
T26	EF	Large Glume -- E
T28	BH	Sparse Branch -- B
T29	GI	Cone -- G
T33	IC	Small Glume -- I
T42	HF	Light Green -- H

Table 2. Number of F_2 plants from each successful intercross between interchanged and normal stocks carrying contrast characters.

TRANSLO-CATION / NORMAL	STOCK NO.										
	1	10	15	19	24	25	26	28	29	33	42
CK60	29		21	24		20				25	
Awnless									21		
Liguless	34	45	23			36					
BLK						24	23				
mr1		21		7							
m2d								15	18		6
PL-1							25				
ms_1									21		
ms_3						16					

Table 3a. Data of F_3 performance on plant height.

CROSS & LINE NO.	TALL	SHORT	TOTAL	CLASSIFICATION*
T1 X liguless				
F_3 - 3	--	--	153	NOR.
F_3 - 27	175	62	237	NOR.
F_3 - 36	59	38	97	NOR.
F_3 - 43	60	0	60	NOR.
F_3 - 11	165	11	176	H.T.
F_3 - 23	121	32	153	H.T.
F_3 - 24	0	217	217	H.T.
F_3 - 25	48	0	48	H.T.
F_3 - 28	14	38	52	H.T.
T10 X liguless				
F_3 - 1	39	22	61	NOR.
F_3 - 34	117	60	177	NOR.
F_3 - 3	62	30	92	H.T.
F_3 - 19	151	0	151	H.T.
F_3 - 36	58	20	78	H.T.
F_3 - 37	141	12	153	H.T.
F_3 - 37 - 1	109	18	127	H.T.
T15 X liguless				
F_3 - 11	123	52	175	NOR.
F_3 - 24	40	19	59	NOR.
F_3 - 6	70	24	94	H.T.
F_3 - 20	36	112	148	H.T.

* NOR. means normal (without translocation) and H.T. means homozygous translocation.

Table 3b. Data of F_3 performance on plant height.

CROSS & LINE NO.	TALL	SHORT	TOTAL	CLASSIFICATION
T25 X liguless				
F_3 - 1	47	180	155	NOR.
F_3 - 2	101	25	126	NOR.
F_3 - 14	135	85	220	NOR.
F_3 - 27	169	20	189	NOR.
T28 X Martin 2 dwarf				
F_3 - 10	10	2	12	NOR.
F_3 - 16	2	1	3	NOR.
F_3 - 23	0	23	23	NOR.
F_3 - 27	1	0	1	NOR.
F_3 - 1	80	40	120	H.T.
F_3 - 8	10	4	14	H.T.
F_3 - 14	4	1	5	H.T.
F_3 - 20	0	11	11	H.T.
F_3 - 27	3	3	6	H.T.
T29 X Martin 2 dwarf				
F_3 - 1	8	20	28	NOR.
F_3 - 18	1	4	5	NOR.
F_3 - 8	2	6	8	H.T.
T25 X Blackhull Kafir				
F_3 - 1	118	51	169	NOR.
F_3 - 19	119	38	157	NOR.
F_3 - 14	188	0	188	H.T.

Table 3c. Data of F_3 performance on plant height.

CROSS & LINE NO.	TALL	SHORT	TOTAL	CLASSIFICATION
T26 X Blackhull Kafir				
F_3 - 6	110	19	129	NOR.
F_3 - 18	193	48	241	NOR.
F_3 - 11	110	42	152	H.T.
F_3 - 15	0	160	160	H.T.
T26 X PL-1				
F_3 - 10	0	106	106	NOR.
F_3 - 24	0	3	3	NOR.
F_3 - 18	15	13	28	H.T.
F_3 - 20	0	22	22	H.T.

Table 4a. Data of F_3 performance on pericarp color.

CROSS & LINE NO.	RED	WHITE	TOTAL	CLASSIFICATION
T1 X CK60				
F_3 - 2	9	3	12	NOR.
F_3 - 12	4	0	4	NOR.
F_3 - 17	14	0	14	NOR.
F_3 - 15	18	7	25	H.T.
F_3 - 26	10	1	11	H.T.
T15 X CK60				
F_3 - 4	160	0	160	NOR.
F_3 - 13	170	48	218	NOR.
F_3 - 16	128	50	178	NOR.
F_3 - 17	126	44	170	NOR.
F_3 - 24	142	40	182	NOR.
F_3 - 9	0	138	138	H.T.
F_3 - 11	0	152	152	H.T.
T19 X CK60				
F_3 - 4	77	28	105	NOR.
F_3 - 8	0	172	172	NOR.
F_3 - 14	0	224	224	NOR.
F_3 - 22	77	0	77	NOR.
F_3 - 24	114	0	114	H.T.
T25 X CK60				
F_3 - 10	151	45	196	NOR.
F_3 - 11	182	0	182	H.T.
F_3 - 19	63	20	83	H.T.

Table 4b. Data of F_3 performance on pericarp color.

CROSS & LINE NO.	RED	WHITE	TOTAL	CLASSIFICATION
T33 X CK60				
F_3 - 4	107	32	139	NOR.
F_3 - 14	0	150	150	NOR.
F_3 - 17	0	191	191	NOR.
F_3 - 24	145	0	145	H.T.
T29 X Awnless				
F_3 - 2	32	0	32	NOR.
F_3 - 4	59	0	59	NOR.
F_3 - 5	12	0	12	NOR.
F_3 - 8	234	0	234	NOR.
F_3 - 9	145	0	145	NOR.
F_3 - 10	41	0	41	NOR.
F_3 - 11	67	0	67	NOR.
F_3 - 12	4	0	4	NOR.
F_3 - 3	53	0	53	H.T.
F_3 - 15	117	0	117	H.T.
F_3 - 19	21	0	21	H.T.
T28 X m2d				
F_3 - 3	1	0	1	NOR.
F_3 - 10	12	0	12	NOR.
F_3 - 16	3	0	3	NOR.
F_3 - 23	23	0	23	NOR.
F_3 - 27	1	0	1	NOR.
F_3 - 1	120	0	120	H.T.
F_3 - 8	14	0	14	H.T.
F_3 - 11	3	0	3	H.T.
F_3 - 14	5	0	5	H.T.
F_3 - 20	11	0	11	H.T.
F_3 - 26	18	0	18	H.T.
F_3 - 37	6	0	6	H.T.

Table 4c. Data of F_3 performance on pericarp color.

CROSS & LINE NO.	RED	WHITE	TOTAL	CLASSIFICATION
T29 X m2d				
F_3 - 1	28	0	28	NOR.
F_3 - 18	5	0	5	NOR.
F_3 - 8	8	0	8	H.T.
T25 X Blackhull Kafir				
F_3 - 1	133	36	169	NOR.
F_3 - 19	0	157	157	NOR.
F_3 - 14	0	188	188	H.T.
T26 X Blackhull Kafir				
F_3 - 6	129	0	129	NOR.
F_3 - 18	0	241	241	NOR.
F_3 - 11	92	60	152	H.T.
F_3 - 15	0	160	160	H.T.

Table 4d. Data of F_3 performance on pericarp color.

CROSS & LINE NO.	RED	WHITE	YELLOW	TOTAL	CLASSIFICATION
T26 X PL-1					
F_3 - 2	0	0	18	18	NOR.
F_3 - 9	9	0	0	9	NOR.
F_3 - 10	79	27	0	106	NOR.
F_3 - 24	3	0	0	3	NOR.
F_3 - 18	24	4	0	28	H.T.
F_3 - 20	17	5	0	22	H.T.

Table 5a. Data of F_3 performance on awness.

CROSS & LINE NO.	AWNLESS	AWNED	TOTAL	CLASSIFICATION
T1 X CK60				
F_3 - 2	8	4	12	NOR.
F_3 - 12	4	0	4	NOR.
F_3 - 17	14	0	14	NOR.
F_3 - 15	25	0	25	H.T.
F_3 - 26	10	1	11	H.T.
T15 X CK60				
F_3 - 4	160	0	160	NOR.
F_3 - 13	155	63	218	NOR.
F_3 - 16	176	2	178	NOR.
F_3 - 17	131	39	170	NOR.
F_3 - 24	135	47	182	NOR.
F_3 - 9	95	43	138	H.T.
F_3 - 11	0	152	152	H.T.
T19 X CK60				
F_3 - 4	68	37	105	NOR.
F_3 - 8	0	172	172	NOR.
F_3 - 14	179	45	224	NOR.
F_3 - 22	60	17	77	NOR.
F_3 - 24	89	25	114	H.T.
T25 X CK60				
F_3 - 10	196	0	196	NOR.
F_3 - 11	0	182	182	H.T.
F_3 - 19	83	0	83	H.T.

Table 5b. Data of F_3 performance on awness.

CROSS & LINE NO.	AWNLESS	AWNED	TOTAL	CLASSIFICATION
T33 X CK60				
F_3 - 4	139	0	139	NOR.
F_3 - 14	121	29	150	NOR.
F_3 - 17	150	41	191	NOR.
F_3 - 24	109	36	145	H.T.
T29 X Awnless				
F_3 - 2	0	32	32	NOR.
F_3 - 4	59	0	59	NOR.
F_3 - 5	0	12	12	NOR.
F_3 - 8	181	53	234	NOR.
F_3 - 9	48	97	145	NOR.
F_3 - 10	29	12	41	NOR.
F_3 - 11	12	55	67	NOR.
F_3 - 12	0	4	4	NOR.
F_3 - 3	33	20	53	H.T.
F_3 - 15	117	0	117	H.T.
F_3 - 19	0	21	21	H.T.
ms_1 X T29				
F_3 - 1	52	16	68	NOR.
F_3 - 2	22	84	106	NOR.
F_3 - 3	31	12	43	NOR.
F_3 - 7	40	11	51	NOR.
F_3 - 8	30	10	40	NOR.
F_3 - 6	17	0	17	H.T.
F_3 - 11	11	0	11	H.T.
ms_3 X T25				
F_3 - 8	0	11	11	NOR.
F_3 - 16	6	1	7	H.T.

Table 5c. Data of F_3 performance on awness.

CROSS & LINE NO.	AWNLESS	AWNED	TOTAL	CLASSIFICATION
T28 X m2d				
F_3 - 3	1	0	1	NOR.
F_3 - 10	12	0	12	NOR.
F_3 - 16	3	0	3	NOR.
F_3 - 23	0	23	23	NOR.
F_3 - 27	1	0	1	NOR.
F_3 - 1	99	21	120	H.T.
F_3 - 8	11	3	14	H.T.
F_3 - 11	3	0	3	H.T.
F_3 - 14	5	0	5	H.T.
F_3 - 20	8	3	11	H.T.
F_3 - 26	3	15	18	H.T.
F_3 - 37	0	6	6	H.T.
T29 X m2d				
F_3 - 1	20	8	28	NOR.
F_3 - 18	5	0	5	NOR.
F_3 - 8	6	2	8	H.T.
T25 X Blackhull Kafir				
F_3 - 1	131	38	169	NOR.
F_3 - 19	157	0	157	NOR.
F_3 - 14	143	45	188	H.T.

Table 5d. Data of F_3 performance on awness.

CROSS & LINE NO.	AWNLESS	AWNED	TOTAL	CLASSIFICATION
T26 X Blackhull Kafir				
F_3 - 6	90	39	129	NOR.
F_3 - 18	0	241	241	NOR.
F_3 - 11	152	0	152	H.T.
F_3 - 15	160	0	160	H.T.
T26 X PL-1				
F_3 - 2	5	13	18	NOR.
F_3 - 9	7	2	9	NOR.
F_3 - 10	86	20	106	NOR.
F_3 - 24	2	1	3	NOR.
F_3 - 18	24	4	28	H.T.
F_3 - 20	1	21	22	H.T.

Table 6. Data of F_3 performance on liguleness.

CROSS & LINE NO.	LIGULED	LIGULESS	TOTAL	CLASSIFICATION
T1 X liguless				
F_3 - 3	113	40	153	NOR.
F_3 - 27	237	0	237	NOR.
F_3 - 36	97	0	97	NOR.
F_3 - 43	48	12	60	NOR.
F_3 - 11	134	42	176	H.T.
F_3 - 23	153	0	153	H.T.
F_3 - 24	217	0	217	H.T.
F_3 - 25	0	48	48	H.T.
F_3 - 28	41	11	52	H.T.
T10 X liguless				
F_3 - 1	0	61	61	NOR.
F_3 - 34	153	24	177	NOR.
F_3 - 3	81	11	92	H.T.
F_3 - 19	151	0	151	H.T.
F_3 - 36	78	0	78	H.T.
F_3 - 37	153	0	153	H.T.
F_3 - 37 - 1	108	19	127	H.T.
T15 X liguless				
F_3 - 11	175	0	175	NOR.
F_3 - 24	0	59	59	NOR.
F_3 - 6	85	9	94	H.T.
F_3 - 20	148	0	148	H.T.
T25 X liguless				
F_3 - 1	115	40	155	NOR.
F_3 - 2	100	26	126	NOR.
F_3 - 14	185	35	220	NOR.
F_3 - 27	189	0	189	NOR.

Table 7. Data of F_3 performance on seed weight.*

CROSS & LINE NO.	SEED WEIGHT (g./100 seeds)	CLASSIFICATION
T26 X PL-1		
F_3 - 2	3.710	NOR.
F_3 - 9	2.684	NOR.
F_3 - 10	2.703	NOR.
F_3 - 18	2.716	H.T.
F_3 - 20	3.061	H.T.

*dry weight obtained form average of several heads for each line.

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DETERMINATION OF GENE-CHROMOSOME RELATIONSHIPS ON *SORGHUM BICOLOR* (L.) MOENCH

by

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ABSTRACT

Chromosome maps in sorghum are far from complete and many gene-chromosome relationships are not known. Only six linkage groups with three or more genes have been identified by crossing over analysis, and a few other groups are represented by only two genes.

This study tried to determine the relationships of some linkage groups with interchange stocks developed by K. F. Schertz, and test the effectiveness of using interchanged stocks in locating genes.

The translocation stocks were used as female plants, and those normal stocks carrying the contrast characters to female stocks were chosen as male parents. Crosses were made in a greenhouse in the spring of 1978. The F_1 seeds were planted for each cross to obtain F_2 seeds which were harvested separately. Then, the F_2 seeds were grown for each cross and were testcrossed to Combine Kafir 60 (as female) to distinguish normal F_2 plants from translocation plants. All F_2 heads were bagged and only fertile ones were saved.

The testcross hybrids were grown in the greenhouse and examined

for pollen stainability to distinguish the normal F_2 plants from interchanged ones. In 1979 summer, performance of the normal and homozygous translocation were compared for expression of traits, such as height genes, seedcoat color, awness, liguleness, and seed weight through F_3 generation.

Owing to the limited stocks, timing of flowering, only certain crosses were performed. Also limited was labor and time essential for testcorss in the field, and inevitable damage from chinch bug further reduced the available data. No positive information, such as gene-chromosome relationship, was obtained in this study.