

## THE EFFECTS OF CHROMOSOME NUMBER ON SEX EXPRESSION IN *ATRIPLEX CANESCENS*<sup>1</sup>

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Native diploid, tetraploid, and hexaploid populations of *Atriplex canescens* were surveyed in southern New Mexico and west Texas. Female to male ratios were approximately equal in diploid populations and female-biased in tetraploid and hexaploid populations. Tetraploids in New Mexico and Texas differed from northern populations with more male and fewer monoecious plants. Hexaploids appeared to have slightly fewer female plants than tetraploids during flowering, but during the winter there were 6%–20% more seed-bearing plants because of the high frequency of monoecious plants. The three cytotype populations generally fitted expected ratios using an X, Y sex-determining model. Monoecious diploid plants cannot be explained by the genetic model. Two types of monoecious expressions were observed, and possible genetic mechanisms are discussed.

### Introduction

*Atriplex canescens* (Pursh) Nutt., a dioecious species, has low frequencies of monoecious plants in tetraploid populations (STUTZ et al. 1975; MCARTHUR 1977; MCARTHUR and FREEMAN 1982). Differences in the ratios of female to male plants were noted between diploid and tetraploid populations. In a diploid gigas population at the Little Sahara Sand Dunes in central Utah, STUTZ et al. (1975) found equal numbers of female and male plants and no monoecious plants. MCARTHUR and FREEMAN (1982) later confirmed these findings in the same  $2x$  population; they found a female-biased ratio of 59.7 female:36.2 male:4.1 monoecious plants in 19 tetraploid ( $4x = 36$ ) populations. At the Snow Field Station at Ephraim, Utah, a significant shift from female to male and monoecious expression was noted in the ratio of a tetraploid half-sib family after unusual moisture and temperature conditions during winter 1972–1973 (MCARTHUR 1977).

Variations in chromosome number of *A. canescens* populations were reported by BASSET and CROMPTON (1971), STUTZ et al. (1975), STUTZ and SANDERSON (1979), and DUNFORD (1984). DUNFORD (1984) found extensive native populations of three *A. canescens* cytotypes in southern New Mexico and west Texas: diploid ( $2x = 18$ ), tetraploid ( $4x = 36$ ), and hexaploid ( $6x = 54$ ). Tetraploids were the most prevalent cytotype and grew primarily on slopes and mesas in finer-textured soils. Diploids generally occupied coarser, sandy loam soils and were often found on sand dunes occupied by mesquite, *Prosopis glandulosa*. Hexaploids grew most frequently in the silty, clay floodplain areas

of the Rio Grande Basin. All three cytotypes are widely distributed in the Southwest, with some intermixing of populations. However, relatively pure stands of each can be found in their respective areas. The precise genetics of sex determination in *A. canescens* is currently unknown, although models have been suggested (STUTZ et al. 1975; MCARTHUR 1977). Distinguishable sex chromosomes or aneuploidy, which determine sex in other species, has not been observed (MCARTHUR 1977).

STUTZ et al. (1975) proposed a simple heterogametic XX, XY model that would express female and male sex characteristics, respectively. MCARTHUR (1977) proposed that, in this model, the YY genotypes were inviable, and equal frequencies of female and male plants in diploid populations could be explained by the equal distribution of the surviving XX and XY genotypes. He also expanded this model to include tetraploids and suggested that the symbols X and Y represent the sex-determining locus or blocks of loci. WESTERGAARD (1958) determined that, in all known dioecious diploids, zygotes must have an X to survive. MCARTHUR (1977) extended this concept and logically proposed that tetraploid zygotes must have two or more X's to survive and that stable female and male expressions are determined by genotypes XXXX and XXYY, respectively, while the XXXY genotype generally would express the female phenotype but was capable of monoecious expression as well as sexual lability. MCARTHUR (1977) and MCARTHUR and FREEMAN (1982) proposed that these expressions are probably induced by environmental stress.

MCARTHUR and FREEMAN (1982) reviewed numerous reports of environmentally induced sex changes in dioecious and monoecious plant species. FREEMAN et al. (1981) and BARKER et al. (1982) observed more males on xeric sites and more females on mesic sites for monoecious shrubs of *Acer* and *Juniperus*. WASSER (1984) reported that,

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particularly on drier sites, males slightly but consistently outnumbered females in *Simmondsia chinensis* (jojoba), a dioecious, wind-pollinated, desert shrub. In contrast to *A. canescens*, sexual expression of specific jojoba plants was not labile from year to year.

While surveying native populations of *A. canescens* in west Texas, New Mexico, and Arizona, I noted differences in the degree of female bias among the three native cytotype populations. Also, the fraction of female plants determined at flowering differed from the fraction of seed-bearing plants observed the following winter. The purpose of this investigation was to determine and compare ratios of female:male:monoecious plants in native diploid, tetraploid, and hexaploid populations and to determine how this information relates to the three cytotypes in native populations.

### Material and methods

Native populations were surveyed in winters 1983–1984, 1984–1985, and 1985–1986 and in summers 1984 and 1985. Flowering dates and the numbers of female, male, and monoecious plants were recorded from native 2x, 4x, and 6x populations in southern New Mexico and west Texas. The populations were determined to be homogeneous for each cytotype by chromosome counts made from root tips or meiotic figures. Samples consisted of the first 75–200 plants classed as I crossed native stands. In large populations, several samples were taken. The sample ratios were compared for cytotypes and for years. Summer readings were made after fertilized fruits were large enough to be distinguished from male flowers on the monoecious plants. Winter observations were made after most male blooms had fallen. The number of monoecious plants is likely to be underestimated because of the difficulty of detecting an occasional female or male flower developing on a branch of the opposite sexual expression.

The diploid populations were growing at relatively uniform sand dune sites occupied by mesquite on the mesa above the Rio Grande and sporadically extending west 100 km to Deming in southern New Mexico. Tetraploid populations were found on heterogeneous sites varying considerably in temperature, elevation, moisture, vegetation, and soil types in the southern half of New Mexico. Hexaploid populations were classed in the Rio Grande Valley on two sites: (1) a silty loam, abandoned farm site at Canutillo, Texas, 50 km south of Las Cruces; and (2) a floodplain with native, desert vegetation at Hill, New Mexico, 25 km north of Las Cruces. These two sites were considered homogeneous. Many of the samples in 1985 were taken from different populations from those in 1984, and when they were taken from the same populations, samples consisted of different plants.

A  $\chi^2$  test (STEEL and TORRIE 1960) was used to evaluate the homogeneity of samples and to compare sample population ratios with expected genetic ratios. To test the populations statistically, it was necessary to develop a hypothetical ratio. To do this, assumptions were made because the actual genetic mechanisms for sex expression and gene frequencies for populations are unknown.

The model proposed by STUTZ et al. (1975) and MCARTHUR (1977) was used as a basis for this study. The data showed that the ratios of female:male:monoecious plants in 4x populations from New Mexico differed significantly from the model ratio ( $\chi^2 = 585.24$ ,  $P < .01$ ) proposed by MCARTHUR (1977) and the actual ratio ( $\chi^2 = 165.83$ ,  $P < .01$ ) obtained by MCARTHUR and FREEMAN (1982) for 19 4x populations. Therefore, because of the milder, more homogeneous climate in New Mexico, I propose that the XXXY genotypes would more likely be expressed as either female or male than as monoecious plants. Consequently, a modified ratio of 60 female:39 male:1 monoecious plant was arbitrarily proposed by shifting the expression of XXXY monoecious plants to male plants to fit more closely the observed New Mexico populations.

Similar reasoning was used to develop the proposed ratio of 56 female:40 male:4 monoecious plants for the New Mexico 6x populations. This ratio is similar to that found by MCARTHUR and FREEMAN (1982) for 4x populations. This ratio was also arbitrarily modified by decreasing the frequency of female plants and by increasing males slightly and monoecious plants by four times. This modification would seem in line because of the added possibilities of monoecious expression that would be added to the 6x populations by the XXXXXY and XXXXXYY genotypes.

### Results and discussion

Diploids and tetraploids flowered simultaneously at all elevations. Floral initials were first noted on these cytotypes ca. March 1 at 600 m and were delayed at higher elevations until early June on 4x plants at 2,380 m. Hexaploids were distinguished from 2x or 4x plants by flowering 4–6 wk later at a given elevation.

A significant observation in the New Mexico diploids (tables 1, 2) was the monoecious plants, which were not found in Utah diploids by STUTZ et al. (1975) or MCARTHUR and FREEMAN (1982). Females approximately equaled males in New Mexico diploids. Three of the 25 samples (N Deming in 1984; and I-10, Mp131a and Jornada, b in 1985) deviated significantly with a strong female bias. This bias in individual populations was likely chance ( $P < .05$ ), but other genetic or environmental causes could not be ruled out. The homogeneity  $\chi^2$  was not significant in 1984 but was in

TABLE 1  
1984 RATIO OF FEMALES TO MALES IN NEW MEXICO DIPLOID POPULATIONS

Site	Females	Males	Monoecious	Total	$\chi^2$ <sup>a</sup>	P
PSRC .....	52	56	1	109	.16	>.75
Drain .....	138	139	0	277	.06	>.90
Dona Ana .....	71	72	0	143	.01	>.90
Deming .....	69	76	2	147	.36	>.75
I-25, Mp26 <sup>b</sup> .....	55	40	1	96	2.35	>.25
N Deming .....	134	91	0	225	8.22**	<.01
Hw 26, Mp44 <sup>b</sup> .....	58	45	1	104	1.63	>.25
W Columbus .....	55	75	0	130	3.08	>.10
Ft. Selden .....	64	60	0	124	.13	>.75
Hw26 Mp43 <sup>b</sup> .....	58	54	0	112	.14	>.75
E Columbus .....	71	78	0	149	.33	>.75
Total .....	825	786	5	1,616	.82	>.50

NOTE.—Total  $\chi^2 = 16.47$ ; pooled  $\chi^2 = .82$ ,  $P > .50$ ; homogeneity  $\chi^2 = 15.65$ ,  $P > .25$ .

<sup>a</sup>  $\chi^2$  calculated using proposed ratio of 1 female:1 male to calculate the expected frequencies (MCARTHUR and FREEMAN 1982).

<sup>b</sup> Highway designation and mile post markers at the sample location.

\*\* The probability of a larger  $\chi^2$  is  $<.01$ .

1985. If the two deviating 1985 samples were removed, the homogeneity  $\chi^2$  was no longer significant, and the remaining samples could be pooled.

The increase in monoecious plants after a stressful winter (MCARTHUR 1977) may account for fewer monoecious plants in the milder New Mexico climate. Therefore, the environment may strongly affect the expression of the XXXY genotypes, which in turn may affect 4x ratios of plants growing at different sites. Three of 33 samples for 1984 and

four of 19 samples for 1985 had significant  $\chi^2$  values (tables 3, 4). One of these (Hw54, Mp131) resulted from excessive numbers of monoecious plants. The homogeneity  $\chi^2$  for 1984 was not significant, and the samples could be pooled. The homogeneity  $\chi^2$  for 1985 was significant for all samples, and even with the four significant samples removed, the value was still so significant that they could not be pooled. This greater sample variability in the tetraploid populations was likely the re-

TABLE 2  
1985 RATIO OF FEMALES TO MALES IN NEW MEXICO DIPLOID POPULATIONS

Site	Females	Males	Monoecious	Total	$\chi^2$ <sup>a</sup>	P
I-10, Mp131a .....	89	37	0	126	21.46**	<.01
I-10, Mp131b .....	53	54	2	109	.05	>.90
I-10, Mp131c .....	61	48	0	109	1.55	>.25
I-10, Mp123 .....	64	68	0	132	.12	>.75
Jornada-a .....	61	61	2	124	.03	>.90
Jornada-b .....	77	49	1	127	6.18*	<.05
Jornada-c .....	50	62	2	114	1.30	>.50
Jornada-d .....	61	64	3	128	.14	>.75
Jornada-e .....	67	66	1	134	.01	>.90
Jornada-f .....	68	65	2	135	.07	>.90
Jornada-g .....	59	58	2	119	.04	>.90
Jornada-h .....	52	57	2	111	.26	>.75
Jornada-i .....	55	55	1	111	.01	>.95
Jornada-j .....	63	56	1	120	.42	>.75
Total .....	880	800	19	1,699	3.98*	<.05

NOTE.—Total  $\chi^2 = 31.64$ ; pooled  $\chi^2 = 3.98$ ,  $P > .05$ ; homogeneity  $\chi^2 = 27.76$ ,  $P < .01$ .

<sup>a</sup>  $\chi^2$  calculated using proposed ratio of 1 female:1 male to calculate the expected frequencies.

\* The probability of a larger  $\chi^2$  is  $<.05$ .

\*\* The probability of a larger  $\chi^2$  is  $<.01$ .

TABLE 3  
1984 RATIO OF FEMALES TO MALES IN NEW MEXICO TETRAPLOID POPULATIONS

Site	Females	Males	Monoecious	Total	$\chi^2$ <sup>a</sup>	P
3 Rivers-a	85	31	0	116	9.07*	<.05
3 Rivers-b	105	48	1	154	4.32	>.25
3 Rivers-c	65	36	1	102	.60	>.75
Ft. Stanton	63	50	0	113	2.23	>.50
Nogal Pass	77	41	0	118	2.29	>.50
Glenwood	67	37	0	104	1.66	>.50
Willard	99	62	0	161	1.67	>.50
Carlsbad	95	38	0	133	7.92*	<.05
Hw54, Mp147	94	44	1	139	3.38	>.25
3 Rivers, pet	78	49	1	128	.10	>.98
Hw54, Mp146	77	37	1	115	2.35	>.25
3 Rivers, Hi	68	37	1	106	.76	>.75
Hw54, Mp154	62	39	0	101	1.04	>.75
Hw54, Mp148	87	54	1	142	.19	>.95
Hw54, Ancho	66	40	0	106	1.23	>.75
Hw54, Mp156	108	56	1	165	2.20	>.50
Highrolls	80	39	0	119	3.42	>.25
Mt. Park	59	33	0	92	1.40	>.50
Nogal-a	63	53	1	117	1.97	>.50
Nogal-b	72	53	0	125	1.78	>.50
Nogal-c	75	43	0	118	1.64	>.75
Nogal-d	62	42	0	104	1.05	>.75
Nogal-e	62	37	2	101	1.18	>.75
Nogal-f	66	48	0	114	1.46	>.75
Ft. Stanton	77	48	0	125	1.37	>.50
Ft. Stanton	96	75	1	172	1.72	>.50
Ft. Stanton Ex.	82	46	0	128	1.96	>.50
Ft. Stanton Ex.	69	37	2	108	1.63	>.50
Ft. Stanton Ex.	59	26	0	85	3.72	>.25
Faywood-a	58	45	0	103	1.81	>.50
Faywood-b	58	51	1	110	2.51	>.50
Faywood-c	53	57	0	110	8.29*	<.05
Faywood-d	63	56	0	119	4.17	>.10
Total	2,450	1,488	15	3,953	19.64**	<.01

NOTE.—Total  $\chi^2 = 82.09$ ; pooled  $\chi^2 = 19.64$ ,  $P < .01$ ; homogeneity  $\chi^2 = 62.45$ ,  $P > .50$ .

<sup>a</sup>  $\chi^2$  calculated using proposed ratio of 60 females:39 male:1 monoecious, derived from Utah 4x populations, to calculate the expected frequencies.

\* The probability of a larger  $\chi^2$  is  $<.05$ .

\*\* The probability of a larger  $\chi^2$  is  $<.01$ .

sult of greater heterogeneity of sites where plants were sampled or to differences in gene frequencies.

The hexaploid sample populations were more homogeneous and closely fitted the proposed 6x ratio (tables 5, 6). Only one sample (Canutillo-i, table 5) deviated significantly because of excessive numbers of monoecious plants. In this sample, eight monoecious plants were growing in a cluster. Monoecious plants often grew in clusters in all three cytotypes, indicating a possibility that these plants share a common gene(s) inherited from a common parent (e.g., the 4x sample, Hw 54, Mp131 in 1985).

In general, all three New Mexico cytotypes appeared to fit the X, Y model proposed by STUTZ et al. (1975) and MCARTHUR (1977). Females approximately equaled males in diploid populations. Frequencies of females in New Mexico tetraploids

were close to the Utah populations with significant differences in the frequencies of male and monoecious plants. The frequency of females in hexaploid populations was slightly less than in tetraploids during summer and much greater in winter because of a high level of monoecious expression in hexaploids. Obvious monoecious expression was four times greater in 6x than in 4x populations, and 4x had slightly more monoecious plants than 2x populations.

MCARTHUR (1977) reasoned, in 4x populations, that the XXXY genotype was responsible for the monoecious character and sexual lability. Expanding this concept, we would expect the XXXXY and XXXYY genotypes to increase the incidence of these characters in 6x populations. The actual frequency of monoecious plants is much greater than that observed during flowering. Two reasons for this are (1) the numbers of flowering female plants

TABLE 4

1985 RATIO OF FEMALES TO MALES IN NEW MEXICO TETRAPLOID POPULATIONS

Site	Females	Males	Monoecious	Total	$\chi^2$ <sup>a</sup>	P
Carlsbad	78	37	0	115	3.76	>.25
Lake Arthur	114	56	0	170	4.71	>.10
Roswell	62	25	0	87	5.08	>.10
Faywood-a	64	52	0	116	2.67	>.50
Faywood-b	66	44	0	110	1.13	>.75
S. Dugway	86	47	0	133	2.24	>.50
3 Rivers-a	64	56	0	120	3.90	>.25
3 Rivers-b	62	59	2	123	4.94	>.10
3 Rivers-c	58	51	4	113	10.14**	<.01
Hw 180, Mp45a	63	58	2	123	4.20	>.25
Hw 180, Mp45b	90	76	3	169	3.82	>.25
Hw 54, Mp131	112	66	14	192	78.20**	<.01
Hw 54, Mp140	71	58	3	132	3.89	>.25
Hw 54, Mp148	75	58	4	137	5.86	>.10
Hw 54, Mp154a	62	44	4	110	7.92*	<.05
Hw 54, Mp154b	89	81	5	175	10.49**	<.01
Hw 54, Mp154c	64	49	2	115	1.27	>.75
Hw 54, Mp154d	97	48	4	149	6.75	>.10
Hw 54, Mp154e	73	64	2	139	3.33	>.25
Total	1,450	1,029	49	2,528	27.03**	<.01

NOTE.—Total  $\chi^2 = 164.12$ ; pooled  $\chi^2 = 27.03$ ,  $P < .01$ ; homogeneity  $\chi^2 = 137.09$ ,  $P < .01$ .

<sup>a</sup>  $\chi^2$  calculated using proposed ratio of 60 females:39 male:1 monoecious, derived from Utah 4x populations, to calculate the expected frequencies.

\* The probability of a larger  $\chi^2$  is  $<.05$ .

\*\* The probability of a larger  $\chi^2$  is  $<.01$ .

TABLE 5

1984 RATIO OF FEMALES TO MALES IN NEW MEXICO HEXAPLOID POPULATIONS

Site	Females	Males	Monoecious	Total	$\chi^2$ <sup>a</sup>	P
N Haines	77	52	8	137	1.28	>.75
S Vado, E	89	62	6	157	.03	>.98
S Vado, W	83	57	8	148	.83	>.75
N Anthony	70	43	5	118	.62	>.75
Canutillo-a	87	60	5	152	.25	>.90
Canutillo-b	86	70	5	161	.99	>.98
Canutillo-c	77	49	4	130	.69	>.75
Canutillo-d	76	53	6	135	.09	>.98
Canutillo-e	74	47	2	123	2.19	>.50
Canutillo-f	73	54	3	130	1.01	>.75
Canutillo-g	84	59	5	148	.15	>.95
Canutillo-h	64	60	3	127	3.24	>.25
Hill-a	53	44	5	102	.74	>.75
Hill-b	59	46	5	110	.28	>.90
Hill-c	72	59	6	137	.66	>.75
Hill-d	79	62	5	146	.43	>.90
Hill-e	57	40	5	102	.21	>.90
Hill-f	68	61	4	133	2.03	>.50
Canutillo-i	90	52	16	158	16.95**	<.01
Canutillo-j	88	72	5	165	1.14	>.75
Canutillo-k	72	46	5	123	.35	>.90
Total	1,578	1,148	116	2,842	.27	>.90

NOTE.—Total  $\chi^2 = 34.16$ ; pooled  $\chi^2 = .27$ ,  $P > .90$ ; homogeneity  $\chi^2 = 33.89$ ,  $P > .75$ .

<sup>a</sup>  $\chi^2$  calculated using the proposed 6x ratio of 56 female:40 male:4 monoecious plants.

\*\* The probability of a larger  $\chi^2$  is  $<.01$ .

TABLE 6  
1985 RATIO OF FEMALES TO MALES IN NEW MEXICO HEXAPLOID POPULATIONS

Site	Females	Males	Monoecious	Total	$\chi^2$ <sup>a</sup>	<i>P</i>
Canutillo-a	67	53	3	123	1.66	>.50
Canutillo-b	81	52	6	139	.33	>.90
Canutillo-c	84	53	2	139	2.44	>.50
Canutillo-d	74	56	3	133	1.57	>.50
Canutillo-e	67	45	8	120	2.67	>.50
Canutillo-f	77	73	4	154	5.46	>.10
Canutillo-g	89	61	4	154	.91	>.75
Canutillo-h	79	46	4	129	.92	>.75
Canutillo-i	93	59	5	157	.51	>.90
Canutillo-j	37	22	1	60	1.01	>.75
Hill-a	61	39	7	107	2.19	>.50
Hill-b	46	26	4	76	.97	>.75
Hill-c	60	40	5	105	.39	>.90
Hill-d	87	46	7	140	2.24	>.50
Hill-e	63	31	4	98	2.04	>.50
Total	1,065	702	67	1,834	3.33	>.25

NOTE.—Total  $\chi^2 = 25.31$ ; pooled  $\chi^2 = 3.33$ , *P* > .25; homogeneity  $\chi^2 = 21.98$ , *P* > .75.

<sup>a</sup>  $\chi^2$  calculated using the proposed 6x ratio of 56 female:40 male:4 monoecious plants.

are 6%–20% lower than the number of seed-bearing plants in the same population the following winter (table 7) and (2) the difficulty of detecting monoecious plants. Sexual lability appeared to be most stable in 2x populations and increased as chromosome sets increased. Also, if one considers the possibility of 6x female plants flowering with a few undetected male flowers, the fraction of monoecious plants would be even greater.

The genetics of hexaploids is complex even if only a single locus determines sex expression. Expanding the X, Y model, one might expect four viable genotypes for hexaploids—XXXXXX, XXXXXY, XXXXYY, and XXXYYY—if it were assumed that three X's are required for viability in the zygote. At this point, one can only guess the phenotypic expression of each genotype. Only the last three would segregate, and the gametic output would depend on the mode of chromatid assortment. In the field, different plants (genotypes) vary greatly in gamete production. In addition, the viability of all combinations of X and Y must be considered (WESTERGAARD 1958). Because of numerous possible assumptions, it is difficult to construct a genetic model to describe hexaploid behavior.

Two major types of monoecious expression were observed during summers 1984 and 1985 that may help in understanding the genetic mode of sex expression. One type was classed as a mixed expression, where the male and female flowers were intermixed on the same branch. This expression was observed on all three cytotypes. The other expression was chimeral, where separate male branches were found on both 4x and 6x female plants. Female branches were also found on 2x, 4x, and 6x male plants. Male or female chimerals were also found on mixed monoecious branches of 4x and 6x plants.

All but one of the diploid monoecious plants were of the mixed type. These plants were female with a few male flowers intermixed on their branches. The X, Y model per se fails to explain male flowers on female, XX, plants. A possible explanation is that the plants were XY, and a modifying gene suppressed the Y "gene" to allow predominant female expression; alternatively, the New Mexico populations may have an altered "Y," an allele, occurring at a low frequency, that is not completely dominant to X under some conditions.

A single 2x male plant with a chimeral female

TABLE 7  
SUMMER (S) AND WINTER (W) COMPARISON OF SEX RATIOS OF HEXAPLOIDS

Site	W 83-84			S 84			W 84-85			S 85			W 85-86		
	♀	♂	♂	♀	♂	♂	♀	♂	♂	♀	♂	♂	♀	♂	♂
Canutillo	76	24	0	56	38	6	62	38	0	57	40	3	69	31	0
Hill	80	20	0	53	43	4	63	37	0	60	35	5	70	30	0

branch was observed ca. 20 km west of Las Cruces. During summer 1986, female flowers were found on the male branches in the mixed expression. The two previous summers the plant was male with the female chimeral branch. This chimeral monoecious expression can be explained using the X, Y model accompanied by somatic crossing-over in meristematic cells (BARROW et al. 1973; BARROW and DUNFORD 1975). For example, if somatic crossing-over occurred between the centromere and the X, Y locus of the male plant, two alternate tissue types would be expected. One product, XX, would explain the female chimeral branch. The other prod-

uct, YY, is not likely to be viable or detectable on the male plant. The female branch remained totally female. The New Mexico diploids either differ genetically from the Utah population, or similar genotypes respond differently in the two areas.

In tetraploid and hexaploid plants, chimeral monoecious plants of both types, i.e., female branches on male plants and male branches on female plants, were observed and can also be explained by somatic crossing-over, based on the X, Y model. The mixed monoecious expression was also observed in these cytotypes.

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