and sucker control again influenced the amount of fruit lost during mechanical harvest (Table 4). As in 1971 the tendency was that ground losses increased as crown width increased. That was true in all cases except the control and the 1.13 kg paraquat/ha treatments. At the 30 cm width the 1.13 kg paraquat gave least ground loss although it was not different from the 0.56 kg paraquat in foam treatment. There was no difference among treatments at the 25 cm width and all treatments except 0.56 kg paraquat sprayed were superior to the control at the 20 cm width.

Comparison of potential yield (data not shown) with harvested yield show why the harvested yield data were not statistically different. Greater crown width favored increased potential yield, but also favored increased ground losses. The effects canceled each other.

Berry size

Analysis of berry size data (not shown) indicated that there was no difference among treatments in any of the years.

Discussion

The highbush blueberry industry became established in Michigan in the post-war years in response to the pioneering efforts of Stanley Johnston[7] and major plantings went in during the years 1945–1955.[1] The plantings at that time were primarily of 'Jersey', and it remains the major cultivar in Michigan to date. Many of these old plantings in recent years have not received adequate pruning which coupled with plentiful rainfall and organic soils resulted in large, unthrifty bushes. Estimates[5] have been given to suggest that 30–40% of the 'Jersey' plantations in the state are in such condition. For an industry with $8–10 million, depending on the season, this is a major economic concern.

We have been concerned with several questions: 1) was the process as outlined a feasible means of returning low productive plantations to peak productivity; 2) could width reduction and maintenance reduce ground losses without reducing production; 3) if 2 was affirmative, what was the optimum width and width maintenance treatment.

Table 5 shows that the answer to question 1 was yes. The rapid regrowth and return to productivity of radically pruned bushes made the approach not only feasible, but also economically desirable in cases of reduced productivity and excess vigor. Tables 3 and 4 showed that width reduction reduces ground loss. The reason was based on the nature of the spring-loaded catching mechanism on commercial harvesters. Reduced width of crown results in a narrower opening of these "pans" and thus allowed less ground loss.

The answer to question 3 was not fully satisfied by this study. The data in Table 5 show that narrow crowns increased in yield more slowly, but by 1973 increased ground losses made the 30 cm treatment nearly identical with the 25 cm treatment. Whether the optimum width is 20 cm or less cannot be determined from these data. The data do suggest that bushes with the 20 cm width crown did catch up with the productivity of wider crown bushes while maintaining reduced ground losses. On that basis the 20 cm width would be preferred.

Maintenance of crown width at the initial status was accomplished via chemical means in this study. Based on the data in Table 1 any of the paraquat treatments would be acceptable. The foam application would be preferred because of drift control. We do not suggest that this chemical approach to width maintenance is the best; however, it does work. Other methods such as mechanical maintenance should be evaluated.

Literature Cited

1. Phillips, E. A. 1959. Methods of vegetative study. Henry Holt Co., Inc. 107 pp.

Inheritance of Sex Expression from Crosses of Dioecious Cucumber (*Cucumis sativus* L.)[1]

J. W. Scott and L. R. Baker[2]
Michigan State University, East Lansing

Abstract. The hybrids and segregating populations obtained by crossing 4 gynoecious with 4 androecious lines were analyzed to determine the inheritance of sex expression in dioecious cucumber (*Cucumis sativus* L.). Sex expression of all F_1 hybrids was characterized by plants with a continuous pistillate stage of flowering on the main stem. This included both gynoecious and predominantly female plants. No reciprocal cross differences were observed in the F_1 and backcross generations. Backcrosses to the gynoecious parents produced plants with a continuous female stage. Backcrosses to the androecious parent produced plants with continuous pistillate, monoecious (without a continuous pistillate stage), and androecious expression in a 2:1:1 ratio, respectively. The F_2 generation segregated 12:3:1 continuous pistillate, monoecious, and androecious phenotypes, respectively. Two major loci, *a* and *acr*, with epistasis are proposed to control sex expression. The *a* locus permits male (*aa*) as opposed to female (*A* –) flower expression. The *acr* locus conditions the intensity of femaleness.

Kubicki (9) reported that androecious (all-male) sex expression of cucumber (*Cucumis sativus* L.) was controlled by a single recessive gene *a* and was also influenced by the *acr* locus. The influence of the *acr* locus on sex expression was reported earlier (16, 17). The *acr* locus is probably analogous to the *st* locus (4), which in still earlier work was called *f* (20). Kubicki (9) obtained entirely gynoecious (all-female) F_1 plants from certain gynoecious x androecious crosses. This result stimulated interest in the use of an androecious parent for hybrid seed production. Use of vigorous, androecious pollinators might be advantageous over current monoecious (11) or hermaphroditic (5, 12) pollinators as used in 3-way hybrid seed production (14).

Our purpose was to determine the inheritance of sex expression in crosses of gynoecious and androecious cucumber. The genetic information is essential to explore the feasibility of using androecious phenotypes as pollinators for hybrid seed production.

[1] Received for publication September 9, 1974. Michigan State University Agricultural Experiment Station Journal Article No. 6969.
[2] Graduate Technician and Associate Professor, Department of Horticulture respectively.
[3] Seed of MSU 1A1, MSU 1A2, and MSU 1A3 was supplied by E. T. Mescherov, All-Union Institute of Plant Industry, Leningrad, USSR. Seed of MSU 2A was supplied by M. Yordanov, Plovdiv, Bulgaria.

Materials and Methods

In August 1972, 4 gynoecious and 4 androecious lines of cucumbers were planted in the greenhouse to produce F_1 and S_1 seed. The 4 gynoecious inbred parents were: 1) Gyl4, a white spined pickling line developed at Clemson University; 2) MSU 713-5, a black spined pickling line developed at Michigan State University; 3) Tablegreen 68G, a white spined slicer line developed at Cornell University; and 4) MSU 394G, an experimental white spined pickling line developed at Michigan State University. The androecious parents were 3 lines of black spined slicing cucumbers designated MSU 1A1, MSU 1A2, and MSU 1A3. The fourth androecious line, designated MSU 2A, was a white spined slicer line with prolific growth and late flowering habit.[3]

A second planting of parental and F_1 seed was made in November 1972 to obtain reciprocal F_1 (RF_1), reciprocal backcrosses to each of the parental lines, and F_2 seed. Induction of male flowers in gyneocious and predominantly female (PF) lines for seed production was accomplished with GA4/7 (13). Ethephon (50 ppm) was used for induction of female flowers for selfing and reciprocal crossing with androecious parent lines (1).

Seed obtained from the various crosses was planted at 2 field locations in the summer of 1973. The S_1, reciprocal F_1 and backcross, and F_2 generations were planted near East Lansing, MI, June 15 and 26. On July 12, a second planting was made near Sodus, MI. A completely randomized design with 3 replications was used at each location. Seedlings were thinned to 25 plants per 9.14 meter (30 foot) plot to avoid excessive crowding. Twenty-five plants were desired yet not always attained due to variable plant stands.

All plants were classified for sex over the entire growing season (June through September) and placed into 4 categories: 1) gynoecious, all female flowers; 2) predominantly female or monogynoecious (PF), some early male flowers followed by a continuous pistillate stage; 3) monoecious, many male with some female flowers, but no continuous female stage; and 4) androecious, only male flowers or some plants with late female flowers formed on third-order laterals.

Homogeneity of replications, F_2 families, reciprocal crosses, pedigrees, and locations were tested by using X_2 contingency tables (18) in order to pool the data.

Table 1. Sex expression of S_1 plants from gynoecious and androecious parental cucumber lines[z].

Parent	Sex[y]				Total plants
	G	PF	M	A	
Gyl4	93	12	0	0	105
MSU 713-5	126	10	0	0	136
MSU 394G	130	8	0	0	138
TG[x]	75	12	0	0	87
MSU 1A1	0	0	0	63	63
MSU 1A2	0	0	0	72	72
MSU 1A3	0	0	0	68	68
MSU 2A	0	0	0	79	79

[z] Each S_1 population consisted of seed from 2 self-pollinated plants; data were homogeneous and pooled.
[y] G = gynoecious; PF = predominantly female; M = monoecious; A = androecious.
[x] TG = Tablegreen 68G.

Results and Discussion

Sex expression of the parental lines was determined (Table 1). All gynoecious lines exhibited a low percentage of PF plants with most plants gynoecious. All androecious parent lines were true-breeding for androecious expression.

Replicates, F_2 families, and reciprocal crosses were homogeneous ($p > .05$) and thus pooled. Different pedigrees of like generation and location proved heterogeneous and were reported separately. When like pedigrees within a generation were compared between locations, most proved to be homogeneous. Location differences were not significant ($p > .05$) within crosses, excluding those involving Tablegreen 68G and a single F_2 population involving MSU 394G x MSU 1A2. Thus all other data are reported with locations pooled (Tables 2 to 5). No definite location effect on sex expression could be determined.

Table 2. Sex expression in the cross of gynoecious × androecious (MSU 1A1) cucumber.

Pedigree	Generation	Sex frequencies[z]				Total no. plants	Genetic relationships			
		G	PF	M	A		Obtained G+PF:M:A	Expected G+PF:M:A	X^2	P
Gyl4 × MSU 1A1	F_1	4	105	0	0	109				
MSU 713-5 × MSU 1A1		3	22	0	0	25				
MSU 394G × MSU 1A1		20	166	2	0	188				
TG[y] × MSU 1A1—E.L.[x]		13	27	0	0	40				
Gyl4 × MSU 1A1	BC_1P_1	85	92	1	0	178				
MSU 713-5 × MSU 1A1		106	97	1	0	203				
MSU 394G × MSU 1A1		187	156	1	0	344				
TG × MSU 1A1—E.L.		38	13	20	0	71				
TG × MSU 1A1—S.[w]		24	1	0	0	25				
Gyl4 × MSU 1A1	BC_1P_2	19	65	48	46	178	84:48:46	2:1:1	0.6068	.74
MSU 713-5 × MSU 1A1		17	58	42	30	147	75:42:30		2.0202	.38
MSU 394G × MSU 1A1		39	108	73	54	274	147:73:54		4.0984	.14
TG × MSU 1A1—E.L.		9	23	12	9	53	32:12:9		2.6224	.28
TG × MSU 1A1—S.		15	22	15	14	66	37:15:14		1.0000	.62
Gyl4 × MSU 1A1	F_2	130	211	83	25	449	341:83:25	12:3:1	0.4037	.82
MSU 713-5 × MSU 1A1		139	267	98	31	535	406:98:31		0.2874	.87
MSU 394G × MSU 1A1		295	383	128	56	862	678:128:56		8.6155	.02
TG × MSU 1A1—E.L.		263	99	58	26	446	362:58:26		10.2424	.008
TG × MSU 1A1—S.		49	33	19	7	108	82:19:7		0.0982	>.95

[z] G = gynoecious; PF = predominantly female; M = monoecious; A = androecious.
[y] TG = Tablegreen 68G.
[x] E.L. = East Lansing location.
[w] S. = Sodus location.

Table 3. Sex expression in the cross of gynoecious × androecious (MSU 1A2) cucumber.

Pedigree	Generation	Sex frequencies[z]				Total no. plants	Genetic relationships			
		G	PF	M	A		Obtained G+PF:M:A	Expected G+PF:M:A	X^2	P
Gyl4 × MSU 1A2	F_1	9	26	0	0	35				
MSU 713-5 × MSU 1A2		14	118	0	0	132				
MSU 394G × MSU 1A2		46	105	0	0	151				
Gyl4 × MSU 1A2	BC_1P_1	85	51	0	0	136				
MSU 713-5 × MSU 1A2		53	40	1	0	94				
MSU 394G × MSU 1A2		326	184	1	0	511				
TG[y] × MSU 1A2—E.L.[x]		46	15	18	0	79				
TG × MSU 1A2—S.[w]		112	27	0	0	139				
Gyl4 × MSU 1A2	BC_1P_2	23	54	47	27	151	77:47:27	2:1:1	5.3576	.08
MSU 713-5 × MSU 1A2		6	20	20	9	55	26:20:9		4.5634	.10
MSU 394G × MSU 1A2		28	60	50	37	175	88:50:37		1.9371	.39
TG × MSU 1A2—S.		20	21	20	17	78	41:20:17		0.4359	.81
Gyl4 × MSU 1A2	F_2	157	129	53	19	358	286:53:19	12:3:1	4.6221	.10
MSU 713-5 × MSU 1A2		151	174	82	28	435	325:82:28		0.0312	>.95
MSU 394G × MSU 1A2—E.L.		207	231	64	25	527	438:64:25		18.8010	<.001
MSU 394G × MSU 1A2—S.		105	69	39	14	227	174:39:14		0.3827	.83
TG × MSU 1A2—E.L.		38	7	6	7	58	45:6:7		5.3687	.07
TG × MSU 1A2—S.		19	10	17	8	54	29:17:8		14.2397	<.001

[z] G = gynoecious: PF = predominantly female; M = monoecious; A = androecious.
[y] TG = Tablegreen 68G.
[x] E.L. = East Lansing location.
[w] S. = Sodus location.

Table 4. Sex expression in the cross of gynoecious × androecious (MSU 1A3) cucumber.

Pedigree	Generation	Sex frequencies[z]				Total no. plants	Genetic relationships			
		G	PF	M	A		Obtained G+PF:M:A	Expected G+PF:M:A	X^2	P
Gyl4 × MSU 1A3	F_1	23	70	2	0	95				
MSU 713-5 × MSU 1A3		23	140	0	0	163				
MSU 394G × MSU 1A3		20	81	0	0	101				
TG[y] × MSU 1A3—E.L.[x]		37	17	6	0	60				
TG × MSU 1A3—S.[w]		8	14	0	0	22				
Gyl4 × MSU 1A3	BC_1P_1	4	7	0	0	11				
MSU 713-5 × MSU 1A3		15	17	0	0	32				
MSU 394G × MSU 1A3		98	64	2	0	164				
TG × MSU 1A3—E.L.		31	0	0	0	31				
TG × MSU 1A3—S.		52	5	0	0	57				
Gyl4 × MSU 1A3	BC_1P_2	19	44	41	33	137	63:41:33	2:1:1	1.8174	.42
MSU 713-5 × MSU 1A3		27	60	38	42	167	87:38:42		0.4849	.79
MSU 394G × MSU 1A3		22	45	20	24	111	67:20:24		5.0540	.08
TG × MSU 1A3—E.L.		32	28	31	17	108	60:31:17		4.9630	.09
TG × MSU 1A3—S.		46	32	32	38	148	78:32:38		0.9189	.64
Gyl4 × MSU 1A3	F_2	132	158	83	30	403	290:83:30	12:3:1	2.3847	.31
MSU 713-5 × MSU 1A3		193	262	116	33	604	455:116:33		0.5769	.75
MSU 394G × MSU 1A3		144	145	58	21	368	289:58:21		2.5123	.29
TG × MSU 1A3—E.L.		188	66	48	20	315	247:48:20		2.5651	.28
TG × MSU 1A3—S.		84	42	30	4	160	126:30:4		3.9000	.15

[z] G = gynoecious; PF = predominantly female; M = monoecious; A = androecious.
[y] TG = Tablegreen 68G.
[x] E.L. = East Lansing location.
[w] S. = Sodus location.

For all crosses (Tables 2 to 5), the F_1 generation exhibited gynoecious and PF plants with infrequent monoecious segregates (10/1404 = .7%). Hence, the heterozygote resulting from the cross of gynoecious x androecious included gynoecious with a relatively high percent (38 to 100) of PF plants. Therefore, no genetic basis for differences between these 2 classes was proposed in this study.

In the BC_1P_1, 50% P_1 genotypes (homozygotes) and 50% F_1 genotypes (heterozygotes) were expected. Thus depending on the percentage of heterozygotes which were gynoecious, a greater number of gynoecious with a lesser number of PF plants was expected. This

Table 5. Sex expression from the cross of gynoecious × androecious (MSU 2A)[z] cucumber.

Pedigree	Generation	Sex frequencies[z]				Total no. plants	Genetic relationships			
		G[y]	PF	M	A		Obtained G+PF:M:A	Expected G+PF:M:A	X^2	P
Gyl4 × MSU 2A	F_1	0	18	0	0	18				
MSU 713-5 × MSU 2A		4	84	0	0	88				
MSU 394G × MSU 2A		24	154	0	0	178				
Gyl4 × MSU 2A	BC_1P_1	38	23	0	0	61				
MSU 713-5 × MSU 2A		135	122	0	0	257				
MSU 394G × MSU 2A		396	238	2	1	637				
Gyl4 × MSU 2A	BC_1P_2	10	47	39	7	103	57:46	1:1	1.1748	.28
MSU 713-5 × MSU 2A		29	130	139	25	323	159:164		0.0704	.79
MSU 394G × MSU 2A		32	95	86	12	225	127:98		3.7378	.05
Gyl4 × MSU 2A	F_2	193	204	115	8	520	397:123	3:1	0.5025	.82
MSU 713-5 × MSU 2A		336	512	282	28	1188	848:310		0.7587	.40
MSU 394G × MSU 2A		460	504	326	32	1322	964:385		3.0207	.09

[z] MSU 2A is suggested to be a monoecious genotype but appears androecious under long day, high temperature conditions.
[y] G = gynoecious; PF = predominantly female; M = monoecious; A = androecious.

was true for all BC_1P_1, populations with the exceptions of Gyl4 x MSU 1A1 (Table 2). In this cross, the heterozygous F_1 population expressed a low percentage (4%) of gynoecious plants in the F_1, so the nearly 1:1 gynoecious to PF ratio in the BC_1 is surprising. Other exceptions were Gyl4 x MSU 1A3 and MSU 713-5 x MSU 1A3 (Table 4), but the population size may be inadequate.

In the BC_1P_2, segregation of monoecious and androecious phenotypes was observed along with gynoecious and PF. The gynoecious and PF phenotypes were combined as a single class (continuous pistillate) since the F_1 populations included both. Moreover, a consistent segregation between the 2 phenotypes was not observed in BC_1P_2 or F_2. The monoecious and androecious classes were nearly equal in frequency while the continuous pistillate class was twice as large. Thus the ratio of continuous pistillate to monoecious to androecious was 2:1:1.

Plants in the F_2 population segregated approximately 12:3:1 for continuous pistillate to monoecious to androecious, respectively. The p values ranged from .07 to > .95 for goodness of fit (Tables 2 to 5). Based on the ratios observed in the BC_1P_2 and F_2 generations, an independently inherited digenic system is proposed. The significant number of androecious segregates in both the BC_1P_2 and F_2 generations seems to discount a more complex system of inheritance for androecious expression.

A model was developed (Table 6) using the genetic nomenclature as proposed by previous researchers. The 2 loci involved are designated as *a* after Kubicki (9) and *acr* as originally designated by Shifriss (16, 17) and then by Kubicki (6, 7, 8). The female flower allele *A* is dominant to the male flower allele *a*. The *acr* locus controls female intensity with acr^F homozygotes conditioning high female intensity; whereas acr^+ homozygotes exhibit a low female intensity. The sex expression of plants heterozygous for *acr* are intermediate between the homozygotes, but tend toward the acr^F homozygote phenotypically (6). The acr^F allele is epistatic to *a*. An *acr* complement results in plants with continuous pistillate stage whereas acr^+ homozygotes do not. The difference between gynoecious and PF may be due to the strength of alleles at the *acr* locus (7) and/or modifier genes (7, 8, 16) and/or environment (2, 3, 4, 10, 16, 19). Plants of both monoecious and androecious phenotypes are acr^+acr^+. The difference between monoecious and androecious is that monoecious is $A-$ whereas androecious is *aa*. Except for the difference between monoecious and androecious, it is beyond the scope of our data to show that $A-$ adds to the femaleness of other sex phenotypes. For example, *aa* acr^F acr^F and $A-$ acr^F acr^F are assumed of equal female intensity for this study and the proposed model.

Table 6. Proposed genetic model for sex expression from the cross of gynoecious × androecious cucumber.

Generation	Ratio	Genotype	Phenotype
Gynoecious Parent (P_1)	1	$AA\ acr^Facr^F$	Gynoecious
Androecious Parent (P_2)	1	$aa\ acr^+acr^+$	Androecious
F_1	1	$Aa\ acr^Facr^+$	Gynoecious/PF[z]
BC_1P_1	3/8	$A-\ acr^Facr^F$	Gynoecious
	1/8	$aa\ acr^Facr^F$	Gynoecious
	3/8	$A-acr^Facr^+$	Gynoecious/PF
	1/8	$aa\ acr^Facr^+$	Gynoecious/PF
BC_1P_2	1/4	$Aa\ acr^Facr^+$	Gynoecious/PF
	1/4	$aa\ acr^Facr^+$	Gynoecious/PF
	1/4	$Aa\ acr^+acr^+$	Monoecious
	1/4	$aa\ acr^+acr^+$	Androecious
F_2	3/16	$A-\ acr^Facr^F$	Gynoecious
	1/16	$aa\ acr^Facr^F$	Gynoecious
	3/8	$A-\ acr^Facr^+$	Gynoecious/PF
	1/8	$aa\ acr^Facr^+$	Gynoecious/PF
	3/16	$A-\ acr^+acr^+$	Monoecious
	1/16	$aa\ acr^+acr^+$	Androecious

[z] PF = predominantly female.

A major deviation from the proposed genetic model occurred with crosses involving MSU 2A (Table 5). This was resolved by demonstrating the monoecious expression of this line under certain environmental conditions. Greenhouse experiments in the fall of 1973 demonstrated that the androecious expression of MSU 2A was unstable under low temp and/or short day conditions. Only under high temp and long day conditions (as with 1973 field experiments) was MSU 2A stable for androecious expression. Under short day (10 to 11 hr) and/or low night temp (10 to 12°C) conditions, MSU 2A exhibited monoecious expression (15). Generally, stronger femaleness in monoecious lines was observed with short days and low night temp conditions (2, 3, 4, 10, 16, 19) which may explain the monoecious expression of MSU 2A.

For these data (Table 5), MSU 2A does not fit a 2:1:1 BC_1P_2 or a 12:3:1 F_2 ratio so the androecious and monoecious classes were combined and 1:1 BC_1P_2 and 3:1 F_2 ratios, typical of monoecious

inheritance (7, 16), were tested and found to be acceptable fits (Table 5). This suggests that the genotype of MSU 2A is $AA\ acr^+\ acr^+$ with monoecious expression. Further studies of crosses between MSU 2A and androecious lines would be necessary to determine genetic differences.

Deviations from expected F_2 ratios occured with 'Tablegreen 68G' crosses and progenies (Tables 2 to 4). In the case of 'Tablegreen 68G' × MSU 1A1 (East Lansing), a higher than expected female tendency was noted; that is, more gynoecious and PF phenotypes. A high percentage of gynoecious segregates were observed in other generations of this cross as well. Varying intensities of femaleness among "gynoecious" lines has been reported previously (7, 8, 16). Moreover, 'Tablegreen 68G' expresses intense femaleness and is difficult to induce male flowers after treatment with GA4/7 (unpublished data).

In the F_2 of MSU 394G × MSU 1A1 and MSU 394G × MSU 1A2 (East Lansing location), the significant deviations result from a higher than expected frequency of continuous pistillate plants. A high female intensity is evident in other crosses with MSU 394G (Tables 2 to 5). The possibility of a unique environmental effect on the F_2 populations of both MSU 394G × 1A2 (East Lansing) and Tablegreen 68G × MSU 1A1 (East Lansing) is apparent since the same pedigrees at the Sodus location were consistent with the expected ratio.

The possibility of using androecious lines as pollinators for the production of hybrid seed is appealing. For hybrid seed production an androecious pollinator would be used in a manner similar to monoecious pollinators (11, 14) resulting in highly female F_1 cultivars. On the other hand, hermaphroditic lines seem more suitable as pollinators for seed production of all-gynoecious F_1 cultivars (5, 12) necessary for parthenocarpic cucumber production (12).

Literature Cited

1. Augustine, J. J., L. R. Baker, and H. M. Sell. 1973. Female flower induction on androecious cucumber, *Cucumis sativus* L. *J. Amer. Soc. Hort. Sci.* 98:197–199.
2. Atsmon, D., and E. Galun. 1962. Physiology of sex in *Cucumis sativus* L. I. Leaf age patterns and sexual differentiation of floral buds. *Ann. Botany* 26:137–146.
3. Fukushima, Eiji, Eisuke Matsuo, and Junimitsu Fujieda. 1968. Studies on the growth behavior of cucumber *Cucumis sativus* L. *J. Fac. Agr. Kyushu Univ.* 14:349–366.
4. Galun, E. 1961. Study of the inheritance of sex expression in the cucumber. The interaction of major genes with modifying genetic and non-genetic factors. *Genetics* 32:134–163.
5. Kubicki, B. 1965. New possibilities of applying different sex types in cucumber breeding. *Genetica Polonica* 6:241–250.
6. ———. 1965. Investigations on the sex determination in cucumbers (*Cucumis sativus* L.). II. The effects of polyploidy on sex expression in monoecious and gynoecious cucumbers. *Genetica Polonica* 6:251–265.
7. ———. 1969. Investigations on sex determination in cucumber (*Cucumis sativus* L.). IV. Multiple alleles of locus acr. *Genetica Polonica* 10:23–67.
8. ———. 1969. Investigations on sex determination in cucumber (*Cucumis sativus* L.). V. Genes controlling intensity of femaleness. *Genetica Polonica* 10:69–85.
9. ———. 1969. Investigations on sex determination in cucumber (*Cucumis sativus* L.). VI. Androecium. *Genetica Polonica* 10:87–99.
10. Nitsch, J. P., E. B. Kurtz, J. L. Liverman, and F. W. Went. 1952. The development of sex expression in cucurbit flowers. *Amer. J. Bot.* 39:32–43.
11. Peterson, C. E., and J. L. Weigle. 1958. A new method for producing hybrid cucumber seed. *MI Quart. Bul.* 40:960–965.
12. Pike, L. M., and W. A. Mulkey. 1971. Use of hermaphrodite cucumber lines in development of gynoecious hybrids. *HortScience* 6:339–340.
13. ———, and C. E. Peterson. 1969. Gibberellin A4/A7 for induction of staminate flowers on the gynoecious cucumber *Cucumis sativus*. *Euphytica* 18:106–109.
14. ———. 1974. 'TAMU Triple Cross' Pickling Cucumber. *HortScience* 9:83.
15. Rudich, J., J. W. Scott, L. R. Baker, and H. M. Sell. 1974. Phenotypic stability and ethylene evolution of androecious cucumber. *HortScience* 9:292 (Abstr.).
16. Shifriss, O. 1961. Sex control in cucumbers. *J. Heredity* 52:5–12.
17. ———, W. L. George, J. A. Quinones. 1964. Gynodioecism in cucumbers. *Genetics* 49:285–291.
18. Steel, R. D. G., and James H. Torrie. 1969. Principles and procedures of statistics. McGraw Hill, New York. 481 pp.
19. Tiedjens, V. A. 1928. Sex ratios in cucumber flowers as affected by different conditions of soil and light. *J. Agr. Res.* 36:721–748.
20. Tkaczenko, N. N. 1935. Preliminary results of a genetic investigation of the cucumber (*Cucumis sativus* L.) *Bul. Appl. Bot. Genet. and Plant Breed.* 9:311–356.

Abnormalities in Seed Development in *Pistacia vera* L.[1]

Muriel V. Bradley and Julian C. Crane[2]

Department of Pomology, University of California, Davis

Abstract. In the pistachio cv. Kerman an average of 26% of the fruits contain no seeds or only poorly developed ones at maturity. A study of aberrations revealed; a) pollen tubes sometimes entered the embryo sacs at the chalazal end (the pistachio is chalazogamous), which may result in eventual degeneration of endosperm or zygote nuclei; b) frequent degeneration of zygote (or egg) or young endosperm nuclei from unknown causes; c) occurrence of a brown spot on the funiculus of many young seeds in some years, the necrosis usually spreading to the embryo sac; d) and hypertrophy of nucellar cells in some older seeds was frequently accompanied by proliferation of other nucellar cells, both limiting development of embryo and endoperm. In cv. Bronte a frequent aberration is protrusion of endosperm or embryo through a greatly distended endostome.

In *Pistacia vera* L. numerous female flowers and young fruits abscise. In addition, various percentages of the nuts that set and remain on the trees to maturity contain no seeds, or only underdeveloped ones. An average of about 26% of the nuts in 'Kerman' are seedless, a portion of which is due to parthenocarpy (2). Degeneration of megaspore mother cells or megaspores and embryo sac degeneration are abnormalities which Grundwag and Fahn (3) found in *P. vera* trees of unknown origin. Since pistachio may become an important crop in CA, events leading to interrupted seed development in 2 cultivars were investigated.

Materials and Methods

Female inflorescences of 'Kerman' were collected from the Wolfskill Experimental Orchard, Winters, CA, at weekly intervals after full bloom (April 22). Flowers, young fruits, and seeds were fixed in

[1] Received for publication September 27, 1974.

[2] The authors gratefully acknowledge the valuable assistance of Mrs. Sarah T. Ross.