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Ethylene Evolution from Cucumber Plants as Related to Sex Expression[1]

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ABSTRACT

Ethylene evolved from monoecious and gynoecious cucumber (*Cucumis sativus*) plants grown under short and long day conditions was determined. More ethylene was evolved from floral buds and apices bearing buds than from whole seedlings of comparable weight. More ethylene also was evolved from apices of the gynoecious than from those of the monoecious type. Furthermore, quantities evolved from female buds were greater than from male ones and plants grown under short day conditions which promote femaleness evolved more ethylene than those grown under long day conditions. The data suggest that ethylene participates in the endogenous regulation of sex expression by promoting femaleness.

Sex expression of cucurbits is influenced by environmental factors such as daylength and temperature. Female tendency is increased under conditions of low temperatures and short days (8).

Sex expression is also influenced by growth regulators (8, 9). High endogenous auxin levels (2) are associated with female tendency, and exogenous auxin treatments (5) enhance the femaleness of cucumber plants, whereas high endogenous gibberellin levels are associated with maleness (1). Ethephon [(2-chloroethyl) phosphonic acid], which releases ethylene in plant tissues (11), also changes the sex expression of cucumbers, enhancing femaleness (6, 10). Treatment with gaseous ethylene (4, 7) also promotes femaleness. Although the effect of external application of ethylene on sex expression seems to be established, there is no available information today on the relationship between endogenous ethylene and sex expression. Such information is essential for understanding the role of ethylene in sex determination. Therefore evolution of ethylene from cucumber plants was determined.

MATERIALS AND METHODS

Monoecious and gynoecious types of the cucumber (*Cucumis sativus* cv. Beit-Alpha) (1) were grown in small pots containing a mixture of gravel and vermiculite. They were irrigated twice daily, once with Hoagland's solution and once with water. Plants were grown in a phytotron either under 8-hr short days of natural daylight or under 16-hr long days composed of 8 hr natural daylight supplemented by 8 hr incandescent lamp illumination of 100 ft-c. Day temperatures were kept at 27 C and night temperatures at 22 C.

Ethylene evolution was determined by gas chromatography using a Packard gas chromatograph equipped with a flame ionization detector and 36- × ¼-inch alumina column. Ethylene was determined in a 2-ml sample removed from a 30- or 100-ml vessel in which the tissue was incubated for 2 hr at 25 C at a light intensity of 600 ft-c. The vessels containing 1 ml of water were sealed with rubber stoppers through which the sample was drawn. The instrument was calibrated with a 1 μl/l ethylene standard. The data presented are from different experiments for each table.

RESULTS AND DISCUSSION

Ethylene evolved from young seedlings was determined in explants cut from the hypocotyl region 1 cm below the cotyledons. The data in Table I show that 11-day-old explants of the monoecious and gynoecious types evolve similar quantities of ethylene. In plant apices tested 19 days after germination, more ethylene was evolved by the gynoecious type (Table II), and the quantities were especially large under short day conditions which promote femaleness.

High rates of ethylene evolution as well as marked differences in ethylene-evolving potential were recorded from stem tips which were excised just below the youngest leaf. Buds with a diameter up to 3 mm were visible on these tips 23 days after germination. These tips evolved especially large quantities of ethylene (Table III). The highest rates of ethylene evolution were found in excised floral buds. Female floral buds up to 3 mm in diameter evolved greater quantities than male buds (Table IV). Since rates of ethylene evolution are affected by cutting and bud excision, equal numbers of buds of similar size and age were always compared. Relative differences between types or daylength treatments may therefore be compared.

Table I. *Evolution of Ethylene from Beit Alpha Cucumber Explants*

These explants taken from 11-day-old plants consisted of the first leaf, cotyledons, and 1 cm of hypocotyl. Incubation time was 2 hr in light at 25 C. Averages are of six replicates, each consisting of two plants per vial.

Sex Type	Daylength		Mean Effect of Sex Type
	16 hr	8 hr	
	$\mu l \times 10^{-4}/hr \cdot g$		
Monoecious	1.85[1]	1.58	1.71
Gynoecious	1.51	1.53	1.52
Mean of daylength effect	1.69	1.54	

[1] All differences are statistically insignificant at p = 0.05.

[1] This paper represents a portion of a Ph.D. thesis of J. Rudich.

Evolution of ethylene increased markedly after plants were sprayed with Ethephon. One or 2 days after treatment, the evolution rate was 100 times that of control plants. Even 10 days after treatment, treated plants evolved more ethylene than controls (Table V). Treated gynoecious plants evolved 14 times as much ethylene as untreated ones, and also exceeded ethylene evolution of treated monoecious plants. These results indicate that the potential for ethylene evolution is greater in the gynoecious type than in the monoecious one.

Table II. *Evolution of Ethylene from 19-day-old Beit Alpha Cucumber Plant Apices as Affected by Sex Type and Daylength*

Averages are of six replicates, each consisting of four apices per vial.

Sex Type	Daylength		Mean Effect of Sex Type
	16 hr	8 hr	
	$\mu l \times 10^{-4}/hr \cdot g$		
Monoecious	17.16	20.43	18.80[1]
Gynoecious	27.06	50.74	38.90
Mean of daylength effect	22.11	35.58	

[1] SE for the effect of sex type and daylength = 3.52 significant at P = 0.01. SE for the interaction sex type times daylength = 4.98; not significant at P = 0.05.

Table III. *Evolution of Ethylene from 23-day-old Beit Alpha Cucumber Plant Apices as Affected by Sex Type and Daylength*

Averages are of six replicates, each consisting of two apices per vial.

Sex Type	Daylength	
	16 hr	8 hr
	$\mu l \times 10^{-4}/hr \cdot g$	
Monoecious	42.65[1]	48.44
Gynoecious	137.26	118.88

[1] SE of sex type effect = 9.45 significant at P = 0.01. Daylength effect and interaction sex type times daylength not significant at P = 0.05.

Table IV. *Evolution of Ethylene from Beit Alpha Cucumber Male and Female Flower Buds*

Averages are of six replicates, each consisting of eight buds of 3 mm diameter per vial.

Sex Type	Daylength	
	16 hr	8 hr
	$\mu l \times 10^{-4}/hr \cdot g$	
Male flower buds	124.90[1]	282.11
Female flower buds	533.00	606.21

[1] SE for the effect of daylength and sex type = 27.45 and differ significantly at P = 0.01.

Table V. *Evolution of Ethylene from Beit Alpha Cucumber Plants as Affected by Sex Type and Ethephon Treatment*

Averages are of eight replicates, each consisting of one plant, 10 days after Ethephon application.

Sex Type	Treatment		Mean Effect of Sex Type
	Control	Ethephon 250 µl/l foliage spray	
	$\mu l \times 10^{-4}/hr \cdot g$		
Monoecious	0.77	8.38	4.57[1]
Gynoecious	1.45	20.18	10.82
Mean effect of treatment	1.11	14.28	

[1] SE for the effect of sex type = 2.094 significant at P = 0.05. SE for Ethephon treatment = 2.094 significant at P = 0.01. SE for the interaction sex type times treatment = 2.962; not significant at P = 0.05.

During their earliest stage of development, cucumber flowers are bisexual, and only later (3) they develop into male or female flowers. The determination of sex is a result of factors affecting the flower at early stages of its development. The results presented here show that gynoecious plants evolve greater quantities of ethylene than monecious ones, and that this is mainly true for the apex in which the floral buds are developing. Excised female buds evolve ethylene at a higher rate than male buds. Short day conditions which enhance femaleness (8) also increase ethylene evolution. Similar results have been obtained also with muskmelons by workers at Michigan State University (R. E. Byers, D. R. Dilley, L. R. Baker, and H. M. Sell, personal communication). The effect of external application of ethylene on sex expression and the correlation between the native evolution of ethylene and the sex tendency of the tissue, strengthens the view that ethylene participates in the endogenous regulation of sex expression.

LITERATURE CITED

1. Atsmon, D., A. Lang, and E. N. Light. 1968. Contents and recovery of gibberellins in monoecious and gynoecious cucumber plants. Plant Physiol. 43: 806–810.
2. Galun, E., S. Izhar, and D. Atsmon. 1965. Determination of relative auxin content in hermaphrodite and andromonoecious *Cucumis sativus* L. Plant Physiol. 40: 321–326.
3. Galun, E., Y. Jung, and A. Lang. 1963. Morphogenesis of floral buds of cucumber cultured *in vitro*. Develop. Biol. 6: 370–387.
4. Iwahori, S., J. N. Lyons, and O. E. Smith. 1970. Sex expression in cucumber as affected by 2-chloroethylphosphonic acid, ethylene, and growth regulators. Plant Physiol. 46: 412–415.
5. Laibach, F. and F. J. Kribben. 1950. Der Einfluss von Wuchsstoff auf die Bildung männlicher und weiblicher Blüten bei einer monözischen Pflanze. Ber. Deut. Bot. Gaz. 62: 53–55.
6. McMurray, A. L. and C. H. Miller. 1968. Cucumber sex expression modified by 2-chloroethanephosphonic acid. Science 162: 1397–1398.
7. Minina, E. G. and L. G. Tylkina. 1947. Physiological study of the effect of gases upon sex differentiation in plants. Dokl. Akad. Nauk SSSR., N. S. 55: 165–168. (Cited from Nitsch [8].)
8. Nitsch, J. P. 1965. Physiology of flower and fruit development. *In:* W. Ruhland, ed., Encyclopedia of Plant Physiology, Vol. XV, Ed. 1. Springer-Verlag. New York. pp. 1537–1647.
9. Peterson, C. E. and L. D. Anhder. 1960. Induction of staminate flower in gynoecious cucumber with GA_3. Science 131: 1673–1674.
10. Rudich, J., A. H. Halevy, and N. Kedar. 1969. Increase in femaleness of three cucurbits by treatment with Ethrel, an ethylene releasing compound. Planta 86: 69–76.
11. Yang, S. F. 1969. Ethylene evolution from 2-chloroethylphosphonic acid. Plant Physiol. 44: 1203–1204.