lyte leakage studies of unchilled field samples followed that same pattern for all maturities tested, this may eventually be more useful in predicting chilling injury susceptibility.

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Effects of Ethephon-gibberellin Combinations on Yield, Size, and Quality of Muskmelon[1]

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Additional index words. Cucumis melo

Abstract. **Mixtures of (2-chloroethyl)phosphonic acid (ethephon) plus gibberellic acid (GA_3) were applied to 'Edisto-47' muskmelon (*Cucumis melo* L.) plants at the 3–4 true leaf stage for 3 growing seasons. Ethephon at 240 mg/liter + GA_3 at 100 mg/liter consistently increased the marketable yield of melons over the control. However, at 480 mg/liter ethephon, increased GA_3 concentration from 50 to 150 mg/liter decreased yields. Average fruit weight and length–diameter ratios were increased by all ethephon + GA_3 combinations, compared to the untreated control. Increased soluble solids and sweetness by 240 mg/liter ethephon + 100 or 150 mg/liter GA_3 combinations were associated with increased fruit weight.**

Ethephon affects the number of fruit produced by cucumber (9), squash (4, 11, 12), and muskmelon (7, 12) primarily by affecting sex expression. Although ethephon treatment can increase yield and enhance ripening, it can also result in unfavorable quality attributes to muskmelon including reduced yields (8, 15), deformed fruit (7), reduction of soluble solids (8, 15), undesirable flavor, and softened fruit (15). GA_3 treatment of cucurbits has been shown to affect sex expression (3, 5, 14) and to enhance fruit size (3). This study was conducted to examine the possible interactive effects of field applications of ethephon and gibberellin mixtures on yield, size, and quality of muskmelon.

Materials and Methods

'Edisto-47' muskmelon plants were grown in plastic trays containing 63 × 58 mm cells filled with Jiffy mix. Four-week

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Table 1. Effects of ethephon and gibberellin on size and yield of muskmelon fruit, 1978.

Ethephon (mg/liter)	GA_3 (mg/liter)	Marketable yield[z]/ha		Fruit	
		MT	No. × 1000	Size (kg/fruit)	Shape (L:D ratio)
0	0	33.8c[y]	30.7b	1.1c	1.15b
0	100	39.1c	21.7c	1.8a	1.30ab
240	0	54.2b	36.1a	1.5b	1.45a
240	100	69.9a	36.8a	1.9a	1.50a

[z]Marketable grade was based on USDA standards for size and quality.
[y]Mean separation in columns by Duncan's multiple range test, 5% level. Interactions are significant at 5% level.

old plants (2 plants/cell) were transplanted 60 cm apart to field plots in rows 180 cm apart. Plots were 12.2 × 1.8 m, separated by an equal area planted with guard rows, but only the midsection of each plot measuring 9.2 × 1.8 m and containing 30 vines was used for data collection. Plants were initially sprayed with aqueous solutions of various concentrations of ethephon (Ethrel formulation) and GA_3 (Gib-Sol) at the 3–4 true leaf stage. Two additional applications were made at weekly intervals. All solutions contained 0.1% Tween-20 surfactant. The 1978 experiment examined the effects of 240 mg/liter ethephon and 100 mg/liter GA_3 applied separately and in combination. Two other experiments (1979, 1980) tested the combinations of 120, 240, and 480 mg/liter ethephon with 50, 100, and 150 mg/liter GA_3. Each experiment was a randomized complete block with 3 replications. In all experiments, fruit from each plot were harvested at about half-slip stage at the intervals of 98, 105, and 112 days from transplanting.

Grading was done according to USDA size and quality standards for fresh market. Marketable fruit were counted, weighed, and measured for polar length to equatorial diameter (L:D) ratios. Soluble solids content (SSC) was determined by a refractometer. Sensory evaluation for sweetness was conducted by a 5-member panel after holding the fruit 3 days from harvest at room temperature.

Results and Discussion

In 1978, ethephon at 240 mg/liter increased while 100 mg/liter GA_3 decreased the number of marketable fruit compared to the untreated control (Table 1). However, when GA_3 was applied with ethephon, the number of fruit produced was the same as for the ethephon alone. This may have been due to the predominant effect of ethephon on increased femaleness in the treated plants. Fruit weight increases by ethephon + GA_3 application over the untreated control were attributed to an increased number of fruit by ethephon and increased size by GA_3. Thus, the highest fruit yield (MT/ha) was produced by ethephon + GA_3 in combination.

In 1979, interactions of ethephon + GA_3 combination effects on fruit size, yield, and quality were significant (Table 2). Total number and weight of marketable fruit were increased over those of the untreated control when treatment combinations included 120 or 240 mg/liter ethephon. But, treatments containing 480 mg/liter ethephon + 100 or 150 mg/liter GA_3 reduced total fruit number and weight.

At 120 mg/liter ethephon concentration, increasing GA_3 from 50 to 100 mg/liter had no effect on number of fruit produced or its total weight (Table 2). However, further increase in GA_3 concentration increased fruit yield over that of the 120 mg/liter ethephon + 100 mg/liter GA_3 treatment. The higher fruit yield (MT/ha) over that of the control was attributed to the increased fruit number by ethephon and the increased fruit size (kg/fruit) induced by GA_3.

At 240 mg/liter ethephon, increasing GA_3 from 50 to 100 mg/liter had no effect on fruit number but increased total fruit weight (Table 2). This net increase in yield is attributed to an increase in fruit size. As GA_3 concentration increased to 150 mg/liter,

Table 2. Effects of ethephon and gibberellin combinations on yield, size, shape, and quality of muskmelon fruit, 1979.

Treatment		Marketable yield[z]/ha		Fruit		Soluble solids (%)
Ethephon (mg/liter)	GA_3 (mg/liter)	MT	No. × 1000	Size (kg/fruit)	Shape (L:D ratio)	
0	0	32.1d[y]	22.9c	1.4c	1.2b	8.2b
120	50	45.1bc	26.5ab	1.7bc	1.4ab	8.1b
	100	42.3c	23.5bc	1.8b	1.4ab	7.3c
	150	63.8a	31.9a	2.0a	1.4ab	7.7bc
240	50	50.9b	28.3ab	1.8b	1.4ab	7.4c
	100	64.9a	29.5ab	2.2a	1.4ab	8.8a
	150	44.6bc	22.3c	2.0a	1.4ab	8.9a
480	50	39.3c	18.7c	2.1a	1.4ab	7.6c
	100	25.4e	12.7d	2.0a	1.3ab	6.8d
	150	24.0e	12.0d	2.0a	1.5a	8.0b

[z]Marketable grade was based on USDA standards for size and quality.
[y]Mean separation within columns by Duncan's multiple range test, 5% level. Interactions are significant at 5% level.

total number of fruit was reduced to the same level as in the control. Total weight remained higher than that of the control but decreased from the 240 mg/liter ethephon + 100 mg/liter GA_3 treatment level.

The 480 mg/liter ethephon + 50 mg/liter GA_3 applications did not affect the number of marketable fruit, but increased fruit size, resulting in a higher total weight over that of the control (Table 2). Increasing GA_3 concentrations to 100 or 150 mg/liter reduced total fruit number and weight. Increased fruit size by these higher GA_3 concentrations was not sufficient to offset the reduction in the number of fruit produced.

In 1980, the effects of 120 mg/liter ethephon + 100 mg/liter GA_3 combination on size and yield were of a different magnitude than that in 1979 (Table 3), but the general trend of increased fruit number and weight as ethephon concentrations increased from 0 to 120 and 240 mg/liter in 1980 was similar to that of 1979. At 240 mg/liter ethephon, increasing levels of GA_3 from 100 to 150 mg/liter reduced fruit number to that of the untreated control. However, increased fruit size by 240 mg/liter ethephon + 150 mg/liter GA_3 resulted in a higher yield (MT/ha) than that of the control. In all experiments, the 240 mg/liter ethephon + 100 mg/liter GA_3 treatments consistently increased the fruit size and total yield (Tables 1, 2, 3). It appears from these tests that GA_3 was the predominant factor in increasing fruit weight.

In all experiments, weight increases due to higher ethephon–GA_3 levels were associated with increased fruit length to diameter (L:D) ratios (Tables 1, 2, 3). Applications of 100 mg/liter GA_3 alone (Table 1) gave L:D ratios smaller to those of the untreated control. Applications of 240 mg/liter ethephon alone resulted in higher L:D ratios compared to those of the control, indicating that ethephon was mainly responsible for fruit elongation. This is in agreement with reports showing that the L:D ratio of cucumber fruit was increased when plants were treated with 250 mg/liter ethephon (2, 8). However, the applications of GA_3 with ethephon further enhanced fruit length.

Although the interactive effects of ethephon and GA_3 on soluble solids content (SSC) were significant, there was no definite trend in response to the treatments (Tables 2, 3). However, in 1979 and 1980, SSC levels were lower than those of the untreated control when 100 mg/liter GA_3 was used in combination with 120 mg/liter ethephon, and no further increase occurred when GA_3 concentrations increased from 100 to 150 mg/liter. In both seasons, the 240 mg/liter ethephon + 150 mg/liter GA_3 treatments produced the highest SSC (Tables 2, 3). There was an apparent trend toward reduction of SSC levels as ethephon concentrations were increased. These results agree with those of earlier reports (8, 15) which showed a significant reduction of SSC of muskmelons treated with ethephon. The increased soluble solids due to higher levels of ethephon + GA_3 may indicate that GA_3 either influenced the process of the sugar accumulation, which is known to be associated with SSC levels (1), or it reversed the effect of ethephon, which tends to reduce the SSC of the fruit (8, 15). Melons from the untreated plants harvested at half slip in 1979 and 1980 had SSC of 8.2 and 8.5%, respectively. However, earlier studies (10, 13) indicate that melons of 'Edisto-47' harvested at full slip had SSC of 10.1 and 11.0%. Evidently, the lower levels of soluble solids in this study are attributed to the stage of maturity at harvest. Gilbart and Dedolph (6) reported that SSC for melons at half slip were 3% less than SSC for melons at full-slip maturity.

In the 1980 experiment, a taste panel scored fruits of untreated control slightly above average, compared to those treated with 120 mg/liter ethephon + 100 or 150 mg/liter GA_3 (Table 3). Fruits produced by plants treated with 240 mg/liter ethephon + 100 mg/liter GA_3 scored in sweetness equivalent to those of the control, whereas the fruit produced by 240 mg/liter ethephon + 150 mg/liter GA_3 scored the highest. The sweetness scores were directly correlated ($P \leq 1\%$) with SSC values found for the same treatments (Table 3). Unlike rapid softening of fruit treated with the ethephon alone reported earlier (15), the combined ethephon + GA_3 treatments in these tests produced firmer fruit. This suggests that the GA_3 effect may have inhibited or slowed down the ripening process which is usually hastened by ethephon treatments. Delay in maturity and persistence of green coloration in the subepidermal layers of fruit treated with higher concentrations of ethephon + GA_3 were observed throughout this study. These observations were associated with increased fruit weight, higher SSC, and higher sweetness scores.

Results of these field experiments carried out in 3 seasons indicate that a mixture of 240 mg/liter ethephon + 100–150 mg/liter GA_3 applied to 'Edisto-47' muskmelon plants increased the total fruit number and weight. These results were probably due to the well-known effects of ethephon in increasing femaleness in cucurbits supplemented by the effects of GA_3 in enhancing fruit growth and development. The inclusion of GA_3 with the ethephon treatments prevented any deformities, reduction of fruit size, or reduction of quality attributes which are known to be associated with ethephon treatments of cucurbits. These results suggest that 'Edisto-47' muskmelon, which has good shipping quality, powdery mildew and alternaria resistance, large fruit, and good fresh color, can be im-

Table 3. Effects of ethephon and gibberellin combinations on yield, size, shape, and quality of muskmelon fruit, 1980.

Treatment		Marketable yield[z]/ha		Fruit		Soluble	
Ethephon (mg/liter)	GA_3 (mg/liter)	MT	No. × 1000	Size (kg)	Shape (L:D ratio)	solids (%)	Sweetness[x] scores
0	0	71.6c[y]	39.8bc	1.8b	1.1b	8.5b	4.2b
120	100	77.8bc	41.0b	1.9b	1.3ab	7.5c	3.4c
	150	73.5c	36.7c	2.0ab	1.3ab	7.7c	3.5c
240	100	112.6a	51.2a	2.2a	1.3ab	8.7b	4.3b
	150	91.1b	43.4b	2.1a	1.4a	9.6a	4.8a

[z]Marketable grade was based on USDA standards for size and quality.
[y]Means in columns followed by the same letter are not significantly different; Duncan's multiple range test, 5% level.
[x]Taste panel evaluations, 1–5 scale (1 = mildly sweet, 3 = moderately sweet, 5 = highly sweet).

proved in quality (flavor and sweetness) by applications of GA_3 + ethephon.

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Simulated Acid Rain Effects on Zinnia as Influenced by Available Nutrients[1]

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Abstract. **Greenhouse-grown plants of *Zinnia elegans* Jacq. were exposed to simulated sulfuric acid rain 30 minutes per day twice a week for 6 weeks at pH 2.8, 4.0, and 5.6. Injury occurred primarily to older, mature leaves and cotyledons at pH 2.8 and 4.0 and to ray flowers at pH 2.8. Plants supplied with higher levels of Hoagland's nutrient solution grew more rapidly, contained greater quantitities of foliar K, P, and Ca, and exhibited more foliar injury after exposure to acidic simulated rain (SR). Dry weight of plants given full-strength nutrient solution (highest level) was depressed at pH 2.8 and increased at pH 4.0 relative to pH 5.6. Loss of ^{86}Rb by leaching from foliage was significantly increased at pH 2.8, but no differences in total foliar content of K, P, and Ca were detected.**

Twenty years ago acid rain in the United States occurred primarily in the Northeast. Since that time the area exposed to acid rain has increased, expanding both southward and westward (1). At present, the annual average acidity of rain and snow falling on most of the northeastern United States is about pH 4.0 (16). The effects of acid rain on plants in nature are unknown. Potential effects suggested by studies under simulated conditions are injury to surface structures (2, 3, 9, 11), altered rates of growth (6, 9, 14), and accelerated leaching of substances from foliage (7, 9, 22). Most of these studies have dealt with agronomic, forest, and vegetable crops with little or no emphasis placed on horticultural plants. Results were occasionally inconsistent, particularly in regard to the foliar leaching of K. Both increased (22) and decreased (7) leaching of K, and no change in foliar concentrations of K (9) have been reported in plants exposed to acidic SR.

Numerous reports exist of nutritional influences on a plant's response to other stress factors. These include sensitivity to insect pests (23), pathogens (8), low (18) and high (20) temperatures, and water stress (13). However, previous studies have not reported the influence of available nutrients on plant sensitivity to acidic SR. The objective of this study was to determine the response of *Zinnia elegans*, a commonly planted horticultural annual, to acidic SR when plants were supplied with different

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