Effect of Season and Growth Regulators on Flowering, Fruit-Set and Development of the Tomato[1]

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ABSTRACT

Two tomato varieties, Floralou and Marglobe, were treated with spray applications of N-m-tolylphthalamic acid at 0, 100, 200, and 300 p/m, and b-naphthoxyacetic acid at 0, 15, 25 and 35 p/m starting at anthesis for six consecutive weeks, totalling six applications. Flowers and quiescent fruits were more abundant during the summer but yield was lower. Growth regulators affected neither flowering nor number of quiescent fruits, but depressed yields. Winter was the best yielding season, although it was the poorest in flowering. B-naphthoxyacetic acid resulted in increased fruit size at the two higher concentrations. Seedless fruits of good quality were produced at the higher concentrations during summer and autumn. Results indicate that flower abscission is not a limiting factor under the conditions of this research.

INTRODUCTION

Theoretically, tomatoes can be planted throughout the year in Puerto Rico, but actually they are planted during the drier months of winter and early spring. There are strong indications that high temperature and high humidity during the summer months (June to September) are unfavorable to tomato production (22). Hemphill and Murneek (7) concluded that the production of greenhouse tomatoes during winter was not as good as production under similar conditions in the spring and early summer. The growth regulator was best utilized when the amount of light was limited.

A major contribution to the understanding of fruit-set was made by Gustafson (5) in 1936, using indolebutyric acid. He showed that in some plants the application of auxins could bring about fruit-set even without pollination.

Since the work of Gustafson, many growth regulators have been used in an attempt to overcome environmental and internal factors involved in flower formation and fruit-set in the tomato.

Moore and Thomas (15) associated the remarkable increase in early yields with either the application of 25 p/m of p-chlorophenoxyacetic acid or the reduction of light intensity when temperature was above the optimum fruit setting range, or both. Moore (14) also found an increase of 38% over the control in total yield.

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Howlett (8) proved that indolebutyric acid is very effective in increasing the number and size of tomatoes. The fruits produced with this treatment developed a gelatinous pulp within the locules where seeds were lacking. Unfilled locules resulted in hollow cavities. Further studies (9) proved that this chemical is more effective during low light intensities. Howlett (10) also found premature softening with different growth regulators.

Murneek et al. (18) reported that p-chlorophenoxyacetic acid and b-naphthoxyacetic acid improved fruit-set in greenhouse tomatoes. They obtained increased yields and no malformation using 20 p/m of b-naphthoxyacetic acid as a whole-plant spray. Further investigation showed that b-naphthoxyacetic acid and p-chlorophenoxyacetic were not effective in increasing yields when light was adequate (17). Moreover, b-naphthoxyacetic acid was better as a whole-plant spray as compared to single cluster spray. Other workers (6, 31, 32, 33, 34, 35) have found this chemical a promising one to increase fruit-set.

Mullison and Mullison (16) increased yields and fruit size with 75 p/m of p-chlorophenoxyacetic and 100 p/m of b-naphthoxyacetic acid. Differential response to the growth regulators among varieties was observed.

Hemphill (6) studied the effect of a-naphthaleneacetic acid, b-naphthoxyacetic acid and p-chlorophenoxyacetic acid at different stages of development of the tomato flowers. Pre-anthesis treatment reduced fruit-set and fruit size, but most fruits were seedless and misshapen. Treatments at anthesis increased fruit-set and fruits were seedless or only partially so. The average fruit size was enlarged by b-naphthoxyacetic acid and p-chlorophenoxyacetic acid, while a-naphthaleneacetic acid reduced it. Sprays applied 4 days after anthesis resulted in the highest yield.

Mann and Minges (12) increased fruit-set with b-naphthoxyacetic acid, p-chlorophenoxyacetic acid, 2,4-dichlorophenoxyacetic and a combination of these chemicals. More than one application of these were injurious to the foliage.

Hemphill (6) increased fruit size with b-naphthoxyacetic acid and p-chlorophenoxyacetic acid. Plants sprayed 4 days after anthesis gave the highest yields. Singletary and Warren (23) increased early yield, but not total yield, with whole-plant sprays of p-chlorophenoxyacetic acid and b-naphthoxyacetic acid.

Garcidueñas and Robles (4) reported that sprays at the bud stage and at anthesis induced 20 and 75%, respectively, of the total number of flowers to set fruit, while setting of the control was only 6%. Chapman and Acland (1) could not produce out-of-season tomatoes in Trinidad with applications of b-naphthoxyacetic acid and sucrose.

Wittwer and Teubner (33) increased the number of flowers by spraying the tomato plants at the cotyledon stage with 200 p/m of N-m-tolylphthalamic acid. They stated that N-m-tolylphthalamic acid is a flowerforming, not a fruit-setting chemical. Teubner and Wittwer (25) increased the number of flowers and fruits using N-m-tolylphthalamic acid as a foliage spray on plants treated 9 to 12 days after cotyledon expansion, obtaining the maximum number of flowers in the first cluster. Moore (14) used whole-plant sprays of N-m-tolylphthalamic acid, increasing yields by 80% over the control; the effect on fruit size, however, was not consistent.

Cordner and Hedger (2) obtained more determinate tomato plants and increased the number of flowers with foliage sprays of 400 p/m of N-m-tolylphthalamic acid in single and multiple applications.

Leopold and Scott (11) observed that the failure of flowers to set fruit is usually expressed in two ways: either the flower abscisses or the sepals enlarge and remain attached to the plant with the tiny ovary in a static condition. They found that the underdevelopment of the ovaries was due to an insufficient supply of nutritive materials and not to the lack of growth regulators.

It is unknown whether the effect of season actually reduces the number of flowers or whether it affects pollination, fruit set, or the subsequent development of the fruits. The present study deals with the response of tomatoes to two growth regulating substances when applied to the foliage of two tomato varieties grown during four consecutive seasons. This should give some indication as to the apparent reasons for making one variety more productive than another in the Lajas Valley. It should also indicate whether flowering, fruit-set, or both, have any direct bearing on differentials in production between Marglobe, a poor variety at Lajas, as compared to Floralou, a good variety (21).

MATERIALS AND METHODS

The gravel culture facilities at the Lajas Substation were used for this study. The unit consists of 14 concrete beds one foot deep, 3.5 feet wide and 50 feet long. Each bed is equipped with an 800-gallon tank and a suction pump.

A factorial experiment in a split-plot design was used. Treatments were replicated three times, with varieties assigned to main plots and growth-regulating chemicals to subplots. Each subplot consisted of eight plants spaced 1.5 feet by 2.5 feet. There were 64 plants in each main plot. Six beds were used during each planting season. The beds were sterilized before each planting with a 39% formaldehyde solution, 1:100.

The two varieties used, Floralou and Marglobe, were direct-seeded and thinned out to leave one plant per hill. Plants were pruned to one stem, staked and sprayed regularly for insect and disease control whenever needed.

During the first week after planting, one pound of ammonium sulfate was added to the 800 gallons of water, after which a complete nutrient solution (30) was used for irrigation (table 1). The beds were flushed three times daily and the tanks were maintained at full capacity at all times. The nutrient solution was corrected weekly for available nitrogen, phosphorus, potash, magnesium, calcium and active acidity. The pH was maintained at 6.5 during the growing period and the whole nutrient solution was replaced three months after planting.

The treatments consisted of N-m-tolylphthalamic acid (NMTA) at 100, 200, and 300 p/m, and beta naphthoxyacetic acid (BNA) at 15, 25, and 35 p/m. Two checks were used, one for each growth regulator, making a total of eight treatments. An aqueous solution of the chemicals

TABLE 1.—*Nutrient solution used for the hydroponic tanks*[1]

Salt	p/m	Lb of salt/80 gal H_2O
KNO_3	7145 NO_3	7.77 lb
	4505 K	
$Ca(H_2PO_4)_2$	2721 H_2PO_4	2.19 lb
	562 Ca	
$CaSO_4$	1596 Ca	5.40 lb
	3824 SO_4	
$MgSO_4$	1103 Mg	3.70 lb
	4357 SO_4	
Fe(chelated form)	—	23.0 g
$MnSO_4 \cdot 4H_2O$	2 Mn	2.0 g
	3 SO_4	
$Na_2B_4O_7 \cdot 10H_2O$	27 Na	69.0 g
	93 B_4O_7	
$CuSO_4 \cdot 5H_2O$	0.2 Cu	0.2 g
	0.2 SO_4	
$ZnSO_4 \cdot 7H_2O$	0.3 Zn	0.40 g
	0.4 SO_4	

[1] Following the formula of Withrow and Withrow (30).

was used as a whole-plant spray, using a 1.5-gallon hand sprayer. The first application was made at anthesis of the first flower cluster, followed by a weekly application for a total of 6 weeks. To minimize drift, two plywood boards were used between plots while spraying.

Eight of the most revealing of the 35 attributes studied during the growing and harvesting periods are fully discussed for a clearer over-all picture of this research. Data for eight variants—number of flowers, developed fruits, quiescent fruits, total yield, marketable yield, average weight of marketable fruits, culls, and seedless fruits—were recorded up to the fifth cluster. Quiescent fruits were those undeveloped, unabscissed ovaries (3), which attained some growth but not enough to be classified as a fruit. Fruits were picked mature green and graded into marketable fruits and culls (less than 0.1 lb). Half of the fruits were cut transversally to take seed counts.

Four experiments were planted, one in each planting season, starting May 24; August 24; November 24, 1966; and the last, February 24, 1967. Data for the entire period of the experiments covering temperature, atmospheric humidity, evaporation, rainfall and solar radiation were obtained from the adjacent Weather Bureau Station (table 2).

Statistical analysis of the experimental data as described by Steel and Torrie (24) was made for each experiment, as well as combined analysis to determine the average treatment response over all planting seasons. The Duncan multiple range test to detect differences among treatments was used when the F-test showed significance.

TABLE 2.—*Monthly means of climatic factors at Lajas Substation*[1]

Month	Temperature F°		Rainfall	Evaporation	Air Humidity[2]	Wind Movement M/h
	Max.	Min.				
			In	*In*	%	
January	86.00	60.80	2.17	4.97	74.53	1.57
February	86.33	60.67	1.26	5.74	74.24	2.13
March	87.60	61.53	1.89	7.57	69.41	2.41
April	88.13	64.40	3.60	7.62	68.31	2.58
May	88.93	67.60	3.50	7.74	72.00	2.75
June	90.40	68.80	2.41	7.74	60.09	2.93
July	91.00	67.93	4.08	7.99	63.13	2.60
August	90.47	68.13	5.92	6.83	67.93	2.03
September	89.53	68.73	6.98	5.87	70.98	1.55
October	88.13	67.47	5.38	5.44	72.27	1.32
November	88.28	65.07	3.92	4.74	67.63	1.06
December	86.80	62.27	2.95	4.42	81.36	1.24

[1] Data covers a span of 15 years for temperature; 20 years for rainfall; 18 years for evaporation; 1 year for air humidity; 12 years for wind movement.

[2] Average of three daily readings (8:00 a.m.; 12:00 noon, and 4:00 p.m.)

RESULTS AND DISCUSSION

FLOWERING

The only significant difference among treatments occurred during summer with the application of 200 p/m of NMTA which resulted in 660 flowers against 543 for the 300 p/m treatment in the Floralou variety (table 3). The variety × treatment × season for the whole year interaction was highly significant. Marglobe produced significantly more flowers than Floralou, 381 vs. 339, in terms of average flowering for the four planting seasons (table 3). The interaction variety × season was highly significant, indicating that the relative superiority of Marglobe varied with season, from only 3% in winter to 17% in autumn. Overall seasonal averages—season exclusive of varieties and treatments—shows that the total number of flowers, 512, was greatest in summer. The difference in flowering between summer and each of the other seasons was highly significant. Flowering in autumn, when compared to flowering in each of the other two seasons, spring and winter, differed significantly. Winter and spring flowering did not differ significantly.

The great blooming capacity of Marglobe over Floralou in autumn and spring can be explained only by varietal differences. This same varietal difference accounts for other variants such as developed and quiescent fruits, yield, and average weight of fruits. Flowering was decidedly affected by season, summer resulting in the best flowering followed by autumn. Climatic factors, especially light duration and intensity, and temperature did certainly influence the results.

TABLE 3.—*Effect of b-naphthoxyacetic acid (BNA), N-m-tolylphthalamic acid (NMTA) and season on flowering of Floralou (F) and Marglobe (M) tomatoes expressed as average number of flowers per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	399	581	296	373	295	300	293	329	321	396
BNA(15 p/m)	416	578	301	403	271	291	301	303	322	394
BNA(25 p/m)	399	541	306	367	290	287	198	297	298	373
BNA(35 p/m)	422	569	296	332	280	293	293	292	323	371
Control	457	575	320	379	272	293	294	303	336	388
NMTA (100 p/m)	535	517	310	377	287	299	286	325	355	380
NMTA (200 p/m)	660	553	319	366	298	314	289	317	392	388
NMTA (300 p/m)	543	443	340	387	300	281	291	318	368	357
Seasonal mean	479	545	311	373	286	295	281	311	339	381
Over-all Seasonal mean	512		342		291		296		360	

DEVELOPED FRUITS

Independent of varieties, the yearly average of the control, 206 fruits, was superior at the 1% level to 185 fruits of the 35 p/m BNA treatment and significantly superior to 191 fruits of the 25 p/m treatment (table 4). No difference was found between the control and the 15 p/m treatment. A marked and progressive decrease in developed fruits was observed as BNA concentration increased. No significant difference was found in the NMTA treatments. During the individual plantings, only the summer planting showed a significant decrease in the number of fruits as concentration of both growth regulators increased. The significant interaction treatment × season shows the effect of both growth regulators on the number of developed fruits. This effect was markedly depressing in summer. Floralou, with 213 fruits, was superior at the 1% level to Marglobe with 181 in total number of developed fruits during the combined four seasons. Although the number of developed fruits in Floralou was always higher than that in Marglobe during the individual seasons, only in winter and spring was fruit development significantly superior.

The relative superiority of Floralou varied from 8% in autumn to 17% in spring. The overall season averages (table 4) show that 234 developed fruits in winter were superior at the 1% level to 166 in summer and 179 in spring, and significantly superior to 211 in autumn. The autumn planting was the second best, being significantly superior to summer and spring. The superiority of Floralou, when compared to Marglobe may be explained by its ability to set fruit under our environment. Winter was the best season in developed fruits for both varieties. Since light is not a

TABLE 4.—*Effect of BNA, NMTA and season on developed fruit of Floralou (F) and Marglobe (M) tomatoes expressed as average number of fruits per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	196	176	222	211	267	216	208	151	223	189
BNA (15 p/m)	172	165	215	207	245	222	215	149	212	186
BNA (25 p/m)	167	143	226	185	249	204	204	151	212	171
BNA (35 p/m)	143	141	197	188	245	209	201	149	197	172
Control	210	185	237	201	252	215	206	152	226	188
NMTA (100 p/m)	193	159	216	217	254	210	202	144	216	183
NMTA (200 p/m)	150	153	229	187	262	232	209	164	212	184
NMTA (300 p/m)	147	149	232	204	254	200	203	152	209	176
Seasonal mean	172	159	222	200	254	214	206	151	213	181
Over-all Seasonal mean	166		211		234		179		197	

limiting factor at Lajas, temperature remains the most important one, affecting fruit production. Growth regulators had little effect except in the summer when they depressed the number of fruits. Inconsistent results for both growth regulators reported by different authors (2, 4, 6, 7, 12, 13, 16, 17, 19, 20, 23, 25, 26, 27, 31, 32, 33) indicate that these chemicals act differently under different conditions. BNA does not increase yields when light is adequate (17), but it does under high temperature and light intensity (4, 16).

QUIESCENT FRUITS

None of the overall responses nor the responses of the growth regulators during individual seasons were significantly different (table 5). Varietal differences for the growth regulators in the yearly averages were highly significant in summer but not in the other seasons. The interaction variety × treatment × season was highly significant. The overall seasonal average (table 5) shows that 164 quiescent fruits in summer were significantly more at the 1% level than the other three seasons. According to Leopold and Scott (11), quiescent fruits abound after considerable fruit setting has already occurred in the cluster. Our research does not agree with this view, since the lowest number of quiescent fruit, 9, occurred in winter when 234 developed fruits were produced. By the same token, the highest number of quiescent fruits, 164, occurred in summer, when 166 fruits were developed.

Summer, which was the poorest season in developed fruits and total marketable yield, had many quiescent fruits, but it was the best for flowering. Therefore, flower abscission is not a problem at Lajas. Low fruit-set during summer is mainly due to a higher percentage of quiescent fruits since there is no heavy flower abscission during this season. The failure of unabscissed flowers to develop into fruits is due more strictly to a limitation of organic nutrients than to deficiency of growth regulators (11). BNA and NMTA effects were not significant for quiescent fruits; thus, this factor is not limiting under the conditions of this research.

TABLE 5.—*Effect of BNA, NMTA and season on quiescent fruit of Floralou (F) and Marglobe (M) tomatoes expressed as average of quiescent fruits per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	138	176	44	85	9	11	58	93	62	91
BNA (15 p/m)	162	207	47	111	3	12	54	74	67	101
BNA (25 p/m)	137	151	49	89	5	17	51	78	60	84
BNA (35 p/m)	133	140	50	82	4	11	52	76	60	77
Control	147	200	58	91	8	14	53	73	66	94
NMTA (100 p/m)	205	144	58	87	7	10	45	87	79	82
NMTA (200 p/m)	258	129	68	94	10	12	50	72	97	77
NMTA (300 p/m)	213	78	57	91	9	8	48	66	82	61
Seasonal mean	174	153	54	91	7	12	51	77	72	83
Over-all Seasonal mean	164		72		9		64		77	

TOTAL YIELDS

A depressing effect of NMTA on yield is indicated by the combined analysis (table 6). The control, with 52 lb, was superior at the 1% level to the 46 lb of the 300 p/m treatment and significantly superior to the 48 lb of the 200 p/m treatment. During summer the NMTA control with 45 lb was superior at the 1% level to 35 lb of the 300 p/m treatment and significantly superior to the 36 lb of the 200 p/m treatment. No significant difference was found during the other three seasons. Floralou, with 50 lb, was significantly superior to Marglobe with 48 lb in the combined analysis, but not in any of the individual seasons. The 64 lb produced in winter was superior to the 39 lb in summer at the 1% level and significantly higher to production in spring and autumn, with 50 and 43 lb respectively. No difference was found between summer, autumn, and spring. The superiority of Floralou over Marglobe in total yield is due to a higher production of developed fruits, since individual fruit weight was higher in Marglobe than in Floralou. A higher yield was expected in winter when temperatures are moderate and closer to the optimum found by Went (28, 29). The depressing effect of the growth regulators may be attributed to the method of application and the concentration. No precaution was

TABLE 6.—*Effect of BNA, NMTA and season on total yield of Floralou (F) and Marglobe (M) tomatoes expressed as average pounds per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	42	39	52	50	65	66	46	41	51	49
BNA (15 p/m)	42	40	50	55	62	66	48	41	50	50
BNA (25 p/m)	44	37	48	47	61	61	49	39	50	46
BNA (35 p/m)	36	37	46	51	64	66	48	39	49	48
Control	49	42	54	50	64	68	49	40	54	50
NMTA (100 p/m)	43	37	49	52	65	65	45	39	51	48
NMTA (200 p/m)	33	39	50	47	64	68	46	40	48	49
NMTA (300 p/m)	33	37	48	50	62	60	45	38	47	46
Seasonal mean	40	38	50	50	63	65	47	40	50	48
Over-all Seasonal mean	39		50		64		43		49	

taken to avoid the harmful practice (6, 17) of spraying the very young flower buds.

MARKETABLE YIELD

In the yearly average 48 lb of the control were superior at the 1% level to the 43 lb of the 300 p/m NMTA treatment, and significantly superior to the 44 lb of the 200 p/m concentration. No significant difference was found between the control and the 100 p/m treatment. Variety × treatment interaction was significant during the summer. In the summer the 42 lb of the control were significantly superior, at the 1% level, to the 30 and 32 lb of the 300 and 200 NMTA p/m concentration, respectively. Neither the growth regulator effects in autumn, spring, and winter nor the 100 p/m treatment showed significant differences over the control.

Floralou, with 47 lb was superior to Marglobe with 45 lb at the 5% level in the yearly average but not in the individual seasons. The winter planting with 64 lb was superior at the 1% level to each of the other three seasons (table 7). No significant difference was found among the other three seasons. Floralou proved to be better adapted than Marglobe to the conditions under which the experiment was conducted. The winter season was the most adequate for the production of marketable fruit, yielding 30.7 tons/acre with 7,680 plants. The production of profitable yields in other seasons indicates that tomatoes can be planted throughout the entire year. The poorest season, summer, yielded 17.6 tons/acre for Floralou and 16.5 for Marglobe.

WEIGHT OF MARKETABLE FRUITS

Marglobe, with 0.30 lb was superior at the 1% level to Floralou with 0.25 lb in the yearly mean weight of fruits as well as in autumn (table 8).

TABLE 7.—*Effect of BNA, NMTA and season on marketable yield of Floralou (F) and Marglobe (M) tomatoes expressed as average pounds of marketable fruits per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	38	36	49	46	65	66	44	36	48	45
BNA (15 p/m)	50	37	47	51	62	66	45	37	48	47
BNA (25 p/m)	43	33	45	43	61	61	46	35	48	42
BNA (35 p/m)	34	33	44	47	64	66	45	37	47	45
Control	46	39	51	46	64	68	46	35	51	46
NMTA (100 p/m)	40	34	47	48	65	65	42	35	48	45
NMTA (200 p/m)	29	36	48	43	64	68	42	35	45	44
NMTA (300 p/m)	30	31	45	45	62	60	42	35	44	42
Seasonal mean	37	35	47	46	63	65	44	35	47	45
Over-all Seasonal mean	36		47		64		40		46	

No significant difference was found between the individual seasons. In the yearly average, 35 p/m of BNA increased significantly the average weight of marketable fruits from 0.27 lb of the control to 0.29 lb, averages of the two varieties (table 8). NMTA failed to promote this increment in weight. Marglobe produced a bigger fruit, a varietal character not affected by season. Fruit size was not affected by season but was improved with BNA, a finding which agrees with previous findings (6, 16).

WEIGHT OF CULLS

Marglobe, with 3.72 lb, was significantly inferior to Floralou with 2.82 lb in total weight of culls (table 9). Marglobe was also significantly a higher producer than Floralou in autumn, but not in the other seasons.

TABLE 8.—*Effect of BNA, NMTA and season on weight of individual marketable fruit of Floralou (F) and Marglobe (M) tomatoes, based on average production in pounds per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	.25	.26	.25	.26	.26	.32	.26	.32	.25	.29
BNA (15 p/m)	.26	.27	.25	.29	.26	.32	.26	.33	.26	.30
BNA (25 p/m)	.27	.27	.23	.27	.26	.32	.27	.30	.26	.29
BNA (35 p/m)	.27	.28	.25	.30	.27	.34	.27	.32	.27	.31
Control	.24	.28	.25	.28	.26	.33	.27	.32	.26	.30
NMTA (100 p/m)	.25	.26	.25	.28	.27	.33	.25	.31	.26	.29
NMTA (200 p/m)	.25	.28	.24	.27	.26	.31	.25	.30	.25	.29
NMTA (300 p/m)	.24	.28	.23	.28	.26	.32	.26	.31	.25	.29
Seasonal mean	.25	.27	.24	.28	.26	.32	.26	.31	.25	.30
Over-all Seasonal mean	.26		.26		.29		.29		.27	

TABLE 9.—*Effect of BNA, NMTA and season on culls of Floralou (F) and Marglobe (M) tomatoes expressed as pounds per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	4.03	3.68	2.70	3.87	2.43	2.77	2.57	4.03	2.93	3.58
BNA (15 p/m)	2.40	3.43	3.00	4.20	2.50	2.67	2.63	4.03	2.63	3.58
BNA (25 p/m)	1.63	3.57	2.90	3.63	3.23	2.07	2.10	3.70	2.47	3.24
BNA (35 p/m)	1.83	3.70	2.37	3.90	1.97	4.03	2.47	4.10	2.16	3.93
Control	2.80	4.20	2.77	3.70	1.80	2.53	2.83	4.77	2.55	3.80
NMTA (100 p/m)	3.27	3.10	2.73	3.80	3.50	2.53	2.50	3.80	3.00	3.31
NMTA (200 p/m)	4.23	3.82	2.33	3.40	3.40	4.10	3.80	4.50	3.44	3.95
NMTA (300 p/m)	3.13	5.13	3.63	4.90	3.23	2.97	3.37	4.30	3.34	4.32
Seasonal mean	2.92	3.83	2.80	3.92	2.76	2.96	2.78	4.15	2.82	3.72
Over-all Seasonal mean	3.71		3.36		2.86		3.47		3.26	

The interaction variety × treatment was significant in summer and winter. Marglobe produced more culls than Floralou because of heavy loss of fruits with blossom end rot, a condition more pronounced during autumn.

SEED FORMATION

Both growth regulators stimulated the production of seedless fruit. This effect was highly significant in the overall response and during summer and autumn. There was no significant effect of the growth regulators in winter and spring. Considering the yearly average, the 25 and 35 p/m of BNA were superior at the 1% level and the 15 p/m at the 5% level as compared to the control. The same effect was noticed during summer and autumn.

The 200 and 300 p/m treatments of NMTA were superior at the 1% level, and the 100 p/m at the 5% level, to the control. During summer and autumn the higher concentrations were significantly superior to the lower ones. A significant interaction treatment × season occurred.

Seed formation was equally affected by the treatments in both varieties. Fruits varied from completely seedless to few seeded for the growth regulator treatments. The summer planting with 21 seedless fruits was superior at the 1% level to each of the other three seasons. There was no difference between autumn, spring and winter (table 10).

Seedlessness is due to a lack of fertilization, but the fruit is developed because of the stimulating effect of the growth regulators, which supply the effect of pollination and fertilization. Seedless fruits appeared normal, with the cavities filled with gelatinous pulp. During summer and autumn, growth regulators increased the number of seedless fruits. An interaction may be possible between the growth regulators and the higher temperatures in summer and autumn (table 1), especially during the application period from the fifth to the tenth week after planting.

TABLE 10.—*Effect of BNA, NMTA and season on seed formation of Floralou (F) and Marglobe (M) tomatoes expressed as seedless fruits per plot*

Treatment	Summer		Autumn		Winter		Spring		Mean	
	F	M	F	M	F	M	F	M	F	M
Control	10	3	0	2	0	0	0	0	3	1
BNA (15 p/m)	16	22	7	7	1	0	2	1	6	8
BNA (25 p/m)	13	28	10	10	1	0	2	2	7	10
BNA (35 p/m)	23	26	9	11	1	0	1	1	9	10
Control	4	8	1	1	1	1	2	0	2	2
NMTA (100 p/m)	20	26	6	5	2	1	2	2	7	8
NMTA (200 p/m)	26	42	5	10	2	1	1	0	9	13
NMTA (300 p/m)	26	42	3	9	1	0	2	1	8	13
Seasonal mean	17	25	5	7	1	0	2	1	6	8
Over-all Seasonal mean	21		6		1		1		7	

RESUMEN

Dos variedades de tomate y dos reguladores de crecimiento a tres concentraciones se probaron en cuatro estaciones sucesivamente durante un año, empezando en verano. Las variedades Marglobe y Floralou florecieron profusamente en las cuatro estaciones, pero la más florífera fue la del verano. Los reguladores de crecimiento no afectaron la floración. La abscisión de la flor no parece ser un factor limitativo para la producción del tomate en Lajas. La variedad Floralou fue superior a la variedad Marglobe en rendimiento total. La limitación en la producción durante el verano, y hasta cierto punto en primavera y otoño se asocia con el gran número de frutas en estado latente. Según demuestra este estudio la mejor época para la siembra del tomate en Lajas es en los meses de diciembre, enero y febrero, aunque también se consiguieron buenos rendimientos el resto del año.

Los ácidos b-naftaloxiacético (BNA) y N-m-tolilftalámico (NMTA)—los dos reguladores de crecimiento usados en este estudio—disminuyeron el número de frutas en el verano. Con la aplicación de 35 ppm de BNA se logró un incremento del peso individual del tomate comercial. La pudrición apical causó un alto numero de frutas desechables en la variedad Marglobe. Los reguladores de crecimiento BNA a 25 y 35 ppm el NMTA a 200 y 300 ppm indujeron la frutación sin semillas, de buena calidad, en el verano y otoño.

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