Vegetable Section

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INDUCTION OF BULBING IN ONION BY ETHEPHON[1]

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Abstract. **When grown under Florida conditions during the winter, onions require up to 6 months to mature. Research was conducted to promote, with ethephon, earlier bulbing of onions grown under short photoperiods and to inhibit seed stalk development. In the first year, several onion (*Allium cepa* L.) cultivars were seeded in the field at Gainesville, Florida on September 10, October 12, November 18, February 10, and March 1. Ethephon was applied from 1 to 3 times at different concentrations after danger of frost was past in the spring or after the plants had at least 6-true leaves. Averaged over all the bulb index (bulb-to-stem diameter ratio) was increased in the September planting by 3 applications of the 1000 or 3000 ppm ethephon, however, individual bulb weights were reduced by all ethephon concentrations. Total marketable yields were also reduced at these ethephon concentrations and the incidence of rotten and cull bulbs increased at all ethephon rates, although not always significantly. Flower stalk initiation was severe on the controls of several of the cultivars grown in this planting. Ethephon retarded flower stalk initiation after floral induction. Similar effects of ethephon on bulb yields were noted from the October and November planting dates. Bulb indexes from the November planting date were significantly improved by ethephon. On the later 2 planting dates lower rates of ethephon were used in order to avoid the high incidence of rotten bulbs. Yields were not improved by any concentration of ethephon.**

In a second year of experiments, ethephon improved yields of a late planting of 'Grano' onions, but did not increase yields in an earlier planting. The amount of cull bulbs were increased in the early planting by ethephon.

Onion bulb production presents Florida growers several problems which, in many cases, has limited their acceptability as a crop. Field curing has long been a problem, although recently, many growers have sold their crop for immediate fresh market or for fresh processed sales, thus avoiding curing (5). Bolting can also be a problem, especially when onions are planted in early fall during warm weather and the plants are subsequently subjected to cold or freezing temperatures during the winter months. When grown in Florida during the winter, onions require 6 to 7 months to mature. The price of bulb onions can vary greatly and is dependant on the supplies of stored and new onions from other areas such as Texas. Thus, timing of harvest is important.

In 1970, Levy and Kedar (6), first reported that ethephon, a compound that releases ethylene, induces bulbing in onions grown under noninductive photoperiods. Subsequent reports (7, 8, 9) have shown that timing and proper concentration are critical for ethephon to work effectively to increase bulb size and yields.

When looking for growth regulators that would induce bolting in onions grown for seed production, Corgan and Montano (3) found that 2 applications of 2500 ppm ethephon reduced bolting from 42% in the control to 11% in the treated plants. The objective of these experiments was to promote earlier bulbing of onions grown under unfavorable photoperiod and to inhibit seed stalk development with ethephon. Ethephon was applied to several cultivars at different concentrations and applications times in order to more clearly determine cultivar seasonal responses to the chemical, under Florida conditions.

Materials and Methods

In the first experiments, several onion cultivars (*Allium cepa* L.) were seeded directly in the field with a Stanhay seeder at Gainesville, Florida during 1976 and 1977. 'Dessex', 'Tropicana', 'Yellow Granex', 'White Granex', 'Red Granex', 'Yellow Grano' and 'Red Grano' onions were seeded on September 10, October 12, November 18, and February 10. 'Yellow Grano' and 'Red Grano' were omitted from the October 12 planting and 'Early Premium' was added to the February 10 planting. Only 'Tropicana' and 'Yellow Grano' were seeded on March 1. The seed was obtained from the Dessert Seed Company, El Centro, California.

All plots were irrigated after planting and the production techniques used were those recommended for Florida (5). The individual plots were 8 m long and rows were 1.3 m apart with plants 5 cm apart in the row. Each planting was considered a separate experiment. All experiments were split plots with cultivar being the main plot and ethephon treatment being the subplot. The main plots were arranged in 4 randomized complete blocks and each treatment was replicated 4 times.

Ethephon ((2-chloroethyl) phosphonic acid) was applied with a back-pack sprayer to run off in water containing 0.1% Tween 20 surfactant at concentrations listed in the Tables. Ethephon was initially applied when the plants had at least 6 to 8 leaves. Spray application and harvest dates are listed in Table 1.

At harvest the plants were pulled from the soil and dried in the field for at least 1 week. Bulb to stem diameter ratios were made by measuring both parts on a random sample of 25 plants of each replication. After curing, tops and roots were removed and the bulbs were separated into marketable, cull, or rotten categories and weighed.

In the second experiment, 'Red Grano' and 'Yellow Grano' onions were seeded on October 14 and October 31, 1977 in single rows 1.3 m apart or double rows 30 cm apart on beds 1.3 m apart. The plots were grown and treated similarly to the first experiment. The main plots consisted of cultivars, subplots consisted of number of rows and in-row spacing, and sub-sub-plots consisted of ethephon treat-

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Table 1. Spray application date and time of harvest for onions.

First Experiment: 1976-77					
Planting date	9/10/76	10/12/76	11/18/76	2/10/77	3/1/77
Spray application dates					
Spray No.					
1	3/8	3/29	4/18	5/18	6/1
2	3/18[z]	4/8[z]	4/28[z]	5/27[y]	
3	3/28	4/18	5/10	6/5	
[z] 3000 ppm, single application					
[y] 500 and 1500 ppm, single application					
Harvest date	4/26	5/10	5/13	6/22	6/22

Second Experiment: 1977-78		
Planting date	10/14/77	10/31/77
Spray application dates		
Spray No.		
1	4/10	4/21
2	4/14[x, w]	4/24
3	4/18	4/27[x, w]
4	4/21	5/1
5	4/24[w]	5/4[w]
6	4/27	5/10
[x] 3000 ppm, single application		
[w] 1500 ppm, double application		
Harvest date	5/16	5/28

ment. The subplots were arranged in 4 randomized complete blocks and each treatment was replicated 4 times. Spray application and harvest dates are listed in Table 1. The plants were harvested and data were taken as previously mentioned. For both experiments, only main effects and significant interactions were reported.

Results and Discussion

Averaged over all cultivars multiple applications of ethephon reduced marketable yields of onions planted in September (Table 2). The weights of rotten and cull bulbs were increased by ethephon application, especially when 3000 ppm was applied 3 times. Individual bulb weights decreased when ethephon was applied, although bulb to stem diameter ratios increased. Not all concentrations of ethephon significantly reduced yields of all cultivars, although ethephon did not increase yield in any cultivar (Table 3). The weight of rotten bulbs in the ethephon treated plots was increased in 'Yellow Granex', 'White Granex' and 'Yellow Grano' (Table 4).

This first experiment was initiated during warm weather in September. The 1976-77 winter was one of the coldest in history, and in the spring the check plots had plants which bolted while none of the ethephon treated plants bolted (data not shown). Bolting was not observed in any of the plants from the other planting dates in either year. Corgan and Izquierdo (2) reported that ethephon at 2500 or 5000 ppm reduced bolting when applied in fall or late winter. However, ethephon-treated plots had lower yields when bolting in the control was low because the chemical reduced bulb size (2, 4). Thus, if weather conditions appear favorable for bolting to occur ethephon might be a valuable tool

Table 2. Main effects of ethephon on yield and bulb size of 7 cultivars of onions, September 10, 1976 planting date.

Ethephon (ppm)	Applications (No.)	Yield (Mt/ha) Marketable	Rot	Cull	Bulb size Wt./bulb (g)	Bulb to stem diameter ratio
0	0	17.2a[z]	0.2b	0.4c	297a	5.4b
1000	3	9.9bc	3.4ab	0.9bc	247b	6.3a
3000	1	12.3ab	2.0ab	1.6a	248b	5.9ab
3000	3	6.7c	4.3a	1.1ab	200c	6.3a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 3. Effect of ethephon on yield of marketable bulbs of 7 onion cultivars, September 10, 1976 planting date.

Ethephon (ppm)	Application (No.)	Cultivar Dessex	Tropicana	Granex Yellow	Granex White	Granex Red	Grano Yellow	Grano Red
		Yield (MT/ha)						
0	0	9.9a[z]	11.8a	22.3a	19.1a	18.4ab	27.1a	12.1ab
1000	3	8.0a	6.8b	8.0b	6.9b	14.8b	14.1b	10.1ab
3000	1	8.8a	8.0ab	9.9b	7.4b	20.8a	16.3b	14.3a
3000	3	6.5a	5.1b	6.9b	4.8b	7.8c	8.5c	7.6b

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 4. Effect of ethephon on weight of rotten bulbs of 7 onion cultivars, September 10, 1976 planting date.

Ethephon (ppm)	Application (No.)	Cultivar Dessex	Tropicana	Granex Yellow	Granex White	Granex Red	Grano Yellow	Grano Red
		Yield (Mt/ha)						
0	0	0a[z]	0.1a	0.1c	0.1b	0.4a	0.4c	0a
1000	3	0.9a	1.3a	5.4a	4.5a	2.5a	6.0ab	3.1a
3000	1	0.1a	0.6a	1.2b	5.6a	1.6a	4.1b	1.1a
3000	3	0.6a	1.4a	5.3a	7.2a	4.0a	8.8a	2.7a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

in Florida to decrease the incidence of flower stalk development.

Yields from the October 2 planting were again reduced by ethephon application (Table 5). The weight of rotten and cull bulbs increased. The high incidence of culls resulted from cracking in the outer scales of the bulb during drying. This might have been due to a more rapid drying of the outer bulb leaves due to the effects of ethephon on senescence. This dead tissue appeared to 'pull-away' from the younger unaffected tissue. The exposure of uncured tissue may have resulted in the higher incidence of rot in the ethephon treatments. This problem appeared in all the planting dates and on all the onion cultivars tested. Bubl et al. (1) reported that ethephon increased postharvest disease and sprouting in onions treated 4 to 12 days before they were lifted for curing in the field. They concluded that foliar desiccation from ethephon tends to increase onion decay in storage. In the present experiment, the longer period between application of ethephon and harvest might have further potientiated field pathogen attack.

Table 5. Main effects of ethephon on yield of 5 cultivars of onions, October 12, 1976 planting date.

Ethephon (ppm)	Application (No.)	Yield (Mt/ha) Marketable	Rot	Cull
0	0	12.8a[z]	0.4c	0.2b
1000	3	7.4b	1.6b	1.6a
3000	1	8.7b	1.3bc	1.6a
3000	3	4.7c	2.5a	1.6a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Averaged over all cultivars the single 3000 ppm ethephon treatment had no effect on yield of onions from the November 18 planting, although bulb to stem diameter ratios were significantly improved by this treatment (Table 6). While the other 2 ethephon treatments also improved this ratio, yield was reduced because of more rotten and cull bulbs. Multiple application of ethephon significantly reduced plant heights.

Yields from the last 2 planting dates were extremely low due to the short growing period. Even though the onions were planted late, it was anticipated that the onions might mature rapidly during the late winter and early spring months. This would allow for an extended harvest period if marketable bulb sizes could be obtained. The use of ethephon at lower concentrations on both the February 10 (Table 7) and March 1 (Table 8) planting dates did not increase yields. The weight of rotten bulbs was not significantly increased by ethephon application, possibly because of the lower concentrations used.

In the 1977-78 experiments, in-row plant spacings were varied and ethephon concentrations were lowered to determine if the incidence of rotten bulbs after ethephon treatment could be reduced. Yields from double rows were significantly higher than from single rows in the October 14

Table 7. Main effects of ethephon on yield of 8 cultivars of onions, February 10, 1976 planting date.

Ethephon (ppm)	Application (No.)	Yield (Mt/ha) Marketable	Rot	Wt/bulb g
0	0	2.2a[z]	0.9a	198a
500	3	2.5a	1.3a	271a
500	1	2.5a	0.9a	196a
1500	1	2.2a	1.6a	304a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 8. Main effects of ethephon on yield of 2 cultivars of onions, March 1, 1976 planting date.

Ethephon (ppm)	Yield (Mt/ha) Marketable	Rot
0	4.0a[z]	0.9a
50	3.8a	1.8a
125	4.3a	1.6a
250	3.4a	1.8a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

planting date (Table 9). The quantity of cull and rotten bulbs was generally higher in the plots with double rows than single rows, regardless of in-row spacing. Individual bulb weights and plant lengths were also higher in the double rows. Ethephon had no significant effect on yield or bulb size, except that the weight of culls was increased by applications of ethephon. Plant spacing appeared to have no effect on yield when ethephon was applied.

In the second planting on October 31, marketable yields were higher from the double rows (Table 10). Yields were highest at the 2-row 10 cm spacing. The yields of cull or rotten bulbs and individual bulb sizes were unaffected by spacing. Bulb to stem diameters were larger in the onions planted in double rows. On this later planting date, ethephon at 1500 ppm applied twice or 3000 ppm applied once, increased marketable yields. The latter concentration also increased the amount of cull bulbs. Ethephon had no effect on the other parameters measured. Again, plant spacing had no apparent effect on the results obtained with ethephon.

Ethephon was applied to onion plants in late winter in order to induce earlier, more uniform, and higher yields of bulbs harvested in the spring. Single or multiple applications of ethephon at various concentrations to several onion cultivars over several planting dates generally decreased yields of marketable bulbs and increased the weight of cull and rotten bulbs. The exceptions to this were the November 18, 1976 and October 31, 1977 planting dates where ethephon significantly increased bulb index or marketable yields of 'Grano' onions.

Even though yields were generally lower in ethephon treatments the index of bulbing (bulb-to-stem diameter

Table 6. Main effects of ethephon on yield of 7 cultivars of onions, November 18, 1976 planting date.

Ethephon (ppm)	Application (No.)	Yield (Mt/ha) Marketable	Rot	Cull	Bulb to Stem diameter	Plant height (cm)
0	0	7.8a[z]	0.4c	0.2b	6.2c	52.4a
1000	3	6.9b	0.9a	0.18a	6.9b	47.9bc
3000	1	7.8a	0.4bc	0.04ab	6.8b	50.6ab
3000	3	6.3b	0.7ab	0.18a	7.3a	46.8c

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 9. Main effects of plant spacing and ethephon on yield and bulb size of 2 cultivars of onions planted October 14, 1977.

Cultivar[z]	Yield (Mt/ha) Marketable	Cull	Rot	Bulb/Size Bulb: Stem	Weight (g)	Plant Height (cm)
Red Grano	17.4a[w]	2.0a	6.2a	5.2b	189a	56a
Yellow Grano	16.6a	0.5b	6.5a	7.7a	223a	45b
No. rows and spacing in row (cm)[y]						
1 x 10	4.5b	0.4c	4.2b	6.6a	189b	47b
2 x 5	22.6a	2.3a	6.4ab	6.4a	214a	54a
2 x 10	24.1a	1.1b	8.4a	6.4a	214a	52a
Ethephon concn (ppm) + no. sprays[x]						
0	18.3a	0.2b	6.1a	6.5a	230a	53a
500 x 6	18.3a	1.6a	6.3a	6.3a	194a	51a
1500 x 2	15.5a	1.8a	6.4a	6.6a	195a	50a
3000 x 1	16.1a	1.5a	6.4a	6.4a	204a	50a
Interactions[v]						
Cultivar x Population	*	*	*	NS	*	*
Cultivar x Ethephon	NS	NS	NS	NS	NS	NS
Population x Ethephon	NS	NS	NS	NS	NS	NS
Cultivar x Population x Ethephon	NS	NS	NS	NS	NS	NS

[z]Data for all plant populations and ethephon treatments summarized for each cultivar.
[y]Data for all cultivars and ethephon treatments summarized for plant population.
[x]Data for all cultivars and plant populations summarized for each ethephon treatment.
[w]Mean separation within columns by Duncan's multiple range test, 5% level.
[v]NS = not significant, * = significant at 5% level.

ratio) was generally higher in plants treated with ethephon. Levy and Kedar (6) attributed this to a retardation of leaf and stem growth but an overall reduction in size of the bulbs resulted. In the present experiments, bulb weights were generally not affected by ethephon but the incidence of rot increased. Growth regulators, such as ethephon, increase the amount of disease in onions, especially during rainy weather (1). Ethephon was applied, in most cases, 5 to 6 weeks before harvest in these experiments, and the plants were subjected to rain during that period. However, the November and late October planting dates were harvested approximately 2 and 4 weeks after ethephon application (Table 1). Possibly, application of ethephon closer to harvest could improve the significant benefits of the chemical on bulbing for other planting dates.

The most beneficial effect of ethephon on onions appeared to be the retardation of flower stalk development after low temperature vernalization. Recently, Corgan and

Table 10. Main effects of plant spacing and ethephon on yield and bulb size of 2 cultivars of onions planted October 31, 1977.

Cultivar[z]	Yield (Mt/ha) Marketable	Cull	Rot	Bulb Size Bulb:stem	Weight (g)	Plant Length (cm)
Red Grano	11.6a[w]	2.1a	1.3a	5.8b	214b	44a
Yellow Grano	14.8a	0.2b	0.9a	7.7a	240a	23b
No. rows and spacing in row (cm)[y]						
1 x 10	7.2c	1.1a	1.1a	6.5b	232a	34a
2 x 5	13.9b	0.9a	0.8a	7.0a	226a	32a
2 x 10	18.4	1.5a	1.5a	6.9a	224a	35a
Ethephon concn (ppm) + no. sprays[x]						
0	12.3a	0.6b	1.1a	6.5a	227a	34a
500 x 6	12.0a	1.0b	1.1a	7.1a	222a	34a
1500 x 2	14.3b	1.0b	1.2a	7.1a	227a	33a
3000 x 1	14.1b	2.1a	1.1a	6.4a	233a	32a
Interactions[v]						
Cultivar x Population	NS	NS	NS	*	NS	NS
Cultivar x Ethephon	NS	NS	NS	NS	NS	NS
Population x Ethephon	NS	NS	NS	NS	NS	NS
Cultivar x Population x Ethephon	NS	NS	NS	NS	NS	NS

[z]Data for all plant populations and ethephon treatments summarized for each cultivar.
[y]Data for all cultivars and ethephon treatments summarized for plant population.
[x]Data for all cultivars and plant populations summarized for each ethephon treatment.
[w]Mean separation within columns by Duncan's multiple range test, 5% level.
[v]NS = not significant, * = significant at 5% level.

Izquierdo (2) reported that when bolting was a problem ethephon increased yields. If bolting did not occur, damage from ethephon resulted in lower yields. They applied ethephon in late fall. In the present work ethephon reduced bolting when it was applied in early spring. Thus, it might be best used to offset bolting if weather conditions are favorable for it to occur.

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THE ASSOCIATION OF BROWN ROOT ROT RESISTANCE WITH YIELD COMPONENTS AND ROOT WEIGHT AMONG TOMATO SELECTIONS GROWN IN INFESTED AND NON-INFESTED SOIL IN DADE COUNTY, FLORIDA[1]

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Abstract. **Brown Root Rot (BRR) in tomato, caused by** Pyrenochaeta lycopersici **(Schneider and Gerlach), infests soil in Dade County, Florida. This organism is a significant contributor to the Old Land Decline syndrome in tomato. Yield components and root weight were compared in tomato selections and cultivars with and without BRR resistance genes grown in fumigated and nonfumigated naturally infested land. Marketable yield of fruit, fruit size, root weight and BRR disease rating were evaluated. In plants grown on non-fumigated soil the mean fruit yield and root weights were significantly reduced 56% and 28% respectively over those plants grown in fumigated soil primarily by the BRR fungus. While some of the selectcross resistant lines have comparable yields to Flora-Dade when grown in fumigated land the BRR resistant selectcrosses favored increased productivity, root size and reduced root lesion development when grown in non-fumigated plots. Although no selectcross completely free of BRR lesions has been obtained to date these results suggest that genetic factors which condition an intermediate level of resistance will significantly improve fruit yield. In addition to genetic factors conditioning resistance to BRR these crosses may also possess other genes conditioning larger roots which may be a factor in improved plant growth and development.**

Brown Root Rot (BRR), a fungal pathogen of tomato roots caused by *Pyrenochaeta lycopersici* Schneider and Gerlach has been prevalent in South Florida since the early 1970's (R. T. McMillan, Jr., unpublished). Damage from this disease is most apparent in fields in which tomatoes have been grown over a successive number of seasons and where soil fumigation is not practiced as a means of control.

This disease is known as a pathogen of tomatoes in the Netherlands (1), the United Kingdom (2, 3), the U.S. (4, 6) and Canada (5). Symptoms are evident in the form of brown, corky lesions which develop on the main roots and secondary roots of the plant. Many of the feeder and lateral roots appear shortened or stubby from the slow but progressive development of the fungus. The growth of the plant is restricted and productivity is reduced.

None of the tomato cultivars recently developed and released by the University of Florida, IFAS have demonstrated resistance to BRR. However, several tomato plant accessions from the germ plasm collection center in Ames, Iowa have been repeatedly screened as part of the Florida tomato breeding program and have been found to possess multiple factors which condition an acceptable level of resistance (6). These accessions are being used in a breeding-selection effort to combine BRR resistance and desirable horticultural characteristics into useful breeding lines.

The objectives of this study were (1) to determine the effect of BRR on fruit productivity and root development and (2) to evaluate the performance of improved crosses selected for multiple disease resistance.

Materials and Methods

Culture

Tomato selections were evaluated in the field during the 1978-79 season (season 1) and during the 1979-80 season (season 2). In the first season, 2 test fields were chosen for comparative evaluations in fumigated and non-fumigated soil beds. The non-fumigated land area had been cropped continuously to tomatoes for approximately 11 years and the soil had never been fumigated or otherwise treated for disease control. In a nearby field soil beds were fumigated to control soil-borne pathogens, including *P. lycopersici.* The fumigant Dowfume® (67% methyl bromide plus 33% chloropicrin) was injected at the rate of 220 lbs/acre (246 kgs/ha) into soil beds which were immediately covered with 0.0015 gauge (inch) plastic film. In the non-fumigated area, tomatoes were grown on soil beds without the plastic mulch cover.

During season 2, replicated tomato selections were grown only in the non-fumigated field but plants were grown on plastic-mulched beds.

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