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RESEARCH NEWSLETTER

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Ethylene Sensitivity of Tulip Cultivars

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Summary

- Over five years, we exposed bulbs of 91 tulip cultivars to 10 ppm ethylene in flowing air streams at 20C in October-November and forced.
- About 35% of the cultivars were substantially resistant to ethylene.
- About 51% of the cultivars were consistently damaged by ethylene.
- The remaining 15% of cultivars showed an inconsistent response to ethylene.
- It is unknown whether similar results would be seen with ethylene exposure earlier in the season (e.g., July-September).
- These results should be interesting for dry sales firms, export companies, tulip breeders, growers and forcers.

Introduction

In the northern hemisphere, tulip bulbs for forcing are shipped from The Netherlands between mid-August and late December in temperature and ventilation controlled containers. Before cooling, ethylene contamination in transport vehicles or storage facilities is a serious threat. The effects of ethylene on tulip bulbs include gummosis, increased respiration, poor rooting, flower abortion, faster flowering, and the inhibition of stem elongation. Symptoms may appear almost immediately or be delayed for months, making 'accurate' diagnosis of ethylene damage difficult.

The major source of ethylene during transport and storage is bulbs infected with the ethylene-producing fungus, *Fusarium*. Ethylene production of infected bulbs reached up to 800 ml $bulb^{-1}day^{-1}$ approximately 3 weeks after

inoculation, and cultivars vary a great deal in how much ethylene they produce when infected (see May 2007 Research Newsletter No. 13 at http://www.flowerbulbs.cornell.edu/newsletter/index.htm)

The last large scale ethylene sensitivity survey conducted was in 1980 by de Hertogh using 27 cultivars. Updates of this list are necessary, as many of those cultivars are no longer in the trade. Here, we present results of our work on ethylene sensitivity of a range of tulip cultivars, and give the largest list of ethylene sensitivity yet published.

What We Did

Over a 5-year period, bulbs of 91 tulip cultivars were exposed to ethylene in the fall, then forced in the spring in a greenhouse. Bulbs (generally 12/+ cm circum.) were received from The Netherlands in mid-September, after transport at 17-18C, in ventilated plastic crates. Upon arrival, bulbs were held in a well-ventilated room at 17C.

Using a variety of valves and meters and microprocessors, we gave ethylene concentrations of 10 ppm to bulbs held in large plexiglass boxes (Figs. 1 and 2). Relative humidity was usually less than about 60% during treatment.

In all cases, treated or control bulbs were given 4 weeks of 17C ventilated storage after ethylene treatment, a treatment that allows full development of ethylene injury. Each cultivar was tested twice per year, each time with 45 bulbs in the control chamber, and 45 bulbs in ethylene. In this newsletter, data are given for 1 to 5 years (that is, 2 to 10 experiments), depending on the cultivar. In some experiments, 10 bulbs per treatment were dissected 4 weeks after the end of ethylene treatment to observe internal injury.

After the 4-week post-ethylene period, bulbs were planted in 25 cm diameter pots with 15

Figure 1. Chamber (here with lily plants) in which bulbs were treated with ethylene. The air stream containing 10 ppm ethylene entered via the fitting on the front, and was exhausted through the blue tube attached to the top of the chamber.

Figure 2. Mass flow controllers and microprocessors to regulate ethylene concentration and air flow.

bulbs per pot. Pots were initially cooled at 9C with temperature decreasing to 1-2C as rooting proceeded for a total of 16 weeks of cold. After cooling, plants were grown in a 17C greenhouse under natural light conditions. Forcing was generally from late March to late-April, depending on the year or experiment. After plants flowered, the number of healthy or aborted (blasted) flowers was counted.

What We Found

Figure 3 shows internal structure of a non-sensitive cultivar ('Ad Rem') and an ethylene sensitive one ('Purple Flag') after the 4 week (17C) post-ethylene period. In the extreme case, ethylene injury was readily seen in 'Purple Flag', where the shoot and flower is completely dead. 'Ad Rem' was apparently uninjured. Figure 4 shows plants grown from the same lot of bulbs as in Fig. 3. Clearly, 'Ad Rem' was unaffected by the ethylene exposure, whereas the 'Purple Flag' was highly damaged. Between these extremes are many other stages of injury.

For this research, ethylene sensitivity was defined as a significant decrease in the percentage flowering due to ethylene treatment. Within each experiment, the cultivar was deemed to be either resistant (equal percentage flowering) or susceptible (less flowering in ethylene-treated plants). All such determinations were totaled, and evaluated into three categories. Consistently resistant cultivars showed equal flowering percentages in all experiments conducted. Those deemed susceptible showed less flowering in the ethylene treatment in all experiments conducted. The "ethylene sensitive but inconsistent" category showed variability between experiments, sometimes it was resistant, other times it was susceptible. This could have happened between years or between the experiments in a single year.

Table 1 shows that 35% of the tested cultivars were consistently resistant to the 2-week ethylene exposure. Half of the cultivars (51%) were susceptible, and 15% of the cultivars showed inconsistent sensitivity to ethylene.

Table 1 presents ethylene sensitivity in the most conservative way possible, based on the available data. That is, if a cultivar showed ethylene injury (bud blasting or abortion), it was listed as either sensitive (always sensitive, in every experiment), or as inconsistent (usually not injured, but it did show injury in at least one experiment in at least one year). Cultivars listed as not sensitive were always resistant (no flower abortion) across all experiment and all years.

The number of years of trials is listed for each cultivar. As mentioned above, one year is two separate experiments, each with 45 ethylene treated, and 45 control bulbs. Obviously, the greater the number of years of experiments, the better the data. It is possible that as more years are accumulated per cultivar, incidences of injury will occur, and therefore some cultivars might shift to the "inconsistent" category.

It is important to remember this classification is based on *late season ethylene treatment,* in the late October to November time frame. Ethylene given to a cultivar earlier in the season (after lifting or before export) might give a very different picture of potential injury.

Is there a relationship between cultivar ethylene sensitivity and the capacity of tulip bulbs to support ethylene production when infected by *Fusarium*? To answer this question, we took earlier data from the Flower Bulb Research Program (http://www.flowerbulbs.cornell.edu/newsletter/index.htm) and compared it to our current

classification of ethylene sensitivity. The result is in Table 2. It is clear there is no relationship between the two factors. For example, cultivars that are consistently resistant support among the very highest and lowest ethylene production rates upon infection with *Fusarium*. Thus, ethylene production when infected by *Fusarium* has no relation to cultivar sensitivity to ethylene.

For this work, we had a narrow definition of ethylene injury: flower blasting or abortion. Plant height or other subtle injuries that may or may not have happened were not considered. Even so, this work represents the largest classification of ethylene sensitivity available. These results should be of interest for dry sales firms, export companies, tulip breeders and those working with tulips in general.

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Table 1.
Listing of tulip cultivars based on ethylene sensitivity after 1-5 years of trials. Bulbs were exposed to 10 ppm ethylene (20C, in air) for 2-weeks, typically in the late October to late November time frame, with two experiments per year. Cultivars listed as non-sensitive never showed significant damage from ethylene (defined by increased flower abortion relative to control plants). Those listed as sensitive were consistently highly damaged by ethylene (flower abortion). Those listed as inconsistent were resistant in most experiments, but were injured in some replicates within a year or were inconsistent between years (thus, more study is needed).

Cultivar	Years of trials per cultivar	Cultivar	Years of trials per cultivar
Consistently insensitive to ethylene 31 cultivars)			
Ad Rem	1	Nashville	3
Blue Ribbon	4	Orange Princess	3
Bright Parrot	5	Pink Floyd	2
Caractere	2	Prominence	3
Couleur Cardinal	3	Remise	2
Corvette	1	Salvo	1
Davenport	1	Sevilla	3
Dynasty	5	Siberia	1
Escape	2	Singapore	2
Friso	3	The Mounties	3
Full House	2	Verandi	2
Kees Nelis	4	White Heaven	2
King's Cloak	3	Wirosa	3
Leen vd Mark	2	Yellow Flight	3
Libretto	3	Yellow Sun	1
Mondial	3		

Cultivar	Years of trialsper cultivar	Cultivar	Years of trialsper cultivar
Consistently sensitive to ethylene (46 cultivars)			
All Season	3	Gironde	1
Angelique	3	Gwen	2
Annie Schilder	3	Ile De France	1
Apeldoorn	3	Innuendo	2
Baby Blue	1	Jan Van Nes	4
Banja Luka	2	Laptop	1
Bearing Point	2	Lilac Pink Cup	1
Black Jack	1	Lundy	1
Bolroyal Pink	2	Mascottee	2
Calgary	4	Miss Elegance	2
Canasta	2	Mistress	2
Cantata	1	Pallada	2
Carola	2	Passionale	2
Charade	2	Popcorn	2
Cilesta	2	Princeps	1
Crème Upstar	3	Purple Flag	5
Denmark	1	Purple Lady	2
Diamond Parrot	1	Royal Ten	2
Double Focus	1	Santander	1
Foxtrot	2	Snowboard	2
Freeman	1	Spryng	1
Fusarino	2	Strawberry Ice	1
Fusor	3	Strong Gold	4
Ethylene sensitive, but inconsistent between years or experiments (14 cultivars)			
Adamo	3	Monte Carlo	3
Agrass White	5	Pieter de Leur	3
Fabio	2	Plaisir	3
Kikomachi	3	Pretty Woman	4
Laura Figi	3	Sapporo	3
Louvre	3	World's Favourite	3

Table 2.
Relationship of ethylene sensitivity as given in Table 1 to ethylene production rate of *Fusarium* inoculated bulbs from Miller et al. (2005). Some cultivars from Miller (2005) are not included since they have not been available for ethylene sensitivity testing. About 145 ul/bulb/day is the historical presumed level of ethylene production of *Fusarium* infected bulbs, dating from the early 1970's work of Wim de Munk of the former LBO.

Cultivar	Ethylene production, 19 d after inoculation (ul/bulb/day)	Consistently ethylene insensitive	Consistently ethylene sensitive	Inconsistent
Nashville	833	x		
Libretto	662	x		
Friso	637	x		
Prominence	615	x		
Annie Schilder	458		x	
Yellow Present	347			x
Orange Princess	219		x	
Pieter de Leur	207			x
Mondial	203	x		
Adamo	147			x
Kikomachi	145			x
Couleur Cardinal	67	x		
Laura Figi	65			x
Yellow Flight	55	x		
Angelique	40		x	
Jan van Nes	35		x	
Sapporo	32			x
Strong Gold	29		x	
Bright Parott	25	x		
Sevilla	18	x		
World's Favourite	18			x
Louvre	17			x
Blue Ribbon	13	x		
Purple Flag	7		x	
Pretty Woman	5			x
Wirosa	5	x		
Calgary	4		x	
Kees Nelis	3	x		

Figure 3.
Appearance of tulip bulbs following a 2 week exposure to 10 ppm ethylene (20C, late October) in a flowing air stream followed by a 4 week 17C ethylene-free period. Top: 'Ad Rem', an ethylene insensitive cultivar. Bottom: 'Purple Flag', an ethylene sensitive cultivar. Left to right in each panel, 5 control bulbs, 5 ethylene-treated bulbs. Note dead shoots in the ethylene-treated 'Purple Flag' bulbs.

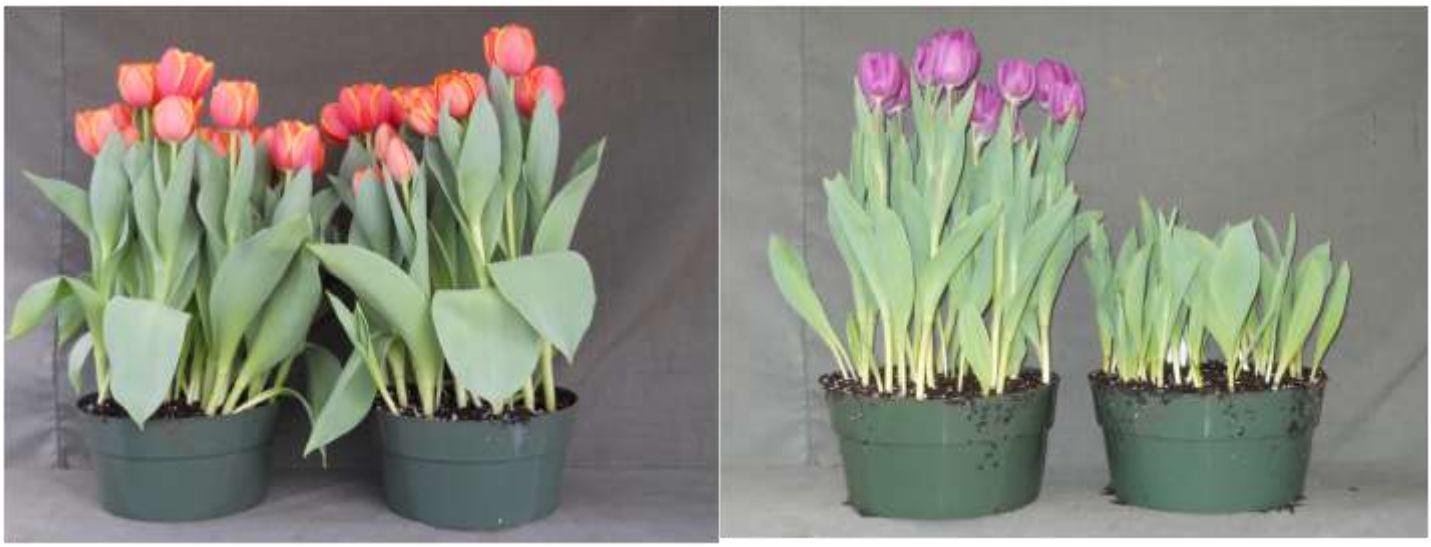

Figure 4.
Effect of ethylene exposure to bulbs (10 ppm ethylene, 20C, 2 weeks, late October, followed by a 4-week 17C ethylene-free period. Bulbs were planted, cooled for 16 weeks, and forced. Top: 'Ad Rem', an ethylene insensitive cultivar. Bottom: 'Purple Flag', an ethylene sensitive cultivar. Left to right in each panel: control bulbs, ethylene-treated bulbs. 15 bulbs per pot.