MA PACKAGING OF TULIP BULBS: PHYSIOLOGICAL IMPLICATIONS, DISEASE CONTROL, AND PACKAGE PERFORMANCE UNDER TEMPERATURE FLUCTUATION

Timothy A. Prince
Dept. of Horticulture
The Ohio State University
Columbus, OH 43210

Robert C. Herner
Dept. of Horticulture
Michigan State University
East Lansing, MI 48824

The optimization of paramaters for a polymeric film package for marketing of precooled tulip bulbs was outlined at the previous CA conference in Corvallis, OR (3). The interaction of bulb respiration and differential permeability of the selected film to atmospheric gasses was shown to result in the establishment of MA conditions within the package at 20° C. Atmospheres of 3-5 % oxygen had previously been demonstrated to reduce post-precooling bulb respiration rates, reduce the detrimental effects of ethylene exposure, and to ultimately increase the time period the bulbs could be held at ambient temperatures before planting (2). Bulbs subjected to normal atmospheric conditions during a holding period yield a high percentage of aborted flowers. While the MA package was observed to reduce this abortion, mold growth was observed on the bulb root plates that was thought to be responsible for less than optimal flowering and reduced root growth from the bulbs. Therefore, studies were undertaken to identify the molds in the packages and to determine strategies for controlling their growth.

The ability of the package to function under fluctuating temperatures was also believed critical to ultimate success in the marketplace. Temperature fluctuation could have profound effects upon the package gaseous atmosphere and upon the growth of disease organisms. The studies outlined here evaluated the response of the package to temperature fluctuation between 15° and 25°C considering both the package atmosphere changes and maintenance of bulb flowering ability.

While the ability of low oxygen environments to reduce abortion of floral buds has been demonstrated (2), little is known about the underlying physiological response of the bulbs. To provide some insight into the bulb response, studies were designed to determine the effect of the package on the fresh and dry matter redistribution between the floral shoot, the bulb scales, and the developing daughter bulbs that occurs during a post-precooling holding period.

Materials and Methods

For all studies reported here, five bulbs were sealed into each LDF-301 low density polyethylene film package as previously described (3). The package was composed of 0.08 m^2 of film surface area with 500 ml of void volume. For the disease control studies, fungicides were applied as prepackaging drenches or as dusts. Following a storage period at 20°C, the bulbs were removed from the packages for disease evaluation and for forcing in the greenhouse. The disease evaluation included both number of bulbs diseased in each package as well as severity of infection expressed as the average percentage of each root plate surface covered with mold. All bulbs utilized in the temperature fluctuation and bulb organ studies were pretreated with a Vanguard (CGA-64251) fungicide drench at 240 µg a.i./ml for 20 min at 21°C prior to packaging. The film permeabilities at the temperatures utilized were measured with a customized permeability cell as previously described (3). For the bulb organ studies, the bulbs in each package were removed at weekly intervals for dissection and pooling of the organs for fresh and dry matter determination.

Results and Discussion

Pure cultures isolated from diseased bulbs were identified as *Penicillium* spp. Three separate isolates of *P. corymbiferum* and one isolate of *P. rugulosum* that were obtained from diseased bulbs were found to be pathogenic on isolated bulb root plates (5). One of the isolates of *P. corymbiferum* was found to be benomyl tolerant and to produce ethylene in culture. This tolerant isolate was likely responsible for the poor infection control afforded by a Benomyl drench (Table 1.). In contrast, drenches of Prochloraz and Vanguard fungicides were both highly effective at controlling fungal growth. This resulted in excellent rooting and high levels of normal flowering from the packaged bulbs. The apparent control of disease with Captan dust may have been to the drying effect of the dust since a drench of Captan was ineffective. The enhancement of disease by the water control dip over non-dipped bulbs was likely due to spread of inoculum from the bulb tunic surface to the root plate during the dipping. In this study, the disease observed on non-dipped bulbs was not as severe as observed in previous studies. This could have been due to variation in bulb susceptibility to infection or to differences in natural inoculum levels. It is expected that under actual marketing conditions, condensation in the packages resulting from temperature fluctuations will create even more ideal conditions for disease development. Fungicide treatment certainly seems warranted to obtain consistent benefit from the MA package. Further details of these studies are being published elsewhere (4).

Table 1. Fungicidal control of infection by *Penicillium spp.* of bulb root plates during 3 weeks of storage at 20°C in LDF-301 film packages and subsequent flowering of the bulbs.

Prepackaging treatment	Rate (µg a.i./ml)	Infected bulbs[a]	% infection per plate	% Normal flowers[b]	Root fresh wt. (gm)[c]
H_2O	---	5.0 a	64 b	15 c	0.4 fg
No dip	---	1.7 b	24 c	87 a	3.3 bc
Benomyl	1000	5.0 a	88 a	5 c	0.1 g
	2000	5.0 a	86 a	5 c	0.1 g
Prochloraz	300	0.5 c	7 c	95 a	3.8 ab
	600	1.0 bc	5 c	95 a	3.8 ab
Vanguard	120	0.5 c	5 c	100 a	5.0 a
	240	0.5 c	12 c	100 a	4.2 ab
Captan	1200	4.5 a	54 b	50 b	1.5 de
	2400	4.5 a	52 b	45 b	1.4 e
Captan dust	10%	1.2 bc	20 c	90 a	4.4 ab
	50%	1.0 bc	13 c	95 a	4.6 ab
Non-packaged					
H_2O	----	1.7 b	6 c	40 b	0.9 ef
No dip	----	0.5 c	7 c	60 b	2.3 cd

[a]Mean separation within columns by Waller-Duncan multiple comparisons procedure at P=0.05.

[b]Non-stored control bulbs yielded 100% normal flowers.

[c]Root fresh weight data analyzed on log (X+1) transformed scale.

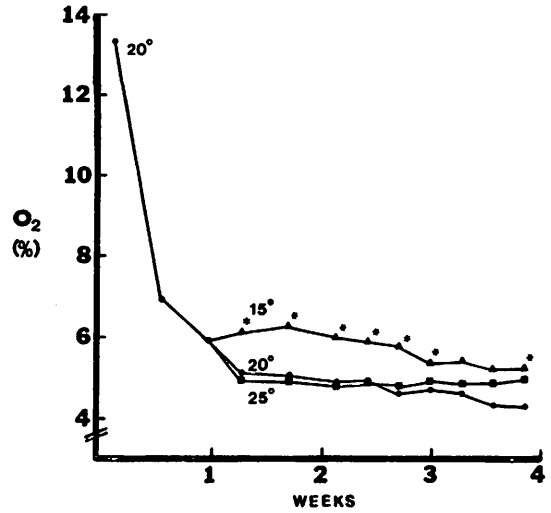

Figure 1. Package oxygen levels during 1 week at 20°C followed by 3 weeks at 15, 20, or 25°C. Asterisk indicates significant difference from 20°C control by Dunnett's procedure within sampling date.

The responses of package oxygen levels to changes in temperature are depicted in Figure 1. Packages were maintained at 20°C for one week to allow an equilibrium level of oxygen to be approached before transferring to different temperatures. This removed the effect of temperature upon the rate at which atmospheric equilibrium is obtained and allowed an examination of temperature effects upon the equilibrium level itself. Transfer from 20°to 25°C resulted in little change in the oxygen level in the packages. A temperature change from 20° to 15°C led to increased package oxygen levels. Changing oxygen levels in a sealed package are due both to changes in oxygen consumption by the commodity and changes in film permeation. Film permeation to oxygen at 15, 20 and 25°C were found to be 2.7, 3.9 and 4.7 liters (STP) / atmosphere gradient / day / m^2 of film respectively. Thus, while respiration increased at 25°C, film permeation also increased leading to little change in the oxygen level. Transfer to 15°C apparently resulted in a greater decrease in oxygen consumption than in permeation which led to increased package oxygen levels. Beneficial effects of maintenance of flowering ability were observed at both temperature extremes.

The impact of the MA packaging on the dry weight changes of the total bulb, floral shoot and daughter bulbs during 4 weeks of holding at 20°C are shown in Figures 2, 3 and 4. Trend analysis revealed a significant packaging x linear storage weeks interaction for the total bulb dry weight data (Figure 2). The MA environment apparently lowered the bulb respiration rate to a significant degree, greatly slowing the loss of dry weight on a total bulb basis during the 4 weeks.

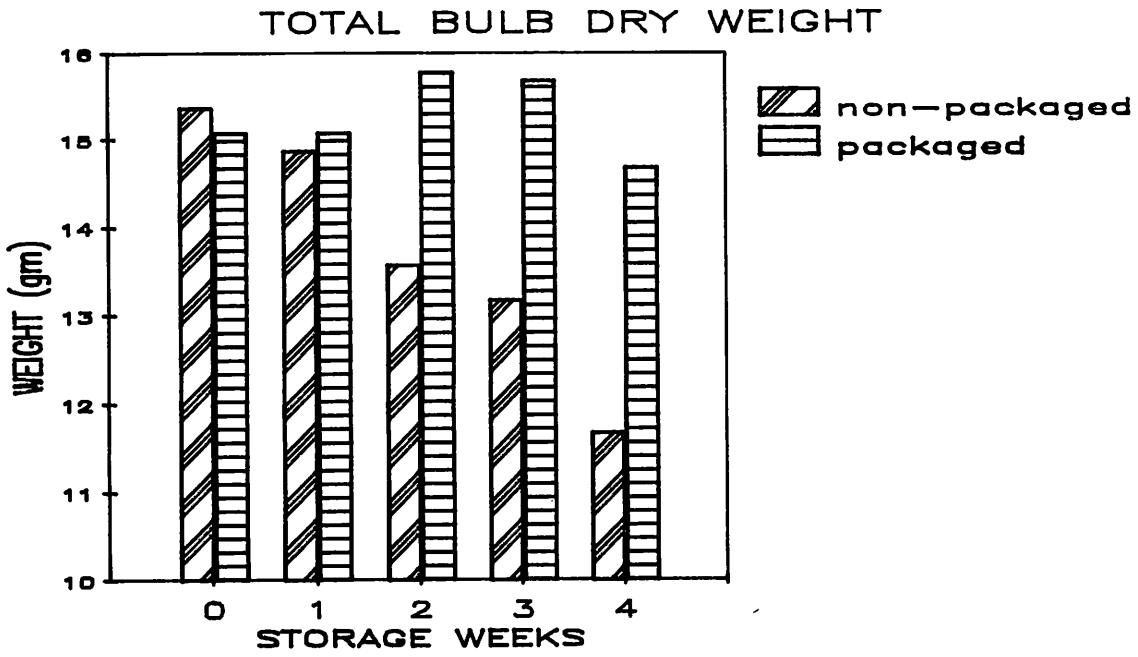

Figure 2. Changes in total bulb dry weight of packaged and non-packaged tulip bulbs during 4 weeks of storage at 20°C.

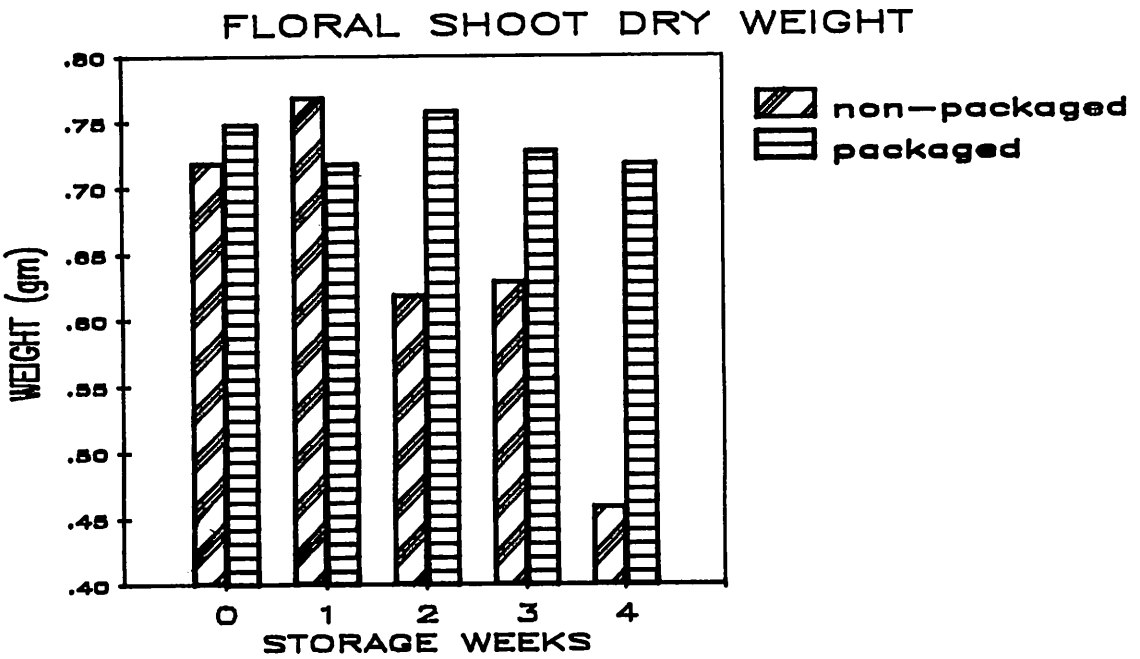

Figure 3. Changes in floral shoot dry weight of packaged and non-packaged bulbs during 4 weeks of storage at 20°C.

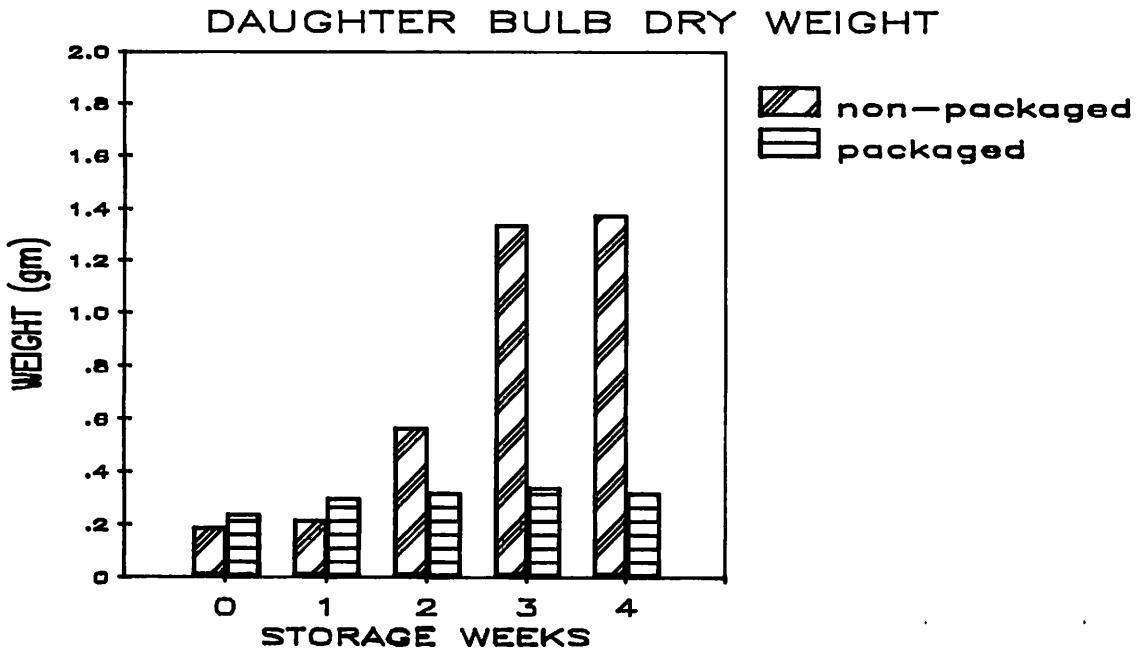

Figure 4. Changes in daughter bulb dry weight of packaged and non-packaged bulbs during 4 weeks of storage at 20°C.

A similar packaging x linear storage weeks interaction was observed for the changes in floral shoot dry weight (Figure 3). Floral shoot dry weight was maintained in the package while non-packaged bulbs displayed a significant loss in dry weight. This was indicative of loss of apical dominance of the floral shoot and ultimately floral abortion. Further evidence of this loss of apical dominance was the increase in the daughter bulb dry weight of non-packaged bulbs that was prevented by the package environment (Figure 4). The increased dry matter in the daughter bulbs likely was transported from the shoot and the bulb scales, which also displayed loss in dry weight (data not shown). The mechanism by which the package atmosphere prevents the loss of apical dominance of the floral shoot and concurrent enlargement of the daughter bulbs is presently unclear.

Conclusions

The MA package appears to have commercial application possibilities for marketing of precooled tulip bulbs. The package aids in maintaining bulb flowering ability in a non-refrigerated environment provided that fungal growth is prevented in the package by fungicide pretreatment of the bulbs. The package appears to be adaptable to reasonable temperature fluctuation in the marketing environment through changes in the film permeabilty. The primary benefit to the bulbs appears to be prevention of the loss of floral shoot apical dominance over the developing daughter bulbs.

Literature Cited

1. Prince, T.A. and R.C. Herner. 1985. Bulb organ fresh and dry matter changes and temperature fluctuation effects in a modified atmosphere package of precooled tulip bulbs. J. Amer. Soc. Hort. Sci. (Submitted).

2. Prince, T.A., R.C. Herner, and A.A. De Hertogh. 1981. Low oxygen storage of special precooled Kees Nelis and Prominence tulip bulbs. J. Amer. Soc. Hort. Sci. 106 :747-751.

3. Prince, T.A., R.C. Herner, and S.W. Gyeszly. 1982. Storage of special precooled tulip bulbs in controlled atmosphere packages, p 77-85. In: D.G. Richardson and M. Meheriuck (eds). Controlled atmospheres for the storage and transport of perishable agricultural commodities. Timber Press, Beaverton, OR.

4. Prince, T.A., R.C. Herner, and C.T. Stephens. 1985. Fungicidal control of infection by *Penicillium spp.* of precooled tulip bulbs in a modified atmosphere package. Plant Disease (Submitted).

5. Prince, T.A., C.T. Stephens, and R.C. Herner. 1985. Pathogenicity, fungicide resistance and ethylene production of *Penicillium spp.* isolated from tulip bulbs. Phytopathology (In preparation).