

An analysis of the post-harvest characteristics of cut tulips

the second part of a study of tulips as cut flowers, including information on total growth, the growth of the last internode and changes in flower size.

INTRODUCTION — In the US and Canada, the current utilization of tulips as cut flowers is less than that of potted tulips. We believe that this in part is due to a lack of information on the postharvest development of cut tulips. In a series of articles, Rogers (15, 16) emphasized the need for research on postharvest handling of cut flowers. Thus, we have endeavored to assem-

ble pertinent information on the various postharvest characteristics of cut tulips.

In a preliminary study the emphasis was placed on flower life and flower shape (7). In this paper, we have expanded the information on those characteristics and have included information on the total growth of the cut tulip, growth of the last internode and the changes

in flower size at various time intervals during their postharvest life.

MATERIALS AND METHODS

CULTURAL PROCEDURES — The tulips (1968-69 season) used in these studies (tables 1 and 2) were forced following the procedures outlined in the "Bulb Forcers'

Table 1. Postharvest flower life and flower shape of tulips at 75 degrees Fahrenheit.

Class, cultivar	Average flower life (days)	Flower shape (degrees)			Classification at 72 hrs	Class, cultivar	Average flower life (days)	Flower shape (degrees)			Classification at 72 hrs
		24 hrs	72 hrs	Last day				24 hrs	72 hrs	Last day	
Single Early tulips						Demeter	> 6	13	28	32	cup
Bellona	5 to 6	15	37	46	semi-cup	Dix' Favourite	5 to 6	23	34	44	semi-cup
Thule	5 to 6	26	35	39	semi-cup	Gander	4 to 5	28	38	45	semi-cup
Tommy	5 to 6	20	38	54	semi-cup	Golden Age	> 6	15	26	25*	cup
Mendel tulips						Insurpassable	5 to 6	10	16	22	cup
Apricot Beauty	4 to 5	34	59	96	open	Mamas	5 to 6	27	39	41	semi-cup
Athleest	5 to 6	24	40	63	semi-cup	Most Miles	4 to 5	21	41	45	semi-cup
Bing Crosby	4 to 5	16	25	32	cup	Paul Richter	5 to 6	23	34	49	semi-cup
Golden Olga	4 to 5	17	31	39	semi-cup	Pink Attraction	> 6	15	24	36	cup
Golden Triumph	> 6	15	28	53	cup	Pink Supreme	5 to 6	17	26	30	cup
Krelage's Triumph	4 to 5	15	33	46	semi-cup	Queen of Bartigons	> 6	15	25	37	cup
Pink Trophy	5 to 6	22	33	42	semi-cup	Queen of Night	5 to 6	12	17	17*	cup
Piquante	5 to 6	9	28	43	cup	Red Pitt	5 to 6	14	23	27	cup
Van der Eerden	> 6	18	31	40	semi-cup	Revell	5 to 6	18	29	36	cup
Triumph tulips						Rose Copland	> 6	8	13	20	cup
Blenda	5 to 6	13	23	26	cup	Vredahof	5 to 6	12	20	34	cup
Crater	5 to 6	20	36	40	semi-cup	Wim van Est	5 to 6	10	19	19*	cup
Dreaming Maid	5 to 6	8	13	16	cup	Single Late tulips					
Emmy Peck	5 to 6	27	49	55	open	Golden Harvest	5 to 6	7	13	26	cup
First Lady	5 to 6	14	23	27	cup	Darwin Hybrid tulips					
Hibernia	5 to 6	15	25	27	cup	Apeldoorn	3 to 4	21	37	43	semi-cup
K & M's Triumph	5 to 6	13	27	41	cup	Beauty of Apeldoorn	3 to 4	15	33	79	semi-cup
Korneforos	5 to 6	8	21	35	cup	Empire State	4 to 5	14	43	52	semi-cup
Lavant	5 to 6	12	23	29	cup	General Eisenhower	3 to 4	28	41	50	semi-cup
Madame Spoor	5 to 6	9	16	14	cup	Golden Apeldoorn	3 to 4	23	41	64	semi-cup
Merry Widow	5 to 6	8	17	23	cup	Gudoshnik	4 to 5	21	36	48	semi-cup
Mirjoran	5 to 6	16	27	31	cup	Jewel of Spring	3 to 4	19	36	49	semi-cup
Olaf	5 to 6	19	40	65	semi-cup	London	3 to 4	23	34	34	semi-cup
Pax	> 6	15	22	27	cup	Oxford	3 to 4	23	34	60	semi-cup
Peerless Pink	> 6	11	19	28	cup	President Kennedy	4 to 5	18	31	51	semi-cup
Preludium	5 to 6	15	25	39	cup	Striped Apeldoorn	4 to 5	25	38	53	semi-cup
Princess Beatrix	5 to 6	22	40	67	semi-cup	Lily-flowering tulips					
Prominence	4 to 5	14	25	28	cup	Aladdin	> 6	33	50	78	open
Purple Star	> 6	7	13	18	cup	Lilac Time	5 to 6	25	36	47	semi-cup
Roland	5 to 6	15	27	23*	cup	Marlette	5 to 6	25	45	47*	open
Sunray	5 to 6	12	40	52	semi-cup	Maytime	> 6	10	18	31	cup
Topscore	5 to 6	22	39	66	semi-cup	Queen of Sheba	5 to 6	34	73	85	open
Darwin tulips						Red Shine	5 to 6	11	38	64	semi-cup
Atila	> 6	12	19	28	cup	White Triumphator	5 to 6	19	36	41	semi-cup
Cantor	5 to 6	14	20	22	cup	Parrot tulips					
Copland's Favourite	> 6	8	13	15	cup	Comet	4 to 5	19	55	85	open
Copland's Purple	> 6	9	15	22	cup	Karel Doorman	5 to 6	25	44	74	semi-cup
Copland's Record	> 6	8	15	22	cup						

*Indicates that the petals of the flowers reflexed inwardly during the final phase of senescence.

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Handbook" (6) and "The Dutch Bulb Manual" (9). A complete description of the cultivars can be found elsewhere (4, 14). The flowers were used at their period of maximum availability (9).

Flowers were removed from the forcing flats at the bud stage (first sign of color) with the bulb left attached and stored dry in an upright position at 35 degrees Fahrenheit (5). When 12 to 14 flowers of a given cultivar were accumulated, the bulbs were removed, and the tulips were bunched, wrapped in paper and stored dry in a horizontal position at 35 degrees (8) for 72 to 120 hours. This length of time was used to simulate a time of transport.

When a study was initiated, the flowers were removed from the refrigerator and taken to a 75-degree

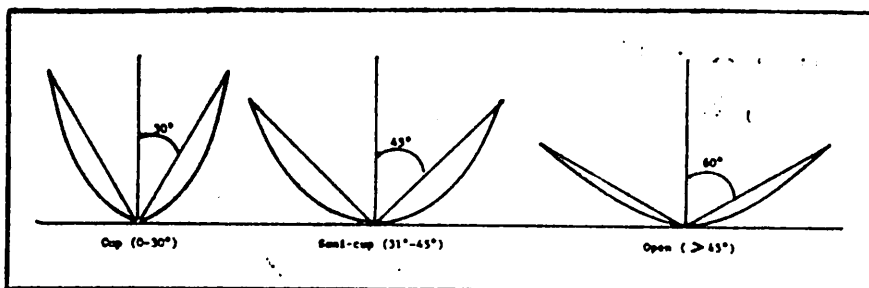


Figure 1. Schematic diagram showing representative shapes of cup, semi-cup and open tulip flowers.

room, approximating that of an average American home. Because the tulip is unaffected by the source of light (1), the flowers received no natural light. They were subjected to continuous artificial light supplied by standard 40-watt, cool-white fluorescent tubes.

The blooms were divided into three replications of four flowers

each. The flowers were subsequently recut, and the initial data were recorded (tables 1 and 2). The tulips were then placed in a vase containing 71-degree tap water. During the study the water was never replaced, only refilled as necessary.

DEVELOPMENTAL CHARACTERISTICS OBSERVED AND RECORDED

Table 2. Growth of total plant, last internode and flowers during postharvest development of cut tulips at 75 degrees Fahrenheit.

Class, cultivar	Total plant growth (cm)	Growth last internode (cm)	Growth of flower (cm)*				Class, cultivar	Total plant growth (cm)	Growth last internode (cm)	Growth of flower (cm)*			
			Initial length	After 24 hrs	Last day	Total growth				Initial length	After 24 hrs	Last day	Total growth
Single Early tulips							Demeter	20	9	5.0	6.0	7.5	2.5
Bellona	17	9	5.5	6.0	7.0	1.5	Dix' Favorite	13	6	5.5	6.0	7.0	1.5
Thule	14	11	6.5	7.0	8.0	1.5	Gander	17	11	6.0	6.5	7.5	1.5
Tommy	15	10	5.0	6.0	7.0	2.0	Golden Age	21	11	5.5	6.5	7.5	2.0
Mendel tulips							Insurpassable	16	10	5.0	6.0	7.5	2.5
Apricot Beauty	12	7	6.0	7.0	9.0	3.0	Mamasa	10	8	6.0	7.0	8.0	2.0
Athleet	18	15	5.5	6.0	7.0	1.5	Most Miles	17	12	6.0	7.0	8.5	2.5
Bing Crosby	15	6	6.0	6.5	8.0	2.0	Paul Richter	14	11	5.0	6.0	7.0	2.0
Golden Olga	15	11	5.5	6.5	7.5	2.0	Pink Attraction	19	14	5.0	5.5	7.0	2.0
Golden Triumph	14	12	5.5	6.0	7.5	2.0	Pink Supreme	15	10	5.0	6.0	7.0	2.0
Krelage's Triumph	15	11	5.5	6.0	7.0	1.5	Queen of Bartignons	18	15	5.0	5.5	6.5	1.5
Pink Trophy	16	10	5.0	6.0	7.0	2.0	Queen of Night	15	8	5.0	5.5	7.0	2.0
Piquante	21	12	6.0	6.5	9.0	3.0	Red Pitt	15	11	5.0	6.0	7.0	2.0
Van der Eerden	12	7	6.0	7.0	8.0	2.0	Révell	15	12	6.0	5.0	7.5	1.5
Triumph tulips							Rose Copland	12	6	5.0	5.0	7.0	2.0
Blenda	14	7	5.0	6.0	7.0	2.0	Vredohof	15	8	5.0	5.0	7.5	2.5
Crater	13	10	5.5	6.5	7.0	1.5	Wim von Est	11	8	5.0	5.0	6.5	1.5
Dreaming Maid	10	4	6.0	7.0	8.0	2.0	Single Late tulips						
Emmy Peeck	17	12	6.0	7.0	8.0	2.0	Golden Harvest	17	10	5.0	6.0	7.0	2.0
First Lady	17	12	6.0	7.0	8.0	2.0	Darwin Hybrid tulips						
Hibernia	10	6	5.0	6.0	7.0	2.0	Apeldoorn	12	10	6.5	7.5	8.5	2.0
K & M's Triumph	15	9	6.0	7.0	8.0	2.0	Beauty of Apeldoorn	12	9	6.0	7.0	8.0	2.0
Korneforos	16	8	6.0	6.5	7.0	1.0	Empire State	15	10	6.5	8.0	8.5	2.0
Levant	19	11	6.0	7.0	8.0	2.0	General Eisenhower	15	12	6.5	9.0	2.5	
Madame Spoor	11	7	6.0	6.5	7.0	1.0	Golden Apeldoorn	14	11	6.0	7.0	8.0	2.0
Merry Widow	13	4	5.5	6.5	7.5	2.0	Gudoshnik	14	9	6.0	7.0	8.0	2.0
Mirjoran	17	7	5.0	5.5	7.0	2.0	Jewel of Spring	15	9	6.5	7.5	9.0	2.5
Olaf	12	7	6.0	7.0	7.5	1.5	London	14	11	6.0	7.0	8.0	2.0
Pax	9	5	5.0	5.5	6.5	1.5	Oxford	17	12	7.0	8.0	10.0	3.0
Peerless Pink	17	12	6.5	7.5	9.0	2.5	President Kennedy	13	10	6.0	7.0	8.0	2.0
Preludium	16	7	5.0	6.0	7.5	2.5	Stripod Apeldoorn	13	11	6.5	7.0	8.0	1.5
Princess Beatrix	19	15	6.0	7.0	8.0	2.0	Uly-flowered tulips						
Prominence	10	6	5.5	6.5	7.0	1.5	Aladdin	14	9	7.0	8.5	10.0	3.0
Purple Star	17	7	5.5	6.5	8.0	2.5	Ulac Timo	12	7	6.0	7.0	7.5	1.5
Roland	20	9	5.0	6.0	7.0	2.0	Marlatta	18	13	7.5	8.5	10.0	2.5
Sunray	21	16	6.0	6.5	7.5	1.5	Maytime	15	9	6.0	7.0	8.0	2.0
Topscore	14	6	5.0	6.0	7.5	2.5	Queen of Sheba	18	13	6.5	8.0	9.5	3.0
Darwin tulips							Red Shine	21	16	6.0	7.0	8.0	2.0
Atilla	16	8	5.0	6.5	8.0	3.0	White Triumphator	15	10	6.5	7.5	9.0	2.5
Cantor	15	10	5.5	6.5	7.5	2.0	Parrot tulips						
Copland's Favourite	11	4	5.0	6.0	7.5	2.5	Comet	12	8	6.0	7.0	8.0	2.0
Copland's Purple	10	5	5.0	6.0	7.0	2.0	Karel Doorman	12	9	6.5	7.5	8.5	2.0
Copland's Record	12	6	5.0	6.0	7.0	2.0							

*2.5 cm equals 1 inch.

Keeping quality. Various senescent characteristics were observed.

(a) **Flaring of the petals.** Flowers were discarded when the petals flared or reflexed downward to the extent that light could be seen along the entire length of the individual petals.

(b) **Discoloration.** This characteristic included such things as drying up or browning of the petals or a large deviation from their normal color. Deviations from the normal color range were measured using a color reflectance meter.

(c) **Petal drop.** Some cultivars exhibit no obvious characteristics of senescence, but ultimately their petals drop during the process of senescence.

(d) **Shaking test.** The unnatural petal drop produced by shaking the flower stem. This simulates movement in the home.

(e) **Bending of the stem.** A natural, stiff, upright stem is a definite attribute to any cut flower. When an individual flower bent below the horizontal plane, it was discarded.

The keeping quality of cut tulips was classified as follows: (a) Keeping quality three to four days: Poor. (b) Keeping quality four to five days: Fair. (c) Keeping quality five to six days: Good. (d) Keeping quality greater than six days: Excellent.

Flower shape. The shapes of the flowers were recorded daily. A schematic diagram of the shapes is presented in figure 1. They were classified as follows: (a) Cup: Flower has the petals remaining in an upright position parallel to the flower stalk (less than 30-degree angle).

(b) Semi-cup: Flower has the petals open at 31 to 45-degree angle to flower stalk. (c) Open: Flower has the petals open at an angle greater than 45 degrees.

Flower size. Each flower was measured daily, from the bud stage until discarded. The outer petal surface, from its tip to the point of attachment to the floral stalk, was measured.

The growth of the last internode and whole plant. The tulip continues to grow after cutting. The last internode, which is that part of the stem between the upper leaf and the flower, was measured daily.

The growth of the total plant included the growth of the flower as well as the stem.

Water uptake. Six flowers of each tulip variety were chosen randomly, and each was placed in a graduated cylinder. The rate and amount of water uptake were recorded during the development of each flower. The water in the cylinders was never changed, only refilled as necessary.

Other data. In addition to the characteristics mentioned, a record was kept of the time and the weather conditions which prevailed when the tulip flowers were harvested. In the laboratory, a record was kept of the type of cut used for recutting the stems. Namely, whether the stem was cut at an angle or square.

RESULTS

Tulips, with few exceptions, will last at least five days when placed in a room at 75 degrees (table 1). The notable exception is the Darwin Hybrid class, which averaged only

three to four days and thus has limited potential in our homes. It is interesting that this class of tulips is popular in Europe at the present time, but, as Hekstra (12) has reported, the life of the tulip is temperature dependent. He found that the lower the temperature, the longer the flower life. Thus in Europe, where central heating is not widespread and the homes are naturally cool, these cultivars are acceptable.

Within a given class of tulips, we observed considerable variability in flower shape (table 1). After 24 hours, the tulip flower undergoes a transformation from the bud stage of development to full flower. We noted that most tulips become cup-shaped in this time period. On the other hand, after 72 hours considerable change was observed in many cultivars. As the flowers progressed toward senescence, we again saw varying changes. In some cases such as Athleet, a complete transition from cup to open was observed. Sometimes the petals reflexed inward during the last stages of senescence, eg, Roland. For practical purposes, the 72-hour stage of development can be used as the expected flower shape.

It should be noted that the shape of the tulip flower is a function of temperature (2, 3, 10, 11, 13, 17). It has been found that the lower the temperature the more cup-shaped the flower will become (11). In addition, fully developed tulip flowers will reflex when moved from a lower to a higher temperature (10). Many florists have observed this

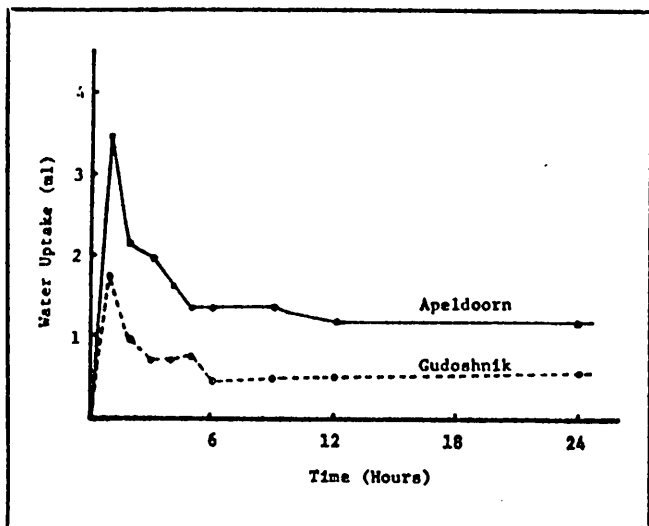


Figure 2. The 24-hour water uptake patterns for Apeldoorn and Gudoshnik tulip cultivars.

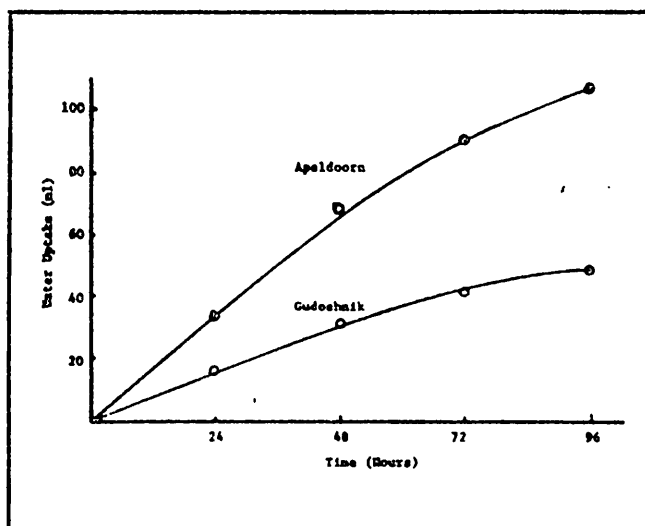


Figure 3. Cumulative 96-hour water uptake patterns for Apeldoorn and Gudoshnik tulip cultivars.

when they moved a design piece from a refrigerator to a warm room. Remember that the tulip flower will assume its normal flower shape (table 1) after about two to four hours of conditioning at room temperature.

An important point to note in table 2 is that tulip flower stems of all cultivars continue to grow after cutting. In particular, we found that considerable variation exists in the elongation of the last internode. With some cultivars, like Apeldoorn, almost all the growth can be accounted for by the last internode. On the other hand, Dreaming Maid grew little in this region. This is important for retail florists to consider, because it points out the need for wiring many tulips if a fixed design is desired. It also tells why designs with tulips change daily. It should be pointed out that the maximum growth of the last internode occurs during the first 24 hours.

We also found that the first 24 hours was the greatest period of growth for the tulip flower (table 2). In most cases, the flower petals elongated as much in the first 24 hours as in the remaining three to five days. This is important, because florists wish to have large flowers. By buying in the bud stage they can obtain a long-lasting flower and one which also will produce a larger flower after it is placed in the design.

Although no data are presented on the changes in flower colors, it was found that the red cultivars undergo the greatest change. Normally, they become much darker in color as they age. They are followed by the deep pinks, pinks, lavenders and then yellows and whites. Thus, the greater the pigmentation, the greater the changes.

The water uptake patterns (figures 2 and 3) were the same for all tulip cultivars tested. The greatest amount of water uptake occurred during the first 24 hours, and within this period of time the initial hour had the greatest rate. This explains why arrangements with tulips need to be refilled after they are sent to the customer. It was interesting to note that there was

always a decline in the rate of water uptake 24 hours prior to the death of the flower. Also, the amount of water taken up can vary between cultivars (figure 3). Perhaps in the development of new cultivars it would be desirable to select for low water uptake cultivars with long vase lives.

Lastly, measurements were made on the effect of the time of harvest (am, noon, pm), the prevailing weather conditions and the angle at which the stems are recut. None of these factors influenced the development of the tulips. The most important aspect was the stage of flower development when cut (8).

CONCLUSIONS

The information presented in this paper is given to serve as a guide for the American florists' industry. From our studies we have concluded that specific findings can be adopted by the industry.

First and foremost, it is necessary to market cut tulips in the bud stage and by cultivar name. If this is done, the information presented in tables 1 and 2 can be of value. It is obvious that each cultivar has its own desirable and undesirable characteristics. It is impossible to predict either the flower shape or life unless one knows the cultivar name.

Figures 2 and 3 show that tulips should be recut, remain wrapped and conditioned in water for at least two hours (preferably three to four) at room temperature to harden the flowers and to initiate the transition from the bud stage of development to full flower. Also, because cut tulips continue to take up water, they demonstrate the need for refilling the containers after the design has been created.

Lastly, we found that there is no specific need to recut the stem of a tulip in any particular manner. Stems should, however, be recut prior to hardening.

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EDITOR'S NOTE: The first portion of this study was presented in the January 16, 1969, issue of the Review, pp 41-43, 91 and 92. The article published in this issue is Michigan Agricultural Experiment Station Journal Article No. 4903. The research was supported in part by a grant from the Netherlands Flower-bulb Institute, New York, N.Y., and the Ornamental Marketing Board of The Hague, The Netherlands. Maarten Benschop is a student at the Agricultural University, Wageningen, The Netherlands, and A. A. De Hertogh is an associate professor, department of horticulture, Michigan State University, East Lansing.