Comparison of Four Production Systems for Dutch Iris in a Tobacco Transplant Greenhouse

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SUMMARY. Pre-cooled bulbs of two dutch iris (*Iris xhollandica*) cultivars, Ideal and White Wedgewood, were grown and harvested as cut flowers in four production systems in a tobacco (*Nicotiana tabacum*) transplant greenhouse from late October until late January in two consecutive production years (2000–01 and 2001–02). All production systems (lily crates, lay-flat bags, pots, and float trays) utilized the same commercial peat-vermiculite, tobacco germination substrate. Stems developed more quickly but were shorter and lighter in 2001–02 than 2000–01 due to warmer growing conditions. Stems grown in float trays were shorter and lighter than other treatments in 2000–01 but similar to the others in 2001–02. Stems grown in lay-flat bags flowered earlier with similar or greater stem lengths and fresh weights as the other systems. Stems of ‘White Wedgewood’

were longer and heavier than ‘Ideal’. In general, ‘White Wedgewood’ provided more consistent production than ‘Ideal’ in both production seasons. An economic analysis in this study concludes that a grower is unlikely to make money growing dutch iris in a tobacco transplant greenhouse using these production systems unless there is a targeted local market.

Traditionally, tobacco transplants have been started in outside ground beds. However, the trend since the late 1980s has been toward growing transplants in vermiculite-based, soilless substrate in polystyrene plug trays floating on shallow beds of nutrient solution (Frantz and Welbaum, 1998; Reed, 1997). Approximately 95% of tobacco transplants are currently started in greenhouses, mostly in the float bed system (W.D. Smith, personal communication). Frantz and Welbaum (1998) stated that approximately 400 plastic-covered greenhouses were used solely for tobacco transplant production in Virginia. Based on peak tobacco production of 731 million lb (331.6 million kg) in 1997 (Beacham et al., 2000), North Carolina has more than 3000 tobacco transplant greenhouses (W.D. Smith, personal communication). These greenhouses are only used for 3 months in the spring and most are empty for the remainder of the year. In North Carolina, the empty period typically lasts from mid-May until mid-February in the east and mid-June until mid-March in the west. In addition, recent quota cutbacks have reduced the space required for tobacco transplant production by more than 50%. Tobacco farmers are interested in exploiting this underutilized resource.

Broccoli (*Brassica oleracea* Botrytis Group) transplants (Niedziela and Gumbi, 1993) and cabbage (*B. oleracea* Capitata Group) transplants (Frantz et al., 1998; Niedziela and Gumbi, 1993) have been grown using the tobacco float bed system. Lettuce (*Lactuca sativa*) has been successfully grown to maturity in float bed systems (Anderson and Schmidt, 2001; Thompson et al., 1998). Frantz and Welbaum (1998) evaluated the growth and development of 12 vegetable and ornamental crops in static and ebb-and-flood float bed systems similar to those used by the tobacco industry. Chinese water spinach (*Ipomoea aquatica*), vegetable

amaranth (*Amaranthus tricolor*), zinnia (*Zinnia elegans*), and sweet basil (*Ocimum basilicum*) were the best suited of the crops tested. Frantz and Welbaum (1998) conducted this research in a glasshouse cooled by a fan and pad system.

Tobacco transplant greenhouses are covered with a double layer of polyethylene and utilize passive ventilation through drop-down side-curtains for cooling (Peek et al., 2002). The side-curtains allow air infiltration, which lowers humidity but increases heating costs. Heaters in tobacco transplant greenhouses are also sized for the moderate ambient temperatures during spring transplant production and may not be able to maintain warm temperatures of 65 °F (18.3 °C) or greater when the outside temperature is below 25 °F (–3.9 °C). The limited capacity for heating should be considered when selecting alternative crops.

Dutch iris is a potential crop for winter cut flower production in tobacco transplant greenhouses. Dutch iris is considered an easy crop to force for several reasons (Berbee, 1991). Dutch iris requires day temperatures of 60 °F (15.6 °C) and night temperatures of 55 °F (12.8 °C) (Armitage, 1993; Berbee, 1991; De Hertogh, 1996; De Munk and Schipper, 1993; Rees, 1972). Dutch iris has few pest problems (De Hertogh, 1996). Dutch iris has a relatively short production schedule (8–12 weeks) and can be grown when the greenhouse is not needed for tobacco transplants.

The objective of this study was to determine the suitability of dutch iris for cut flower production in a tobacco transplant greenhouse in four production systems.

Materials and methods

This study consisted of two identical (except for randomization) experiments run over two consecutive years (2000–01 and 2001–02) in a 30 ft wide × 60 ft long (9.1 × 18.3 m) tobacco transplant, double polyethylene covered greenhouse at the Virginia Polytechnic Institute and State University Southern Piedmont Agricultural Research and Extension Center in Blackstone. Greenhouse thermostats were set to begin heating at 55 °F and cooling at 63 °F (17.2 °C). A 60% shade cloth provided additional cooling from planting until 22 Nov. each year.

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Pre-cooled 3.9- to 4.3-inch-circumference (10–11 cm) dutch iris bulbs of the cultivars Ideal and White Wedgewood were stored at 45 °F (7.2 °C) following their arrival on 13 Oct. 2000 and 25 Oct. 2001. Prior to planting, all bulbs were dipped in a solution of etridiazole at 180 mg·L⁻¹ (ppm) and thiophanate-methyl at 300 mg·L⁻¹ (Banrot 40WP; Scotts-Sierra Horticultural Products, Marysville, Ohio) for 30 min. 'White Wedgewood' and 'Ideal' were planted on 19 and 20 Oct. in 2000 and 29 and 30 Oct. in 2001, respectively.

The four production systems tested in this study were lily crates, pots, lay-flat bags, and float trays. Lily crates were the plastic trays [23.6 inches long × 15.7 inches wide × 5.9 inches deep (60 × 40 × 15 cm)] used to ship bulbs. The crates were lined with a layer of newspaper before being filled with substrate to a depth of 4 inches (10.2 cm). Pots were 10-inch-diameter (25.4 cm) bulb pans, which held 1.3 gal (5 L). Lay-flat bags (Veggie Bags, Carolina Soils, Kinston, N.C.) were 44.9 inches long × 11.8 inches wide × 1.2 inches deep (114 × 30 × 3 cm) when filled. Float trays were 32-cell, polystyrene trays (Speedling, Sun City, Fla.) with the same outer tray dimensions as those used to propagate tobacco transplants [26.4 inches long × 13.8 inches wide × 2.0 inches deep (67 × 35 × 5 cm)]. Individual cells within the float trays tapered from 2.95 inches (7.5 cm) square at the top to 0.39 inches (1.0 cm) square at the bottom with a total volume of 5.7 in³ (94 cm³). A wood frame for the float bed was constructed from 5.5 × 1.5-inch (13.97 × 3.81 cm) pressure-treated lumber and lined with 6-mil [0.006 inch (0.1524 mm) thick] black plastic (Carlisle Plastics, Minneapolis, Minn.). The interior dimensions of each float bed were 55 inches long × 43 inches wide × 5.5 inches deep (139.7 × 109.2 × 13.97 cm).

Substrate in all systems was a commercial peat-vermiculite, tobacco germination medium (Carolina Soils). The lily crates, pots, and lay-flat bags were irrigated using an automated system with drippers (Netafim USA, Fresno, Calif.). Commencing 1 week after planting, plants were fertigated weekly with 400 mg·L⁻¹ N from calcium nitrate [Ca(NO₃)₂] through a fertilizer injector (model DI 16; Dosatron International, Clearwater, Fla.). Float trays were floated continuously

on 4 inches of tap water for the first week, and on a solution of 50 mg·L⁻¹ N from Ca(NO₃)₂ thereafter. Float bed solutions were evaluated weekly with an electrical conductivity (EC) meter (Model 09-328, Fisher Scientific, Atlanta). Water and Ca(NO₃)₂ were added to the float beds based on the weekly evaluations to maintain a 4-inch depth and an EC equivalent to ±25% of 50 mg·L⁻¹ N based on a standard curve plotted using known concentrations of Ca(NO₃)₂.

The experimental unit was 4.6 × 3.6 ft (1.40 × 1.10 m) containing six lily crates, 23 pots, five lay-flat bags, or six float trays. Each experimental unit was planted with 192 bulbs, which established a planting density of 11.6 bulbs/ft² (124.87 bulbs/m²). Mortality counts were taken 17 Nov. 2000 and 7 Dec. 2001. Individual stems were harvested with a floral tip of approximately 0.39 inches showing color using hand pruners to cut stems at the substrate line. Data collected at harvest included stem length, stem fresh weight, number of stems, and days from planting to harvest of the first stem from each experimental unit [abbreviated as days to first harvest (DFH)].

The experimental design can be viewed as a split-split plot layout with 16 subplots arranged in a Latin square within each main plot. The years were main plots. The four production systems, each repeated four times in each year, provided 16 subplots per main plot. Each subplot was then divided in half to accommodate the cultivars as sub-subplots. Every treatment combination (year × production system × cultivar) was thus replicated four times. Data were subjected to analysis of variance using PROC ANOVA in SAS 8.0

(SAS Institute, Cary, N.C.), as the data were balanced. Means were separated using the protected LSD.

Results and discussion

Stem length is an important factor determining commercial cut flower quality in dutch iris (De Munk and Schipper, 1993). The minimum marketable stem length is 18 inches (45.7 cm) and marketability increases with stem length (S. Popoulakis, personal communication). 'White Wedgewood' stems were longer than 'Ideal' [20.59 inches (52.3 cm) and 19.72 inches (50.1 cm), respectively; LSD_{0.05} = 0.51 inches (1.3 cm)]. All systems produced longer stems in 2000–01 than 2001–02 (Table 1). However, the lily crates, lay-flat bags, and pots produced longer stems than the float trays in 2000–01. In 2001–02, all systems had similar stem lengths. In 2000–01, stems from the lay-flat bags were heaviest, followed by lily crates, then pots and, finally, float trays. In 2001–02, all stem fresh weights were similar. Stems were harvested earlier from lay-flat bags than the other systems. The LSDs in Table 1 are from an analysis of data for the 2 years combined. For stem length and stem fresh weight there was a significant interaction between year and production system, so an LSD is provided for making comparisons within year or within production system. For DFH, there was no interaction with years, so production systems can be compared across years. Likewise, cultivars and production systems did not interact, so each factor can be averaged across the other. Similar arguments explain the construction and use of LSDs in Tables 2 and 3.

Stems of both cultivars were heavier in 2000–01 than 2001–02 (Table

Table 1. Effect of production system and year on the stem length and fresh weight and production system on days to first harvest (DFH) of 'White Wedgewood' and 'Ideal' dutch iris plants grown in a tobacco transplant greenhouse during 2 years (2000–01 and 2001–02). Data for DFH were averaged across years.

System	Stem length (inches) ^z		Stem fresh wt (g) ^z		DFH
	2000–01	2001–02	2000–01	2001–02	
Lily crate	23.31	18.31	36.1	21.8	62.2
Lay-flat bag	22.52	18.82	38.3	22.3	57.3
Pot	22.60	18.42	33.9	21.5	61.7
Float tray	20.43	18.27	31.3	23.0	61.6
LSD _{0.05} ^y	0.90		1.9		2.6

^z1.0 inch = 2.54 cm; 1.0 g = 0.0353 oz.

^yLSD values for stem length and fresh weight are for comparing systems within each year or years within each system. LSD value for DFH is for comparing between systems.

Table 2. Effect of cultivar and year on the stem fresh weight and days to first harvest (DFH) of 'White Wedgewood' and 'Ideal' dutch iris plants grown in a tobacco transplant greenhouse during 2 years (2000–01 and 2001–02).

Cultivar	Stem fresh wt			
	(g) ^z		DFH	
	2000–01	2001–02	2000–01	2001–02
Ideal	32.1	20.8	76.6	43.9
White Wedgewood	37.7	23.4	72.9	49.4
LSD _{0.05} ^y	1.1		0.9	

^z 1.0 g = 0.0353 oz.

^y LSD values are for comparing cultivars within each year or years within each cultivar.

2). Stems of 'White Wedgewood' were heavier than those of 'Ideal' in both years. However, the cultivar differences were greater in 2000–01 than 2001–02. Although there were significant cultivar differences for stem length, stem fresh weight, and DFH, cultivars did not interact significantly with production systems and therefore it was appropriate to compare cultivars averaged across production systems. In 2000–01, 'White Wedgewood' was earlier than 'Ideal'; however, in 2001–02, 'Ideal' was earlier than 'White Wedgewood.' Plants matured more quickly in 2001–02 than 2000–01.

Following 2000–01, it was concluded that one possible factor influencing the stem length was the N level in the float bed solution. In 2001–02, Mullins et al. (2002) conducted a study in the same greenhouse at the same time to determine whether stem length was influenced by N level in the float tray system. Float trays on continuous 200 mg·L⁻¹ N produced longer stems than lay-flat bags fertigated weekly at 400 mg·L⁻¹ N but had similar stem lengths

to those in float trays at 50 and 100 mg·L⁻¹ N (Mullins et al., 2002).

However, since the float trays and other treatments had equal stem lengths in 2001–02, this indicates that fertility is not the only variable responsible for stem length differences. Another possible cause of shorter stems in float trays in 2000–01 was a seismomorphogenic response to wind and vibrations (Schnelle et al., 1993). Stems may have been shorter because the float trays float on the nutrient solution, thereby moving and vibrating occasionally. Air movement would be greater when the side curtains are lowered for cooling. The shorter stems in all treatments in 2001–02 may have been related to two phenomena: temperature and air movement. The daily mean ambient temperatures were warmer in 2001–02 than 2000–01. Mean monthly temperatures averaged 9.7 °F (5.39 °C), 13.7 °F (7.61 °C), and 5.4 °F (3.00 °C) higher in Nov. 2001, Dec. 2001, and Jan. 2002, respectively, than the corresponding months the previous year. The warmer

temperatures would increase transpiration, which might increase water stress and thereby decrease stem length and weight and accelerate the maturation process. Nelson and Niedziela (1998) observed that tulips (*Tulipa gesneriana*) were shorter and weighed less when forced at higher temperatures. In addition to the effect of increased water stress on growth and development, higher ambient temperatures would lead to the side curtains remaining open longer. This would increase air movement in the greenhouse and decrease stem length and weight. Shorter time to maturity is preferable if quality can be maintained. However, stems were shorter and lighter in 2001–02, likely due to the warmer growing conditions. The lay-flat system had the advantage of earlier maturity than the other systems while maintaining stem length and weight.

In 2000–01, the mean total yield was similar between systems within cultivar and cultivars within system. In 2001–02, 'White Wedgewood' had similar total yields in all systems (Table 3). However, 'Ideal' in lay-flat bags had a higher total yield than in other systems. In 2001–02, 'White Wedgewood' produced higher total yields than 'Ideal' in lily crates, pots, and float trays. Lily crates, pots, and float trays planted with 'Ideal' had higher total yields in 2000–01 than in 2001–02.

In 2000–01, mortality was similar for the two cultivars but 'Ideal' suffered higher mortality in lay-flat bags than in pots or float trays (Table 3). In 2001–02, lily crates and float trays

Table 3. Effect of production system, cultivar, and year on total yield (TY), mortality, and marketable yield (MY) of 'White Wedgewood' and 'Ideal' dutch iris plants grown in a tobacco transplant greenhouse during 2 years (2000–01 and 2001–02).

System	TY ^z (stems/ft ²)		Mortality (%)		MY ^z (stems/ft ²)	
	Ideal	White Wedgewood	Ideal	White Wedgewood	Ideal	White Wedgewood
2000–01						
Lily crate	10.8	11.2	2.7	1.2	10.4	11.3
Lay-flat bag	10.8	11.2	4.4	2.5	9.8	11.1
Pot11.1	11.6	1.4	0.0	10.1	11.6	
Float tray	11.3	11.1	1.0	1.7	11.0	11.2
2001–02						
Lily crate	9.6	11.1	8.4	2.3	4.7	8.6
Lay-flat bag	11.4	11.1	1.3	1.2	7.6	8.9
Pot10.2	11.3	2.1	0.8	3.7	8.5	
Float tray	9.6	11.3	11.9	0.5	3.0	9.8
LSD _{0.05} ^y	0.7		2.7		1.3	

^z 1.0 stem/ft² = 10.76 stems/m².

^y LSD values are for comparing systems within each cultivar × year combination, cultivars within each system × year combination, and years within each cultivar × system combination.

had higher mortality when planted with 'Ideal' than 'White Wedgewood'. In 2001–02, for 'Ideal', float trays had the highest mortality, followed by lily crates and then lay-flat bags and pots. 'White Wedgewood' had similar mortality levels across production systems and years. The bulbs of both cultivars showed no visible signs of disease at planting in either year. In 2000–01, the higher mortality of 'Ideal' in the lay-flat bags may be attributed to high moisture in the shallow substrate. However, 'Ideal' had the lowest mortality in lay-flat bags in 2001–02. It might also be expected that the float trays would also have a high mortality due to constant exposure to water. 'Ideal' in float trays had the lowest mortality in 2000–01 but the highest in 2001–02. 'Ideal' in the deep lily crate also had a high mortality in 2001–02. This variable response of 'Ideal' to the production systems is probably due to the different environmental conditions during the 2 years.

Short stem length was the primary reason for unmarketable stems. The marketable stems were those having a minimum length of 18 inches and free of defects. In 2000–01, marketable yield did not differ significantly between systems for either cultivar (Table 3). For dutch iris grown in pots, marketable yield was higher for 'White Wedgewood' than 'Ideal' in the first year. In 2001–02, 'Ideal' in lay-flat bags had higher marketable yields than when grown under other systems. In 2001–02, 'White Wedgewood' produced a higher marketable yield in float trays than pots. In general, marketable yields were lower in 2001–02 than 2000–01.

Budgets were created using typical economic practices where expenditures are the actual costs incurred over the 2 years of the study. Both fixed and variable costs were included in the budgets with the assumption that tobacco transplants would continue to be grown in the greenhouse. In other words, the cost of the greenhouse was only counted during the actual time that the greenhouse was being used to grow, prepare to grow, or cleanup after growing the dutch iris crop. Major expenses were bulbs, propane for heating, and labor. Some of the fixed costs, including land charge and building cost, were calculated using

the available interest rate at the time of this study. Actual production costs vary from operation to operation. The estimated costs of production for float trays, lay-flat bags, lily crates, and pots were \$0.50, \$0.56, \$0.55, and \$0.60 per stem, respectively. The price paid by wholesale florists in the mid-Atlantic region fluctuates from \$0.25 to \$0.50 per stem. Retail flower shops typically pay wholesale florists \$0.40 to \$0.80 per stem. The price range is \$1.00 to \$1.39 per stem at local supermarket chains. This research indicates that dutch iris is not economical to grow in a tobacco transplant greenhouse and market to wholesale florists; however, this crop may be profitable to market to a retail florist or directly to consumers, depending on the production system.

In summary, lay-flat bags had earlier production and maintained equal or greater yield, stem length, and stem fresh weight than other production systems for the forcing of dutch iris in a tobacco transplant greenhouse. In general, 'White Wedgewood' had more consistent yield and longer and heavier stems throughout the two production seasons than 'Ideal.' Other blue cultivars with greater yield and quality production should be investigated. Environmental conditions from year to year can impact yield and stem quality. Future research should focus on additional cut flower species that may be grown more economically in a tobacco transplant greenhouse. Since tobacco production in the U.S. has decreased in recent years, some tobacco transplant greenhouses are currently available year-round for production of alternative crops. Expansion into other periods of the year should also be investigated.

Literature cited

- Anderson, R.G. and L.S. Schmidt. 2001. Nutrient analysis of commercial organic fertilizers for greenhouse vegetable production. *HortScience* 36:503 (Abstr.).
- Armitage, A.M. 1993. Specialty cut flowers. 1st ed. Varsity Press/Timber Press, Portland, Ore.
- Beacham, C., A.B. Brown, and M.L. Walcen. 2000. The impact of the 1998 tobacco settlement on the North Carolina economy. N.C. Rural Econ. Dev. Ctr. Tech. Rpt. 104.
- Berbee, H. 1991. Iris (*Iris hollandica*), p. 611–614. In: V. Ball (ed.). Ball redbook. Geo. J. Ball, Chicago.
- De Hertogh, A. 1996. Holland bulb forcers guide. 5th ed. Alkemade Printing B.V., Lisse, The Netherlands.
- De Munk, W.J. and J. Schipper. 1993. *Iris*—Bulbous and rhizomatous, p. 349–379. In: A. De Hertogh and M. Le Nard (eds.). The physiology of flower bulbs. Elsevier Science Publ., Amsterdam.
- Frantz, J.M. and G.E. Welbaum. 1998. Producing horticulture crops using hydroponic transplant systems. *HortTechnology* 8:392–395.
- Frantz, J.M., G.E. Welbaum, Z. Shen, and R. Morse. 1998. Comparison of cabbage seedling growth in four transplant production systems. *HortScience* 33:976–979.
- Mullins, C.D., C.E. Niedziela, Jr., T.D. Reed, and A. Atalay. 2002. Effect of calcium nitrate concentration on the growth and flowering of dutch iris (*Iris hollandica*) in the float bed system. *Va. J. Sci.* 53:57 (Abstr.).
- Nelson, P.V. and C.E. Niedziela, Jr. 1998. Effect of ancymidol in combination with temperature regime, calcium nitrate, and cultivar selection on calcium deficiency symptoms during hydroponic forcing of tulip. *Scientia Hort.* 74:207–218.
- Niedziela, C.E. and P. Gumbi. 1993. Effect of cell size on the growth of broccoli and cabbage transplants in the tobacco float system. *HortScience* 28:530 (Abstr.).
- Peek, D.R., T.D. Reed, J.L. Jones, C.S. Johnson, P.J. Semtner, and C.A. Wilkinson. 2002. Burley tobacco production guide. *Va. Coop. Ext. Publ.* 436–050.
- Reed, T.D. 1997. Float greenhouse tobacco transplant production guide. *Va. Coop. Ext. Publ.* 436–051.
- Rees, A.R. 1972. The growth of bulbs: Applied aspects of the physiology of ornamental bulbous crop plants. 1st ed. Academic Press, New York.
- Schnelle, M.A., B.D. McCraw, and J.M. Dole. 1993. Height control of flowering crops and vegetable transplants. *Okla. Coop. Ext. Publ. No.* F-6714.
- Thompson, H.C., R.W. Langhans, A.J. Both, and L.D. Albright. 1998. Shoot and root temperature effects on lettuce growth in a floating hydroponic system. *J. Amer. Soc. Hort. Sci.* 123:361–364.