Greenhouse-grown Transplants as an Alternative to Bare-root Transplants for Onion

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Additional index words. Allium cepa, artificial media, development, flats, inserts, maturity

Abstract. Commercially produced bare-root onion (Allium cepa L.) transplants may not be uniform in size and require a period following planting in which to begin regrowth. There is little information on how, when established in the field, plants developed from greenhouse grown onion transplants differ from those that develop from bare-root transplants. Development and yield for onions grown from bare-root transplants were compared to plants produced from transplants grown in single cells with volumes of 36 or 58 cm³ in seedling production trays in a greenhouse. ‘Texas Grano 1015 Y’ and ‘Walla Walla’ onions were established in the field with commercially available bare-root transplants or with greenhouse grown transplants produced in trays. Bare-root transplants were heavier than 8-week-old greenhouse grown transplants. Fresh weights of transplants produced in 58-cm³ cells were heavier than those from 36-cm³ cells, but dry weights were similar. From when about 20% of onion tops were broken over, onion bulb diameters did not increase sufficiently to justify delaying harvest until 50% of tops had broken over. Yields of ‘Walla Walla’ were better than those of ‘Texas 1015 Y’ and yields from plants developed from seedlings grown in 58-cm³ cells were similar to those from plants developed from bare-root transplants and better than those from plants developed from seedlings grown in 36-cm³ cells. Individual bulb weights of ‘Texas 1015 Y’ were not affected by transplant type and averaged 162 g. Individual bulbs for ‘Walla Walla’ from plants developed from bare-root transplants and those produced in 58-cm³ cells were similar in weight (averaged 300 g) and were heavier than those from plants developed from transplants grown in 36-cm³ cells (240 g). Greenhouse transplants produced in trays with the larger cells may provide an alternative to the use of bare-root transplants, if transplant production costs are comparable.

Bare-root transplants are widely used to establish onion (Allium cepa L.) in the field. To produce bare-root transplants seed are sown in close proximity. Developing plants are lifted from beds, tops and roots are trimmed, and plants are bundled for shipping. Differences in seed size and weight, time to germination, and plant density may cause bare-root transplants to lack uniformity in size that may affect their vigor, and possibly affect yield from plants that developed from them (Gamiely et al., 1990). Bare-root transplants have to renew growth when they are established in the field.

There has been increased interest in the production of onion transplants in the greenhouse. Greenhouse production allows overcoming transplant shock when established in the field.

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Materials and Methods

The experiment was conducted at Lane, Okla., on a Berwone fine-loamy, siliceous, thermic Glossic Paleudalf soil. Fertilizer was added to bring soil residual fertilizer levels to 100N–112P–212K kg·ha⁻¹ in response to soil test results (Motes and Roberts, 1994). Fertilizer was incorporated with a multifunction soil preparation implement (Do-All, Forrest City, Ark.). The source of N was ammonium nitrate, P was soluble P₂O₅, and K was muriate of potash. Following disking, rough beds were formed with a hiller-furrower (Powell Manufacturing, Bennettsville, S.C.). Beds were planted on 0.9-m centers, for a tillower and bed-shaper (Ferguson, Suffolk, Va.), were 30 cm high and 46 cm across the top, and oriented east to west.

Eight-week-old (four- to five-leaf stage) transplants of ‘Texas Grano 1015 Y’, a short-day cultivar, and ‘Walla Walla’, a long-day cultivar, were produced in a greenhouse at Lane. These cultivars were chosen based on results of trials of transplanted cultivars at Lane (Shrufler and Taylor, 2002). Age of transplants used was based on the best estimation of yield from other research where seedling ages ranged from 4 to 12 weeks (Brewster, 1994; Herison et al., 1993; Kanton et al., 2002; Leskovar and Vavrina, 1999). The trays in which transplants were produced contain 128 cells (Speedling, American Plant Products, Oklahoma City, Okla.). Cell dimensions were 35 × 35 mm, length and width, and depths were 65 or 115 mm. Cells in trays are inverted, truncated, pyramids. To determine cell volumes the hole in the bottom of the cell was plugged, the cell was filled with water, the hole was unplugged, the water dispensed in to a graduated cylinder, and the volume measured in milliliters and converted to cm³ (1 mL = 1 cm³). The shorter cells had volumes of 36 cm³ and the taller volumes of 58 cm³. Reddi-Earth potting mix (Scotts-Sierra Horticultural Products, Marysville, Ohio) was used in the trays. Daytime temperature in the greenhouse was maintained at about 32 °C and night time temperatures did not drop below 20 °C. Additional light to extend the illumination period to 10 h was with fluorescent bulbs (Son Agro: Phillips, Sommerset, N.J.) providing 430 lumens/m².

Commercially available bare-root transplants (Dixondale Farms, Carrizo Springs, Texas) of these same cultivars were also used. Bare-root transplants were grown outdoors at the company’s production site. The age at lifting and clipping of the bare-root transplants is not known, but bare-root transplants were shipped, received, and established in the field in the time period recommended for this location. The bare-root transplants are typically 120 d old when shipped. Packages of bare-rooted transplants contained some substandard plants which were discarded. Only those bare-root transplants that would be able to be planted with a mechanical transplanter were used. Ten randomly chosen transplants from each type and cultivar were put aside. The growing medium was washed from the roots of the greenhouse produced transplants. Fresh weights were determined and the trans-
Table 1. ANOVA for treatment effects on fresh and dry weights of bare-root and 8-week-old greenhouse grown onion transplants, yields, and average marketable bulb weight.

| Source      | Transplant wt (g) | Yield (Mg ha⁻¹) | Avg marketable bulb wt (g) |
|-------------|-------------------|-----------------|---------------------------|
| Year (Y)    | Fresh NS          | Dry NS          | NS                        |
| Cultivar (C) | **                | **              | **                        |
| Transplant type (T) | **    | **              | **                        |
| Interaction C × T | **  | **              | **                        |

*Only the C × T interaction was significant.
NS, ** Non-significant, or significant at P < 0.05 or 0.01, ANOVA.

Fig. 1. Effect of interaction of cultivar and transplant type on fresh and dry weights of transplants averaged over years. Bare = bare-rooted transplants and 58 and 36 cc = transplants from cells with volumes of 58 and 36 cm³ in transplant trays, respectively. Vertical lines represent standard error of the means.

Methods procedures in SAS, ver. 7.1 (SAS Institute, Cary, N.C.).

Results and Discussion

Year did not affect transplant fresh and dry weights, bulb yields, and average bulb weight, but cultivar, transplant type, and the interaction of cultivar and transplant type did affect transplant fresh and dry weights, bulb yields and average bulb weight (Table 1). Data were pooled over years and the results of the interaction are presented. Transplant fresh and dry weights are presented in Fig. 1. Fresh weight of bare-root ‘Texas 1015 Y’ were greater than for ‘Walla Walla’. Fresh weights of transplants produced in trays with cell volumes of 58 cm³ were heavier than those with cell volumes of 36 cm³ for both cultivars, and transplants produced in trays were less than that for bare-rooted plants. Dry weights for greenhouse grown transplants were similar for the cultivars, and less than for bare-root transplants.

Final plant populations averaged 69,270 and 70,000 plants/ha in 2000 and 2002, respectively, are about one-fourth of those used in other onion production regions, and not affected by treatment. In 2000, onion bulb diameter increased 10.9% and 2.0%, for ‘Texas Grano 1015 Y’ (Fig. 2A) and ‘Walla Walla’ (Fig. 2B), respectively for the 5 to 12 d before harvest. Only for ‘Texas Grano 1015 Y’ seedlings produced in 58 cm³ cells the increase in bulb diameter result in an increase in class size (from medium to jumbo). In 2002, onion bulb diameter increased 4.4% and 2.2% for ‘Texas Grano 1015 Y’ (Fig. 3A) and ‘Walla Walla’ (Fig. 3B), respectively for the 5 to 31 d before harvest. There was no increase in class size due to increases in bulb diameter. Sargent et al. (2001) found that harvest about 8 d before harvest, when 100% of tops were broken over, produced acceptable yields for fresh market, short-day, onions. In this experiment it was found that harvest could be as early as when 20% of tops were broken over of tops for the cultivars tested. Between the time when 20% and 50% of tops were broken over there was little increase in bulb size and class size was generally not increased. Producers may wish to consider earlier harvest, with adequate curing.

Yields of marketable onions are presented in Fig. 4. For ‘Texas 1015 Y’ yields of medium grade bulbs for plants developed from bare-root transplants were greater than yields of medium onions from bare-root ‘Walla Walla’ transplants. Yield of medium bulbs from other plants were similar. ‘Walla Walla’ jumbo class yields were similar for plants developed from bare-rooted transplants and transplants from 58-cm³ cell volumes, and these were greater than jumbo yields from ‘Texas 1015 Y’ or jumbo yields of ‘Walla Walla’ for plants developed from transplants produced in 36-cm³ cells. Yield of colossal onions was greater with ‘Walla Walla’ from all transplant sources compared to the comparable transplant source for ‘Texas 1015 Y’. In all cases total marketable yield was greater for ‘Walla Walla’ than for ‘Texas 1015 Y’, and total yields were least for plants developed from transplants produced in 36-cm³ cells.
The effect of treatment on average bulb weight is presented in Fig. 5. Average bulb weight of 'Texas Grano 1015 Y' was less than for 'Walla Walla' for plants developed from each type of transplant. 'Texas 1015 Y' average bulb weight were similar regardless of transplant source. 'Walla Walla' average bulb weights for plants from bare-root transplants and plants developed from transplants produced in cells with a volume of 58 cm³ were similar, and heavier, than those from plants developed from transplants produced in cells with a volume of 36 cm³.

Leskovar and Vavrina (1999), reporting on a system using transplant trays with cell volumes of 4 and 7.1 cm³ to produce onion seedlings, showed that cell volume was not related to total yield, but that yield of medium and jumbo size bulbs was improved with the use of the larger cell. This paper reports that size and yield of bulbs, from plants developed from transplants produced in trays, were also affected by cell size, with the larger volume providing a benefit. The differences between these studies may be that larger cell sizes (36 and 58 cm³) were used in this study than those used by Leskovar and Vavrina (1999).

The objective of this research was to compare
an existing technology to an alternative technology using transplants of two onion cultivars. The greenhouse transplants were smaller than bare-root transplants even though the bare-root transplants had the roots and about 50% of the tops removed. It remains to be determined if maintaining seedlings in the greenhouse until they were the same size as bare-root transplants would improve performance.

Greenhouse grown transplants have functioning leaf and root systems whereas the bare-root transplants have to regenerate the leaf and root systems. This suggests that the greenhouse transplants should have a developmental advantage, and in fact plants that developed from transplants produced in 58-cm³ cells performed as well as bare-root transplants.

In some instances total yields from bare-root and greenhouse grown transplants were about a third of those that are common for established production regions. It may be possible to attain the higher yields in southeastern Oklahoma if plant populations are increased. It will require about 350 m² of greenhouse space to produce 179,200 transplants, a plant population for 1 ha used in established growing regions. The

Fig 3. Percentage of tops broken over and change in bulb diameter of ‘Texas Grano 1015 Y’ (A) and ‘Walla Walla’ (B) for up to 31 d before harvest in 2002. Vertical lines connect the bulb diameter with the point at which about 20% tops were broken over. Abbreviations in the legend stand for: BR-Break = % of tops broken over for plants from bare-root transplants; 36-Break = % of tops broken over for plants from transplants from 36 cm³ cells in transplant trays; 58-Break = % of tops broken over for plants from transplants from 58 cm³ cells in transplant trays; BR-Dia = bulb diameters for plants from bare-root transplants; 36-Dia = bulb diameters for plants from transplants from 36-cm³ cells in transplant trays; and 58-Dia = bulb diameters for plants from transplants from 56-cm³ cells in transplant trays.
production of onion transplants would likely need to be done by commercial operations in much the same way other vegetable transplants are produced. If the economics of greenhouse production are acceptable, use of transplants produced in trays with the larger cells may provide an alternative to the use of bare-root transplants.

**Fig. 4.** Effect of interaction of cultivar and transplant type on harvest grades or size distribution of plants developed from transplants in 2000. Bare = bare-rooted transplants and 58 and 36 cc = transplants from 58- and 36-cm³ cells in transplant trays, respectively. Vertical lines represent standard error of the means.

**Fig. 5.** Effect of interaction of cultivar and transplant type on average bulb weight in 2002. Bare = bare-rooted transplants and 58 and 36 cc = transplants from 58- and 36-cm³ cells in transplant trays, respectively. Vertical lines represent standard error of the means.

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