# Technology & Product Reports

# Annual Culture of Globe Artichoke from Seed in Virginia

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***Additional index words.*** vernalization, *Cynara scolymus*

***Summary.*** The globe artichoke (*Cynara scolymus* L.) is usually propagated vegetatively because plants grown from seed lack uniformity. Furthermore, in much of the United States, only a small percentage of plants grown from seed flower during the first season due to insufficient chilling for vernalization. Artichokes cannot be grown reliably as perennials without winter protection where temperatures are consistently below –10C. The new cultivars Imperial Star (IS) and Talpiot (TP) reportedly produce uniform plants from seed and a high percentage of flower heads (capitulum) the first year with minimal chilling. 'Imperial Star' and TP were compared with the standard seed-propagated cultivars 'Green Globe Improved' (GG) and 'Grande Buerre' (GB). Plants of each cultivar were tested over a 3-year period in Blacksburg, Va., or for 1year in three other locations. Essentially all IS and GG plants flowered after receiving 1356 h of chilling at <10C. With 205 h of chilling, 83% of IS plants flowered compared to 25% for GG. No TP or GB plants flowered after receiving as much as 528 h of chilling. In the mountains of western Virginia, only IS plants established in the field in early May received sufficient chilling to produce flower heads during the late summer and early fall. June transplants did not flower because sufficient chilling was not obtained for vernalization. In warmer areas of central and eastern Virginia, fall establishment for spring harvest may yield a higher percentage of flowering plants compared to spring planting and summer harvest.

The globe artichoke is native to the Mediterranean region and has been grown in the United States since colonial times (Ryder et al., 1983). The "globe" refers to the immature flower head, or capitulum, which includes the fleshy bases of the outer bracts, the inner bracts, the receptacle, and portions of the floral stem that are eaten after cooking (De Vos, 1992). Thomas Jefferson raised globe artichokes on his plantation in central Virginia as early as 1767 (Betts, 1944). Jefferson showed renewed interest in globe artichokes after serving as ambassador to France, and he resumed his globe artichoke trials at Monticello in the early 1800s.

Although Jefferson enjoyed some success growing globe artichokes in Virginia, he encountered several major problems (Betts, 1944). Artichokes generally do not produce plants that are true-to-type from seed. Also, artichoke plants grown from seed are often barren the first season because they are not vernalized. Furthermore, globe artichokes are not winter-hardy and must be reestablished annually in areas where temperatures remain below –10C for prolonged periods (Baggett et al., 1982). Globe artichoke plants are quite stress-tolerant, but cool temperatures are required for the production of fleshy, non-fibrous flower heads. Jefferson's plants flowered in late June, when high temperatures caused the flower heads to be tough and fibrous (Betts, 1944).

In the 1800s, commercial globe artichoke production began along the central coast of California, where the mild climate is nearly perfect for perennial culture (De Vos, 1992). California continues to dominate artichoke production in the United States, with ≈4500 ha (De Vos, 1992).

Attempts have been made to grow the globe artichoke as an annual from seed in Michigan (Harwood and Markarian, 1968), Oregon (Baggett, et al., 1982), Connecticut (Hill and Maynard, 1989), and Florida (Maynard and Howe, 1986), with varied results. In Oregon, most plants established from seed during the spring received sufficient chilling to flower during the first season (Baggett et al., 1982), whereas in Florida, spring establishment resulted in barren plants (Maynard and Howe, 1986). Flowering in warm climates may be reduced by devernalization at temperatures >26C (Gerakis et al., 1969). Seeds or immature plants may be placed in cold storage to increase the percentage of plants that flower during the first season, but this practice is not adapted easily to large-scale commercial production, is costly, and is labor-intensive (Hill and Maynard, 1989). Spray treatments with gibberellic acid may increase the number of flowering plants during the first season (Hill and Maynard, 1989; Snyder et al., 1971). The recent introduction of cultivars that produce flower heads during the first season from seed may allow the globe artichoke to be grown as an annual in areas where perennial culture is not possible. However, little is known about how "annual" cultivars perform under short-season conditions in the eastern United States.

In 1991 and 1992, 'Imperial Star' (IS, Keithley Williams Seed Co., Yuma, Ariz.), a cultivar developed to produce uniform flower heads during the first season from seed (Schrader and Mayberry, 1992), was compared with a standard cultivar—Green Globe Improved (GG, Park Seed Co., Greenwood, S.C.) in Blacksburg, Va. At the same location in 1993, IS was compared to 'Talpiot' (TP, Hazera Se-

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Table 1. *A comparison of means for 'Green Globe Improved' and 'Imperial Star' globe artichokes grown from seed as annuals in 1991 and 1992 in Blacksburg, Va.*

| | Percent | | Mean | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plants surviving transplanting | Plants producing flower heads | Days to harvest | Flower head fresh wt (g) | Flower heads/ plant | Off-type flower heads/plant | Flower heads >75 g/plant | Marketable flower heads/plant |
| Cultivar | | | | | | | | |
| IS | 89 | 92 | 91.3 | 75.8 | 9.9 | 1.1 | 3.9 | 3.4 |
| GG | 90 | 62 | 91.4 | 69.3 | 11.0 | 1.2 | 3.8 | 3.4 |
| Significance | NS | * | NS | NS | NS | NS | NS | NS |
| Year | | | | | | | | |
| 1991 | 84 | 55 | 92.6 | 78.4 | 10.3 | 1.5 | 4.9 | 4.2 |
| 1992 | 95 | 99 | 90.0 | 66.8 | 10.6 | 0.8 | 2.8 | 2.6 |
| Significance | * | * | NS | * | NS | * | * | * |

NS,* Nonsignificant or significant by F test at $P \leq 0.05$, respectively.

lected Seeds, Haifa, Israel), another cultivar developed to grow true-to-type from seed, and 'Grand Buerre' (GB, Tompson and Morgan, Jackson, N.J.), a cultivar that is often grown from seed. IS also was grown in Leesburg, Virginia Beach, and Cana, Va., in 1993.

Seeds were sown in polystyrene trays with 3.2 × 3.2 × 4.5-cm cells in March in a greenhouse maintained above 16C. Six- to 8-week-old transplants were planted into fine-loamy, mixed, mesic, Ultic Hapludalf soil near Blacksburg, Va., on 14 May 1991, 18 Apr. 1992, and 18 May 1993. In 1992, GB, IS, and TP also were direct-seeded on 24 Apr. At other locations, 20 to 40 eight- to 10-week-old transplants were planted after 7 June 1993. In-row spacing was 0.9 m, and rows were spaced either 0.9 or 1.2 m apart.

In 1991 and 1993, black plastic mulch (64 µm thick, 1.2 m wide) was used for all treatments. In 1991, the mulch deteriorated in late June and was removed. Fertilizer (18.5N–8.0P–15.4K, $kg \cdot ha^{-1}$) was banded beneath each row before planting. A drench consisting of 9N–19.4P–12.5K fertilizer (4 $g \cdot liter^{-1}$) was applied at a rate of 250 ml/plant at transplanting. Ammonium nitrate was top-dressed at a rate of 48.5 $kg \cdot ha^{-1}$ in mid-July. At least 2.5 cm of water was applied weekly via sprinkler irrigation in 1991 and 1992 and drip irrigation in 1993.

Flower heads were harvested when they had attained maximum size, but before the lowest bract began to open. Heads weighing <75 g were classified as culls. Mean flower head production per plant was calculated only for plants that flowered. Chilling hours were calculated from the date of transplanting to first harvest using a base temperature of 10C (Gerakis et al., 1969). Temperatures were recorded at a weather station on the research farm. The experimental design in Blacksburg for 1991, 1992, and 1993 was a randomized complete-block with four replications and 10 plants of each cultivar per block. Percentage data were arcsin-transformed prior to analysis to normalize the variances of binomial data.

Field establishment using transplants was more successful than direct seeding. More than 89% of both cultivars survived transplanting (Table 1). The percent emergence in all direct-seeded plots was<10% due to soil crusting and fluctuating temperatures. In 1991, 84% of the transplants survived, but, in 1992, with an earlier planting date and cooler temperatures, the survival rate was 95%.

Both IS and GG produced marketable flower heads 91 days after transplanting (Table 1). A higher percentage of IS plants flowered compared to GG, and a greater percentage of plants of both cultivars flowered in 1992 (Table 1). Flower heads of GG were 71.8 ± 1.2 mm tall and more elongated than IS (64.9 ± 0.6 mm). The average flower head diameter was 79.3 ± 3.3 mm for GG, compared to 77.9 ± 2.0 mm for IS. The flower head fresh weight of each cultivar was essentially the same, but heads in 1991 had greater fresh weight than in 1992 (Table 1). Of the plants that flowered, the mean number of heads per plant was 10 and 11 for IS and GG, respectively (Table 1). Of the total, about one off-type head per plant was produced by both cultivars, and there were more off-type heads produced in 1991 (Table 1). Because only about four flower heads per plant weighed >75 g for both cultivars, most heads were rated unmarketable for lack of size (Table 1). The marketable yield was 3.4 flower heads per plant for both cultivars, and there were more marketable flower heads per plant in 1991 (Table 1). Many of the differences between years could be attributed to the higher mean daily temperatures in 1991 (21.4 ± 0.6C) compared to 1992 (16.4 ± 0.6C). Overall, 46% of IS flower heads were rated marketable, compared to 42% for GG. Based on this study, a hectare of IS should produce 29,600 marketable heads if all plants flowered.

Flower heads produced by IS plants grown from seed in Virginia were smaller and more variable than those typically produced by vegetatively propagated plants in California. There was no noticeable difference in taste among cultivars. IS quality should prove acceptable for gardeners and local markets in Virginia, if not for wholesale trade.

Under identical conditions, IS generally produced a higher percentage of flowering plants than GG. This suggests that IS requires less chilling hours to induce flowering. Nearly all GG and IS plants produced flower heads after 1356 h of chilling (Fig. 1). However, 83% of IS plants flowered after 204 h of chilling, compared to 25% for GG (Fig. 1). TP and GB did not produce flower heads during the first season from seed after receiving up to 528 h of chilling. Both GG and IS plants were barren when no chilling hours were accumulated (Fig. 1). June plantings of all cultivars in Blacksburg, Leesburg, Cana, and Virginia Beach produced no flower heads due to insufficient chilling hours, because temperatures were never below 10C. All TP plants flowered after overwintering in Virginia Beach, but the number of hours of chilling were not recorded.

Gerakis et al. (1969) found that

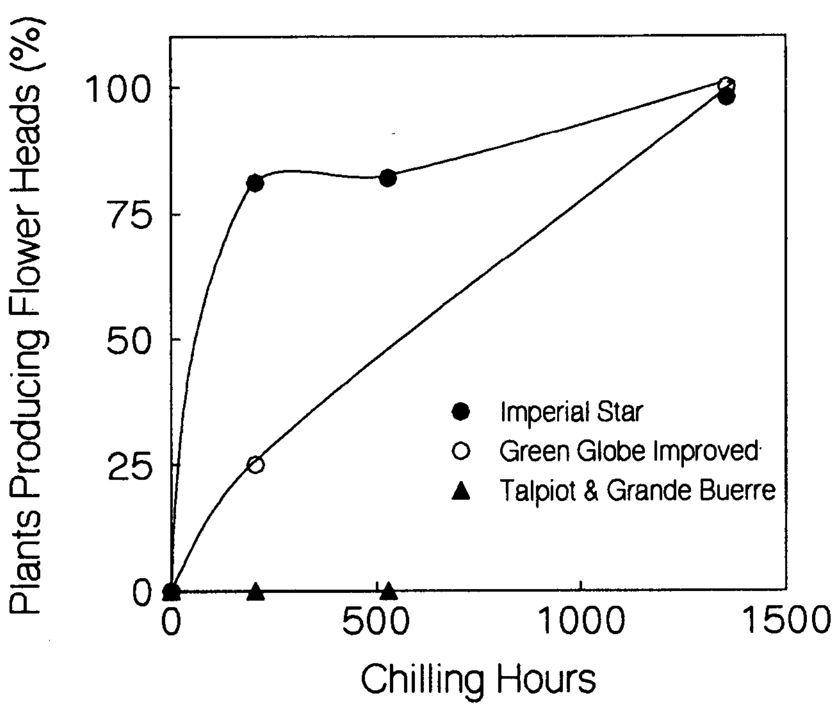


Fig. 1. ***The number of plants producing flower heads plotted against chilling hours accumulated from transplanting until harvest using 10C as the base temperature. Results of experiments in 1991, 1992, and 1993 have been combined for all locations. 'Imperial Star' required fewer chilling hours to produce flower heads.***

artichoke plants are devernalized at temperatures >26C. In both 1991 and 1992, the total time above 26C greatly exceeded the time below 10C, indicating that the hours above 26C did not directly cancel the chilling hours. In 1992, essentially all plants flowered in spite of accumulating several hundred hours above 26C. These results suggest that the cultivars in this study were not as sensitive to devernalization as those in the previous study, or that the threshold for devernalization may be higher than 26C. Subtracting an hour above 32C from the total accumulated chilling hours shifted all points in Fig. 1 uniformly to the left and did not alter the relationship between chilling hours and cultivars. In 1992, nearly all plants produced flower heads with no exposure to temperatures above 32C. In both 1991 and 1993, 83% of IS plants produced flower heads after exposure to 120 and 157 h above 32C, respectively. It is unclear whether the higher percentage of barren plants in 1991 and 1993 resulted from insufficient chilling or devernalization, because all plants were exposed to temperatures >32C in both years. However, high temperature did delay flower-head formation (Fig. 2).

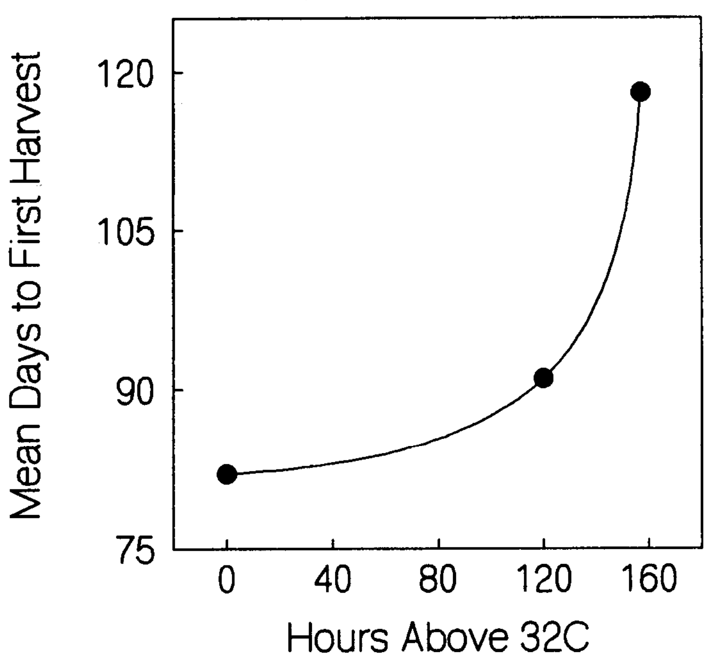


Fig. 2. ***The cumulative hours above 32C are plotted against the mean days to harvest for 'Imperial Star' grown in Blacksburg, Va., in 1991, 1992, and 1993. Higher temperatures delayed flower bead development.***

IS has a lower chilling requirement for vernalization than GG, TP, and GB and will flower during the first season from seed with as little as 200 h of chilling. In the mountains of western Virginia, late April or early May appears to be the optimum planting date to ensure that a high percentage of IS plants produce flower heads. April or May planting dates also result in flower head development in late summer and early fall, when cooler temperatures favor high-quality flower-head production.

In warmer climates, such as the Piedmont and coastal plain of eastern Virginia, artichoke production from seed is problematic even when IS is grown. Field establishment in early spring allows plants to receive sufficient chilling for vernalization; however, flowering occurs when summer temperatures are highest, causing delayed maturity and fibrous flower heads. In areas where minimum winter temperatures are above –10C, field establishment during the fall with harvest the following spring provides sufficient chilling to meet the vernalization requirement and allows flower-head development to occur under the cool conditions that favor highest quality.

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# Physical Properties of Hawaiian Golf Course Sands

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***Additional index words.*** USGA, coral sand, recreational turf, turfgrass

***Summary.*** Physical properties (particle size distribution, bulk density, capillary pore space, non-capillary pore space, hydraulic conductivity, and water retention) of three imported silica sands (Perth, Malaysian, and Newcastle), a man-made sand product (Mansand), and coral sand alone and in peatmoss mixtures were determined to evaluate their suitability as golf-green substrates. Based on laboratory evaluation of physical properties, the silica sands amended with peatmoss (15%) were superior to coral sand or crushed basalt (Mansand) amended with 15% peatmoss for use in high-traffic turfgrass areas.

Soils provide anchorage for plants, the oxygen necessary for root growth, adequate water storage capacity, and the essential mineral elements for plant growth. Ideally, soils would be composed of ≈50% solid particles and 50% pore space. The solid portion of the soil would be ≈95% mineral particles (sand, silt, and clay) and 5% organic matter. The pore space should be about half large (non-capillary) and half small (capillary). This ratio of large and small pore space provides good rootzone aeration, yet stores enough water to make frequent irrigation unnecessary.

Turfgrass sites subjected to heavy or constant traffic, such as golf putting greens or athletic fields, should be constructed with sand or mixtures dominated by sand. Sand retains sufficient large pore space for adequate rootzone aeration and drainage. Sand particles are relatively large and are not easily compactable. Rootzone mixtures dominated by silt or clay particles may have adequate large pore space when uncompacted because many particles may be grouped into aggregates. The aggregates act as one large particle. The forces binding these particles into aggregates, however, are relatively weak, so they are broken quickly into individual fragments when compacted.

Sand has been the physical soil amendment of choice for construction of high-traffic turfgrass areas. The term sand, however, simply refers to the size of the individual particles and does not indicate the chemical composition of the material. In continental areas, silica sand is plentiful and is the most common amending material. Turfgrass researchers and soil physicists have characterized the properties of sand suitable for turfgrass areas. This research has resulted in the present recommendations of the United States Golf Assn. (USGA) Green Section on golf greens construction (U.S. Golf Assn. Green Section Staff, 1974). They specify that sands with particle sizes ranging from 1.0 to 0.1 mm in diameter are suitable for use in constructing golf putting greens. They further recommend that a minimum of 75% of the particles should be in the "medium" sand classification (0.5 to 0.25 mm in diameter).

Although tropical islands usually have broad sandy beaches, the sand on these beaches is composed of broken coral that has been ground to sand size by wave action. There are no deposits of silica sand in Hawaii or other Pacific islands. While coral sand may in some instances have desirable physical properties, it is composed primarily of calcium carbonate. This results in some undesirable chemical properties. The pH of turfgrass rootzones constructed of coral sand is usually 7.5 to 9.0. The high pH results in reduced availability of several essential elements, especially micronutrients such as Fe, Zn, and Mn.

Unfortunately, it is not possible to adjust the pH of rootzones constructed of coral sand. Acidic materials added to the soil simply react with the coral until the acid is neutralized. This results in dissolution of some of the

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