Project title:
Lettuce transplanting – a potential late summer planting strategy for Yuma head lettuce production

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Location of Research:
University of Arizona, Yuma Agriculture Center, Yuma, AZ (main location)
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Project Duration: July 1, 2014 to December 31, 2015

Overall Project Accomplishments:
Transplanting is a widely used strategy for rapid stand establishment in the field under unfavorable climate conditions and to achieve earlier yields than with direct seeding. Yuma County Arizona, is the major winter lettuce production site in the US (15,978 ha) and producers currently use direct seedling followed by manual thinning as a standard practice. Direct seeding earlier than September is problematic as it likely results in undesirable bolting due to exposure to high temperature and long photoperiod. Therefore, use of seedlings grown under relatively cooler climate inside a controlled environment facility or in a selected geographical location may delay bolting so that lettuce heads could be harvestable before plants exhibit bolting.

During the 2014 and 2015 crop seasons, experiments were conducted using two iceberg lettuce cultivars (Syngenta 7101A and Vanguard 1221) using a half-acre field plot at the University of Arizona, Yuma Agriculture Center. The two cultivars were selected based on industry recommendations and increased bolting tolerance. In 2014 (August 15 – December 2), iceberg transplants were grown four weeks inside a controlled environment chamber (CEAC chamber) and compared with the plants seeded on the same day (August 15) in the experimental field plot. In 2015 (July 31 – November 20), transplants were grown for 4 weeks under three distinctly different environmental conditions (nurseries in Yuma and Chino Valley, and CEAC chamber) to evaluate the performance of transplants grown under different environmental and climatic conditions. At both nurseries in Yuma and Chino Valley, lettuce transplants were grown outdoors or under open-roof conditions. In CEAC chamber, lettuce transplants were grown under LED lighting under cooler temperature conditions (Table 1).

In 2014 season, all transplants grown in CEAC chamber (seeded on 8/15; Transplanted on 9/12) survived to harvest while some loss was observed for direct-seeded plants. Transplanted lettuce was harvested on November 7, approximately one month earlier than the conventional crop with a seeding date of September 12 (harvested on December 2). However, when direct-seeded in August, both lettuce cultivars exhibited core extension at the time of harvest. The core length was significantly longer for August direct-deeded plants (5.5±0.25 cm, DS-815 in Fig. 1) than transplanted plants (4.6±0.09 cm, TR-815 in Fig. 1). Harvested lettuce fresh weight was also significantly greater for transplanted plots (4.6±0.07 kg for a box of 12 heads) than direct-seeded plants (3.8±0.12 kg per box). However, while transplanting showed some merit in achieving earlier yield and mitigating bolting at the early seeding date (August 15), the highest yields and head quality were achieved for conventional September seeded plants (DS-912 in Fig. 1), suggesting that use of transplants should be evaluated over various planting dates.

Fig. 1. ‘7101A’ lettuces at harvest. TR-815 plants were seeded on 8/15 and transplanted on 9/12. DS-815 and DS-912 plants were direct-seeded in the field plot on 8/15 and 9/12 respectively.

In 2015 season, for both planting dates examined (July 31 and September 1), we observed significantly high bolting incidence (nearly 100% bolting for all plant types for July 31 planting and more than 50% bolting for September 1 planting with transplants) (Table 1). ‘7101A’ lettuce cultivar exhibited slightly higher bolting incidence than ‘1221’ lettuce cultivars. Direct-seeded plants (Sept 1) did not exhibit bolting. Among three transplant growing conditions, ‘7101A’ lettuce plants grown in Yuma exhibited significantly lower bolting percentage than those grown in two other conditions, despite the warmer average temperature in Yuma during nursery period (Table 2).

Table 3 shows the key parameters for transplant quality as affected by growing sites (plants used for September 1 transplanting). The seedlings grown outdoors in Yuma were compact and had a greater ratio of shoot to root, indicating well-established roots. All transplants survived in the field at acceptable rates (97.5%-99.4%). Transplants grown in the CEAC chamber exhibited consistently high survival (>99%) for both plantings, despite the relatively lower light level than outdoor conditions (Table 2). This was presumably due to the cooler temperature and light quality deficit in far-red light.

Table 1. Percent bolting (%) observed on November 9th for September 1, 2015 plants (transplanted or seeded). Percent data were arcsin transformed for analysis.

Cultivar/planting materials	Days after seeding	Bolting (%)^Z
7101A / CEAC chamber	98	77.7±6.5 a
7101A / Chino outdoor	98	84.3±4.7 a
7101A / Yuma outdoor	98	51.1±5.4 b
7101A / Direct seeded	70	0.0±0.0 c
1221 / CEAC chamber	98	56.9±5.4 b
1221 / Chino outdoor	98	66.3±4.3 ab
1221 / Yuma outdoor	98	50.6±5.5 b
1221 / Direct seeded	70	0.0±0.0 c
P value		*0.0169*

^{Z}Means followed by different letters are significantly different.

Table 2. Average temperature, day length and solar radiation during transplant growth during the transplant production period (August 3rd to August 31st, 2015).

Growing sites	Average temp (C/F)	Day length (h)	Average daily light integral (mol m^{-2} d^{-1})
CEAC chamber	19.4 ± 1.6°C (66.9 ± 2.9°F)	12	10.6
Chino outdoor	23.4 ± 1.6°C (74.1 ± 2.9°F)	13-13.75	41.4 ± 10.5^Z
Yuma outdoor	34.1 ± 1.4°C (93.4 ± 2.5°F)	13-13.75	51.7 ± 6.5^Z

^{Z} Estimated from solar radiation (MJ m^{-2}, 1.0 MJ m^{-2} = 2.1 mol m^{-2})

Table 3. Number of leaves, plant height, and shoot-to-root fresh weight ratio as affected by growth conditions (averages of 10 plants sampled on September 1st planting date). Field survival was assessed after 12 days of planting.

Growing sites	Leaves (# per plant)	Height^Z (cm)	S/R ratio^Y	Field survival (%)
CEAC chamber	4.7 ± 0.07 b	6.7 ± 0.16 b	3.82 ± 0.14 b	99.2-99.4%
Chino outdoor	5.3 ± 0.13 a	9.7 ± 0.23 a	5.96 ± 0.25 a	96.1-98.6%
Yuma outdoor	5.2 ± 0.11 ab	4.5 ± 0.11 c	1.62 ± 0.04 c	97.5-97.8%
P value	*0.0434*	*0.0001*	*0.0001*	*N/A*

^{Z} Distance from the highest tip of the leaf to the crown (this is plant height, not the stem length).

^{Y} Smaller number indicates more root growth relative to shoot.

Fig.2 ‘7101A’ lettuce seedlings (4 weeks old) used for September 1st transplanting. CEAC Chamber: Seedlings grown indoor under electric lighting; Chino Valley and Yuma: Seedlings grown at outdoor nurseries. Seedlings grown in Yuma had more established root system and compact morphology, generally considered suitable for transplanting.

In summary, the results obtained in this study showed that:

- Growing conditions of transplants affected survival in the field. Indoor-grown transplants had consistently high (99-100%) survival rates.
- Transplant quality (size and survival rate) grown in outdoor nurseries were largely affected by the climate conditions and the nursery management practices.
- Sensitivity to bolting was cultivar-specific and also affected by transplant growing conditions and likely greenhouse management methods.
- In 2014 season, growing transplants at cooler temperature helped to delay the onset of bolting compared with the direct seeded plants that experienced higher temperature during the first 4 weeks. However, in 2015 season, bolting incidence was not correlated with temperature during transplant production.
- More research is necessary on lettuce plant physiology of pre-mature bolting, in order to develop transplanting strategies and transplant production technologies for establishing potential early season fresh head lettuce production in Yuma.

Benefit for Arizona Farmers

The two-season study we report here is the first attempt of using transplants for early fall production of iceberg lettuce in Yuma, AZ. Our results clearly indicated that growing conditions and the resulting transplant quality largely affect the stand establishment as well as risk of premature bolting in the field.

While lettuce breeding contributed to making bolting resistant cultivars available in the market, the physiological mechanism and its interaction with climate conditions are not well known. Further investigation is needed especially for the interactions between genotypes and environment conditions (air temperature x day length) at different physiological stages of plants. While transplanting is an additional cost to lettuce growers, potential advantages include:

- Better field establishment (nearly 100% for high quality transplants)
- Eliminating labor costs for thinning, bird protection, as well as seed costs
- Lowering the use of water needed for the early stage of production
- Early harvest of fall crop