

Direct Seeding Short-day Onions in Southeastern Georgia

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SUMMARY. Onions (*Allium cepa*) in southeastern Georgia are almost exclusively transplanted, with the associated high costs and labor requirements. This study was undertaken to evaluate direct-seeded onions as an alternative production method. This study evaluates variety, sowing date, and fertility on direct seeding short-day onions in southeastern Georgia. Sowing dates, early or mid-October (5 and 15 Oct. 2001 and 7 and 21 Oct. 2002), did not affect total, jumbo (≥ 3 inches diameter), or medium (≥ 2 inches and < 3 inches diameter) yields. Late October sowing (29 Oct. 2001) did not produce sufficient stand or yield to warrant harvesting. Variety also had no effect on yield of direct-seeded onions. Seedstems (flowering), an undesirable characteristic, was significantly greater with the early October sowing date across all varieties compared with the mid- or late- October sowing dates. Neither variety nor sowing date significantly affected plant stand or plant spacing. Fertilization treatments of 150 or 195 lb/acre nitrogen (N) with various application timings and fertilizer sources did not affect total or medium yields. Jumbo yield was affected in only 1 year with calcium nitrate as the primary N source at 195 lb/acre total N having the highest yield, but did not differ from some treatments at 150 lb/acre N. In addition, fertilization treatments did not affect seedstems, plant stand, or plant spacing. Based on this study, we are recommending that growers should direct seed onions in southeastern Georgia in mid-October, plus or minus 1 week depending on field accessibility. In addition, current fertilizer recommendations for transplanted dry bulb onions should be followed, which includes 150 lb/acre N. This eliminates all of the cost and resources required for transplant production.

Onion production in the Vidalia production region of southeastern Georgia has traditionally used transplants to produce dry bulb onions. Transplants are grown on-farm in high-density plantings, which are then pulled and transplanted to their final spacing (Boyhan et al., 2001a). All of this relies on hand labor, which adds to the cost of production. Current University of Georgia Cooperative Extension Service fertilizer recommendations for onions includes 130 lb/acre N for

transplant production and an additional 150 lb/acre N for dry bulb production (Boyhan et al., 2001a). The total N requirement of 280 lb/acre is the highest for any vegetable in Georgia, which might be reduced with direct-seeded onions (Kissel, 2003). Furthermore, the Texas Agricultural Extension Service recommends 120 lb/acre N to produce direct-seeded onions, which further supports the possibility of reducing fertilizer requirements (Hall et al., 2000).

A variety of studies have been conducted to evaluate direct seeding, transplanting, and using sets to produce onions. Comparisons of direct-seeded, bare root transplants and

228-cell flat production has been conducted where plants from cell flats with one plant per cell produced the greatest percentage of jumbo onions (≥ 3 inches diameter) compared with bare root plants or cell flats with three plants per cell (Leskovar et al., 2004).

Sowing date has been shown to affect yield with transplanted onions. Onions sown on 10 Aug. had greater yield with 'Agrifound Dark Red' in Junagadh, India, compared with 25 Aug. or 9 Sept. sowing dates (Movalia et al., 1999). In a study in Egypt evaluating direct-seeded onions, it was found that those sown on 20 Sept. had higher yields compared with those sown on 23 Aug. or 18 Oct. (Gamie et al., 1996). Transplanted onions were found to have greater yields and increased bulb size compared with direct seeding in a study in India among different varieties (Khokhar et al., 1990). In a comprehensive study of onion varieties and sowing dates in New Mexico from 9 to 30 Sept., it was found that delayed sowing resulted in less bolting, greater yield, and delayed maturity (Cramer, 2003). Bolting resistance in 'NuMex Mesa' played a greater role than sowing date on having lower numbers of seedstems regardless of sowing date.

Transplant age and days after transplanting have been investigated for their effect on yield. In Nasik, Maharashtra, India, 'Agrifound Light Red' was found to have the greatest yield from 8-week-old transplants harvested 125 d after transplanting compared with 7- or 9-week-old transplants and harvest dates of 110 and 140 d after transplanting (Bhonde et al., 2001).

Fertilizers and sowing date have been evaluated with variety Al-Hasawi in Saudi Arabia (Al-Abdulsalam and Hamaiel, 2004). It was found that a 20 Oct. sowing date with fertilizer formulation 14N-16.6P-8.3K gave the best yields compared

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
1.1209	lb/acre	kg·ha ⁻¹	0.8922
(°F - 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

with 20 Sept. or 20 Nov. sowing dates and fertilizers 20N–8.7P–16.6K, 19N–12.7P–9.1K, or 16N–3.9P–21.6K. Brewster (1990) found in the United Kingdom that earlier sowing, greater plant density, and various fertilizer rates accelerated bulb development across locations and years. This was attributed to larger leaf area index and accumulation of thermal time (degree days).

Texas is the closest region to southeastern Georgia in terms of environment for onion production. However, Texas has several regions of production, including the Lower Valley on the Mexican border, the Winter Garden northwest of the Lower Valley, the Trans-Pecos in western Texas, and the High Plains in northern Texas (Hall et al., 2000). Their recommendations for sowing dates extend from October to March, with short-day, intermediate-day, and long-day onion varieties, depending on the region.

The studies cited above indicate that geographic location is important in determining the optimum sowing date with different varieties evaluated at each location. In addition, fertilizer interaction with sowing date is an important factor in onion development.

Because of the relative higher cost of transplant production, primarily because of greater labor requirements, compared with direct seeding, coupled with the potential lack of labor, this study was undertaken to evaluate effects of sowing date, variety, and fertility on direct seeding short-day onions in southeastern Georgia with the aim that this might lower overall production costs.

Materials and methods

VARIETY AND SOWING DATE EXPERIMENTS. In 2001, coated seeds (Filmcoat Plus; Harris Moran Seed Co., Modesto, CA) were sown on three different dates with a Monosem vacuum planter (model 540; Monosem Corp., Lenexa, KS). A 36-hole plate was used and the planter was set to B2 for a 5 $\frac{3}{8}$ -inch in-row spacing, according to the owner's manual. The between-row spacing was set to 12 inches. Four rows were planted per bed with beds formed on 6-ft centers. This would result in \approx 65,000 plants per acre. Insect, disease, weed control, and fertilization followed

University of Georgia Cooperative Extension Service recommendations (Boyhan et al., 2001a). Plants were irrigated with drip irrigation that used two drip tapes (4-inch emitter spacing, 24 gal/h per 100 ft) per bed.

The experiment was arranged in a split-block design with the sowing date being the main plot effect and variety as the subplot effect. About 450 ft of row was sown for each variety on each date and for each replication. The sowing dates were 5, 15, and 29 Oct. 2001. Each bed was planted with four varieties: Pegasus, Sweet Vidalia, Nirvana, and PS 7092. With two of the replications, 'Pegasus' and 'PS 7092' were planted to the outside rows with 'Sweet Vidalia' and 'Nirvana' planted to the inside rows. This was reversed with the other two replications. Each experimental unit was a single row of onions 50 ft in length. Onion seed sown on 5 Oct. 2001 were harvested on 30 Apr. 2002, and onions sown on 15 Oct. 2001 were harvested on 9 May 2002. Onions sown on 29 Oct. 2001 did not have sufficient stand or size to warrant harvesting.

At harvest, onions had their tops and roots removed before being immediately weighed in the field. Bulbs were then heat cured for a minimum of 24 h at 95 °F. Bulbs were then graded into jumbo (\geq 3 inches diameter) and medium (\leq 2 inches and $<$ 3 inches diameter) size classes and these weights were recorded (U.S. Department of Agriculture, 1995).

Onion stand and in-row spacing were measured on 7 Jan. 2002 for two 3-ft sections for each variety and sowing date within each replication. These data were used to report plant stand and the in-row spacing as the percentage below 4 inches and above 6.5 inches. Seedstems were recorded for a 50-ft section of row on 14 May 2002 among onions remaining in the field.

In the second year (2002), coated onion seeds were sown in a similar fashion to 2001 with varieties Pegasus, Sweet Vidalia, Nirvana, and Century. 'Century' was substituted for 'PS 7092' because 'PS 7092' was discontinued. 'Century' is in the same maturity class as 'PS 7092' and from the same seed company. Onions were sown on 7 and 21 Oct. 2002. The experiment was arranged in a split-

plot design with the sowing date as the main plot effect and variety as the subplot effect. There were four replications with the experimental unit a single row 20 ft long. Cultural practices were the same as for the previous year.

Plant spacing for the first sowing date (7 Oct.) was measured on two 3-ft sections for each experimental unit on 23 Jan. 2003. For the second sowing date, plant spacing was measured on 24 Mar. 2003. The number of seedstems or flowers was recorded for each experimental unit on 29 Apr. 2003. Onions were harvested on 1 May 2003 and were immediately weighed. Bulbs were then heat cured, graded, and weighted as in 2002.

FERTILITY EXPERIMENTS. Experiments in the 2003–04 and 2004–05 seasons were arranged in randomized complete block design of four replications with all treatments receiving a base rate of 800 lb/acre of 5N–4.3P–12.4K with 9% sulfur (S) applied pre-plant and incorporated. This resulted in 40 lb/acre N, 35 lb/acre phosphorus, 100 lb/acre potassium, and 72 lb/acre S, respectively. In 2003–04, encrusted seed (Onx encrustation; Incotec, Salinas, CA) of varieties Granex Yellow PRR and Savannah Sweet were sown on 13 Oct. 2003 with a Monosem vacuum planter (36-hole plate, set to C3) on beds formed on 6-ft centers with four rows spaced 12 inches apart and with an in-row spacing of 4 inches. 'Yellow Granex PRR' seeds were sown for replications 1 and 3 and 'Savannah Sweet' seeds were sown for replications 2 and 4. This was done because we had insufficient coated seeds of either variety for the entire trial. In 2004–05, coated seeds of variety Century were sown on 13 Oct. 2004 for the entire experiment. All the seeds for both years were obtained from a local grower and represent midseason, short-day onion varieties in the Vidalia onion-growing region of southeastern Georgia. The experimental unit was 30 ft of planted bed in 2003–04 and 20 ft of planted bed in 2004–05. In both years, weed, disease, and insect control and cultural practices followed University of Georgia Cooperative Extension Service recommendations (Boyhan et al., 2001a).

Treatments are listed in Table 1. "Low frequency" refers to those treatments that had no fertilizer

Table 1. Treatment list for fertility experiment of direct-seeded onions with application dates, material used, and amount applied.^z

Treatment no.	Treatment ^{z,y,x}	2003–04		2004–05	
		Date	Nitrogen (lb/acre) ^{z,x}	Date ^x	Nitrogen (lb/acre) ^{z,x}
1	195 lb/acre N	18 Nov. 2003	25	24 Nov. 2004	25
	Ca(NO ₃) ₂	8 Dec. 2003	25	12 Jan. 2005	50
	High frequency ^w	6 Jan. 2003	25	20 Jan. 2005	27
		2 Feb. 2004	27	16 Feb. 2005	53
		23 Feb. 2004	27	NA	NA
		15 Mar. 2004	26	NA	NA
2	150 lb/acre N	18 Nov. 2003	25	24 Nov. 2004	25
	Ca(NO ₃) ₂	2 Feb. 2004	28	16 Feb. 2005	85
	Low frequency ^w	23 Feb. 2004	28	NA	NA
		15 Mar. 2004	29	NA	NA
3	195 lb/acre N	18 Nov. 2003	40	24 Nov. 2004	40
	Ca(NO ₃) ₂	2 Feb. 2004	38	16 Feb. 2005	115
	Low frequency	23 Feb. 2004	38	NA	NA
		15 Mar. 2004	39	NA	NA
4	150 lb/acre N	18 Nov. 2003	25 [(NH ₄) ₂ HPO ₄]	24 Nov. 2004	25 [(NH ₄) ₂ HPO ₄]
	Standard ^v	2 Feb. 2004	43 (5N–4.3P–12.4K)	12 Jan. 2005	43 (6N–5.2P–14.9K)
		23 Feb. 2004	42 [Ca(NO ₃) ₂]	16 Feb. 2005	42 [Ca(NO ₃) ₂]
5	150 lb/acre N,	18 Nov. 2003	25	24 Nov. 2004	25
	[(NH ₄) ₂ HPO ₄]	8 Dec. 2003	25	12 Jan. 2005	45
	High frequency	2 Feb. 2004	20	16 Jan. 2005	40
		23 Feb. 2004	20	NA	NA
		15 Mar. 2004	20	NA	NA
6	195 lb/acre N	18 Nov. 2003	40	25 Nov. 2004	40
	10N–4.4P–8.3K	2 Feb. 2004	38	16 Feb. 2005	115
	Low frequency	23 Feb. 2004	38	NA	NA
		15 Mar. 2004	39	NA	NA
7	150 lb/acre N	18 Nov. 2003	25	24 Nov. 2004	25
	10N–4.4P–8.3K	2 Feb. 2004	28	16 Feb. 2005	85
	Low frequency	23 Feb. 2004	28	NA	NA
		15 Mar. 2004	29	NA	NA
8	150 lb/acre N	18 Nov. 2003	25	24 Nov. 2004	25
	10N–4.4P–8.3K	8 Dec. 2003	25	12 Jan. 2005	50
	High frequency	6 Jan. 2004	25	20 Jan. 2005	12
		2 Feb. 2004	12	16 Feb. 2005	23
		23 Feb. 2004	12	NA	NA
		15 Mar. 2004	11	NA	NA

^zAll treatments had 800 lb/acre (1 lb/acre = 1.1209 kg·ha⁻¹) 5N–4.3P–12.4K with 9% sulfur applied preplant and incorporated. Sowing dates were 13 Oct. 2003 and 13 Oct. 2004.

^yNitrogen (N) fertilizer amount, N source, and application frequency.

^xCa(NO₃)₂ = calcium nitrate, (NH₄)₂HPO₄ = diammonium phosphate, NA = not applicable.

^wHigh frequency indicates fertilizer application in December or January, low frequency indicates no fertilizer in December and January.

^vStandard is similar to current recommended fertilization with fertilizer source listed in nitrogen columns (Boyhan et al., 2001a).

applied during December and January, and “high frequency” refers to treatments that had fertilizer applied in December and January. The standard treatment included materials and applications common to the Vidalia region (Boyhan et al., 2001a). This included 5N–4.3P–12.4K, calcium nitrate [Ca(NO₃)₂], and diammonium phosphate [(NH₄)₂HPO₄].

Plant spacing was measured on two randomly chosen 3-ft row sections for each experimental unit. This was done on 13 Jan. 2004 and 28 Feb. 2005. The percentage of onions

with spacing below 4 inches and above 6.5 inches was calculated and reported. Seedstem numbers for the entire experimental unit or plot were recorded on 22 Apr. 2004. There were too few seedstems in 2005 to collect meaningful data.

In 2004, onions were harvested on 11 May, and in 2005, onions were harvested on 31 May. Weights were recorded in the field after tops and roots were removed. Onions were then graded into jumbo (≥3 inches diameter) and medium (≥2 inches and <3 inches diameter) size classes.

Data were analyzed with Excel 11.3.5 (Microsoft Corp., Redmond, WA) and Stata 9.2 (StataCorp, College Station, TX). The sowing date/variety split-plot experiments were analyzed assuming years as a random factor with varieties and sowing dates as fixed factors (Gomez and Gomez, 1984).

Results and discussion

There was no difference in total yield because of variety or sowing date (Table 2). In addition, there was no treatment by year interactions for

Table 2. Effect of variety and sowing date on yield, graded yield, seedstem formation (flowering), plant stand, and plant spacing in direct-seeded onions for the 2001–02 and 2002–03 seasons.

		Total yield ^y	Jumbo ^y	Medium ^y	Seedstems		Plant stand	Plant spacing	
					2002	2003		Below	Above
Variety	Sowing date ^z				(lb/acre) ^x			---(no./plot) ^w ---	
------(%)-----									
Pegasus	Early	26,671	12,802	3,004	9.3	0.8	5.5	10	14
	Mid	23,134	8,552	4,908	0.3	0.0	6.2	11	19
	Late	—	—	—	0.0	—	5.4	0	33
Sweet	Early	26,758	12,471	2,755	25.0	4.0	6.6	15	10
Vidalia	Mid	31,145	15,788	5,043	1.5	0.0	6.9	14	11
	Late	—	—	—	0.0	—	5.9	12	28
	Early	25,308	11,689	4,138	7.0	1.0	5.5	14	18
Nirvana	Mid	18,578	6,701	5,234	0.0	0.0	6.1	10	19
	Late	—	—	—	0.3	—	4.3	7	40
	Early	31,152	13,920	2,604	8.8	0.3	5.8	19	17
PS 7092 ^v	Mid	22,372	8,734	7,187	0.3	0.0	6.9	16	6
	Late	—	—	—	0.0	—	5.5	3	19
	Probabilities								
	Year	0.829	0.016	0.010		0.017	0.699	0.028	0.401
	Variety	0.073	0.314	0.738		0.528	0.072	0.328	0.110
	Year × Variety	0.682	0.430	0.047 ^u		0.021 ^u	0.101	0.030 ^w	0.612
	Sowing Date	0.206	0.188	0.346		0.523	0.167	0.104	0.152
	Year × Date	0.526	0.820	0.110		0.029	0.627	0.938	0.712
	Variety × Date	0.316	0.614	0.468		0.314	0.280	0.030 ^w	0.318
	Sowing date 2002				0.000				
	Sowing date 2003					0.034			

^zSowing dates for the 2001–02 season: Early = 5 Oct. 2001, mid = 15 Oct. 2001, late = 29 Oct. 2001. Sowing dates for the 2002–03 season: Early = 7 Oct. 2002, mid = 21 Oct. 2002.

^yJumbo ≥ 3 inches diameter, medium ≥ 2 inches and < 3 inches diameter.

^x1 lb/acre = 1.1209 kg·ha⁻¹, 1 ft = 0.3048 m, 1 inch = 2.54 cm.

^wPlot size in the 2001–02 season was a single row, 50-ft-long and in the 2002–03 season, it was a single row, 20 ft long.

^v'Century' substituted for 'PS 7092' in 2002–03 season because of discontinuation of 'PS 7092'.

^uExamination of interactions indicated no differences.

variety or sowing date, nor was there a variety by sowing date interaction. The results were the same for jumbo yields. For medium yields, there was a variety by year interaction. An examination of medium yields for each year indicated no differences between varieties (data not shown). There was no variety by sowing date interaction for medium.

There was a year by variety interaction for seedstems; however, an examination of seedstems in each year indicated no differences (data not shown). There was a sowing date by year interaction, therefore, these results are reported separately for 2002 and 2003 (Table 2). In 2002 and 2003, the numbers of seedstems were greater on the early sowing date compared with the mid or late sowing dates. There was no variety by sowing date interaction for seedstems.

There was no difference in plant stand based on variety or sowing date and no by year interaction effects, nor was there a variety by sowing date interaction (Table 2). In addition, the

percentage of onions spaced below 4 inches had by year interactions for variety and a variety by sowing date interaction, but an examination of these interactions showed no difference (data not shown). The variety by date interaction was examined based on individual varieties and sowing dates. Finally, there were no differences among varieties or sowing dates for the percentage of stand above 6.5 inches. There were no three-way interactions, variety by sowing date by year interactions, for any of the tested parameters.

Preliminary work before these studies indicated that seed singulation and sowing date were going to be critical to successful plant establishment in the Vidalia-growing region (Boyhan and Hill, 2002; Boyhan et al., 2001b). Using a belt planter and raw seed proved to be unsatisfactory with seed sown too closely. Even with a vacuum planter, seed singulation continued to be a problem until seeds were coated. Initial work looked at seeding around the

time plant beds are sown for transplant production (the end of September), which resulted in almost 100% seedstems. Additional experiments evaluating growth regulators maleic hydrazide and ethephon to control seedstems also proved fruitless (Boyhan and Hill, 2002). Mowing onion tops to simulate the effect of transplanting also proved fruitless, with tops recovering in 2 weeks to the point that it was difficult to distinguish mowed from unmowed plants.

Differences in seedstem formation from variety is well established (Boyhan et al., 2005; Cramer, 2003). In this study, we did not see seedstem differences among varieties, but early sowing dates influenced seedstems, and this was consistent across all varieties.

Based on this experiment, growers should sow onion seed around 15 Oct., plus or minus 1 week in southeastern Georgia. Earlier plantings are susceptible to high numbers of seedstems, which render these onions unmarketable. Later

plantings result in plants that are too small to survive the winter. Onions sown on 29 Oct. 2001 were not harvested because of poor stand and size. Smaller onions are more prone to being lost during winter months. An examination of late-sown onions indicates that many were lost to botrytis neck rot (*Botrytis alli*), which often attacks below the soil line. Growing onions will usually slough off these infected outer leaf scales. It has been observed that larger onions, during cooler winter temperatures when growth has slowed or temporarily stopped, can withstand these infections better than smaller onions. Stands of smaller onions are often

observed to loose plants through attrition during cooler winter months regardless of production method—direct-seeded or transplanted.

There was no difference in total yield between the different fertilizer treatments nor was there any treatment by year interaction (Table 3). There was a significant treatment by year interaction for jumbo yields. In 2004, there was no difference among treatments, but in 2005, there were significant differences between the treatments, with the highest yield using 195 lb/acre total N with no fertilizer application in December or January (Treatment 3). This treatment had significantly greater jumbo

yields than the treatment with 150 lb/acre total N with an application in January and $(\text{NH}_4)_2\text{HPO}_4$ as the primary N source (Treatment 5). In addition, (Treatment 3) jumbo yield in 2005 was greater than 150 lb/acre N with and without fertilizer application in January and 10N-4.3P-12.4K as the primary N source (Treatments 7 and 8).

There were no treatment effects on medium yields nor was there any treatment by year interaction effect on medium. In addition, there were no differences among treatments for number of seedstems, plant stand, or percentage of onions spaced below 4 inches or above 6.5 inches.

Table 3. Effect of different fertilization protocols on yield, graded yield, seedstem formation (flowering), plant stand, and plant spacing in direct-seeded onions for the 2003–04 and 2004–05 seasons.^z

No.	Treatments ^{z,y}	Total yield	Jumbo ^x		Medium ^x	Seedstems (2004) (no./plot) ^w	Plant stand (no./3 ft row) ^v	Plant spacing	
			2004	2005				Below	Above
								4 inches ^v	6.5 inches ^v
		(lb/acre) ^z						(%)	
1	195 lb/acre N, Ca(NO ₃) ₂ , high frequency	35,197	24,472	24,194	1,634	9.5	8.0	44	13
2	150 lb/acre N, Ca(NO ₃) ₂ , low frequency	43,791	26,614	24,920	2,308	14.3	7.8	47	12
3	195 lb/acre N Ca(NO ₃) ₂ , low frequency	44,520	26,221	30,782	2,118	16.3	7.8	39	19
4	150 lb/acre N, Standard	47,399	27,963	25,428	2,066	6.8	8.1	45	15
5	150 lb/acre N, (NH ₄) ₂ HPO ₄ , high frequency	43,548	25,331	17,769	1,918	14.3	7.5	42	24
6	195 lb/acre N, 10N-4.3P-12.4K, low frequency	47,350	27,812	24,484	1,407	20.8	8.0	40	16
7	150 lb/acre N, 10N-4.3P-12.4K, low frequency	43,590	27,897	20,346	1,494	29.0	7.8	44	17
8	150 lb/acre N, 10N-4.3P-12.4K, high frequency	45,570	27,933	18,658	1,367	9.8	7.6	47	22
Probabilities									
Year		0.000	0.550		0.024		0.000	0.000	0.018
Treatments		0.090	0.252		0.320	0.177	0.738	0.759	0.322
Treatments × Year		0.710	0.016		0.055		0.587	0.254	0.804
Treatments 2004		0.525							
Treatments 2005			0.014						
LSD(0.05) ^u			6.762						

In Georgia, the combined N requirement for transplants and dry bulb onions is 280 lb/acre, with 130 lb/acre N for transplants and the remainder for dry bulbs (Boyhan et al., 2001a). In addition, the Texas Agricultural Extension Service recommends 120 lb/acre N for dry bulb production from seed (Hall et al., 2000). This suggests that Georgia could reduce N fertilizer with direct-seeded production; therefore, rates of 150 and 195 lb/acre N were used as treatments.

Bolting (flowering) has been a particular problem with direct-seeded onions, particularly when sown early. The low-frequency fertilizer application (no fertilizer in December and January) was an attempt to slow growth during the winter so that plants would be smaller in the spring, reducing the chance of high seedstem numbers.

$(\text{NH}_4)_2\text{HPO}_4$ was included because of past response during cooler winter months. Although most cultivated soils in southeastern Georgia are high in P, it can become unavailable during cooler months in winter. Onion plants respond to $(\text{NH}_4)_2\text{HPO}_4$ application with greener and more top growth, although this has not generally translated into greater yields. Additional fertilizers used in this study were 10N-4.4P-8.3K, 5N-4.3P-12.4K, and $\text{Ca}(\text{NO}_3)_2$, all of which are commonly used fertilizers in this area.

With the exception of differences in jumbo yield in 2005, onion yield was largely the same across these fertilizer treatments, suggesting that 150 lb/acre N would be adequate for direct-seeded onion production. This would eliminate all of the fertilizer used in transplant production, along with the associated costs.

Transplant cost, both production and setting, is estimated at \$555.00/acre, which would be eliminated with direct seeding (Boyhan et al., 2001a). This cost represents about 16% of the total variable and fixed costs. The onion budget for Georgia was developed assuming an average yield of 20,000 lb/acre with a potential range of 10,000 to 40,000 lb/acre for a transplanted crop. These experiments fall within this yield range, suggesting that direct seeding would not result in reduced yields compared with transplanting.

Transplant production dominates onion production in Georgia for several reasons. In the early 1980s, onion production was evenly split between transplants and direct-seeding, but a couple of years of single-digit temperatures quickly resulted in almost all onion production going to transplants (D. Pickenpaugh, pers. comm.). Transplants, because they are set deeper in the soil, are better able to survive severely cold weather compared with direct-seeded onions, which develop at or near the soil surface.

In addition, transplant production results in a perfect stand, whereas with direct-seeded onions, even under the best of circumstances, there are going to be some onions misplanted, resulting in skips or spacing that is too close. This was evident in these experiments (Tables 2 and 3). Because of the possibility of misplanted onions, growers are advised to exercise care with direct seeding to maximize success. Using a vacuum planter with coated seeds to insure good singulation, coupled with proper land preparation and timely water applications, is critical to success with direct seeding. Another advantage of transplants is weed control. The primary herbicide, oxyfluorfen, can be used at the maximum rate for onions immediately after transplanting because the plant tops have been removed. Removal of tops reduces herbicide damage to the plants. In direct-seeded onions, the maximum rate of oxyfluorfen can be used, but it has to be applied at lower rates in multiple applications. Weed control success in direct-seeded onions is critically dependent on herbicide application timing.

Direct-seeded onions have some advantages as well, with the primary one being cost savings because transplant production is not needed. This includes all of the chemicals, equipment use, and labor.

In addition, onions in southeastern Georgia are hand transplanted with migrant labor. The entire Vidalia onion crop of 12,000 to 14,000 acres is hand transplanted in an 8- to 9-week period. This requires a large labor force. Although this labor force has been readily available, there is concern that future labor availability may be limited. For this reason, growers should become familiar with

direct seeding, if for no other reason than to gain experience with this production method in case there is a labor shortage.

In conclusion, onion from transplants will likely continue to dominate production in the Vidalia region of southeastern Georgia for the foreseeable future. Growers, however, do have an alternative in direct seeding that can save money. In addition, if labor availability becomes scarce, direct seeding can be a viable alternative that can be successfully adopted.

Literature cited

- Al-Abdulsalam, M.A. and A.F. Hamaiel. 2004. Effect of planting dates and compound fertilizers on growth, yield and quality of Hassawi onion under Al-Hassa oasis conditions. *Scientific J. King Faisal Univ. (Basic Appl. Sci.)*. 5:65-79.
- Bhonde, S.R., A.B. Chougule, and N.B. Singh. 2001. Studies on the effect of age of seedlings and date of harvesting on yield and quality of onion during late kharif season. *Nwsl. Natl. Hort. Res. Dev. Foundation* 21:27-30.
- Boyhan, G. and C.R. Hill. 2002. Direct seeding Vidalia onions. *Univ. Georgia Coop. Res. Ext. Publ. No. 3-2002:9-12*.
- Boyhan, G.E., D.M. Granberry, and W.T. Kelley. 2001a. Onion production guide. *Univ. Georgia Bull. No. 1198*.
- Boyhan, G.E., A.C. Purvis, W.M. Randle, R.L. Torrance, M.J.I. Cook, G. Hardison, R.H. Blackley, H. Paradise, C.R. Hill, and J.T. Paulk. 2005. Harvest and postharvest quality of short-day onions in variety trials in Georgia, 2000-03. *HortTechnology* 15:694-706.
- Boyhan, G.E., R.L. Torrance, D.E. Curry, and C.R. Hill. 2001b. Preliminary results of direct-seeded Vidalia onions. *Univ. Georgia Coop. Res. Ext. Publ. No. 3-2001:12-13*.
- Brewster, J.L. 1990. The influence of cultural and environmental factors on the time of maturity of bulb onion crops. *Acta Hort.* 267:289-296.
- Cramer, C.S. 2003. Performance of fall-sown onion cultivars using four seeding dates. *J. Amer. Soc. Hort. Sci.* 128:472-478.
- Gamie, A.A., G.H.A. El-Rhim, M.K. Imam, and A.E. Abdoh. 1996. Effect of sowing dates on yield and bulb quality of some onion cultivars grown by direct seeding. *Assiut J. Agr. Sci.* 27:101-110.

- Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research. Wiley, New York.
- Hall, K.D., R.L. Holloway, and D. Smith. 2000. Texas crop profile onions. Texas A&M Univ. Publ. E-18.
- Khokhar, K.M., N. Kaska, S.I. Hussain, K.M. Qureshi, and T. Mahmood. 1990. Effect of different sowing dates, direct seeding and transplanting of seedling on maturation, bulb weight and yield in onion (*Allium cepa*) cultivars. Indian J. Agr. Sci. 60:668–671.
- Kissel, D. 2003. Soil test handbook for Georgia. University of Georgia, Athens.
- Leskovar, D.I., M. Cantamutto, P. Marinangelli, and E. Gaido. 2004. Effects of direct-seeded, bareroot, and various tray seedling densities on the growth dynamics and yield of long-day onion. Agronomie 24:35–40.
- Movalia, A.G., B.B. Kaneria, V.D. Khanpara, K.V. Jadav, and R.K. Mathukia. 1999. Response of direct seeded and transplanted onion (*Allium cepa* L.) to dates of sowing and nitrogen levels. Gujarat Agr. Univ. Res. J. 25:90–93.
- U.S. Department of Agriculture. 1995. United States standards for grades of Bermuda-Granex-Grano type onions. U.S. Dept. of Agriculture, Washington, DC.