Table 6. Regression models and estimated maximum responses for yields and average head mass for crisphead lettuce responses to N fertilization in Florida 1990-1994.

		Regression model			Estimate of maximum
Season	Variable	Intercept	N	N^2	Response @ Max. N rate $kg \cdot ha^{-1}$
1990	$MT \cdot ha^{-1}$	20.1500	0.1700	-0.000534	33.7 $MT \cdot ha^{-1}$ @ 160
	kg/head	0.5300	0.0017	-0.000005	0.67 kg @ 170
1992	$MT \cdot ha^{-1}$	0.3600	0.3420	-0.000900	32.9 $MT \cdot ha^{-1}$ @ 190
	kg/head	0.0806	0.0063	-0.000017	0.66 kg @ 185
1993	$MT \cdot ha^{-1}$	6.6030	0.2687	-0.000810	28.9 $MT \cdot ha^{-1}$ @ 165
	kg/head	0.2491	0.0048	-0.000014	0.66 kg @ 170
1994	$MT \cdot ha^{-1}$	3.0956	0.3948	-0.001004	41.9 $MT \cdot ha^{-1}$ @ 195
	kg/head	0.1052	0.0078	-0.000020	0.87 kg @ 195

flood irrigation led to unequal wetting patterns in Florida's sandy soils (Everett, 1980). Further, drip irrigation permits delivery of nutrients to the plants as needed. The use of drip irrigation also permits double-cropping, since chemicals can continue to be delivered to the second or third crop. Extremes in temperature are common during winter in Florida. Applying all of the fertilizer through the drip tubing provided adequate nutritional levels to the plants.

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PERFORMANCE OF DIRECT SEEDED AND TRANSPLANTED LETTUCE GROWN ON THE SANDY SOILS OF FLORIDA

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Abstract. **Research on lettuce production on mineral soils in Florida is limited. The present research was designed to determine (1) the potential for lettuce production over a 10-month growing season on sandy soils in northern Florida, and (2) the effect of plant establishment method on overall yields and head quality. Significant seasonal responses and interactions were observed throughout this experiment. Based on this study, marketable yields of lettuce grown in north Florida could be obtained between 15 Sept. and 15 March. The fall planting dates led to greater marketable yields compared to the winter or spring plantings. April plantings resulted in poorest quality and lowest yields of lettuce. 'Desert Queen' produced significantly greater total fresh weight and total marketable yields than 'Maverick' over the entire growing season. Head diameters were within the recommended guidelines for marketable lettuce. Core lengths were longest in direct-seeded lettuce especially early and late in the growing season when field temperatures were high. Transplanted lettuce had earlier harvest, more uniform stands, and generally better head quality compared to direct-seeded lettuce. Polyethylene mulch for fumigation in combinations with drip irrigation for the delivery of water and fertilizer was essential to optimize lettuce production in north Florida.**

Introduction and Literature Review

During the 1990 vegetable production season, the total harvested acreage of lettuce in the U.S. was 93,677 ha (231,300 acres) having a value of $840 million (Nat'l Agr. Stats. Serv., 1991). The most economically important lettuce types are iceberg or crisphead, romaine (cos), butterhead, bibb, Boston, and leaf lettuce. Three states contribute approximately all of the crisphead lettuce produced in the U.S. California contributes 80% of the market, Arizona supplies 16% and most of the winter crop, and Florida, 4% of the market.

Florida lettuce is grown primarily on the Histosols (muck soils) in the Everglades area of southern Florida. Zellwood and Lake Placid also contribute to the overall production of

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Florida lettuce. Planting in Florida usually starts in early September and lasts through March. Harvest begins in November and continues to late May or early June, depending on the weather during the growing season. During the 1991-92 growing season, Florida produced 3402 harvested hectares (8400 acres) of lettuce, of which 2673 ha (6600 acres) were iceberg lettuce valued at $18.7 million (Fla. Agr. Stats. Serv., 1993).

Farming on muck soils presents a number of problems for lettuce producers. Oxidation and wind erosion have substantially reduced muck soil levels over the years (Cantliffe and Karchi, 1992). Weeds, root rot diseases, and poor lettuce head quality that is related to high temperatures are also major problems. Urban expansion, pollution, and erratic rainfall patterns potentially could lead to water use restrictions which might regulate the amount of water available for irrigation. The poor conditions of existing shallow muck soils and the unavailability of new muck soil sites for future production expansion, may signal the end of lettuce production on organic soils in Florida.

There is approximately 6500 hectares (16,000 acres) of limited production land currently available for lettuce grown on the Histosols (Cantliffe and Karchi 1992). However, there is approximately 28,000 hectares (70,000 acres) of lettuce that could be marketed from Florida if the crop were grown on sandy soils. It seems obvious that expansion of lettuce production onto mineral soils would greatly expand the industry in Florida.

Research has been minimal for lettuce production practices on mineral soils in Florida. Everett (1980) reported that head weights of transplanted lettuce grown on polyethylene mulched beds on mineral soils were significantly higher than heads grown on nonmulched beds. Seale (1986) reported that the use of containerized transplants resulted in more uniform head size at maturity and heads tended to be heavier compared to direct-seeded lettuce. Adaptable cultivars are also imperative if expansion of lettuce production is to occur in Florida. Cantliffe and Karchi (1992) reported that lettuce cultivars Desert Queen, Maverick, and Mesa produced good quality heads in field trials and in walk-in tunnels in northern Florida. Polyethylene mulch, containerized transplants, and drip irrigation were used in these experiments. In order to maximize lettuce production on mineral soils, these practices might be an integral part of production practices.

Previous research on growing lettuce on mineral sand soils has not addressed two important issues: (1) how lettuce would respond to the field environment over an entire growing season in northern Florida; and (2) does the plant establishment method (direct-seeding or containerized transplants) have an effect on overall yields and head quality of lettuce grown on mineral soils over an entire growing season?

The present study was conducted to evaluate yield and head quality of two lettuce cultivars over a 10-month growing season characterized by temperature fluctuations, varying duration and intensity of light, and erratic climatic conditions. Performance (yield and head quality) of the two cultivars evaluated under two systems of plant establishment (direct-seeding or transplants) was determined as well as defining cultural practices for lettuce grown on mineral soils.

Materials and Methods

All field experiments were conducted at the University of Florida's IFAS Horticultural Research Unit in Gainesville Fl. on Arredondo fine sand (loamy siliceous hyperthermic Grossarenic Paleudults). Soil sample analysis indicated that the pH was 6.4 and the soil was very high in P (116 $mg \cdot kg^{-1}$) and Ca (280 $mg \cdot kg^{-1}$), and medium in Mg (28 $mg \cdot kg^{-1}$) and low in K (28 $mg \cdot kg^{-1}$) as determined in a Melich-1 extract.

Preplant fertilizer was incorporated into the beds for experiments 1 through 9 at a rate of 280 $kg \cdot ha^{-1}$ 13-2-10 N-P-K. For experiments 10 through 15, no preplant fertilizer was applied. The decision was made to change the procedure due to problems with the irrigation system which was causing fertilizer leaching and the cooler soil temperatures of the winter months.

A one-time application of 22 $kg \cdot ha^{-1}$ $MgSO_4$ (11 $kg \cdot ha^{-1}$ S) was added through the drip system during the third or fourth week after planting. Fertilizer rates per day were adjusted based on the season so that a total of 168 $kg \cdot ha^{-1}$ of N and K each was applied over the entire 10-month growing season for each crop (Hochmuth and Smajstrla, 1997).

During the fall and spring when the weather tended to be warmer, higher N and K rates were applied during week 3 through 5 after transplanting or week 5 through 8 after direct-seeding. Highest N and K rates for winter were supplied during week 4 through 7 for transplants and week 4 through 9 for direct-seeding (Robles, 1997). Potassium and N were supplied from KNO_3 and NH_4NO_3. Since there was no preplant fertilizer for experiments 10 through15, fertigation commenced 4 days after planting for transplants and 8 days after sowing for direct-seeding for these experiments. During the cool and cloudy periods of winter, if the fertigation schedule was completed before lettuce heads were harvestable, the last rate of fertilizer was applied until one week before harvest. During the entire growing season, water was applied for 20 minutes immediately after sowing or transplanting, two times a day, or as needed.

Six beds (76 m long × 61 cm wide and 20.3 cm high) were constructed on 1.2 m centers. Fumigant (33% chloropicrin 67% methyl bromide) at a rate of 448 $kg \cdot ha^{-1}$ was injected during bed preparation. Immediately, 16 mm Typhoon® 10 mil. drip tubing with 30.5 cm emitter spacing (Netafim Inc., Altamonte Springs, Fla.) was laid on the center surface of the bed. The beds were covered simultaneously with white-on-black polyethylene mulch (1.5 mil) (Polyon Inc.) for the first nine experiments and white-on-white polyethylene mulch was used for the remaining experiments. White-on-black polyethylene was used primarily during periods of low temperatures while white-on-white was used primarily during periods of high temperatures (Cantliffe and Karchi, 1992).

Planting dates were scheduled for the 1st and 15th day of every month starting in September and ending in April. Seeding dates for transplants at Speedling Inc. (Bushnell, Fl.) started in August and ended in March (Robles, 1997). However, actual planting dates in the field varied as the season progressed due to drastically changing environmental conditions in the transplant production greenhouse.

Field culture. Plots were 4.6 m long with 61 cm across the surface of the beds. Double-rows 30 cm apart were punched using an 8-cm manual hole puncher creating a diagonal hole pattern for planting and 36-cm spacings within rows. Plant population was equivalent to 54,000 plants per ha (22,000 plants per acre). Primed and pelleted seeds of lettuce (*Lactuca sativa* L.) cultivars 'Desert Queen' and 'Maverick' provided by Asgrow Seed Company (Asgrow Inc., San Juan Bautista, Calif.) were used.

Direct seeding procedures. The soil at individual hole surfaces was leveled and a slight depression was made. Four seeds were placed in each hole and pressed lightly into the soil. The seeds were then covered with 28 grams of LMV GrowSorb (Mid Florida Mining Co., Ocala, Fla).

Transplants. Transplants were grown and provided by Speedling Inc. of Bushnell, Fla. Approximately 150 ml of 20-8-16 (N-P-K) fertilizer (680 g per 95 L) was applied to the soil after planting.

Polypropylene non-woven row covers (Agryl Inc., Alpharetta, Ga.) were used during the winter season as frost protection. The covers were 1.5 m (5 ft.) wide and covered the entire length of the row. The covers were removed as soon as the air temperature warmed up sufficiently past the freezing point.

Data collection. Daily measurements of soil, air, and soil bed temperatures were taken using a remote thermograph (Weathertronics Inc., West Sacramento, Calif.). A disease incidence rating based on a 0-5 scale (0 = no or very little disease to 5 = completely diseased).

All lettuce plots were harvested one time. The planting dates, harvest dates and days to harvest, of direct-seeded and transplanted lettuce are presented in Table 1. A total of 18 heads were harvested per plot which was equivalent to two 2.3-m rows. Average marketable head weight and internal core length were measured. A marketable head is sometimes considered to be 1 kg (2.2 lbs) (Ryder 1979), but for this experiment, a marketable head weight of 0.69 kg (1.5 lbs) was used. This was obtained by taking the average weight of lettuce heads from 4 local supermarkets. A percentage of trimmed weight, and marketable yields was also calculated.

A split-plot experimental design was used with four replications of each experimental unit. Main blocks were planting dates, subplots were plant establishment methods, and cultivars were sub-sub plots.

Results

Seasons were categorized in the following manner; fall - 1 Sept., through 15 Nov., winter-8 Dec., 1992 through 15 Feb., 1993, spring-5 Mar., through 15 April. The greatest total fresh weight yields occurred from 11 Jan., 1993, 15 Sept., and 1 Oct., 1992 planting dates (data not shown). During the winter and spring seasons, yields were generally not significantly different among cultivars.

Table 1. Planting dates, harvest dates, and days-to-harvest of direct-seeded (D.S.) and transplanted (T.P.) lettuce cultivars 'Desert Queen' and 'Maverick'.

	Harvest dates		Days to harvest	
Planting dates	D.S.	T.P.	D.S.	T.P.
1 Sept., 1992	10 Nov., 1992	27 Oct., 1992	71	57
15 Sept.	23 Nov.	16 Nov.	70	63
1 Oct.	18 Dec.	25 Nov.	79	66
15 Oct.	12 Jan., 1993	21 Dec.	89	67
1 Nov.	11 Feb.	13 Jan., 1993	103	74
15 Nov.	11 Mar.	17 Feb.	117	74
8 Dec.	22 Mar.	11 Mar.	105	94
28 Dec.	8 Apr.	18 Mar.	101	80
11 Jan., 1993	23 Apr.	8 Apr.	104	89
28 Jan.	30 Apr.	16 Apr.	92	78
15 Feb.	10 May	26 Apr.	84	70
5 Mar.	25 May	10 May	82	67
18 Mar.	2 June	14 May	77	58
8 April[z]	17 June	2 June	50	35
15 April[z]		17 June		64

[z]April planting dates were harvested early due to poor stand establishment in direct-seeded plants and a high incidence of disease in both cultivars of transplants and direct-seeded lettuce. Poor head quality was apparent in heads left in the field after 1 June.

Yields in April were less than with other planting dates because of a severe storm that occurred during March that damaged the seedlings and transplants. The mean yields of 'Desert Queen' were significantly greater in April than those for 'Maverick' during the same period (data not shown). Unfortunately, the plants had to be harvested early, and thus, head weights were generally below the marketable weight.

There was a greater percentage of lettuce with damaged leaves removed produced during the late winter to spring growing season than fall to early winter (Table 2) The 11 Jan., 1993 planting date resulted in the highest metric tons per hectare, averaged over all cultivars and planting methods, of total fresh weight (47.7 MT·ha^{-1}) and total trimmed weight (45.2 MT·ha^{-1}) and the second highest percentage (95%) of trimmed lettuce yield. The highest percentages of trimmed yield (98%) were from the plants of the 18 Mar., 1993 planting date.

The greatest total marketable weight occurred with the 11 Jan., 1 Oct., and 15 Sept. planting dates (Table 3). There was also a significant planting date × plant establishment method

Table 2. Percent trimmed-weight yield, and marketable yield (≥ 0.69 kg) of lettuce as influenced by planting dates.

Planting dates	Total fresh weight	Total trimmed weight	Total marketable weight (≤ 0.69)[z]	Percent trimmed weight yield	Percent marketable yield[z]
	MT·ha^{-1}			%	
1 Sept., 92	26.8	11.3	12.0	42	45
15 Sept.	41.5	33.4	30.2	80	72
1 Oct.	39.2	29.6	28.9	75	74
15 Oct.	34.7	21.4	22.2	62	64
1 Nov.	30.3	13.6	13.7	45	45
15 Nov.	18.7	6.7	0.1	36	0.5
8 Dec.	21.2	8.8	0.4	42	2
28 Dec.	30.4	24.9	15.9	82	52
11 Jan., 93	47.7	45.2	34.3	95	72
28 Jan.	25.3	18.2	01.5	72	6
15 Feb.	32.7	30.0	14.2	92	43
5 Mar.	31.6	28.4	12.4	90	39
18 Mar.	35.1	34.6	15.5	98	44

[z]Based on using only 0.69 kg head weights or larger.

Table 3. Total marketable head weight (≥ 0.69) of lettuce cultivars Desert Queen (D.Q.) and Maverick (Mav) as influenced by planting date and plant establishment method.

Planting date		Plant establishment method[z]	
		Transplant	Direct-seed
		MT·ha⁻¹	
1 Sept., 1992		6.7	17.4
15 Sept.		35.1	25.3
1 Oct.		39.6	18.4
15 Oct.		23.9	20.7
1 Nov.		25.6	1.9
15 Nov.		0.3	0.0
8 Dec.		0.0	0.9
28 Dec.		16.1	30.3
11 Jan., 1993		63.0	5.7
28 Jan.		2.44	0.6
15 Feb.		11.2	17.2
5 Mar.		10.7	14.3
18 Mar.		13.1	18.1
Cultivar	DQ	17.1[y]	
	MAV	13.9	

[z]LSD (0.05) for planting date × plant establishment method = 9.0 $MT \cdot ha^{-1}$.
[y]Means were significantly different at $P \leq 0.05$.

interaction. Transplanted lettuce had significantly greater yields than direct-seeded lettuce. The 15 Nov. and 8 Dec. planting dates resulted in the lowest marketable yields across treatments.

'Desert Queen' had significantly greater average total yields 17.1 $MT \cdot ha^{-1}$, than 'Maverick' 13.9 $MT \cdot ha^{-1}$, when considering only head weights of 0.69 kg or larger as marketable, averaged over all planting dates and establishment methods.

When yields were calculated on the basis of 24 heads (over 0.69 kg) per box, the greatest yields and the highest percentage of marketable weight lettuce heads were from the 11 Jan., 1 Oct., and 15 Sept. planting dates (Table 4). The planting date × cultivar interaction revealed that transplants had more 24 head boxes per ha of lettuce 1917, 1885, and 1588, respectively than direct-seeded lettuce during these planting dates. Transplants also had higher percentage of marketable weight lettuce heads 85, 84, and 70% respectively than direct-seeded lettuce heads on those same harvest dates. With the exception of 11 Jan., the winter season resulted in the poorest yields across treatments.

Table 4. Number of boxes per ha (24 heads per box) of marketable head weight (≥ 0.69 kg per head) lettuce cultivars Desert Queen (D.Q.) and Maverick (Mav) as influenced by planting date and plant establishment method.

Planting Dates		Plant establishment method[z]	
		Transplant	Direct-seed
		boxes per acre	
1 Sept., 1992		373	768
15 Sept.		1588	1168
1 Oct.		1885	951
15 Oct.		1200	981
1 Nov.		1309	109
15 Nov.		15	0
8 Dec.		0	25
28 Dec.		94	1247
11 Jan., 1993		1917	311
28 Jan.		141	32
15 Feb.		608	857
5 Mar.		593	746
18 Mar.		702	981
Cultivar	DQ	1561[y]	
	MAV	1302	

[z]LSD (0.05) for planting date × plant establishment method interaction = 818 boxes per ha.
[y]Means were significantly different at $P \leq 0.05$.

Table 5. Average marketable head weight (≥ 0.69) for lettuce cultivars Desert Queen (D.Q.) and Maverick (Mav) as influenced by planting date and plant establishment method.

Planting dates	Plant establishment method	
	Transplants	Direct-seeded
	kg	
1 Sept., 1992	0.75	0.95
15 Sept.	0.92	0.90
1 Oct.	0.87	0.79
15 Oct.	0.83	0.89
1 Nov.	0.81	0.72
15 Nov.	0.70	—
8 Dec.	—	0.79
28 Dec.	0.73	0.95
11 Jan., 1993	1.28	0.76
28 Jan.	0.72	0.73
15 Feb.	0.77	0.81
5 Mar.	0.77	0.78
18 Mar.	0.77	0.77

[z]LSD (0.05) for planting date × plant establishment method = 0.10 kg.

Direct-seeded lettuce had higher marketable head weights on 1 and 15 Sept. and 28 Dec. than the transplanted lettuce, while the reverse was true for the 11 Jan. planting date (Table 5).

Head quality characteristics. The fall season led to longer core lengths, especially from the 1 Sept. through the 1 Oct. planting dates (Table 6). 'Desert Queen' had the longest cores (18.5, 17.3 and 10.5 cm) during the September period regardless of plant establishment method.

Undoubtedly, high temperatures caused the increased core length during that period. However, high greenhouse

Table 6. Average core length of lettuce cultivars Desert Queen (D.Q.) and Maverick (Mav) as influenced by planting date and plant establishment method.

Planting dates	Plant establishment method[z]			
	Direct-seeded		Transplants	
	Mav	D.Q.	Mav	D.Q.
	cm			
1 Sept., 1992	5.8	18.5	3.7	10.5
15 Sept.	3.8	17.3	4.4	6.6
1 Oct.	5.0	5.5	4.8	4.9
15 Oct.	3.9	4.4	3.8	3.8
1 Nov.	3.2	3.5	3.7	3.6
15 Nov.	2.4	4.4	2.8	4.2
8 Dec.	1.8	2.8	2.6	2.7
28 Dec.	2.1	2.4	2.1	2.6
11 Jan., 1993	2.3	2.8	2.5	3.1
28 Jan.	2.6	2.6	2.7	2.9
15 Feb.	3.1	2.8	3.6	3.0
5 Mar.	6.2	3.5	6.0	3.5
18 Mar.	7.2	4.0	7.2	4.3

[z]LSD (0.05) for planting date × cultivars × plant establishment method = 1.6 cm.

Table 7. Disease rating of lettuce cultivars 'Desert Queen' and 'Maverick' as influenced by planting date and plant establishment method.

Planting dates	Cultivar[z]	
	Maverick	Desert Queen
	disease rating[y]	
1 Sept., 1992	0.0	0.0
15 Sept.	0.0	0.0
1 Oct.	1.5	0.0
15 Oct.	0.0	2.0
1 Nov.	0.0	1.5
15 Nov.	1.0	2.5
8 Dec.	0.0	2.5
28 Dec.	0.0	0.0
11 Jan., 1993	0.0	0.0
28 Jan.	0.0	1.0
15 Feb.	0.0	0.0
5 Mar.	1.0	1.0
18 Mar.	1.0	2.0

[z]LSD (0.05) value for disease rating for planting date × cultivar interaction = 0.9.
[y]0 = no disease to 5 = completely diseased.

temperature may also have contributed to the poor transplant quality and possibly the initiation of the bolting process. Based on the core length data reported for 1 Sept. and 15 Sept. 'Desert Queen' had bolted. The cores actually circle around within the lettuce heads rather than break through the surface of the head. Late fall and winter growing periods led to the lowest core lengths over all planting dates. Over all planting dates, the shortest core lengths were measured during the winter months with a slight increase in core lengths from plants maturing during the spring.

Botrytis cinerea (blight) affected primarily 'Desert Queen' during the late fall and early winter season (Table 7). *Erwinia carotovora* (bacterial soft rot) affected 'Desert Queen' during the spring season. The affected plant samples were diagnosed by the University of Florida's IFAS Plant Disease Clinic. Plants grown from transplants expressed more of the disease symptoms than those from direct-seeded treatments.

Normally high air temperatures (25°C and higher) were recorded during the early part of the fall season. Undoubtedly, this was a contributor to the long core lengths recorded in Sept. and Oct. 'Desert Queen' displayed more susceptibility to longer core lengths than 'Maverick'. Both cultivars are used in the early fall by lettuce producers in Arizona. This may be a genetic response of 'Desert Queen' to the fluctuating temperatures.

As the fall season progressed toward early winter, bed, air and soil temperatures fluctuated dramatically (data not shown). The first freeze was recorded on 30 Nov., 1992. Four days earlier, the high temperature was 27°C and the low was 17°C. This was indicative of the erratic environment to which the lettuce crop was subjected.

The winter season was characterized not only by fluctuating temperatures and several freezes, but a number of cool and cloudy days which reduced solar radiation which is vital for lettuce growth and development. Soil and bed temperatures did not fluctuate as much during this period. This may he attributed to the polyethylene mulch covering the bed.

The spring season was characterized by the "storm of the century" which occurred on 14 Mar., 1993. Air temperatures were below zero for three days. However, bed temperatures remained warm and relatively stable up to the last reading on 14 March. Air temperature data recorded in April depicted a gradual warming trend which started in mid-March despite two days of near freezing temperatures. This may have accounted for the increase in marketable yields during the spring season.

Discussion

The significance of the seasonal effect on yield and quality characteristics and the subsequent interactions between plant establishment and cultivar, and planting date × plant establishment method was evident throughout this experiment. Cantliffe and Karchi (1992), Guzman (1981), and Burdine and Morris (1972) reported similar results. Dramatic fluctuations in air temperature were a regular occurrence throughout the growing season. Predictably high temperatures (above 25°C) were recorded early and late in the growing season. At least fifteen days of freezing or below freezing temperatures were recorded between 1 Nov. and 14 March. A polyethylene nonwoven row cover was used during those periods as frost protection. There were a number of cool and cloudy days during the winter. Lettuce growth during those times was greatly reduced or ceased entirely. This resulted in extended days to harvest particularly for direct-seeded lettuce. The greatest total marketable yields and the greatest percentage of marketable yield were produced during the fall season.

One of the anomalies of this experiment was that the 11 Jan., 1993 planting date resulted in the greatest number of superior heads of all the planting dates irrespective of plant establishment method. This planting was made in the middle of the winter growing season. The unusual response could probably have been a genetic response by 'Desert Queen' to the optimum environmental conditions during that growing period. Lettuce from the 28 Dec. or 28 Jan. planting dates had significantly lower mean yields per hectare than the 11 Jan. date.

'Desert Queen' and 'Maverick' are sown early in September by lettuce growers in Yuma, Arizona. Temperatures normally do not fluctuate as drastically as in Florida. The variation in responses in yields during the fall and spring growing seasons might be attributed to genotypic differences.

With the exception of the 11 Jan. planting date, the winter season led to the lowest yields across treatments and parameters measured. Cantliffe and Karchi (1992) utilized walk-in tunnels during the winter season to grow lettuce in north Florida. They found that head weights and head quality of lettuce grown under the tunnels were similar to those grown in open-field culture. Adequate ventilation during the warmer season apparently was a problem. Walk-in tunnels will give frost protection and may be the answer for growing lettuce in mid-winter in northern Florida. Further research would have to be conducted to determine the economic viability of such a practice.

Undoubtedly transplants are the best method of plant establishment for open-field production. The biggest benefit observed during this experiment was the earliness of harvest when compared to direct-seeding. For a grower, this translates into less time for the crop to be in the field and exposed to potential environmental stresses. Another benefit is reduction of fertilizer and pesticide inputs thus minimizing the risk of pollution which is a major concern for growers in southern Florida. There is also the potential for extending the growing season which could result in increased profits for the grower.

If transplants are to be used, however, transplant quality must improve. Transplants used in this experiment were generally of poor quality. During the fall and spring seasons, transplants suffered from extremely poor root structure, extended hypocotyls, and long, brittle leaves. Transplants produced in the winter also had very poor root structures and very short pale green leaves. Soundy (1996) developed a methodology, through proper fertilization, to grow excellent lettuce transplants via floatation irrigation. Both P and K could be supplied via fertilization to optimize plant growth. Lettuce seedling growth could be optimized during summer or winter by 30 to 60 $mg \cdot liter^{-1}$ N supplied every other day via floatation fertigation.

Age of transplants and pretransplant conditioning also have been reported to affect transplant quality (Leskovar and Cantliffe 1993; Wurr and Fellows, 1991). Lettuce transplants appear to be best between 21 and 28 days after sowing.

High temperatures in open-field culture have been reported to lead to bolting, puffy heads, bitterness, and increased internal disorders of lettuce (Kahn and Magnello, 1986; Guzman, 1981). Sadler (1990) reported that transplants exposed to greenhouse temperatures between 25° to 35°C flowered earlier in open-field culture than transplants exposed to greenhouse temperatures between 20° to 25°C.

'Desert Queen' was the superior cultivar for all yield parameters throughout this work. 'Desert Queen' had the highest of the top three cultivars in a cultivar performance study reported by Cantliffe and Karchi (1992). 'Desert Queen' could be used as the standard for further research on adaptable cultivars to be grown on mineral soils under northern Florida growing conditions.

The combination of polyethylene mulch and drip irrigation were important for production of high-quality lettuce on mineral soils. Weed pressure in the beds was not a major production problem during this experiment. Weed pressure in the row middles was a factor in the fall and spring growing seasons and was controlled by a recommended herbicide.

The use of white-on-black mulch led to higher bed temperatures than white-on-white mulch. Further research would have to determine if using white-on-black mulch during the mid winter would have any effect on yields of lettuce cultivars.

For the efficient use of water and the effective delivery of fertilizer, drip irrigation is essential. Fertigation trials should be conducted to establish fertility standards for lettuce grown on mineral soils. One problem that has to be addressed is the situation of when the recommended duration of fertilizer application falls short of the overall length of the crop life cycle. This occurred at least twice during the winter season where plant growth was slowed when temperatures were cool and irradiance was reduced due to cloud cover and short photoperiods. With the unpredictable nature of weather in north Florida, this problem will persist.

This study suggested that a potential exists for expansion of lettuce production onto the mineral sandy soils of Florida. Economically, most the marketable yields obtained during this study exceeded the marketable yields achieved during the 1992-1993 Florida lettuce growing season. During the 1992-93 growing season, Florida lettuce producers averaged 19.2 $MT \cdot ha^{-1}$ of lettuce (Fla. Agr. Stats. Serv., 1994). During the late winter and spring season in the present study, the trimmed yields ranged from 18.2 (the lowest) to 45.2 $MT \cdot ha^{-1}$. In the fall, marketable weight yields ranged from 0.1 to 30.2 $MT \cdot ha^{-1}$. The 5-year average (1988-93) for lettuce produced in Florida was 17 $MT \cdot ha^{-1}$. The trimmed yields and 30% of marketable yields recorded in this study were generally above this 5-year average (Fla. Agr. Stats. Serv., 1994). Thus, head quality, not quantity has to be improved.

Based on this study, the time to plant lettuce in northern Florida is from 15 Sept. through 15 March. Before or after this period, temperatures in northern Florida are too hot and adversely affect marketable yields. Care must be taken to prevent frost and/or freeze damage to the plants during winter. Future research will eventually address the problems of transplant quality, fertility, more adaptable cultivars, optimal mulch color, reduction of potential diseases, and other cultural practices to maximize production and quality of crisphead lettuce grown on sandy soils of northern Florida.

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