LETTUCE CULTIVAR RESPONSE TO THE SOUTH FLORIDA ENVIRONMENT

HOWARD W. BURDINE

IFAS Agricultural Research & Education Center
Belle Glade

Abstract. **Four head lettuce cultivars, 'Great Lakes 659,' 'Oswego,' 'Fulton,' and 'Minetto,' were grown in glazed crocks filled with Perlite for two successive years in the fall and early winter, winter, and spring in the open south Florida environment to determine cultivar interactions with season. Nutrients were provided by solutions using two N variables. Solution 1 contained 15 meq/1 NO_3-N, Solution 2 contained 13 meq/1 NO_3-N + 2 meq/1 NH_4-N. Among the significant responses were season x N interactions. Zinc content of the plants was higher in the fall with solution 1, higher in the winter with solution 2. Iron was higher in the spring with NH_4-N. Solution 1 reduced Mn uptake in the spring. There were cultivar x seasons interactions with respect to fresh and dry weight, ribbiness, tipburn, % Mg and N, ppm B, Cu, and Mn.**

South of Lake Okeechobee, lettuce planting season starts about October 1 and ends about March 15. Harvesting season starts about December 15 and ends in late May. Fig. 1 points up the fact that the growing season in south Florida with respect to daylength and temperature relationships is opposite to that in the temperate zone regions. In the fall plants under the influence of shortening days and decreasing temperatures. Shortest days and lowest temperatures occur from December 15 through the first week of January. Daylength and temperature during the spring growing period are somewhat better correlated with temperate zone conditions, however temperatures are higher than corresponding daylengths found in the northern U. S.

The literature on environmental effects on plant nutrition is widely scattered. Lingle and Davis (13), Locascio and Warren (14), among others, found root temperatures below 70°F de-

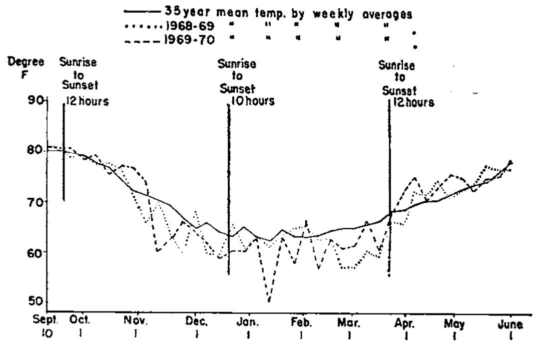

Fig. 1. Mean average temperature by weekly averages from September 10 to June 1 at the Agricultural Research and Education Center at Belle Glade, Fla.

creased P uptake in the tomato. Mn requirements for some plants are decreased at high light intensity (17). Hoagland (11) reported visible Zn deficiency symptoms were restricted to the summer in California orchards, while Ozane (19) in Australia found Zn deficiency in subterranean clover most severe during the short day period. Lowenhaupt (15) found high light intensity incleased leaf accumulation of B in sunflower.

Temperature and length of photoperiod are known to be prime factors in growth and reproduction of many plants (25) (18). Lettuce is no exception (20) (22) (24). Consumer requirements for smooth, symmetrical, reasonably firm heads with short stems put special emphasis on the importance of these environmental factors in the production of head lettuce. Wide differences in the use of lettuce cultivars in the various lettuce producing areas of the United States emphasize the genetic variability, as isolated by plant breeders for response to these factors. This has been recognized by horticulturists (1) (21), and along with resistance to pathogens, have been the primary factors for classification of cultivars in the temperate climates (21) into seasonal adaptation for the early, midseason, and late categories. Factors that produce such changes would be expected to affect other processes in the plant.

Lettuce has been grown intermittently in south Florida for many years (2). Many cultivars have been tried, but only a few Great Lakes selections (Crisphead types) persisted. Recent attempts to establish a Florida lettuce industry on a more permanent basis have focused attention on the New

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York cultivars, 'Oswego,' 'Fulton,' and 'Minetto' (21), also crisphead types.

After two years, it became apparent that organic soil nutritional recommendations for lettuce that have been followed since 1950 (8) were out of date. As part of a study to find some of the differences in response between the older and the newer lettuce cultivars, two experiments were conducted under uniform nutritional conditions provided by the solution culture technique. This experiment was conducted in open environment during: a) fall and early winter; b) late winter; and c) spring seasons. Original plans were to grow the fall treatment for maturity before December 20 to complete growth during the fall. However, problems in seed germination in the greenhouse flats of two cultivars during late September resulted in a late start the first season. This starting pattern was continued the secondr year for the sake of orthogonality in the experimental design (Table 1).

Experimental Methods

Four lettuce cultivars were grown for two successive years by solution culture outside in late fall and early winter, winter, and spring, respectively, with two N treatments. The experimental design was a 3 x 4 x 2 factorial experiment with years as replication. Table 1 gives seeding, transplanting, and harvest dates.

Seed of the head lettuce cultivars, 'Great Lakes 659,' 'Oswego,' 'Fulton,' and 'Minetto' were germinated in flats of quartz sand, previously washed with demineralized H_2O. After germination, moisture and plant nutrients were supplied with alternate applications of Hoaglands No. 2 solution (10) and demineralized H_2O. When plants reached the 4 leaf stage, they were transplanted to 2 quart glazed crocks filled with Perlite. Two separate lots of Perlite were used, one during 1968-69, the other during 1969-70.

Major nutrients were supplied in two modified Hoagland's solutions (10). Solution 1 supplied 15 meq/1 all NO_3-N. Solution 2 supplied 13 meq/1 NO_3-N + 2 meq/1 NH_4-N. Reagent grade chemicals, KH_2PO_4, KNO_3, KCl, K_2SO_4, $Ca(NO_3)_2 \cdot 4H_2O$, $MgSO_4 \cdot 7H_2O$, $(NH_4)_2SO_4$, and $NaNO_3$ in M solutions with demineralized H_2O, were balanced to supply 6 K, 10 Ca, 2 Mg, 1 H_2PO_4, and 4 SO_4, all in meq/1, to each solution, respectively. Total solution concentration of major nutrients was 20 meq/1. Micronutrients were supplied as suggested by Hoagland and Arnon (10). Fe was added to all solutions as 1 ml/1 of 0.5% ferric tartrate at each application.

Mg was held constant in all solutions at one-half that normally used in Hoagland's Solution to determine whether or not the addition of NH_4-N would increase the amount of chlorosis that has been observed in field grown 'Fulton' and 'Minetto' in the late winter and spring.

Four hundred ml of solution were poured through each culture every second day for the first 30 days after transplanting. The same amount of demineralized H_2O was used on alternate days. After 30 days, 400 ml of H_2O were used each morning and 400 ml of the appropriate solution were applied each afternoon. Drains in the bottom of the crocks permitted excess solution and H_2O to drain.

Duplicate treatments were used throughout to reduce error from possible genetic diversity. The plants were grown until heads were fairly firm, comparable to harvest maturity. The two heads from each treatment were dried at 75°C for 72 hours and ground in a stainless steel Wiley mill.

Total N in plant tissue was determined by micro-Kjeldahl following digestion in conc H_2SO_4-salicylic acid (12). Following $HClO_4$-HNO_3 digestion of plant tissue, P was determined colorimetrically by the vanadomolybdophosphoric method (9), K by the flame emission spectrophotometer, Ca and Mg by titration with Versene (7). Fe, Mn, Zn, and Cu were determined by atomic absorption spectrophotometry (3). B was taken up from dry ashed material in 0.36 N H_2SO_4 and

Table 1. Experimental design data for seasons x cultivar experiment grown outside.

Operation	Season Fall	Winter	Spring
A. Rep. I, 1968-69:			
1. Seeding date in flats	10/31/68	1/6/69	3/20/69
2. Transplanted to crocks	11/18/68	2/4/69	4/7/69
3. Harvested:			
a. GL 659	1/23/69	3/31/69	5/27/70
b. Oswego	1/23/69	3/31/69	5/20/69
c. Fulton	1/16/69	3/24/69	5/20/69
d. Minetto	1/16/69	3/24/69	5/20/69
B. Rep. II, 1969-70:			
1. Seeding date in flats	10/30/69	1/4/70	3/24/70
2. Transplanted to crocks	11/16/69	2/3/70	4/10/69
3. Harvested:			
a. GL 659	1/20/70	3/28/70	5/30/70
b. Oswego	1/20/70	3/28/70	5/28/70
c. Fulton	1/13/70	3/21/70	5/26/70
d. Minetto	1/13/70	3/21/70	5/26/70

Table 2. Main effect averages of season, cultivars, and nitrogen treatments on growth and physiological characteristics of head lettuce.

Variable	Head wt. in grams	No. chlorotic leaves	Marginal tipburn [z/]	Ribbiness rating [y/]	% Dry weight
Season:					
Spring	355[a] [x/]	5.1[b]	2.4[a]	2.9[b]	5.09[a]
Fall	308[b]	5.2[b]	2.6[a]	2.7[b]	3.94[c]
Winter	219[c]	6.1[a]	2.3[a]	3.8[a]	4.67[b]
Cultivars:					
GL 659	412[a]	5.0[b]	1.7[b]	3.8[a]	5.34[a]
Oswego	278[b]	6.1[a]	2.8[a]	2.8[b]	4.22[b]
Fulton	254[bc]	5.7[a]	2.6[a]	3.9[a]	4.41[b]
Minetto	232[c]	5.2[b]	2.4[a]	2.0[c]	4.29[b]
Nitrogen:					
All NO_3-N	284	5.3	2.4	3.2	4.34
2 meq/l NH_4-N	303	5.7	2.4	3.0	4.79
Sig.	N.S.[w/]	N.S.	N.S.	N.S.	**

z/ Rated 1 = none to 8 very severe.

y/ Rated 1 = straight normal rib to 8 very severely twisted rib and leaf.

x/ Means in the same group carrying the same letter are not significantly different at the .05 level (DMRT).

w/ ** or N.S. Difference between means are significant at .01 level or not significant, respectively.

colorimetrically determined by the quinalizarin method (16).

Results and Discussion

Main effect averages are given in Tables 2 and 3. The significance of the comparisons are obvious in the Tables. Many of the significant effects noted are qualified by the significant nitrogen source x seasons and cultivar x seasons interactions given in Tables 4 and 5, respectively.

The experiment reported here was not designed to produce nutritional deficiencies *per se*, but to evaluate seasonal effects on nutrient absorption by the various cultivars. Mg was held constant at 2 meq/1, one-half that normally used in Hoagland's solutions, to determine whether or not the addition of the NH_4-N would increase the amount of chlorosis that has been observed, particularly on 'Fulton,' and occasionally on 'Minetto,' in the late winter and spring. These organic soils are known to accumulate sizable amounts of exchangeable NH_4-N under certain conditions (26). In the author's experience, 2 meq/1 of Mg in Hoagland's solutions is above the threshold level, and analysis of plant tissue has shown this amount has yielded plant tissue with Mg content more consistent with corresponding tissue produced on these organic soils. Nitrogen treatment effects on Mg content were not significant. Chlorosis produced in these cultures (Table 2) was not typical of that found at times in the field on the several yellow wrapper leaves. It occurred on one leaf at a time, appearing on the oldest leaf in a relatively moderate amount, after which the leaf turned brown and withered. The data are expressed as the number of leaves on which this occurred during the entire growth period rather

Table 3. Main effect averages of season, cultivars and nitrogen treatments on tissue content of some plant nutrients in head lettuce (dry weight basis).

Variable	% N	% P	% K	% Mg	ppm B	ppm Cu	ppm Fe	ppm Mn	ppm Zn
Season:									
Spring	3.57^{c} z/	$.466^{c}$	4.69^{b}	$.439^{a}$	50.1^{a}	15.9^{a}	128^{b}	95^{a}	35.7^{b}
Fall	4.17^{a}	$.644^{a}$	6.04^{a}	$.350^{c}$	44.9^{b}	13.4^{b}	161^{a}	108^{b}	52.9^{a}
Winter	3.99^{b}	$.557^{b}$	6.07^{a}	$.414^{b}$	43.0^{b}	7.4^{c}	121^{b}	111^{b}	49.3^{a}
Cultivars:									
GL 659	3.40^{c}	$.475^{c}$	4.56^{c}	$.369^{c}$	43.8^{b}	7.9^{b}	112^{b}	83^{c}	37.1^{a}
Oswego	4.13^{a}	$.588^{a}$	6.06^{a}	$.419^{a}$	49.2^{a}	14.4^{a}	172^{a}	117^{a}	48.7^{a}
Fulton	3.90^{b}	$.555^{b}$	5.60^{b}	$.394^{b}$	47.7^{a}	12.9^{a}	125^{b}	104^{b}	47.0^{a}
Minetto	4.21^{a}	$.578^{a}$	6.14^{a}	$.423^{a}$	44.4^{b}	12.8^{a}	138^{ab}	116^{a}	50.9^{a}
Nitrogen:									
All NO_3-N	3.97	.558	6.00	.404	45.5	12.3	125	104	46.0
2 meq/l NH_4-N	3.86	.540	5.19	.399	47.1	12.1	149	149	46.0
Sig.	N.S. y/	N.S.	**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

z/ Means carrying the same letter in each group are not significantly different at the .05 level (DMRT).

y/ ** or N.S. Differences between groups of means are significantly different at or exceeding the .01 level, or not significant, respectively.

than number of chlorotic leaves at maturity. This type of phenomenon is more typical of leaf senescence. There were, however, significant differences due to cultivar and season.

Recent information indicates that marginal tipburn (Tables 2 and 5) is probably a Ca deficiency (23), and can be induced by environmental factors, as with blackheart in celery. There are known cultivar differences in susceptibility.

Table 4. Nitrogen source x season interactions for Zn, Fe and Mn content of head lettuce (all cultivars).

Element	Nitrogen treatment	Spring	Fall	Winter
Zn, ppm	All NO_3-N	33.2^{b} z/	60.6^{a}	44.1^{ab}
	2 meq/l NH_4-N	38.2^{b}	45.2^{ab}	54.5^{a}
Sig.		N.S. y/	*	N.S.
Fe, ppm	All NO_3-N	91^{b}	169^{a}	115^{ab}
	2 meq/l NH_4-N	165^{a}	154^{a}	128^{b}
Sig.		*	N.S.	N.S.
Mn, ppm	All NO_3-N	86^{b}	113^{a}	113^{a}
	2 meq/l NH_4-N	104^{b}	103^{b}	110^{a}
Sig.		**	*	N.S.

z/ Means carrying the same letter are not significantly different between seasons for the same N treatment (DMRT).

y/ * or ** or N.S., Nitrogen treatment means are significantly different at the .05 level, .01, or not significant, respectively, for the same season.

The cultivars used here are considered somewhat resistant. However, tipburn on 'GL 659' was rated slightly, but significantly, less severe than on the New York cultivars. The significant cultivar x season interaction (Table 5) indicated 'GL 659' was most severely affected during the spring season, while the New York cultivars were most severely affected during the fall season.

Tendency to ribbiness may be affected by light conditions and related to auxin production within the plant. Plants were more ribby during the winter, 'GL 659' and 'Fulton' were more ribby than the other cultivars. "Minetto' was least ribby of all confirming field observations. 'Oswego' was most severely influenced by season in this respect.

It should not be surprising that factors affecting such profound changes as differentiation from a vegetative stage to a reproductive stage in sensitive plants, might also show differences in plant nutrient accumulation.

Differences among cultivars have been found before for responses to levels of various nutrient elements, usually under otherwise reasonably uniform conditions. One should not be too surprised to find also cultivar x environmental interactions in this respect in highly selected materials. After

Table 5. Cultivar x season interactions of four head lettuce cultivars grown outside.

Response	Season	Cultivar GL 659	Oswego	Fulton	Minetto
Fresh weight	Spring	527^{a} x/	323^{b}	306^{b}	263^{b}
	Fall	451^{a}	301^{b}	245^{b}	235^{b}
	Winter	257^{a}	211^{a}	211^{a}	196^{a}
Sig.		* w/	*	*	N.S.
Marginal tipburn z/	Spring	2.8^{a}	2.8^{a}	1.7^{b}	2.1^{ab}
	Fall	1.2^{c}	3.4^{ab}	3.6^{a}	3.3^{ab}
	Winter	1.1^{c}	3.6^{a}	2.5^{b}	1.9^{bc}
Sig.		*	*	*	*
Ribbiness y/	Spring	4.2^{a}	1.5^{b}	3.6^{a}	2.3^{b}
	Fall	3.3^{a}	2.9^{a}	3.6^{a}	1.1^{b}
	Winter	4.1^{a}	4.1^{a}	4.6^{a}	2.5^{b}
Sig.		N.S.	*	N.S.	*
% N	Spring	2.86^{c}	3.73^{b}	3.59^{b}	4.12^{a}
	Fall	3.63^{c}	4.55^{a}	4.21^{b}	4.29^{ab}
	Winter	3.70^{c}	4.12^{ab}	3.91^{bc}	4.23^{a}
Sig.		*	*	*	N.S.
% Mg	Spring	$.362^{b}$	$.486^{a}$	$.435^{a}$	$.475^{a}$
	Fall	$.336^{a}$	$.353^{a}$	$.348^{a}$	$.363^{a}$
	Winter	$.409^{a}$	$.419^{a}$	$.397^{a}$	$.430^{a}$
Sig.		*	*	*	*
ppm B	Spring	46.6^{b}	59.4^{a}	51.6^{b}	46.9^{b}
	Fall	41.6^{a}	44.3^{a}	47.3^{a}	46.4^{a}
	Winter	43.3^{a}	43.8^{s}	44.4^{a}	40.7^{a}
Sig.		N.S.	*	*	N.S.
ppm Cu	Spring	11.7^{b}	22.7^{a}	14.6^{b}	14.6^{b}
	Fall	8.9^{b}	12.9^{ab}	16.9^{a}	15.5^{a}
	Winter	5.7^{a}	7.6^{a}	8.0^{a}	8.3^{a}
Sig.		*	*	*	*
ppm Mn	Spring	67^{d}	109^{b}	90^{c}	115^{a}
	Fall	91^{b}	116^{a}	110^{a}	120^{a}
	Winter	90^{c}	132^{a}	112^{b}	113^{b}
Sig.		*	*	*	N.S.

z/ Rated for severity, 1 = none to 8 very severe.

y/ Rated for severity, 1 = normal leaf to 8 very prominent twisted rib and leaf.

x/ Cultivars carrying the same letter are not significantly different at the .05 level or more during the same season (DMRT).

w/ * or N.S. Season means for the same cultivar are significantly different at the .05 level or more, or are not significant, respectively.

all, cultivar responses are due to actions of an isolated pool of genes that makes it a different entity from other cultivars.

Conclusions

Environmental factors of daylength and temperature not only affect reproduction and appearance in head lettuce, but appear to influence uptake of mineral nutrients. Lettuce cultivars used in this experiment showed considerable differences in response to fall and early winter, winter, and spring growing conditions in solution culture in the open south Florida environment. There were also differences in N, P, K, Mg, B, Cu, Mn, and Zn content of plant tissue. A small amount of NH_4-*N in* one solution affected Zn, Fe, and Mn content in the spring and fall seasons. These data may also be useful to those interested in leaf analysis as a diagnostic tool in plant nutrition.

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