Effect of Soil Type, Light Intensity, and Cultivar on Leaf Nutrients in Mustard Greens

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ABSTRACT

A greenhouse experiment was conducted near Weslaco, Texas (Lat. 26º 8' N, Long. 97º 57' W) between 17 Dec. 2001 and 14 Feb. 2002 to evaluate the effect of soil type, light environment, and cultivar on the leaf nutrients of mustard greens. Cultivars Tendergreen and Florida Broadleaf (*Brassica juncea*) were sown in four soils, Bobillo, Hebbronville, Hidalgo, and Raymondville (listed in order of increasing clay content), and grown in two light environments: 87 (50% shaded) and 168 $MJ \cdot m^{-2}$ (ambient) cumulative average hourly light having 18.2 and 19.0ºC mean season temperatures, respectively. Mustard greens grown under reduced light had lower leaf transpiration rates and ascorbic acid content, but had higher leaf area, chlorophyll, carotenoids, total N, NO_3, and most leaf mineral nutrients. Root fresh wt., but not shoot fresh wt. was reduced by low light. Plants grown in heavier textured soil had increased leaf area at both light levels, but when grown in reduced light, leaf area, pigment, and nutrient levels were even higher than in the heavy textured soils exposed to ambient light. Leaf ascorbate was higher in plants grown in ambient light than in reduced light. Folate was not affected by cultivar, light, or soil type (P<0.05).

RESUMEN

Se condujo un experimento en invernadero en una localidad cerca de Weslaco, Texas (Lat. 26º 8' N, Long. 97º 57' W) del 17 de diciembre de 2001 al 14 de febrero del 2002 para evaluar el efecto del tipo de suelo, cantidad de luz ambiental y el cultivar sobre los nutrientes de la hoja de plantas de mostaza. Los cultivares Tendergreen y Florida Broadleaf (*Brassica juncea*) se sembraron en 4 tipos de suelo: Bobillo, Hebbronville, Hidalgo, y Raymondville (el orden de esa lista corresponde al orden de acuerdo al incremento en contenido de arcilla) y se cultivaron en dos regímenes de luz ambiental cuyo promedio acumulativo de luz por hora fue 87 $MJ \cdot m^{-2}$ (50% de sombra) y 168 $MJ \cdot m^{-2}$ (ambiente) y que presentaron temperaturas promedio de 18.2ºC y 19ºC respectivamente. Las plantas de mostaza que crecieron bajo cantidades reducidas de luz presentaron menores tasas de transpiración y una reducción en el contenido de ácido ascórbico foliar, pero tuvieron mayor área foliar, y mayor contenido de clorofila, carotenoides, N total , NO_3 y de la mayoría de los nutrientes minerales en las hojas. La luz baja redujo el peso fresco de la raíz, pero no el peso fresco del brote. Las plantas que crecieron en suelo con textura pesada tuvieron mayor superficie foliar bajo ambos niveles de luz, pero cuando crecieron en luz reducida, la superficie de la hoja, los pigmentos, y los niveles de nutrientes fueron aun mayores que en los suelos de texturas pesadas expuestos a la luz ambiental. El contenido de ascorbato foliar fue mayor en las plantas que crecieron bajo luz ambiental que bajo luz reducida. La cantidad de folato no fue afectada por el cultivar, la luz, o el tipo de suelo (P<0.05).

Keywords: Brassica juncea, ascorbic acid, folic acid, shading

Leafy greens are an excellent source of mineral nutrients and vitamins for the human diet (U. S. Dept. Agriculture, 1982). The growing environment and cultural practices can affect the accumulation of nutrients in (leafy) vegetables. Previous research has demonstrated that vegetable amaranth grown under reduced light accumulates higher levels of most mineral nutrients, NO_3, leaf protein, carotenoids, and soluble oxalates (Makus and Hettiarachchy, 2001). The source and rate of supplemental N application can also influence leaf nutrients, carotenoids, and oxalate levels (Makus and Hettiarachchy, 1999). Decreasing light levels increases area per leaf, mineral nutrients, and pigments (dry wt. basis) of snap bean leaves (Makus, 2001). 'Carlo' snap beans, when grown under reduced light, had higher dry matter (%) and Mn levels but lower Fe levels in sieve size No. 3 pods (Makus, 2001). High light intensity prior to asparagus harvest, increased spear ascorbate content, whereas cool pre-harvest temperatures increased spear soluble solids concentration (Makus, 1992). Lester and Crosby (2002) have reported that location or soil type, cultivar, year, and size influence honeydew melon fruit ascorbate, folate, and K levels.

Soils used in vegetable production in south Texas vary in chemical and physical properties. These differences influence fertilizer and soil moisture dynamics and ultimately the nutritional quality of the vegetable crops grown on them. Furthermore, spring

Table 1. Chemical analysis (in kg/ha) of soils used in greenhouse study.[z]

Soil	Ca	K	Mg	Mn	P	S	Na	Fe	NO_3	Zn	Cu	B	Al
Bobillo	805	281	116	36	36	12	14	62	26	2.6	1.2	0.7	385
Hebbronville	2012	442	317	73	54	9	26	58	5	1.0	2.2	0.5	638
Hidalgo	12700	1284	524	139	110	198	118	40	153	4.3	4.2	3.6	831
Raymondville	12940	1200	526	142	107	201	123	41	13	4.3	4.0	3.3	767

[z]Bobillo: Loamy, siliceous, hyperthermic Grossarenic Paleustalfs
Hebbronville: Course-loamy, mixed, hyperthermic Aridic Haplustalfs
Hidalgo silt loam: Fine-loamy, mixed, hyperthermic Typic Calciustolls
Raymondville: Fine, mixed, hyperthermic Vertic Calciustolls

Table 2. Chemical and physical attributes of soils used in greenhouse study.

Soil	pH	E.C.	Total (%)			Bulk Density[z]	Texture (%)		
			N	Org. C	Carbon		Sand	Silt	Clay
		dS•M^{-1}							
Bodillo	6.1	0.13	0.19	0.41	0.37	1.48	65	24	11
Hebbronville	7.6	0.08	0.03	0.25	0.30	1.51	47	42	11
Hidalgo	8.0	0.68	0.07	0.60	1.01	1.22	55	22	23
Raymondville	8.2	0.22	0.07	0.63	1.64	1.24	20	34	46

[z]At termination of experiment

and fall-grown crops are often exposed to different light environments. The objective of the present study was to evaluate the effects of several soil types and two light regimes on leaf nutrients of two greenhouse-grown mustard greens cultivars.

MATERIAL AND METHODS

The experiment consisted of two cultivars, four soil types, and two light environments with all treatments replicated four times in an RCB design within each light environment. There were 64 pots. Approximately 2.2 kg of air-dried, unsterilized soil (see Tables 1, 2 for type and attributes) were added to 15 cm dia. x 15 cm h white plastic pots and placed in plastic-covered greenhouses receiving either ambient (available) light or 50% of ambient light. A 50% shade fabric was used for the light reduction treatment Minimum night temperatures were set at 12 ± 2ºC and day temperatures were set to cool at 29 ± 2ºC in both houses. Temperature and photosynthetically active radiation (PAR) were measured by thermocouples and LI-190SA quantum sensors in both houses every 60s and outputted hourly to a CR-10 data logger (Campbell Sci, Logan, UT). Average hourly PAR values were summed by hourly interval over the 58/59 day growing period, converted to kW•m^{-2}, and then to SI units of MJ•m^{-2}. Four seeds per pot of 'Tendergreen' and 'Florida Broadleaf' (Willhite Seed, Poolville, TX) were sown on 17 Dec. 2001, and stand counts taken 4 and 10 days later. Plants were thinned to 1 per pot 14 DAP (days after planting). One gram of water soluble 20N-20P-20K fertilizer in 100 ml was added to pot saucers at 11 and 42 DAP, and 0.2 g added at 48 DAP. Soluble trace elements (Peter's S.T.E.M.) were added at 0.05 g in 100 ml at 21 DAP. Deionized water was added to pot saucers at an initial depth of approx. 5 mm. Frequency of watering was based on incipient soil drying.

Porometry measurements were made 52 DAP with a LI-1600 Steady State Porometer (LI-COR, Lincoln, NE). Ambient light-grown and shaded plants were harvested 58 and 59 DAP, respectively. Root fresh weight was determined from 'Florida Broadleaf' plants and soil bulk density was determined from pots with 'Tendergreen' plants. On each harvest date plant fresh weight, leaf number, and leaf area were determined. Approx. 20 g of fresh leaf material was used for ascorbate and folate analyses based on the procedure of Lester and Crosby (2002). Approx. 85 g of leaves were frozen, lyophilized, and ground by a Wiley Mill to pass through a 40 mesh screen. From the latter sub-samples, plant dry weight (%) was determined; pigments were analyzed spectrometrically (Wellburn and Lichtenthaler, 1984); and leaf and soil nutrients were determined by ICP spectroscopy (Plank, 1992). Soil texture was determined by the pipet method (Gee and Bauder, 1986).

Light environment was analyzed as the main plots and cultivars and soil types were the sub-plots. Differences between response means were tested using the PDIFF option of the LSMEANS statement of PROC GLM of SAS Version 8.2 (SAS Institute, Cary, NC).

RESULTS

Soils and environment. The taxonomic classification of the four soils are given in Table 1. The Calciustolls, Hidalgo and Raymondville soils, were typically 2 to 18 times higher in extractable Ca, K, Mg, Mn, P, S, Na, Zn, Cu, and B than the lighter textured Bobillo and Hebbronville soils. The lighter textured soils contained the least clay and % carbon, had lower pH and electrolytes and the highest bulk density, compared to the heavier textured Hidalgo and Raymondville soils (Table 2). The cumulative average hourly PAR between 400 and 700 nm for the 58/59 day growing periods was equivalent to 87 and 168 MJ•m^{-2} for the shaded and ambient (unshaded) greenhouses, respectively. Mean season temperatures were 19.0 ± 5.1 and 18.2 ± 4.9 C, respectively.

Porometry. At 52 DAP, leaf transpiration rates were 14% greater under ambient light than in reduced light. Leaf

Table 3. Effect of cultivar, soil type, and light environment on mustard greens leaf porometry 52 DAP.

	Stomatal Conductance	Transpiration	Leaf Temperature
	cm • s^{-1}	µg • s^{-1} • cm^2	ºC
Light Level (LL):			
Ambient	0.74 b	9.7 a	24.6 a
Reduced	0.89 a	8.5 b	21.7 b
	*[z]	0.11[y]	*
Ambient			
Cultivar:			
Florida Broadleaf	0.66 b	8.9 b	24.8
Tendergreen	0.81 a	10.5 a	24.3
	*	*	NS
Soil Type:			
Bodillo	0.57 c	7.1 b	25.2 a
Hebbronville	0.69 bc	9.2 ab	24.6 ab
Hidalgo	0.78 ab	10.3 ab	24.3 b
Raymondville	0.91 a	11.8 a	24.2 b
	*	**	*
Reduced			
Cultivar:			
Florida Broadleaf	0.80 b	7.9 b	21.5
Tendergreen	0.98 a	9.1 a	21.9
	**	**	NS
Soil Type:			
Bodillo	0.75 b	7.6 b	22.2 a
Hebbronville	0.93 a	8.8 ab	21.6 b
Hidalgo	0.91 a	8.6 ab	21.6 b
Raymondville	0.97 a	8.9 a	21.3 b
	*	0.12	*
Interaction			
CV x Soil	0.07	0.09	NS
LL x Soil	NS	NS	NS
LL x CV	NS	0.07	NS
LL x CV x Soil	NS	NS	NS

[Z]NS, *, ** = Not significant or significant at P=0.05 P=0.01, respectively.
[Y]Probability of a greater 'F' value.

temperatures of plants grown in ambient light were 13% higher (Table 3). In both light regimes, leaves of plants grown in the lighter-textured Bobillo soil had significantly lower stomatal conductance and transpiration rates, and correspondingly higher leaf temperatures than leaves from Raymondville-grown plants. 'Tendergreen' leaves transpired more water per unit area of leaf than did 'Florida Broadleaf' leaves.

Agronomic. Seed emergence after 4 days was higher in full light, and significantly higher in Hebbronville than in Raymondville soil (Table 4). In reduced light, early germination was higher in 'Tendergreen' seed and lowest in Raymondville soil compared to other soil types. There were no differences in germination 10 days after sowing between cultivars, soils, or light regimes.

Shoot (top) fresh weight was not affected by light, but under ambient light 'Tendergreen' had more weight than 'Florida Broadleaf'. Plants grown in Hidalgo soil had the greatest leaf mass under ambient light and numerically the highest leaf mass under reduced light.

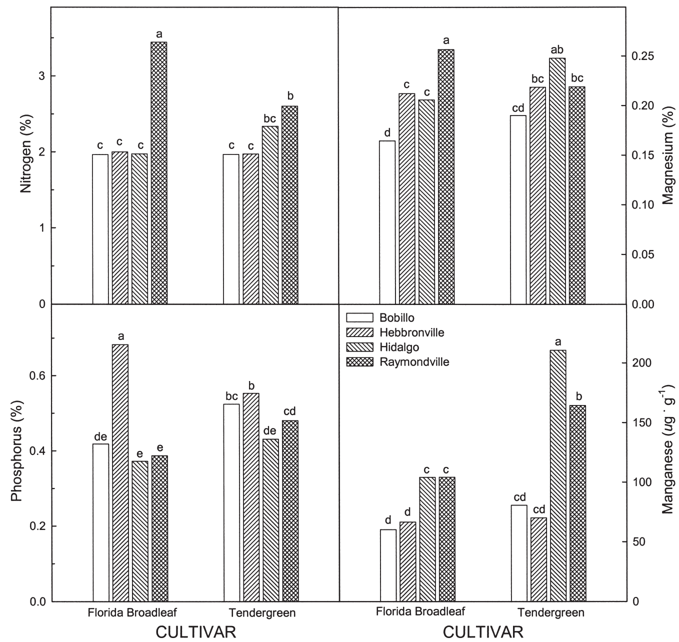

Fig. 1. Cultivar by soil type interactions for leaf total-N, P, Mg, and Mn (dry wt. basis), P=0.05.

Root fresh weight ('Florida Broadleaf', only) was greater in plants grown under ambient light. Hidalgo soil supported the highest root weight and numerically the lowest shoot:root ratio in both light regimes. Root weights of plants grown in Bobillo soil were not affected by light environment.

Total plant leaf area and area per leaf was increased by shading. 'Tendergreen' produced more leaves per plant than 'Florida Broadleaf', but the magnitude of the differences were not as great under reduced light. 'Florida Broadleaf' had larger leaves than 'Tendergreen'. Plants grown in Hidalgo soil had larger leaves than those grown in Hebbronville soil.

Leaf pigments and vitamins. The reduced light environment increased leaf total chlorophyll and carotenoid contents by 60 and 46%, respectively, but reduced ascorbate levels 22% (Table 5). The chlorophyll a:b ratio was reduced and the chlorophyll:carotenoid ratio increased when light levels were reduced. There were no light by cultivar interactions but there were light by soil interactions for all responses except folate. Leaves grown in ambient light had the highest pigment levels in Raymondville and Hebbronville soils, but under reduced light, leaves from plants grown in Raymondville and Hidalgo soils had higher pigment levels. Single degree of freedom contrasts between light and heavy soil indicated that leaves from plants grown in the heavy soils had higher leaf pigment levels in reduced light. Leaf ascorbate levels appeared to be higher (P=0.06) in leaves grown in the lighter textured soils in reduced light. Folate levels appeared to be higher in 'Tendergreen' leaves grown under reduced light (P=0.06).

Mineral nutrients. The low light regime increased total leaf cations 41% compared to the ambient light-grown leaves (Table 6). Leaf total-N, K, Ca, P, S, Mg, Na, NO_3, and Mn were all increased (dry wt. basis) by reduced light. There were no cultivar x light level differences. 'Tendergreen' leaves were

Table 4. Agronomic performance of two mustard greens in four soils grown under two light regimes.

	Seed Germination 4-day	Seed Germination 10-day	Plant Top Wt.	Plant Root Wt.	Shoot:Root Ratio	Leaf Area	Leaf No.	Area/Leaf
	—— % ——		—— g FW ——			cm²		cm²
Light Level (LL):								
Ambient	58 a	80	126	30 a	4.2 b	2182 b	12.7	177 b
Reduced	42 b	83	119	21 b	6.2 a	2384 a	12.3	196 a
	**z	NS	NS	**	**	*	NS	*
Ambient								
Cultivar:								
Florida Broadleaf	53	83	118 b	30	4.2	2150	10.2 b	209 a
Tendergreen	62	78	133 a	-	-	2215	15.2 a	146 b
	NS	NS	*	-	-	NS	**	**
Soil Type:								
Bodillo	56 ab	66	117 b	22 b	5.3 a	1994 b	12.8 b	162 b
Hebbronville	78 a	84	110 b	26 b	3.9 b	1833 b	11.9 b	162 b
Hidalgo	59 ab	84	160 a	47 a	3.4 b	2798 a	14.8 a	199 a
Raymondville	38 b	88	116 b	26 b	4.3 a	2104 b	11.5 b	186 ab
	**	NS	**	**	0.09y	**	**	*
Reduced								
Cultivar:								
Florida Broadleaf	26 b	76	119	21	6.2	2443	10.9 b	223 a
Tendergreen	58 a	89	123	-	-	2326	13.7 a	169 b
	**	NS	NS	-	-	NS	**	**
Soil Type:								
Bodillo	50 a	81	123 a	22 b	5.8	2331 a	12.1	198 ab
Hebronville	50 a	81	93 b	18 b	5.3	1790 b	11.5	161 b
Hidalgo	50 a	84	136 a	27 a	5.0	2812 a	12.9	220 a
Raymondville	19 b	84	133 a	16 b	8.5	2605 a	12.7	205 a
	**	NS	**	0.09	NS	**	NS	**
Interaction								
CV x Soil	NS	NS	NS	-	-	NS	NS	NS
LL x Soil	*	NS	NS	-	-	NS	**	NS
LL x CV	NS	NS	*	0.08	**	NS	NS	NS
LL x CV x Soil	NS	NS	NS	-	-	NS	NS	NS

YNS, *, ** = Not significant or significant at P=0.05, P=0.01, respectively.
XProbability of a greater 'F' value.

higher in most mineral nutrients compared to 'Florida Broadleaf' leaves. The light level x soil interactions for N, K, S, Na (P<0.06), NO_3, Al, Fe, Zn, and total cations are shown in Table 6. Within each light level, the heavier soils tended to produce leaves with higher levels of nutrients, with the exception of P, compared to light textured soils. Interactions between cultivar and soil for N, P, Mg, and Mn are shown in Fig. 1.

Neither ascorbate nor folate were correlated with any soil attribute, but leaf nutrients were, with the exception of Fe, B, Na, and Al (ambient light, only), positively correlated with the corresponding soil nutrient. Leaf P was negatively correlated with soil P. Soil total organic carbon (%) and total carbon (%) were generally correlated with all leaf nutrients, except Na and B, and negatively correlated with leaf P (correlation data not shown).

DISCUSSION

The effect of reduced light to increase leaf pigments area, and mineral accumulation, while reducing transpiration and temperature, has been observed in vegetable amaranth (Makus and Hettiarachchy, 2001) and snap bean leaves (Makus, 2001). However, transpiration rates, which were determined transiently by porometry, do not explain the increase in mineral nutrients (on a dry wt. basis) of shaded leaves. Soil texture is known to affect water holding capacity. It may have been possible that critical short-term moisture depletion between re-watering took place more often under ambient light, providing periods of low level intermittent stress or reduced water influx by the root system. However, when total nutrients per plant shoot were determined based on an estimate of shoot dry weight, light environment differences in leaf nutrients, with few exceptions, disappeared (data not shown). Plants grown without shade had higher shoot dry wts. and dry matter (%) than shaded plants (data not shown). Assuming soil nutrients were not limiting in the pot system, the nutrient differences (dry wt. basis) could have been due to a dilution effect of increased dry wt. observed in plants grown in ambient light compared to reduced light. With the exception of Fe and P, the heavier-textured, more mineralized soils tend to support higher nutrient uptake.

The effects of light intensity on ascorbate levels in *Brassica juncea* leaves were consistent with those in other plants. Mozafar (1994), in a review of the literature, concluded that light duration and/or intensity can increase ascorbate and that supplemental or adequate soil levels of K, Mn, Mo, Cu, Zn, and Co tend to improve ascorbate levels, whereas N application tends to improve carotene, niacin, riboflavin, and thiamine levels in vegetables.

CONCLUSIONS

The choice of season, soil, and cultivar can influence mustard greens leaf nutrients. Greens grown under reduced light produce higher levels of plant pigments (dry wt. basis), accumulate more mineral nutrients (dry wt. basis), have larger leaf areas, but are lower in ascorbate concentrations. Greens grown in heavier textured soils tend to have higher transpiration rates, pigment and nutrient concentrations, and leaf areas. 'Tendergreen' leaves were generally higher in mineral nutrients, but were lower in ascorbate than 'Florida Broadleaf' leaves.

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Table 5. Effect of cultivar, soil type, and light environment on leaf chlorophylls, total carotenoids, ascorbate, and folate.[Z]

	Chlorophyll			a:b	Total	Chloro:Carot		
	'a'	'b'	Total	ratio	Carot.	Ratio	Folate	Ascorbate
	mg/g DW				mg/g DW		µg/100g FW	
Light Level (LL):								
Ambient	2.80 b	0.99 b	3.79 b	2.8 a	1.01 b	3.7 b	108	122 a
Reduced	4.24 a	1.83 a	6.08 a	2.4 b	1.47 a	4.1 a	107	95 b
	**[Y]	*	**	*	**	**	NS	*
Ambient								
Cultivar:								
Florida Broadleaf	2.72	0.93	3.65	2.91 a	0.98	3.70	110	135 a
Tendergreen	2.87	1.05	3.92	2.76 b	1.04	3.73	106	110 b
	NS	NS	NS	**	NS	NS	NS	**
Soil Type:								
Bodillo	2.20 c	0.78 b	2.98 c	2.81	0.85 b	3.50 b	108	141 a
Hebbronville	2.88 ab	1.02 ab	3.91 ab	2.82	1.02 ab	3.81 a	102	110 b
Hidalgo	2.76 b	0.96 ab	3.72 bc	2.89	1.01 ab	3.69 a	106	121 b
Raymondville	3.34 a	1.19 a	4.54 a	2.83	1.17 a	3.85 a	116	118 b
	**	**	**	NS	**	**	NS	**
Reduced								
Cultivar:								
Florida Broadleaf	4.14	1.82	5.96	2.43	1.43	4.14	97 b	104 a
Tendergreen	4.34	1.85	6.20	2.42	1.50	4.10	114 a	87 b
	NS	NS	NS	NS	NS	NS	0.06[X]	*
Soil Type:								
Bodillo	3.98 b	1.63 b	5.61 b	2.55 a	1.36 b	4.10	115	101
Hebbronville	3.76 b	1.46 b	5.22 b	2.62 a	1.26 b	4.11	96	104
Hidalgo	4.30 ab	1.84 b	6.15 ab	2.44 a	1.50 ab	4.08	109	96
Raymondville	4.92 a	2.40 a	7.32 a	2.09 b	1.75 a	4.19	107	73
	**	**	**	**	**	NS	NS	NS
Contrast:	*	*	*	*	*	NS	NS	0.06
Interaction:								
LL x Soil	0.06	**	*	*	*	**	NS	*

[Z]There were no significant (P<0.05) Cult x Soil, LL x Cult, or LL x Cult x Soil interactions nor contrasts of light vs heavy soils at ambient light levels.

[Y]NS, *, ** = Not significant or significant at P=0.05, P=0.01, respectively.

[X]Probability of a greater 'F' value.

Table 6. Effect of cultivar, soil type, and light environment on mustard greens leaf N and mineral nutrients.

	N	K	Ca	P	S	Mg	Na	NO3	Al	Mn	Fe	B	Zn	Cu	Total Cations
	%						µg . g^{-1}								%
Light Level (LL):															
Ambient	1.86 b	2.52 b	2.06 b	0.433 b	0.322 b	0.188 b	2554 b	332 b	135 a	89 b	77	52	18 b	9.3	5.81 b
Reduced	2.70 a	4.06 a	2.47 a	0.530 a	0.439 a	0.241 a	4018 a	605 a	117 b	126 a	66	60	23 a	9.5	8.18 a
	**[z]	**	*	**	*	*	*	*	*	*	NS	NS	0.09	NS	**
Ambient															
Cultivar:															
Florida Broadleaf	1.85	2.38 b	1.92 b	0.411 b	0.299 b	0.183	1927 b	229 b	133	71 b	78	44 b	16 b	9.6	5.42 b
Tendergreen	1.87	2.67 a	2.19 a	0.454 a	0.344 a	0.193	3182 a	435 a	137	107 a	76	59 a	19 a	9.0	6.21 a
	NS	*	*	0.10[y]	*	NS	**	**	NS	**	NS	**	*	NS	*
Soil Type:															
Bodillo	1.61 b	2.08 c	1.24 c	0.397 b	0.244 b	0.148 b	3523 a	342	115 b	56 b	71	51	15 b	8.0 b	4.48 c
Hebbronville	1.82 b	2.37 bc	1.94 b	0.583 a	0.240 b	0.200 a	2119 b	308	160 a	65 b	93	48	16 b	8.4 b	5.58 b
Hidalgo	1.79 b	2.76 ab	2.51 a	0.348 b	0.422 a	0.201 a	2212 b	295	125 b	123 a	71	56	17 ab	11.4 a	6.50 a
Raymondville	2.22 a	2.88 a	2.53 a	0.403 b	0.386 a	0.203 a	2364 b	384	138 ab	112 a	72	52	22 a	9.4 ab	6.69 a
	**	**	**	**	**	**	**	NS	0.07	**	NS	NS	**	*	**
Contrast	**	**	**	**	**	**	0.09	NS	NS	**	NS	0.08	**	**	**
Reduced															
Cultivar:															
Florida Broadleaf	2.84	3.80 b	2.38	0.520	0.440	0.237	3164 b	541	113	96 b	71 b	50 b	22	9.3	7.74 b
Tendergreen	2.56	4.31 a	2.55	0.541	0.438	0.246	4872 a	668	120	156 a	61 a	70 a	24	9.6	8.62 a
	NS	0.07	NS	NS	NS	NS	**	NS	NS	**	0.07	**	NS	NS	*
Soil Type:															
Bodillo	2.32 b	3.18 c	1.80 b	0.547 b	0.325 b	0.209 b	4756 a	487 b	99 b	85 b	66	62 ab	20 b	7.2 c	6.57 c
Hebbronville	2.14 b	2.75 c	2.21 b	0.654 a	0.250 b	0.230 b	2553 b	467 b	102 b	72 b	62	52 b	17 b	7.4 c	6.38 c
Hidalgo	2.52 b	4.36 b	2.89 a	0.456 b	0.601 a	0.253 ab	4446 a	432 b	129 a	192 a	59	66 a	21 b	9.1 b	9.06 b
Raymondville	3.82 a	5.95 a	2.97 a	0.465 b	0.880 a	0.273 a	4315 a	1034 a	137 a	156 a	77	59 ab	33 a	14.1 a	10.72 a
	**	**	**	**	**	**	**	**	**	**	NS	0.07	**	**	**
Contrast	**	**	**	**	**	**	0.07	NS	**	**	NS	NS	**	**	**
Interaction															
CV x Soil	**	NS	NS	**	NS	**	NS	NS	NS	**	NS	0.08	NS	0.08	0.07
LL x Soil	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LL x CV	**	**	NS	NS	*	NS	0.06	*	**	0.10	*	NS	**	NS	**
LL x CV x Soil	**	0.10	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

[Z]NS, *, ** = Not significant or significant at *P*=0.05, *P*=0.05, respectively.

[Y]Probability of a greater 'F' value.

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