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Using different nitrogen and compost levels on lettuce grown in coconut fiber

A. A. A. Farag[1], M. A. A. Abdrabbo[1]* and E. M. Abd-Elmoniem[2]

[1]The Central Laboratory for Agricultural Climate, 6 Michail Bakhoum St., Dokki, Giza, Egypt.
[2]Soils Department, Faculty of Agriculture, Ain Shams University, Shoubra El-khema, Cairo, Egypt.

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The present investigation was conducted for two seasons (2006 and 2007) into white polyethylene container filled with coconut fiber, to study the effect of three nitrogen levels (50, 100 and 150 ppm) applied by fertigation system and three compost levels (0, 2 and 4% by volume). Lettuce plant (*Lactuca sativa L.*) with two types' iceberg and romaine lettuce were transplanted in October to study the effect of treatments on vegetative growth, nutrients content (nitrogen, phosphors, potassium, calcium, magnesium and nitrate) as well as total yield. The experimental design was a split- plot with three replications. The obtained results indicated that the increasing nitrogen level up to 150 ppm significantly increased plant height, number of leaves per plant, dry weight and yield. Compost at 4% gave the highest vegetative growth and yield comparing with the other treatments. The highest nitrogen level (150 ppm) combined with compost 4% increased significantly vegetative growth and total yield of lettuce. On the other hand, 50 ppm nitrogen gave the highest nitrogen use efficiency (NUE) and the least value of nitrate content in leaves followed by 100 ppm.

Key words: Lettuce, polyethylene container, nitrogen use efficiency, coconut fiber, nitrate.

INTRODUCTION

Vegetables are the group of foods which makes the greatest contribution to nitrate consumption and leafy crops such as lettuce and spinach are particularly likely to contain high levels of nitrates. An EU regulation has set limits of 4,500 mg·kg^{-1} of nitrate in the fresh product for lettuce harvested from November 1 to March 31 and 3,500 mg·kg^{-1} from April 1 to October 31(Byrne et al., 2001).

Lettuce (*Lactuca sativa* L.) is a plant of considerable agricultural and economic interest but as a leafy vegetable it accumulates large quantities of nitrate especially when grown in high NO_3-N availability and low radiation. The accumulation of nitrate in plants depends on their genetic characteristics as well as on many environmental factors such as nitrogen supply for example replacement a part of NO_3-N concentration by urea or methods of application, light intensity, photoperiod, temperature o Large inputs of mineral fertilizer nitrogen (N) are routinely used to maintain the yield and quality of crops. Nitrogen not recovered by crops can pollute adjacent r water supply (Maynard andBarker, 1972; Zhu et al., 2000). terrestrial and aquatic habitats. This can cause a reduction in biodiversity since species that are characteristic of infertile habitats do not tend to thrive following nutrient-enrichment (Grime, 2001).

Nitrogen is one of the most important mineral nutrients determining plant growth and crop yield. Its effects are

*Corresponding author. E-mail: abdrabbo@yahoo.com.

Table 1. Chemical and physical properties of the coconut fiber of the experiment analyzed before cultivation.

Salinity (dS m^{-1})	pH	Moisture content, *W*m (% m/m)	Dry Matter, *DM* (%nm/m)	Organic matter, *W*om (% m/m)	Bulk density, *DB* (g L^{-1})	Water capacity (g/100 g DM)	Total pore space, *PS* (% v/v)	Water capacity, *WV*(% v/v)	Air capacity, *AV* (% v/v)
1.2	6.5	17	83	95	40	230	96	10	88

associated with leaf area growth and photosynthetic rate (Pinheiro Henriques and Marcellis, 2000; Pons and Westbeek, 2004).

The particular structure of coconut fibers and their physical and chemical properties, make them suitable for container media purposes (Batra, 1985). In fact the use of coconut fiber in European greenhouse production is well accepted as new technology. Coir contains equal portions of lignin and cellulose and is rich in potassium and the micronutrients Fe, Mn, Zn and Cu. Due to the high potassium content of the media a reduction in potassium fertilization has been shown to produce beneficial results (Savithri et al., 1993).

Compost contains many essential nutrients andimproves soil physical and chemical properties. It without a doubt is a valuable product as compost improves soil organic matter content, nutrient availability, soil aeration, and water holding capacity, and reduces soil bulk density. Compost, if properly prepared, is beneficial to the productivity of field and container crops (Brinton, 1997).

MATERIALS AND METHODS

The two experiments were carried out in the two successive seasons in 2006 and 2007 at Dokki location, Agricultural Research Center, Giza governorate Egypt. Each experiment included three nitrogen levels 50,100 and 150 ppm applied by fertigation, which were the combination with three compost levels 0, 2 and 4% volume of medium. Seeds of iceberg lettuce (" *Lactuca sativa*" var. capitata L.) cv. 'Vanity' and romaine lettuce (" *Lactuca sativa*" var. longifolia L.) cv. 'Balady' sown were at 22 and 26 August. Dates of transplanting were October 5 and 9 of 2006 and 2007, for the first and the second seasons, respectively. Lettuce grown in white polyethylene container of 0.60 m Length × 0.25 m Width × 0.25 m height, filled with 30 L coconut fiber. Each container contained three plants. Experiment design was a split plot with three replications where nitrogen fertilizer levels were distributed in the main plot and compost levels allocated in sub plots. Analysis of data was done by computer, using ANOVA program for statistical analysis. The differences among means for all traits were tested for significance at 5% level according to Waller and Duncan (1969). All other agriculture practices of cultivation were performed as recommended by the Ministry of Agriculture. Fresh and dry weights of individual heads were taken at 55- day interval on samples of three plants randomly harvested. Total dry weight was determined after oven-drying the samples at 75℃ for 48 h. N, P and K were determined in leaf. Samples which were dried at 70℃ in an air forced oven for 48 h. Dried leaves were digested in H_2SO_4 and the fallowing mineral contents were estimated (phosphorous "and" potassium) in the acid digested solution by colorimetric method (ammonium molybdate) using spectrophotometer and flame photometer (Chapman and Pratt, 1961). Nitrogen uptake was derived from dry weight in which total nitrogen concentration was determined by a micro-Kjeldahl method (Bremner and Mulvaney, 1982). Nitrogen use efficiency (NUE) was calculated as the yield obtained from the N(Yn) fertilized plot minus control (Yc), divided by a unit weight of the applied fertilizer (Nw for nitrogen):

NUE = (Yn-Yc)/Nw

RESULTS AND DISCUSSION

Vegetative growth

The effect of different nitrogen levels on vegetative growth characters of different compost levels in Tables 1 and 2. Regarding the effect of different nitrogen treatments, data showed that using 150 ppm nitrogen level increased lettuce plant height, number of leaves and dry weight significantly followed by 100 ppm treatment. The lowest vegetative growth was obtained by 50 ppm treatment during the two studied seasons.

The compost levels had same response on vegetative growth indicated that 4% compost had the highest vegetative growth followed by 2% compost with significant difference between them with the two lettuce types. Regarding the interaction effect between different nitrogen levels and compost levels, data illustrated that the highest vegetative growth characters obtained by using 150 ppm nitrogen level combined with 4% compost followed by 100 ppm nitrogen level with 4% compost. On the other hand, the lowest vegetative growth characters were obtained by using 50 ppm nitrogen level treatment with 0% compost with the two lettuce types.

Compost improves coconut fiber properties water holding capacity and CEC and that reflect to improve plant mineral uptake that led to improve plant growth. Nitrogen is one of the most important mineral nutrients determining plant growth; this result agree with Broadley et al. (2000) and Pons and Westbeek (2004) which found that removing N supply to lettuce considerably reduced plant growth. Reductions in the plant growth of N-limited plants correlate with decreases in leaf area, fresh and dry weight a reallocation of C from shoots to roots and a reduction in net C assimilation.

Yield

The effect of different treatments on lettuce yield is

Table 2. Chemical properties of the compost used in the experiment analyzed before cultivation.

EC	pH	Cations (Meg/L)				Anions (Meg/L)				N	C	C/N	O.M.
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO^{3-}	HCO_3^{-}	Cl^{-}	$SO4^{2-}$	(%)	(%)	(%)	(%)
7.95	5.39	19.0	51	48	1.05	0.0	3.1	34	38.15	0.32	4.94	15.41	9.88

Table 3. Effect of different applied nitrogen and compost levels on plant height, and number of leaves for iceberg lettuce plants during the 2006 and 2007seasons.

Nitrogen levels (%)	2006 season				2007 season			
	50	100	150	Mean A	50	100	150	Mean A
	ppm				ppm			
Hybrids	**Plant height**				**Plant height**			
0	12.6^{g}	13.7^{f}	15.4^{d}	13.9^{c}	13.1^{e}	14.3^{d}	16.1^{c}	14.5^{c}
2	13.8^{f}	17.6^{c}	18.8^{b}	16.7^{b}	14.4^{d}	18.3^{b}	18.1^{b}	16.9^{b}
4	15.1^{d}	18.9^{b}	20.1^{a}	18.0^{a}	14.5^{d}	18.2^{b}	19.3^{a}	17.3^{a}
Mean B	13.8^{c}	16.7^{b}	18.1^{a}		14.0^{b}	16.9^{aB}	17.8^{a}	
	Number of leaf				**Number of leaf**			
0	29.2^{f}	32.5^{e}	35.7^{d}	32.4^{c}	30.4^{g}	33.9^{e}	37.2^{d}	33.8^{c}
2	31.2^{eF}	40.6^{c}	44.2^{bC}	38.6^{b}	32.5^{f}	42.3^{c}	42.8^{bC}	39.2^{b}
4	34.4^{dE}	45.5^{b}	48.7^{a}	42.8^{a}	33.1^{eF}	43.9^{b}	46.9^{a}	41.3^{a}
Mean B	31.6^{c}	39.5^{b}	42.8^{a}		32.0^{c}	40.0^{b}	42.3^{a}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level. Means followed by the same letter within column are not significantly different (P<0.05).

Table 4. Effect of different applied nitrogen and compost levels on plant height, and number of leaves for romaine lettuce plants during the 2006 and 2007 seasons.

Nitrogen levels (%)	2006 season				2007 season			
	50	100	150	Mean A	50	100	150	Mean A
	ppm				ppm			
Hybrids	**Plant height**				**Plant height**			
0	22.4^{h}	28.3^{f}	33.8^{d}	28.2^{c}	21.6^{h}	27.3^{f}	32.6^{e}	27.2^{c}
2	26.4^{g}	33.6^{d}	38.4^{c}	32.8^{b}	25.4^{g}	35.8^{d}	40.9^{c}	34.0^{b}
4	31.68^{e}	40.3^{b}	46.0^{a}	39.3^{a}	33.7^{de}	43.9^{b}	49.6^{a}	42.4^{a}
Mean B	26.8^{c}	34.1^{b}	39.4^{a}		26.9^{c}	35.7^{b}	41.0^{a}	
	Number of leaf				**Number of leaf**			
0	11.9^{g}	18.2^{e}	23.1^{d}	17.7^{c}	11.4^{h}	17.5^{f}	22.3^{de}	17.1^{c}
2	15.3^{f}	22.1^{de}	27.2^{b}	21.5^{b}	14.7^{g}	23.5^{d}	29.6^{b}	22.6^{b}
4	18.7^{e}	25.5^{c}	35.7^{a}	26.6^{a}	19.9^{e}	27.2^{c}	38.1^{a}	28.4^{a}
Mean B	15.3^{c}	21.9^{b}	28.7^{a}		15.3^{c}	22.7^{b}	30.0^{a}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level.Means followed by the same letter within column are not significantly different (P<0.05).

presented in Tables 3 and 4. Referring the effect of different nitrogen levels, data showed that using 150 ppm nitrogen level increased had weight significantly followed by 100 ppm nitrogen level comparing with 50 ppm nitrogen level. Regarding the effect of different compost levels on yield, data showed that the highest yield weight obtained by 4% compost followed by 2% compost with significant difference between them. The lowest yield weight was obtained by 0% compost with the two lettuce types. Regarding the interaction effect between different

Table 5. Effect of different applied nitrogen and compost levels on head fresh and dry weight of leaves for iceberg lettuce plants during the 2006 and 2007 seasons.

Head	2006 season				2007 season			
Nitrogen levels	50	100	150	Mean A	50	100	150	Mean A
(%)	ppm				ppm			
Hybrids	Head fresh weight (g)				Head fresh weight (g)			
0	230^{h}	275^{f}	344^{d}	283^{c}	240^{d}	287^{c}	359^{bc}	295^{c}
2	261^{g}	351^{d}	382^{c}	331^{b}	272^{c}	366^{b}	368^{b}	335^{b}
4	291^{e}	422^{b}	442^{a}	385^{a}	280^{c}	407^{ab}	426^{a}	371^{a}
Mean B	260^{c}	349^{b}	389^{a}		264^{c}	353^{b}	384^{a}	
	Head dry weight (g)				Head dry weight (g)			
0	15.0^{i}	23.9^{h}	26.8^{f}	21.9^{c}	15.6^{g}	24.9^{f}	27.9^{d}	22.8^{c}
2	24.5^{g}	32.9^{d}	35.9^{c}	31.1^{b}	25.5^{ef}	34.3^{c}	34.6^{c}	31.4^{b}
4	27.3^{f}	39.6^{b}	41.5^{a}	36.1^{a}	26.3^{e}	38.2^{b}	40.1^{a}	34.8^{a}
Mean B	22.2^{c}	32.1^{b}	34.7^{a}		22.4^{c}	32.46^{b}	34.2^{a}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level.Means followed by the same letter within column are not significantly different (P<0.05).

Table 6. Effect of different applied nitrogen and compost levels on head fresh and dry weight of leaves for romaine lettuce plants during the 2006 and 2007 seasons.

Romaine	2006 season				2007 season			
Nitrogen levels	50	100	150	Meana	50	100	150	Mean A
(%)	ppm				ppm			
Hybrids	Plant fresh weight (g)				Plant fresh weight (g)			
0	234^{g}	365^{d}	497^{c}	365.3333	225^{f}	352^{de}	479^{c}	352
2	295^{f}	505^{c}	616^{b}	472	284^{e}	538^{b}	657^{ab}	493
4	347^{e}	623.9^{ab}	636.2^{a}	535.7	370^{d}	665^{ab}	678^{a}	571
Mean B	292	497.9667	583.0667		293	518.3333	604.6667	
	Plant dry weight (G)				Plant dry weight (G)			
0	21.1^{f}	32.8^{d}	44.7^{bc}	32.9^{c}	20.3^{g}	31.6^{ef}	43.1^{d}	31.7^{c}
2	26.5^{e}	45.4^{b}	55.4^{ab}	42.4^{b}	25.5^{f}	48.4^{c}	59.6^{b}	44.5^{b}
4	31.3^{de}	56.1^{a}	57.2^{a}	48.2^{a}	33.3^{e}	59.8^{b}	61.5^{a}	51.5^{a}
Mean B	26.3^{c}	44.8^{b}	52.4^{a}		26.4^{c}	46.6^{b}	54.7^{a}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level. Means followed by the same letter within column are not significantly different (P<0.05).

nitrogen levels and compost, data showed that using 150 ppm nitrogen level combined with 4% compost increased yield weight significantly followed by 100 ppm nitrogen level combined with 4% compost with iceberg lettuce, but there were no significantly differences between them with romaine lettuce. The lowest yield was obtained by 50 ppm nitrogen level with 0% compost with the two lettuce types. The increases in yield might be due to the increased utilization of N fertilizer in stimulating meristimatic activities. The accumulation of synthesized metabolites resulted in high dry matter accumulation and finally high yield. The obtained results are a good line with those reported by Pinheiro and Marcellis (2000). Yuri et al. (2004) conclude that the use of 56.0 t ha^{-1} of organic compost applied in pre plant provides an increase in yield and commercial quality of crisp head lettuce.

Nitrogen use efficiency (NUE)

Data in nitrogen use efficiency which is defined as the economic production obtained per unit of nitrogen applied is presented in Tables 5 and 6. It is evident from the data obtained that the highest NUE was obtained by 50 ppm nitrogen level followed by 100 ppm nitrogen level with

Table 7. Effect of different applied nitrogen and compost levels on nitrogen use efficiency of leaves for iceberg lettuce plants during the 2006 and 2007 seasons.

Head	2006 season				2007 season			
Nitrogen levels	50	100	150	Mean A	50	100	150	Mean A
(%)	ppm				ppm			
Hybrids	NUE				NUE			
0	38.1^{c}	22.7^{fg}	18.9^{h}	26.6^{c}	39.7^{b}	23.6^{e}	19.7^{f}	27.7^{c}
2	43.5^{b}	29.1^{e}	21.0^{g}	31.2^{b}	45.2^{ab}	30.3^{d}	20.3^{f}	31.9^{b}
4	48.2^{a}	34.9^{d}	24.3^{f}	35.9^{a}	46.4^{a}	33.6^{c}	23.4^{e}	34.5^{a}
Mean B	43.3^{a}	29.0^{b}	21.5^{c}		43.9^{a}	29.2^{b}	21.2^{c}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level.Means followed by the same letter within column are not significantly different (P<0.05).

Table 8. Effect of different applied nitrogen and compost levels on nitrogen use efficiency of leaves for romaine lettuce plants during the 2006 and 2007seasons.

Romaine	2006 season				2007 season			
Nitrogen levels	50	100	150	Mean A	50	100	150	Mean A
(%)	ppm				ppm			
Hybrids	NUE				NUE			
0	39.0^{e}	30.2^{g}	27.5h	32.2^{c}	37.5^{d}	29.0^{e}	26.5^{f}	31.0^{c}
2	48.9^{c}	41.9^{d}	34.1^{f}	41.6^{b}	47.1^{c}	44.6^{cd}	36.3^{de}	42.7^{b}
4	57.7^{a}	51.7^{b}	35.1^{f}	48.2^{a}	54.9^{a}	50.6^{b}	37.4^{d}	47.6^{a}
Mean B	48.5^{a}	41.2^{b}	32.2^{c}		46.5^{a}	41.4^{b}	33.4^{c}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level.Means followed by the same letter within column are not significantly different (P<0.05).

significant difference between them. The lowest NUE was obtained by 150 ppm nitrogen level. On the other hand, 50 ppm nitrogen level combined with4% compost gave the highest NUE followed by 50 ppm nitrogen level combined with 2% compost with iceberg lettuce, but with romaine lettuce 50 ppm nitrogen level combined with 4% compost gave the highest NUE followed by 100 ppm nitrogen level combined with 2% compost with significant difference between them.

This result agree with (Abu- Rayyan et al. 2004) who found that maximizing the nitrogen-use efficiency of crop production can be achieved (i) by optimizing the supply of N to meet the requirements of a crop during growth and development or (ii) by growing N-efficient crop genotypes. There is therefore much advantage to be derived from using economic rate that will enhance higher nitrogen use efficiency and maximize production, based on the value of increased nitrogen input resulted in a decline observed in NUE (Kogbe and Adediran, 2003).

Mineral contents

According to the effect of nitrogen levels (Tables 7 and 8), it was shown that using 150 ppm nitrogen led to increase N, P, K, Ca and Mg% significantly in dry weight followed by 100 ppm nitrogen with significant difference between them. The lowest N, P and K% was obtained by 50 ppm nitrogen. Data showed the effect of different compost levels on N, P, K, Ca and Mg% in dry weight. The highest N, P, K, Ca and Mg% was observed by 4% compost followed by 2% compost with significant difference between them. The lowest N, P, K, Ca and Mg% was obtained by 0% compost. The interaction effect between nitrogen levels and compost showed that using 150 ppm nitrogen combined with 4% compost increased N, P, K, Ca and Mg%. The lowest N, P, K, Ca and Mg% proceeded by 50 ppm nitrogen with 0% compost with the two lettuce types.

These results are in agreement with that of Economakis and Koleilat (1997) they reported that the uptake of N, P and K increased with increasing N concentration in the nutrient solution. Souza et al. (2005) reported that the protein, phosphorus, potassium, calcium and magnesium contents in lettuce leaves increased with the doses of organic compost.

Nitrate contents

Data in Tables 9 and 10 indicate NO_3-N in dry weight and

Table 9. Effect of different applied nitrogen and compost levels on N, P, K, and Ca, Mg and NO_3 of leaves for iceberg lettuce plants during the 2006 and 2007seasons.

Head	2006 season				2007 season			
Nitrogen levels	50	100	150	Mean A	50	100	150	Mean A
(%)	ppm				ppm			
Hybrids	N (%)				N (%)			
0	1.91^{f}	2.44^{d}	2.83^{bc}	2.36^{c}	1.96^{h}	2.53^{e}	2.94^{c}	2.47^{c}
2	2.14^{e}	2.63^{c}	2.90^{b}	2.55^{b}	2.17^{g}	2.75d	3.13^{b}	2.68^{b}
4	2.32^{d}	2.81^{bc}	3.15^{a}	2.73^{a}	2.34f	2.92^{c}	3.36^{a}	2.87^{a}
Mean B	2.12^{c}	2.62^{b}	2.93^{a}		2.16^{c}	2.73^{b}	3.14^{a}	
	P (%)				P (%)			
0	0.33^{h}	0.36^{g}	0.38f	0.35^{c}	0.34^{g}	0.37f	0.39^{e}	0.36^{c}
2	0.35^{gh}	0.41^{e}	0.46^{c}	0.41^{b}	$0.36f^{g}$	0.42d	0.44^{c}	0.41^{b}
4	0.44^{d}	0.48^{b}	0.55^{a}	0.49^{a}	0.38^{g}	0.46^{b}	0.53^{a}	0.45^{a}
Mean B	0.37^{c}	0.41^{b}	0.46^{a}		0.36^{c}	0.41^{b}	0.45^{a}	
	K (%)				K (%)			
0	1.77^{h}	1.89^{g}	2.05f	1.90^{c}	1.84i	1.97^{h}	2.14^{g}	1.98^{c}
2	2.15^{e}	2.27^{d}	2.40^{c}	2.27^{b}	2.24f	2.36^{c}	2.31d	2.30^{b}
4	2.35^{cd}	2.61^{b}	2.73^{a}	2.56^{a}	2.26^{e}	2.51^{b}	2.63^{a}	2.46^{a}
Mean B	2.09^{c}	2.25^{b}	2.39^{a}		2.11^{c}	2.28^{b}	2.36^{a}	
	Ca (%)				Ca (%)			
0	0.51^{f}	0.59^{e}	0.66d	0.59^{c}	0.53^{g}	0.61f	0.68^{e}	0.61^{c}
2	0.72^{cd}	0.74^{c}	0.79^{bc}	0.75^{b}	0.75d	0.77^{c}	0.76^{c}d	0.76^{b}
4	0.81^{b}	0.85^{ab}	0.89^{a}	0.85^{a}	0.78^{bc}	0.80^{b}	0.85^{a}	0.81^{a}
Mean B	0.68^{a}	0.72^{b}	0.78^{c}		0.68^{c}	0.72^{b}	0.76^{a}	
	Mg (%)				Mg (%)			
0	0.18^{f}	0.21^{e}	0.24d	0.21	0.18^{e}	0.21^{d}	0.25^{c}	0.21^{c}
2	0.26^{cd}	0.27^{c}	0.28^{b}	0.27	0.27^{bc}	0.28^{b}	0.27^{bc}	0.27^{b}
4	0.29b	0.31^{a}	0.32^{a}	0.306667	0.27^{bc}	0.29^{ab}	0.30^{a}	0.29^{a}
Mean B	0.24^{c}	0.26^{b}	0.28^{a}		0.24^{b}	0.26^{ab}	0.27^{a}	
	NO_3 (ppm)				NO_3 (ppm)			
0	527f	723^{d}	1055^{b}	768^{b}	495^{h}	712^{e}	1060^{c}	764^{b}
2	544^{e}f	738^{cd}	1120^{ab}	800^{ab}	549g	731^{de}	1105^{b}	791^{ab}
4	581^{e}	774^{c}	1155^{a}	828.0^{a}	589f	767^{d}	1148^{a}	821^{a}
Mean B	541^{c}	745^{b}	1110^{a}		536^{c}	736^{b}	1104^{a}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level.Means followed by the same letter within column are not significantly different ($P<0.05$).

NO_3-N as a percentage from total nitrogen, as affected by nitrogen levels and compost levels in lettuce plants. Nitrate contents in dry weight recorded the least values with 50 ppm nitrogen (366 to 540 D.W) ppm and 0% compost level (586 to 825 D.W) ppm in both type's iceberg and romaine of lettuce plant. The interaction between nitrogen and compost recorded the last value in 0% compost with 50 ppm nitrogen in both types of lettuce plant.

Accumulation of nitrates in lettuce has been shown to be affected by the soil texture, amount of fertilizer-N, the timing of fertilizer-N release, the light intensity and duration. In most types of lettuce, including the romaine type had the highest concentration of nitrates and is normally observed in the external leaves (Santamaria et al., 1999; Abu-Rayyan et al., 2004).

Table 10. Effect of different applied nitrogen and compost levels on N, P, K, and Ca, Mg and NO_3 of leaves for romaine lettuce plants during the 2006 and 2007seasons.

Romaine	2006 season				2007 season			
Nitrogen levels	50	100	150	Mean A	50	100	150	Mean A
(%)	ppm				ppm			
Hybrids	N (%)				N (%)			
0	2.12^{f}	2.68^{d}	3.13^{bc}	2.64^{c}	2.06h	2.66^{e}	3.09^{c}	2.60c
2	2.35^{e}	2.91^{c}	3.24^{b}	2.83^{b}	2.28^{g}	2.89^{d}	3.29^{b}	2.81^{b}
4	2.57^{de}	3.14^{bc}	3.47^{a}	3.06^{a}	2.46f	3.06^{c}	3.52^{a}	3.01^{a}
Mean B	2.35^{c}	2.91^{b}	3.28^{a}		2.26^{c}	2.87^{b}	3.30^{a}	
	P (%)				P (%)			
0	0.36^{f}	0.40^{de}	0.42^{d}	0.39^{c}	0.35^{g}	0.38f	0.41^{e}	0.38c
2	0.39^{e}	0.45^{cd}	0.51^{bc}	0.45^{b}	0.37f^{g}	0.48^{d}	0.54^{c}	0.46^{b}
4	0.49^{c}	0.53^{b}	0.61^{a}	0.54^{a}	0.52^{cd}	0.57^{b}	0.65^{a}	0.58^{a}
Mean B	0.41^{c}	0.46^{b}	0.51^{a}		0.41^{c}	0.48^{b}	0.53^{a}	
	K (%)				K (%)			
0	0.26^{h}	0.31^{g}	0.34^{f}	0.303333	0.25^{h}	0.30^{g}	0.33^{f}	0.29^{c}
2	0.38^{de}	0.39^{d}	0.42^{c}	0.396667	0.36^{e}	0.41^{d}	0.44^{cd}	0.40^{b}
4	0.37^{e}	0.44^{b}	0.47^{a}	0.426667	0.45^{c}	0.47^{b}	0.52^{a}	0.48^{a}
Mean B	0.34^{c}	0.38^{b}	0.41^{a}		0.35^{c}	0.39^{b}	0.43^{a}	
	Ca (%)				Ca (%)			
0%	0.57^{h}	0.67^{g}	0.74^{f}	0.66	0.55^{h}	0.64^{g}	0.71^{f}	0.63^{c}
2%	0.81^{e}	0.83^{de}	0.88^{c}	0.84	0.78^{e}	0.89^{d}	0.94^{cd}	0.87^{b}
4%	0.85^{d}	0.95^{b}	1.06^{a}	0.953333	0.97^{c}	1.02^{b}	1.07^{a}	1.02^{a}
Mean B	0.74^{c}	0.87^{b}	0.89^{a}		0.77^{c}	0.85^{b}	0.91^{a}	
	Mg (%)				Mg (%)			
0	0.20^{g}	0.24^{f}	0.27^{e}	0.24^{c}	0.20^{h}	0.23^{g}	0.26f	0.23^{c}
2	0.29^{de}	0.30^{d}	0.32^{c}	0.30^{b}	0.28^{e}	0.32^{d}	0.34^{cd}	0.31^{b}
4	0.33^{bc}	0.34^{b}	0.36^{a}	0.34^{a}	0.35^{c}	0.37^{b}	0.39^{a}	0.37^{a}
Mean B	0.27^{c}	0.29^{b}	0.32^{a}		0.28^{c}	0.31^{b}	0.33^{a}	
	NO_3 (ppm)				NO_3 (ppm)			
0	549i	772^{f}	1160^{c}	845^{b}	560^{h}	799^{f}	1122^{c}	817^{b}
2	588^{h}	812^{e}	1232^{b}	880^{ab}	586^{h}	785^{e}	1191^{b}	851^{ab}
4	639^{g}	852^{d}	1270^{a}	910^{a}	654^{g}	864^{d}	1242^{a}	880^{a}
Mean B	596^{c}	819^{b}	1221^{a}		576^{c}	792^{b}	1180^{a}	

Mean A: The mean value of the compost level. Mean B: The mean value of the nitrogen level.Means followed by the same letter within column are not significantly different ($P<0.05$).

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