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COMBINED EFFECT OF N-FERTILIZATION LEVELS AND FOLIAR APPLICATION WITH Ca Cl_2 AND CITRIC ACID ON YIELD AND NITRATE CONTENT OF LETTUCE PLANTS

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ABSTRACT

To study the combined effect of nitrogen levels and foliar spray with $CaCl_2$ and citric acid on growth, yield and chemical constituents of lettuce cultivar Balady (Romine), two field experiments were conducted at experimental farm of Barramoon, Dakahlia governorate during the winter seasons of 2005/2006 and 2006/2007.Twelve treatments representing all possible combinations of four N levels (0, 40, 60 and 80 kg N fed^{-1}) and three foliar sprays; control (water), $CaCl_2$ (2000ppm) and citric acid (100ppm) were used in split plot design with three replicates. The obtained results can be summarized as follows;

1. Increasing N-levels from 0 up to 80 kg N fed^{-1} considerably increased all the studied vegetative growth and yield parameters and 80 kg N fed^{-1} level was the most superior one.
2. Foliar application of $CaCl_2$ (2000 ppm) and citric acid (100 ppm) significantly increased all studied vegetative growth and yield parameters of lettuce plants compared with the control (water).
3. Vegetative growth and yield of lettuce plants were affected significantly by applying the rate of 80 kg N fed^{-1} and foliar spray with $CaCl_2$ (2000pm) followed by 80 kg N fed^{-1} and foliar spray with citric acid (100ppm) as compared to the control treatment.
4. Increasing N levels from 0 up to 80 kg N fed^{-1} significantly increased N, P, K, Mg% and NO^{-}_{3} (mg kg DW^{-1}) except for Ca% compared with the control.
5. Sprayed lettuce plants with citric acid (100ppm) significantly increased N and K % and foliar application with $CaCl_2$ (2000ppm) increased P, Ca and Mg % and decreased NO^{-}_{3} and NO_2 accumulation.
6. Applying of 80 kg N fed^{-1} and foliar spray with $CaCl_2$ (2000ppm) and citric acid (100ppm) gave the highest values of N, P and K % and its uptake (kg fed^{-1}) as compared to the other treatments.
7. The highest values of Ca % were obtained from plants fertilized with 40 kg N fed^{-1} and foliar spray with $CaCl_2$ (2000ppm). Plants fertilized with 80 kg N fed^{-1} and without foliar application with $CaCl_2$ or citric acid gave the highest values of NO^{-}_{3} or NO^{-}_{2} (mg kg DW^{-1}).

Finally, it could be concluded that 80 kg N fed^{-1} and foliar spray with $CaCl_2$ (2000ppm) was the best treatment for maximizing the growth and yield of lettuce plants and minimizing NO^{-}_{3} content of leaves. So, it could be regarded as the best treatment on basis of yield and NO^{-}_{3} safety for human nutrition.

Keywords: Nitrogen levels, $CaCl_2$, citric acid, NO^{-}_{3} Content, lettuce Plants,

INTRODUCTION

Lettuce (Lactuca sativa L.) is one of the most important leafy vegetables of high nutritional value (vitamin A, B1, B2 and C), as well as calcium and iron. Nitrogen is an important element in leafy plants fertilization.

Excessive application of nitrogen fertilizers, to enhance growth rates and maximum yield of crops, is a common agricultural practice. Many investigators studied the effect of nitrogen levels on plant growth and yield of lettuce, Mohamoud and Agwah (1993) used four nitrogen rates (0, 40, 70 and 100 kg N fed^{-1} on lettuce plants, they found that the application of 100kg N fed^{-1} produced the highest values of leaves/plant, plant fresh weight and dry matter (%). Moussa *et al.,* (1993) and Ramadan (2000) found that application of N rate between 80 and 120 kg fed^{-1} is adequate to keep N requirement for best growth. Also, several investigators reported that nitrate content of plants rose with increasing the dose of nitrogen application (Bardisi and Abdel-Bary, 2000; El-Sissy 2000; Ramadan, 2000; El-Zalaki, 2002; Ahmed *et al.,* 2004 and El-Mancy and Badran, 2007).This extreme fertilizer application often leads to the accumulation of nitrate in plant tissues (Maynard *et al.,* 1976 and Greenwood and Hunt, 1986) and ground water (Viets and Haeman, 1971).

Nitrate accumulation in plant organs is a natural process occurring when the rate of NO^{-}_{3} uptake by roots exceeds its rate of reduction and subsequent assimilation within the plant. Thus, nitrogen supply is one of the most important factors affecting nitrate accumulation in growing plant.

The world health organization has tentatively fixed the acceptable daily intake of nitrate at 3.65 mg kg^{-1} body weight and for nitrite at 0.13 mg kg^{-1} (Reinink, 1988). From the stand point of human health, high nitrate levels in vegetables are considered undesirable (Hill, 1990). High levels of nitrate in the diet can indirectly inhibit oxygen transport by blood, leading to methemoglobin formation and producing a medical condition known as haemoglobinemia in infants because of the reduction of nitrate to nitrite (Lyons *et al.,* 1994). Nitrites can react with amines and may be converted to nitrosamines, which usually cause cancer (Whitney *et al.,* 1990 and Gunes *et al.,* 1995).

Abdel-Fattah and Agwah, 1987 and Hanafy Ahmed (1996) reported that foliar spray with $CaCl_2$ significantly increased yield of lettuce and reduced nitrate content. Moreover, Hanafy Ahmed *et al.,* (1997) mentioned that the highest value of yield ton fed^{-1} was recorded by plants sprayed with citric acid.

The present study was undertaken to evaluate the interactive effects of nitrogen levels (0, 40, 60 and 80 kg N fed^{-1}) and foliar application with $CaCl_2$ (2000 ppm) and citric acid (100ppm) on lettuce for maximum yield and minimum accumulation of hazardous nitrates and nitrite in leaves.

MATERIALS AND METHODS

This study was carried out at the Barramoon experimental farm, Hort. Res., Institute, Dakahlia Governorate, Egypt during the two winter seasons of 2005/2006 and 2006/2007. Two field experiments were conducted to investigate the performance of lettuce cultivar Balady (Romine) in relation to different nitrogen levels and foliar application of $CaCl_2$ and citric acid on production and quality of lettuce heads. The soil is clayey loam in texture. Some physical and chemical properties of the studied soil are shown in Table 1 (Page,1982).

Table 1: Some physical and chemical properties of the experimental soil.

Seasons	Sand %	Clay %	Silt %	Texture	PH 1:5 Ext.	EC dSm^{-1} (1:2.5)	Soluble cations (mg kg $soil^{-1}$)				Soluble anions (mg kg $soil^{-1}$)			
							Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	SO^{--}_4
2005/06	**27.8**	**40.6**	**31.5**	**C. Loam**	7.8	0.52	5.0	4.0	0.55	12.6	--	9.2	10.5	2.5
2006/07	**27.0**	**41.0**	**32.0**		8.1	1.29	5.3	4.4	0.60	12.8	--	9.8	10.9	2.4

Available Nutrients (mg kg $soil^{-1}$)			
	N	**P**	**K**
2005/06	25	9.5	350
2006/07	30	11	400

The experiment included 12 treatments representing the combination of four nitrogen levels and three foliar application of $CaCl_2$, citric acid and control (water) treatments. A split plot design in a randomized complete block with three replicates was used. Nitrogen levels treatments (0, 40, 60 and 80 kg N fed^{-1}) were considered as the main plot and the three foliar applications ($CaCl_2$ at 2000 ppm, citric acid at 100 ppm and control) were randomly assigned within each main plot consisting of five rows, 4 m long and 0.7 m a part, occupying an area of $14m^2$. Transplanting was carried out in 20th and 15th November of 2005 and 2006 seasons, respectively, at both sides of ridges. Spacing between plants within rows was 20 cm.

Calcium super phosphate (15.5 % P_2O_5) and potassium sulfate (48 – 52 % K_2O) were applied as basal dose for all the experimental plots at the rate of 15.5 kg P_2O_5 and 24 kg K_2O fed^{-1}, respectively.

The nitrogenous fertilizer in form of urea (46%N) and potassium fertilizer were added in two equal portions after 21 and 35 days from transplanting. Pest control and other cultural practices were applied whenever it was necessary and as commonly recommended for the commercial lettuce production. The following parameters were taken for evaluation:

1. **Fresh weight of plant at marketing stage:** after 70 days from transplantation to determine the following characters:

a. Number of leaves
b. Plant height (cm)
c. Stem length (cm)
d. Fresh weight of leaves (g)
e. Dry weight of leaves (g)
f. Fresh weight of plant (g/plant)

2. **Marketable yield (ton fed^{-1}):** at harvest time, all plants of each experimental unit were weighted in kg/plot and then converted to ton fed^{-1}.
3. **Chemical analysis:** Plant samples were taken after 70 days from transplanting (Marketing stage) for determination of the following chemical analysis:

a. N, P and K % and its uptake by the plant as well as Ca% and Mg% of leaves as described by (Cottenie *et al.,* 1982).
b. NO_3^- and NO^-_2-N were determined according to the method recorded by (Singh, 1988) in the dry leaves.

4. **Utilization efficiency of applied N (UEN%):** using the equation suggested by Fink (1982):

$$UEN\ \% = \frac{\text{Total removed* – removed from soil reserves**}}{\text{Nutrient amount of fertilizer***}} \times 100$$

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) and the least significant differences between the treatment means were compared as published by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A- Vegetative Growth:

1- Effect of N-levels:

Data in Table 2 show that fertilization with 80 kg N fed^{-1} compared with 0, 40 and 60 kg fed^{-1} gave the highest values of leaves number, plant height, stem length and dry weight of leaves/plant. These results might be attributed to the stimulated effect of nitrogen on the merstimatic activity of plant tissues. These results could be supported those obtained by Mahmoud and Agwah (1993); Moussa *et al.,* (1993); Ramadan (2000) and Ahmad *et al.,* (2004).

Table 2: Effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on some vegetative growth parameters of lettuce plants during 2005/2006 and 2006/2007 seasons.

Characters / Treatments	No. of leaves		Plant height (cm)		Stem length (cm)		Dry weight of leaves(g)	
	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
N-Levels (kg fed^{-1})								
Control	19.08	17.78	19.19	18.61	5.22	5.17	25.69	24.89
40	23.08	21.44	22.84	25.59	6.33	9.11	36.14	39.25
60	25.42	27.94	25.51	27.72	9.33	12.89	44.59	48.06
80	28.44	32.37	26.87	29.06	19.65	19.44	57.34	50.71
LSD at 0.05	**2.27**	**3.19**	**1.5**	**1.6**	**1.26**	**2.9**	**5.25**	**4.50**
Foliar Applications								
Control (Water)	22.70	21.67	22.71	23.75	9.10	10.21	31.56	28.66
$CaCl_2$	25.44	27.44	24.70	27.09	11.49	12.97	46.09	40.00
Citric Acid	23.84	25.63	23.40	24.92	10.13	11.30	37.89	34.30
LSD at 0.05	**3.05**	**2.13**	**0.78**	**1.38**	**0.80**	**0.67**	**2.98**	**3.12**

2- Effect of $CaCl_2$ and citric acid foliar applications:

Data in Table 2 show clearly that foliar application with $Cacl_2$ and citric acid significantly increased number of leaves, plant height, stem length and dry weight of leaves/plant compared with control. These results were true in the two seasons of study. Moreover, data in Table 6 reveal that using calcium chloride and citric acid as foliar application tended to increase the concentration of N, P, Ca and Mg of lettuce leaves. These elements are known to be closely associated with the main internal physiogical and metabolically status of plant as chlorophyll, enzymes, amino acids, sugars, ATP, nucleic acid and etc. synthesis. Similar results were obtained by Blom-Zandstra and Lampe (1983); Talaat (1995) and Hanafy Ahmed (1996) on lettuce plants.

2- Effect of interaction:

For the interaction effect, data in Table 3 reveal that lettuce plants received 80 kg N fed^{-1} and foliar application with $CaCl_2$ at 2000 ppm

significantly increased number of leaves, plant height, stem length and dry weight of leaves (g plant^{-1}) during both seasons. Meanwhile, the lowest values were obtained by unfertilized plants and control (sprayed with tap water). As shown in Table 1, the soil was alkaline in pH and total N was very low, where these levels were less than the critical level (40 ppm).

Table 3: Combined effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on vegetative growth of lettuce plants during 2005/2006 and 2006/2007 seasons.

Characters / Treatments		No. of leaves		Plant height (cm)		Stem length (cm)		Dry weight of leaves(g plant^{-1})	
		2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
Control	Control	17.17	15.67	18.00	16.17	5.17	5.17	17.55	15.17
	$CaCl_2$	20.75	19.67	21.13	22.17	5.50	5.83	23.93	23.00
	Citric Acid	19.33	18.00	18.33	17.00	5.00	5.00	17.58	18.43
40	Control	25.50	20.00	22.00	20.83	6.25	7.50	26.23	25.07
	$CaCl_2$	23.75	22.67	23.77	26.10	6.50	10.67	34.60	41.50
	Citric Acid	23.00	21.67	22.75	25.83	6.25	9.17	29.60	31.10
60	Control	24.75	24.33	24.50	27.17	8.50	11.50	36.93	38.17
	$CaCl_2$	26.25	31.67	26.27	28.50	11.50	15.00	40.50	44.50
	Citric Acid	25.26	27.83	25.77	27.50	9.50	12.17	36.67	43.50
80	Control	26.58	26.33	26.33	26.80	16.50	16.67	45.00	36.23
	$CaCl_2$	31.0	35.77	27.50	31.00	22.43	20.33	61.33	53.73
	Citric Acid	27.76	35.00	26.77	29.33	19.75	18.33	47.70	44.17
LSD at 0.05		1.94	1.85	2.67	2.00	1.37	1.46	6.12	8.54

B. Marketable Yield:

1- Effect of N-levels:

Concerning N-levels effect, data in Table 4 reveal that increasing N levels from 0 to 80 kg N fed^{-1} significantly increased fresh weight of leaves, plant fresh weight and yield (ton fed^{-1}) during two seasons. Similar results are reported by Shafshak and Abo-Sedra (1990) who stated that N rate from 0 to 90 kg N fed^{-1} gave a gradual increase in fresh weight and yield of lettuce plants; Moussa *et al.,* (1993); Ramadan (2000) and El-Mancy and Badran (2007) on lettuce plants.

2- Effect of $CaCl_2$ and citric acid foliar applications:

Data illustrated in Table 4 represent the effect of foliar application with $CaCl_2$ at 2000 ppm and citric acid at 100 ppm on fresh weight of leaves, plant fresh weight and yield of lettuce plant during both seasons. Moreover, data in Table 4 reveal that foliar application with $CaCl_2$ and citric acid significantly increased yield of lettuce compared with control. The highest values were obtained by foliar application with $CaCl_2$ at 2000 ppm compared to the control. These results are in harmony of those obtained by Blom-Zandstra and Lampe (1983); Awad (1992); Moussa *et al.,* (1993); Talaat (1995) and Hanafy Ahmed (1996).

3- Effect of interaction:

Regarding the combined effect of N-levels and foliar application with $CaCl_2$ at 2000 ppm and citric acid at 100 ppm, data in Table 5 show that yield of lettuce plants were significantly affected by interaction during both

seasons. Lettuce plants treated with 80 kg N fed^{-1} and foliar application with $Cacl_2$ at 2000 ppm gave the highest values of yield. Meanwhile, plants treated with sprayed water and untreated with nitrogen gave the lowest values of these attributes. Data in Table 3 show obviously that the same treatments gave the highest values of No. of leaves, plant height and dry weight of leaves which contribute to growth enhancement and yield production. These results are confirmed with those of Hanafy Ahmed (1996) who found that foliar application with $CaCl_2$ significantly increased amino acids, calcium and total sugar which could be used to increase yield and quality.

Table 4: Effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on Fresh weight of leaves (g), fresh weight (g/plant) and Marketable Yield (ton fed^{-1}) of lettuce plants during 2005/2006 and 2006/2007 seasons.

Characters / Treatments	Fresh weight of leaves (g)		Plant fresh weight (g)		Marketable Yield (ton fed^{-1})	
	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
N-Levels (kg fed^{-1})						
Control	245.39	231.44	275.33	255.00	8.027	7.62
40	386.39	383.89	429.22	433.33	12.56	12.97
60	479.17	540.28	533.33	619.44	16.34	18.59
80	629.11	573.60	705.56	712.22	21.07	21.33
LSD at 0.05	**41.14**	**50.83**	**22.86**	**45.70**	**0.57**	**1.36**
Foliar application						
Control (Water)	383.79	359.62	432.92	421.67	13.00	12.67
$CaCl_2$	499.75	500.21	562.58	585.42	16.59	17.54
Citric Acid	421.50	437.08	462.08	507.92	14.08	15.18
LSD at 0.05	**33.36**	**43.60**	**22.83**	**45.17**	**1.10**	**1.34**

Table 5: Combined effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on Fresh weight of leaves (g), fresh weight (g $plant^{-1}$) and Marketable Yield (ton fed^{-1}) of lettuce plants during 2005/2006 and 2006/2007 seasons.

Characters / Treatments		Fresh weight of leaves (g)		Plant fresh Weight (g $plant^{-1}$)		Marketable Yield (ton fed^{-1})	
		2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
Control	**Control**	214.33	182.67	240.00	203.33	7.20	6.10
	$CaCl_2$	302.50	285.0	337.67	308.33	10.14	9.27
	Citric Acid	219.33	226.67	248.33	253.33	7.45	7.50
40	**Control**	335.0	316.67	375.00	441.67	11.27	10.77
	$CaCl_2$	441.67	443.33	487.67	558.33	13.63	15.03
	Citric Acid	382.50	391.67	425.00	500.0	12.77	13.10
60	**Control**	452.50	485.0	500.00	650.00	15.00	16.77
	$CaCl_2$	517.50	565.83	575.00	560.00	17.27	19.50
	Citric Acid	467.50	570.0	525.00	650.00	16.77	19.50
80	**Control**	533.33	454.13	616.67	566.67	18.53	17.03
	$CaCl_2$	737.33	706.67	850.00	883.33	25.33	26.33
	Citric Acid	616.67	560.0	650.00	686.67	19.33	20.62
LSD at 0.05		**66.25**	**75.21**	**27.93**	**30.58**	**2.05**	**2.60**

C- Chemical composition:

1- Effect of N-levels:

Data presented in Table 6 show the effect of N levels on N, P, K, Ca, Mg, NO^{-}_{3} and NO^{-}_{2}. Except for K%, fertilization of lettuce plants with 80 kg N fed^{-1} significantly increased N, P, Mg%, NO^{-}_{3} and NO^{-}_{2} (mg kg DW^{-1}) and reduced significantly Ca%. The obtained results are in correspondence with those reported by Stopes *et al.,* (1989) they found that lettuce plants which received 80 and 160 kg N ha^{-1} significantly increased nitrate accumulation compared with the untreated plants. Increasing N levels significantly increased nitrate accumulation in plant tissues, El-Talawy (1998); Ramadan (2000); El-Zalaki (2002) and Ahmad *et al*., (2004). While, El-Mancy and Badran (2007) indicated that N and P and K contents were increased with increasing N levels up to 90 kg N fed^{-1}.

2- Effect of $CaCl_2$ and citric acid foliar applications :-

Data illustrated in Table 6 show that foliar application with $CaCl_2$ at 2000ppm significantly increased P, Ca and Mg content (%) and reduce NO^{-}_{3} and NO^{-}_{2} accumulation (mg kg DW^{-1}) in lettuce leaves compared with control. Meanwhile, spray application with citric acid at 1000 ppm significantly increased N and K and reduced NO^{-}_{3} and NO^{-}_{2} compared with the control. The foliar application of $CaCl_2$ and citric acid may increase the anionic concentration in leaves and hence encourage the reductase system of the plant to convert NO^{-}_{3} to amines in order to establish the ionic balance. The reduction of NO^{-}_{3} will further increase the amine groups leading to the formation of amino acids and protein. These results are in harmony of those obtained by Talaat (1995) on lettuce plants. In this respect, Hanafy Ahmed (1996) reported that application with $CaCl_2$ and citric acid tended to increase the concentration of calcium, sugars and total free amino acids. Similar suggestion was reported by Blom-Zandstra and Lampe (1983 and 1985). In addition, a negative relationship between potassium concentration and nitrate accumulation Hanafy Ahmed *et al.* (1997) and Abou El-Nasr (2002).

3- Effect of interaction:

As for the interaction between N-levels and foliar application with $CaCl_2$ and citric acid, data in Table 7 show that N, P, K, Ca, Mg %, NO^{-}_{3} and NO^{-}_{2} (mg kg DW^{-1}) were significantly affected by the combined effect of N-levels and foliar application with $CaCl_2$ and citric acid. Fertilization of lettuce plants with 80 kg N fed^{-1} and foliar spray with citric acid gave the highest values of N, K (%), meanwhile application of 80 kg N fed^{-1} and foliar application with citric acid gave the highest values of P and Mg %.The highest value of Ca % was obtained by fertilization with 40 kg N fed^{-1} and foliar application with $CaCl_2$ during both seasons. The highest values of NO^{-}_{3} and NO^{-}_{2} (mg kg DW^{-1}) were obtained from plants fertilized with 80 kg N fed^{-1} without foliar spray (water). However, Figs (1, 2 and 3) show that, increasing application of N-levels from 0 up to 80 kg N fed^{-1}under the combined effect of foliar applications with $CaCl_2$ and citric acid increased the values of absorbed N, P and K (kg fed^{-1}) by lettuce leaves as compared to the other treatments during two growing seasons. Except for absorbed P (kg fed^{-1}) by lettuce leaves, the highest values of absorbed N and K (kg fed^{-1}) by lettuce leaves

were achieved as a result of fertilization with 80 kg N fed^{-1} and foliar application with $CaCl_2$ (2000ppm) during both seasons.

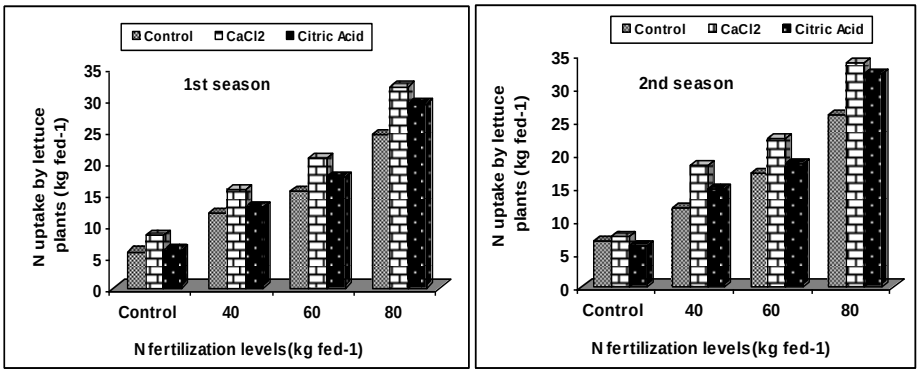

Fig 1: Effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on N uptake (kg fed^{-1}) of lettuce plants during 1st and 2nd seasons.

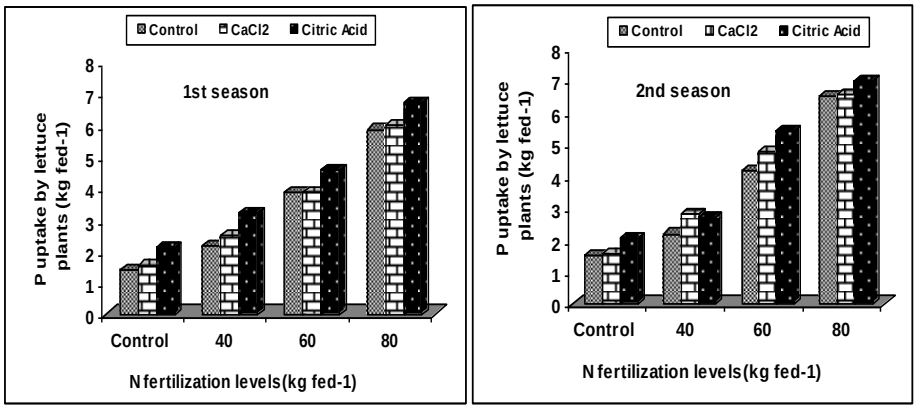

Fig 2:Effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on P uptake (kg fed^{-1}) of lettuce plants during 1st and 2nd seasons.

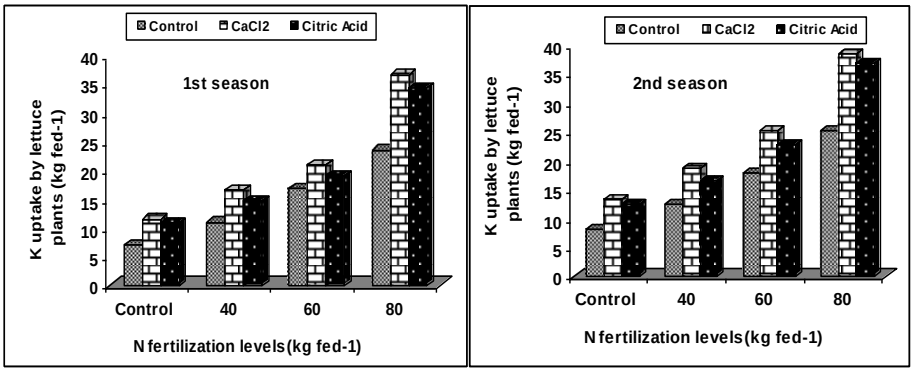

Fig 3: Effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on K uptake (kg fed^{-1}) of lettuce plants during 1st and 2nd seasons.

Table 6: Effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on chemical composition of lettuce plants during 2005/2006 and 2006/2007 seasons.

Characters / Treatments	N%		P%		K%		Ca%		Mg%		NO^-_3 (ppm)		NO^-_2 (ppm)	
	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
N-Levels (kg fed^{-1})														
Control	3.28	3.00	0.472	0.425	3.54	3.12	0.39	0.33	0.41	0.43	30.92	32.59	0.95	0.98
40	3.33	3.21	0.444	0.443	3.54	3.25	0.35	0.35	0.32	0.35	57.07	60.02	0.96	0.98
60	3.76	3.54	0.507	0.510	3.82	3.91	0.35	0.34	0.46	0.46	79.55	80.25	1.04	1.00
80	3.93	3.85	0.523	0.520	3.92	3.98	0.31	0.32	0.50	0.54	140.27	143.59	1.24	1.31
LSD at 0.05	**0.07**	**0.09**	**0.001**	**0.001**	**--**	**--**	**0.01**	**--**	**0.03**	**0.02**	**23.09**	**25.02**	**0.08**	**0.10**
Foliar application														
Control (Water)	3.43	3.12	0.435	0.433	3.09	3.01	0.37	0.37	0.39	0.39	87.03	90.3	1.08	1.00
$CaCl_2$	3.50	3.24	0.445	0.441	4.17	4.10	0.43	0.44	0.55	0.54	74.37	73.5	1.03	1.03
Citric Acid	3.64	3.30	0.537	0.532	3.54	3.23	0.33	0.34	0.35	0.37	76.21	77.6	1.04	1.05
LSD at 0.05	**0.06**	**0.04**	**0.002**	**0.001**	**0.55**	**0.66**	**0.02**	**0.02**	**0.04**	**0.05**	**5.70**	**5.25**	**0.04**	**0.07**

Table 7: Combined effect of nitrogen levels, $CaCl_2$ and citric acid foliar applications on chemical composition of lettuce plants during 2005/2006 and 2006/2007 seasons.

Characters / Treatments		N%		P%		K%		Ca%		Mg%		NO^-_3 (ppm)		NO^-_2 (ppm)	
		2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
Control	**Control (water)**	2.93	2.99	0.436	0.430	2.73	2.85	0.24	0.30	0.34	0.32	32.04	35.12	1.26	1.00
	$CaCl_2$	2.7	2.56	0.437	0.440	4.06	3.89	0.45	0.43	0.63	0.60	29.62	33.25	0.65	0.58
	Citric Acid	2.98	3.00	0.507	0.500	4.20	3.86	0.42	0.40	0.27	0.29	31.11	35.26	0.94	0.86
40	**Control (water)**	3.40	3.36	0.372	0.378	2.80	2.59	0.42	0.38	0.35	0.39	60.48	66.58	0.86	0.90
	$CaCl_2$	3.64	3.59	0.441	0.442	4.20	3.99	0.54	0.53	0.43	0.46	54.12	61.35	1.53	1.20
	Citric Acid	4.07	4.12	0.523	0.521	3.64	3.85	0.36	0.37	0.18	0.23	56.60	60.45	0.40	0.50
60	**Control (Water)**	3.36	3.42	0.458	0.469	3.56	3.57	0.41	0.39	0.51	0.57	92.03	99.58	0.60	0.60
	$CaCl_2$	3.74	3.85	0.450	0.449	3.56	3.99	0.52	0.49	0.48	0.52	73.12	77.29	1.05	1.02
	Citric Acid	3.97	3.99	0.558	0.526	4.34	4.12	0.37	0.36	0.40	0.43	73.50	84.26	0.46	0.60
80	**Control (water)**	3.93	4.12	0.473	0.480	3.64	3.81	0.31	0.36	0.37	0.38	154.57	146.28	1.58	1.68
	$CaCl_2$	3.80	4.00	0.500	0.514	3.64	4.00	0.46	0.45	0.60	0.62	140.63	136.25	0.92	1.19
	Citric Acid	4.35	4.26	0.558	0.550	4.48	4.25	0.36	0.42	0.53	0.49	143.16	141.50	1.23	1.42
LSD at 0.05		**0.11**	**0.14**	**0.004**	**0.003**	**0.46**	**0.49**	**0.04**	**0.02**	**0.08**	**0.10**	**11.2**	**13.0**	**0.03**	**0.03**

4- Utilization efficiency (%):

Results concerning the effect of N-levels on UE% of applied nitrogen under the combined effect of foliar application with $CaCl_2$ and citric acid, Table 8 reveal that increasing N-levels increase the mean values of UEN%. Where, N rate of 80 kg N fed^{-1} gave the highest value of UEN (%) as compared to the other treatments during both seasons, respectively.

Table 8: Utilization efficiency (%) of applied nitrogen as influenced by N-levels under the combined effect of $CaCl_2$ and citric acid foliar applications.

Foliar appl. / N-levels	Control		$CaCl_2$		Citric acid	
	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
Control	**0**	**0**	**0**	**0**	**0**	**0**
40	15.24	12.55	18.30	26.85	17.15	21.36
60	15.92	16.90	20.60	24.68	19.30	20.48
80	23.39	23.81	29.66	32.66	29.06	31.40

Thoroughly, the interaction of N-levels along with $CaCl_2$ and citric acid foliar applications exhibited clear variations and $CaCl_2$ plus 80 kg N fed^{-1} gave the highest values of UEN% comparing with the other treatments in both growing seasons, respectively.

Data in Table 8 represented a simple correlation showed that, NO^{-}_{3} (mg kg^{-1}) is correlated positively and significantly associated with N uptake (kg fed^{-1}) and the yield of lettuce**.**

Table 9: Multiple linear regression between accumulated NO^{-}_{3} (mg kg^{-1}) of lettuce and absorbed N (kg fed^{-1}) and yield of plants.

Variables	NO^{-}_{3}(mg kg^{-1})	N uptake (kg fed^{-1})	Yield (ton fed^{-1})
NO^{-}_{3} (mg kg^{-1})	--	--	
N uptake(kg fed^{-1})	0.911^{**}	--	--
Yield (ton fed^{-1})	0.819^{*}	0.959^{**}	--

The multiple linear regressions as shown in the following equation revealed that, the parameters of the absorbed N by lettuce tissues had a significant role in predicting the NO^{-}_{3} accumulated in leaves. Adversely, the yield of lettuce plants did not induce significant variation in accumulated NO^{-}_{3}. The expected equation to predict accumulated NO^{-}_{3} in lettuce leaves was computed as: **NO^{-}_{3} = - 0.1 + 3.90 N uptake - 1.89 Yield**

The technique stepwise regression analysis showed that, the most important variables which contribute accumulated NO^{-}_{3} (**y**) was N uptake (**r^2 = 83.7 %**).** The polynomial predicting equation for fresh yield of lettuce plants as following:

$Y = 13.9623 + 1.11951X + 1.42E\text{-}02X^{**2}$ (Fig 4)

Generally, it could be concluded that 80 kg N fed^{-1} and foliar spray with $CaCl_2$ (2000ppm) were the best treatments for maximizing the growth, yield and nutritional status of lettuce plants and low NO^{-}_{3} content of leaves. So, it concluded as the beast treatment on basis of yield and NO^{-}_{3} safety for human nutrition.

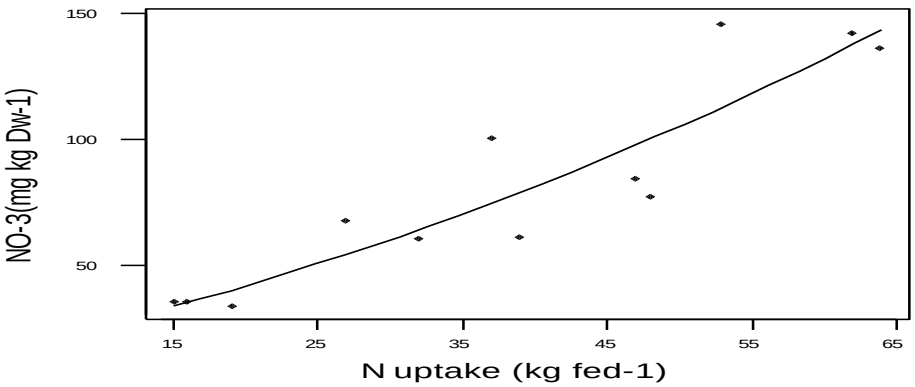

Fig 4: Simple regression coefficient between accumulated NO^{-}_{3}(mg kg^{-1}) and N uptake (kg fad^{-1}) of lettuce plants.

REFERENCES

Abd El-Fattah, M. A. and Agwah, E. M. R. (1987). Physiological studies on lettuce tipbum. Egypt. J. Hort., 114(2):143-153.

Abou El-Nasr, M. E. (2002). Effect of some sources and potassium levels on yield, quality and nitrate accumulation in lettuce leaves. J. Agric. Sci. Mansoura Univ., 27 (5):3401 – 3411.

Ahmed, A. A.; M. M. H. Abd El-Baky and Magda M. Hafez (2004). Effect of different sources and rates of nitrogen on growth, yield and quality of lettuce plant. J. Agric. Sci. Mansoura Univ., 29 (3): 1381 – 1893.

Awad, A. and M. H. M. Griesh (1992): Manure and inorganic fertilizer effects on growth and yield of some sunflower cultivars. Annals of Agric. Sci. Moshtohor, 30(1): 127-144.

Bardisi, A. and E. Abdel-Bary (2000). Growth and yield of lettuce (*Lactuca sativa* L.) and nitrate and nitrite accumulation as affected by nitrogen sources and levels. Zagazig J. Agric. Res., 27(4) 1053 – 1067.

Blom–Zandstra, M. and Lampe, J. E. M. (1983). The effect of chloride and sulphate salts on the nitrate content in lettuce plants. J. Plant Nutrition. , 6:611- 628.

Blom–Zandstra, M. and Lampe, J. E. M. (1985). The role nitrate in the osmoregulation of lettuce (*Lactuca sativa* L.) grown at different light intensities. J. of Experimental Botany, 36(168):1043:1052.

Cottenie, A.; Verloo, M.; Velghe, G. and Camerlynch, R. (1982). Chemical Analysis of Plants and Soil. Laboratory of Analytical and Chemistry. State of Univ. Gent, Belgium.

El-Sissy, M. H. L. (2000). Assessing the pollution caused by excessive nitrogen fertilization. J. Agric. Sci. Mansoura Univ., 25 (11): 7297 – 7313.

El-Talawy, M. M. (1998). Effect of nitrogen and some micronutrient application on spinach (*Spinacia oleracea* L.) M. Sc.Thesis, Fac. Agric. Moshtohor, Zagazig Univ.

El-Mancy, M. H. A. and Nadia, M. Badran (2007). Effect of some sources and levels of nitrogen and their interactions on lettuce yield. Egypt, J. Appl. Sci. (in press).

El-Zalaki, Frenda, M. Z. (2002). Free nitrate content of plant as affected by types of N fertilizers used. Ph.D. Thesis, Fac. of Agric. Mansoura Univ.

Fink, A. (1982). Fertilizers and Fertilization. Introduction and practical guide to crop fertilization. Weinheim Deerfield Beach, Florida . Basel, 54 -168.

Gomez, K. A. and A. A. Gomez (1984). Statistical Procedures for Agriculture Research. Jhon Willy and Sons Inc. New York.

Greenwood, A. J. and J. Hunt (1986). Effect of nitrogen fertilizer on the nitrate contents of field vegetables grown in Britain. J. Sci. Food Agric., 37: 373 – 383.

Gunes, A.; W. H. K. Post and M. Ktas (1995). Effect of partial replacement of nitrate by NH^{+}_{4} - N,urea – N and amino acid – N in nutrient solution on nitrate accumulation in lettuce (*Lactuca sativa* L). Agrochemia, 39: 326 – 333.

Hanafy Ahmed, A. H. (1996). Physiological studies on tipburn and nitrate accumulation in lettuce plants. J. Agric. Sci., Mansoura Univ., 21(11): 3971-3994.

Hanafy Ahmed, A. H.; Kheir, N. F. and Talaat, N. B. (1997). Physiological studies on reducing the accumulation of nitrate in jew smallon (*Corchorus Olitorius*) and radish (*Raphanus sativus*, L.). Plants Bul. Fac. Agric., Univ. Cairo, 48:25-46.

Hil, M. J. (1990). Nitrate and nitrites in food and water. Ellis Horwod in Food Science and Technology. 193 pp.

Lyons, D. J.; G. E. Rayment; P. E. Nobbs and L. Mc. Callum (1994). Nitrate and nitrite in fresh vegetables from Queenland. J. Sci. Food Agric., 64: 279 – 281.

Mahmoud, H. A. F. and Agwah, E. M. R. (1993). Response of lettuce plants gron on calcariuos soil to plant spacing and N-fertilizer level. Egypt, J. Appl. Sci., 8(7):222-236.

Maynard, D. N.; A. V. Barker; P. L. Minotto and N. H. Peck (1976). Nitrate accumulation in vegetables. Advances in Agronomy, 28 : 70 – 118.

Moussa, A. G.; A. El-Shal; A. Abddel–Razik and H. Abdel-Razzak (1993). Efficiency of organic and mineral fertilization on yield of lettuce (*Lactuca sativa* L.) Zagazig J. Agric. Res., 20 (5): 1583-1592.

Page, A. l.; R. H. Miller and D. R. Keeney (eds) (1982). Methods of soil Analysis. Part 2., Chemical and Microbiological Properties. 2nd Amer. Soc. Agron. Madison, W. I. USA.

Ramadan, A. Y. (2000). Studies on lettuce fertilization (*Lactuca sativa* L), M. Sci. Thesis, Fac., Agric., Mansoura Univ.

Reinink, K. (1988). Improving quality of lettuce by breading for low nitrate content. Acta Hort.; 222:121-128.

Shafshak, N. S. and F. A. Abo-Sedera (1990). Effect of different nitrogen sources and levels on growth, yield and nitrate accumulation in some lettuce varieties. Annal of Agric. Sci. Moshtohor, 28 (1) 619 – 631.

Singh, J. P. (1988). A rapid method for determination of nitrate in soil and plant extracts. Plant and Soil., 110: 137 – 139.

Stopes, G.; Woodward, L.; Forde, G. and Vgtmanm, H. (1989). Effects of composed FYM and a compound fertilizer on yield and nitrate accumulation in three summer lettuce cultivars grown on an organic

system. Agriculture, Ecosystems environment, 27(14): 555-559. (C.F. Hort. Abst.; 16:9982).

Talaat, B. N. (1995). Physiological studies on reducing the accumulation of nitrate in some vegetable plants. M. Sc. Thesis, Fac. Agric. Cairo Univ., Egypt .

Viets, F. G. and R. H. Haeman (1971). Factors affecting the accumulation of nitrate in soil, water and plants. Agric. Handbook, 413, ARS, USDA, Washington, DC.

Whitney, E. N.; E. M. N. Hamilton and S. R. Rolfes (1990). Understanding Nutrition (5thed.) West Publishing Company, St. Paul, USA, P543.

التأثير المشترك لمستويات التسميد النتروجيني والرش الورقي بكلوريد الكالسيوم وحمض الستريك على محصول الخس ومحتواه من النترات

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***قسم بحوث الخضر- معهد بحوث البساتين - مركز البحوث الزراعية- الجيزة**

****قسم الأراضي واستغلال المياه – المركز القومي للبحوث – الدقي – القاهرة**

أجريت تجربتان حقليتان بالمزرعة البحثية بالبرمون – معهد بحوث البساتين – محافظة الدقهلية على محصول الخس (صنف بلدي) الشائع زراعته بالمحافظة خلال موسمي الزراعة 2005 و2006، وذلك لدراسة التأثير المشترك لمستويات التسميد النتروجيني (صفر، 40 ، 60 ، 80 كجم/فدان)، والرش بكلوريد الكالسيوم بتركيز 2000جزء في المليون وحمض الستريك بتركيز100جزء في المليون بالإضافة إلى معاملة بدون رش (الكنترول) على محصول الخس والتركيب الكيماوي للأوراق. ويمكن تلخيص أهم النتائج كالآتي:

- إزداد النمو الخضري والمحصول بزيادة التسميد النتروجيني حتى معدل 80 كجم/فدان، كما أدى الرش بكلوريد الكالسيوم أو بحمض الستريك إلى زيادة معنوية في النمو الخضري والمحصول.
- التسميد بمعدل 80 كجم ن/فدان مع الرش بكلوريد الكالسيوم أوحمض الستريك أدى إلى زيادة النمو الخضري والمحصول زيادة معنوية مقارنة بالكنترول.
- زيادة التسميد النتروجيني حتى معدل 80كجم ن/فدان يؤدي إلى زيادة محتوى النباتات من النتروجين والفوسفور والبوتاسيوم، وقلة محتوى النباتات من الكالسيوم وزيادة محتوى الأوراق من المغنسيوم والنترات والنتريت.
- الرش بكلوريد الكالسيوم يؤدي إلى زيادة محتوى النبات من الفوسفور والكالسيوم والمغنسيوم، ولكن يؤدي إلى نقص محتوى النبات من النترات والنيتريت. كما وجد أن الرش بحمض الستريك يؤدي إلى زيادة محتوى الأوراق من النتروجين والبوتاسيوم.
- التسميد بمعدل 80 كجم ن/فدان مع الرش بكلوريد الكالسيوم أو حمض الستريك يؤدي إلى زيادة محتوى النبات من النتروجين والفوسفور والبوتاسيوم، وكانت أعلى قيم للكالسيوم تم الحصول عليها من الرش بكلوريد الكالسيوم + 40كجم ن/فدان.
- التسميد بمعدل80 كجم ن بدون الرش بكلوريد الكالسيوم أوحمض الستريك يؤدي إلى زيادة محتوى الأوراق من النترات والنيتريت.
- وجد أن أعلى كفاءة استفادة (UR=%32.66) من السماد النتروجيني المضاف تحت التأثير المشترك لكلوريد الكالسيوم (2000جزء في المليون) مع المعاملة 80 كجم وحدة نتروجين/فدان بالمقارنة بالمعاملات الأخرى.
- وجود ارتباط إيجابي ومعنوي جداً بين النترات المتراكمة في أوراق الخس ومحتواها من النتروجين الممتص تحت ظروف التفاعل.

توصي الدراسة بتسميد الخس بـ80 كجم ن/فدان مع الرش بكلوريد الكالسيوم بتركيز 2000جزء في المليون كأفضل معاملة لإعطاء أعلى نمو خضري ومحصول وأفضل تركيب معدني، ومحتوى أقل من النترات في الحدود الآمنة للتغذية والصحة.