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MAXIMIZING USE EFFICIENCY OF MINERAL N-FERTILIZATION FOR SPINACH AND ROCKET PLANTS

El-Agrody, M. W. M.* ; G. A. Baddour; A. M. El-Ghamry* and Marwa A. Kany***

*** Soils Dept., Faculty of Agriculture, Mansoura University, Egypt.**

**** Plant Nutrition Dept., Soil, water and Enviro. Res. Inst., Agric. Res. Center.**

ABSTRACT

Two field experiments were conducted at the experimental farm of Faculty of Agricultural., Mansoura Univ. during the successive winter seasons of 2009-2010 and 2010-2011 to investigate some of the available options to reduce the losses and increase the efficiency of N-fertilization for Spinach (*Spinacia Oleracea*) and Rocket (*Eurco Visicaria L.*) plants.

Thirty treatments were arranged in split-split block design, which were the simple possible combination between five treatments of mineral N, i.e ammonium nitrate (AN), AN+inhibitor (DCD), Urea (U), U+DCD and calcium nitrate (Ca-N) as a control treatment at the rate of 60 kgN/fad were arranged in the main plots. Treatments of N-fertilization were divided into 2, 3 or 4 doses and adapted as sub-plots. Two methods of N-applied were allocated as sub-sub plots, once as side dressing (SD) and the other as deep placement (DP).

The results of these investigation indicated that ; the highest safe yield of spinach and rocket plants and the most suitable treatment for realizing the highest use efficiency can be obtained due to applying N-fertilizer in the form of urea plus nitrification inhibitor (DCD) as deep placement in four doses.

The obtained data, also revealed that under any form of N-fertilization the contents of nitrate in the leaves of spinach and rocket plants in the absence of (DCD) were higher than that obtained in the presence of (DCD) as a nitrification inhibitor. The study highlighted that; the heighest NUE values were recorded for the plants fertilized with U+DCD and splitting N-fertilizer to four doses and applied using deep placement method for realizing the highest safe yield for spinach and rocket plants.

Keywords: N-fertilization, forms, time, nitrification inhibitors, spinach and rocket plant**.**

INTRODUCTION

Most Egyption agricultured soils are deficient in nitrogen (N) for the growth of crops. This deficiency can be overcome by using N fertilizers, but fertilizer N is not being used efficiency. Because of N fertilizer can be lost by leaching, erosion and run off, or by gaseous emissions, it use efficiency is always low. The relative importance of these processes can vary widely depending on the agriculture system and the environment. However, gaseous emission of N via ammonia (NH_3) volatilization, and de-nitrification have been identified as the dominant mechanisms of fertilizer N loss in many different agricultural systems. (Freney *et al.,* 1992 and people *et al.,* 1995)

Since ammonia or ammonium producing compounds are the main sources of fertilizer N ,maintenance of the applied N in the ammonium form should mean that less N is lost by de-nitrification. One mechanism of maintaining added N as ammonium is to add a nitrification inhibitor with the fertilizer. Numerous substances have been tested for their ability to inhibit nitrification, and several of these have been patent. The most commonly used nitrification inhibitor, dicyandiamide (D.C.D). Several studies emphasized that treating N-fertilizers with (D.C.D) as a nitrification inhibitor helped in delaying nitrification of ammonium based fertilizers by preventing rapid formation of nitrate in the soil, leaching and de-nitrification losses of nitrogen are limited ,thus increasing the efficiency of N-fertilizers. Moreover, (D.C.D) not only decreases nitrate leaching and nitrose oxide emission, but also decreases the leaching loss of cations nutrients such as Ca^{++}, K^{+} and Mg^{++} (Laskshmanan and prasad 2004, Di and Cameron 2004 and Ibrahim *et al.,* 2006)

The most efficient management practice to maximize plant uptake and minimize losses is to synchronies the N-supply with the plant demand for this nutrient. Plant uptake of fertilizer N can be improved and total N losses reduced from levels achieved with surface broadcasting, by various methods of application such as deep placement and banding. Relative recoveries and levels of N losses can also be influenced by fertilizer composition and the rate or timing of application. Each of these factors will specifically affect ammonium volatilization and loss by denitrification. (Sainz Rozas *et al.,* 2004, Kelley and Sweeney 2005 and Hosein *et al.,* 2007)

In soils with good aeration nitrate $(NO_3)^-$ is the dominate form of available nitrogen in higher plants .Its absorption and pattern of distribution in different parts of a plant is very important. Nitrate that is not absorbed by plants may contaminate underground or surface water by nitrate leaching or soil erosion. On the other hand, high absorption of nitrate causes its accumulation in plants which is one of main anxieties in recent year. Increasing nitrogen use efficiency in plants is considered as major way to decrease nitrate accumulation and it's leaching in the soil (Bao-ming *et al.,* 2004, saniz *et al.,* 2004 and Hossein *et al.,* 2007)

This study was conducted to determine the effect of N-forms; methods of application and doses number of N-applied in the presence and absence of nitrification inhibitor (DCD) on spinach and Rocket plant in regard to better nitrogen utilization efficiency.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm of Faculty of Agric., El-Mansoura Univ. during the successive winter seasons of 2009-2010 and 2010-2011 to investigate some of the available options to reduce the losses and increase the efficiency of N-fertilization for spinach (*Spinacia Oleracea*) and rocket (*Eurco Visicaria L.*) plants.

Thirty treatments were arranged in split-split block design, which were the simple possible combination between five treatments of N-applied, i.e ammonium nitrate (AN), AN+inhibitor (DCD), Urea (U), U+DCD and calcium nitrate (Ca-N) as a control treatment averaged in the main plots. Treatments of N-fertilization were divided into 2, 3 or 4 doses and adapted as sub-plots. Two methods of N-applied were allocated as sub-sub plots, once as side dressing (SD) and the other as deep placement (DP).

Representative samples were collected from the surface layer (0-30cm) of the experimental soil and analyzed for some physical and chemical properties as shown in Table (1).

Plots of six meters square were build-up. Each plot consisted of five rows; 3m long and 40cm wide. Spinach cv. Pacific and Rocket cv. Mansora strains Seeds were sown on December 3rd and 5th of 2009 and 2010 seasons, respectively; in hills; 15cm apart on both sides of rows. Two weeks later; plants were thinned to three plants per hill. Thus, the plant population could be estimated as about 400,000 plants per Fadden.

Table (1): Some physical and chemical properties of the experimental soil during both seasons of 2009-2010 and 2010-2011.

Soil characters		2009-2010	2010-2011
Mechanical analysis (%)	Coarse sand	1.88	2.76
	Fine sand	16.75	17.03
	Silt	30.42	29.65
	Clay	50.95	50.56
	Texture class	Clayey	Clayey
E.C. $dS.m^{-1}$(paste ext.)		2.76	2.69
pH (paste)		8.17	8.02
S.P. %		62	65
O.M. %		1.63	1.92
T. $CaCO_3$ %		2.72	2.90
Available (mg/kg)	N	46.2	41.7
	P	5.8	4.3
	K	275	288

Ammonium nitrate (33.5%N), calcium nitrate (15%) and urea (46%) were the respective of N-sources. The rate of N-applied for the two crops studied was 60kg N/fad. as recommended by the ministry of Agric; and soil recl. (MASR) for leafy vegetables. Thus each plot received 255.7, 186.3, and 571.4grams from AN, U and Ca-N fertilizers, respectively. Dicyandiamide was added as a nitrification inhibitor by mixing it with N-fertilizer at the rate of 4% from the quantity of N-applied. Treatments of N-applied were divided into two, three and four equal doses and added as sub-plots with 10 days intervals between each dose and the other. The first dose was added after 15 days from sowing. All treatments were investigated twice once as side dressing and the other as deep placement. All other practical agriculture were carried out as prevailing in the area of the experiment for the commercial production of leafy vegetable.

At marketing stage; 65 days after sowing of spinach and rocket plants, samples of twenty plants were randomly taken from each experimental plot; put in paper bags and carried immediately to the laboratory. Fresh weight of plant was determined as the average weight per plant and consequently as ton/fed. Then, NO_3-N was determined in the fresh plant sample. The plant samples were oven dried at 70^o c till constant weight. Then, the dried plant samples were thoroughly ground and stored for chemical analysis.

♠ Soil Analysis:

- $CaCo_3$ and organic matter% were determined according to Jackson 1967.
- Mechanical analysis was carried out according to Piper 1950.
- Available N, P and K in the soil were determined according to the methods of Bremner and Mulvany 1982, Olsen and Sommers 1982 and Black 1965.

♠ Plant Analysis*:*

- Total N, P and K% were determined in the digested plant materials using the methods of Pregle 1945, Jackson 1967, Black 1965, respectively.
- N, use efficiency was calculated as grain yield (kg/g) produced due to adding units of fertilizer (N.U.E=Grain yield; kg / kg of nitrogen fertilizer added.)

All obtained data were subjected to statistical analysis according to Gomez and Gomez (1984). Means of treatments were compared using new least significant differences (NLSD).

RESULTS AND DISCUSSION

1-Fresh yield and N-use efficiency (NUE):

Effect of N-fertilization; forms, methods of application and Number of doses as well as their interactions on fresh yield, ton/fed. and NUE of spinach and rocket plants are presented in Table (2).

a) Fresh yield ton.fed^{-1}:

Regarding the effect of N-forms on fresh yield, data in Table (2) indicate that, the mean values of fresh yield for spinach and rocket plants were significantly increased due to an addition of the different N-forms, i.e. AN, AN+DCD, U or U+DCD as compared to the (Ca-N) treatment. Comparing with the (Ca-N) treatment, fresh yield of rocket plant was increased by 10.2, 31.3, 29.1 & 42.3% in the 1st season and 6.3, 31.5, 29.3 & 41.4% in the 2nd season for the treatments of AN, AN+DCD, U or U+DCD, respectively .The same trend was realized for spinach plant during both seasons of the experimentation.

Concerning the effect of number of doses data in the same Tables showed that; an application of N-fertilizer in four doses was most affective for increasing the fresh yield of spinach and rocket plants than the other doses and this effect was significance during both seasons of 2009-2010 and 2010-2011.

As shown from data in Table (2) it can be observed that; the average values of fresh yield for spinach and rocket plants treated with N-fertilizer as deep placement were more increased than that treated with N-fertilizer as side-dressing . This trend was true during the two experimental seasons.

Table (2): Fresh yield ton/fed. and N used efficiency of spinach and rocket plants as affected by N-forms, number of doses, methods of application and their interactions during both seasons of 2009-2010 (1st) and 2010-2011 (2nd).

Ch.			Spinach plant				Rocket plant			
			Total fresh yield ton/fed.		NUE		Total fresh yield ton/fed.		NUE	
Treat.			1st	2nd	1st	2nd	1st	2nd	1st	2nd
A. N-forms										
AN			9.78	10.03	163	167	4.43	4.39	74	73
AN + DCD			11.44	11.72	191	195	5.28	5.43	88	91
U			10.26	10.95	177	183	5.19	5.34	86	89
U + DCD			12.28	12.61	205	210	5.72	5.84	95	97
Ca-N			8.98	9.21	150	153	4.02	4.13	67	66
N.L.S.D at 5%			**0.03**	**0.25**	**0.08**	**0.80**	**0.25**	**0.24**	**1.60**	**0.75**
B. No. of doses										
2 doses			10.47	10.78	174	180	4.91	4.95	82	83
3 doses			10.62	10.84	177	181	4.92	5.04	82	84
4 doses			10.78	11.10	173	178	4.95	5.08	79	79
N.L.S.D at 5%			**0.02**	**0.17**	**0.08**	**0.06**	**N.S**	**0.17**	**0.12**	**0.08**
C. Methods of applications										
SD			10.39	10.65	173	177	4.83	4.89	80	81
DP			10.86	11.17	181	186	5.03	5.16	84	85
N.L.S.D at 5%			**0.01**	**0.13**	**2.66**	**2.45**	**0.05**	**0.14**	**2.50**	**1.30**
D. A*B*C										
AN	**2**	**SD**	9.41	9.70	157	162	4.22	3.34	70	56
		DP	9.89	10.11	165	169	4.48	4.63	75	77
	3	**SD**	9.56	9.82	159	164	4.31	4.42	72	74
		DP	9.98	10.17	166	170	4.55	4.66	76	78
	4	**SD**	9.70	9.96	162	166	4.39	4.52	73	75
		DP	10.18	10.44	170	174	4.65	4.77	78	80
AN + DCD	**2**	**SD**	11.04	11.25	184	188	5.07	5.22	85	87
		DP	11.53	11.79	192	197	5.30	5.44	88	91
	3	**SD**	11.18	11.49	186	192	5.15	5.31	86	89
		DP	11.69	11.99	195	200	5.42	5.56	90	93
	4	**SD**	11.34	11.65	189	194	5.29	5.45	88	91
		DP	11.85	12.15	198	203	5.48	5.62	91	94
U	**2**	**SD**	10.22	10.62	170	177	5.31	5.46	89	91
		DP	10.69	11.06	178	184	5.56	5.74	93	96
	3	**SD**	10.41	10.77	174	180	5.39	5.56	90	93
		DP	10.87	11.08	181	185	4.96	5.12	83	85
	4	**SD**	10.54	10.88	176	181	4.83	4.97	81	83
		DP	11.02	11.30	184	188	5.06	5.20	84	87
U + DCD	**2**	**SD**	11.86	12.20	198	203	5.50	5.67	92	95
		DP	12.36	12.70	206	212	5.78	5.91	96	99
	3	**SD**	12.06	12.43	201	207	5.57	5.52	93	92
		DP	12.53	12.89	209	215	5.84	6.02	97	100
	4	**SD**	12.22	12.47	204	208	5.71	5.86	95	98
		DP	12.66	12.98	211	216	5.93	6.04	99	101
Ca-N	**2**	**SD**	8.62	8.95	144	149	3.84	3.97	64	66
		DP	9.07	9.42	151	157	4.07	4.14	68	69
	3	**SD**	8.75	8.16	146	136	3.89	4.01	65	67
		DP	9.16	9.58	153	160	4.11	4.26	69	71
	4	**SD**	8.90	9.33	148	156	3.97	4.06	66	68
		DP	9.39	9.70	157	162	4.22	3.34	70	56
N.L.S.D at 5%			**0.16**	**0.54**	**0.80**	**0.80**	**0.18**	**0.12**	**0.75**	**1.25**

AN=ammonium nitrate U=urea Ca-N=calcium nitrate
DCD=dicyandiamide SD=side dressing DP=deep placement

As for the interaction effect between the previously mentioned parameters data in the same Table, also detected that; the highest mean values of fresh yield for spinach and rocket plants were realized for the plants treated with U+DCD as deep placement in four doses, while the lowest one was connected with an application of Ca-N in two doses as side-dressing. On the other hands the average values of the aforementioned trait due to an addition of N-forms in the presence of nitrification inhibitor (DCD) was more pronounced increased than that obtained in the absence of (DCD) for spinach and rocket plants in the two seasons of the experiment. This trend was the same under any number of doses or methods of application.

b) Use efficiency of N fertilizer:

The calculated use efficiency of N-fertilizer as affected by N-forms, doses and method of application are presented in Table (2).

It is clear from the data that the estimated use efficiency reached the maximum with the application of urea in the presence of DCD. Whereas it reached the minimum for the plants treated with calcium nitrate in single form. The rate of increases over the control treatment (Ca-N) for spinach plant was accounted to be 8.7, 27.3, 18.0 & 36.7% in the 1^{st} season and 9.2, 27.5, 19.6 and 37.3% in the second season. The same trend was realized for rocket plant during the two seasons of the experiment.

Data in Table (2), also indicate that there are significantly differences between the average values of Nitrogen use efficiency, in the leaves of spinach and rocket plants as influenced by the number of doses for N-fertilization applying the nitrogen fertilizers in 3 doses induced the best NUE for both grops and seasons in the same trend, an addition of N-fertilizer as deep placement significantly increased the mean values of the calculated N-use efficiency in the leaves of spinach and rocket plants. This trend was the same during both seasons of the experimentation.

Based on the data presented in Table (2) the most effective treatment for realizing the highest values of N-use efficiency were connected with the plants treated with N-fertilizer in the form of urea combined with DCD in four doses as a deep placement. The estimated use efficiency of nitrogen averaged 211 and 216kg spinach per kgN^{-1} in the 1^{st} and 2^{nd} seasons, respectively. The same trend was realized for rocket plant during both seasons of 2009-2010 and 2010-2011.

The results of these investigation suggest that because of fertilizer-N can be lost by leaching , erosion and run-off , or by gaseous emissions , one mechanisms of maintaining added N as ammonia is to add a nitrification inhibitor with the fertilize to maximize plant uptake and minimize losses and consequently increases the use efficiency of N-fertilizer. The objective of using nitrification inhibitors is to control the loss of nitrate by leaching or the production of nitrous oxide (N_2O) by denitrification from the topsoil by keeping N in the ammonium form longer and thus increasing N-use efficiency. The most efficient management practice to maximize plant uptake and minimize losses is to synchronies the N-supply with the plant demand for this nutrient. Plant uptake of fertilizer N can be improved and total N losses reduced from levels achieved with surface broadcasting, by various methods of application such as deep placement and banding. Relative recoveries and levels of N losses can also be influenced by fertilizer composition and the rate or timing of application. Each of these factors will specifically affect ammonium volatilization and loss by denitrification.

These findings are in accordance with the results of ; weiske *et al.*, (2001), Edmeades (2004), Di and Cameron (2004), Alam *et al.*, (2005), Ibrahim *et al.*, (2006) and Trenkel (2010).

2-N, P, K% and NO_3-N ppm:

Data illustrated in Tables (3&4) reflect the effect of N-forms ,number of doses and method of application as well as its interactions on nitrogen , phosphorus and potassium percentages as well as NO_3-N ppm in the leaves of spinach and rocket plants in the two seasons of the experiment.

a) N, P and K %:

Results show that , adding of N-fertilizer in the form of Urea +DCD was superior for increasing the average values of N, P and K % for spinach and rocket plants following by an application of AN+DCD , U , AN and finally Ca-N. The rate of increases % for N % in spinach plant over the Ca-N treatment were accounted to be 7.6, 11.8, 12.6 and 29.7% in the 1st season and 7.3, 20.8, 12.8 & 29.6% in the 2nd season due to the fertilization by AN, AN+DCD, U and U+DCD respectively. Such effect was the same for P and K% in the leaves of spinach and rocket plants during the two seasons of investigation.

The different comparisons tabulated in Tables (3&4) indicate that, except for the differences between the mean values of K% in the 1st season for the rocket plant, which had no significant effect ; a significant stimulation effect was happened on the contents of N, P and K% as a result of adding N-fertilizer in four doses .

Data at the Tables 3&4 also reveal that; N, P and K percentage can be improved and consequently total N-P and K losses reduced by an application of N-fertilizer as deep placement more than that obtained for the plants treated with N- fertilizer as side- dressing. This effect was significant for spinach and rocket plants, during both seasons of the experimentation.

Table (3): N, P, K% and NO3-N, ppm of spinach plant as affected by N-forms, number of doses, methods of application and their interactions during both seasons of 2009-2010 (1st) and 2010-2011(2nd).

Treat.		Ch.	N%		P%		K%		NO_3-N ppm	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
A. N-forms										
AN			2.83	2.94	0.460	0.471	3.60	3.75	436.7	476.7
AN + DCD			2.94	3.31	0.533	0.545	4.27	4.43	362.2	378.4
U			2.96	3.09	0.499	0.508	3.92	4.08	408.8	430.0
U + DCD			3.41	3.55	0.568	0.580	4.60	4.78	318.2	334.5
Ca-N			2.63	2.74	0.429	0.440	3.31	3.47	502.4	493.3
N.L.S.D at 5%			**0.09**	**0.02**	**0.002**	**0.004**	**0.03**	**0.03**	**23.83**	**3.68**
B. No. of doses										
2 doses			2.87	3.08	0.491	0.502	3.88	4.03	411.8	441.2
3 doses			2.95	3.12	0.498	0.509	3.94	4.11	413.6	435.2
4 doses			3.04	3.17	0.504	0.515	4.00	4.16	391.6	391.4
N.L.S.D at 5%			**0.05**	**0.02**	**0.002**	**0.002**	**0.01**	**0.01**	**17.04**	**2.94**
C. Methods of applications										
SD			2.90	3.06	0.488	0.499	3.86	4.02	416.3	431.6
DP			3.00	3.19	0.507	0.519	4.02	4.18	395.0	413.6
N.L.S.D at 5%			**0.05**	**0.01**	**0.002**	**0.001**	**0.02**	**0.01**	**13.92**	**2.68**
D. A*B*C										
AN	**2**	**SD**	2.71	2.82	0.446	0.453	3.47	3.61	474.3	495.1
		DP	2.86	2.95	0.462	0.469	3.60	3.73	358.7	471.3
	3	**SD**	2.78	2.90	0.451	0.460	3.51	3.68	470.0	502.7
		DP	2.89	3.00	0.470	0.482	3.67	3.82	448.0	470.3
	4	**SD**	2.81	2.91	0.458	0.473	3.57	3.72	439.0	468.7
		DP	2.90	3.02	0.473	0.489	3.77	3.92	430.0	451.8
AN + DCD	**2**	**SD**	3.13	3.27	0.516	0.529	4.11	4.24	383.3	404.2
		DP	2.25	3.35	0.537	0.549	4.30	4.46	364.3	379.9
	3	**SD**	2.51	3.17	0.522	0.531	4.22	4.39	373.0	390.5
		DP	3.26	3.35	0.541	0.556	4.30	4.49	356.7	371.4
	4	**SD**	3.18	3.30	0.534	0.544	4.27	4.43	351.3	367.6
		DP	3.31	3.42	0.546	0.559	4.40	4.58	344.7	357.0
U	**2**	**SD**	2.84	2.94	0.481	0.490	3.80	3.94	430.0	453.2
		DP	3.03	3.12	0.501	0.511	3.93	4.07	414.3	432.7
	3	**SD**	2.88	2.99	0.489	0.499	3.83	3.99	422.3	451.8
		DP	3.04	3.16	0.511	0.522	4.00	4.20	405.0	426.4
	4	**SD**	2.90	3.04	0.496	0.500	3.87	4.04	394.7	413.5
		DP	3.09	3.26	0.514	0.526	4.09	4.22	386.7	402.6
U + DCD	**2**	**SD**	3.32	3.45	0.550	0.566	4.48	4.67	337.7	356.4
		DP	3.43	3.54	0.571	0.581	4.63	4.78	323.0	342.8
	3	**SD**	3.36	3.50	0.560	0.570	4.53	4.74	332.7	346.8
		DP	3.48	3.63	0.579	0.591	4.68	4.87	314.7	330.5
	4	**SD**	3.39	3.51	0.565	0.574	4.55	4.73	305.3	319.5
		DP	3.50	3.69	0.585	0.596	4.73	4.89	295.7	311.1
Ca-N	**2**	**SD**	2.54	2.64	0.412	0.424	3.17	3.34	525.0	548.3
		DP	2.63	2.74	0.434	0.444	3.35	3.50	507.0	528.5
	3	**SD**	2.58	2.72	0.419	0.430	3.22	3.34	518.0	543.3
		DP	2.69	2.81	0.437	0.450	3.39	3.56	496.0	517.9
	4	**SD**	2.60	2.70	0.429	0.438	3.29	3.45	488.3	412.5
		DP	2.71	2.82	0.445	0.453	3.45	3.61	480.3	495.1
N.L.S.D at 5%			**0.20**	**0.04**	**N.S**	**N.S**	**0.10**	**0.05**	**8.75**	**1.78**

Table (4): N, P, K% and NO3-N, ppm of rocket plant as affected by N-forms, number of doses, methods of application and their interactions during both seasons of 2009-2010 (1st) and 2010-2011 (2nd).

Treat.		Ch.	N% 1st	N% 2nd	P% 1st	P% 2nd	K% 1st	K% 2nd	NO_3-N ppm 1st	NO_3-N ppm 2nd
A. N-forms										
AN			2.69	2.74	0.516	0.524	3.47	3.57	491.0	496.2
AN +DCD			3.26	3.34	0.624	0.628	4.31	4.43	388.4	382.1
U			2.88	2.97	0.571	0.573	4.56	4.67	439.5	431.5
U + DCD			3.56	3.63	0.670	0.676	4.20	4.80	342.5	334.4
Ca-N			2.53	2.44	0.469	0.479	3.20	3.32	543.8	530.3
N.L.S.D at 5%			**0.09**	**0.01**	**0.005**	**0.007**	**0.24**	**0.02**	**5.54**	**23.24**
B. No. of doses										
2 doses			3.00	2.96	0.557	0.563	3.94	4.05	454.5	463.8
3 doses			2.95	3.03	0.571	0.578	3.94	4.16	446.9	427.4
4 doses			3.00	3.08	0.581	0.587	3.96	4.26	421.7	413.6
N.L.S.D at 5%			**0.03**	**0.02**	**0.003**	**0.003**	**N.S**	**0.01**	**3.81**	**16.88**
C. Methods of applications										
SD			2.93	2.94	0.551	0.557	3.86	4.04	450.0	446.9
DP			3.04	3.11	0.589	0.596	4.04	4.27	432.0	422.9
N.L.S.D at 5%			**0.05**	**0.01**	**0.002**	**0.003**	**0.05**	**0.01**	**1.99**	**13.61**
D. A*B*C										
AN	**2**	**SD**	2.57	2.61	0.487	0.495	3.28	3.37	512.7	582.7
		DP	2.71	2.73	0.522	0.529	3.51	3.60	491.3	485.3
	3	**SD**	2.66	2.71	0.496	0.503	3.34	3.46	515.3	507.4
		DP	2.72	2.82	0.535	0.546	3.58	3.68	483.3	475.6
	4	**SD**	2.66	2.71	0.510	0.516	3.41	3.52	477.0	467.4
		DP	2.80	2.85	0.549	0.557	3.69	3.77	466.3	458.8
AN + DCD	**2**	**SD**	3.17	3.23	0.592	0.591	4.13	4.21	416.3	411.5
		DP	3.30	3.35	0.625	0.622	4.36	4.45	386.3	380.8
	3	**SD**	3.19	3.26	0.606	0.609	4.25	4.34	400.7	395.5
		DP	3.33	3.42	0.647	0.657	4.39	4.51	384.3	374.4
	4	**SD**	3.23	3.34	0.619	0.627	4.31	4.47	376.0	370.5
		DP	3.35	3.42	0.655	0.665	4.46	4.58	366.7	359.6
U	**2**	**SD**	2.79	2.88	0.536	0.543	4.31	4.43	463.0	458.0
		DP	2.96	3.02	0.576	0.582	4.59	4.68	440.3	431.9
	3	**SD**	2.65	2.75	0.553	0.555	4.37	4.52	457.3	446.2
		DP	3.01	3.12	0.595	0.602	4.73	4.83	436.7	427.6
	4	**SD**	2.84	2.93	0.558	0.546	4.49	4.61	425.3	418.9
		DP	3.05	3.14	0.605	0.611	4.85	4.93	414.3	406.4
U + DCD	**2**	**SD**	3.43	3.48	0.641	0.652	4.40	4.54	366.3	361.4
		DP	3.59	3.65	0.675	0.678	4.59	4.66	350.0	438.2
	3	**SD**	3.50	3.56	0.648	0.659	4.43	4.56	359.7	349.8
		DP	3.63	3.71	0.692	0.695	4.94	5.03	337.0	229.6
	4	**SD**	3.54	3.62	0.665	0.672	4.81	4.90	326.3	320.3
		DP	3.64	3.73	0.698	0.700	5.03	5.10	315.7	307.4
Ca-N	**2**	**SD**	2.03	2.15	0.443	0.451	3.04	3.18	566.0	551.0
		DP	2.45	2.52	0.476	0.490	3.23	3.36	553.0	536.7
	3	**SD**	2.34	2.37	0.452	0.463	3.15	3.27	555.3	540.4
		DP	2.50	2.56	0.486	0.495	3.27	3.41	539.3	527.2
	4	**SD**	2.39	2.45	0.462	0.469	3.18	3.27	533.3	521.8
		DP	2.50	2.61	0.494	0.495	3.33	3.37	516.0	582.7
N.L.S.D at 5%			**0.19**	**0.04**	**N.S**	**N.S**	**0.19**	**0.05**	**7.71**	**52.72**

It has been demonstrated from the data in Tables (3&4) that; adding of Urea+DCD in four doses as deep placement was superior for increasing the contents of N and K% in the leaves of spinach and rocket plants while, such effect did not reach to the level of significance between the values of P% during both seasons of 2009-2010 and 2010-2011. According to the data in the same Tables it can be shown that the average values of N and K% were more significantly increased due to an addition any of N-forms studied mixing with DCD than that obtained for the plants treated with N-forms without DCD. This trend was true during both seasons of investigation.

b) Nitrate accumulation (ppm):

It is evident from the data presented in Tables (3&4) that; the highest values of No_3-N in the leaves of spinach and rocket plants were realized for the plant fertilized with calcium nitrate in single form while, the lowest values were connected with the treatment of Urea mixed with DCD . In addition, using the nitrification inhibitor (DCD) in the presence of any N-fertilizers investigated sharply decreases the values of nitrate contents than those obtained for the plants treated with these N-fertilizers only. On other words, the rates of decreases in nitrate contents in spinach plant in the 1st season were accounted to be 18.6% and 13.1% for the treatments of Urea and ammonium nitrate, respectively. The same trend was happened for nitrate contents in spinach and rocket plants during the two seasons of the experiment.

Based on the same data in Tables (3&4) it can be observed that; an addition of N-fertilizer either in four doses or as deep placement were most effective in decreasing the values of nitrate in the leaves of spinach and rocket plants than the other doses or methods of application .Such effect was significant during both seasons of 2009-2010 and 2010-2011.

The comparison among the means of the various combined treatment of N-forms, number of doses and methods of application as shown in Tables (3&4) illustrate that ,the most suitable treatment for decreasing the values of No_3-N content in spinach and rocket leaves were connected with the plants fertilized with Urea+DCD in 4 doses as deep placement .

The present investigation , also indicate that under any form of N-fertilizers the contents of nitrate in the leaves of spinach and rocket plants in the absence of (DCD) were higher than that obtained in the presence of (DCD) as a nitrification inhibitor. This can be explained as follow; in the absence of DCD; most soil nitrogen will be in the form of NO_3 and plants may absorb great quantity of nitrogen than its assimilation capacity. The different between N-absorption and its assimilation may be great and the unutilized nitrogen well be stored as nitrate in plant tissues. In this respect; amending of N-fertilizer with a nitrification inhibitor will improve the quality of grown crops, especially nitrate accumulation in spinach and rocket. The favorable role of N application in the form of U+DCD in four doses as deep placement on stimulating the contents of N,P and K % in spinach and rocket leaves may be attributed to decrease the accumulation of NO3 and in the same time increasing the compound of nitrogen percentages , which may be rather a consequence of improved photosynthesis leading to increasing the contents of these macro nutrients

These results confirmed with the findings of El-Agrody *et al.*, (2001), Egea and Alargon (2004), Xu *et al.*, (2005), Di *et al.*, (2004) and Salem (2010)

Conclusion

Under the same conditions of this investigation it could be recommended that; for minimizing loses and, consequently maximizing the use efficiency of N-fertilizers the most suitable treatment must be added in the form of urea plus DCD as a nitrification inhibitor in deep placement at four doses. This can realize the highest safe yield of spinach and rocket plants.

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تعظيم كفاءة استخدام التسميد الأزوتي المعدني لنباتى السبانخ والجرجير.

محمد وجدى محمد العجرودى*, جمال الدين عبد الخالق بدور, أيمن محمد الغمرى* و مروه احمد كانى*.**
*** قسم الأراضى - كليه الزراعه – جامعه المنصوره- مصر.**
**** قسم بحوث تغذيه النبات - معهد بحوث الاراضى والمياه والبيئه- مركز البحوث الزراعيه – الجيزه – مصر.**

نفذت تجرتان حقليتان فى المزرعه التجريبيه، كليه الزراعه، جامعه المنصوره فى خلال الموسمين الشتويين 2009- 2010 ، 2010- 2011 وذلك لدراسه تأثير بعض الخيارات المتاحه لتقليل الفقد وزياده كفاءة استخدام التسميد النيتروجينى لنباتى السبانخ والجرجير.

اشتملت التجربه على ثلاثين معامله فى تصميم قطاعات تحت منشقه وهى تمثل كل التفاعلات الممكنه بين 5 معلملات من صور التسميد النيتروجينى كمعاملات رئيسيه (نترات أمونيوم، نترات أمونيوم + مثبط، يوريا، يوريا + مثبط، إضافه الى نترات الكالسيوم كمعامله كنترول وذلك عند معدل 60 كجم/فدان) تم تقسيم كل جرعه من الاسمده الى جرعات 2، 3، 4 ووضعت كقطع منشقه، تم اضافه الاسمده بطريقتين إضافه جانبيه او إضافه عميقه ونفذت كقطع تحت منشقه.

وقد اظهرت نتائج التجربه ان:-

- انسب معامله للحصول على اكبر محصول آمن من السبانخ والجرجير- وتحقيق أعلى استفاده من السماد الازوتى كانت متمثله فى اضافه السماد الازوتى على صوره يوريا مخلوطه بمثبط التأزت ومضافه اضافه عميقه تحت سطح التربه على اربع جرعات.
- كما اوضحت النتائج انه عند استخدام اى صوره من صور التسميد الازوتى فان محتوى النترات فى اوراق السبانخ والجرجير فى غياب مثبط التازت كان اعلى مقارنة فى حالة وجود مثبط التازت.
- اظهرت النتائج بوضوح ان اعلى كفاءه لاستخدام السماد الازوتى قد سجلت عند اضافه السماد الازوتى فى 4 جرعات اضافه ارضيه عميقه – وقد ادى ذلك الى تحقيق اعلى محصول امن من السبانخ والجرجير.

قام بتحكيم البحث

أ.د / زكريا مسعد الصيرفي	**كلية الزراعة – جامعة المنصورة**
أ.د / أحمد سعيد متولي إبراهيم	**كلية الزراعة – جامعة الزقازيق**