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Canola productivity as affected by nitrogen fertilizer sources and rates grown in calcareous soil irrigated with saline water

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ABSTRACT

A field experiment was carried out in two successive winter seasons of 2011/2012 and 2012/2013 to study the effect of nitrogen sources (ammonium nitrate, ammonium sulphate and urea) and rates (30, 45 and 60 kg N/fed.) on the productivity and nutritional value of canola plant grown in calcareous soil at El -Areish Agricultural Research station, (ARC) North Sinai Governorate, Egypt (lat. 31.05 and long. 33.50 and 30.57m above the mean sea level). The main results were: In most cases, ammonium nitrate achieved a significant positive effect on most yield characteristics and seed yield as well as N, P, K, Oil and protein percentages as well as Oil yield in both seasons. However, branches number, plant highest, N content and protein % of seed did not respond significantly toward the nitrogen sources in first season, flowering 100 % in the second one as well as flowering 50 %, P content and oil % in both seasons. The highest nitrogen level significantly affected positively all canola tested parameters compared to other levels in both season. Generally, the highest obtained values for most characteristics of canola under investigation were achieved when the plants received ammonium nitrate with highest rate. Meanwhile, there were insignificant differences due to the interacted treatments on No. of branches / plant in the first season.

Keywords: *Canola productivity, Nitrogen, soil, Saline water.*

INTRODUCTION

In Egypt, calcareous soil represents a great area, some of which being expected to be cultivated with near-future. In such soils, presence of $CaCO_3$ plays a big role in defining the status of macro and micronutrients and their interactions in soil; this is usually reflected on availability to plants as well as interaction within grown plant tissues.

Concerning to water salinity, supplies of good-quality water are lessening short of demand for intensive irrigated agriculture in many arid and semi-arid area due to increased requires to produce more for the growing population as well as competition from urban, industrial and environmental divisions. So, available freshwater supplies need to be used more efficiently. Also, reliance on saline waters generated by irrigated agriculture or pumped from aquifers seems expected for irrigation. Recently, at least 20 % of the world's irrigated land is salt affected and/or irrigated with waters containing high levels of salts. The evaporation rate is generally high and exceeds that of rainfall in such regions. Thus, the inadequate rainfall together with high evaporative demand and shallow ground water in most locations improve the movement of salts to the soil surface. There are two main negative effects of high salt concentrations that influence plant growth and development water deficit (Munns and Termaat, 1986) and ion toxicity connected with excessive Cl^- and Na^+ (Niu, 1995) leading to a Ca^{+2} and K^+ shortage and to other nutrients imbalance (Marschner,1995).

During the last decades the acreage of winter oil seed rape has been increased considerably in the world, production of edible oils during canola plantations has been only noticed in recent years. Management of balanced and efficient use of fertilizers is certainly necessary to get greatest yield and quality (Sieling and Kage, 2010). Winter rapeseed (*Brassica napus* L.) is an important agricultural crop, grown commonly for oil or biofuel production. After oil extraction, the high protein seed residue can be used as animal feed. Regarding to salinity, Mendham and Salisbury (1995) stated that canola has some tolerance to soil salinity and is sown into relatively saline soils. The canola crop is harvested in summer, under warm, dry conditions which produces seed of low moisture with good storage characteristics. These conditions also favour high seed quality low in chlorophyll and free fatty acids.

For newly introduced crops, it is essential to assess the appropriate production technology for different environments. Amongst many others, the nutritional requirements of the crop are considered to be the most imperative factor. Ion uptake and fragmentation are critical not only for normal growth but also for growth under saline conditions (Adams, 1992). Nitrogen is essential mineral required for normal physiological processes of crops. Seed yield and yield attributes improved by increasing nitrogen rates. Nitrogen fertilizer plays a vital role in enhancing crop yield, canola nitrogen requirement is higher than cereals and it is considered as a high nitrogen demanding crop. High nitrogen levels application are essential and economically gainful when canola has a desirable growth in irrigated fields. Many soils have difficulties to provide the required nitrogen for energetic growth and maximum yield production of canola; therefore nitrogen fertilizers are effective in all growth stages of plant (Rathke, 2005).

Choosing the correct source and dose of N fertilizer application is therefore an important aspect of successful rapeseed production. The problem of nitrogen fertilizers type, rarely taken into kindness by researches and in practice, is even more ambiguous. Öztürk , (2010) found that ammonium sulfate and urea gave higher seed yield than ammonium nitrate. Mean values of both seasons indicated that 100 and 150 kg N ha^{-1} rate improved significantly yield and quality traits with regard to other N treatments. He also suggest that, ammonium sulfate at 150 kg N ha^{-1} will be about adequate to meet rapeseed crop N requirements. Ahmad (2011) obtained that nitrogen increased seed yield. Conversely, salinity decreased seed yield and yield components dramatically. Furthermore, plant height was increased due to nitrogen application. N application improved seed number per silique and 1000-seed weight over two years. Oil percentage was decreased due to nitrogen and salinity in the first year. Salinity stress increased glucosinolate and protein content. Other treatments, however, had no significant effect on these traits. Salt stress induction decreased N, P, K,Ca and Mg content, but increased Na, Cl and Na/K ratio.

The purpose of the present investigation is to clarify the response of applied N forms (as ammonium nitrate, ammonium sulfate and urea) and three rates, i.e., 30, 45 and 60 kg N fed., to canola plants under irrigation with saline water. Such study was performed through evaluating plant growth and their status of N, P and K in seed as well as both seed oil and protein percent.

MATERIAL AND METHODS

The research was carried out in El- Areish Agricultural Research Station, North Sinai Governorate, Egypt, during the growing seasons 2011-2012 and 2012-2013. The experimental site is located at lat. 31.05, long. 33.50 and 30.57m above the mean sea level. Soil samples (0-30 cm) were taken at sowing to determine their particle size distribution, chemical analysis (Soil & Water) according to the stander methods by Ryan, (1996) and listed in (Tables 1, 2 and 3).

Table 1. Some physical and chemical properties of the studied soils

Seasons	pH	ECe dSm^{-1}	$CaCO_3$ %	C. sand	F. sand	Silt	Clay	Soil texture
2011/2012	8.23	2.28	22.80	27.15	40.40	31.30	1.15	Sandy loam
2012/2013	8.15	2.63	25.30	25.70	42.57	30.73	1.00	Sandy loam

Table 2. Some chemical properties of the studied soils

Seasons	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	N	P	K
	Meq/L								Available		(ppm)
2011/2012	4.10	5.33	11.20	0.37	0.00	7.65	8.50	4.85	13.10	4.40	36.35
2012/2013	4.88	6.10	12.80	0.43	0.00	7.21	10.10	6.90	14.30	5.80	39.00

Table 3. Some chemical analysis of the used irrigation water

Characters		2011/2012	2012/2013
pH		7.1	7.3
EC dSm^{-1}		5.66	5.74
Soluble cations meq/l	Ca^{+2}	9.9	10.3
	Mg^{+2}	8.8	9.1
	Na^{+}	36.6	37.5
	K^{+}	0.1	0.3
Soluble anions meq/l	HCO_3^{-}	6.8	7.3
	Cl^{-}	37.1	38.6
	SO_4^{--}	11.5	11.3

Sowing was done with hand On November, 27th and 20th in 2011/2012 and 2012/2013 seasons, respectively. The variety used in the experiment was ' Egyptian variety; Serw 4 as (double zero) because of low or absence of erucic acid and low glucosinolate content, this variety was obtained from Oil Crop Res. Dept., Agric. Res.

The study used a split plot design, with N fertilizer source (ammonium nitrate (AN), ammonium sulfate (AS), and urea (U) as the main plot and N rate as the subplot. Nitrogen treatments were 30 (N1), 45 (N2), and 60 (N3) kg N fed. The experiment was replicated three times. Plots were over seeded and subsequently thinned to final plant density of about 50 plants m-2 at seedling stage. The experimental unit was $21m^2$ (1/200 fad.) and consisted of seven ridges, five meter in length and 60 cm apart. Nitrogen fertilizer was applied in four equal portions, (20, 35, 50 and 65 days from sowing).

Fertilization was carried out according to the recommendation of the Ministry of Agriculture in Egypt as follow: superphosphate and potassium sulphate were applied with equipment of soil for planting at rates 100 kg P_2O_5 and 48 kg K_2O/fed^{-1}, respectively, to all experimental plots before sowing in both seasons.
At harvest, the canola plants of three internal rows from each sub-plot were collected to determine the seed yield and yield components, i.e., Plant height (cm), number of branches/plant, 50 &100 % from flowering days, number and Seed weight /plant (g). The dry seed samples were ground and wet digested with H_2SO_4-$HclO_4$ mixture. NPK were determined using the method as described by Ryan, (1996). Crude protein percentage was calculated by multiplying N% by the converting factor 6.25 (Robinson, 1975). Seed oil percentage was determined according to A.O.A.C. (1990). Oil yield (kg/fed.) was calculated by multiplying oil percentage by seed yield.

The results were statistically analyzed using the M-STAT-C statistical package (Crop and Soil Department, Michigan State University, Michigan, USA, to calculate F ratio according to Snedecor and Cochran (1980). Least significant differences method (L.S.D) was used to differentiate means at the 0.05 level (Waller and Duncan, 1969).

RESULTS AND DISCUSSION

Plant growth

Data presented in Table (4) show that a significant increase in plant growth parameters (plant height, No. of branches) by using ammonium nitrate compared to ammonium sulphate in the second season only. Meanwhile, such parameters weren't affected by N sources in the first one and flowering 50 % in both seasons. Nitrogen fertilizer is the most vital element for crop growth and maximum yield with good quality as it causes an increase in metabolites synthesized, photosynthesis rate, meristematic activity and assimilates transport to the seed. N fertilizer is expected to promote the growing in critical periods. However, this positive reaction continues increasing to a certain level and declines (Kusvuran, 2011). Nitrogen not only affects plant growth but may also alter the salinity tolerance of plants depending on its ionic form (Ben-Oliel, 2005). The beneficial effects of nitrate under saline conditions have been attributed to the antagonism between NO_3^- and Cl^- ions (Feigin, 1990).

With regard to the effect of nitrogen rates on plant height, branches number and flowering 50 % of canola plant, results reveal that the plant height and flowering 50 % increased significantly by adding the second and third nitrogen fertilizer rate compared to the lowest one in both seasons and first one, respectively. Meanwhile, other parameters weren't affected by N fertilizer rates. The increase in branches number per plant with increase in N rate may be due to the fact that N promoted vegetative growth and branching on the inflorescence. These results agree with those obtained by Uddin, (1992), who stated that branches number per plant significantly increased with N rates from 0 to 150 kg ha^{-1}.

Table 4. Effect of nitrogen fertilizer (sources and rates) on canola grown in calcareous soil irrigated with saline water

	Plant height (cm)				Number of branches				flowering 50%			
	Season 2011/2012											
treatment	N1	N2	N3	mean	N1	N2	N3	Mean	N1	N2	N3	mean
Urea	99.25	104.50	101.00	101.60	3.75	3.65	3.55	3.65	85.00	87.75	88.75	87.17
Ammonium nitrate	94.50	96.25	94.00	94.92	3.45	3.50	3.05	3.33	87.75	89.50	90.50	89.25
Ammonium sulphate	98.25	102.50	102.30	101.00	3.55	3.35	3.65	3.52	83.75	86.75	87.75	86.08
Mean	97.33	101.10	99.08		3.58	3.50	3.42		85.50	88.00	89.00	
L.S.D at 5%												
N Sources	NS				NS				NS			
N rates	3.205				NS				1.024			
Interaction	5.551				NS				1.774			
	Season 2012/2013											
Urea	79.75	83.75	83.50	82.33	4.30	4.55	4.50	4.45	83.25	85.25	85.75	84.75
Ammonium nitrate	89.50	93.00	96.75	93.08	4.15	4.85	4.95	4.65	90.25	87.75	88.75	88.92
Ammonium sulphate	73.75	81.50	84.00	79.75	4.20	3.95	3.85	4.00	81.00	85.50	84.50	83.67
mean	81.00	86.08	88.08		4.22	4.45	4.43		84.83	86.17	86.33	
L.S.D at 5%												
N Sources	4.96				0.5324				NS			
N rates	2.678				NS				NS			
Interaction	4.639				0.4994				6.251			

For the interaction effect between nitrogen fertilizer sources and rates on such parameters, data indicate that the plant height increased significantly by using urea and ammonium sulphate at 2nd and 3rd nitrogen fertilizer rates compared with ammonium nitrate at any levels in the first season only. Oppositely, ammonium nitrate at 2nd and 3rd nitrogen fertilizer rates gave the highest significant values of flowering 50 % and plant height, while, the lowest one was recorded when ammonium sulphate at the lowest level (30 kg N/fed.) was applied in the first and second seasons, respectively. Meanwhile, other parameters weren't affected by N fertilizer rates.

Seed weight /plant, seed yield and flowering 100%

Results in Table (5) illustrate that the seed weight/ plant and fed., improved significantly by using ammonium nitrate in both seasons. While, the lowest ones were obtained by urea in the first season and ammonium sulphate in the second one. The ammonium nitrate and urea gave the highest significant value of flowering 100% compared to ammonium sulphate in the first season only, while; the same parameter wasn't affected significantly in the second one. The required nitrogen fertilizer for vigorous growth and maximum yield production of canola are effective in all growth stages of plant. Canola plants supplied with 50:50 ratios of NH_4^+ and NO_3^- nutrition accumulated more dry matter yield than other ratios. The nitrogen form that is supplied to plants affects the uptake of other cations and anions, cellular pH regulation and the soil in the rhizosphere (Bybordi, 2012).

Table 5. Effect of nitrogen fertilizer (sources and rates) on Canola harvest in calcareous soil irrigated with saline water

treatment	Seed weight/plant (g)				Seed yield (kg\fed)				flowering 100%			
	Season 2009/2010											
	N1	N2	N3	mean	N1	N2	N3	mean	N1	N2	N3	mean
Urea	26.33	26.85	27.90	27.02	629.7	663.1	681.3	658.1	92.50	94.75	97.00	94.75
Ammonium nitrate	28.05	28.80	29.55	28.80	650.0	676.6	693.6	673.4	96.00	97.50	98.75	97.42
Ammonium sulphate	27.90	28.65	29.40	28.65	639.5	670.2	688.2	666.0	91.25	94.00	96.25	93.83
mean	27.42	28.10	28.95		639.8	670.0	687.7		93.25	95.42	97.33	
L.S.D at 5%												
N Sources	1.655				3.732				3.107			
N rates	0.3547				6.783				1.292			
Interaction	0.6143				11.75				2.238			
	Season 2010/2011											
Urea	21.98	24.15	25.50	23.88	618.2	639.8	659.2	639.1	89.75	92.50	94.25	92.17
Ammonium nitrate	23.40	29.83	27.58	26.93	648.4	668.9	727.6	681.6	93.75	92.50	93.50	93.25
Ammonium sulphate	19.65	21.52	23.55	21.58	595.4	610.4	624.0	609.9	87.50	90.75	92.75	90.33
mean	21.67	25.17	25.54		620.7	639.7	670.3		90.33	91.92	93.50	
L.S.D at 5%												
N Sources	3.530				44.67				NS			
N rates	2.726				19.53				2.624			
Interaction	4.721				33.83				4.545			

Seed weight /plant, seed yield and flowering 100% were increased by increasing nitrogen levels up to 60 kg N/fed., compared with the lowest level of nitrogen fertilizer 30 kg N/fed., in both seasons. The same trend was observed by adding the second level 45 kg/fed., for seed weight /plant and flowering 100% in the second season only. Rapeseed yield response to increasing N rates varies with different environmental variables, including weather, soil type, residual fertility (especially nitrate), soil water content, and cultivar. Growth and yield of rapeseed are superior significantly by high levels of applied N, which influencing on a number of growth parameters such as branches number, pods per plant, seeds per pod and 1000 seed weight by producing more vigorous growth and development (Cheema, 2001 and Khan, 2002). Jan, (2002), found that seed yield of winter rapeseed increased significantly when N was increased from 0 to 220 kg N ha-1 depending on site conditions. Maximum yield at higher N rates than control may be due to the fact that all yield components, i.e., number of branches per plant, number of pods per plant, number of seeds per pod and 1000 seed weight, increased with increase in N rates.

Respecting the interacted factors under study on seed weight /plant, seed yield and flowering 100%; in most cases, data presented in Table (5) show that applying ammonium nitrate at the 2nd and 3rd rates led to significant increase of such parameters compared to urea and ammonium nitrate at the lowest nitrogen fertilizer rate in both seasons. In this respect, Ghazy (2013) found that nitrogen sources had a significant effect on crop growth rate and net assimilation rate at all growth periods of sugar beet in both seasons. Ammonium nitrate surpassed other nitrogen sources in crop growth rate, root yield/fed., sugar yield/fed., TSS% and sucrose % in both seasons. Nitrogen is a major nutrient element and it's needed in large amount for high yield and it considered the most factor affecting the growth and productivity of sugar beet.

Macronutrients content in canola seed

Available data in Table (6) demonstrate that the potassium content of canola seed was increased significantly with ammonium nitrate or sulphate compared to urea form in the first season only. N and K % improved significantly when ammonium nitrate was applied compared with other nitrogen forms in the second season. On the other hand, N and P % weren't affected by nitrogen sources in the first and both season, respectively. Ashraf, (2008.) found that the comparison of N sources pointed to that calcium ammonium nitrate was better than urea because the tallest plants were in the plots treated with calcium ammonium nitrate in saline as well as normal conditions.

Table 6. Effect of nitrogen fertilizer (sources and rates) on macronutrients content for seed canola in calcareous soil irrigated with saline water

treatment	N content in seed (Kg\fed)				P content in seed (Kg\fed)				K content in seed (Kg\fed)			
	Season 2009/2010											
	N1	N2	N3	mean	N1	N2	N3	mean	N1	N2	N3	mean
Urea	18.20	21.71	21.58	20.50	2.14	2.75	3.07	2.65	12.31	13.99	16.61	14.30
Ammonium nitrate	19.13	19.86	22.62	20.54	2.42	2.56	3.17	2.72	13.69	15.65	16.89	15.41
Ammonium sulphate	18.36	20.24	21.55	20.05	2.26	2.61	2.94	2.60	13.49	15.80	16.63	15.31
Mean	18.56	20.60	21.92		2.27	2.64	3.059		13.16	15.15	16.71	
L.S.D at 5%												
N Sources	NS				NS				0.5910			
N rates	0.9178				0.2832				0.4440			
Interaction	1.590				0.4905				0.7691			
	Season 2010/2011											
Urea	17.45	19.18	21.25	19.30	2.17	2.61	2.93	2.57	12.47	14.81	15.85	14.38
Ammonium nitrate	19.59	20.83	23.07	21.16	2.24	2.78	3.34	2.79	13.89	15.98	17.89	15.92
Ammonium sulphate	17.95	19.52	20.27	19.25	2.02	2.82	2.93	2.59	12.44	14.17	15.33	13.98
mean	18.33	19.84	21.53		2.15	2.74	3.06		12.93	14.99	16.36	
L.S.D at 5%												
N Sources	1.292				NS				1.270			
N rates	0.9895				0.1937				0.6137			
Interaction	1.714				0.3355				1.063			

With respect to nitrogen fertilizer level on N, P and K % of canola seed, results reveal that the highest nitrogen level 60 kg N/fed., gave the highest significant increases of such parameters compared to the lowest level 30 kg N /fed., in both seasons. In this connection, El-Habbasha, and Taha, (2011) concluded that increasing nitrogen rates from 20 to 60 kg N/fed. significantly increased nitrogen percentage and seed protein content, while seed oil content significantly decreased.

Regarding the interacted factors under study on macronutrients content in seed, data in Table (6) revealed that a significant increase in macronutrients content with increasing doses of all sources of N application particularly ammonium nitrate, the lowest ones were recorded with three nitrogen fertilizer forms at lowest rates 30 kg N /fed., in both seasons.

Oil yield and protein percent

Results in Table (7) show that the ammonium nitrate source improved significantly oil yield of canola seed in both seasons, the same trend was observed by adding urea form in the second season only. The lowest one was recorded by ammonium sulphate and urea in both and first season, respectively. On the other hand, ammonium nitrate and sulphate gave the highest significant value of protein percentage compared to urea form in the second season only. In the first season, the same parameter wasn't affected significantly by adding different nitrogen fertilizer sources. Muharnmad, et al., (2007) concluded that the highest seed protein was produced by calcium ammonium nitrate fertilizer which was statistically at par with ammonium sulphate source while the lowest one was obtained by urea fertilizer. This may be due to high volatilization of NH_3 from urea as compared to calcium ammonium nitrate and ammonium sulphate.

Table 7. Effect of nitrogen fertilizer (sources and rates) on oil yield, oil % and protein % for seed canola in calcareous soil irrigated with saline water

Treatment	Oil yield (kg\fed)				Oil %				Protein %			
	Season 2009/2010											
	N1	N2	N3	mean	N1	N2	N3	mean	N1	N2	N3	Mean
Urea	253.6	273.8	291.6	273.0	40.27	41.29	42.80	41.45	17.94	18.88	19.56	18.79
Ammonium nitrate	265.8	286.3	297.9	283.3	40.89	42.31	42.95	42.05	18.06	20.45	19.78	19.43
Ammonium sulphate	257.4	280.9	293.0	277.1	40.25	41.91	42.57	41.58	18.39	18.34	20.39	19.04
Mean	258.9	280.3	294.1		40.47	41.84	42.77		18.13	19.23	19.91	
L.S.D at 5%												
N Sources	6.228				NS				NS			
N rates	5.160				0.5421				0.7823			
Interaction	8.937				1.0231				1.355			
Season 2010/2011												
Urea	244.3	264.1	278.3	262.2	39.52	41.28	42.22	41.01	17.65	18.74	20.14	18.84
Ammonium nitrate	255.8	280.4	306.9	281.0	39.45	41.20	42.18	40.94	18.38	19.91	20.56	19.62
Ammonium sulphate	238.4	247.5	261.8	249.2	40.04	40.55	41.91	40.85	18.59	19.55	20.21	19.45
Mean	246.2	264.0	282.3		39.67	41.01	42.12		18.21	19.40	20.30	

L.S.D at 5%			
N Sources	20.68	NS	0.3670
N rates	9.24	0.3116	0.4068
Interaction	16.01	1.1528	0.7047

Applying of highest rate of nitrogen fertilizer 60 kg N/ fed., gave the highest significant values of oil yield and protein % compared to the lower rates in both seasons. Also, data reveal that they weren't significantly affected by the 2nd and 3rd N fertilizer rate on protein % in the first season only. Öztürk, (2010)stated that canola is not only an oilseed crop, but also contains a relatively high seed protein concentration (> 400 g kg-1 oil-free meal) and its meal is used as a protein supplement for animals and possibly will be for humans in the near future. Because of its high protein content, canola and other Brassica species in general require sufficient N fertilizer during their growth for protein synthesis (Wang, 2008). Also, Öztürk, (2010)found that seed oil content increased with rising N application from 0 to 100 kg ha^{-1} and then it decreased significantly. The possible reason for the decrease in oil content with N increase may be due to the fact that N is the major constituent of protein so it might increase seed protein %, as a result oil % might decrease since it has inverse relationship with protein.

Concerning the interacted factors under study on oil yield and protein percent in canola seed, data in Table (7) show that the oil yield of canola seed increased significantly by increasing N applied rates with ammonium nitrate form compared to the lower N level with urea and ammonium sulphate forms in both seasons. On the other hand, the highest N level with any N fertilizer sources improved significantly the protein % compared to the lower N level with urea and ammonium sulphate forms in both seasons.

In calcareous soils, with pH > 7, the balance shifts to the left due the higher OH^- concentration and gaseous NH_3 is formed and lost by diffusion into the atmosphere. The formation of $(NH_4)_2CO_3$ and thus the extent of ammonia losses depends on the anion supplementary the NH_4^+ cation in the fertilizer, which forms the Ca salt. If the Ca salt is an insoluble one, then the reaction will proceed to the right causing more $(NH_4)_2CO_3$ to be formed and thus more NH_3 is generated and volatilized. But when the accompanying anion forms a soluble Ca compound, less $(NH_4)_2CO_3$ will be formed. Therefore that source which forms precipitates of low solubility with Ca such as ammonium sulfate and phosphate will suffer larger ammonia losses than ammonium nitrate or chloride, which form soluble reaction products with Ca (Wiezler, 1998). Ammonia loss can also occur in the surrounding area of hydrolyzing urea applied on the surface of high pH soils. Ammonium carbonate is produced upon urea hydrolysis, which dissociates to form NH_4^+, OH^- and CO_2. In alkaline conditions, NH_4^+ forms NH_3 that may be lost by volatilization (Mortvedt, 1999).

CONCLUSION

Nitrogen is known to be one of the most important elements for plant nutrition and development because it plays an important role as a constituent of all proteins, nucleic acids and enzymes. The sources and rates of nitrogen, the cultivars considered and the physico-chemical properties of the soil are all related to the use of nitrogen by plants. The form of nitrogen applied can play an important role in plant growth and productivity. Ammonium (NH_4^+), nitrate (NO_3^-) and urea are the forms of N fertilizers generally applied. Different nitrogen sources may be preferred for use with different plant species. Results from this investigation, ammonium nitrate as a nitrogen fertilizer source with higher level (60 kg N/fed.), surpassed other nitrogen fertilizer sources, i.e. urea or ammonium sulphate, and produced the highest significant values of all parameters of canola plants irrigated by saline water in calcareous soil.

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