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RESPONSE OF RAPESEED PLANT TO NITROGEN NUTRITION.

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ABSTRACT

The present study was carried out in pots during two growing seasons of 1997 and 1998 to study the effect of three levels (30, 60, and 90 kg N/ fed.) of three nitrogen sources (ammonium nitrate, calcium nitrate and urea) on growth, yield and some chemical compositions of rapeseed plants (*Brassica napus* L. variety N. A. 145). The obtained results indicated that, plant height, total leaf area/plant, dry weight of roots and shoots as well as number of fruiting branches/plant were significantly increased by applying different nitrogen levels. Besides, the different nitrogen sources at the level of 60 kg N/fed. significantly increased rapeseed yield and its components as well. Chlorophylls a, b and carotenoids, nitrate reductase activity, NPK contents, total carbohydrates and total free amino acids in leaves, as well as NPK concentrations, total carbohydrates, crude protein and oil percentage in seeds were also, increased by increasing nitrogen levels up to 60 kg N/fed. Meanwhile, only oil percentage and yield/plant were decreased with 90 kg N/fed. by different nitrogen forms.

In this concern, the application of ammonium nitrate followed by urea at the level of 60 kg N/fed. was the most effective level among the different applied nitrogen sources and levels on seed yield and oil yield of rapeseed plants.

INTRODUCTION

Rapeseed plant (*Brassica napus* L.*)* is consider one of the most important oil crops in the world because its seeds contain about 40 -46% oil (Hassan & El- Hakeem, 1996) . This oil could be used as an edible oil for human consumption . In Egypt, the production of oil crops is insufficient since, cropping composition does not allow enough space for oil crops. Therefore, of interest is to increase its productivity by the application of adequate form and amount of nitrogen fertilizer.

Nitrogen nutrition of this crop is important to its productivity and optimum requirements of the major nutrients which is relatively high and has been shown to vary from soil to soil. In this respect, many investigators (Noureldin *et al*., 1993; Pradhan *et al*., 1994; Hassan and El-Hakeem, 1996; Saini and Sidhu, 1997 and Said and Keshta, 1999) showed that growth and yield characters of rapeseed plant (i.e., plant height, dry matter production, number of branches/plant, number of pods/plant, seed yield/plan, weight of 1000 seeds and seed yield were significantly increased by increasing nitrogen application. Moreover, number and weight of seeds/pod were decreased with increasing N application (Abd El-Gawad *et al*., 1990 and Hocking and Mason, 1993). While, Zhao *et al.* (1993) and Islam and Evans (1994) found that seed yield parameters of rapeseed plant were significantly

increased by increasing N levels up to 300 kg N/ha. Marschner (1995) mentioned that additional application of nitrogen at the onset of flowering in crucifers plant led to an increase in seed number and yield.

The activity of nitrate reductase (NRA) could be used as a N nutritional index of the plant and also could be considered an index of the availability of reduced N by the plant for protein synthesis (Gonzalez *et al.,* 1990; Isabel *et al.,* 1992; Gasic *et al.,* 1993 and Marschner, 1995).

On the other hand, seed protein content was increased by increaseing N levels (Zhao *et al.*, 1993 and Islam and Evans, 1994). On the contrary, seed oil content decreased by increasing N application (Abd El-Gawad *et. al.*, 1990 and Said and Keshta, 1999).

The present study mainly aimed to unique the best and effective level of nitrogen sources that give in turn the highest yield of seeds and oil of rapeseed plant. Besides, this research also studied the effect of nitrogen sources and levels on the growth, yield components and some chemical constituents of rapeseed plant, all these parameters are greatly linked with the final yield.

MATERIALS AND METHODS

Two pot experiments were carried out in the greenhouse at the experimental station, Agricultural Botany Department, Faculty of Agriculture, Moshtohor, Zagazig University, Benha branch, during two growing successive seasons of 1996/97 and 1997/98 to study the effect of nitrogen nutrition on growth, yield and some chemical compositions of rapeseed (*Brassica napus*, L. variety N. A. 145) plants. Their seeds were obtained from the Field Crop Research Institute, Agricultural Research Centre, Giza Egypt. The seeds were planted (10 seeds/pot) at the 7^{th} and 10^{th} of November in the two seasons, respectively. The seedlings were thinned 20 days after sowing to four plants per pot.

Plastic pots of 30 cm in diameter were filled with 9 kg mixture of clay and sand soil (2: 1 w/w). Phosphorus and potassium fertilizers were added to the soil before sowing at the rate of 1.75 g/pot calcium superphosphate (15.5% P_2O_5) and 0.94 g/pot potassium sulphate (48% K_2O). The treatments were arranged in completely randomized design, 15 replicates (15 pots for each treatment).

Three nitrogen sources i.e., calcium nitrate (15.5% N), ammonium nitrate (33.5% N) and urea (46.0% N) were used. Each nitrogen source was applied in three levels, i.e., 30, 60, and 90 kg N/ fed. as well as without any addition of nitrogen (control). The quantities were added to each pot as 1.73, 3.48 and 5.22 g calcium nitrate/pot, 0.801, 1.611 and 2.412 g ammonium nitrate/pot and 0.585, 1.17 and 1.77 g urea/pot. The different N sources with their levels were added in two equal doses; the first dose was added at bolting formation stage (30 days after sowing), while the second one was added at the flowering stage (55 days after sowing).

- Sampling and collecting data :-

Three random samples (ten plants) were taken from each treatment at 45, 75 and 145 days after sowing in the two seasons. The plants were cleaned and separated into their main organs, (roots, shoots and pods). Also, representative samples of these organs were dried at 70°C to a constant weight. The following growth and yield characters were estimated:-

Plant height (cm), total leaf area (cm^2/plant) by using digital planimeter kp- 90 N, dry weight of root and shoot systems (g/plant), number of fruiting branches/plant, number of pods/plant, number of seeds/pod, Pod weight (g/plant), weight of 1000 seeds (g) and seed yield (g/plant).

- Photosynthetic pigments, Nitrate-reductase activity (NRA) and Total free amino acids were determined in fresh leaves according to the methods described by Nornal (1982), Jaworsky (1971) and Rosen (1957), respectively.

Total nitrogen, nitrate-N, phosphorus and potassium concentrations were determined according to the methods described by Horneck and Miller (1998), Black (1965), Sandell (1950) and Horneck and Hanson (1998), respectively. Sugars and total carbohydrates and oil contents were determined according to the methods described by Dubois *et al.* (1956) and A. O. A. C. (1990), respectively. Data concerning growth and yield characters were subjected to statistical analysis according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Growth characters:

1-Vegetative growth:

It is clear from the results in Table (1) that all applied levels of different nitrogen sources showed significant increase in plant height almost during different growth stages and the dominant significant increase of the total leaf area in both seasons. In general two parameters were increased with increasing the nitrogen levels.

On the other hand, 60 kg N/fed. of ammonium nitrate was the most effective in this respect .

In general, considering plant height and total leaf area; ammonium nitrate being the more effective source of nitrogen followed by calcium nitrate while urea ranked the last in this respect .

Also data presented in Table (1) show that, dry weight of roots was increased by using different assigned nitrogen sources parally to the applied levels.

Meanwhile the maximum significant increment in dry weight of shoots was detected by applying calcium nitrate at 60 kg N/fed during two growth

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periods when compared with other N sources and levels. The enhancement of rapeseed growth with N addition could be attributed to 1-)) increasing all division and elongation through auxin production thereby increasing internodes length and top growth (Said and Keshta, 1999) 2- Its effect upon protoplasm function hence enhancement the number of leaves and their area as well (Pradhan, 1994) and 3- enhancement of vegetative growth especially leaf area and photosynthetic activity being reflected on dry matter accumulation (in roots and shoots) during different periods and that could be in agreement to Marschner (1995) .

2- Reproductive growth :

Data presented in Table (2) show that, number of fruiting branches per plant, Pod weight, weight of 1000 seeds and seed yield per plant of rapeseed were significantly affected by applying different sources of nitrogen and their levels at 75 and 145 days after sowing in both growing seasons compared with the untreated plants.

Since, increasing nitrogen levels from 30 up to 60 kg N/fed. significantly increased most of these parameters in both seasons.

Also, the application of ammonium nitrate source at the level of 60 Kg N/ fed. gave the highest significant increase of these characters in both seasons compared with other treatments.

Moreover, as shown in Table (2) number of seeds per pod was significantly increased by the application of nitrogen sources in the first season, while insignificant increase existed in the second season when compared with the control. The maximum values of number of seeds/pod were achieved by using ammonium nitrate at the level of 30 Kg N/fed., (20.21 and 28.46 in both seasons) when compared with other treatments.

Also, it could be noticed that the high N level (90 kg N/fed) of each source caused significant reduction of the weight of 1000 seeds and seed yield in both seasons when compared with the level of 60 kg N/fed. That could be attributed to the excessive nitrogen effect on the vegetative growth more than the reproductive growth since it is well established that the unbalanced C/N ratio occurs within the plant . The obtained increases of different reproductive growth parameters of rapeseed plant with nitrogen nutrition could be attributed to the pronounced increase of leaf area (Table, 1)and efficient photosynthetic activity.hence number fruiting branches increased which increased number of flowers and pods per plant as a direct effect of nitrogen fertilizer. All of these could be reflected also on seed number / pod .In this respect, Marschner(1995) reported that the additional application of nitrogen at the onset of flowering, led to an increase in seed number and yield . Also, nearly similar results were obtained by Kullmann *et al*. (1990). Saini and Sidhu, (1997) as well as Said and Keshta, (1999) .

Some chemical constituents of rapeseed plants:

Photosynthetic pigments :

As indicated in Table (3) at 45 days after sowing calcium nitrate exhibited the highest increase of chlorophylls (chl. a & b) concentration. Meanwhile, carotenoids showed its maximum increase with ammonium

nitrate treatment followed by calcium nitrate while, urea ranked the last. On the other hand, at 75 days after sowing, NH_4NO_3 exhibited the highest increase of both chlorophylls and carotenoids as well. Also, it could be noticed that 60 kg N/fed. level of ammonium nitrate was more effective when compared with other levels of ammonium nitrate or other sources at 75 days after sowing. This result could be explained that nitrogen is an essential constituent of chlorophyll molecules and consequently chlorophyll synthesis is related to nitrogen supply.

In this respect, Gregory *et al. (*1981*)* concluded that the photosynthetic rates were closely correlated with concentration of nitrogen in the leaf. High nitrogen concentrations are usually associated with the increase in protein concentrations in leaves. Most of this protein is RUBP carboxylase, which was also increased. Therefore, emphasized the important of maintaining an adequate supply of nitrogen to leaves. Also, Marschner *(*1995*)* mentioned that nitrogen supply cause an enhancement of protein synthesis and chloroplast formation leading to an increase in the lipid content of leaves, as well as to an increase in chloroplast constituents such as chlorophyll and carotene.

Nitrate Reductase Activity (NRA) and Nitrate concentration:

Data in Table (3) clearly indicate that at 30 days after N nutrition; nitrate reductase activity (NRA) reached its maximum increase in case of ammonium nitrate treatment followed by calcium nitrate, meanwhile, urea ranked the last in this respect. Also, it could be noticed that the enzyme activity was proportional to the applied N levels of different sources. Moreover, at 55 days after sowing the two nitrate forms stimulated NRA in both two times of determination (24 & 72 hours). These results may be attributed to nitrate concentration and leaf age as mentioned by Isabel *et al.* (1992); Gasic *et al.* (1993) and Marschner (1995) that nitrate reductase activity increased with increasing nitrate concentration. However, nitrate concentration was decreased at 30 days after sowing, but it was, increased at 55 days after sowing in the two times of determination (24 & 72 hours).These findings could be attributed to the vigorous growth of treated plants during this stage as well as to the effective absorption of nitrogen. Also nitrate reduction in shoots depends on various factors such as the level of nitrate supply, plant species, plant age and carbon economy of plants (Marschner, 1995). In addition, Gonzalez *et al.* (1990), mentioned that increasing of N fertilization increased the NO_3 content and nitrate reductase activity (NRA) of wheat plant.

N, P and K concentrations and contents in leaves:

As shown in Table (4) different nitrogen sources (with different applied levels) increased NPK concentrations in the leaves. That was true either at 45 or 75 days of plant age. Also, it could be noticed that N and K concentration at 75 days dominantly exceeded when compared with their values that existed at 45 days of plant age. In addition, in most cases, calcium nitrate being more effective followed by ammonium nitrate.

Meanwhile, urea ranked the last in this respect. Furthermore, the level of 60 kg N/fed. for each nitrogen source being more effective than the other two levels (30 or 90 kg N/fed).

As for NPK, contents, data also in Table (4) show that, 60 kg N/fed. of each nitrogen source was the most effective when compared with the other applied levels. In addition, the above mentioned effects were nearly the same in the two stages of plant growth. The only exception was that slight increase of K by 90 kg N/fed. of ammonium nitrate at 75 days after sowing. The highest increase of total amount of NPK was existed in case of calcium nitrate at 60 kg N/fed. followed by ammonium nitrate. In this respect, Hocking and Mason *(*1993*)* and Islam and Evans *(*1994*)* were nearly in agreement with the present findings. Also, it is well known that, nitrate commonly increase cations absorption while ammonia could increase the absorption of anions (Marschner, 1995).

Similarly, Nieuwhof and Jansen *(*1993*),* working on radish, mentioned that increasing N-fertilization enhanced nutrient uptake. This may due to the role of nitrogen in activating the physiological functions of plant cells and in turn, stimulate the uptake of these nutrients from the soil solution. Moreover, antagonism between high nitrogen level and P or K uptake was reported in lettuce plants by Shafshak and Abo Sedera *(*1990). These increases in mineral uptake especially N, might contributed to their superiority in increasing vegetative growth of plant and increasing nitrogen and amino acids concentrations.

Total free amino acids, sugars and total carbohydrates concentrations in leaves:

As indicated in Table (5) both nitrate forms (calcium and ammonium nitrates) increased total free amino acids concentrations in leaves of treated plants. On the other hand, urea as nitrogen source strictly decreased this concentrations compared with the untreated plants. The favourable effect of nitrogen fertilization on the total free amino acids content might be due to high nitrogen content in the plant tissues (Table 4) and high photosynthetic activity leading to high keto and amino acids formation in rapseed leaves (Sakr and Mohamed, 1996). In this respect, Abo El-Ghait (1993), working on *Strelitzia reginae Ait*, mentioned that the total amino acids increased by urea followed by ammonium nitrate.

With regard to the sugars concentrations, data in Table (5) showed that different nitrogen sources with the applied levels increased the total sugars content in leaves of rapeseed at 75 days after sowing. Also, it could be noticed that calcium nitrate was more effective followed by urea, but ammonium nitrate ranked the last. Also, both reducing and non-reducing sugars were increased with different nitrogen forms. The highest increase of reducing sugars was existed in case of urea followed by calcium nitrate. Meanwhile, calcium nitrate followed by urea showed the highest, increases of the non-reducing ones.

The total carbohydrates concentration was highly increased by, ammonium nitrate application in comparison with calcium nitrate or urea as

other nitrogen sources (Table 5). Also, the levels of 30 and 60 kg N /fed. of each nitrogen source were more effective than the highest applied level (90 kg N/ fed.)

Regarding the positive effects of nitrogen fertilizers on sugars and carbohydrates concentration may be due to its influence on photosynthetic efficiency (Gregory *et al.,* 1981). Similar effects were, nearly, found by Abo El-Ghait *(*1993*)* who found that urea and ammonium nitrate at 80 and 120 kg N/fed. significantly increased total carbohydrate content in leaves of *Strelitzia reginae Ait*.

N, P and K, crude protein, total carbohydrates and oil percentage and yield/plant in seeds:

Data in Table (5) clearly indicate that different nitrogen sources with different levels increased NPK concentrations in the seeds of treated rapeseed plants. Also, it could be noticed that in most cases the level of 60 kg N/fed. of each nitrogen source exhibited maximum increase of NPK concentrations. Moreover, only in case of urea different levels decreased potassium concentration. Exception, was only that increase existed in potassium concentration with 60 kg N/fed. Furthermore, it is obvious that ammonium nitrate was the most effective source for nitrogen when compared with the two other sources (calcium nitrate and urea) regarding NPK concentrations. In this respect, Bullock and Sawyer (1991) and Hocking and Mason (1993) working on rapeseed nearly reported similar results with different nitrogen sources.

As for the crude protein in seeds of rapeseed plants, data in Table (5), clearly, indicate that different nitrogen sources and levels increased this content. Also, ammonium nitrate was more effective in this respect followed by urea while calcium nitrate ranked the last.

With regard to carbohydrates, different nitrogen sources as well as their levels showed obvious increase of its content similarly to the effect upon crude protein. In addition, the increases of oil percentages in seeds of nitrogen feeded plants are completely reversed on the total oil yield per plant. In this respect, Said and Keshta (1999) found that seed oil percentage was decreased by nitrogen level at 60 kg N/fed., while, seed oil yield/plant was significantly increased with increasing N level from 30 kg N/fed. to 60 kg N/fed. However, 90 kg N/fed. decreased the oil yield/plant with different applied nitrogen sources. This reduction in seed oil percentage may be due to adversely established correlation between N application and seed oil content. On the other hand, Increasing the level of N nutrition enhanced the content of crude protein and decreased seed fat content in rapeseed plants (Appelqvist, 1986 and Abd El-Gawad *et al.,* 1990).

Mostly, different nitrogen sources with their applied levels increased different major assimilation products i.e. protein, carbohydrate and oil as well.

Generally, the significant and positive effect of nitrogen nutrition upon different growth and yield aspects of rapeseed plant are mostly preceded with the stimulation of both enzymes creation and activities responsible for various methabolic processes. Most growth and yield parameters were increased

with nitrogen addition and the maximum growth was existed in case of the two nitrate forms. The increase in photosynthetic area and chlorophyll content (Table, 3) are accompanied with more dry matter accumulation with nitrates addition (Table, 1). Hence, the enhancement of growth is the result of the reflection of the uptake of the different nutrients (Table, 4) as NPK as well as the net product of different bioconstituents (Table, 5). Therefore, the obtained data of the present study confirm the priority of ammonium nitrate at the level of 60 kg N/fed. as a precise indicator for the growth and yield of rapeseed plant. On the other hand, calcium nitrate was highly stimulated the vegetative growth and to some extend the dry matter accumulation and minerals content. However, this enhancement being on the account of the economic part of such a plant, *i.e.,* seed yield and oil yield as well.

Therefore, the present study strongly recommends the use of ammonium nitrate with the level of 60 kg N/fed. followed by urea with 60 kg N/fed. as they increased seed yield and oil yield in rapeseed plants.

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استجابة نبات الشلجم للتغذية بالنيتروجين

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أجريت تجربة أصص خلال عامي ١٩٩٧، ١٩٩٨ بهدف دراسة تأثير ثلاث صور من النيتروجين بثلاث مستويات لكل منها علي النمو ومكونات المحصول وبعض المكونات الكيميائية في أعضاء النبات المختلفة وأيضاً البذور. استخدمت ثلاث صور من النيتروجين هي نترات الكالسيوم و نترات الأمونيوم و اليوريا بثلاث مستويات هي ٣٠، ٦٠، ٩٠ كجم ن/للفدان أضيفت علي دفعتين بعد ٣٠، ٥٥ يوم من الزراعة بالاضافة إلي معاملة المقارنة (بدون اضافة النيتروجين) وأهم النتائج المتحصل عليها هي:

- أظهرت النتائج زيادة معنوية فى طول النبات ، مساحة الأوراق الكلية/للنبات ، الوزن الجاف لكل من المجموع الجذري و الخضري ، وعدد الأفرع الثمرية بكل من صور ومستويات النيتروجين المستخدمة مقارنة بالنباتات الغير معاملة في مراحل النمو المختلفة.
- أدّت المعاملة بمستوي ٦٠ كجم ن/للفدان من كل من صور النيتروجين الثلاثة (نترات الأمونيوم و اليوريا ونترات الكالسيوم) إلي زيادة معنوية في مكونات المحصول وهي عدد القرون للنبات الواحد، عدد البذور في القرن، وزن ١٠٠٠ بذرة و محصول البذرة للنبات الواحد في معظم الحالات.
- أظهرت النتائج زيادة محتوي الأوراق من الكلوروفيلات والكاروتينات ونشاط إنزيم اختزال النترات، النيتروجين والفسفور والبوتاسيوم والنيتروجين النتراتي ، السكريات والكربوهيدرات الكلية والأحماض الأمينية االحرة لكلية بمستوي النيتروجين ٦٠ كجم ن/للفدان لكل من الصور الثلاثة المستخدمة.
- كما أظهرت النتائج زيادة محتوي البذور من النيتروجين والفوسفور و البوتاسيوم ، البروتين ، الكربوهيدرات والنسبة المئوية للزيت ومحصول الزيت/نبات بزيادة المستوي النيتروجيني حتى ٦٠ كجم ن/للفدان وعلي العكس انخفضت النسبة المئوية ومحصول النبات من الزيت بمستوي النيتروجين ٩٠ كجم ن/للفدان من كل من الصور الثلاثة المستخدمة.
- كما أظهرت النتائج أن أعلي زيادة في النسبة المئوية ومحصول النبات الواحد من الزيت كانت باستخدام نترات الأمونيوم يليها اليوريا بمستوي ٦٠ كجم ن/للفدان لكل منها.
- أظهرت الدراسة أن أفضل صورة يمكن استخدامها لزيادة محصول البذور والزيت لنبات الشلجم هي نترات الأمونيوم بمستوي ٦٠ كجم ن/للفدان ثم اليوريا بمستوي ٦٠ كجم ن/للفدان أيضا. مما يوصي باستخدام هذه الصور بغرض الحصول علي أعلي محصول من البذور والزيت من نبات الشلجم بالإضافة إلي المكونات الأخرى للبذور بعد استخلاص الزيت منها.

Table (3) Effect of different nitrogen sources and levels on photosynthetic pigments , nitrate reductase activity (μg NO_2/ g^{-1} f.w/h^{-1}) and nitrate content (mg/g d.w.) in leaves of rapeseed plant during 1998 season.

Treatments		Chlorophylls mg/g f.w								Nitrate reductase activity (μg NO_2/ g^{-1} f.w/h^{-1})				Nitrate (mg/g d.w.)			
N sources	N levels kgN/fed.	at 45 days after sowing				at 75 days after sowing				Days after sowing				Days after sowing			
		Chl. a	Chl. b	Chl. a+b	Carot-enoids	Chl. a	Chl. b	Chl. a+b	Carot-enoids	30		55		30		55	
										24 h	72 h	24 h	72 h	24 h	72 h	24 h	72 h
Control		0.754	0.348	1.102	0.498	0.172	0.082	0.253	0.184	0.156	0.212	0.268	0.393	1.107	2.104	0.939	1.221
Calcium nitrate	30	1.553	0.790	2.343	0.788	0.432	0.233	0.665	0.237	0.349	0.456	0.399	0.587	1.065	2.024	1.149	1.494
	60	1.560	0.857	2.417	0.878	0.463	0.238	0.701	0.253	0.393	0.518	0.555	0.618	1.093	2.077	1.177	1.530
	90	1.725	0.828	2.553	0.620	0.360	0.182	0.542	0.223	0.368	0.537	0.574	0.630	0.967	1.837	1.233	1.603
Average		1.613	0.825	2.438	0.762	0.418	0.218	0.636	0.238	0.370	0.503	0.510	0.612	1.041	1.98	1.186	1.54
Ammonium nitrate	30	1.276	0.778	2.054	0.781	0.552	0.259	0.811	0.274	0.268	0.543	0.655	0.618	1.093	2.077	1.009	1.312
	60	1.253	0.614	1.867	0.871	0.578	0.341	0.919	0.282	0.406	0.555	0.668	0.636	1.065	2.024	0.967	1.257
	90	1.516	0.775	2.291	0.788	0.400	0.204	0.604	0.221	0.612	0.568	0.674	0.643	1.055	2.024	0.967	1.257
Average		1.348	0.722	2.070	0.813	0.510	0.268	0.778	0.259	0.428	0.555	0.666	0.632	1.074	2.042	0.981	1.275
Urea	30	1.255	0.610	1.865	0.541	0.315	0.149	0.464	0.178	0.200	0.381	0.324	0.468	0.981	1.864	0.897	1.166
	60	1.983	0.574	2.557	0.472	0.291	0.197	0.488	0.180	0.175	0.318	0.343	0.361	0.930	1.470	0.650	0.865
	90	1.067	0.554	1.621	0.456	0.442	0.202	0.643	0.244	0.181	0.275	0.406	0.474	0.771	1.464	0.671	1.037
Average		1.435	0.579	2.014	0.490	0.349	0.182	0.532	0.201	0.185	0.324	0.358	0.434	0.894	1.600	0.740	1.023

Table (4) Effect of different nitrogen sources and levels on N, P and K concentrations and contents in leaves of rapeseed plant during 1998 season.

Treatments		Concentration (mg/g d.w.)						Contents (mg/plant)					
		N		P		K		N	P	K			
N sources	N levels kgN/fed	Days after sowing						Days after sowing					
		45	75	45	75	45	75	45	75	45	75	45	75
Control		5.95	8.05	3.30	4.40	9.81	11.10	21.02	81.73	11.7	44.7	34.67	112.69
Calcium nitrate	30	16.80	22.40	6.60	5.00	13.75	17.60	214.93	434.86	84.4	97.1	175.91	341.67
	60	18.20	26.88	7.20	5.50	12.44	18.15	281.43	593.60	111.3	121.5	192.34	400.81
	90	18.20	24.50	7.20	5.50	13.75	18.70	226.71	467.38	89.6	104.9	171.28	356.79
Average		17.73	24.59	7.00	5.30	13.31	18.15	241.02	498.52	95.1	107.83	179.84	366.4
Ammonium nitrate	30	23.80	15.40	7.70	5.50	10.06	15.95	241.09	257.95	78.0	92.1	101.90	267.16
	60	24.50	19.60	8.80	6.10	11.00	15.95	265.01	341.76	95.2	106.4	118.98	278.11
	90	22.40	20.30	7.70	5.00	11.55	17.75	224.00	337.39	77.0	83.1	115.50	295.03
Average		23.57	18.43	8.10	5.50	10.87	16.55	243.37	312.37	83.4	93.87	112.13	280.10
Urea	30	18.20	14.00	4.40	6.10	10.32	13.75	149.66	207.81	36.2	90.5	84.89	204.10
	60	15.40	16.52	3.90	6.30	9.97	15.02	155.90	276.60	39.5	105.5	100.92	251.54
	90	15.40	15.40	3.30	6.10	9.89	15.22	146.81	248.76	31.5	98.5	94.33	245.92
Average		16.33	15.31	3.90	6.10	10.06	14.67	150.79	244.39	35.73	98.17	93.38	233.85

Table (5) Effect of different nitrogen sources and levels on total free amino acids, total carbohydrates and sugars in leaves and NPK, crude protein, total carbohydrates and oil percentage and yield/plant of seeds of rapeseed plant during 1998 season.

Treatments		Leaves					Seeds						
		at 75 days after sowing					at 145 days after sowing						
N sources	N levels kg N/Fed.	Total free amino acids mg/g f.w.	Total carbohydrates mg/g d.w	Sugars mg/g f.w.			N	P	K	Crude protein mg/g	Total carbohydrates mg/g	Oil %	Oil yield/ plant (g)
				reducing	non-reducing	Total	mg/g d.w.						
Control		5.24	473.9	2.59	3.92	6.51	16.5	0.63	9.35	87.5	235.0	25.23	7.43
Calcium nitrate	30	5.71	498.1	3.07	11.44	14.51	24.6	0.77	9.63	130.4	326.3	35.24	10.62
	60	6.10	499.5	5.30	12.86	18.16	27.5	0.88	10.55	145.8	353.2	36.21	11.63
	90	5.71	476.9	4.75	12.28	17.03	22.8	0.83	9.99	120.8	304.0	30.12	9.15
Average		5.84	491.5	4.38	12.19	16.57	24.97	0.83	10.05	132.3	327.8	33.86	10.47
Ammonium nitrate	30	5.96	572.2	2.90	5.82	8.72	27.5	0.83	9.16	145.8	412.3	37.26	13.13
	60	6.02	603.3	5.15	4.54	9.69	34.5	0.96	9.72	182.9	364.8	39.56	14.74
	90	5.99	589.8	3.29	6.24	9.53	37.2	0.94	9.42	197.2	355.2	32.42	10.79
Average		5.99	588.3	3.78	5.53	9.31	33.10	0.91	9.44	175.3	376.1	36.41	12.89
Urea	30	2.91	505.7	5.15	4.24	9.39	39.5	0.74	8.31	161.7	326.3	33.21	10.38
	60	2.94	498.1	3.71	9.25	12.96	33.00	0.80	8.80	174.9	351.4	40.25	13.07
	90	2.88	494.4	5.44	5.91	11.35	30.50	0.72	8.87	161.7	353.2	31.21	9.57
Average		2.91	499.4	4.77	6.47	11.24	31.30	0.75	8.66	166.1	343.6	34.89	11.01

Table (1): Effect of different nitrogen sources and levels on plant height, total leaf area (cm^2), dry weight of roots and shoots / plant (g) of rapeseed plant during different periods of growth in the two successive seasons,1997 and 1998.

Treatments		Plant height (cm2)				Total leaf area / plant(cm^2)				Dry weight of Roots / plant (g)				Dry weight of shoots/plant (g)			
		Seasons				Seasons				Seasons				Seasons			
		1997		1998		1997		1998		1997		1998		1997		1998	
		Days after sowing				Days after sowing				Days after sowing				Days after sowing			
N Source	N Levels kg N/fed.	75	145	75	145	45	75	45	75	45	75	45	75	45	75	45	75
Control		52.34	103.40	65.32	129.34	2234	2765	2456	3134	0.452	0.498	0.523	0.689	9.340	26.32	10.60	30.46
Calcium Nitrate	30	65.34	134.25	70.23	165.23	3421	5321	4687	5987	0.543	0.576	0.632	0.756	28.230	55.41	38.38	58.24
	60	69.84	145.36	73.26	172.35	3984	5674	4951	6412	0.602	0.635	0.654	0.783	35.000	60.07	46.39	66.25
	90	70.34	142.34	69.35	172.09	3657	5823	4832	6321	0.587	0.612	0.556	0.689	36.000	56.52	37.37	57.23
Average		68.51	140.65	70.95	169.89	3687	5606	4823	6240	0.58	0.61	0.61	0.74	33.08	57.33	40.71	60.57
Ammonium Nitrate	30	60.35	186.35	74.35	187.65	4211	6341	4678	6124	0.632	0.665	0.701	0.754	18.730	30.22	30.39	50.25
	60	72.35	188.67	76.45	202.13	4531	6541	4689	6357	0.654	0.675	0.698	0.812	22.230	33.47	32.45	52.31
	90	69.85	179.35	71.25	189.58	4721	6423	4632	6241	0.573	0.586	0.666	0.810	17.940	26.74	30.00	49.86
Average		67.52	184.79	74.02	193.12	4488	6435	4666	6241	0.62	0.64	0.69	0.79	19.63	30.14	30.95	50.81
Urea	30	56.67	129.35	69.13	169.83	3751	5321	4321	7124	0.498	0.512	0.543	0.712	17.230	38.40	24.67	44.53
	60	66.35	146.25	70.25	170.32	3642	5671	4561	7345	0.512	0.532	0.567	0.743	24.230	36.20	30.37	50.23
	90	63.21	144.00	73.25	172.23	4237	5732	4351	7012	0.506	0.511	0.512	0.712	21.250	35.15	28.60	48.46
Average		62.08	139.87	70.88	170.79	3877	5575	4411	7160	0.51	0.52	0.54	0.72	20.90	36.58	27.88	47.74
L.S.D. at 5%		2.54	1.34	5.26	2.81	189	200	123	116	N.S	0.130	0.029	0.126	0.750	1.65	0.260	1.72

N.S. = Not significant

Table (2): Effect of different nitrogen sources and levels on yield and yield components of rapeseed plant at 75 and 145 days after sowing in the two successive seasons1997 and 1998.

Treatments		No. of fruiting branches / plant				Number of pods/plant				Pod weight (g)		Number of seeds /pod		Weight of 1000 seeds (g)		Seeds yield/plant (g)	
		Seasons				Seasons				Seasons		Seasons		Seasons		Season	
		1997		1998		1997		1998		1997	1998	1997	1998	1997	1998	1997	1998
		Days after sowing				Days after sowing				Days after sowing				Days after sowing			
N Source	N Levels kg N/fed.	75	145	75	145	75	145	75	145	145	145	145	145	145	145	145	145
Control	0	4.00	6.30	5.12	9.14	22.35	87.35	28.21	103.25	1.07	1.98	13.65	19.23	1.028	2.250	20.03	29.45
Calcium Nitrate	30	7.75	10.40	8.35	14.20	32.45	123.54	42.31	142.35	1.15	2.13	16.02	22.56	1.261	2.760	20.49	30.13
	60	7.50	11.02	9.25	10.50	33.21	145.23	41.21	148.32	1.55	2.87	18.08	25.46	1.179	2.580	21.84	32.12
	90	5.50	10.12	9.86	11.09	38.21	144.21	40.35	140.25	1.37	2.54	17.19	24.21	1.074	2.350	20.66	30.38
Average		6.92	10.51	9.15	11.93	34.62	137.66	41.29	143.64	1.36	2.51	17.09	24.08	1.17	2.56	21.00	30.88
Ammonium Nitrate	30	6.5	7.13	9.36	9.05	37.65	150.21	46.35	155.65	1.45	2.68	20.21	28.46	1.362	2.980	23.96	35.24
	60	8.75	10.12	9.87	11.23	38.57	156.02	48.37	184.32	1.68	3.12	19.34	27.24	1.426	3.120	25.33	37.25
	90	9.75	11.06	8.68	10.35	35.36	154.20	45.32	175.32	1.51	2.79	18.86	26.57	1.321	2.890	22.62	33.27
Average		8.33	9.44	9.30	10.21	37.19	153.48	46.68	171.76	1.55	2.86	19.47	27.42	1.37	3.00	23.97	35.25
Urea	30	5.50	7.12	9.23	13.06	28.26	119.32	32.38	145.23	1.27	2.36	17.28	24.34	1.426	3.120	21.26	31.26
	60	4.50	7.57	8.36	20.12	29.34	120.21	35.32	148.32	1.44	2.67	16.66	23.46	1.485	3.250	22.08	32.47
	90	5.25	6.98	10.20	15.47	27.21	119.56	34.26	147.23	1.16	2.14	16.81	23.67	0.909	1.990	20.86	30.67
Average		5.08	7.22	9.26	16.22	28.27	119.70	33.99	146.93	1.29	2.39	16.91	23.82	1.274	2.787	21.40	31.47
L.S.D. at 5%		1.36	0.95	1.03	0.52	0.65	5.60	0.35	3.20	N.S.	0.02	0.6	N.S.	0.050	0.062	0.54	0.64

N.S. = Not significant