# Physical and chemical studies on some rapeseed varieties undr different levels of nitrogen fertilization

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**Abstract**

The present work was carried out at El-Serw Agric. Res. Station during the tow successive seasons of 2002/2003 and 2003/2004, to study the effect of four levels of nitrogen fertilization (0, 30, 60 and 90 kg/N/acre) on three rapeseed varieties, namely, Pactol, Serw 4 and Serw 6. The study included seed yield and some yield components, some physical and chemical properties of the extracted oils and total glucosinolates of the seed. The obtained results could be summarized as follow:

1- Serw 6 var. gave the highest seed yield followed by Serw 4 and Pactol, which gave the lowest yield.

2- the optimum N dose for realizing the highest seed yield for Serw 4 and Serw 6 was 90 kg N/acre while, for Pactol was 60 kg N/acre.

3- Pactol Var. contained the highest content of oil compared with the other tow varieties, but it gave the lowest value of seed yield and subsequently oil yield. Increasing N rate up to 90 kg/acre decreased seed oil content, but increased oil yield/acre and protein content and protein yield in all varieties.

4- Negligible differences in saponification values. While, refractive index and iodine values of oils of Serw 4 and Serw 6 were similar and exceeded those of Pactol. N fertilization had no effect on saponification values, while N rates up to 90 kg/acre caused a slight decrease in iodine value and refractive index.

5- Total saturated fatty acids were similar in the three varieties and ranged between 6.7 and 7.8%. Palmitic was the most predominant.

6- Oleic was the predominant unsaturated fatty acid in the three varieties.

7- The highest amount of linoleic acid was found in Serw 4 followed by Serw 6 and Pactol. So, Serw 4 characterized with high content of essential fatty acid linoleic indicating high nutrition value.

8- Erucic acid content of the three rapeseed oils was very low, less than 2%. Therefore, there is no hazard in consumption rapeseed oil extracted from the varieties under investigation.

9- Nitrogen rates up to 90 kg/acre caused little differences in fatty acid composition. For instance, oleic acid content increased at the expense of linoleic and linolenic acids.

10- All rapeseed varieties under study characterized by having low contents of glucosinolates (less than 30 μmoles/g meal), N fertilization had insignificant effect on total glucosinolates in meals of rapeseed varieties.

11- Finally, increasing N rates increased NPK contents in seeds of the three rapeseed varieties.

## Introduction

Due to the fact Egyptian Farmers are not acquaint with such newly introduced crop as rapeseed. So, several advantages are favoring rapeseed to grown in Egypt as a source of edible oil. Recently, Egyptian plant breeders were meditating on producing new varieties with very low or free from erucic acids as well as free or contain very low level of glucosinolates (double zero rapeseed). In other words, the new varieties contain no more than 2% erucic acid and glucosinolates less than 20 μ moles/g meal (Keshta and Leilah, 2003).

Nitrogen fertilization is important factor affect yield and quality of rapeseed genotypes. Seed yield and yield attributes increased by increasing N levels up to 240 kg/ha (Mekki, 2003). While Ali and Zaman(1997) mentioned that the N application up to 120 kg/ha. Caused the highest seed yield, yield components and Stover yields/ha.

The quality of rapeseed oil for human consumption is evaluated by its erucic acid content, since it is believed to cause myocardial lesions in experimental male rate, however, it is poorly digested by man (Tahoun et al., 1999). In this respect, wetter et al. (1970) concluded that oil content and its fatty acids composition of rapeseed oil did not appear to be seriously affected by fertilizers and environment. However, numerous studies reported that increasing nitrogen rate decreased the oil content, but increased oil yield, while both protein content and protein yield increased with higher nitrogen rate (Abdel – Gawad et al. 1990, Brenan et al. 2000 and Sahoo et al. 2000).

On the other hand, the glucosinolates content of rape meal in animal feeding is important due to the bitter taste of their products impart to the meal reduced its palatability. Nordestgaard et al. (1984) concluded that rapeseed with nitrogen rate from 0 to 300 kg/ha, no changes were observed in the content of glucosinolaes.

Concerning element contents, Mekki (2003) pointed out that nitrogen, phosphorus and potassium concentration increased with increasing nitrogen rates. Also, in the later growth stages much of the nitrogen and phosphorus was translocated to the developing seeds.

This study was implemented to investigate the effect of nitrogen fertilization levels on some characteristics of rapeseed varieties under Egyptian agro ecological conditions.

These include seed yield, seed index, oil contents and oil yield, crude protein contents and protein yield, element contents,

some physical and chemical properties of extracted oil, total carbohydrates, crude fiber and total glucosinolate contents.

## Material and methods

Tow field experiments were conducted at El-Serw Agricultural Research station, Damietta Governorate, Egypt during tow successive winter seasons 2002/2003 and 2003/2004. The soil type at the experimental site is clay in texture with Ph 8.2-8.4 and 1.5-1.6 organic matter, E.C ds/m 4.8-5.1 and available N was 38-42.

A split-plot design with four replications was implemented. Three rapeseed varieties (Brassica napus L.) were allocated to the main plots. The sub-plots (3.5 m long and 3.0 m width) were devoted to the following nitrogen rates (0, 30, 60 and 90 kg/acre) supplied from urea (46% N). On November, 24 and 18 in 2002/2003 and 2003/2004 seasons, seeds of French rapeseed Pactol cultivar and tow Egyptian varieties, Serw 4 and Serw 6 as (double zero) because of low or absence of erucic acid and low glucosinolate content were sown. The three varieties were obtained from Oil Crop Res. Dep., Agric. Res. Center. Nitrogen fertilizer was applied in tow equal doses after thinning just before the first irrigation and the second irrigation. Equal doses (15 kg $P_2O_5$/acre) of super phosphate (15% $P_2O_5$) were added to all treatments before planting.

At harvest the three inner rows from each sub-plot were taken for determine the seed yield and yield attributes. The dry seed samples were ground and wet digested with $H_2SO_4$-$HclO_4$ mixture. NPK% was determined using the method as described by Jakson (1967). Crude protein content was calculated by multiplying N% by the converting factor 6.25 (Robinson, 1975). Protein yield (kg/acre) was also calculated by multiplying crude protein by seed yield. Seed oil percentage, fatty acid composition and its physical and chemical characteristics were determined according to AOAC (1990). Oil yield (kg/acre) was calculated by multiplying oil percentage by seed yield. Average values from the four replications of each treatment were interpreted using the analysis of variance (ANOVA) with separation of means accomplished using LSD at 5% according to Snedecor and Cochran(1967).

## Results and discusions

*1- Seed yield and seed index:*

Data in Table (1) revealed that there was significant increase in seed yield for Pactol variety with the increasing of nitrogen levels up to 60 kg/acre, then the seed yield was decreased by adding 90 kg N/acre. The increment percentage of seed yield (means of the tow seasons) was 36.40, 57.50 and 55.20% at 30, 60 and 90 kg N/acre respectively compared with the control. The same trend was observed for the 1000 seed weight.

Regarding to Serw 4 and Serw 6 varieties, data in Table (1) showed significant increase in seed yield due to nitrogen application rates up to 90 kg N/acre. The increment percentage of seed yield were 26.00, 56.80 and 71.80% for Serw 4 and 25.18, 49.36 and 65.63% for Serw 6 over the control at the above mentioned n rates, respectively.

The same trend was observed for the seed index. On the other hand, these results indicated that rapeseed varieties serw 4 and Serw 6 were more responsive to nitrogen fertilization than Pactol variety. This may be attributed to suitable Egyptian agro ecological conditions for growing the local varieties. These results are in agreement with those obtained by Abdel Gawad et al. (1990), Ahmed et al. (1999) and Keshta and Leilah (2003).

*2- Oil content and oil yield:*

Data in Table (1) showed that Pactol Var. gave the highest values of oil contents while; Serw 6 gave the lowest values among the three varieties under investigation. It may be due to genetic factors properties (Jiao, 1991). On the other hand, nitrogen had adverse effect on oil content as the levels of N increased up to 90 kg/acre. This might be due to reducing the availability of carbohydrates for oil synthesis at adequate N supply (Mekki, 2003).

Regarding the oil yield, Serw 4 Var. recorded the highest values of oil yields while, Pactol Var. gave the lowest mean values of oil yield. Although, increasing nitrogen fertilization rates decreased oil content of rapeseed, the oil yield could be increased due to the increase in seed yield as a result of increasing nitrogen fertilization. In this respect, increasing N rates from 0 to 30, 60 or 90 kg/acre increased oil yield by 34.9, 52.7 and 48.3% respectively for Pactol Var., 24.0, 52.1 and 63.1% for Serw 4 and 23.6, 45.8 and 58.4% over the control for Serw 6. Abdel Gawad et al. (1990) reported that nitrogen fertilization of rapeseed plants up to 90 kg/acre increased oil yield, but oil percentage decreased.

*3- Protein content and protein yield:*

Data in Table (1) showed that there was a significant increase in protein content of rapeseed varieties as a result of raising nitrogen rate from 0 up to 90 kg/acre. Also, protein content was found to be higher in Serw 6 than the other two varieties. The increment in protein content might be explained by increasing amination of such metabolites, which are precursors common to both amino acids and acetyl CoA.

Concerning protein yield, the same Table revealed that increasing N fertilization up to 90kg/acre increased protein yield compared to control. The same results obtained by Jeff Russel (1999) and Mekki (2003).

*4- Physical and chemical properties of the extracted oil of rapeseed:*

The quality of oil could be detected by determination of some physical and chemical properties of oil extracted from rapeseed varieties under investigation such as refractive index (RI), Iodine value (IV), Saponification value (SV) and Fatty acids composition.

**Table (1): Yield and yield components of rapeseed varieties as affected by nitrogen fertilization.**

| Treatments | Seed yield Kg /acre | 1000 seed weight g | Oil % | Oil yield Kg/acre | Protein % | Protein yield Kg/acre |
|---|---|---|---|---|---|---|
| | | | First season | | | |
| Varieties | | | | | | |
| Pactol | 754.7 | 3.00 | 43.73 | 330.03 | 19.14 | 144.45 |
| Serw 4 | 1023.3 | 3.26 | 42.00 | 429.79 | 20.22 | 206.91 |
| Serw 6 | 1054.3 | 3.25 | 40.19 | 423.72 | 21.38 | 225.41 |
| LSD at 0.05 | 29.10 | 0.04 | 1.20 | 28.6 | 0.80 | 21.7 |
| N levels (kg/acre) | | | | | | |
| 0 | 740.5 | 3.16 | 43.02 | 318.56 | 18.71 | 138.55 |
| 30 | 932.6 | 3.16 | 42.38 | 395.24 | 19.57 | 182.51 |
| 60 | 1160.0 | 3.31 | 41.75 | 484.30 | 20.68 | 239.89 |
| 90 | 1260.0 | 3.41 | 40.75 | 513.45 | 21.93 | 276.32 |
| LSD at 0.05 | 45.70 | 0.18 | 0.14 | 27.31 | 0.92 | 34.30 |
| | | | Second season | | | |
| Varsities | | | | | | |
| Pactol | 841.6 | 3.1 | 43.99 | 370.22 | 18.78 | 158.05 |
| Serw 4 | 1045.5 | 3.43 | 42.14 | 440.57 | 20.34 | 212.65 |
| Serw 6 | 1082.2 | 3.28 | 40.19 | 434.94 | 21.45 | 232.13 |
| LSD at 0.05 | 33.40 | 0.12 | 1.33 | 26.8 | 0.95 | 23.4 |
| N Levels (kg/acre) | | | | | | |
| 0 | 751.4 | 3.25 | 43.14 | 324.15 | 18.94 | 142.32 |
| 30 | 947.5 | 3.35 | 42.49 | 402.59 | 19.84 | 179.46 |
| 60 | 1180.0 | 3.51 | 41.83 | 493.59 | 20.92 | 246.86 |
| 90 | 1303.0 | 3.59 | 41.10 | 535.53 | 21.64 | 281.97 |
| LSD at 0.05 | 51.10 | 0.04 | 0.17 | 39.82 | 0.41 | 33.21 |

Physical properties

Refractive index and iodine value are used basically for estimation the unsaturation degree. Data in Table (2) showed a slight decrease of refractive index and iodine value of rapeseed oil as a result of raising N levels up to 90 kg/acre. Pactol recorded the lowest values, while Serw 4 had much higher values in the means than the other two varieties. Also, the decrease in both RI and IV is clearer at the high rate of N level (90 kg/acre). This may be attributed to late flowering, which affected fatty acids synthesis and lowered both RI and IV (Saleh, 1997).

On the other hand, saponification value (SV) inversely proportional to the molecular weight of the oil. The replacement of long chain fatty acids like erucic acid ($C_{22:1}$) by $C_{18}$ fatty acids increase the saponification number due to the reduction in molecular weight (Ackman, 1999). The present data in Table (2) showed that the three studied rapeseed oils had almostly no differences in saponification acid and peroxide values as a result of raising N levels. The same trend was obtained by Saleh, (1997).

It can be noticed from the obtained data that nitrogen fertilization levels has almost slight effect on oil physical properties of the three rapeseed varieties under study.

Chemical properties

Data in Table (3) show the fatty acids composition of the rapeseed varieties under study. It is evident from these results that GLC chromatography of the extracted oil showed the presence of the following fatty acids: $C_{14:0}$, $C_{16:0}$, $C_{16:1}$, $C_{18:0}$, $C_{18:2}$, $C_{20:0}$, $C_{20:1}$ and $C_{22:1}$.

(A):Saturated fatty acids (SFA):

The same data showed that saturated fatty acids, myristic ($C_{14:0}$), stearic

($C_{18:0}$), and arachidic ($C_{20:0}$) were detected in small amount (1% or below). While, the predominant saturated fatty acid was palmitic ($C_{16:0}$) for the three rapeseed varieties.

With regard to N fertilization effect, data showed a slight effect on saturated fatty acid contents of Pactol and Serw 4, while saturated fatty acid contents of Serw 6 were no affected by N fertilization.

(B): Unsaturated fatty acids (UFA):

Concerning the mono-unsaturated fatty acids, data in Table (3) revealed that oleic acid ($C_{18:1}$) was the most prevalent unsaturated fatty acid of the three varieties under study. The highest amount was recorded for Pactol followed by Serw 6 and Serw 4 to be 67.0, 62.0 and 58.8%, respectively in 0 treatment (without N fertilizer). Addition of nitrogen fertilizer caused slight increase of oleic acid content of rapeseed varieties.

On the other hand, the data showed a very low percentage of mono-unsaturated fatty acid, erucic acid (C22: 1) ranging between 0.4 and 0.8% for Pactol and Serw 6 varieties, respectively. While, serw 4 indicated 0.0 to 0.1%.

Therefore, these varieties are belonging to Canola (LEAR(, containing < 2% erucic acid. As shown in Table (3), fertilization of rapeseed varieties with nitrogen did not affect erucic acid content.

**Table (2): Some physical and chemical properties of crude oil of rapeseed as affected by nitrogen fertilization levels.**

| Treatments | Refrective Index (RI) | Iodine Value (IV) | Saponification Value (SV) | Acid Value (AV) | Peroxide Value (PV) |
|---|---|---|---|---|---|
| Pactol | | | | | |
| N0 | 1.4712 | 119.0 | 190.0 | 0.35 | 0.48 |
| N30 | 1.4711 | 118.0 | 191.0 | 0.37 | 0.46 |
| N60 | 1.4707 | 118.0 | 190.0 | 0.37 | 0.48 |
| N90 | 1.4701 | 113.0 | 189.5 | 0.39 | 0.49 |
| Serw 4 | | | | | |
| N0 | 1.4723 | 128.0 | 188.0 | 0.74 | 0.48 |
| N30 | 1.4721 | 127.0 | 189.0 | 0.76 | 0.48 |
| N60 | 1.4721 | 127.5 | 188.0 | 0.74 | 0.49 |
| N90 | 1.4710 | 123.0 | 190.0 | 0.77 | 0.49 |
| Serw 6 | | | | | |
| N0 | 1.4720 | 125.5 | 187.0 | 0.75 | 0.66 |
| N30 | 1.4717 | 123.0 | 187.0 | 0.77 | 0.64 |
| N60 | 1.4715 | 123.0 | 186.5 | 0.77 | 0.65 |
| N90 | 1.4710 | 119.5 | 188.5 | 0.78 | 0.66 |

Each value is the main result of the tw0 growing seasons

**Table (3): Fatty acid composition (%) of rapeseed varieties as affected by nitrogen fertilizer levels.**

| Fatty acid | Pactol | | | | Serw 4 | | | | Serw 6 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N_0$ | $N_{30}$ | $N_{60}$ | $N_{90}$ | $N_0$ | $N_{30}$ | $N_{60}$ | $N_{90}$ | $N_0$ | $N_{30}$ | $N_{60}$ | $N_{90}$ |
| Myristic | 0.6 | 0.4 | 0.4 | 0.7 | 0.6 | 0.8 | 0.8 | 0.6 | 0.2 | 0.9 | 0.4 | 0.5 |
| Palmitic | 4.6 | 4.4 | 4.8 | 4.6 | 5.5 | 6.2 | 6.2 | 6.4 | 4.5 | 4.4 | 4.4 | 4.5 |
| Stearic | 1.1 | 1.0 | 1.0 | 1.3 | 0.2 | 0.2 | 0.3 | 0.2 | 1.3 | 1.1 | 1.2 | 1.0 |
| Arachidic | 0.4 | 0.4 | 0.5 | 0.8 | 0.8 | 0.2 | 0.5 | 0.6 | 1.4 | 1.2 | 1.2 | 1.1 |
| Total SFA | 6.7 | 6.4 | 6.7 | 7.4 | 7.1 | 7.4 | 7.8 | 7.8 | 7.4 | 7.6 | 7.2 | 7.1 |
| Palmitoleic | 0.2 | 0.1 | 0.2 | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.4 |
| Oleic | 67.0 | 67.8 | 67.8 | 69.6 | 58.0 | 60.0 | 60.0 | 61.0 | 62.0 | 63.8 | 63.8 | 65.4 |
| Arachidonic | 0.6 | 0.6 | 0.4 | 0.6 | 1.6 | 1.4 | 1.4 | 1.4 | 1.2 | 1.0 | 1.0 | 1.2 |
| Erucic | 0.4 | 0.6 | 0.6 | 0.5 | 0.1 | --- | --- | 0.1 | 0.6 | 0.5 | 0.8 | 0.8 |
| Total MUFA | 68.2 | 69.1 | 69.0 | 71.1 | 59.9 | 61.5 | 61.5 | 62.6 | 64.0 | 65.7 | 66.1 | 67.8 |
| Linoleic | 14.7 | 14.0 | 14.5 | 13.8 | 22.8 | 21.5 | 21.3 | 21.0 | 20.2 | 19.0 | 19.0 | 18.7 |
| Linolenic | 8.5 | 7.5 | 7.6 | 7.0 | 9.8 | 8.0 | 8.0 | 7.8 | 8.0 | 7.5 | 7.6 | 6.5 |
| Total PUFA | 23.2 | 21.5 | 21.1 | 20.8 | 32.6 | 29.5 | 29.3 | 28.8 | 28.2 | 26.5 | 26.6 | 25.2 |
| Total unsaturated Fatty acid | 91.4 | 90.6 | 91.1 | 91 | 92.5 | 91.0 | 90.8 | 91.4 | 92.2 | 92.2 | 92.7 | 93.0 |

Each value is the main results of the tow seasons
SFA: Saturated fatty acid, MUFA: Mono-unsaturated fatty acid,
PUFA: Poly-unsaturated fatty acid.

For poly-unsaturated fatty acids, data showed that the essential fatty acid, linoleic ($C_{18:2}$) was the most prevalent. The highest amount of linoleic acid was found in Serw 4 followed by Serw 6 and Pactol varieties, respectively. So, Serw 4 was characterized with high concentration of the essential fatty acid (linoleic) indicating high nutritional value compared with the tow other varieties. Lenoleic acid percentage decreased from 14.7 to 13.8, from 22.8 to21.0 and 20.2 to 18.7% for Pactol, Serw 4 and Serw 6, respectively as a result of raising nitrogen rate from 0 to 90 kg/acre. Similar results were obtained by Slawomir et al.(2000).

On the other hand, linolenic acid ($C_{18:3}$), is an essential fatty acid and present in considerable amount in rapeseed oils. Its presence in high amount lowers oil stability during storage. Data in Table (3) showed that linoleinic acid contents in Pactol, Serw 4 and Serw 6 varieties are 8.5, 9.8 and 8.0%, respectively.

On contrast, raising N fertilization up to 9o kg/acre decreased linoleneic acid contents to be 7.0, 7.8 and 6.6% for the aforementioned varieties, respectively.

These values agreed in large extent with those obtained by Ackman (1990 and Rady et al. (1990).

*5- Total carbohydrates contents:*

Data in Table (4) indicated that Serw 6 variety contained lower amounts of carbohydrates than the other two varieties. Also, there was a significant decrease in total carbohydrates percent of rapeseed varieties as a result of increasing nitrogen level up to 90kg/acre in both seasons. This might be due to the inter change of carbohydrates metabolites to protein as a result of increasing nitrogen uptake (Saleh, 1997).

*6- Crude fiber contents:*

It is obvious from the data in Table (4) that the three-rapeseed varieties under study had high fiber content (8-9%). It has been reported that the relatively high level of crude fiber may reduce the availability of some minerals (Bell, 1993).

Also, the data showed that there was a significant decrease in crude fiber content of rapeseed varieties caused by

increasing nitrogen rates up to 90 kg/acre in both seasons. The decrease ranged from 2.7- 3.5%, 2.0 – 4.5% and 3.7 – 4.6% for Pactol, Serw 4 and Serw 6 varieties, respectively. Similar results were obtained by Saleh (1997), he hound that crude fiber content decreased in sunflower and cotton seeds as a result of increasing nitrogen rates.

*7-Total glucosinolates content:*

Data in Table (4) indicated that the meal of Serw 6 contained the highest value of total glucosinolates (22 µmoles /g meal), while those of the two other varieties contained lower amounts of antiquality substances (17 and 18 µmoles/g meal for Pactol and Serw 4, respectively). The variation in glucosinolates content may be due to genetic factors and also on environment conditions especially the amount of available sulphur in soil (Zukalova et al., 2003). On the other hand, the data showed that nitrogen fertilization had no effect on total glucosinolates content of rapeseeds. Similar results were obtained by Slawomir et al. (2000). On the contrary, Bang et al. (1988) indicated that seed meal contents of glucosinolates decreased with increasing nitrogen rate.

*8- Elements contents:*

Nitrogen, phosphorus and potassium elements were determined in seeds of rapeseed varieties under study to evaluate rapeseed meals as mineral feedstuff. It could be seen from the data in Table (5) that N, P and K contents in seeds increased significantly with increasing nitrogen rates up to 90 kg/acre. This increment of NPK contents might be due to the fact that nitrogen application resulted in better growth and dry matter accumulation in plants and deeper roots, which caused higher uptake of nutrients (Mekki, 2003).

**Table(4): Total carbohydrates and crude fiber contents of seed and total glucosinolates contents of meals of rapeseed as affected by nitrogen fertilizer levels.**

| Treatments | Total carbohydrates % | | Crude fiber % | | Total glucosinolates µ moles/g meal | |
|---|---|---|---|---|---|---|
| | 1st season | 2nd season | 1st season | 2nd season | 1st season | 2nd season |
| Pactol | | | | | | |
| 0 | 24.41 | 24.10 | 8.69 | 8.79 | 16.94 | 17.07 |
| 30 | 24.09 | 23.58 | 8.40 | 8.59 | 16.75 | 17.01 |
| 60 | 23.67 | 23.40 | 8.27 | 8.46 | 16.98 | 16.94 |
| 90 | 23.61 | 23.35 | 8.38 | 8.48 | 17.06 | 17.01 |
| LSD at 0.05 | 0.12 | 0.10 | 0.17 | 0.11 | --- | --- |
| Serw 4 | | | | | | |
| 0 | 24.64 | 24.45 | 8.36 | 8.29 | 18.42 | 18.36 |
| 30 | 24.33 | 24.16 | 8.20 | 8.11 | 18.55 | 18.42 |
| 60 | 24.12 | 23.82 | 7.95 | 7.90 | 18.14 | 18.04 |
| 90 | 24.08 | 23.67 | 7.96 | 7.93 | 18.55 | 18.55 |
| LSD at 0.05 | 0.12 | 0.07 | 0.08 | 0.12 | --- | --- |
| Serw 6 | | | | | | |
| 0 | 23.60 | 23.32 | 9.57 | 9.43 | 21.92 | 21.74 |
| 30 | 23.47 | 23.08 | 9.19 | 9.09 | 21.96 | 21.83 |
| 60 | 23.17 | 22.83 | 9.04 | 9.05 | 21.73 | 21.69 |
| 90 | 23.18 | 22.81 | 9.06 | 9.06 | 21.96 | 21.74 |
| LSD at 0.05 | 0.17 | 0.09 | 0.04 | 0.04 | --- | --- |

**Table (5): Effect of nitrogen fertilization levels on N, P and K % of rapeseed.**

| Treat. | Pactol | | | Serw 4 | | | Serw 6 | | |
|---|---|---|---|---|---|---|---|---|---|
| | N% | P% | K% | N% | P% | K% | N% | P% | K% |
| First season | | | | | | | | | |
| N rates (kg/acre) | | | | | | | | | |
| 0 | 2.84 | 0.660 | 0.758 | 2.99 | 0.714 | 0.631 | 3.20 | 0.718 | 0.668 |
| 30 | 2.93 | 0.693 | 0.799 | 3.13 | 0.760 | 0.680 | 3.33 | 0.748 | 0.712 |
| 60 | 3.16 | 0.710 | 0.842 | 3.31 | 0.782 | 0.712 | 3.48 | 0.772 | 0.747 |
| 90 | 3.32 | 0.704 | 0.854 | 3.51 | 0.787 | 0.718 | 3.66 | 0.780 | 0.743 |
| Second season | | | | | | | | | |
| N rates (kg/acre) | | | | | | | | | |
| 0 | 2.79 | 0.642 | 0.742 | 3.03 | 0.683 | 0.626 | 3.21 | 0.743 | 0.646 |
| 30 | 2.87 | 0.678 | 0.783 | 3.17 | 0.758 | 0.695 | 3.35 | 0.770 | 0.697 |
| 60 | 3.04 | 0.697 | 0.821 | 3.35 | 0.781 | 0.687 | 3.52 | 0.782 | 0.725 |
| 90 | 3.28 | 0.699 | 0.842 | 3.46 | 0.789 | 0.698 | 3.65 | 0.795 | 0.738 |

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