Response of oil yield and quality of three varieties of rapeseed (*Brassica napus* L.) to NPK fertilizer

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ABSTRACT

Rapeseed oil is considered as one of the high quality plant oils used in human food, industry and medicine , this study was carried out under the rain-fed conditions at Qlyasan research station located 2 Km North West of Sulaimani Governorate/ Iraqi Kurdistan Region during the winter season of 2016-2017, to study the effect of three varieties, namely (Serw, Hybrid and Reandy), NPK levels (0, 150, and 300 Kg ha-^{1}), and their interactions on oil yield, fatty acid compositions and some phenolic acid contents. Using Randomized Complete Block Design (RCBD) with split plot arrangement, with three replications, the main plots were allocated for the NPK levels and conducted in Randomized Complete Block Design (RCBD) with three replications, while the varieties implemented in sub-plots. Comparisons between means were carried out by the least significant difference (L.S.D) at 0.05 and 0.01 levels of significance. The results of this investigation confirm that, the application of 300 kg NPK fertilizer ha^{-1} gave the maximum value of oil yield and all fatty acids composition (Stearic acid, Linolenic acid, Linoleic acid, Oleic acid, and p-hydroxybenzoic acid) with the exception of caffeic acid and Ellagic acid were recorded 1558.312 kg ha-1, 0.454%, 0.330%,31.722 %, 47.609% and 0.535% respectively, while the non-fertilizer application of NPK ended up with the highest caffeic acid. Reandy variety produced the best values for oil yield and some fatty acids composition (steairc acid and caffeic acid) % while Serw variety predominated in other fatty acids (oleic, linoleic, and linolenic acids)

Key words: *Rapeseed varieties, NPK Fertilizer, oil yield, fatty acid, and phenolic acids.*

استجابة المحصول الزيتي ونوعيته للسماد المركب NPK في ثلاثة أصناف من السلجم (*Brassica napus* L)

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دكتوراه في المحاصيل الصناعية

قسم التقنيات الحياتية و علوم المحاصيل, كلية علوم الهندسة الزراعية, جامعة السليمانية

الخلاصة

نظرا لأهمية زيت السلجم في المواد الغذائية والصناعية والطبية ، أجريت هذه الدراسة في ظل الظروف الديمية في محطة أبحاث قليسان الواقعة على بعد 2 كم شمال غرب محافظة السليمانية / إقليم كردستان العراق خلال فصل الشتاء 2016-2017 ، لدراسة تأثير ثلاثة أصناف من المحصول وهي (Serw و Hybrid و Reandy) ومستويات من سماد نتروجين فسفور بوتاسيوم NPK (0 و 150 و 300 كغم هكتار (-1 وتداخلاتها على محصول الزيت وتركيبات الأحماض الدهنية وبعض محتويات الحمض الفينول. باستخدام تصميم القطاعات العشوائية الكاملة (RCBD) بترتيب القطع المنشقة، بثلاثة مكررات ،

تم تخصيص القطع الرئيسية لمستويات NPK وأجريت في تصميم القطاعات العشوائية الكاملة (RCBD) بثلاثة مكررات ، بينما تم وضع الأصناف في القطع الثانوية. تم إجراء المقارنات بين االمتوسطات باختبار أقل فرق معنوي (L.S.D) عند مستويات أهمية 0.05 و 0.01. تؤكد نتائج هذا البحث أن إضافة 300 كجم من سماد NPK هكتار 1 أعطت أعلى قيمة لمحصول الزيت وجميع مكونات الأحماض الدهنية) حامض ستياريك , , حامض اللينولينك , حامض اللينوليك , حامض االوليك وحامض p- hydroxybenzoic) باستثناء حامض الكافيك و حامض الاجيك 558.312 كجم هكتار $^{-1}$، 0.454٪ ، 0.330٪ ، 31.722٪ ، 47.609٪ و 0.535٪ على التوالي ، في حين أن المعاملة غير المستخدم فيه سماد NPK انتهى بأعلى نسبة من حامض الكافيين. أنتج صنف Reandy أفضل القيم لإنتاج الزيت وبعض مكونات الأحماض الدهنية(حامض ستياريك و حامض الكافيك)، بينما ساد صنف Serw في الأحماض الدهنية الأخرى(حامض ألوليك ، حامض اللينوليك و حامض اللينولينيك) .

الكلمات المفتاحية: أصناف السلجم ، سماد NPK ، محصول الزيت ، الأحماض الدهنية ، والأحماض الفينولية

INTRODUCTION

Rapeseed oil is an important source of energy in human nutrition (24) and degreased rapeseeds are used as feedstuffs (7). It takes the second place among vegetable oil crops cultivation after soybean in the world in respect of production (21). Rapeseed oil is a distinguished edible oil, which is also determined by a relatively high proportion of unsaturated fatty acids such as linoleic acid (C18:2) and α-linolenic acid (C18:3) that are classified as essential unsaturated fatty acids (EFAs) and have been associated with blood lipid profiles associated with a lower risk of coronary heart disease (23). Rapeseed oil has a lower level of saturated fatty acids (5–10%), higher level of monounsaturated fatty acids (44–75%), and moderate level of α-linolenic acid (9–13%) (31). The value of rapeseed, as a source of vegetable oils and proteins, may be improved by: increasing the content of oil, modifying the composition of fatty acids in oil, and reducing the anti-nutritional compounds, mainly fiber and glucosinolates, in rapeseed meal (17). Canola yield and quality mostly depend upon the genetic power of the growing varieties, the environmental conditions and chemical fertilizer application (28).

Fertilizer applications, especially on nutrient deficient soils, can therefore increase crop yields and quality (1). Addition of NPK fertilizers increase generally the crop yield as well as nutritional quality, Nitrogen (N), phosphorus (P) and Potassium (K) plays a play a vital role in crop yield (26), they increase oil concentration in oil seed crops (30). Nitrogen fertilization increases the seed yield but decreases oil content of seed in rapeseed. However, decreases in oil ratios of seed compensate by increases in the seed yield (10, 19). With regard to the effects of phosphorus (P) fertilization on canola, reports showed that phosphorus is required in large quantities, especially in meristemic tissues, where cells are rapidly dividing and enlarging (8). The phosphorus fertilization helps in energy storage, early maturity of crops and root development (20). Seeds of rapeseed contain higher unsaturated fatty acids than other oil seed plants. It is clear from literature that the genotype factor significantly affects oil yield fatty acid synthesis and proportions of oleic and linoleic acids during oil formation in the seed. However, at the same time, the ratio of oleic to linoleic acid in the seed oil is also dependent upon environmental variables, such as moisture and temperature, furthermore the availability of important nutrient especially phosphorus during seed maturation (14). As a consequence, genotype–environment interactions greatly influence the composition of rapeseed oil, as confirmed by various authors (11, 15,4). Edible oil extracted from a wide range of plants content a number of phenolic compounds, such as a caffeic acid, Ellagic

acid, Gallic acid and P-Hydroxybenzoic acid, while are a class of micronutrient, contribute to oxidative stability, they have many health benefits, including anti-inflammatory, anti-cancer and antiviral abilities (9). The aim of the research was showing the range of variation in the oil yield and fatty acids content depending upon application of NPK fertilization of three rapeseed varieties and their interactions, under the rainfed condition.

MATERIALS AND METHODS

Field site description:

This study carried out in Sulaimani Governorate / Kurdistan Region, at Qlyasan Agricultural Research Station, College of Agricultural Sciences, University of Sulaimani (Latitude 35° 34′ 307″ ; N, Longitude 45° 21′ 992″ ; E, and an Altitude 765 masl), which located 2 km North West of Sulaimani during the winter season of 2017-2018. The experiment was containing 2 factors, first: different levels of NPK fertilizer complex (0, 150 and 300 Kg ha-1) from (15-15-15) and the second factor was three Rapeseed varieties were selected for cultivation, which has been provided by the Baghdad Agricultural Research Center, namely; (Serw, Hybrid and Reandy). the experiment conduct in Completely Randomized Block Design(CRBD) with split block arrangement each treatment combination repeated three times.

Each main plot was consisted of three subplots with four rows each, four meters long and 0.25 meter apart. Seeds were cultivated at a rate of 12 Kg ha^{-1}. The LSD test was conducted to find the significant differences between treatment means at 1 % and 5% probability level. Mature plants were harvested on July 20, of 2017 to estimate seed yield, yield components and growth rate.

Seed oil determination:

Two grams of the harvested seed of each treatment was powdered by electric blender. Digital Soxhlet instrument used for oil distillation, with n-hexane solvent (BDH, UK), (12) the oil content calculated as follows:

Oil percent = [(W2-W1) × 100] / S

W1 = weight of empty flask (g).

W2 = weight of flask and extracted oil (g)

S = weight of sample.

Oil yield (Kg ha^{-1}):

The oil yield (**Kg $ha^{-1)}$** is the product of seed yield **Kg ha^{-1}**in oil divided by one hundred according by **(2)**. .as shown in the following equation: -

$$\text{Oil yield (Kg ha}^{-1}\text{)} = \frac{\text{Oil content (\%)}}{\text{Seed yield (Kg ha}^{-1}\text{)}} \times$$

Separation of fatty acids:

Separation of fatty acids was done using High Performance Liquid Chromatography HPLC (College of Agriculture / Salahaddin University- Erbil), on reversed phase C-8 (50×2.6mm ID) column.3µm particle size, mobile phase was acetonitril: tetrahydrofuran: 0.1 percent phosphoric acid (51:37:12v/v), the flow rate 1ml$minute^{-1}$. The eluted peaks were mentioned by UV detector set at 215 nm, and quantitative analyzed by comparing the area of well-known standard with the area of the sample under the same separation condition (16).

Conc. of sample µgml^{-1} = Area of sample /Area of standard × conce. Of standard × dilution factor

 ISSN 2072-387

Statistical Analysis:

The data were statistically analyzed according to the methods of analysis of variance as a general test; all possible comparisons among the means were carried out by using Least Significant Difference (L.S.D) test at significant levels of 0.05 and 0.01 (3).

RESULTS AND DISCUSSION

The effect of NPK fertilizer application was found to be highly significant on fatty acid compositions and oil yield with the exception of Gallic acid (Table 1.). Oil yield and all fatty acids composition such as stearic, linolenic, linoleic, oleic and p-hydroxybenzoic acid
acids respond to the application of 300 kg NPK ha-1 with the exception of caffeic acid highly significantly. The highest values of 1558.312 kg ha-1, 0.454%, 0.330%,31.722 %, 47.609% and 0.535% were recorded respectively, while the non-fertilizer application of NPK ended up with the highest caffeic acid (Table 1.). This result is confirming the role of phosphorus (P) in crop yield, it increases oil concentration in oil seed crops. (26,30). Also, others (8) confirmed that nitrogen fertilizer reduces the oil content of rapeseed. The maximum oil content of 35.52% was observed at the average of locations when 0.00 NPK was applied. These results agree with other findings (22) to clarify that the highest oil content was acquired in unfertilized oilseed rape. Besides nitrogen and phosphor, potassium fertilization has been accounted for to impact the efficiency of seed yield and its oil concentrations (4).

Table 1: Effect of NPK fertilizers on rapeseed oil yield, fatty acid, and phenolic acids contents.

NPK fertilizer Kgha^{-1}	oil yield Kgha^{-1}	Stearic acid %	Linolenic acid omga3 %	Linoleic acid omga6 %	Oleic acid omga 9 %	caffeic acid %	Ellagic acid %	Gallic acid %	p-hydroxybenzoic acid %
0	1001.608	0.396	0.316	28.302	41.097	0.030	0.028	0.027	0.409
150	1528.857	0.422	0.303	29.598	44.101	0.028	0.027	0.029	0.438
300	1558.312	0.454	0.330	31.722	47.609	0.027	0.027	0.026	0.535
LSD 0.05	**343.303**	**0.004**	**0.006**	**0.387**	**0.563**	**0.001**	**0.000**	**n.s**	**0.036**
LSD 0.01	**472.999**	**0.005**	**0.008**	**0.533**	**0.776**	**0.001**	**0.000**	**n.s**	**0.050**

Table 2. show the effect of rapeseeds variety on the oil yield, percentage of fatty acid compositions and some phenolic acid content, oil content, seed yield, and oil yield. This effect was highly significant on most traits with the exception of oil yield, gallic acid and p-hydroxibezoic acids which was significant only. (Table2.). Regarding the oil yield Kgha-1, It was observed that the variety Reandy were recorded maximum values with1664.379 Kg ha-1, while the minimum value recorded by Serw variety with1171.321 Kg ha-1. This may be due to genetic variation and adaptation differences among genotypes. This result was agreed with (5) and (6) they explained that cultivars had significant effect on oil content. While, the estimated fatty acid contents such as

palmitic and stearic acid in rapeseed oil according to (13,29) was 10%, the data in Table 2 refers that palmitic not detected, and stearic acid was very low, which reached to 0.424% as average of the three varieties, and the varieties highly significantly differ between themselves in stearic acid concentration, as the Reandy recorded 0.436 % the highest significant concentration of stearic acid, the lowest level 0.411% was detected in Serw variety and the Hybrid variety was in between.

Regarding the monounsaturated fatty acid oleic, and the polyunsaturated linoleic and linolenic acids, the obtained results in Table 1 represents high significant differences between the varieties. The linolenic, linoleic, and oleic acids 0.331%, 30.811%, and 44.269 % respectively recorded in Srew were predominated significantly compared to other varieties. This may be due to genetic variation. This result was agreed with (27 ,25,18) they explained that different variety had significant effect on oleic acid percentage. Similar to many edible oils extracted from plants the data in Table 2 shows trace concentrations of some phenolic acids, they were statistically differ between the three varieties, such as caffeic acid and p- hydrobenzoic. Caffeic acid with high significant concentrations detected in Reandy variety which were 0.030%, while p- hydrobenzoic with high significant concentrations detected in Serw variety which were 0.485%, compared to lowest concentrations of caffeic acids 0.027 in Serw variety and the lowest concentration 0.437% of p- hydroxybenzoic acid that detected in Reandy variety. Hence the rapeseed oil considers possessing medical properties (9).

Table 2: Effect of rapeseed varieties on oil yield, fatty acid, and phenolic acids content.

Varieties	**oil yield Kgha^{-1}**	**steairc acid %**	**Linolenic acid omga3 %**	**Linoleic acid omga6 %**	**Oleic acid omga9 %**	**caffeic acid %**	**Ellagic acid %**	**Gallic acid %**	**p-hydroxybenzoic acid**
Serw	1171.321	0.411	0.331	30.811	45.846	0.027	0.028	0.027	0.485
Hybrid	1253.076	0.425	0.314	29.882	43.966	0.028	0.027	0.026	0.461
Reandy	1664.379	0.436	0.303	28.929	42.996	0.030	0.027	0.029	0.437
LSD 0.05	**343.303**	**0.004**	**0.006**	**0.387**	**0.563**	**0.001**	**0.000**	**0.000**	**0.036**
LSD 0.01	**n.s**	**0.005**	**0.008**	**0.533**	**0.776**	**0.001**	**0.000**	**n.s**	**n.s**

Table 3 showed non-significant variation of oil yield and all fatty acid composition between the treatment combinations with exception of caffeic acid and ellagic acid which was highly significant variation analysis due to interaction treatment between fertilization application and varieties. Concerning caffeic acid, the maximum value with 0.033 % was recorded by interaction between Srew variety and 150 Kg ha-1 NPK, and the minimum value with 0.026% was recorded by the interaction between Reandy variety and control treatment.

Table 3: Effect of interaction between fertilization and rapeseed varieties on rapeseed oil yield, fatty acid, and phenolic acids content.

NPK × Varieties Kgha^{-1}	oil yield Kgha^{-1}	steairc acid %	Linolenic acid omga3 %	Linoleic acid omga6 %	Oleic acid omga 9 %	caffeic acid %	Ellagic acid %	Gallic acid %	p-hydroxybenzoic acid
0× Serw	789.587	0.385	0.330	29.337	42.817	0.028	0.029	0.027	0.418
150× Serw	959.513	0.397	0.313	28.280	40.657	0.029	0.028	0.028	0.406
300× Serw	1255.723	0.405	0.303	27.290	39.817	0.033	0.028	0.027	0.403
0 × Hybrid	1583.150	0.406	0.317	30.550	45.603	0.028	0.027	0.027	0.456
150 × Hybrid	1259.037	0.425	0.303	29.533	43.943	0.028	0.027	0.026	0.432
300 × Hybrid	1744.383	0.436	0.290	28.710	42.757	0.029	0.027	0.036	0.426
0 × Reandy	1141.227	0.440	0.347	32.547	49.117	0.026	0.027	0.026	0.582
0 × Reandy	1540.680	0.452	0.327	31.833	47.297	0.027	0.027	0.026	0.543
0 × Reandy	1993.030	0.469	0.317	30.787	46.413	0.027	0.026	0.026	0.481
L.S.D (P ≤ 0.05)	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**0.001**	**0.000**	**n.s**	**n.s**
L.S.D (P ≤ 0.01)	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**0.002**	**0.000**	**n.s**	**n.s**

CONCLUSION:

It was observed that the, application of 300 kg NPK fertilizer ha^{-1} gave the maximum value of oil yield and all fatty acids composition with the exception of caffeic acid, Reandy variety produced the best values for oil yield and some fatty acids composition, while Serw variety predominated in other fatty acids. It is acceptable for cultivation under the rainfed condition of Sulaimani/Kurdistan region. Regarding to the quality of the oil of these varieties and on the base of linoleic to oleic ratio which was close to 3:1 consider to be a good quality. In addition to fatty acid contents, the oil of the studied varieties was contained in trace concentrations of some phenolic acid which have benefits to human health, this provides medical properties to the rapeseed oil of these varieties. The results also confirmed the great influence of NPK nutrient in improving the growth, yield, and yield components of the rapeseed ultimately increasing oil quantity and quality.

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