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INFLUENCES OF USING MINERAL AND NATURAL SOURCE OF K FERTILIZER IN COMBINATION WITH BIO FERTILIZATION ON GROWTH AND YIELD OF CANOLA PLANT (BRASSICA NAPUS *L.*) GROWN IN SANDY SOIL

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ABSTRACT: Two field experiments were performed at the Experimental Farm at Ismailia Agricultural Research Station, Egypt ARC during two growing winter seasons 2020/2021 and 2021/2022 to study the integrated effect of inorganic K- fertilizer (KS) and natural feldspar (KF) in combination with silicate dissolving bacteria (SDB) as bio-fertilizer on growth, yield and nutrient NPK uptake for canola plant (*Brassica napus* L. serw 4). The results indicated that with all growth studied characters, adding 75% KS + 25% KF application plus seed inoculation with SDB had a positive and significant increase in growth characters i.e. No. of pods/plant, No. of branch /plant, and give a relative increase in seed and straw yields 98.9 and 99.8 %, respectively compared with the 100% individual inorganic K- fertilizer. Also, the combined treatment of 75% KS + 25% KF + SDB recorded insignificant increases in oil and protein contents as well as NPK uptake in both seed and straw for the canola plant. Conclusively, the same combined treatment (75% KS + 25% KF + SDB) can be recommended to improve growth, yield and chemical composition for canola plants in sandy soil and also, the utilization of natural K- feldspar led to reducing the high cost of chemical fertilizer and minimizing the environmental pollution.

Key words: Potassium, Feldspar, Silicate dissolving bacteria and Canola

INTRODUCTION

Canola (Brassica napus *L.*) a type of oil seed rape with low glycosinolates and low erucic acid, is an important oil crop of temperature regions and it is for its industrially important oil.

Potassium is an important macronutrient and the most abundant cation in higher plants. K plays an important role in the growth and development of plants. Also enhances photosynthesis, reduces respiration, and helps in the transport of sugar and N uptake (Machner, 2001and Silva, 2004).

Feldspar as natural potassium is a low-cost resource for providing plants with K, which could alternate the expensive applied K-chemical fertilizers (Labib *et al.*, 2012 and Abdel-Rahman 2016). The high price of chemical fertilizers is a major reason for us aiming at providing plants with K-released from mineral non-soluble sources (Hellal *et al.*, 2009 Manning, 2010 and Ekin, 2010).

The use of rhizobacteria such as potassium solubilizing bacteria as a bio fertilizer was suggested as a sustainable solution to improve growth and nutrition for plants (Styriakova *et al.*, 2003). In addition, potassium-solubilizing bacteria play a vital role in solubilizing rock- K mineral powder such as (mica, illite and feldspar by organic acids, which chelate silicon ions to bring K into solution (Bennett *et al.*, 1998). Styriakova *et al.* (2003) showed that bacillus circulans silicate dissolving bacteria (SDB) play an important role in the biological weathering of soil minerals and it could promote K and Si releasing from feldspar. Salah *et al.* (2020) reported that bio fertilizer is an alternative method for fertilization and reduces using of inorganic fertilizers, which cause hazard effects on environment and human health.

Generally, this investigation aimed to investigate the combination of inorganic and natural K fertilizer with silicate dissolving bacteria on growth, yield and nutrient uptake for

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canola plant (*Brassica napus* L. serw 4) in sandy soil.

MATERIALS AND METHODS

Site description

Two field experiments were carried out at Ismailia Agricultural Research Station, ARC, Egypt (Lat. 30º 35⁻ – 41º 9⁻ N, Long. 32º 10⁻ - 45º 83⁻ E), during two successive growing winter seasons of 2020/2021 and 2021/2022. Main properties of soil carried out according to Jackson (1973) and Klute (1986). The obtained data are recorded in Table 1.

Experimental design and treatments

The present field experiment included ten treatments arranged in a complete randomize block design with three replicates. The treatments were as follows:

(T1) K_0 (without K application)

(T2) 100% Ks: 100% of recommended dose of K (57.6 kg K ha^{-1}) in the form of potassium sulphate K_2SO_4 (0.398 kg K kg^{-1})

(T3) 75% Ks + 25% KF: 75 % K_2SO_4 + 25 % of recommended dose of K as feldspar (0.011 kg K kg^{-1})

(T4) 75% Ks + 25% KF + SDB: 75 % K_2SO_4 + 25 % feldspar + silicate dissolving bacteria (SDB).

(T5) 50% Ks + 50% KF: 50 % K_2SO_4 + 50 % feldspar.

(T6) 50% Ks + 50% KF + SDB: 50 % K_2SO_4 + 50 % feldspar + SDB.

(T7) 25% Ks + 75% KF: 25 % K_2SO_4 + 75 % feldspar.

(T8) 25% Ks + 75% KF + SDB: 25 % K_2SO_4 + 75 % feldspar + SDB.

(T9) 100% KF.

(T10) 100% KF + SDB.

The used feldspar in this study was produced by Al-Ahram for mining Co. Ltd. Chemical properties of the feldspar was determined according to Soltanpour *et al.* (1996) and the found data are presented in Table 2.

Crop management

The experimental unit area was 10.5 m2 with dimensions 3 x 3.5 m; each plot included 4 ridges (3.5 m in length and 30 cm in width). Canola seed (*Brassica napus* L. serw 4) were sown at 15 Nov. 2020 in the first season and 19 Nov. 2021 in the second season. Seed of canola plant were sown in hills spaced 20 cm apart on both sides of the ridge (planting line), under sprinkler irrigation system. Canola seed inoculation with silicate dissolving bacteria (Bacillus circlants) was supplied by Micro. Depr. Soil, Water and Environ. Instit.ARC Egypt in a concentration of 10^{10}cells ml^{-1}) at rat of 20 ml kg^{-1} seed. Feldspar and P fertilizer were applied to the soil before sowing during land preparation, where P applied as superphosphate (67.74 g P kg^{-1}). Nitrogen fertilizer was added as ammonium nitrate (0.34 kg N kg^{-1}) at rate of 108 kg N ha^{-1} in two equal doses at 30 and 50 days after sowing. Phosphorus was applied in the form of super phosphate (0.068 kg P kg^{-1}) at a rate of 31 kg P ha^{-1}. K- Sulfate was applied at two equal doses at planting and after 30 days from sowing. Plants were thinned to two plants / hill after 21 days from planting.

Yield measurements

At harvesting (150 days after planting), yield of seed and straw were recorded as kg ha^{-1}as well as its components. P samples of both seeds and straw were taken for determination of some growth parameter (No. of pods/plant, 1000-seed weight (g), plant height (cm), dry weight (g) and No. of branches/ plant. In addition, uptake of macronutrients (percentages of N, P and K) as well as oil content of canola seeds were determined.

Table 1. Main characteristics of the studied soil.

Particle size distribution (%)				Texture class	Calcium carbonate (%)	Organic matter (%)
Coarse sand	Fine sand	Silt	Clay	Sandy	0.51	0.47
76.22	13.01	4.20	7.20			
Soluble cations (mmolcL^{-1})				pH	EC (dSm^{-1})	CEC (cmolc/kg soil)
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	7.34	0.46	3.27
1.27	1.86	1.30	0.33			
Soluble anions (mmolcL^{-1})				Available macronutrient (mg/kg soil)		
$CO3^{-}$	HCO_3^{-}	Cl^{-}	SO_4^{-}	N	P	K
0.00	2.65	1.55	0.56	18.50	5.63	37.85

*(pH soil: water susp.) at 1: 2.5, EC in soil saturation extract.

Table 2. Main characteristics of the used natural feldspar.

pH	EC (dSm^{-1})	K (g kg^{-1})	Na_2O	Al_2O_2	$CaCo_3$	SiO_2	Fe_2O_3	P_2O_5
8.15	0.60	10.5	1.85	14.98	0.39	63.58	0.07	0.06

pH of 1 : 5 feldspar : water suspension. EC: of 1: 10: water extract.

Plant analysis

Plant samples were oven dried at 70 º C and digested by mixture of H_2SO_4 and $HClO_4$ according to Jackson, (1973). N was determined using micro-Kjeldahl, P was determined calorimetrically and K was measured using a flame photometer, according to Oil content of seeds were determined using soxchlet according to A.O.A.C. (1990) while, oil yield estimated by multiplying seed yield (kg ha^{-1}) by oil content. Crude protein was calculated by multiplying total seed N-content by 5.75.

Data obtained were subjected to two-way analysis of variance (ANOVA) to test the significance of treatment effects. Test of significances for differences in means was done using Least-square difference (LSD) described by Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

Growth characters and yield component

Data presented in Tables 3 and 4 show a positive response of growth parameters and yield components of canola plant as affected by all treatments. The highest values of all studied characters were recorded with the treatment of 100 % Ks that give significant increase compared with the most treated, while the lowest values in growth and yield characters were received by the treatment of 100 % KF, except the found with the control treatment. In addition, seed inoculation with silicate dissolving bacteria gave a significant increase in growth and yield when combined with KS or KF. Worthy to noted that, the treatment of 75% Ks + 25% KF + SDB in all studied characters give values nearly or similar to the standard treatment (KS) and there was non-significant difference between them. The relative increases were 90, 87.4, 97.01, 98.9 and 99.80 for plant height, dry weight / plant, No. of pods, seed and straw, respectively compared with the individual application of chemical fertilizer (100 % KS). In addition, the mean values of the treatment 50 % KS + 50 % KF + SDB in some cases recorded nearly treatment of 75% Ks + 25% KF + SDB. These increases might be due to seed inoculation with SDB combined with mineral potassium fertilizer or natural feldspar leading to solubilizing them and thus provide faster and continuous supply of K for plant growth. These results are in the same line with those obtained by Abou El-Seoud (2012), Shams and Wafaa (2014) and Abdel-Rahman (2016).

Table 3. Effect of potassium sulfate and feldspar with silicate dissolving bacteria on yield of canola plant (average of two seasons).

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI (%)	CI (%)
K0	815.47	923.33	88.32	46.90
100%Ks	1553.27	1650.10	95.02	48.80
75%Ks + 25%KF	1493.43	1600.63	93.30	48.27
75%Ks + 25%KF+SDB	1537.67	1647.03	94.85	48.28
50%Ks + 50%KF	1440.97	1505.93	95.69	48.90
50%Ks + 50%KF+SDB	1529.77	1600.73	95.57	48.97
25%Ks + 75%KF	1248.00	1309.00	95.34	48.81
25%Ks + 75%KF+SDB	1183.73	1257.60	94.11	48.48
100%KF	854.67	988.05	86.73	46.45
100%KF+SDB	962.53	1051.90	91.50	47.77
LSD $_{0.05}$	19.25	4.25	0.51	1.50

K0: without application, KS: potassium sulfate, KF: feldspar and SDB: silicate dissolving bacteria.
HI: harvest index= (seed / (seed +straw)) x100, CI: crop index= (seed /straw) x100

Table 4. Effect of potassium sulfate and feldspar with silicate dissolving bacteria on growth characters of canola plant (average of two seasons).

Treatments	No. of pods/plant	1000-seed weight (g)	Plant height (cm)	Dry weight (g / plant)	No .of branches/ plant
K0	154.67	2.32	82.13	70.20	5.20
100%Ks	369.00	2.63	174.20	143.93	16.89
75%Ks + 25%KF	315.33	2.41	154.93	125.90	14.40
75%Ks + 25%KF+SDB	359.89	2.53	156.37	125.73	16.31
50%Ks + 50%KF	305.00	2.30	115.73	189.20	13.10
50%Ks + 50%KF+SDB	346.00	2.49	126.73	122.37	60.47
25%Ks + 75%KF	252.33	2.14	142.70	88.73	12.47
25%Ks + 75%KF+SDB	245.33	2.24	105.00	107.13	14.37
100%KF	163.00	2.06	101.40	72.83	6.37
100%KF+SDB	196.00	2.32	114.30	102.30	8.16
LSD $_{0.05}$	12.80	0.12	15.52	25.96	0.78

K0: without application, KS: potassium sulfate, KF: feldspar and SDB: silicate dissolving bacteria.

Oil and protein content

Concerning the effect of the inorganic and natural K as combined with silicate dissolving bacteria on oil and protein content in the seeds of canola plant, the results in Table 5 indicated that oil and protein content were significantly increase with all treatments as compared with control and also significantly affected between them. The obtained results also showed that all studied trials gave positive and significant increase by using of bio fertilization (SDB) comparing with untreated ones. In general, the treatment of 75% Ks + 25% KF + SDB in all cases gave results similar to the individual application of 100% KS. The relative increases were 99.2, 98.5 and 99.5 % for oil and protein contents and oil yield, respectively. Such results emphasize that bio fertilization most a substitute but partial supplement to mineral K fertilizer that increase the solubility of potassium in natural feldspar. These results are similar to those recorded by Abdel-Rahman (2016) and Sarhan and Abd El-Gayed (2017).

Nutrient uptake

Regarding to the uptake of N, P and K in both seed and straw for canola plant the obtained results in Tables 6 and 7 showed a positive effect of NPK uptake with all treatments especially by using of potassium sulfate combined with SDB. The highest values were recorded at the standard treatment of 100 % KS followed the pattern of > 75 % Ks + 25% KF+SDB > 75% Ks + 25% KF > 50 %Ks + 50 % KF+SDB > 50% Ks + 50 %KF > 25% Ks + 75% KF+SDB > 25% Ks + 75% KF > 100 % KF+SDB > 100 % KF. The treatment of 100 % KF that recorded the lowest values in both the two seasons can be explained by the slow and long release of K from through stages of growth. In addition, it can be noted that in all cases there were non-significant differences between the two treatments of 100 % KS and 75% Ks + 25% KF+SDB. The relative increases were 97.70, 98.30 and 98.63 % for N, P and K in seed respectively while, in straw were 98.90, 96.00 and 90.70 respectively. Moreover, in some cases the treatment of 50 % Ks + 50 % KF+SDB produced mean values nearly by using of 75 % Ks + 25% KF+SDB. These results agreed with Abdel-Rahman (2016), Sorhan and Abd El-Gayed (2017) and Salah *et al.* (2020).

Table 5. Effect of potassium sulfate and feldspar with silicate dissolving bacteria on oil and protein content of canola plant (average of two seasons).

Treatments	Oil content (%)	Oil yield (kg/ha)	Protein content (%)	Protein yield (kg ha^{-1})
K0	42.52	305.61	19.23	156.79
100%Ks	45.34	713.29	23.35	367.30
75%Ks + 25%KF	44.50	664.48	22.77	340.01
75%Ks + 25%KF+SDB	45.00	702.66	23.25	355.94
50%Ks + 50%KF	43.68	643.90	22.11	318.65
50%Ks + 50%KF+SDB	44.28	674.27	22.87	349.86
25%Ks + 75%KF	44.09	566.61	21.38	266.82
25%Ks + 75%KF+SDB	43.52	524.30	22.14	262.08
100%KF	42.72	364.40	19.56	167.15
100%KF+SDB	43.19	408.50	20.30	195.39
LSD $_{0.05}$	0.49	21.34	0.12	19.74

K0: without application, KS: potassium sulfate, KF: feldspar and SDB: silicate dissolving bacteria.

Table 6. Effect of potassium sulfate and feldspar with silicate dissolving bacteria on NPK uptake ($kg\ ha^{-1}$) by seeds of canola plant (average of two seasons).

Treatments	N ($kg\ ha^{-1}$)	P ($kg\ ha^{-1}$)	K ($kg\ ha^{-1}$)
K0	17.10	1.55	11.45
100%Ks	40.73	8.84	34.39
75%Ks + 25%KF	38.26	6.29	28.41
75%Ks + 25%KF+SDB	39.44	8.69	33.92
50%Ks + 50%KF	36.36	4.99	21.31
50%Ks + 50%KF+SDB	37.28	5.47	23.62
25%Ks + 75%KF	30.42	4.42	18.69
25%Ks + 75%KF+SDB	35.38	5.87	20.34
100%KF	32.61	4.01	14.65
100%KF+SDB	33.13	4.62	17.60
$LSD_{0.05}$	2.10	0.28	0.60

K0: without application, KS: potassium sulfate, KF: feldspar and SDB: silicate dissolving bacteria.

Table 7. Effect of potassium sulfate and feldspar with silicate dissolving bacteria on NPK uptake ($kg\ ha^{-1}$) by straw of canola plant (average of two seasons).

Treatments	N	P	K
K0	12.50	1.63	8.34
100%Ks	26.25	5.99	24.42
75%Ks + 25%KF	23.22	4.98	21.43
75%Ks + 25%KF+SDB	25.98	5.75	22.15
50%Ks + 50%KF	22.21	3.39	17.23
50%Ks + 50%KF+SDB	23.73	4.00	20.76
25%Ks + 75%KF	20.41	2.97	14.72
25%Ks + 75%KF+SDB	21.28	3.47	72.36
100%KF	16.47	2.78	9.82
100%KF+SDB	18.95	3.22	11.27
$LSD_{0.05}$	0.41	0.22	3.2

K0: without application, KS: potassium sulfate, KF: feldspar and SDB: silicate dissolving bacteria.

Conclusion

On the bases of results, it can be concluded that, canola plant when fertilized at a rate of 75 % of the recommended dose of K in the form of potassium sulfate plus seed inoculation with silicate dissolving bacteria appeared to be most appropriate and suitable treatment for harvesting a good crop for canola plant in sandy soil. This mean that treatment can be consider the best combined treatment which can use alternative 25% of K-chemical fertilizer in canola fields. In addition, using naturally deposited materials of K-feldspar with bio fertilizer can be saved 25 or 50 % from high cost of chemical fertilizers and reduced the environment pollution from extensive application of mineral fertilizer.

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تأثير استخدام المصادر المعدنية والطبيعية لأسمدة البوتاسيوم مختلطا مع السماد الحيوى على نمو ومحصول الكانولا فى الأرض الرملية

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الملخص العربى

أجريت تجربتين حقليتين فى مزرعة محطة البحوث الزراعية بالإسماعيلية – مركز البحوث الزراعية خلال موسمى نمومتعاقبين ٢٠٢٠ / ٢٠٢١ و ٢٠٢١ / ٢٠٢٢ وذلك لدراسة التأثير المتكامل للسماد البوتاسى المعدنى والفلسبار الطبيعى مختلطا مع البكتريا المذيبة للسليكات كسماد حيوى على نمو ومحصول وامتصاص عناصر ال NPK فى كلا من القش والحبوب لنبات الكانولا ولقد أوضحت النتائج فى كل الصفات المدروسة أن إضافة المعاملة ٧٥٪ من سلفات البوتاسيوم + ٢٥٪ من الفلسبار الطبيعى + البكتريا المذيبة للسليكات أعطت زيادة معنوية فى صفات النمو (عدد القرون / نبات – عدد الأفرع / نبات) وأعطت زيادة نسبية مقارنة بالإضافة المنفردة من ١٠٠ % من السماد المعدنى البوتاسى فى كلا من الحبوب والقش ٩٨,٩ و ٩٩,٨ % على التوالى. وأيضا هذه المعاملة المختلطة (٧٥٪ من سلفات البوتاسيوم + ٢٥ % من الفلسبار الطبيعى + البكتريا المذيبة للسليكات) سجلت زيادة معنوية فى كل الصفات المدروسة من محتوى البذور من الزيت والبروتين ومحصول الزيت لنبات الكانولا. وبشكل قاطع تعتبر هذه المعاملة المختلطة موصى بها لتحسين النمو والإنتاج المحصولى والتركيب الكيميائى لمحصول الكانولا فى الأراضى الرملية. أيضا استخدام الفلسبار الطبيعى يؤدى الى تقليل إرتفاع أسعار الأسمدة المعدنية وتقليل التلوث البيئى.