International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
Volume 37 العدد
Part 2 المجلد
المجلة الدولية للعلوم والتقنية
International Science and Technology Journal
ISTJ

http://www.doi.org/10.62341/hdtj1020

Received	**2025/11/30**	**تم استلام الورقة العلمية في**
Accepted	**2025/12/28**	**تم قبول الورقة العلمية في**
Published	**2025/12/29**	**تم نشر الورقة العلمية في**

Effect of foliar application of potassium nitrate levels on growth, yield and seed quality of local faba bean

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Abstract

A field experiment was conducted at El- Osait, Al-Jabal Al- Akdar, Libya, during two consecutive seasons 2022-2023 and 2023-2024 To evaluate the effect of foliar application of potassium nitrate at levels of 0, 10 and 20 L ha-1 on the growth, yield, and quality of a local faba bean cultivar. The experiment was arranged in a randomized complete block design (RCBD) with four replications. Measured traits included: plant height, number of pods per plant, pod length, number and we right of seeds per pod and per plant, biological yield, seed yield, 100-seed weight, harvest index and seed protein content. Results indicated that foliar application of potassium nitrate significantly enhanced most growth and yield parameters, with the highest values 95. 71 and 106.27 cm for plant height, 7.67 and 7.03 pods/ plant; 16.14, 15.39 cm of pod length; 6.31 and 7.03 seed/ pod; 7.03 pods/ plant; 16.14 , 15.39 cm of pod length; 6.31 and 7.03 seed/ pod; 8.69 and 8.50 g of pod seeds weight; 7.67 and 7.03 pods/ plants; 40.41 and 35.43 seeds/ plant; 34.86 and 30.70g of plant seeds weight; 4260 and 8510 kg/ ha of biological yield; 2600 and 3510 kg/ ha of seed yield; 61.03 and 60.41 % harvest index; 50.46 and 64.59 g of 100- seed weight and 22.83 and 23.0 % of seed protein content, generally obtained at 20 L ha-1 compared to the control. Regression, correlation and determination coefficient analysis for all the parameters showed a strong positive relationship across treatments with slope (b), correlation coefficient (r) and determination coefficient (R2) in both the two seasons. These results confirm that kNo3 foliar application particularly at 20 L ha-1 can be

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an effective practice to improve the productivity and quality of faba bean under the environmental conditions of El-osiata, Libya.
Keywords: faba bean, potassium nitrate, foliar application.

تأثير الرش الخضري لمستويات مختلفة من نترات البوتاسيوم في نمو وإنتاج وجودة بذور الصنف المحلي من الفول البلدي (*Vicia faba L*) تحت ظروف منطقة الوسيطة

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الملخص

نفذت تجربة حقلية في منطقة الوسيطة، الجبل الأخضر، ليبيا، خلال موسمين متتالين 2022–2023، 2023–2024م لدراسة تأثير الرش الخضري لنترات البوتاسيوم بالمستويات 0، 10، 20 لتر / هكتار على نمو محصول وجودة الصنف المحلي من الفول البلدي. نفذت الدراسة بإتباع تصميم القطاعات كاملة العشوائية (R C B D) بأربعة مكررات شملت الصفات المدروسة: ارتفاع النبات، عدد قرون النبات، طول القرن، عدد ووزن بذور القرن والنبات، المحصول البيولوجي، محصول البذور، دليل الحصاد، وزن 100 بذرة ومحتوى البذور من البروتين. أظهرت النتائج بأن الرش الخضري KNO3 أدى إلى زيادة معنوية في معظم الصفات المدروسة وكانت أقصى قيمة لارتفاع النبات 95.71 و 106.27 سم وعدد قرون النبات 7.67 و 7.03 قرن / للنبات و 16.14 و 15.39 سم لطول القرن و 6.31 و 7.03 بذرة / للقرن و 8.69، 8.50 جم لوزن القرن و 7.67 ، 7.036 قرن للنبات؛ 40.40، 35.43 بذرة للنبات و 34.86، 30.70 جم لوزن بذور النبات و 4260، 5810 كجم/ هـ/ للمحصول البيولوجي؛ 2600، 3510 كجم/ هـ، لمحصول البذور و 61.03، 60.41% لدليل الحصاد و 50.46، 64.59 جم لوزن 100 بذرة و 22.83 ، 23.00 % لمحتويات البذور من البروتين. سجلته أعلى القيم غالبًا عند رش المستوى 20 لتر/ هـ، مقارنة بالشاهد غير المرشوشة، في كلا الموسمين الأول والثاني بالترتيب، أظهر تحليل الانحدار، الارتباط ومعامل التحديد لجميع تلك الصفات علاقة طردية قوية جدًا بمعامل

http://www.doi.org/10.62341/hdtj1020

الانحدار (b) والارتباط (r) والتقدير (R2) في كلا موسمي الدراسة الأول والثاني، تؤكد هذه النتائج أن الرش الخضري لنترات البوتاسيوم خاصة بالمعدل 20 لتر / هـــ يُـــعد ممارسة فعالة لتحسين إنتاج وجودة الفول البلدي تحت ظروف منطقة الوسيطة.

الكلمات المفتاحية: الفول البلدي، الرش الخضري لنترات البوتاسيوم.

Introduction:

faba bean is an important crop cultivated widely in semi-arid environments for high protein. Content and Soil- enriching properties through biological nitrogen fixation. (Merga *et al*., 2019). Its productivity and quality are heavily influenced by agronomic practices, particularly foliar fertilization, which can rapidly correct nutrient deficiencies and enhance growth under stress conditions. (kawichar *et al*, 2011). Potassium nitrate (KNO3) is a key foliar fertilizer, supplying both Potassium and nitrate nitrogen, essential for photosynthesis, enzyme activation, and protein synthesis, (shawer, 2019). Foliar application of (KNO3) can significantly influence plant physiological traits, growth parameters, and ultimately seed yield and quality, (Marschner, 2012). The El-Osaita region in the Green Mountain area of Libya is characterized by semi-arid condition, where nutrient availability and water stress can limit crop performance, Abdullah *et al*., 2015. Understanding the relationship between (KNO3) application and crop response is essential to optimize input use. (Merkeb, 2023).

This study aims to :

- Evaluate the effect of different foliar potassium nitrate levels on growth, yield and seed quality of local faba bean.
- Determine the strength and direction of association using correlation analysis.
- Quantify the predictability of (KNO3) levels on crop traits through regression and determination coefficient (R2).

Materials and Methods:

Experimental site and conditions:

The experiment was conducted at the agricultural climatic conditions of El-osuita, Green Mountain region, Libya, Latitude 32.47o N, Longitude 21.39 o E, Altitude 365m). during successive winter seasons (2022-2023) and (2023-2024) the region is characterized by a semi-arid Mediterranean climate with cool

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winters and moderate rainfall during the growing season. Sowing dates was in 15th and 13th November in both seasons, respectively. Diammonium phosphate (DAP, 18: 46: 0) was applied at a rate of 50 kg/ ha before sowing.
Soil properties was in Table.(1)

Table1: Soil physical and chemical properties of the experimental site (El- Osuita) before sowing in 2022-2023 and 2023-2024.

Property	Unit	Value	Method
Soil texture	-	Clay	Hydrometer
Bulk density	9 cm^{-3}	1.19	core
Field capacity	%	28.46	Pressure plate
Permanent wiling point	%	9.62	Pressure plate
Available water	mm	16.67	Field capacity - pwp
Soil PH (1:2.5) soil water	-	7.57	PH meter
Electrical conductivity Ece	ds/ m	0.191	Conductivity meter
Organic mattor	%	3.4	Walkley-block
Cation exchange capacity CEC	Meq/ 100 g soil	27.80	Ammonium acetate
Total nitrogen N	%	0.15	Kjed/ hal
Available phosphorus P	Mg/ kg	7.2	01 sen
Available potassium K	Mg/ kg	280	Flame photomet

Experimental Design:
The experiment was laid out in a randomize complete block design (RCBD) with the three levels of foliar potassium nitrate (KNO3): oL/ ha control; 10 L/ ha and 20 L/ ha. Each treatment was replicated four times, resulting in a total 12 plots per season. Plot size 3m x 4m = 12 m^2 per experiment unit. Foliar application by sprays were applied once per season at the vegetative stage (beging of elongation) using knapsack sprayer with spray volume of 600 L/ ha. All plots received uniform irrigation from sowing until physiological maturity to maintain a dequate soil moisture and prevent water stress. Standard agronomic practices including weeding and pest management were followed throughout both seasons.

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Measured parameters :

At physiological maturity, the following traits were recorded from 10 randomly selected plants per plot:

1-Plant height (cm); Number of pods per plant; Number of seed per pod; pod length (cm); pod seeds weight (g); pods per plant; seeds per plant number and weight and 100-seed weight.

2-Biological and Economic yied (kg/ ha); Harvest index calculated from dividing economic yield over biological yield multiplied by 100.

3-Seed protein content (%) estimated using kjeldahl method, as recorded by Ikenna and floro-Glad, 2022 and the nitrogen content is multiplied by a conversion factor (usually 6.25) to estimate the protein content as reported by (Henrik *et al*., 2011).

Statitical and analytical methods :

•Data were analyzed separatly and using standard statistical procedures discussed by (snedecor and Cochran, 1989).

Correlation analysis, pearson correlation coefficients (r) were calculated between (KNO3) levels and each measured trait were (r):

$$r = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}} where\ x\ independent$$

Variable (KNO3) and y = dependent trait and N; number of observations.

•Liner Regression analysis, simple linear regression was performed for each trait using the following model :

Y= a + bx where y = predicted value of trait; x = (KNO3) level (L/ ha); a = intercept and b = slope of regression line.

Where:

$$b = \frac{n\,\Sigma xy - \Sigma x\,\Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \quad and \quad a = \frac{\Sigma y - b\Sigma x}{n}$$

O-T the determination coefficient (R2) was calculated from regression analysis to express the proportion of variation in the dependent variable explained by potassium nitrate where :

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$$R^2 = \frac{Explained\ variation}{Total\ variation} \cong r^2 \ where\ R$$

Value ranges from 0 to 1 (xinbo *et al*., 2022) reported calculation methods and by (asuero *et al*., 2006)

2006 .for correlation coefficient analysis. All statistical analysis were performed by software using Gensat v12 as reported by (paul and Jac, 2009) and spss 25 software discussed by IBM spss statistics.

Results and discussion :

Data in the table 2 and 3 showing the following:

1 -**vegetative and yield attributes response**

Plant height was highly significantly affected by foliar (KNO3) application in both seasons, reflecting the strong role of potassium in promoting vegetative growth and cell elongation. Weak relationship between (KNO3) and plant height in 1st season, regression coefficient (b) was 0.071, correlation factors also weak (r): 0.260 and less R2= 6.8 %, while a strong relationship in 2nd season, that b = 1.358, r = 0.998 and R2 = 99.6% (table 3) this relation indicated the effect of season on these relationships, (Emad *et al*., 2021) showed the same discussion.

Number of pods/ plants was significant in 1st season but not in 2nd. This could be due seasonal variation in weather conditions or environment stress affecting reproductive development. These results reflected weakness of regression coefficient b = 0.089 and 0.052 of production capability with KNO3 levels, while, appositive strong correlation r = 0942 and 0.956 and strong relation by determination effect of KNO3 by R2 = 88.8 and 90.0 % in the both seasons, respectively, with same interpretation found (Abou-Amer *et al*., 2014).

Pod length showed highly significant differences in both seasons table 2, suggesting a consistent and strong positive effect of KNO3 on pod elongation, likely due enhanced nutrient translocation and hormone activity. This data showed strong relation of KNO3 effect on pod length, b = 0.43 and 1.23; r = 0.999 and 0.992 and R2= 99.9 in both two seasons, respectively. Similar findings showed by. (Alharbi and Adhinlari, 2020)

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Number of seeds per pod was highly significantly affected in the first season but not in the second table 2, possibly indicating an environmental limitation during the reproductive in the 2nd season with strong relationship between (KNO3) and seed/ pod (table 3) with b = 1.114, 0.035; r = 0.998, 996 and R2 = 97.8 and 99.2% similar direction showed by (Shabbier *et al*., 2021).

pod seeds weight was highly significant increases in 1st season and significant in the 2nd season (table 2), confirming that (KNO3) enhances seed development and filling. High strong relation between (KNO3) levels and seed filling (table 3) revealed that coefficients of b = 0.645 and, 1.29; r = 0.999 and 0.962 and R2 = 99.8 and 92.5 % in both season, notable memorable (Jyoti *et al*., 2016) showed the similar direction.

Pods number per plant was significant differences in 1st season but not in the second. This could be due to seasonal variation in weather conditions or environment stress affecting reproductive development. pods / plant relation to (KNO3) were: b= 0.088, 0.052; r = 0.942, 0.956 and R2 = 88.8, 91.3 % for both seasons, respectively. Despite the lack of statistically significant in 2nd season based on ANOVA, the correlation and determination values are still high, indicating a consistent trend where increased (KNO3), Improved the amount of bods/ plant. (Mona *et al*., 2011) reported the similar findings.

Number of seeds per plant showed a highly significant increase in both seasons (table 2), affirming the cumulative effect of improved pod sitting and seed development. The results showed very good slope of regression b = 2.055 and 1.525 meaning that every additional of 1 L/ ha (KNO3) led to increase 205.50 and 152.50 % in the capability of faba bean plants +0 bearing seeds in both two seasons and what supports that strong positive correlation r = 0.979 and 0.910 between (KNO3) levels and seeds per plant. The variation in this trait was due to (KNO3) application with higher values in both seasons, of determination coefficient (R2) = 95.90 and 83.90 % compfirmed that the observation improvement in seeds / plant were largly attributed to foliar application of (KNO3) rather than other factors. (Alharbi and Adhinkari, 2020) revealed the same discussion.

Plant seeds weight, significantly increased by (KNO3) levels in both seasons (table 2) to 34.86 and 90.7 g due to 20 L/ ha

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application, showing appositive yield response, these results showing that regression analysis by use the slope (b) = 2.00 and 5.255, indicated the contribution of (KNO3) to plant seeds weight by 200 and 525.50% in 1st and 2nd season, respectively, that mean every 1 L/ ha (KNO3) increase the plant seeds weight by these percentages. Highlighting a strong positive response with a correlation = 0.879* and 0969 ** a strong correlation of this effect of (KNO3) application, similar direction of contribution was shown by R2 = 77.30 and 93.90% indicated the contribution of the (KNO3) percent to the degree of seeds weight increase; other remainder might be to other factors. Similar discussion shows by (Taha *et al*.,2016).

Biological yield (table 2) report that, both seasons responded highly significantly to foliar potassium nitrate with 20 L / ha (4260 and 5810 kg /ha in first and second seasons, respectively. This aligns with the known role of nitrogen and potassium in photosynthesis and dry matter accumulation. The results of regression analysis indicated that the slope b = 990.00 and 825.00 which mean an increase L/ ha of (KNO3) led to increase in biological yield by 990 kg/ha and 825 kg/ ha in both seasons respectively- highlighting a strong positive response. Correlation coefficient between (KNO3) levels and biological yield nodded that response to r = 0.981** and 0.919 ** highly significant response to (KNO3) in 20 L/ ha level in both seasons. This response is reinforced by analysis of the coefficient of determination R2 which = 96.20 and 84.50% that mean the strong response of biological yield to (KNO3) application, the rest of 3.8 and 15.5% change in biological yield might be attributed to weather or environmental factors..

Similar explication reported by przemy (law *et al*., 2018)

Grain yield showed highly significant and significant affected by potassium nitrate foliar application (table 2). 20 L/ ha exhibited the greatest 2600 and 3510 kg/ ha in both seasons. This is the result and effect of that rate on pods/ plant ; seeds number and weight per plant in the evidence of that rise regression slope b = 915.0 and 1160.0 that mean every 1 L/ ha (KNO3) increase the grain yield by 915 and 1160% with variation between levels r = 0.998** and 0.957** of highly variation with control in increase of grain yield, and the contribution of (KNO3) in grain yield by determination coefficient R2 = 99.00 and 91.60% and the rest sand 8.4% was from other

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factors in 1st and 2nd season respectively. Similar finding showed by (christain *et al*., 2014).

Harvest index, reported highly significant response to foliar (KNO3) application (table 2) 20 L/ ha exhibited the highest values 61.03 and 60.41% in both 1st and 2nd season, respectively, (KNO3) contributed at regression slope analysis an increase of HI by 13.63 of 15-90 increase than control with highly positive correlation r = 0.997** in 1st seasons and 0.765* in 2nd season, with variation of contribution due to high R2 99.40 % in 1st season that mean 0.60% from other effect, while 41.60% effect from rather than (KNO3) in the 2nd season which mean variation effect of environment, which accordance with (Christian *et al.*, 2014.)

100- seed weight exhibited significant increase by 20 L/ ha potassium nitrate in the first season and not in the second season (table 2) , which that weight increased to 50.469 , suggesting better seed filling under more favorable condition. Supported with regression analysis indicated how much this weight increase with increase (KNO3) level, that b factor recorded 2.22 and 0.390 in both season meaning that every 1 L/ ha (KNO3) led to 222 and 39% in the 100 seed weight with high positive correlation r = 0.997** and 0.986** in 1st and 2nd season, respectively (table 3) between (KNO3) foliar application and the 100-seed weight. The coefficient of determination R2 showed in table3 high contribution of (KNO3) in this weight by 99.40 and 97.2% and the rest 0.60 and 2.80 are from other effects, similar explination reported by (Mohamed, 2020)

Seed protein content (%) was highly significant affected from foliar application in first season 22.83% and significantly in second season 23.0% (table 2) due to the level 20 L/ ha. This highlights the nutrional quality improvement due to (KNO3) which potassium supports nitrogen assimilation.

Table3: indicate a very strong positive linear relationship between (KNO3) foliar application and seed protein content were b = 0.86 and 1.90 which any 1 L (KNO3) / ha increase the % of protein by 86 and 190% and the correlation r between (KNO3) and protein content was highly significant r = 0.993** and 0.999**. The contribution of (KNO3) on seed of faba bean protein R2 were by 98.60 and 99.80 % in both seasons, respectively and the rast 1.40

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and 0.20 was from other factors. Similar finding was reconded by Nusrat and rafigy, 2011 and by (Alhasany *et al*., 2024).

Table 2. Effects of foliar Application of potassium Nitrate (KNO_3) levels (L/ha) on the local variety of faba bean traits during the two season 2022-2023 and 2023-2024 at El- Osaita conditions.

Traits	Foliar Application of potassium levels						F		LSD	
	Control		10 L/ ha		20 L/ ha					
	First	second	First	second	First	second	First	second	First	second
	Season		season		season		season		season	
Plant height (cm)	94.29	79.11	95.02	94.90	95.71	106.27	**	**	0.31	19.95
Pods per plant	5.90	6.00	6.24	6.79	7.67	7.03	*	N. S	1.29	-
Pod length (cm)	15.13	12.94	15.54	14.43	16.14	15.39	**	**	0.35	0.70
Seeds per pod	4.02	6.34	5.14	6.74	6.31	7.03	**	N. S	0.32	-
Pod seeds weight (g)	7.40	5.92	8.09	7.67	8.69	8.50	**	*	0.33	2.50
Pods per plant	5.90	6.00	6.24	6.79	7.67	7.03	**	N. S	1.29	-
Seeds per plant	36.30	32.38	39.10	32.75	40.41	35.43	**	**	2.03	2.21
Plant seeds weight (g)	30.86	20.19	30.98	27.79	34.86	30.70	*	*	2.89	2.41
Biological yield Rg/ha	2280	4160	3590	4370	4260	5810	**	**	1330	990
Grain yield kg/ ha	770	1190	1770	2960	2600	3510	**	*	490	1010
Harvest index (%)	33.77	28.61	49.30	67.73	61.03	60.41	**	**	11.21	18.36
100- seed weight (g)	46.03	63.81	46.77	64.38	50.46	64.59	*	N. S	3.44	-
Seed protein content (%)	21.12	19.20	22.57	21.44	22.83	23.00	**	*	0.64	2.24

Ns: not significant differences at P < 0.05 *: significant differences at P < 0.05 **: Highly significant differences at P < 0.01

Table 3: coefficient relationship between potassium nitrate level and growth and yield and attributes trait of regression, correlation and determination in both season 2022-23 and 2023-24 at El- Osaifa conditions.

Traits	regression coefficient b		Correlation coefficient r		Determination coefficient % R^2	
	First	Second	First	second	First	second
	Season		Season		Season	
Plant height	0.071	1.358	0.260n.s	0.998**	6.80	99.60
Pods / plant	0.089	0.052	0.942**	0.956**	88.80	90.00
Pod length	0.430	1.230	0.999**	0.992**	98.80	98.50
Seeds pod	0.114	0.035	0.997**	0.996**	97.80	99.20
seeds / Pod weight	0.645	1.290	0.999**	0.962**	99.80	92.50
Pods / plant	0.515	0.885	0.955**	0.942**	91.20	88.70
Seeds / plant	2.055	1.525	0.979**	0.910**	95.90	83.90
Plant seeds weight	2.000	5.255	0.879**	0969**	77.30	93.90
Biological yield	990.00	825.00	0.981**	0.191**	96.20	84.50
Grain yield	915.00	1160.00	0.998**	0.957**	99.00	91.60
Harvest index	13.63	15.90	0.997**	0.765**	99.40	58.40
100- seed weight	2.22	0.390	0.997**	0.986**	99.40	97.20
Seed protein (%)	0.86	1.90	0.993**	0.999**	98.60	99.80

Ns: not significant differences at P < 0.05 *: significant differences at P < 0.05 **: Highly significant differences at P < 0.01

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Conclusion:

The foliar application of potassium nitrate significantly improved the vegetable growth, reproductive performances, yield and protein content of faba bean, particularly at the 20 L/ ha rate. The treatment was most effective in increasing seed number and weight per pod and per plant, biological and economic yield, 100-seed weight, harvest index and seed protein content. The results were consistent across two seasons with minor variation dur to climatic factors.

Recommendations:

Apply foliar (KNO3) at 20 L/ ha during the vegetative stage of faba bean to achieve optimal yield and protein content under semi- arid conditions like those in El- Osaita, conduct further studies to evaluate the economic feasibility and timing optimization of foliar potassium under various environmental conditions consider integration potassium foliar application with irrigation and other nutrient management strategies for sustainable faba bean production.

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