EFFECT OF SALICYLIC ACID SPRAYING ON YIELD AND IT'S COMPONENTS OF LINSEED CULTIVARS

A. A. Mohammed* **J. M. Abbas** **M. H. K. Al-Baldawi**
Researcher **Prof.** **Prof.**
Dept. of Field Crops - College of Agriculture Engineering Sciences - University of Baghdad

ABSTRACT

A field trails was carried out during winter season of 2017-2018 and 2018-2019 at Field Crops Department - College of Agricultural Engineering Sciences - University of Baghdad / Jadriyah to study the effect of salicylic acid spraying on yield and it's components of linseed cultivars. Randomized complete block design (RCBD) arranged within split plots was used with three replicates. The trail included three salicylic acid concentrations (100, 200 and 300 mg L^{-1}) in addition to control treatment (distilled water spraying) within main plots and three linseed cultivars (Syrian, Egyptian and Iraqi local) within sub plots. The results showed that the Syrian cv. produced the highest number of main branches 7.09 and 7.11 branch $plant^{-1}$, sub branch 28.45 and 27.10 branch $plant^{-1}$ and number of capsules 122.39 and 117.89 capsule $plant^{-1}$, number of seeds 8.63 and 8.45 seed $capsule^{-1}$, seed yield 1.19 and 1.17 mton ha^{-1}, while the Egyptian cv. gave highest means of 1000 seeds weight 6.83 and 6.54 g for the two seasons, respectively. The results showed that the spraying of salicylic acid at 200 mg L^{-1} significantly superiored and produced the highest number of main branches 7.10 and 6.82 branch $plant^{-1}$, sub branch 29.05 and 26.48 branch $plant^{-1}$, number of capsules 120.48 and 114.54 capsule $plant^{-1}$, number of seeds 8.44 and 8.26 seed $capsule^{-1}$ and seed yield 1.19 and 1.15 mton ha^{-1}, for the two seasons, respectively. The interaction between the two factors had significant effect on all studied characters.

Key words: *Linum usitatissimum* L., plant hormones, number of branches, seed weight, seed yield.
***Part of Ph.D. dissertation of the 1st author.**

مجلة العلوم الزراعية العراقية -2020 :51(2):585-591 محمد وآخرون

تأثير رش حامض السالسلك في الحاصل ومكوناته لبذور أصناف من الكتان

أوس علي محمد* **جاسم محمد عباس** **محمد هذال كاظم البلداوي**
الباحث **أستاذ** **أستاذ**
قسم المحاصيل الحقلية – كلية علوم الهندسة الزراعية – جامعة بغداد

المستخلص

نفذت تجربة حقلية في الموسمين الشتوين 2017–2018 و2018–2019 في محطة الأبحاث الزراعية C التابعة لقسم المحاصيل الحقلية – كلية علوم الهندسة الزراعية – جامعة بغداد / الجادرية لمعرفة تأثير رش حامض السالسلك في مكونات الحاصل وحاصل البذور لأصناف مختلفة من الكتان. طبقت التجربة بترتيب الألواح المنشقة وفق تصميم القطاعات الكاملة المعشاة وبثلاثة مكررات, اشتملت الألواح الرئيسة ثلاثة تراكيز من حامض السالسلك (100 و200 و300 ملغم لتر$^{-1}$) فضلا عن معاملة المقارنة (رش النباتات بالماء المقطر), بينما اشتملت الألواح الثانوية ثلاثة أصناف من الكتان (السوري والمصري والعراقي المحلي). أظهرت النتائج تفوق الصنف السوري معنويا وأعطى أعلى النتائج لعدد الأفرع الرئيسة 7.09 و7.11 فرع نبات$^{-1}$ والثانوية 28.45 و27.10 فرع نبات$^{-1}$ وعدد الكبسولات 122.39 و117.89 كبسولة نبات$^{-1}$ وعدد البذور 8.63 و8.45 بذرة كبسولة$^{-1}$ وحاصل البذور 1.19 و1.17 طن متري هـ$^{-1}$, بينما تفوق الصنف المصري بأعلى متوسط لوزن 1000 بذرة 6.83 و6.54 غم لموسمي الدراسة بالتتابع. أظهرت النتائج أن رش حامض السالسلك بالتركيز 200 ملغم لتر$^{-1}$ تفوق معنويا وأعطى أعلى النتائج لعدد الأفرع الرئيسة 7.10 و6.82 فرع نبات$^{-1}$ والثانوية 29.05 و26.48 فرع نبات$^{-1}$ وعدد الكبسولات 120.48 و114.54 كبسولة نبات$^{-1}$ وعدد البذور 8.44 و8.26 بذرة كبسولة$^{-1}$ وحاصل البذور 1.19 و1.15 طن هـ$^{-1}$ لموسمي الدراسة بالتتابع. كان تأثير التداخل بين عاملي الدراسة معنويا في الصفات المدروسة جميعها.

الكلمات المفتاحية: الكتان, الهرمونات النباتية, عدد التفرعات, وزن البذور, حاصل البذور.

***البحث مستل من أطروحة دكتوراه للباحث الأول.**

***Received:28/8/2019, Accepted:10/11/2019**

INTRODUCTION

Linseed *Linum usitatissimum* L. a dual purpose industrial crop, grown at different regions of the world to obtain fiber and oil. Linseed seeds contain a high percentage of oil, ranging from 30-45% with high quality and medicinal importance, due to its unsaturated fatty acids such as oleic, linoleic and linolenic (20). The cultivation of this crop in Iraq suffers from several problems, including limited cultivars suitable for iraqi environmental conditions, which led to the dependence of agriculture on the experimental scale on the local cultivar, this requires the study of other cultivars with the local cultivar taking advantage of the genetic variation of these cultivars and their interaction with environmental conditions to reach the best environmentally adapted cultivars. The cultivation of the appropriate cultivar is an important factor in obtaining high productivity of the economic yield, but the cultivar alone isn't enough to achieve this, but requires the application of some field practices aimed at stimulating its genetic and physiological ability. The genetic and physiological ability of the cultivars to exploit environmental conditions could be increased by spraying some plant growth regulators, including salicylic acid, which plays an important roles in physiological activities that occur within plant tissues such as regulating the absorption of ions from soil solution (2, 11), stimulating cell division and differentiation, accelerate the formation of photosynthetic pigments and delay the aging of leaves (10), as well as its role in increasing plant hormones that stimulate growth (13, 16), and finally increase the efficiency of photosynthesis and the transition of its metabolic products to reproductive parts and improve seed yield and its components (5). El-Mergawy and Abdel-Wahed (7) and Raskin (17) reported that the activity of salicylic acid depends on spraying concentrations and stage, plant species, cultivar, growth stage of the plant as well as environmental conditions. Bakry et al., (4) and Sadak and Abd-Elhamid (18) found significant effect of salicylic acid spraying on the yield and its component of linseed. The aims of this research are to study the effect of salicylic acid spraying on yield and it's components of linseed cultivars.

MATERIALS AND METHODS

A field trails were carried out during winter season of 2017-2018 and 2018-2019 at Field Crops Department - College of Agricultural Engineering Sciences - University of Baghdad / Jadriyah in a clay loam soil to study the effect of salicylic acid spraying on yield and it's components of linseed cultivars. Randomized complete block design RCBD arranged within split plots used with three replicates. The trails included spraying salicylic acid with three concentrations (100, 200 and 300 mg L^{-1}) after 45 days of planting (18) in addition to control treatment (distilled water spraying) within main plots and three linseed cultivars (Syrian, Egyptian and Iraqi local) within sub plots. Soil management were carried out, and then the experiment land was divided into 36 experimental units, the area of each experimental unit was 4 m^2 which contained 10 lines, 20 cm apart. Chemical fertilizers were added with an average 90 kg N ha^{-1}, 120 kg P ha^{-1} and 80 kg K ha^{-1} (14). The seeds of the linseed cultivars were sown at a seed rate of 40 kg ha^{-1} (8) on the 12 and 13 Nov. for the two seasons, respectively. Crop management were carried out as needed, and the plants were harvested after the appearance of maturity signs.

Studied Traits

1. Number of main branches $plant^{-1}$ from ten plant randomly taken from the guarded lines for each experimental unit at the harvest stage was calculated.
2. Number of sub branches $plant^{-1}$ from ten plant randomly taken from the guarded lines for each experimental unit at the harvest stage was calculated.
3. Number of capsules $plant^{-1}$ was calculated.

4. Number of seeds capsule^{-1} was calculated by dividing the number of seeds capsules^{-1} by the number of capsules ten plants^{-1}.

5. Weight of 1000 seeds (g) calculated after mixing the seeds of the harvested plants from each experimental unit and taking 1000 seeds from them randomly and then weighed.

6. A sample of 1 m^2 of each experimental unit was harvested and the seeds were isolated from the straw, weighed and converted from gm m^{-2} to mton ha^{-1} for seed yield.

The data were analyzed statistically by using Gnestat program, and least significant difference (LSD) test at 0.05 probability level was used to compare the treatment means (19).

RESULTS AND DISCUSSION

Number of main branches plant^{-1}

The results at the Table 1 indicate that the cultivars were significantly different in the number of main branches plant^{-1}. The Syrian cv. gave the highest means 7.09 and 7.11 branches plant^{-1} compared with Egyptian cv. which gave the lowest means 5.43 and 5.26 branches plant^{-1} for the two seasons, respectively. These results show that the Syrian cv. was more responsive to environmental conditions and invested towards stimulating the growth of lateral buds and then an increasing the number of main branches plant^{-1} (1). Data at the Table 1 show that the number of main branches was significantly affected by spraying of salicylic acid. The spraying 200 mg L^{-1} had the highest means 7.10 and 6.82 branches plant^{-1}, whereas the control treatment had the lowest means 5.28 and 5.43 branches plant^{-1} for the two seasons, respectively. The increases could be due to the synergic role of salicylic acid with plant hormones responsible for cell division, elongation and expansion (12, 14, 15), which led to increased synthesis of growth-stimulating plant hormones and increased number of main branches plant^{-1}. The interaction between two factors was significant effect on the number of main branches plant^{-1}. The Syrian cv. with 200 mg SA L^{-1} had the highest values 7.97 and 7.81 branches plant^{-1} without significant differences on the same cultivar with 100 mg SA L^{-1} 7.74 branches plant^{-1} in the second season only, while the Egyptian cv. with control treatment had the lowest values 4.32 and 4.60 branches plant^{-1} for the two seasons, respectively.

Table 1. Effect of salicylic acid on the number of main branches plant^{-1} for the seasons 2018 and 2019

Salicylic acid concentrations	Linseed cultivar's			Mean
	Syrian	Egyptian	Iraqi	
2017-2018				
Control	6.16	4.32	5.35	5.28
100	6.75	5.48	5.98	6.07
200	7.97	5.89	7.44	7.10
300	7.50	6.02	6.56	6.70
LSD 0.05		0.38		0.28
Mean	7.09	5.43	6.33	
LSD 0.05		0.19		
2018-2019				
Control	6.04	4.60	5.66	5.43
100	7.74	4.89	6.07	6.23
200	7.81	5.61	7.04	6.82
300	6.86	5.94	6.11	6.30
LSD 0.05		0.69		0.47
Mean	7.11	5.26	6.22	
LSD 0.05		0.34		

Number of sub branches plant^{-1}

The results at the Table 2 show that there are significant differences among cultivars in the number of sub branches. The Syrian cv. gave the highest means 28.46 and 27.10 branches plant^{-1} compared with Egyptian cv. which gave the lowest means 22.82 and 20.57 branches plant^{-1} for the two seasons, respectively. The superiority of the Syrian cv. could be due to superior in the number of main branches plant^{-1} (Table 1). These results are in agreement with Al-Sudani (1). The spraying 200 mg SA L^{-1} was significantly superior in the number of sub branches 29.05 and 26.48 branches plant^{-1}, while the control treatment had the lowest means 22.26 and 21.03 branches plant^{-1} for the two seasons, respectively (Table 2). The superiority of 200 mg SA L^{-1} concentration could be due to superiority in the number of main branches

plant^{-1} (Table 1). The interaction between two factors was significant effect on the number of sub branches (Table 2). The Syrian cv. with 200 mg SA L^{-1} gave the highest values 33.22 and 30.07 branches plant^{-1} without significant differences on the same cultivar with 100 mg SA L^{-1} 29.68 branches plant^{-1} in the second season only, while the Egyptian cv. with control treatment gave the lowest values 20.05 and 18.05 branches plant^{-1} for the two seasons, respectively.

Table 2. Effect of salicylic acid on the number of sub branches plant^{-1} for the seasons 2018 and 2019

2017-2018				
Salicylic acid concentrations	Linseed cultivar's			Mean
	Syrian	Egyptian	Iraqi	
Control	24.55	20.05	22.17	22.26
100	26.99	22.65	24.56	24.74
200	33.22	23.47	30.48	29.05
300	29.09	25.13	26.56	26.93
LSD 0.05		2.14		2.02
Mean	28.46	22.82	25.94	
LSD 0.05		1.07		
2018-2019				
Control	23.17	18.05	21.86	21.03
100	29.68	19.49	24.29	24.49
200	30.07	21.77	27.59	26.48
300	25.49	22.98	24.71	24.40
LSD 0.05		2.36		1.62
Mean	27.10	20.57	24.62	
LSD 0.05		1.18		

Number of capsules plant^{-1}

The differences in the number of capsules among cultivars have been found significant (Table 3). The Syrian cv. was produced the highest means 122.39 and 117.89 capsules plant^{-1} compared with Egyptian cv. which had the lowest means 98.52 and 92.14 capsules plant^{-1} for the two seasons, respectively. The superiority of the Syrian cv. could be due to the superiority in number of main and sub branches plant^{-1} (Tables 1 and 2). These results are in agreement with Al-Sudani (1) who found that the increase in number of main and sub branches plant^{-1} led to an increase in the number of capsules plant^{-1}. Data at the Table 3 show that the number of capsules were significantly affected by spraying of salicylic acid concentrations. The spraying 200 mg SA L^{-1} gave the best results 120.48 and 114.54 capsules plant^{-1} compared with control treatment which had the lowest mean 101.99 and 94.57 capsules plant^{-1} for two seasons, respectively. The superiority of 200 mg SA L^{-1} concentration could be due to superior in number of main and sub branches plant^{-1} (Tables 1 and 2). These results are in agreement with Bakry et al., (4) and Sadak and Abd-Elhamid (18). The interaction between two factors affect significantly on the number of capsules plant^{-1} (Table 3). The Syrian cv. with 200 mg SA L^{-1} gave the highest values 133.56 and 127.76 capsules plant^{-1} without significant differences on the same cultivar with 100 mg SA L^{-1} 124.84 capsules plant^{-1} in the second season only, while the Egyptian cv. with control treatment gave the lowest values 90.24 and 84.16 capsules plant^{-1} for the two seasons, respectively.

Table 3. Effect of salicylic acid on the number of capsules plant^{-1} for the seasons 2018 and 2019

2017-2018				
Salicylic acid concentrations	Linseed cultivar's			Mean
	Syrian	Egyptian	Iraqi	
Control	110.32	90.24	105.41	101.99
100	119.33	96.55	111.18	109.02
200	133.56	102.10	125.79	120.48
300	126.34	105.21	116.54	116.03
LSD 0.05		5.40		4.01
Mean	122.39	98.52	114.73	
LSD 0.05		2.70		
2018-2019				
Control	105.21	84.16	94.34	94.57
100	124.84	87.92	108.84	107.20
200	127.76	96.20	119.66	114.54
300	113.75	100.27	104.17	106.06
LSD 0.05		6.29		4.93
Mean	117.89	92.14	106.75	
LSD 0.05		3.15		

Number of seeds capsule^{-1}

Results at the Table 4 show that the significantly differences among cultivars in the number of seeds capsule^{-1}. The Syrian cv. recorded the highest means 8.63 and 8.45 seeds capsule^{-1} compared with other cultivars

especially Egyptian cv. which recorded the lowest means 6.55 and 6.48 seeds capsule^{-1} for the two seasons, respectively. The differences among cultivars could be due to their genetical components and their response to the environmental conditions. These results are in agreement with Al-Sudani (1) and Andruszczak (3). Data at the Table 4 also show that the number of seeds capsule^{-1} was significantly affected by spraying of salicylic acid concentrations. The spraying 200 mg SA L^{-1} had the highest means 8.44 and 8.26 seeds capsule^{-1}, while the control treatment gave the lowest means 6.88 and 6.57 seeds capsule^{-1} for the two seasons, respectively.

Table 4. Effect of salicylic acid on the number of seeds capsule^{-1} for the seasons 2018 and 2019

2017-2018				
Salicylic acid concentrations	Linseed cultivar's			Mean
	Syrian	Egyptian	Iraqi	
Control	7.74	5.88	7.03	6.88
100	8.49	6.41	7.57	7.49
200	9.48	6.88	8.95	8.44
300	8.81	7.04	8.05	7.97
LSD 0.05		0.45		0.40
Mean	8.63	6.55	7.90	
LSD 0.05		0.22		
2018-2019				
Control	7.32	5.63	6.77	6.57
100	9.06	6.38	7.50	7.65
200	9.40	6.82	8.54	8.26
300	8.00	7.10	7.44	7.51
LSD 0.05		0.68		0.52
Mean	8.45	6.48	7.56	
LSD 0.05		0.34		

The increasing in the number of seeds could be due to the positive effect of salicylic acid to increase the efficiency of physiological activities including photosynthesis and an increasing their metabolic products and transfer to reproductive parts and that led to increase the pollen germination, number of fertilized ovules, reduce seed abortions and then an increasing the number of seeds capsule^{-1}. These results are in agreement with Sadak and Abd-Elhamid (18). The interaction between two factors affect significantly on the number of seeds capsules^{-1} (Table 4). The Syrian cv. with 200 mg SA L^{-1} had the highest values 9.48 and 9.40 seeds capsule^{-1} without significant differences on the same cultivar with 100 mg SA L^{-1} 9.06 seeds capsule^{-1} in the second season only, while the Egyptian cv. with control treatment had the lowest values 5.88 and 5.63 seeds capsule^{-1} for the two seasons, respectively.

1000 seeds weight

The differences in 1000 seeds weight among cultivars have been found significant (Table 5). The Egyptian cv. gave the highest means 6.83 and 6.54 g compared with Syrian cv. which gave the lowest means 5.81 and 5.39 g for the two seasons, respectively. The superiority of the Egyptian cv. could be due to the low number of capsules plant^{-1} and number of seeds capsule^{-1} (Tables 3 and 4) and that led to seed getting a greater amount of metabolic compounds and an increasing its weight. These results are in agreement with Al-Sudani (1) who reported that the Egyptian cv. gave the highest mean of 1000 seeds weight. The results at the Table 5 indicate that the control treatment was significantly superior in the 1000 seeds weight 6.66 and 6.35 g compared with spraying of salicylic acid concentrations especially 200 mg SA L^{-1} which had the lowest means 5.89 and 5.62 g for the two seasons, respectively. The reason of the lowest weight of 1000 seeds in the 200 mg SA L^{-1} could be due to superior in the number of capsules plant^{-1} and number of seeds capsule^{-1} (Tables 3 and 4). Further, more greatest number of seeds capsule^{-1} greater competition among them for the metabolic compounds of photosynthesis which leads to the distribution and partitioning of these products to a larger number of seeds and then the seed weight is lower. The interaction between cultivars and salicylic acid concentrations was significant differences on the 1000 seeds weight in the second season only (Table 5). The Egyptian cv. with control treatment had the highest values 7.17 and 6.91 g, whereas the Syrian cv. with 200 mg SA L^{-1} concentration

had the lowest values 5.25 and 4.94 g for the two seasons, respectively without significant differences on the same cultivar with 100 mg SA L^{-1} concentration 5.08 g in the second season only.

Table 5. Effect of salicylic acid on the 1000 seeds weight (g) for the seasons 2018 and 2019

2017-2018				
Salicylic acid concentrations	Linseed cultivar's			Mean
	Syrian	Egyptian	Iraqi	
Control	6.21	7.17	6.60	6.66
100	5.92	6.92	6.32	6.39
200	5.25	6.70	5.72	5.89
300	5.87	6.52	6.15	6.18
LSD 0.05		0.22		0.16
Mean	5.81	6.83	6.20	
LSD 0.05		0.11		
2018-2019				
Control	5.88	6.91	6.26	6.35
100	5.08	6.71	5.93	5.91
200	4.94	6.35	5.58	5.62
300	5.65	6.17	6.08	5.97
LSD 0.05		0.17		0.14
Mean	5.39	6.54	5.97	
LSD 0.05		0.08		

Seeds yield

The seeds yield differences among cultivars were significant (Table 6). The Syrian cv. had the highest means 1.19 and 1.17 mton ha^{-1} while the Egyptian cv. produced the lowest means 0.94 and 0.89 mton ha^{-1} for the two seasons, respectively. The superiority of the Syrian cv. could be due to superiority in the number of capsules $plant^{-1}$ and number of seeds $capsules^{-1}$ (Tables 3 and 4). These results are in agreement with Al-Sudani (1), El-Borhamy (6) and Gupta (9). Data at the Table 6 show that the seed yield was significantly affected by salicylic acid spraying. The spraying of salicylic acid at concentration 200 mg L^{-1} produced the highest means 1.19 and 1.15 mton ha^{-1}, while the control treatment had the lowest means 0.91 and 0.90 mton ha^{-1} for the two seasons, respectively. The superiority of salicylic acid at concentration 200 mg L^{-1} could be due to the increase in the number of capsules $plant^{-1}$ and number of seeds $capsule^{-1}$ (Tables 3 and 4). These results are in agreement with Bakry et al., (4) and Sadak and Abd-Elhamid (18) who noted that the spraying of salicylic acid caused significant increases in the seed yield of linseed compared with control treatment. The interaction between two factors was significant effect on the seed yield. Data in Table 6 show that the Syrian cv. with 200 mg SA L^{-1} had the highest values 1.33 and 1.30 mton ha^{-1} without significant differences on the same cultivar with 100 mg SA L^{-1} 1.28 mton ha^{-1}, while the Egyptian cv. with control treatment gave the lowest values 0.79 and 0.77 mton ha^{-1} for the two seasons, respectively.

Table 5. Effect of salicylic acid on the seed yield (mton ha^{-1}) for the seasons 2018 and 2019

2017-2018				
Salicylic acid concentrations	Linseed cultivar's			Mean
	Syrian	Egyptian	Iraqi	
Control	1.02	0.79	0.91	0.91
100	1.18	0.94	1.09	1.07
200	1.33	1.00	1.24	1.19
300	1.23	1.01	1.14	1.12
LSD 0.05		0.05		0.04
Mean	1.19	0.94	1.09	
LSD 0.05		0.03		
2018-2019				
Control	1.00	0.77	0.93	0.90
100	1.28	0.83	1.04	1.05
200	1.30	0.96	1.18	1.15
300	1.10	0.99	1.06	1.05
LSD 0.05		0.10		0.07
Mean	1.17	0.89	1.05	
LSD 0.05		0.05		

REFFERNCES

1. Al-Sudani, E. Kh. F. 2018. Effect of Bio Fertilization on Linseed Yield and Oil Qualities. MSc. Thesis, Dept. of Field Crops, Coll. of Agric. Engin. Sci. Univ. of Baghdad. pp. 99.

2. Alwan, U. A.; H. M. Aboud and B. H. Majeed. 2016. Effect of bio-fertilizer and salicylic acid on availability of some nutrients in soil and plant and some vegetative and production quality of beans irrigated with saline water. Iraqi J. Agric. Sci. 47(1): 291-302.

3. Andruszczak, S.; U. Gawlik-Dziki; P. Kraska; E. Kwiecińska-Poppe; K. Różyło and E. Pałys. 2015 .Yield and quality traits of two linseed (*Linum usitatissimum* L.) cultivars as affected by some agronomic factors. Plant Soil Environ. 61(6): 247–252.

4. Bakry, B. A.; D. M. El-Hariri; M. Sh. Sadak and H. M. S. El-Bassiouny. 2012. Drought stress mitigation by foliar application of salicylic acid in two linseed varieties grown under newly reclaimed sandy soil. J. of Appl. Sci. Res. 8(7): 3503-3514.

5. Belkhadi, A.; Z. H. Abbes; I. Nouairi; Z. Barhoumi; M. Zarrouk; W. Chaibi and W. Djebali. 2010. Effects of exogenous salicylic acid pre-treatment on cadmium toxicity and leaf lipid content in Linum usitatissimum L. Ecotox Environ Safe. 73: 1004-1011.

6. El-Borhamy, A. M. A. 2016. Effect of seeding rates and nitrogen fertilizer levels on yield and yield components of two new flax cultivars. J. Agric. Res. Kafr El-Sheikh Univ. 42(2): 183-195.

7. El-Mergawy, A. A. and M. S. A. Abdel-Wahed. 2004. Diversity in salicylic acid effects on growth criteria and different indole acetic acid forms among faba bean and maize. Egypt J. Agron. 26: 49-61.

8. Elsahookie, M. M. 1978. Effects of varying row spacing on linseed yield and quality. Can. J. Plant Sci. 58: 935-931.

9. Gupta, M.; S. Kour; V. Gupta; R. Bharat and C. Sharma. 2017. Effect of different doses of fertilizers on yield and NPK uptake of linseed (*Linum usitatissimum* L.). Bangladesh J. Bot. 46(2): 575-581.

10. Hayat, S. and A. Ahmad. 2007. Salicylic acid: A plant hormone. Springer (edrs.). Dortrecht, Netherlands. pp. 401.

11. Horvath, E.; G. Szalai and T. Janda. 2007. Induction of abiotic stress tolerance by salicylic acid signaling. J. Plant Growth Reg. 26: 290-300.

12. Jaddoa, K. A. and B. A. Ibrahim. 2014. Effect of salicylic acid on some vegetative and fruiting characteristics of *Nigella sativa* L. Iraqi J. Agric. Sci. 45(8)(Special issue): 845-853.

13. Mateo, A. F. D.; P. Muhlenbock; B. Kular; P. M. Mullineaux and S. Karpinski. 2006. Controlled levels of salicylic acid are required for optimal photosynthesis redox homeostasis. J. Exp. Bot. 57(8): 1795-1807.

14. Mohammed Ali, Kh. I.; A. A. A. Al-Jubori; M. H. K. Al-Baldaw and Z. A. Abdul Al-Majeed. 2010. Field Crops Production. 1st Edn., Alwaquf Al-Haditha Press. pp. 285.

15. Osbourn, A. E. and V. Lanzotti. 2009. Plant-derived Natural Products, Synthesis, Function and Application. Springer Dordrecht, Netherlands. pp. 124.

16. Popova, L.; T. Pancheva and A. Uzunova. 1997. Salicylic acid: Properties, biosynthesis and physiological role. Bulg. J. Plant Physiol. 23: 85-93.

17. Raskin, I. 1992. Salicylate, a new plant hormone. Plant Physiol. 99: 799-803.

18. Sadak, M. Sh. and E. M. Abd-Elhamid. 2013. Physiological response of flax cultivars to the effect of salinity and salicylic acid. J. of Appl. Sci. Res. 9(6): 3573-3581.

19. Steel, R. G. and Y. H. Torrie. 1960. Principles and Procedures of Statistics. Mc Grow - Hill Book Co., Inc. New York. pp. 480.

20. Storlien, L.; A. J. Hulbert and P. L. Else. 1998. Polyunsaturated fatty acids, membrane function and metabolic diseases such as diabetes and obesity. Curr. Opin. Clinical Nutrition and Metabolic Care. 1: 559-563.