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EFFECTS OF SALICYLIC ACID ELICITOR AND POTASSIUM FERTILIZER AS FOLIAR SPRAY ON CANOLA PRODUCTION IN THE RECLAIMED LAND IN ISMAILIA GOVERNORATE, EGYPT

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ABSTRACT. A field experiment was conducted at the farm of Faculty of Agriculture, Suez Canal University, Ismailia Governorate, Egypt, during 2013/'14 and 2014/'15 seasons, to determine the effects of salicylic acid elicitor (SA) and potassium fertilizer (K) as foliar spray on canola production in the reclaimed land. Canola plants were sprayed with three rates of K and SA separately and together. The concentrations of SA with a surfactant triton 0.1% and concentrations of K sprayed after 30 days of sowing by one week interval for three times using hydraulic sprayer. Results indicated that K and SA provided good nutrition and resistance for pathogens, enhanced plant height (cm), number of branches/ plant, fruiting zone (cm), seed yield/ plant (g), seed yield/ fed and oil percentage of canola cultivar (Serw 4) in the reclaimed land. K and SA separately or in combination at the rate of (6.0 cm^{-1} + 300 mg^{-1} SA) provided the best nutrition for enhancing resistance of plants against biotic and a biotic factors, consequently, enhancing vegetative growth and yield production during seasons of study 2013/'14 and 2014/'15.

Key words: Salicylic acid; Potassium fertilizer; Foliar spray; Canola production.

INTRODUCTION

Egypt has been facing a shortage of edible oils. As a result, large quantities of edible oil are being imported annually from other countries. Introduction of canola (*Brassica napus* L.) in Egypt has a bright future to contribute in reducing oil deficiency gap between production

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and consumption of edible oil, particularly it could be successfully grown during winter season in newly reclaimed land outside the old one of Nile valley to get around the competition with other crops occupied the old cultivated area (Sharaan *et al.,* 2002). The oil obtained from the seed is used also in industry to produce varnish, detergents and cleaning products, soaps, glycerin, cosmetics and in the leather and rubber industry, too. In addition to the use of canola in food industry, seed of canola is used to produce a biodiesel in recent years. This type of biodiesel is called rape methyl ester, which is used as renewable source of energy instead of oil and fossil fuels

Salicylic acid (SA), as an antioxidant compound and plant growth regulator, is known to relate on different physiological processes in plants including growth (Khodary, 2004; Hussein *et al.,* 2007), defense responses (Chen *et al.,* 2010). On the other hand, the role of SA has demonstrated in modulating plant responses to a wide range of oxidative stresses (Borsani *et al.,* 2001; Choudhury and Panda, 2004) and regulating the activities of antioxidant enzymes and increase plant tolerance to abiotic stress (Noreen *et al.,* 2009; Erdal *et al.,* 2011).

Nutrients have pivotal role in increasing crop production. Besides N and P, the use of K has been reported to influence seed yield and seed oil contents (Pervez *et al.,* 2004). K plays a vital role in photosynthesis, translocation of photosynthates, protein synthesis, control of ionic balance, regulation of plant stomata and water use, activation of plant enzymes and many other processes (Reddya *et al.,* 2004). It is not only an essential macronutrient for plant growth and development, but also is a primary osmoticum in maintaining low water potential of plant tissues. Efficient use of nutrients by canola cultivars are capable of producing high yields with low nutrient inputs and therefore have the potential to increase the productivity in soil with low nutrient availability. Many studies have reported the significant variation among the canola genotypes in efficiency of N and P uptake and utilization (Svecnjak and Rengel, 2006).

Therefore, the purpose of this research is to investigate the impact of potassin-F (K) and salicylic acid elicitor (SA) on growth and production of canola plants in the reclaimed land in Ismailia, Egypt.

MATERIALS AND METHODS

Experimental design

A field experiment was conducted at the experimental farm, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt, during 2013-‘14 and 2014-‘15 seasons. Canola, cv. Serw 4 (the most common cultivar grown in Ismailia region) was sown on 21 October 2013 and on 20 October 2014. The soil of the experimental site was sandy soil (86.21% sand, 10.5 % silt and 3.29 clay), with pH 8.02 and EC 0.44 dSm^{-1}. Plants were thinned to one plant per hill; 20 cm between hills to insure 27.000 plants/fed. Recommended cultural and agronomic practices were adopted from sowing to harvest. No insecticide was sprayed in and around the experimental fields. The experimental area was divided into ten treatment areas. The treatments details are shown in *Table 1*.

Table 1 - Potassin-F and salicylic acid treatment levels used in the present study

Treatments	SA (mg^{-1})	Potassin-F (cm^{-1})
T1	0 (Control)	0 (Control)
T2	0	1.5
T3	0	3.0
T4	0	6.0
T5	100	0
T6	200	0
T7	300	0
T8	100	1.5
T9	200	3.0
T10	300	6.0

Each treatment included four replicates. The replicates were distributed in a complete randomized block design.

Treatments

Canola plants were sprayed with three levels of potassin-F and salicylic acid separately and together. Potassin-F was purchased from the Agriculture Research Center, Giza and salicylic acid was initially dissolved in a few drops ethanol and then dispersed in water to give required rate. The concentrations of SA with a surfactant triton 0.1% and concentrations of K sprayed after 30 days of sowing by one week interval for three times using hydraulic sprayer. Control plants applied only with distilled water, each treatment was replicated four times.

Effect of potassin-F and salicylic acid elicitor on canola production

At harvest time, ten individual plants were chosen randomly from the middle ridge of each plot in both seasons and some parameters were measured as follows:
- plant height (cm);
- number of branches/plant;
- fruiting zone length (cm);
- seed yield/plant (g);

Plants in the three inner ridges were harvested, dried, threshed and seeds were weighed in kg/m^2, then it was converted to estimate:
- seed yield/fed. (kg);
- seed oil percentage according to A.O.A.C (1980).

Statistical analysis

Data obtained in the present study was subjected to an analysis of variance (ANOVA) with the honestly significant difference value calculated as Tukey's statistic at $p \leq 0.05$. (SAS Institute, 2004).

RESULTS AND DISCUSSION

Results in *Tables 2-7* showed the quantitative and qualitative parameters that measured in different 10 treatments. Data showed significant differences between the studied treatments in all parameters [plant height (cm), number of branches/ plant, fruiting zone (cm), seed yield/plant, seed yield/fed and oil percentage]. Plant height (cm) of canola crop in all treatments from T_2 to T_{10} had higher values than control (T_1) in 2013/'14 and 2014/'15 seasons, and showed significant differences among treatment in both seasons (F= 82.77; $p \leq$ 0.0000 and F=98.84; $p \leq$ 0.0000), respectively. Also, data indicated that plant height significantly increased with increasing rate of P and SA, when they sprayed alone or in combination, compared to unsprayed plants (*Table 2*).

Data in *Table 3* cleared that number of branches/ plant was significantly increased with increasing K and SA, such as in in the high rate of their combination (6.0 cm^{-1} K + 300 mg^{-1} SA). *Table 4* revealed that fruiting zone (cm) was significantly increased with increasing K and SA, such as in in the high rate of their combination (6.0 cm^{-1} K + 300 mg^{-1} SA).

Table 5 showed effects of different treatment of K and SA either alone or in combination on fruiting zone (cm). All treatments from T_2 to T_{10} had higher values than control (T_1) in 2013/'14 and 2014/'15 seasons, and showed significant differences among treatment in both seasons (F=97.81; $p \leq$ 0.0000 and F=125.88; $p \leq$ 0.0000), respectively. Number of seed per plant showed high values in combination treatments (T_8, T_9 and T_{10}) in both growing seasons. It was 37.4, 37.9 and 40.1 g for the first season and 37.6, 37.6 and 40.0 g in the second season, respectively. In addition to, results revealed that plant number of seed per plant increased with increasing rate of K and SA, when they sprayed alone or in combination, compared to unsprayed plants (*Table 5*).

Table 2 - Effect of three level of potassin-F, salicylic acid and combination between them on plant height (cm) of canola in 2013-'14 and 2014-'15 seasons

Treatments	Plant height (cm)	
	2013/'14	2014/'15
T1 (Control)	140.5 d	139.8 f
T2 (1.5 cm^{-1} K)	151.8 c	149.8 e
T3 (3.0 cm^{-1} K)	158.5 c	155.3 e
T4 (6.0 cm^{-1} K)	169.0 b	167.2 d
T5 (100 mg^{-1} SA)	154.6 c	153.6 e
T6 (200 mg^{-1} SA)	168.5 b	169.2 cd
T7 (300 mg^{-1} SA)	177.2 a	175.1 bc
T8 (1.5 cm^{-1} K + 100 mg^{-1} SA)	178.4 a	176.2 b
T9 (3.0 cm^{-1} K + 200 mg^{-1} SA)	180.5 a	179.1 ab
T10 (6.0 cm^{-1} K + 300 mg^{-1} SA)	184.0 a	183.7 a
LSD 0.05	4.442	4.081
F	82.777	98.84
$p \leq$	0.0000	0.0000

Means followed with the same letters (row wise) are not significantly different (Tukey' HSD; $p \leq$ 0.05)

Table 3 - Effect of three level of potassin-F, salicylic acid and combination between them on number of branches/ plant of canola in 2013/'14 and 2014/'15 seasons

Treatments	Number of branches/ plant	
	2013/'14	2014/'15
T1 (Control)	5.1 e	5.1 f
T2 (1.5 cm^{-1} K)	5.9 de	6.0 e
T3 (3.0 cm^{-1} K)	6.6 cd	6.8 d
T4 (6.0 cm^{-1} K)	7.2 bc	7.1 cd
T5 (100 mg^{-1} SA)	5.7 e	5.8 ef
T6 (200 mg^{-1} SA)	7.1 bc	7.0 cd
T7 (200 mg^{-1} SA)	8.2 a	7.6 bc
T8 (1.5 cm^{-1} K + 100 mg^{-1} SA)	7.8 ab	7.7 bc
T9 (3.0 cm^{-1} K + 200 mg^{-1} SA)	8.1 a	8.2 ab
T10 (6.0 cm^{-1} K + 300 mg^{-1} SA)	8.5 a	8.7 a
LSD 0.05	0.524	0.407
F	39.03	44.761
$p \leq$	0.0000	0.0000

Means followed with the same letters (row wise) are not significantly different (Tukey' HSD; $p \leq 0.05$).

Table 4 - Effect of three level of potassin-F, salicylic acid and combination between them on fruiting zone length (cm) of canola in 2013/'14 and 2014/'15 seasons

Treatments	Fruiting zone length (cm)	
	2013/'14	2014/'15
T1 (Control)	110.5 h	113.0 f
T2 (1.5 cm^{-1} K)	119.5 g	117.8 ef
T3 (3.0 cm^{-1} K)	128.0 f	125.5 d
T4 (6.0 cm^{-1} K)	134.4 de	133.4 cd
T5 (100 mg^{-1} SA)	121.1 g	1221.3 ef
T6 (200 mg^{-1} SA)	132.0 ef	132.2 cd
T7 (200 mg^{-1} SA)	139.5 cd	140.3 bc
T8 (1.5 cm^{-1} K + 100 mg^{-1} SA)	141 bc	140.4 bc
T9 (3.0 cm^{-1} K + 200 mg^{-1} SA)	145.6 ab	146.9 ab
T10 (6.0 cm^{-1} K + 300 mg^{-1} SA)	146.5 a	150.2 a
LSD 0.05	3.407	3.138
F	97.813	125.88
$p \leq$	0.0000	0.0000

Means followed with the same letters (row wise) are not significantly different (Tukey' HSD; $p \leq 0.05$)

Table 5 - Effect of three level of potassin-F, salicylic acid and combination between them on seed yield/ plant (g) of canola in 2013/'14 and 2014/'15 seasons

Treatments	Seed yield/ plant (g)	
	2013/'14	2014/'15
T1 (Control)	30.3 h	31.1 f
T2 (1.5 cm^{-1} K)	33.0 g	32.9 def
T3 (3.0 cm^{-1} K)	34.09 f	33.5 de
T4 (6.0 cm^{-1} K)	35.8 de	36.0 bc
T5 (100 mg^{-1} SA)	31.5 g	32.4 ef
T6 (200 mg^{-1} SA)	34.6 ef	34.6 cd
T7 (200 mg^{-1} SA)	36.1 cd	37.1 b
T8 (1.5 cm^{-1} K + 100 mg^{-1} SA)	37.4 bc	37.6 b
T9 (3.0 cm^{-1} K + 200 mg^{-1} SA)	37.9 ab	37.6 b
T10 (6.0 cm^{-1} K + 300 mg^{-1} SA)	40.1 a	40.0 a
LSD 0.05	1.1894	1.172
F	50.272	45.685
$p\leq$	0.0000	0.0000

Means followed with the same letters (row wise) are not significantly different (Tukey' HSD; $p\leq$ 0.05)

Table 6 - Effect of three level of potassin-F, salicylic acid and combination between them on seed yield/ fed (kg) of canola in 2013/'14 and 2014/'15 seasons

Treatments	Seed yield/ fed (kg)	
	2013/'14	2014/'15
T1 (Control)	666.6 g	684.2 e
T2 (1.5 cm^{-1} K)	726.0 ef	717.2 de
T3 (3.0 cm^{-1} K)	752.4 de	734.8 d
T4 (6.0 cm^{-1} K)	787.6 cd	800.8 bc
T5 (100 mg^{-1} SA)	693.0 fg	715.0 de
T6 (200 mg^{-1} SA)	761.2 de	781.0 c
T7 (200 mg^{-1} SA)	794.2 bcd	807.4 bc
T8 (1.5 cm^{-1} K + 100 mg^{-1} SA)	822.8 bc	827.2 b
T9 (3.0 cm^{-1} K + 200 mg^{-1} SA)	833.8 b	829.4 b
T10 (6.0 cm^{-1} K + 300 mg^{-1} SA)	882.2 a	877.8 a
LSD 0.05	26.167	26.572
F	50.272	42.576
$p \leq$	0.0000	0.0000

Means followed with the same letters (row wise) are not significantly different (Tukey' HSD; $p\leq$ 0.05)

Table 7 - Effect of three level of potassin-F, salicylic acid and combination between them on seed oil percentage of canola in 2013/'14 and 2014/'15 seasons

Treatments	Seed oil percentage	
	2013/'14	2014/'15
T1 (Control)	42.36 e	42.68 bc
T2 (1.5 cm^{-1} K)	42.69 cd	42.79 bc
T3 (3.0 cm^{-1} K)	42.95 ab	42.86 ab
T4 (6.0 cm^{-1} K)	43.02 a	43.17 a
T5 (100 mg^{-1} SA)	42.35 e	42.53 bc
T6 (200 mg^{-1} SA)	42.54 e	42.66 bc
T7 (200 mg^{-1} SA)	42.55 cde	42.51 c
T8 (1.5 cm^{-1} K + 100 mg^{-1} SA)	42.48 de	42.63 bc
T9 (3.0 cm^{-1} K + 200 mg^{-1} SA)	42.54 cd	42.55 bc
T10 (6.0 cm^{-1} K + 300 mg^{-1} SA)	42.74 bc	42.64 bc
LSD 0.05	0.1564	0.2037
F	16.689	7.447
p≤	0.0000	0.0000

Means followed with the same letters (row wise) are not significantly different (Tukey' HSD; $p \leq 0.05$)

Results in *Table 6* showed that the best treatment was T_{10} (6.0 cm^{-1} K + 300 mg^{-1} SA); it produced 882.2 kg per ha in the season of 2013/'14 and 877.8 kg per ha in the 2014/'15 season, respectively, followed by T_9 (3.0 cm^{-1} K + 200 mg^{-1} SA); it produced 833.8 kg per ha in the season of 2013/'14 and 829.4 kg per ha in the 2014/'15 season, respectively. Then, T_8 (1.5 cm^{-1} K + 100 mg^{-1} SA), produced 822.8 kg per ha in the season of 2013/'14 and 827.2 kg per ha in the 2014/'15 season, respectively.

Also, oil percentage (*Table 7*) recorded the highest values in T_3 and T_4 than other of treatments. It was 42.95% in the growing season of 2013/'14 and 42.86% in the season of 2014/'15 for T_3 and 43.02% in the growing season of 2013/'14 and 43.17% in the growing season of 2014/'15 for T_4. Results indicated that the highest values of most studied characters were produced by spraying canola with (6.0 cm^{-1} K + 300 mg^{-1} SA). This promotive effect of the previous treatment could be attributed, in part, to its effect on many metabolic and physiological processes or increase the defense mechanism of canola against pathogens and stress.

In general, treatment of K and SA separately or in combination, particularly at the high rates (6.0 cm^{-1} K + 300 mg^{-1} SA) clearly caused significant increase in all studied characters (plant height, number of branching, fruiting zone, seed yield per plant and seed yield per fed) during 2013/'14 and 2014/'15 season. Therefore, application of K and SA through development of canola is so necessary for encouraging the defense system or tolerant and increasing vegetative growth and yield. Mahmoud (2013) reported that application of potassin-F and salicylic acid separately or in combination on sesame plants in the reclaimed soil had enhanced the growth rates and yield. Karimi *et al.* (2012) mentioned that potassium increase yield, splitting percentage; nut fresh mass and kernel dry mass and decrease blank percentage whereas the application of salicylic acid was unaffected on splitting percentage and decrease blank percentage. Simultaneous application of salicylic acid and potassium increase K and Zn concentrations of leaves. The interaction of K and SA indicated that all studied characters were significantly increased than their applied separately or control. It may be related to alleviating environmental stresses, enhancing plant resistance and increasing translocation carbohydrate content resulted to photosynthesis. The effects of SA and K on decreasing of abiotic stress and increasing production of crop plants reported by numerous works (Amin *et al.,* 2007; Eraslan *et al.,* 2007).

CONCLUSION

Potassin-F (K) and salicylic acid (SA) provided the good nutrition for enhancing resistance of plants against biotic and a biotic factors, consequently, enhancing vegetative growth and yield production during seasons of study 2013/'14 and 2014/'15. It could be recommended that using K and SA in combination at high rate of (6.0 cm^{-1} K + 300 mg^{-1} SA) in the reclaimed land for enhancing vegetative growth and yield production of canola.

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