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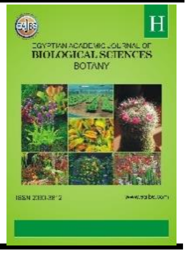

Role of Salicylic Acid and Yeast Extract in Wheat Production Under Saline Soils Conditions

Gomaa[1], M. A., Essam E. Kandil[1], E. G. Galal[2] and A.M. El- Shehata[3]

1-Plant Production Department, Faculty of Agriculture, Saba Basha, Alexandria University, Egypt.

2-Agricultural Reaches Center, Nubaria Station, Alexandria

3-Agricultural Reaches Center, El-Sabhia Station, Alexandria

*E-Mail: amrshehata09@gmail.com

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ABSTRACT

To investigate the effect of foliar application of salicylic rates and yeast extract on yield and quality of wheat, in this respect the two experiments were carried out at the Experimental Farm, Faculty of Agriculture, Saba Basha, Alexandria University, Alexandria Governorate, Egypt, during the two winter seasons of 2019/2020 and 2020/2021. This factorial experiment was laid out in randomized complete block design (RCBD) with three replications in both seasons. The first factor was salicylic acid concentrations (spray water, 150, 300 and 450 ml/l), while the second factor was yeast (water = control, 2, 4 and 6 g/l water) was in both seasons. The obtained results showed that foliar application of salicylic acid (SA) and yeast extract of wheat significantly affected yield and its component, whereas increasing of SA and yeast extract increased yield and yield component characters of wheat in both seasons. The interaction between SA and yeast was significant on all the studied characters, where planting Giza 171 with foliar application of 450 ppm SA/L and 4 and 6 g yeast/L recorded the highest ones in the two seasons under the study conditions.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important world's leading cereal crop. In Egypt, wheat is considered the chief crop used as a source of human food. While wheat production/unit area in Egypt has significantly increased during the past years, wheat production supplies about 40 % of its annual domestic demand only. Wheat is the essential crop in Egypt and grows on an area of 3.39 million faddan (faddan = 4200 m2) with an annual production of about 9.28 million tonnes and with an average yield of 2.74 tons per feddan (FAO, 2019).

Salinity as an abiotic stress agent is one of the most vital factors appearing in areas categorized by low amounts of freshwater, high evapotranspiration rate, and lack of precipitation, which has a harmful effect on crop production. Salinity is an obstacle in agriculture, and the ability to maintain or even improve soybean production levels under this constraint will require a good understanding of the genetic components responsible for salt tolerance. Salt stress affects major crop processes as photosynthesis, protein synthesis and lipid metabolism (Parvaiz and Satyawati, 2008). El Sebai *et al.* (2016) reported that salt stress is considered one of the most important abiotic stress limiting plant growth and productivity through increases in reactive oxygen species (ROS).

Salicylic acid (SA) is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plants. Salicylic acid plays an important role in the regulation of plant growth, development, defense from biotic and abiotic stress, and in-plant immune responses (Pasala *et al*., 2016; Maruri-López *et al*., 2019; Pasternak *et al*., 2019). Salicylic acid (SA) enhances plant growth and photosynthetic capacity in saline conditions (Noreen *et al*., 2012). On the otherwise, Khodary (2004) found that SA could be encouraged salt tolerance in maize plants *via* improving their photosynthesis performance and carbohydrate metabolism. Foliar application of SA significantly affected growth and photosynthesis. Photosynthesis acts an essential role in plant productivity and takes place in green leaves and depends on its content of chlorophyll. (Khodary, 2004 and El-Tayeb, 2005). The phytohormones have critical roles in plant responses to salinity in addition to the application of salicylic acid (SA) improves photosynthesis activity and plant growth under salinity conditions (Afzal *et al*., 2006 and Khan *et al*., 2014). On the other trend, Abdelaal *et al.* (2020) revealed that foliar application of SA led to improvements in the plant growth characters, as stem length, number of leaves, and dry weight of plants, in addition to relative water content; however, electrolyte leakage and lipid peroxidation were decreased. Furthermore, foliar application of SA led to enhanced yield characters in stressed plants compared with untreated stressed barley plants. Also, SA plays a pivotal role as a plant growth regulator and influences intra- and inter-plant communication attributable to its methyl ester form, methyl salicylate, which is highly volatile. Under stress, including HM stress, SA interacts with other plant hormones (e.g., auxins, abscisic acid, gibberellin) and promotes the stimulation of antioxidant compounds and enzymes thereby alerting HM-treated plants and helping in counteracting HM stress (Sharma *et al*., 2020). Gomaa *et al.* (2020 a and 2020 b) indicated that SA application increased yield and yield components of soybean under the soil as affected by salinity.

Yeasts create antimicrobial and other useful materials required for plant growth from amino acids and sugars secreted by bacteria, organic matter and plant roots (Boraste *et al*., 2009). However, Agamy *et al*. (2013) showed that the use of yeast as a bio-fertilizer in agriculture has received considerable attention because of its bioactivity and safety for humans and the environment. Also, Ismail and Amin (2014) showed that application of yeast (6 g /l) + B12 or yeast (6 g /l) + arginine showed the heaviest 100 seeds as a compared with untreated plant. Moreover, it could be decided that foliar spraying of yeast (4 g/l) +Arg. caused the highest values of yielded seeds protein, while the highest values of yielded carbohydrates at yeast extract (4 g/l) +B12 of wheat plants. However, Abdelaal *et al.* (2017) showed that the application of yeast extract (6 g/L), improved the physiological characteristics and yields of salt-stressed plants as compared with untreated stressed plants. They showed the important role of yeast extracts in enhancing sweet pepper growth and tolerance to salinity stress via modulation of the physiological parameters and antioxidants machinery.

The aims of this study were to:

1- Study the effect of salicylic acid (SA) and yeast extracts on yield and yield components of wheat, and
2- study the interaction effect between salicylic acid (SA) and yeast extracts concentrations on yield and its components characters of wheat to determine the best combination, which will increase the production of wheat and avoid exposure of the crop to salt stress.

MATERIALS AND METHODS

Two field experiments were conducted out at the experimental farm, Faculty of Agriculture, Saba Basha, Alexandria University, Alexandria Governorate, Egypt, during the two winter seasons of 2019/2020 and 2020/2021 to study the effect of foliar application of salicylic acid (SA) concentrations, yeast extracts and their interaction on wheat (cv. Giza 171) productivity under the soil as affected by salts.

The physical and chemical properties of experimental soil are presented in Table 1 which according to the method described by Page *et al.* (1982).

The two factorial experiments were laid out in randomized completely block design (RCBD) with three replications in both seasons. The first factor was salicylic acid concentrations (spray water, 150, 300 and 450 ml/l), while the second factor was yeast (water = control, 2, 4 and 6 g/l water) was in both seasons.

Table 1. Soil physical and chemical properties of experimental sites in both seasons.

Soil properties	Seasons	
	2019/ 2020	2020/2021
A- Mechanical analysis		
Sand	14.50	14.70
Silt	42.10	42.10
Clay	43.40	43.20
Soil texture	Clay loam	Clay loam
B- Chemical properties		
pH (1:1)	7.70	7.60
EC (1:1) dS/m	4.10	4.20
1- Soluble cations (1:2)		
K^+	1.40	1.45
Ca^{++}	14.20	15.40
Mg^{++}	11.30	11.50
Na^+	13.60	13.80
2- Soluble anions (1:2)		
CO^-_3+ HCO^-_3	2.80	2.90
CL^-	19.70	19.80
SO^-_4	12.40	12.50
Calcium carbonate (%)	6.70	6.90
Total nitrogen (%)	1.10	1.20
Available P (mg/kg)	3.70	3.60
Organic matter (%)	1.50	1.60

In both seasons of 2019/2020 and 2020/2021, wheat grains were sown on 22nd November and 20 November.

The area of the plot was 10.5 m^2 as 3.5 meters long and 3.0 m in width. The broadcasting method called (Afair) was used and all the other cultural practices were followed as the recommendation of Ministry of Agriculture and Land Reclamation recommendations.

The commercial SA from El Jomhoureya Company – Cairo- Egypt were prepared in concentrations of 150, 300 and 450 ml/l and sprayed two times during the growing season after 30, and 45 days after sowing at the same times control was sprayed with tab water.

At harvest time, the number of spikes/m^2, 1000- grain weight (g), grain yield (t/ha), straw yield (t/ha), biological yield (t/ha), harvest index (%), and grain protein content (%) were recorded in both seasons.

Data obtained was exposed to the proper method of statistical analysis of variance as described by Gomez and Gomez (1984). The treatment means were compared using the least significant differences test (L.S.D.) at a 5% level of probability. All the statistical analysis using CoStat 6.311 (2005) computer software package.

RESULTS AND DISCUSSION

The results presented in Tables (2 and 3) showed the effect of salicylic acid (SA) concentrations, yeast extract and their interaction on a number of spikes/m^2, number of spikelets/spike, number of grains/spikes, 1000- grain weight (g), grain yield, straw yield, biological yield (t/fed) and harvest index (HI%) during 2019/2020 and 2020/2021 seasons.

Concern to the effect of SA on yield and its components characters, the results in Tables (2 and 3) revealed that application of SA concentration affected yield and yield components of wheat in both seasons, where the highest values of the number of spikes/m^2, number of spikelets/spike, number of grains/spike, 1000- grain weight (g), grain yield, straw yield, and biological yield (t/fed) were recorded with 450 mg/l of SA with no significant difference between the rate of the other 300 mg/l and 450 mg/l on the most of yield and its components characters. On the other hand, the rate of SA at 150 mg gave the highest HI % during the two seasons, meanwhile, the control (spray water) treatment gave the lowest ones in both seasons. This increase may be due to the foliar application of SA which appears to promote shoot growth and components of yield to counteract the adverse effect of abiotic stresses in a number of crop plants. Also, Azimi *et al.* (2013) reported a positive effect of SA on the physiological process of ovule fertilization, resulting in significant promotion of the grain dry weight of plants under moisture stress. It seems that spraying plants with SA before spike emergence and at the flowering stage can result in an improved weight of grains per spike as well as the number of spikes. These results are in accordance with those confirmed by Sharafizad *et al*. (2013); Ziasmin *et al.* (2017); Öztürkci and Arpali (2019); Gomaa *et al.* (2020 a and 2020 b) who reported that application of SA increased yield and its components of many crops under different stresses.

Regard the effect of yeast extract on yield and its components characters, the results in Tables (2 and 3) showed that increasing yeast extract from 0 to 6 g/l increased the number of spikes/m^2, number of spikelets/spike, number of grains/spike, 1000- grain weight (g), grain yield, straw yield, and biological yield (t/fed) of wheat, meanwhile the highest harvest index (HI%) gave with 4 or 2 g yeast extract/L in both seasons, where the highest values of these traits were recorded with 6 g/l, while the lowest ones were given with the control (0 g/l), on the otherwise the lowest HI % were recorded with the higher rate of yeast extract (6 g/L) in both seasons. These results are in harmony with those reported by Zaki *et al*. (2007); Hammad and Ali (2014); Abou-Aly *et al.* (2015); Mohamed and Almaroai (2016); Mohamed *et al.* (2018) who indicated that using yeast extracts increased yield and yield components.

Belong to the interaction between SA and yeast extract, Table (2 &3) showed that the highest values of the number of spikes/m^2, number of spikelets/spikes, number of grains/spikes, 1000- grain weight (g), grain yield, straw yield, and biological yield (t/fed) were obtained with the combination with 300 mg/l of SA concentration + 6 g/l of yeast extract, while the lowest ones were given with the combination with the control treatments (spray water + untreated treatments) in both seasons. On the other hand, the highest HI % recorded with 150 mg SA/L + 4 g yeast extract/L, while the lowest HI % was given with the higher concentration from SA and yeast extract in both seasons.

Table 2. Plant attributes of wheat as affected by SA concentration, yeast extract and their interaction in both seasons.

Attributes	A). SA concentration (mg/l)	Season 2019/2020								Season 2020/2021							
		B). Yeast extracts (g/l)				Average (A)	L.S.D. at 0.05			B). Yeast extracts (g/l)				Average (A)	L.S.D. at 0.05		
		0	2	4	6		A	B	AB	0	2	4	6		A	B	AB
Number of spikes/m^2	Spray water	247.22	279.99	309.21	347.33	295.94 d	4.72	4.72	9.43	287.46	324.94	343.39	363.33	329.78 d	7.77	7.77	15.54
	150	263.19	297.68	328.43	385.66	318.74 c				305.87	345.02	361.32	395.67	351.97 c			
	300	290.95	316.30	348.68	409.33	341.32 b				337.35	366.17	370.33	420.33	373.55 b			
	450	318.97	335.88	369.96	404.00	357.20 a				369.82	388.39	388.66	416.00	390.72 a			
Average (B)		280.08 d	307.46 c	339.07 b	386.58 a					325.13 d	356.13 c	365.93 b	398.83 a				
Number of spikelets/spikes	Spray water	17.77	20.30	23.43	27.24	22.18 c	0.86	0.86	1.73	17.40	18.30	23.76	24.91	21.09 b	1.49	1.49	2.97
	150	19.23	22.05	25.10	28.41	23.68 b				17.95	20.05	23.10	26.41	21.88 b			
	300	21.38	23.90	27.10	28.93	25.33 a				19.38	21.90	25.62	28.93	23.96 a			
	450	19.67	24.39	27.16	28.33	24.90 a				19.28	23.20	26.72	28.33	24.38 a			
Average (B)		19.53 d	22.65 c	25.70 b	28.20 a					18.50 d	20.86 c	24.80 b	27.15 a				
	Spray water	35.88	40.67	46.85	54.48	44.47 b				35.13	39.29	44.72	52.15	42.82 c			
Number of grains/spikes	150	37.00	43.00	47.69	54.33	45.51 b	1.80	1.80	3.66	36.23	41.02	46.51	54.67	44.61 bc	2.26	2.26	4.52
	300	39.31	47.25	49.33	53.66	47.39 a				38.96	43.8	48.47	56.20	46.86 ab			
	450	38.00	50.11	53.33	55.33	49.19 a				38.33	46.49	53.89	57.67	49.10 a			
Average (B)		37.55 d	45.26 c	49.30 b	54.45 a					37.16 d	42.65 c	48.40 b	55.17 a				
1000- grain weight (g)	Spray water	33.80	38.17	43.30	50.81	41.52 c				33.81	37.79	42.39	49.81	40.95 c			
	150	34.33	40.50	44.69	49.33	42.21 c	1.84	1.84	3.68	34.67	40.43	45.01	51.67	42.95 bc	2.30	2.30	4.70
	300	37.31	43.91	45.83	51.33	44.60 b				37.48	42.17	47.50	53.37	45.13 b			
	450	38.83	47.61	49.33	53.50	47.32 a				38.67	47.83	51.56	56.00	48.52 a			
Average (A)		36.07 d	42.55 c	45.79 b	51.24 a					36.16 d	42.06 c	46.62 b	52.71 a				
Means in column (s)/row(s) followed by the same letter are not significant at 0.05 level of probability.																	

Table 3. Plant attributes of wheat as affected by SA concentration, yeast extract and their interaction in both seasons.

Attributes	A). SA concentration (mg/l)	Season 2019/2020								Season 2020/2021							
		B). Yeast extracts (g/l)				Average (A)	L.S.D. at 0.05			B). Yeast extracts (g/l)				Average (A)	L.S.D. at 0.05		
		0	2	4	6		A	B	AB	0	2	4	6		A	B	AB
Grain yield (t/fed)	Spray water	2.02	2.14	2.39	2.75	2.33 b	0.09	0.09	0.18	2.04	2.17	2.38	2.85	2.36 b	0.08	0.08	0.16
	150	1.97	2.37	2.53	2.83	2.43 a				2.17	2.49	2.52	2.93	2.53 a			
	300	2.07	2.40	2.61	2.83	2.48 a				2.10	2.44	2.64	2.96	2.54 a			
	450	2.12	2.60	2.50	2.80	2.51 a				2.27	2.56	2.67	2.87	2.59 a			
Average (B)		2.05 d	2.38 c	2.51 b	2.80 a					2.15 d	2.42 c	2.55 b	2.90 a				
Straw yield (t/fed)	Spray water	2.75	2.94	3.08	3.60	3.09 d	0.14	0.14	0.28	2.87	2.93	3.13	3.70	3.16 d	0.13	0.13	0.27
	150	2.77	3.20	3.24	4.00	3.30 c				3.00	3.30	3.23	4.03	3.39 c			
	300	2.93	3.13	3.41	4.43	3.48 b				2.93	3.33	3.44	4.43	3.53 b			
	450	3.00	3.40	3.57	4.50	3.62 a				3.20	3.37	3.80	4.93	3.83 a			
Average (B)		2.86 d	3.17 c	3.33 b	4.13 a					3.00 d	3.23 c	3.40 b	4.27 a				
Biological yield (t/fed)	Spray water	4.77	5.08	5.47	6.35	5.42c	0.18	0.18	0.38	4.91	5.10	5.51	6.55	5.52 c	0.19	0.19	0.39
	150	4.74	5.57	5.77	6.83	5.73b				5.17	5.79	5.75	6.96	5.92 b			
	300	5.00	5.53	6.02	7.26	5.95a				5.03	5.77	6.08	7.39	6.07 b			
	450	5.12	6.00	6.07	7.30	6.12a				5.47	5.93	6.47	7.80	6.42 a			
Average (B)		4.91c	5.55b	5.83b	6.94a					5.15 d	5.65 c	5.95 b	7.18 a				
	Spray water	42.35	42.13	43.69	43.31	42.87 a				41.55	42.55	43.19	43.51	42.70 ab			
	150	41.56	42.55	43.85	41.43	42.35 ab				41.97	43.01	43.83	42.10	42.73 a			
Harvest index (HI %)	300	41.40	43.40	43.36	38.98	41.78 bc	1.03	1.03	2.06	41.75	42.29	43.42	40.05	41.88 b	0.85	0.85	1.70
	450	41.41	43.33	41.19	38.36	41.07 c				41.50	43.17	41.27	36.79	40.68 c			
Average (B)		41.68 b	42.85 a	43.02 a	40.52 c					41.69 b	42.75 a	42.93 a	40.61 c				
Means in column (s)/row(s) followed by the same letter are not significant at 0.05 level of probability.																	

CONCLUSION:

From the result of these two growing seasons field᾽s study, it was concluded that yield and its components of the wheat crop increased with planting date cv. Giza 171 with combination between foliar application of salicylic acid (SA) at the rate of 300 mg/l and yeast extract at the rate of 4 g/l under study conditions at Alexandria Governorate, Egypt.

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ARABIC SUMMARY

دور حامض السالسليك ومستخلص الخميرة في إنتاج القمح تحت ظروف الأراضي الملحية

محمود عبد العزيز جمعة[1] ، عصام إسماعيل إسماعيل قنديل[1] ، الحسين غلاب جلال[2] ، عمرو محمد شحاته الشحات[3]
1- قسم الأنتاج النباتي – كلية الزراعة – سابا باشا – جامعة الأسكندرية
2- مركز البحوث الزراعية – محطة بحوث النوبارية - الأسكندرية
3- مركز البحوث الزراعية – محطة بحوث الصبحية - الأسكندرية

أجريت هذه الدراسة فى مزرعة كلية الزراعة – سابا باشا بمنطقة ابيس – محافظة الأسكندرية خلال الموسم الشتوي لعامى 2020/2019 و 2021/2020 و ذلك لدراسة استجابة محصول القمح للرش الورقي بحامض السالسيليك والخميرة تحت ظروف الأراضي المتأثرة بالملوحة. ووزعت المعاملات عشوائياً تصميم تجريبى هو القطاعات العشوائية الكاملة لتجربة عاملية ذات عاملين فى ثلاث مكررات مع التوزيع العشوائى للمعاملات التجربية وهى:
العامل الأول : حامض السالسليك (بدون رش – 150 – 300 – 450 مليجرام/لتر) .
العامل الثاني : الخميرة (بدون رش – 2 – 4 – 6 جرام/لتر ماء) ، حيث يتم الرش مرتين بعد 30 و 45 يوم من الزراعة. وأظهرت النتائج أنه:

كان للرش الورقي لحامض السالسليك تأثيراً معنوياً على كل من عدد السنابل/م^2 وعدد السنيبلات/سنبلة وعدد الحبوب/سنبلة ووزن 1000 حبة ومحصول الحبوب (طن/فدان) ومحصول القش (طن/فدان) والمحصول البيولوجي (طن/فدان) ودليل الحصاد (%) حيث وجد أن الرش الورقي بحمض السالسليك بمعدل 450 مليجم/لتر حقق اعلى قيم لصفات المحصول الأتية مثل طول السنبلة وعدد السنابل/م^2 وعدد السنيبلات/سنبلة و عدد الحبوب/سنبلة ولم يكن هناك فرق معنوي بين التركيزين 400 و 300 مليجم/لتر في صفتي عدد السنبيلات/سنبلة وعدد الحبوب /سنبلة والتركيز الأعلى حقق أعلى وزن 1000 حبة (جم) ومحصول الحبوب ومحصول القش والمحصول البيولوجي لكن لم يكون هناك اختلاف معنوي بين معاملات الرش بحامض السالسليك الثلاثة بالنسبة لصفة محصول الحبوب وبين 450 و300 مليجم/لتر بالنسبة لصفة المحصول البيولوجي ، في حين أن الرش بالماء (كنترول بدون سالسليك اسيد) أعطى أقل القيم للصفات المحصولية اما بالنسبة دليل الحصاد المعدل 150 مليجرام من السالسليك أعطى أكبر دليل بدون اختلاف معنوي مع الكنترول خلال موسمي الدراسة.

كما أثر الرش الورقي مستخلص الخميرة معنوياً على كل من عدد السنابل/م^2 وعدد السنيبلات/سنبلة وعدد الحبوب/سنبلة ووزن 1000 حبة ومحصول الحبوب (طن/فدان) ومحصول القش (طن/فدان) والمحصول البيولوجي (طن/فدان) ودليل الحصاد (%) حيث وجد أن الرش الورقي بمستخلص الخميرة بمعدل 6جم/لتر حقق اعلى قيم للصفات المحصولية المدروسة فيما عدا دليل الحصاد فالرش الورقي بمعدل 4 جم/لتر أو 2 جم ومن جهة اخرى فإن الرش بالماء (كنترول) اعطى أقل قيم للصفات المحصولية المدروسة خلال موسمي الدراسة.

ايضاً كان التداخل بين عاملى الدراسة (الرش الورقي بحامض السالسليك ومستخلص الخميرة) معنوياً على صفات النبات المدروسة يث وجد أن الرش الورقي لحامض السالسيلك بتركيز 450 مليجم/لتر + بمستخلص الخميرة بمعدل 6جم/لتر اعطى حقق أعلى قيم لصفات المحصول فيما عدا محصول الحبوب ودليل الحصاد فبالنسبة لمحصول الحبوب وجد أن 300 مليجم من السالسليك مع 6 جم/لتر من مستخلص الخميرة حققا أعلى محصول حبوب للفدان اما بالنسبة لدليل الحصاد فإن معدل 150 ملجم سالسليك اسيد + معدل 4 جم من مستخلص الخميرة للتر ماء اعطى أعلى دليل حصاد بينما الكنترول (الرش الورقي) حقق أقل قيم للصفات المحصولية خلال موسمي الزراعة.

التوصية: يوصى البحث بزراعة صنف القمح جيزة 171 مع الرش الورقي بمعدلات 300 ملجم/لتر من حامض السالسليك و 6 جم/لتر حيث أن ذلك حقق أعلى محصول حبوب ومكوناته وجودته تحت ظروف التربة المتأثرة بالملوحة خلال موسمي الدراسة وتحت ظروف منطقة أبيس – محافظة الأسكندرية – مصر وظروف المناطق المماثلة لها.