

Influence of Nitrogen Fertilizer and Foliar Application of Salicylic Acid on Wheat

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Abstract

Two cemented plots experiments were carried out during the winter seasons of 2012/2013 and 2013/2014, Soil Salinity Laboratory, Alexandria, Egypt, to study the effect of three levels of salicylic acid (SA) (0, 50, 100 ppm) and three rates of nitrogen fertilizer (75, 100, 125 kg N/feddan) on yield and yield components of wheat (Sakha 93). The experimental design was split plot with four replicates. The results indicated that increasing nitrogen fertilizer rates resulted in significant increase in plant height (cm), number of grain/spike, number of spikes/m², 1000 grain weight (gm), grain yield (gm/plot), straw yield (gm/plot), and biological yield (gm/plot). Increasing salicylic acid rates resulted in significant increase in all the previous characters, in addition to grain weight/spike (gm). The interactions had no significant effect on the studied characters. The path analysis revealed that 1000 grain weight was the most important character with direct effect of 0.54 followed by number of spikes/m² with direct effect of 0.33 followed by number of grain/spike with direct effect of 0.16.

Keywords

Wheat, Salicylic Acid, Nitrogen Fertilizer, Path Analysis

1. Introduction

Wheat (*Triticum aestivum* L.) is considered one of the most important cereal crops not only in Egypt but also in the world. Its importance comes from using its grain as a main food source for human and its straw as feed for

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livestock. As land and water resources are limited in Egypt, increasing the productivity of wheat from the unit area is an important part in increasing the total production and minimizes the gap between consumption and production. Such target will be achieved by increasing the cultivated area, cultivating high yield varieties, and adoption of improved cultural practices.

Salicylic acid (SA) is a phenolic compound naturally produced by the plants and function as growth regulator [1]. Exogenous application of SA may influence some physiological processes, e.g., growth and photosynthesis [2]-[4]. Photosynthesis plays an important role in plant productivity and takes place in green leaves and depends on its content of chlorophyll. [5] found that maize cultivars that maintained higher rates of photosynthesis produced higher grain yield, also, these cultivars had higher stomatal conductance, transpiration rate and leaf area. Thus, the biological and economic yield can be increased by increasing the rate of photosynthesis. In this respect [6] recorded an increase in wheat yield by exogenous application of SA, also, [7] [8] recorded similar results in corn. [9] reported also that SA reversed the closure of stomata caused by abscisic acid which induced by abiotic stresses like salinity and draught.

Nitrogen fertilizer has been extensively used in agriculture in recent years, however, the intensive using of nitrogen fertilizers have hazard effect on the environment [10] in addition to decreasing the net profit per unit area as the prices of inputs increased. Thus, in response of all afore-mentioned reports, the present study was conducted to investigate the effect of foliar application of SA and three rates of nitrogen fertilizer on the productivity of wheat plants cultivar (Sakha 93).

2. Materials and Methods

Grain of wheat cultivar Sakha 93 was obtained from Crops Research Institute, Agricultural Research Center, Egypt. The experiment was conducted during the winter seasons of 2012/2013 and 2013/2014 to investigate the effect of three levels of SA (0, 50, 100 ppm) and nitrogen fertilizer rates (75, 100, 125 kg N/feddan) on yield and yield components. The experimental soil was analyzed according to [11] before sowing and the mechanical and chemical characters in both seasons are presented in **Table 1**.

The experimental design was split plot with four replicates where the nitrogen fertilizer rates were located in the main plot, while SA rates were in the subplot, the experimental unit was a cemented plot with a dimension of 150 cm in long and 75 cm in wide with an area of 1.125 m². Every cemented plot contains four rows, the grain were sowing in mid-November in each year and before sowing the cemented plot were prepared by adding calcium superphosphate 15.5% P₂O₅ at a rate of 100 kg/feddan (26.78 gm/cemented plot) and potassium sulphate 48% K₂O at a rate of 100 kg/feddan (13.39 gm/cemented plot), the nitrogen fertilizer rates were added at the rate of 75, 100, 125 kg N/feddan) of ammonium sulphate 20.5% N (98, 130.7, 163.4 gm/cemented plot at three doses, the first at sowing, the second at the first irrigation, and the third at the second irrigation).

SA was initially dissolved in a few drops of Dimethylsulfoxide and the final volume was reached by adding distilled water, then the pH was adjusted at 6 - 7 with NaOH (1.0N). A constant volume of solutions were sprayed twice early in the morning on the leaves when the plants had their fourth leaf and two weeks later.

At the end of the experiment random samples were taken to measure the following characters:

Plant height (cm), spike weight (gm), number of grain/spike, number of grain/spike, grain weight/spike (gm), number of spikes/m², number of spikelets/spike, 1000 grain weight (gm), grain yield (gm/cemented plot), biological yield (gm/cemented plot), straw yield (gm/cemented plot), harvest index as the ratio between grain yield and biological yield.

A combined analysis was conducted as the Bartlete test for homogeneity of variance revealed that the variances of the studied characters of the two seasons were homogeneous, the data of the two seasons were subjected to analysis of variance using SAS computer software v.9.1.3 SP4, 2003. The mean values were compared with the least significant difference test according to [12].

Table 1. Physical and chemical analyses of the used soil.

Sand %	Silt %	Clay %	Soil texture	E.C. dS/m	pH	SAR	Ca ²⁺ meq/l	Mg ²⁺ meq/l	Na ⁺ meq/l	K ⁺ meq/l	Cl ⁻ meq/l	HCO ₃ ⁻ meq/l
74.0	10.4	15.6	Sandy loam	1.82	7.53	1.49	1.50	12.5	3.95	0.34	10.5	2.80

3. Results and Discussions

3.1. Effect of Nitrogen Fertilizer Rates

Table 2 shows that with increasing the nitrogen fertilizer rates plant height, Number of grain/spike and number of grain/spike significantly increased, but, spike weight had no specific trend or significant differences. In addition, grain weight/spike insignificantly increased with increasing nitrogen fertilizer rates. **Table 3** indicates that increasing nitrogen fertilizer rates resulted in significant increase in number of spikes/m², 1000 grain weight, grain yield, straw yield, and biological yield. However, no significant difference was observed in number of spikelets/spike and harvest index.

3.2. Effect of Salicylic Acid

Table 2 indicates that exogenous application of SA significantly increased plant height, Number of grain/spike, number of grain/spike, and grain weight/spike. Spike weight was also not significantly affected by SA. These results are consistent with those obtained by [13] who reported similar increase in the growth of shoots of soybean plants in response to salicylic acid treatment. Also, [14] [15] indicate that SA increases the leaf area in sugar cane plants. [16] recorded significant increase in Emergence index (EI), leaf area (LI), dry weight of leaves and crown, leaves and tillers number and shoot apex length than untreated or control treatments. The highest enhancement in mentioned traits was observed in concentrations of 1000 µM and 1500 µM. More recently [17] also reported that salicylic acid spraying affect morphological traits and resulted in considerable and

Table 2. Effect of nitrogen fertilizer rates and salicylic acid on plant height and spike characters of wheat plants (combined analysis of the two seasons).

	Plant height, cm	Spike weight, gm	Spike length, cm	Number of grain/spike	Grain weight/spike, gm
Nitrogen fertilizer rates					
75 kg N/fed	95.4 b	3.2 a	9.9 b	50.5 b	2.3 a
100 kg N/fed	98.8 ab	2.9 a	10.0 ab	53.1 b	2.4 a
125 kg N/fed	100.9 a	3.2 a	10.3 a	57.5 a	2.6 a
Salicylic acid					
Control	94.2 c	3.1 a	9.6 c	48.7 c	2.2 c
SA1 (50 ppm)	97.7 b	3.0 a	10.1 b	54.2 b	2.4 b
SA2 (100 ppm)	103.2 a	3.1 a	10.6 a	58.2 a	2.7 a

Table 3. Effect of nitrogen fertilizer rates and salicylic acid on wheat yield and its components (combined analysis of the two seasons).

	Number of spikes/m ²	Number of spikelets/spike	1000 grain weight, gm	Grain yield, gm/plot	Straw yield, gm/plot	Biological yield, gm/plot	Harvest index
Nitrogen fertilizer rates							
75 kg N/fed	226.1 b	18.7 a	43.9 b	566.5 b	958.6 b	1525.2 b	0.37 a
100 kg N/fed	242.4 ab	18.8 a	46.0 a	573.8 ab	977.4 b	1551.3 b	0.36 a
125 kg N/fed	251.0 a	18.8 a	46.1 a	596.8 a	1039.6 a	1636.4 a	0.36 a
Salicylic acid							
Control	226.0 c	18.8 a	43.5 c	511.2 c	896.5 c	1407.7 c	0.36 a
SA1 (50 ppm)	241.2 b	18.7 a	45.1 b	585.0 b	985.2 b	1570.2 b	0.37 a
SA2 (100 ppm)	252.3 a	18.8 a	47.5 a	641.0 a	1093.9 a	1734.9 a	0.37 a

significant increase in plant height, ear height, leaf area of the main ear, row no/ear, kern el no/row and ear length of corn plants. **Table 3** reveal that exogenous application of 50 and 100 ppm SA resulted in significant increase in number of spikes/m², 1000 grain weight, grain yield, straw yield, and biological yield, however, significant difference was observed in number of spikelets/spike and harvest index. It is worth to mention that exogenous application of 50 and 100 ppm of SA caused an increase in grain yield/cemented plot by almost 15% and 25% respectively as compared to the control (**Figure 1**), this increase in grain yield may be attributed to the increase in number of spikes/m² and 1000 grain weight. These results were in accordance with those obtained by [18] who reported that application of SA significantly affected seed yield and plant biomass of coriander (*Coriandrum sativum*).

Finally, it can be concluded that fertilizing wheat with 100 kg N/feddan and application of 100 ppm of SA can produce a reasonable yield.

3.3. Path Analysis and Correlation between Grain Yield and Yield Components

All possible correlations among the different yield components were measured (**Table 4**). Grain yield showed positive and significant correlation with number of grain/spike (0.69), number of spikes/m² (0.56), and 1000 grain weight (0.73) which gave an understanding that 1000 grain weight was the most important yield component.

The data of direct effects (**Table 5** and **Figure 2**) and indirect effects (**Table 5**) of yield components on grain yield revealed that 1000 grain weight had maximum positive direct effect on grain yield (0.54) followed by number of spikes/m² (0.33) followed by number of grain/spike (0.16). The results of correlation and path analysis are matching for 1000 grain weight, however, the reverse was the case for the other two components where number of grain/spike was the second correlated components (0.69) and the third in direct effect (0.16), this may be due to the indirect effect of number of spikes/m² and 1000 grain weight via number of grain/spike, 0.19 and 0.35, respectively which was more than the indirect effect of number of grain/spike and 1000 grain weight via number of spikes/m², 0.09 and 0.14, respectively, where the more the indirect effect the less direct effect.

The results of correlation and direct effect of number of spikes/m² and 1000 grain weight are agreed with those obtained from [19].

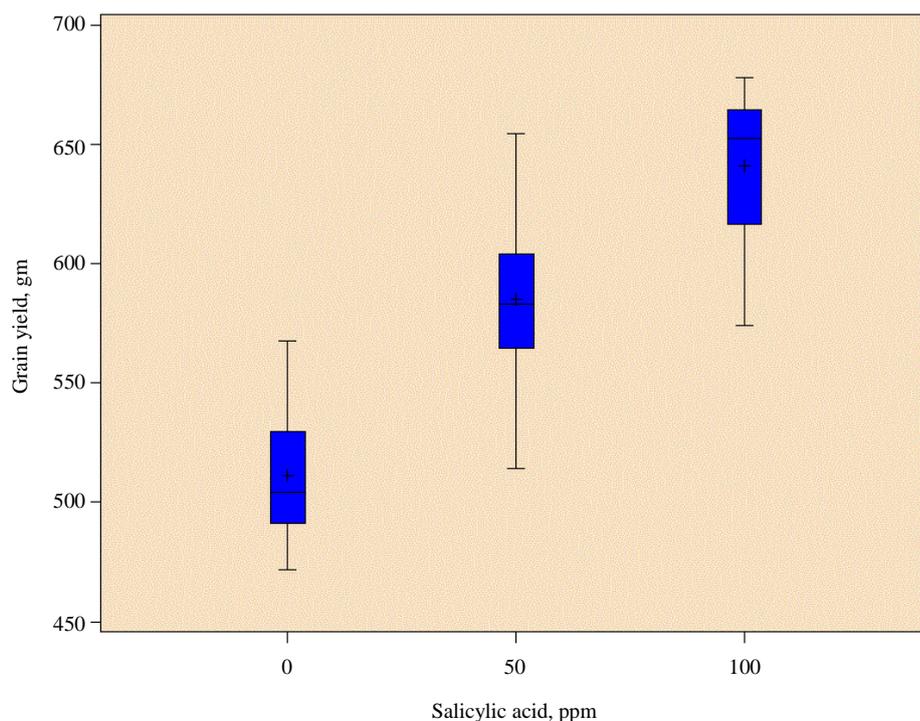


Figure 1. Effect of Salicylic acid on the grain yield of wheat.

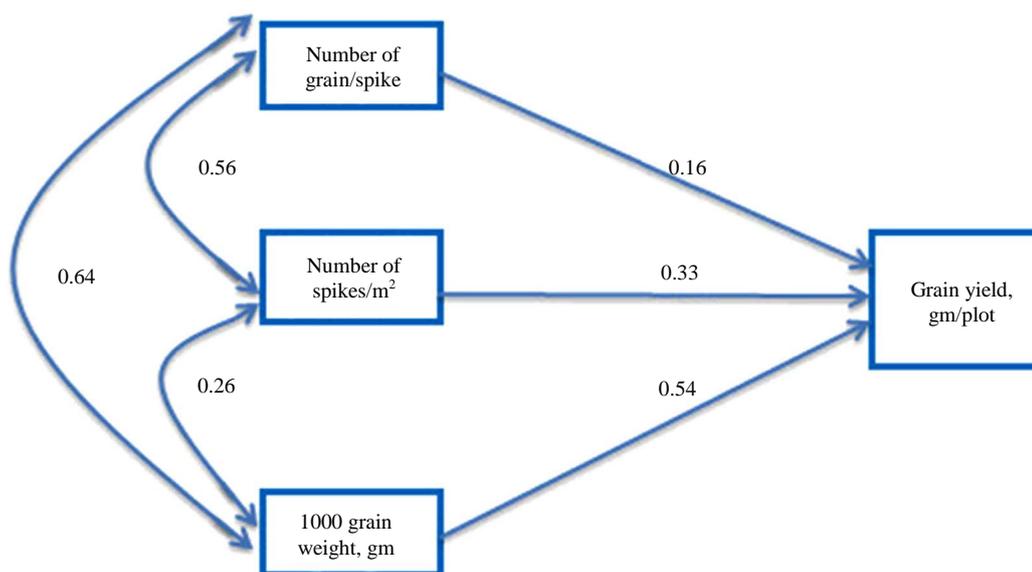
Table 4. Correlation coefficients between yield components and grain yield of wheat.

	Number of grain/spike	Number of spikes/m ²	1000 grain weight, gm	Grain yield, gm/plot
Number of grain/spike	1.00			
Number of spikes/m ²	0.56**	1.00		
1000 grain weight, gm	0.64**	0.26 ^{ns}	1.00	
Grain yield, gm/plot	0.69**	0.56**	0.73**	1.00

** significant at 0.01 significance level; ^{ns}not significant.

Table 5. Direct (underlined) and indirect effects of three yield components on grain yield of wheat.

	Number of grain/spike	Number of spikes/m ²	1000 grain weight, gm
Number of grain/spike	<u>0.16</u>	0.19	0.35
Number of spikes/m ²	0.09	<u>0.33</u>	0.14
1000 grain weight, gm	0.10	0.09	<u>0.54</u>

**Figure 2.** Path diagram and correlation coefficients of three yield components (single headed arrow denotes direct effect on grain yield; double headed arrow denotes the correlation coefficients between traits).

4. Conclusion

The current study revealed that both nitrogen fertilizer and salicylic acid were significantly affected yield and its components. The highest effects on yield and its components in wheat were obtained by the level of 125 kg/feddan of nitrogen fertilizer and 100 ppm of salicylic acid. In conclusion, data indicated that a high yield could be obtained by adding 100 kg/feddan of nitrogen fertilizer and spraying of 100 ppm of salicylic acid, and suggested that salicylic acid could be used as a potential growth regulator to improve plant growth.

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