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Response of Bread Wheat to Nitrogen Fertilizer Rates and Spraying with Ascorbic, Citric and Salicylic Acids

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ABSTRACT

A field experiment was carried out at Bahtim Agricultural Research Station Farm through 2013/2014 and 2014/2015 seasons. The experimental site is located at lat. 30.80, long 31.16 and 14.00 m above the mean sea level, to study the effect of foliar spray of some antioxidants (ascorbic, citric and salicylic acids) under three nitrogen fertilizer rates (40, 60 and 80 kg N fed^{-1}) and their interactions on yield and its attributes as well as macronutrients uptake and protein percentage of bread wheat variety (Misr 1). The obtained results could be summarized as follows:1- Application of the highest nitrogen fertilizer rate (80 kg N fed^{-1}) gave a significant increase in grain weight $spike^{-1}$, spike number spike m^{-2}, grain number $spike^{-1}$ and 1000 grain weight (g). Also, grain, straw, biological yield and harvest index as well as NPK uptake of wheat grain, straw, biological and protein % of grain were increased significantly when adding 80 and 60 kg N fed^{-1} in both seasons.2- Generally, in most cases, foliar application of any organic acids (ascorbic, citric or salicylic) gave a significant increases in yield and its some components as well as macronutrients uptake and protein percentage of wheat in both seasons. 3- The highest significant values of some yield components, grain, straw, biological yield and harvest index as well as NPK uptake of wheat grain, straw and biological were noticed by spraying any organic acid under soil application of 60 or 80 kg N fed^{-1} in both seasons. Thus, the increases in wheat yield (quality and quantity)may be attributed to the organic acids guide to an enhancing wheat plant growth and promote its nutrients uptake as well as improving the efficiency of nitrogen fertilizer. So, under the same conditions we can reduce the recommendation of nitrogen fertilizer for wheat from 80 to 60 kg N fed^{-1} with foliar application with ascorbic, citric or salicylic acids to get the best possible wheat productivity.

Keywords: wheat, productivity, N fertilizer, ascorbic, citric or salicylic acids.

INTRODUCTION

In Egypt and all over the world, wheat (*Triticum aestivum* L.) is one of the majority vital dietetic cereal crops. It's the firm food crop of the municipal regions; furthermore it's used broadly in amalgamation with corn flour in country areas to make food for human as well as straw of wheat is a source of animals fodder. In Egypt, production of wheat is inadequate for local expenditure. This describes for larger notice of all the worried to raise the production to meet the permanent command and decrease the gap between the consumption and production wheat. Accordingly, grand efforts have been made to achieve appropriate practices of agronomic for obtaining maximum wheat productivity with most favorable quality properties. It is also well known that applying N fertilizer improves wheat grain protein content and its energy source. Thus, it is highly important to enhance the quantity and quality of the produce during proper crop nutrition. Nutritionally, whole bread grain wheat flour contains approximately 70% carbohydrate, 11.5% protein (varying from 8-15%), 2% fibre, 2% fat, 1.5% ash, and 13% water (Handiso, 2010).

Nitrogen is the key nutrient in plant growth and the majority often scarce nutrient markedly affecting plant growth. Crop response to N fertilizer varies with rate and time of application concerning plant development. It is a necessary component of cell wall, nucleic acids (the regenerative portions of the living cell), cytoplasmic proteins, chlorophyll and a vast array of other cell components. Aroiee and Omidbaigi (2004) reported that nitrogen fertilizer increased leaf chlorophyll and had a linear affiliation between leaf chlorophyll content and leaf nitrogen concentration. It is well recognized that sufficient N fertilizer is necessary for acceptable growth of wheat, development and yield. Nitrogen is recognized to encourage production, partitioning and dry matter accumulation in crop plant (Akanbi *et al.,* 2007). An encouragement effect of N fertilizers on chlorophyll content might be attributed to the fact that nitrogen fertilizer is a ingredient of chlorophyll molecule and contribute in amino acid constructions to make proteins that has a structural role in chloroplast (Basela and Mahadeen, 2008). Nitrogen is one of the major inputs of the wheat crop. Its efficient management is essential to optimizing its consumption while decreasing pollution risks and operational costs (Campillo, *et al.,* 2010).

Organic acids as antioxidants (such as citric, salicylic and ascorbic acid) play an important role in plant metabolism. Citric acid as non enzymatic antioxidant in chelating these free radicals and defending plant from injury could result in extending the shelf life of plant cells and enhancing growth parameters (Rao, *et al,* 2000). It's careful to be the most powerful organic anion to mobilize phosphorous in the soil. Hamdia, *et al.,* (1996) stated that the organic acids amalgamation and breakdown serve as a mechanism for pH regulation in cell of plant. Also, some processes of physiology and slow downing others depending on its concentration, species of plant, development stages and ecological conditions were promotes by adding the salicylic acid (Senaratna *et al*. 2000). Besides, salicylic acid has a direct physiological influence during the alteration of antioxidant enzyme activities, persuades flowering, raises life of flower and retards senescence as well as enhances metabolic rate of cell. The continued rate of salicylic acid may be a requirement for the auxin and/or cytokinin synthesis (Metwally *et al*. 2003). Ascorbic acid application (vitamin-c) to plants stimulates their growth, so, apart from their major function as coenzymes, it is not doubtful that vitamins may moreover play other independent roles in the biochemical procedures of plants, repairing the damaging effects of unfavorable conditions. Ascorbic acid can

scavenge the immediate oxygen species which are extremely negative to the growth of plant. It is a producer of D-glucose metabolism which affects some nutritional cycle activities in higher plants and plays a vital role in the transport system of electron (El-Kobisy *et al.,* 2005). Likewise, Azza *et al.* (2011) concluded that the promoting effect of ascorbic acid on carbohydrates as a total may be attributable to their imperative function of biosynthesis of chlorophyll molecules which in turn affected total carbohydrates content. So, this investigation is aiming to evaluate the effect of foliar spray of ascorbic, citric and salicylic acids with nitrogen fertilizer levels as well as their interactions on growth, yields and its attributes as well as NPK uptake of grain, straw and biological parameters of wheat Misr1 variety under the environmental conditions of the study region.

MATERIALS AND METHODS

A field experiment was conducted at Bahtim Agricultural Research Station Farm during 2013/2014 and 2014/2015 seasons. The experimental site is located at lat. 30.80, long 31.16 and 14.00 m above the mean sea level, to evaluate the effect of foliar spraying with antioxidants (ascorbic, citric and salicylic acids) and nitrogen fertilizer levels as well as their interactions on growth, yields and its components as well as NPK uptake of grain, straw and biological characters of wheat Misr1 cultivar was obtained from Wheat Research Section, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Some physical and chemical analysis of the experimental soil samples were taken before planting and the corresponding data are presented in Table 1, which were measured and determined according to Ryan *et al*., (1996).

The experiment was carried out in a split- plot design with four replicates. The experiment included thirty six plots comprising, three foliar spraying organic acid treatments and three N fertilizer rates. The main plots were included three N fertilizer levels treatments as following: 40, 60 and 80 kg N fed-1

The sup main-plots were devoted to three foliar spraying treatments as follows: foliar spraying with ascorbic, citric and salicylic acid (AA) at the level of 500 ppm for each one.

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

Characters		2013/2014	2014/2015
Particle size distribution	Coarse sand %	2.6	2.25
	Fine sand %	14.4	5.75
	Silt %	35	40
	Clay %	48	52
	Textural class	Clay	Clay
pH (1:2.5) in soil suspension		7.54	7.45
$CaCO_3$ (%)		2.64	2.72
EC_e (dSm^{-1}) in soil paste		0.96	1.02
Soluble cations meq L^{-1} (in soil paste extract)	Ca^{+2}	3.68	3.76
	Mg^{+2}	2.72	2.89
	Na^{+}	2.79	2.81
	K^{+}	0.47	0.56
Soluble anions meq L^{-1} (in soil paste extract)	HCO_3^{-}	2.61	2.72
	Cl^{-}	2.84	2.96
	SO_4^{--}	4.21	4.34
Available nutrients (ppm)	N	46.25	39.35
	P	3.60	4.55
	K	382.40	368.25

Single super- phosphate (15.0% P2O5) as a P fertilizer source and K fertilizer in the potassium sulphate form (48.0% K2O) were applied during soil preparation. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was used in two equal portions prior the 1st and the 2nd irrigations. Foliar spraying with organic acids was done twice after 40 and 55 days from sowing. The volume of foliar solution was 200 L fed-1 and spraying was conducted by hand sprayer for experimental plots.

Misr 1 seed was sown at November 17th and 20th in the 1st and the 2nd seasons, respectively. Wheat grains at the rate of 60 kg fed-1 were broadcasted using afeer method. The other recommended agricultural practices for growing wheat in the studied area were followed according to the recommendations of Ministry of Agriculture, except the factors under study. Every experimental unit area was 3×3.5 m occupying an area of 10.5 m2 i.e., 1/400 feddan (one feddan= 4200 m2). The preceding summer crop was maize (*Zea mays* L.) in both seasons.

At harvesting time, one square meter was randomly selected from every sub-plot to estimate the following parameters: number of spikes m-2, number of grains spike-1, grains weight spike-1 (g) and 1000 grain weight (g) as well as grain, straw and biological yield (kg fed-1). It was calculated by harvesting whole plants in each experimental plot and air dried, then threshed and the grains at 13% moisture were weighed in kg, also, NPK in grain, straw and biological yield as well as protein % were determined.

Samples of wheat grain and straw were dried at 70C, ground and wet digested. Nitrogen was determined by using the modified kjeldahl method, recorded then, the grains protein percentage was calculated by multiplying N % by 5.75. Phosphorus was estimated calorimetrically using ammonium molybdate and ammonium metavanadate according to the procedure outlined by (Ryan *et al.,* 1996). Potassium was determined by using the flame spectrophotometer method (Black, 1982).

All obtained data was statistically analyzed according to the technique of analysis of variance (ANOVA) for the split -plot design as published by Gomez and Gomez (1984) using MSTAT statistical package (MSTAT-C, Crop and Soil Sciences Department, Michigan State University, USA) developed by Russell (1986). Least Significant Difference (LSD) method was used to test the differences between treatments means at 5% level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Wheat yield attributes

Tabulated data in Table 2 show that the addition of the highest nitrogen fertilizer rate 80 kg N fed-1 gave a significant increase of grain weight spike-1 along with the lowest N rate in both seasons. But, spike number spike m-2 was improved significantly by adding 80 kg N fed-1 compared to 40 kg N fed-1 in the 1st season, while, the trend was opposite in second one. Also, results reveal that the addition of 80 and 40 kg N fed-1 led to a significant increase of grain number spike-1 and 1000 grain weight (g) compared with other treatments in the 1st and 2nd season, respectively. The improve in yield components of wheat

due to applying nitrogen fertilizer is an indication for the role of N in plant growth development and production. These results are in agreement with those achieved by Iqtidar *et al.*, (2006) who stated that rising N fertilizer application level from 0 to 200 kg N ha-1 resulted in significantly higher numbers of grains per spike as compared to the control treatment.

Concerning the effect of spraying organic acids on abovementioned parameters, results illustrate that the spike number spike m-2 was increased significantly by foliar application of citric acid compared to salicylic one in the 1st season, whereas, the trend was contrary in second one. While, spraying citric or ascorbic acid gave the highest significant value of grain number spike-1 along with salicylic one in the 1st season and the trend was contrary for grain weight spike-1 in second one. These results may be due to the potential effect of antioxidants which act as free radical scavenger. It might be accomplished that, these lessening in activities of enzyme could be due to direct influences of antioxidants on scavenge ROS (O-2), hydrogen peroxide (H2O2) and singlet oxygen (O-2) and /or preventing the improvement of the mentioned activated oxygen species. Sadak, and Orabi, (2015) concluded that foliar application of citric acid gave activities of many metabolic and physiological processes of wheat plant that reflected in raising quality of grain yield. The quality of the wheat grain yield has being better responded to citric acid.

Table 2. Effect of N fertilizer rates and spraying organic acids on wheat attributes in both seasons.

Treatments	spike number spike m^{-2}				1000 grain weight (g)				grain number $spike^{-1}$				grain weight $spike^{-1}$ (g)			
	First season															
	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean
40 kgNfed-1	387.3	363.3	354.0	368.2	47.60	52.17	61.27	53.68	79.67	80.67	76.00	78.78	3.787	4.203	4.653	4.214
60 $kgNfed^{-1}$	416.7	376.7	362.0	385.1	47.77	54.67	54.57	52.33	93.00	85.33	85.33	87.89	4.513	4.660	4.657	4.610
80 $kgNfed^{-1}$	404.7	381.3	369.0	385.0	51.37	50.93	52.70	51.67	103.0	101.3	83.00	95.78	5.293	5.163	4.370	4.942
Mean	402.9	373.8	361.7		48.91	52.59	56.18		91.89	89.11	81.44		4.531	4.676	4.560	
LSD																
N rates		16.42				NS				3.95				0.299		
Organic		12.94				2.06				3.36				NS		
Interaction		22.41				3.56				5.81				0.447		
Second season																
40 $kgNfed^{-1}$	456.7	397.7	376.0	410.1	41.00	53.00	68.00	54.00	92.33	95.00	93.67	93.67	3.773	5.043	6.360	5.059
60 $kgNfed^{-1}$	421.7	364.3	359.0	381.7	44.33	57.00	66.67	56.00	93.00	95.67	96.00	94. 89	4.133	5.450	6.400	5.328
80 $kgNfed^{-1}$	395.0	370.0	335.7	366.9	45.67	63.00	64.33	57.67	97.67	93.33	93.33	94.78	4.520	5.880	6.010	5.470
Mean	424.4	377.3	356.9		43.67	57.67	66.33		94.33	94.67	94.33		4.142	5.458	6.257	
LSD																
N rates		13.91				3.02				NS				0.252		
Organic		9.81				2.79				NS				0.274		
Interaction		17.00				4.84				2.975				0.474		

Asc = Ascorbic, Sal = Salicylic

Regarding the interaction effect between nitrogen fertilizer levels and spraying organic acids on such parameters, data demonstrate that spraying citric acid under 60 or 80 kg N fed-1 and 40 kg N fed-1 gave the highest significant value of spike number m-2 in the first and second season, respectively. But, the lowest one was recorded with foliar spray of salicylic acid under any nitrogen fertilizer rate in both seasons. Meanwhile, the trend was opposite for 1000 grain weight in both ones. Moreover, data show that the foliar application of citric or ascorbic acids under application of 80 kg N fed-1 led to a significance increase of grain number and weight spike-1 compared to other treatments in both and the first season, respectively. But, spraying salicylic acid under any nitrogen fertilizer rate gave the highest significant value of grain weight spike-1 compared to other treatments in the 2nd season only. Modern wheat cultivars have a bigger biomass proportion allocated to grain, either during having heavier and more grains spike-1. It was indicated that the grains number spike-1 was the greatest indicator of wheat response to nitrogen fertilizer application and that grain spike-1 is negatively affected by insufficiency of nitrogen. (Braian *et al.,* 2007) suggested that the increasing nitrogen fertilizer rate from the control level to 200 kg ha-1 gave an increase in number of spike m-2. Maximum number of spike m-2 was observed when the N dose was 200 kg ha-1 whereas the minimum number of spike m-2 was recorded in control treatment. Also, Tilahun Gelato *et al.*, (2008) concluded that fertilized soils produced extra spikes than the unfertilized one and the authors concluded that such response can be due to the sufficient N availability which might make possible the tillering ability of the plants, resulting in a greater population of spike. Moreover, Citric acid is one of the organic acids presented in tri-carboxilic acid cycle or malic acid conversion to citric acid.

Wheat yield

Results in Table 3 show that the application of the highest nitrogen fertilizer level 80 kg N fed-1 gave the highest significant increases of grain, straw, biological yield and harvest index compared to the lowest level in both seasons, with one exception, straw yield wasn't affected significantly by adding nitrogen fertilizer rate in the 1st season. Similar trend was recorded for grain, straw and biological wheat yield when adding 60 kg N fed-1 in the second season only. The increases in abovementioned parameters, due to the increase in nitrogen fertilizer rate is a result of the effect of N which increasing spikes number m-2, grains number and weight spike-1 as well as 1000-grain weight. This is clear illustration for the prominent role of nitrogen in increasing grain, straw and biological yield under the same conditions. These results reported by Iqtidar *et al.,* (2006) who showed that biological yield was increased as quantity of N fertilizer was increased from the control rate to 200 kg ha-1. Maximum biological yield was recorded at 200 kg ha-1,. They suggested that applying nitrogen fertilizer enhances the wheat vegetative growth that delays

senescence, which ultimately increases biological yield. Sinclair and Amir (2006) indicated that nitrogen can be an imperative preventive factor for wheat yield by contributing to the determination of grain number during the progress of the spikes and florets. Yield and its components of high yielding cultivars generally increase by increasing nitrogen fertilizer rate.

Table 3. Effect of N fertilizer rates and spraying organic acids on wheat yield in both seasons.

Treatments	Grain yield kg fed^{-1}				Straw yield kg fed^{-1}				Biological yield kg fed^{-1}				Harvest index			
	First season															
	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean
40 kgNfed^{-1}	2752	2984	2713	2816	4139	4126	4907	4391	6891	7109	6869	6956	29.93	31.49	29.58	30.34
60 kgNfed^{-1}	2787	3028	2857	2891	4016	4082	4100	4066	6803	7109	6956	6956	30.70	31.95	30.81	31.16
80 kgNfed^{-1}	2892	3238	2997	3043	4397	4112	3916	4142	7285	7350	6913	7182	29.72	33.03	32.52	31.76
Mean	2810	3083	2855		4184	4107	4307		6993	7190	6913		30.12	32.16	30.97	
LSD																
N rates		77				NS				185				1.31		
Organic		160				NS				207				1.16		
Interaction		276				812				358				2.00		
Second season																
40 kgNfed^{-1}	2824	2494	2603	2640	3306	2694	2957	2986	6130	5188	5559	5626	34.55	36.10	35.14	35.26
60 kgNfed^{-1}	3315	3060	3203	3193	3525	3244	3419	3396	6840	6304	6621	6588	36.36	36.41	36.28	36.35
80 kgNfed^{-1}	3405	3116	3371	3298	3516	3500	3088	3368	6921	6617	6459	6665	36.91	35.34	39.15	37.13
Mean	3182	2890	3059		3449	3146	3155		6631	6036	6213		35.94	35.95	36.86	
LSD																
N rates		210				319				524				0.70		
Organic		66				142				188				0.65		
Interaction		114				246				325				1.13		

Spraying ascorbic acid led to significant increase in grain, biological yield and harvest index compared to other treatments in the first season. But, grain, straw and biological yield were improved significantly by foliar spray of citric acid along with other foliar one in the 2nd season. Also, data reveal that salicylic acid as a foliar application gave the highest significant value of harvest index compared to other treatments in the 2nd one. In this connection, Keles and Oncel, (2002) stated that the antioxidant defense system in plants contains enzymatic and non–enzymatic antioxidants. The enzymatic system consists of enzymes such as catalase and superoxide dismutase. Mohamed, (2013) the foliar applications of ascorbic acid significantly improved the wheat grain and straw yields per feddan as well as biomass fed-1 in relative to the check treatment. The beneficial effects of ascorbic acid on producing vigour plants as well as improving yield components surely reflected on improving production of wheat plants.

Respecting the interacted factors under study on such parameters, as a general rule, results show that the highest significant values of grain, straw, biological yield and harvest index were noticed by spraying ascorbic acid under soil application of 60 or 80 kg N fed-1 in both seasons. Whereas, the lowest ones were recorded by foliar spray of any organic acid under the lowest N fertilizer rate 40 kg N fed-1 in both ones. These results may be due to the organic acids led to an enhancing root development and encourage uptake of macro and micronutrients by wheat plant, consequently, improving the efficiency of nitrogen fertilizer. These results are in harmony with those achieved by Senaratna *et al*. (2000); El-Kobisy *et al.,* (2005); Basela and Mahadeen, (2008); and Campillo *et al.,* (2010).

N, P and K uptake (kg fed^{-1}) as well as protein % of wheat grain

Data in Table 4 demonstrate that the addition of 80 kg N fed-1 led to the highest significant increases of N, P and K uptake (kg fed-1) as well as protein % of wheat grain compared to the lowest nitrogen fertilizer level in both seasons. The same trend was obtained for P and K uptake of grain wheat by adding 60 kg N fed-1 in the second season only. These findings were recorded by Garrido-Lestache *et al.,* (2004) who found highly significant response of grain protein content to nitrogen fertilizer rate, increasing with rising nitrogen fertilizer rates. Grain protein content is the result of complex interactions between different environmental factors in which N is the major determinant. Thus, the major factor that determines the grain protein content is N availability. The maximum effect of N fertilization on quality of wheat grain is attained during its effect on concentration of protein in wheat grain. Nitrogen fertilization contributes significantly to the improving in protein content of grain, particularly when fertilizer levels satisfy the necessities of both yield and formation of protein. Also, Braian *et al.* (2007) showed that raising nitrogen fertilizer levels consistently increased grain protein content.

Foliar application of ascorbic acid gave significant increase of N, K uptake and protein % of wheat grain compared to other treatments in the first season. Similar trend was noticed by spraying salicylic acid for potassium uptake and protein % in the same season. On the other hand, N, P and K uptake of wheat grain were improved significantly by foliar spray of citric or salicylic acid along with other foliar one in the 2nd season. Also, data reveal that salicylic or ascorbic acid as a foliar application gave the highest significant value of protein % compared to other treatments in the 2nd one. These results may be due to the organic acids led to an enhancing root development and the uptake of water and nutrients. Mohamed, (2013) stated that the application of ascorbic acid gave the highest significant values of N, P, K, in the leaves and P, K in the seeds in relative to the check treatment. The effect in terms of increase and reduce was related to using ascorbic acid. These results were true during two seasons. Moreover, Salicylic acid has a direct physiological effect during the modification of antioxidant enzyme activities and it

can augment photosynthesis and uptake of nutrient antioxidant activity as well as many substrates of metabolic. According to the Renhua *et al.,*(2008), exogenous salicylic acid could change the system of antioxidant and continue the nutritional value for vegetables and fruits, which have a superior ability to withstand oxidation injuries.

Table 4. Effect of N fertilizer rates and spraying organic acids on N, P and K uptake as well as protein % of wheat grain in both seasons.

Treatments	Grain N uptake kg fed^{-1} kg/fed.,				Grain P uptake kg fed^{-1} kg/fed.,				Grain K uptake kg fed^{-1} kg/fed.,				Protein %			
	First season															
	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean
40 kg N fed^{-1}	52.78	58.17	53.15	54.70	7.97	8.36	8.39	8.24	11.21	12.38	12.12	11.90	11.02	11.21	11.27	11.17
60 kg N fed^{-1}	55.47	63.48	59.94	59.63	9.09	9.29	9.33	9.23	12.55	13.62	13.04	13.07	11.44	12.06	12.06	11.85
80 kg N fed^{-1}	62.94	69.62	64.33	65.63	9.52	10.03	9.48	9.68	12.87	15.04	14.28	14.06	12.54	12.36	12.34	12.42
Mean	57.06	63.76	59.14		8.86	9.23	9.07		12.21	13.68	13.15		11.67	11.88	11.89	
LSD																
N rates		1.94				0.11				0.82				0.08		
Organic		3.23				0.39				0.86				0.12		
Interaction		5.60				0.68				1.48				0.20		
Second season																
40 kg N fed^{-1}	55.43	49.22	51.55	52.07	8.65	7.41	8.53	8.20	12.21	10.71	12.13	11.69	11.3	11.33	11.37	11.33
60 kg N fed^{-1}	67.63	65.72	69.10	67.49	11.57	9.83	11.00	10.80	15.59	14.29	15.14	15.01	11.73	12.37	12.4	12.17
80 kg N fed^{-1}	76.20	68.95	74.45	73.21	11.85	10.30	11.25	11.13	16.15	14.89	16.62	15.89	12.87	12.73	12.67	12.76
Mean	66.43	61.30	65.03		10.70	9.18	10.26		14.66	13.30	14.63		11.97	12.14	12.14	
LSD																
N rates		5.23				0.9				1.58				0.23		
Organic		1.6				0.38				0.62				0.1		
Interaction		2.76				0.67				1.07				0.18		

In addition to, Khandaker, *et al.,* (2011) concluded that the foliar spray of salicylic acid on red amaranth enhances biosynthesis of photosynthetic pigment chlorophyll and bioactive compounds betacyanins, total polyphenol and their activity of antioxidant. Application of salicylic acid with the same level also increased leaf number per plant, leaf size, as well as fresh and dry matter yield of red amaranth. Therefore, salicylic acid as a foliar spray improved yield of red amaranth and nutritional valued bioactive compounds.

With regard to the interacted factors under study on abovementioned parameters, data reveal that the highest significant values of such parameters were recorded by spraying any organic acid under soil application of 80 kg N fed-1 in both seasons. Similar trend was obtained by foliar spray of citric acid with addition of 60 kg N fed-1 for P and K uptake in the second season only. Whereas, the lowest ones were recorded by foliar spray of any organic acid under the lowest N fertilizer rate 40 kg N fed-1 in two seasons. These results may be due to the organic acids led to an enhancing wheat plant growth and promote macronutrients uptake of wheat grain as well as protein percentage, consequently, it civilizing the efficiency of nitrogen fertilizer. These results are in harmony with those recorded by Senaratna *et al*. (2000); El-Kobisy *et al.,* (2005); Basela and Mahadeen, (2008) and Campillo *et al.,* (2010).

N, P and K uptake (kg fed^{-1}) of wheat straw

Available data in Table 5 illustrate that the adding of 80 kg N fed-1 gave the highest significant values of N, P and K uptake (kg fed-1) of wheat straw compared to the lowest nitrogen fertilizer rate in both seasons. Similar trend was noticed by adding 60 kg N fed-1 in the second season only. The increase in N, P and K uptake of wheat straw related with rising N fertilizer rates may be due to the role of N fertilizer in increasing growth of wheat through heartening plants to uptake other macro and micronutrients as well as accordingly enhancing photosynthesis. These results are in agreement with those reported by Seadh *et al*., (2008); Antoun *et al*., (2010) and Shirazi *et al*. (2014), they concluded that the attractive effect of higher N fertilizer rate on yields and quality of grain can be easily ascribed to the nitrogen which think as one of the major nutrient for plant nutrition and it enlarges the vegetative plant growth and forms strong plants with long spikes. Furthermore, nitrogen give confidences plant to uptake other macro and micronutrients activating, thus plants growth, accordingly increasing measurements of growth and all yield attributes.

Foliar application of citric or ascorbic acid gave significant increase of N uptake of wheat straw compared to other treatments in the first season. But, N, P and K uptake of wheat straw were improved significantly by foliar spray of citric acid along with other foliar one in the 2nd season. Also, data show that salicylic acid as a foliar application gave the highest significant value of P uptake compared to other treatments in the 2nd season. The positive effect of ascorbic or citric treatments on N, P and K uptake of wheat straw which resulted in the accumulation of nutrients by foliar application of ascorbic or citric acids may be due to the positive effect of such organic acids on root growth accordingly increasing nutrients absorption. These results agree with those obtained by Amin *et al.,* (2008) who found that ascorbic acid as a foliar application significantly improved content of PK in wheat grains relative to their untreated controls. Also, El-Gabas (2006) found that the foliar spray of ascorbic acid significantly increased content of NPK in leaves and seeds of sunflower plants compared with their controls.

For the interacted factors under study on abovementioned parameters, in most cases, results demonstrate that the highest significant values of such parameters were obtained with spraying any organic acid under soil application of 80 kg N fed-1 in both seasons. The same trend was recorded by foliar spray of citric acid

with addition of 60 kg N fed-1 for P and K uptake in the second season only. Whereas, the lowest ones were evidenced by foliar application of any organic acid under the lowest N fertilizer rate 40 kg N fed-1 in both ones. The increases in NPK uptake of wheat straw may be due to the organic acids lead to an enhancing wheat plant growth and promote its nutrients uptake, consequently, its raising the efficiency of nitrogen fertilizer. These findings are in agreement with those obtained by Senaratna *et al*. (2000); El-Kobisy *et al.,* (2005); Basela and Mahadeen, (2008) and Campillo *et al.,* (2010).

Table 5. Effect of N fertilizer rates and spraying organic acids on N, P and K uptake of wheat straw in both seasons.

Treatments	Straw N uptake kg fed^{-1}				Straw P uptake kg fed^{-1}				Straw K uptake kg fed^{-1}			
	First season											
	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean	Citric	Asc	Sal	Mean
40 kg N fed^{-1}	13.52	13.19	13.29	13.34	7.85	8.39	8.03	8.09	70.55	71.74	69.42	70.57
60 kg N fed^{-1}	15.53	16.43	15.98	15.98	8.43	8.03	8.74	8.40	69.48	71.40	72.14	71.01
80 kg N fed^{-1}	19.66	18.08	16.82	18.19	9.23	9.05	9.14	9.14	76.35	75.38	74.69	75.45
Mean	16.24	15.90	15.37		8.51	8.48	8.64		72.13	72.84	72.08	
LSD												
N rates		1.51				0.21				3.06		
Organic		0.68				NS				NS		
Interaction		1.17				0.76				1.48		
Second season												
40 kg N fed^{-1}	11.60	9.14	10.03	10.25	6.59	5.36	6.00	5.98	58.20	47.15	50.72	52.03
60 kg N fed^{-1}	14.38	13.25	13.95	13.86	7.85	6.79	6.87	7.17	62.53	58.18	61.65	60.78
80 kg N fed^{-1}	16.50	16.07	13.95	15.51	7.73	8.04	7.51	7.76	62.83	65.65	60.00	62.83
Mean	14.16	12.83	12.65		7.39	6.73	6.79		61.19	56.99	57.46	
LSD												
N rates		1.83				0.76				6.37		
Organic		0.78				0.64				3.07		
Interaction		1.35				1.11				5.32		

N, P and K uptake of wheat biological yield

Results in Table 6 show that the addition of the highest nitrogen fertilizer at level 80 kg N fed-1 gave the highest significant increases of N, P and K uptake of wheat biological yield compared to lowest level in both seasons. Similar trend was recorded for K uptake of wheat biological when adding 60 kg N fed-1 in the second season only. The positive effect of nitrogen fertilizer on N, P and K uptake of wheat biological may be attributed to the nitrogen occupies a noticeable place in metabolism of plant and it also enhances the yield of wheat and nutrients uptake. An sufficient addition of N fertilizer is associated with high photosynthetic activity, vigorous growth of vegetative and uptake of nutrients, and its addition influences the yield utilization. Kandil *et al.,* (2016) study the effect of humic acid, amino acid and mixture of them as a foliar spray under N fertilizer rates (166, 214 and 262 kg N ha-1) on yield, yield components and quality characters of grain for three cultivars of bread wheat (Shaka 93, Gemiza 9 and Giza 168). They found that all studied parameters of wheat plants were gradually improved as a result of increasing the rates of N fertilizer from 166 up to 262 kg N ha-1.

Table 6. Effect of N fertilizer rates and spraying organic acids on N, P and K uptake of wheat biological yield in both seasons.

Treatments	Biological N uptake kg fed^{-1}				Biological P uptake kg fed^{-1}				Biological K uptake kg fed^{-1}			
	First season											
	Citric	Ascorbic	Salicylic	Mean	Citric	Ascorbic	Salicylic	Mean	Citric	Ascorbic	Salicylic	Mean
40 kgNfed^{-1}	66.30	71.36	66.44	68.04	15.82	16.75	16.42	16.33	81.76	84.12	81.54	82.47
60 kgNfed^{-1}	71.00	79.91	75.92	75.61	17.52	17.32	18.07	17.63	82.03	85.02	85.18	84.08
80 kgNfed^{-1}	82.60	87.70	81.15	83.82	18.75	19.08	18.62	18.82	89.22	90.42	88.97	89.51
Mean	73.30	79.66	74.51		17.37	17.71	17.71		84.34	86.52	85.23	
LSD												
N rates		2.70				0.19				3.44		
Organic		3.18				NS				2.18		
Interaction		5.51				0.90				3.78		
Second season												
40 kgNfed^{-1}	67.03	58.36	61.58	62.32	15.24	12.77	14.53	14.18	70.41	57.86	62.85	63.72
60 kgNfed^{-1}	82.01	78.97	83.05	81.35	19.42	16.62	17.87	17.97	78.12	72.47	76.79	75.79
80 kgNfed^{-1}	92.70	85.02	88.40	88.72	19.58	18.34	18.76	18.89	78.98	80.54	76.62	78.72
Mean	80.59	74.13	77.68		18.09	15.91	17.05		75.85	70.29	72.09	
LSD												
N rates		6.50				1.12				7.50		
Organic		1.88				1.49				3.33		
Interaction		3.25				2.57				5.77		

With respect to the foliar spray of organic acids on such parameters, data show that spraying ascorbic acid gave a significant increase of N and K uptake of wheat biological compared to other treatments in the first season. The same trend was obtained by spraying salicylic acid for K uptake in the same season. But, N and K uptake of wheat biological were increased significantly by foliar spray of citric acid along with other foliar ones in the 2nd season. Also, data show that the P uptake wasn't affected significantly by spraying organic acids in both ones. The increases in macronutrients uptake of wheat biological yield may be due to the ascorbic acid is one of the majority vital water soluble antioxidants in plants, acting as a modulator of plant growth during hormone signaling and

as coenzyme in responses by which carbohydrates, proteins and fats are metabolized. These findings agree with those obtained by El-Gabas (2006) and Amin *et al.,* (2008). Moreover, Pastori *et al.* (2003) suggested that the enhancement occurred because salicylic acid it's self a plant-produced phenolic compound, also an endogenous regulator of growth, which contributes in the regulation of physiological processes in plants. Salicylic acid, which belongs to a group of plant phenolics, is broadly dispersed in plants and is now considered as a hormone-like substance, which plays an imperative role in the plant growth regulation (Pila *et al.,* 2010).

Regarding the interacted factors under study on aforementioned parameters, as a general rule, data reveal that the highest significant values of NPK uptake of wheat biological were noticed by spraying any organic acid under soil application of 80 kg N fed-1 in both seasons. Alike trend was recorded by spraying any organic acid under addition of 60 kg N fed-1 for P and K uptake in the second season. Whereas, the lowest ones were obtained by spraying any organic acid under the lowest N fertilizer rate 40 kg N fed-1 in both ones. Ascorbic acid could be considered natural and safety bio-regulator compounds which relatively in low concentrations exerted deep influences upon many physiological processes. The increases in NPK uptake of wheat biological yield may be attributed to the organic acids guide to enhancing wheat plant growth and consequently promote its nutrients uptake. These findings are in agreement with those obtained by Senaratna *et al*. (2000); El-Kobisy *et al.,* (2005); Basela and Mahadeen, (2008) and Campillo *et al.,* (2010).

From the abovementioned results, in most cases, we can concluded that the increases in wheat yield and its components as well as NPK uptake of all wheat parts may be attributed to the organic acids guide to an enhancing wheat plant growth and promote its nutrients uptake as well as improving the efficiency of nitrogen fertilizer. So, under the same conditions we can reduce the recommendation of nitrogen fertilizer for wheat from 80 to 60 kg N fed-1 with foliar application of ascorbic, citric or salicylic acids to get the best possible wheat productivity both quality and quantity.

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استجابة قمح الخبز لمعدلات من التسميد النيتروجينى والرش باحماض الاسكوربيك والستريك والسالسيليك

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أقيمت تجربة حقلية فى محطة البحوث الزراعية بيهتيم – مركز البحوث الزراعية , مصر خلال موسمين زراعيين متتاليين 2014/2013 و 2015/2014، لدراسة تأثير الرش بالاحماض (الاسكوربيك والستريك والسالسيليك) تحت معدلات مختلفة من التسميد النيتروجينى (40 و60 و80 كجم نيتروجين فدان$^{-1}$) وكذلك التداخل بينهما على محصول القمح وبعض مكوناته وكذلك الممتص من بعض العناصر الكبرى والنسبة المئوية للبروتين لقمح الخبز صنف مصر1. واستخدم في ذلك تصميم القطع المنشقة مره واحدة في ثلاث مكررات. وكانت أهم النتائج المتحصل عليها كما يلي:1 - تشير النتائج الى انه باضافة اعلى معدل من السماد النيتروجينى (80 كجم نيتروجين فدان$^{-1}$) قد اعطى اعلى القيم معنويا لوزن حبوب السنبلة وعدد السنابل فى المتر المربع وعدد حبوب السنبلة ووزن الالف حبة . ايضا فان محصول الحبوب والقش والبيولوجى ودليل الحصاد وكذلك الممتص من النيتروجين والفوسفور والبوتاسيوم فى محصول الحبوب و القش والبيولوجى وكذلك نسبة البروتين فى الحبوب قد زاد معنويا باضافة كلا من 60 او 80 كجم نيتروجين فدان$^{-1}$ فى كلا الموسمين.2- عموما وفى معظم الحالات ، باضافة اى من الاحماض العضوية (الاسكوربيك والستريك والسالسيليك) رشا على النبات قد اعطى اعلى القيم معنويا لمعظم صفات مكونات المحصول ومحصول الحبوب والقش والبيولوجى ودليل الحصاد وكذلك الممتص من بعض العناصر الكبرى فى ومحصول الحبوب والقش والبيولوجى وكذلك نسبة البروتين فى الحبوب مقارنة بباقى المعاملات فى كلا الموسمين. 3- سجلت اعلى القيم معنويا لمعظم صفات مكونات المحصول ومحصول الحبوب والقش والبيولوجى ودليل الحصاد وكذلك الممتص من بعض العناصر الكبرى فى ومحصول الحبوب والقش والبيولوجى وكذلك نسبة البروتين فى الحبوب باضافة اى من الاحماض العضوية مع الاضافة الارضية من التسميد الميتروجينى بكلا من 60 او 80 كجم نيتروجين فدان$^{-1}$ فى كلا الموسمين. ولزيادة محصول القمح (كما ونوعا) ربما ينصح باضافة اى من الاحماض العضوية رشا لتشجيع نمو محصول القمح ولتنشيط امتصاص العناصر الغذائية ولتحسين كفاءة التسميد النيتروجينى. لذا، تحت نفس ظروف هذه التجربة يمكننا تخفيض كمية السماد النيتروجينى المستخدم من 80 الى 60 كجم نيتروجين فدان$^{-1}$ مع الاضافة الورقية بحامض (الاسكوربيك والستريك والسالسيليك) للحصول على افضل انتاجية ممكنة من محصول القمح.