EFFECT OF SOIL AND FOLIAR APPLICATIONS OF DIFFERENT DOSES OF NPK FERTILIZERS ON QUALITY AND QUANTITY OF WHEAT (*Triticum aestivum* L.) CROP

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ABSTRACT

Two field experiments were designed in the Farm of Sids Agricultural Reasearch Station, ARC, Beni Swif Governorate, Egypt to study the effect of different doses of N, P, and K through soil and foliar applications and their interactions on wheat plant (*Triticum aestivum* L.). Three levels of soil NPK applications, i.e., 0.0, 50%, and 100% from its recommended rates (RR) and four foliar spraying treatments were used (without spraying and spraying two, threee and four times). The results revealed that, plant height, dry weight/plant, number of spikes/m^2, number of grains/spike, grain and straw yields, N, P and K concentration and uptake by grains and/or straw as well as protein percentages in grains were significantly increased by increasing the soil application of N, P and K up to the recommended rates or by spraying the plants four times. Combined 50% RR NPK + foliar spraying four times gave highest values of the abovementioned parameters, equal to those obtained by 100% RR NPK. The highest values of N, P and K uptake by grains and/or straw and protein percentage in grains produced under 100% RR + foliar spraying four times. The weight of thouthand grain significantly increased by increasing soil application rates, while, it did not affect by the number of foliar spraying numbers.

Key words: Wheat, Soil application NPK, Foliar application NPK, Growth; yield and its components, Nutrient content

INTRODUCTION

Wheat (*Triticum aestivum* L.) is considered the most important crop in food security prospective. Wheat represents the stable food for more than one third of the world population. In Egypt, wheat provides about 37% of the total calories for the people and 40% of the protein in the Egyptian diet. Also, it is major source of straw for animal fedding. However, the local production of wheat grains (about 8.8 million ton) covers only 60% of local consumption demand which reflect the need to import about 40% of wheat grains from abroad (Abd El-Ghany *et al.*, 2012). Wheat yield can be increased by the use of the recently developed high yielding; lodging and disease resistant varieties, irrigation and use of appropriate amounts of macro and micro-nutrients either as a soil or foliar application.

Primary nutrients are used by plants in comparatively large quantity and often complemented as fertilizers (nitrogen, phosphorus, and potassium). The function of nutrients is one of the chief importance in improving quality and productivity of

cereals which require mineral nutrients in large amounts and continuous inorganic fertilizers consumption which results in micronutreients deficiency, disproportion in physiochemical properties of soil, low production of crops and environmental pullution. For this reasons these mineral are practiced in foliar form. Foliar form of application is most effective when roots are incapable for absorbing required amount of nutrients from soil due to some reasons like high degree of fixation, lack of soil moisture, losses from leaching and low soil temperature.

The beneficial effect of foliar nutrition of N, P and K in mineral form as supplemental or a partial substitution to soil application were repoted by many authors such as Abou El-Nour and Abdel-Maguid (2003) and Afifi *et al.* (2011) on maize, Brar and Brar (2004) on cotton; Shaaaban *et al.* (2009), Yassen *et al.* (2010), Abass and Ali (2011), and Salem and Al- Doss (2014) on wheat, and Afifi *et al.* (2010) on faba bean.

Moreover Rahman *et al.* (2014) mentioned that among fertilizer application methods, one of the most important methods of application is foliar nutrition because foliar nutrients facilitale easy and quick consumption of nutrients by penetrating the stomata of leaf cuticle and enters the cells. It is determined that during crop growth supplementary foliar fertilization increase plants mineral status and improve crop yields. They added that foliar feeding of mineral nutrients at tillering, jointing, booting and varions stages of wheat crop in utilization of nutrients has been shown much effective and increase yield.

With this idea in mind, the experiments were conducted to study the individual effect of foliar applied of NPK and soil applied of NPK and also to study the combined effect of foliar + soil application in growth and yield as well as nutrients status of wheat.

MATERIAL AND METHODS

Two field trails on wheat (*Triticum aestivum*) cv Sids 1 were preformed during the consecutive winter seasons of 2013/2014 and 2014/2015 at the Farm of Sids Agricultural Research Station, ARC, Egypt to evaluate the effects of soil and foliar application of different concentrations of NPK on different growth (plant height, cm; dry weight/plant (g); yield comoneds, i.e. number of spikes/m^2, number of grains/spike and 1000-grain weight, (g); grain and straw yields (ardab/feddan and ton/feddan, respectively) as well N, P and K status. For this purposes, 12 treatments (2 factors) with four replicates for each were done in factorial complete randomized block disgen.

The NPK soil application treatments were 0.0, 50, 100% of its recommended rates, RR (the recommended rates of NPK were 70, 15.5 and 24 kg N, P2O5 and K2O/feddan, respectively). While, NPK foliar application treatments were 0.0; twice at 15 and 35 days; three times at 15, 25 and 35 days and four times at 15, 25, 35 and 45 days after sowing. The soil applications were ammonium nitrate (33.5% N), calcium superphosphate (15.5 P2O5) and potassium sulphate (48% K2O) for N, P, and K, respectively. However, foliar applications were 2% urea solution for nitrogen treatment and 2% KH2PO4 (monopotassium phosphate) solution for both phosphorus and potassium treatments.

A presentative surface soil sample were taken from the field of each experiment were taken and particle size distribution was determined according to Klute (1986) and some chemical properties were determined according to Page *et al.* (1982) and listed in Table (1).

Wheat grains were sowing in plots (plot area was 10.5 m^2 = 1/400 feddan) in November 13th and 20th in the two seasons, respectively. Soil application treatments of P and K were added before sowing, during land preparation as calcium superphosphate (15.5 P2O5) and potassium sulphate (48 % K2O), respectively. While soil nitrogen application was added at two equal doses before the first and the second irrigation. At maturity, wheat plants were harvested in May and plant growth and yield and its components were recorded. Samples of grain and straw were taken for determine its content of N, P and K according to Chapman and Pratt (1978). Then the NPK uptake by grains and straw were calculated. Standard cultural practice for growing wheat in district were adapted.

Table 1: Partical size distribution and some chemical properties of the studied soil before sowing.

Soil properties	First season	Second season
Physical properties:		
Particle size distribution:		
Clay (%)	53.04	53.85
Silt (%)	31.85	29.39
Sand (%)	15.11	16.76
Texture grade	Clay	Clay
Chemical properties:		
pH (1:2.5 soil-water suspension)	8.11	8.06
EC, soil paste (ds m^{-1})	1.11	1.23
Organic matter (%)	1.66	1.75
CaCO3 (%)	2.75	3.35
Available N (ugg^{-1})	29.71	25.79
Available P (ugg^{-1})	12.54	11.82
Available K (ugg^{-1})	186.00	187.00

Data were subjected to statistical of variance, and means of treatments and were compared by LSD at 5% level of significance according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSIONS

1. Plant growth

Data in Table 2 show that the method of fertilizers application exhibited a significant variation in their plant height and dry weight of wheat plants in both seasons of study. As for soil application, the tallest and heaviest plants were given by adding NPK at 100% from its recommended rates which surpassed that received 0.0 and 50% from its recommended rates by about 34.4 and 9.0% in the first season, and 34.0 and 9.2% in the second one. The corresponding values for wheat dry weight were 46.4 and 15.3%in the first season and 44.9 and 14.1% in second one. This explained by the fact that among the essential nutrients needed by the plant, nitrogen, phosphorus and potassium play a highly recognized role in plant life. An adequate

supply of these nutrients greatly improves the quality and quantity of productivity (Jamal and Chaudhary, 2007). These results are in similar to those obtained by Galal (2007) and Ali *et al.* (2009) who reported that wheat plant growth was significantly responded to NPK fertilization.

Concerning the foliar application the results clearly show that both plant height and dry weight were markedly improved by adding N, P and K as foliar application. It is obvious to notice that as increasing the times of foliar application, the values of plant height and dry weight were increased. Maximum plant height and dry weight were recorded in those plots received mixture of N, P and K solution as foliar spray four times, while minmum values of the two growth parameters were recorded on that without foliar application. This may be attributed to foliar feeding of nutrient may actually promote root aborbition of the same nutrient (Oosterhuis, 1998 and Soepardi, 1998) or other nutrients through improving root growth and increasing nutrients uptake (EL-Fouly and El-Sayed, 1997). The positive effect of foliar application of NPK on wheat growth were reported by many authors such as Al-Qurashi (2005) and Rahman *et al.* (2014).

Table 2: Effect of soil and foliar application of NPK on plant growth.

Soil application of NPK (A)	Foliar application of NPK (B)	Plant height (cm)		Dry weight/plant (g)	
		2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	70.8	72.6	2.53	2.60
	Twice times	77.2	78.1	2.80	2.89
	Three times	80.6	81.9	2.95	3.02
	Four times	86.4	87.2	3.20	3.31
Mean		78.8	80.0	2.87	2.96
50% of NPK Recommended rate (50% RR)	0.0	87.6	88.1	3.16	3.30
	Twice times	95.7	95.6	3.41	3.50
	Three times	100.1	101.7	3.83	3.89
	Four times	105.2	107.3	4.25	4.35
Mean		97.2	98.2	3.67	3.76
100% of NPK Recommended rate (100% RR)	0.0	105.2	107.0	4.11	4.33
	Twice times	106.8	107.2	4.22	4.25
	Three times	105.1	106.8	4.29	4.29
	Four times	106.4	107.7	4.30	4.30
Mean		105.9	107.2	4.23	4.29
Mean of foliar application	0.0	87.9	89.2	3.27	3.41
	Twice times	93.2	93.6	3.48	3.55
	Three times	95.3	96.8	3.69	3.73
	Four times	99.3	100.7	3.92	3.99
L. S. D. at 5%					
(A)		2.6	3.1	0.20	0.25
(B)		1.1	1.6	0.08	0.09
(A x B)		3.8	4.05	0.28	0.38

As for the interaction effect, the data clearly reveal that added 50% RR of NPK plus spraying NPK solution four time yielded plant height and dry weight significantly equal to those fertilized with 100% RR. On the other hand the plant without NPK addition whether soil or foliar application exerted the shortest and

lightest wheat plants. These results are in agreement with those finding by El-Defan et al. (1999) and Jamal and Chaudhary (2007) who concluded that soil + foliar treatments were superior for increasing wheat growth.

2. Yield components

Results in Table 3 indicate that number of spikes/m^2, number of grains/spike and 1000-grain weight were significantly affected by fertilizer doses as soil application, where higher soil application at its recommended rate gave higher values for these parameters in both seasons. The increasing percentages of these parameters due to 100% RR reached to 14.3 and 4.4, 35.6 and 8.5, and 29.2 and 14.4% comparing to 0.0 and 50% RR, in the first season, respectively. The same trends were obtained for the second season. This is mainly due to N, P and K are major element found in plant; N combined with C, H, O, and sometimes S to form amino acids, amino enzymes, nucleic acids, chlorophyll, alkaloids and purine bases, while P is a component of certain enzymes and proteins, adenosine triphosphate (ATP), ribonucleic acids (RNA), deoxyribonucleic acids (DNA), and phytin. Furthermore, K involved in maintaining the water status of the plant and the turgor pressure of its cells and the opening and closing of its stomata. Potassium is required in the accumulation and translocation of newly formed carbohydrates. For these functions of N, P and K in plant nutrition, adding these elements in adequate doses improved growth as well as yield components of wheat (Jones *et al.*, 1990). These results are in harmony with those obtained by Salwau (1994) and Jamal and Chaudhary (2007) and Shaaban *et al.* (2009).

Table 3: Effect of soil and foliar application of NPK on yield components.

Soil application of NPK (A)	Foliar application of NPK (B)	No. of spikes/m^2		No. of grains/spike		1000-grain weight (g)	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	270.1	273.3	50.3	50.4	34.01	34.03
	Twice times	277.3	279.6	58.2	58.6	34.26	34.10
	Three times	282.6	286.0	62.5	63.0	34.52	34.09
	Four times	290.6	293.3	66.3	67.7	34.69	34.11
Mean		280.1	283.1	59.3	59.9	34.37	34.08
50% of NPK Recommended rate (50% RR)	0.0	292.1	294.5	67.7	68.2	38.77	38.79
	Twice times	305.5	306.9	72.1	73.6	38.76	38.77
	Three times	310.1	312.3	76.3	77.4	38.81	38.69
	Four times	319.6	322.0	80.4	80.8	38.81	38.75
Mean		306.8	308.9	74.1	75.0	38.79	38.75
100% of NPK Recommended rate (100% RR)	0.0	320.2	322.7	80.2	80.7	44.36	44.43
	Twice times	320.1	321.9	80.6	80.5	44.39	44.41
	Three times	319.8	322.1	80.2	80.6	44.41	44.52
	Four times	320.5	321.8	80.4	80.6	44.39	44.56
Mean		320.2	322.1	80.4	80.6	44.39	44.48
Mean of foliar application	0.0	294.1	296.8	66.1	66.3	39.05	39.08
	Twice times	301.0	302.8	70.3	70.9	39.14	39.09
	Three times	304.2	306.8	73.0	73.7	39.25	39.10
	Four times	310.2	312.4	75.7	76.4	39.30	39.14
L. S. D. at 5%							
(A)		2.16	2.20	1.13	1.20	1.01	1.16
(B)		0.96	0.97	0.36	0.42	N. S.	N. S.
(A x B)		3.19	3.21	2.66	2.79	N. S.	N. S.

Concerning foliar application, the data in Table 3 reveal that NPK foliar application has positive effect on the studied yield component parameters, except 1000-grain weight. Irrespective of soil application the highest number of spikes/m^2 and number of grains/spike were obtained from those plots sprayed with 2% N, P and K four times. On the other hand the minimum number of spikes/m^2 and number of grains/spike wer recorded in plots without NPK foliar application in both seasons. This might be due to foliar application of N, P and K solution enhance plant height and dry wheat of plant as discussed earlier, which in turn resulted in maximum number of spikes/m^2 and number of grains/spike (Gul *et al.*, 2011). These results agree with those obtained by Rogalski (1994) and Abd El-Ghany *et al.* (2012).

Regarding the interaction effect, the results reveal the combined foliar + soil applied treatments gave higher values of number of spikes/m^2 and number of grains/spike. The highest values of the two parameters were obtained under the treatment of 100% RR alone or in combined with foliar spray at any of the different times. Also, it is obvious to notice that 50% RR as soil application + 2% NPK as foliar spraying at four times exerted highest number of spikes/m^2 and number of grains/spike significantly equal to those produce under 100% RR NPK treatments. It is worthy to mention that number of spikes/m^2 and number of grains/spike are actually determined the yield of wheat. The results are in line with those obtained by Jamal and Chaudhary (20007) and Gul *et al.* (2011).

3. Grain and straw yields

It is quite clear from the data presented in Table 4 that addition of N, P and K at its recommended rates as soil application increased grain and straw yields in both seasons. This increments reached to 21.9 and 100%; and 8.2 and 45.2% over 50% RR and 0.0% RR in the first season, respectively. The corresponding inceases for grain and straw yields in the second season were 7.1 and 74.6%; and 8.9 and 50% in the obovementined respect. This may be attributed to the fact that N, P and K are the most important nutrients for the plants which needed it in large amounts, so their application showed marked positive effect on growth and yield components of wheat (Tables 2 and 3), consequantly increased both grain and straw yields. The present results are in line with the results of Ali *et al.* (2009) and Rahman *et al.* (2014).

Table 4: Effect of soil and foliar application of NPK on grain and straw yields.

Soil application of NPK(A)	Foliar application of NPK (B)	Grain yield (ardab/feddan)		Straw yield (ton/feddan)	
		2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	10.3	10.5	3.13	3.27
	Twice times	12.4	12.5	3.51	3.54
	Three times	13.6	13.7	3.83	3.70
	Four times	14.9	15.1	4.14	4.07
Mean		12.8	13.0	3.65	3.65
50% of NPK Recommended rate (50% RR)	0.0	17.1	17.3	4.40	3.53
	Twice times	19.1	19.4	4.73	4.81
	Three times	22.0	22.3	5.01	5.14
	Four times	25.6	25.8	5.44	5.65
Mean		21.0	21.2	4.90	5.03
100% of NPK Recommended rate (100% RR)	0.0	25.5	25.7	5.32	5.44
	Twice times	26.1	25.8	5.30	5.52
	Three times	25.3	25.4	5.26	5.41
	Four times	25.6	25.7	5.33	5.56
Mean		25.6	22.7	5.30	5.48
Mean of foliar application	0.0	17.6	17.8	4.28	4.41
	Twice times	19.2	19.2	4.51	4.62
	Three times	20.3	20.5	4.70	4.75
	Four times	22.0	22.2	4.97	5.09
L. S. D. at 5%					
(A)		2.9	2.8	0.25	0.26
(B)		1.6	1.4	0.06	0.07
(A x B)		3.3	3.1	0.37	0.29

With regard to the foliar application effect, the results clearly show that wheat grain and straw yields were significantly responded to add NPK as foliar application. Both grain and straw yields were graudually increased as the number of foliar spraying increased in both seasons. The wheat plants sprayed with NPK solutions four times produced grain and straw yields increased than that sprayed 3, 2 and 0.0 times by about 5.3, 14.6 and 25; and 5.7, 10.2 and 16.1% in the first season, respectively. Similar trend were obtained in the second season. The positive effect of foliar application of N, P and K on grain and straw yields is mostly due to the effect of these method on growth and yield components as mentioned former, which in turn increased grain and straw yields.

As the interaction effect, the results reveal that combined 50% RR +foliar spray of NPK four times gave grain and straw yields significantly equal to those produce under 100% RR with or without foliar application which meaning the possibility of supplement 50% from the recommened rates of N, P and K by spray 2% of N, P and K four times. On the other hand wheat plants without N, P and K fertilization, whether soil or foliar application recorded the lowest grain and straw yields. It is obvious to notice that using foliar method was not significantly affected grain or straw yield under 100% RR, which may be prove the non importance of the additional foliar application after soil addition of recommended dose of fertilizers. These finding are similar to those obtained by El-Ghamry *et al.* (2009), Parvez *et al.* (2009) and Wazir *et al.* (2011).

4. Nutrient contents and protein percentage

Data in Tables 5 and 6 presented the effect of soil and foliar application of N, P and K on N, P and K concentration in both grains and straw as well as protein percentage in grains. As for the effect of soil application, the results clearly show that grain and straw N, P and K concentrations as well as protein percentage had a linear relationship with N, P and K rates, where NPK at its recommended rates gave the highest values of these nutrient concentrations in both seasons. Comparing with 0.0 and 50% RR, additional N, P and K fertilizers at the full recommended rates increased N, P and K contents in grains by about 25.2 and 8.9; 57.1 and27.9; and 53.3 and 25.5% in grains in the first season, respectively. Similar results were noticed in the second season for grains and the two seasons for straw. These results support the importance of N, P and K nutrients, especially at large amounts. Similar results were obtained by Ismail *et al.* (2014).

Table 5: Effect of soil and foliar application of NPK on N, P and K concentrations as well as protein (%) in grains.

Soil application of NPK (A)	Foliar application of NPK (B)	N%		P%		K%		Protein%	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	1.01	1.00	0.30	0.28	0.41	0.43	6.31	6.25
	Twice	1.06	1.04	0.33	0.31	0.44	0.46	6.63	6.50
	Three times	1.09	1.08	0.36	0.34	0.46	0.49	6.81	6.75
	Four times	1.12	1.11	0.39	0.37	0.49	0.52	7.00	6.94
Mean		1.07	1.06	0.35	0.33	0.45	0.48	6.69	6.61
50% of NPK Recommended rate (50% RR)	0.0	1.16	1.14	0.41	0.40	0.51	0.53	7.25	7.13
	Twice	1.20	1.21	0.44	0.42	0.53	0.55	7.50	7.56
	Three times	1.25	1.23	0.46	0.44	0.56	0.59	7.81	7.69
	Four times	1.30	1.31	0.49	0.46	0.58	0.62	8.13	8.19
Mean		1.23	1.22	0.45	0.43	0.55	0.57	7.67	7.64
100% of NPK Recommended rate (100% RR)	0.0	1.31	1.33	0.52	0.50	0.62	0.64	8.19	8.31
	Twice	1.33	1.35	0.54	0.52	0.67	0.68	8.31	8.44
	Three times	1.35	1.37	0.56	0.54	0.71	0.74	8.44	8.56
	Four times	1.37	1.39	0.58	0.56	0.75	0.78	8.56	8.69
Mean		1.34	1.36	0.55	0.53	0.69	0.71	8.38	8.50
Mean of foliar application	0.0	1.16	1.16	0.41	0.39	0.51	0.53	7.25	7.23
	Twice	1.20	1.20	0.44	0.42	0.55	0.56	7.48	7.50
	Three times	1.23	1.23	0.46	0.44	0.58	0.61	7.69	7.67
	Four times	1.26	1.27	0.49	0.46	0.61	0.64	7.90	7.94
L. S. D. at 5% (A)		0.06	0.07	0.03	0.04	0.04	0.03	0.37	0.43
(B)		0.04	0.05	0.01	0.02	0.02	0.02	0.25	0.26
(A x B)		N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.	N. S.

Table 6: Effect of soil and foliar application of NPK on N, P and K concentrations in straw

Soil application of NPK (A)	Foliar application of NPK (B)	N%		P%		K%	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	0.29	0.28	0.08	0.07	1.11	1.13
	Twice times	0.32	0.31	0.09	0.09	1.19	1.21
	Three times	0.36	0.35	0.10	0.10	1.25	1.26
	Four times	0.40	0.38	0.12	0.11	1.29	1.32
Mean		**0.34**	**0.33**	**0.10**	**0.09**	**1.21**	**1.23**
50% of NPK Recommended rate (50% RR)	0.0	0.41	0.40	0.11	0.10	1.34	1.36
	Twice times	0.44	0.43	0.13	0.12	1.38	1.39
	Three times	0.47	0.46	0.14	0.13	1.42	1.44
	Four times	0.50	0.50	0.15	0.15	1.49	1.52
Mean		**0.46**	**0.45**	**0.13**	**0.13**	**1.41**	**1.43**
100% of NPK Recommended rate (100% RR)	0.0	0.51	0.50	0.15	0.14	1.49	1.53
	Twice times	0.54	0.52	0.16	0.15	1.53	1.55
	Three times	0.57	0.55	0.18	0.17	1.57	1.59
	Four times	0.61	0.60	0.20	0.19	1.61	1.63
Mean		**0.56**	**0.54**	**0.17**	**0.16**	**1.55**	**1.58**
Mean of foliar application	0.0	**0.40**	**0.39**	**0.11**	**0.10**	**1.31**	**1.34**
	Twice times	**0.43**	**0.42**	**0.13**	**0.12**	**1.37**	**1.38**
	Three times	**0.47**	**0.45**	**0.14**	**0.13**	**1.41**	**1.43**
	Four times	**0.50**	**0.49**	**0.17**	**0.15**	**1.46**	**1.49**
L. S. D. at 5%							
(A)		**0.04**	**0.04**	**0.02**	**0.02**	**0.11**	**0.13**
(B)		**0.02**	**0.02**	**0.01**	**0.01**	**0.03**	**0.03**
(A x B)		**N. S.**	**N. S.**	**N. S.**	**N. S.**	**N. S.**	**N. S.**

Considering the foliar application, data reveal that N, P and K concentrations in both grains and straw were positively and graudually responded the times of foliar spraying treatments. The relative increasing of N, P and K concentrations in grains reached to 8.6, 5.0 and 2.4%; 19.5, 11.4 and 6.5%; and 19.6, 10.9 and 5.2% in the first season, respectively. The corresponding values for straw in the first season were 25.0, 16.3 and 6.4; and 54.5, 30.8 and 21.4; and 11.5, 6.6 and 3.5% in the abovementioned order. Similar trends were obtained for grains and straw in the second season. This is may be due to the stimulating effect of the N, P and K solution through improving the physiological performance of plants and multiple advantage of foliar application method such as, rapid and efficient response to plant needs, less product needed and independence of soil conditions (Yildirim *et al.*, 2007). These results are similar to those obtained by Kolota and Osinka (2001) and Yasseen *et al.* (2010). Furthermore, protein percentage had similar trends as the effect of N, P and K addition on N percentages whether soil or foliar application, since protein percentage calculated as multiplyed nitrogen percentage in grains by 6.25. The higher N, P and K application as soil or foliar method, the higher is protein percentage in grains.

As for the interaction, the data reveal that N, P and K percentages in grains or straw as well as protein percentage in grains did not affect by the interaction between the two studied treatments. This meaning that as increasing fertilizers rate whether soil or foliar application, the nutrient concentrations and protein percentage increased. It is obvious to mention that wheat grain and straw

yields did not respond to foliar spraying of N, P and K solutions under supplied wheat plants with the recommended rates of N, P and K fertilizers, while protein percentage increased as N, P and K fertilizers increased, whether as soil or foliar methods. Similar results were obtained by Yasseen *et al.* (2010).

5. N, P and K uptake

Data in Tables 7, 8 and 9 show the effect of soil and foliar application of N, P and K on N, P and K uptake by grains and/or straw. Remarkable increases in nutrients uptake by grains and/or straw were observed due to increasing soil application of N, P and K up to the recommended rate. The increment of total N, P and K uptake due to additional of 100% RR reached to 142.8, 189.7 and 105.3%, respectively in the first season. The corresponding values for the second season were 148.7, 228.1 and 109.2% in the same abovementioned order. This mostly explained by the positive effect of soil application of fertilizers on both grain and straw yields as well as its effect on nutrient concentrations in grains and straw, since nutrient uptake calculated by myltiplying grains or straw yield by its nutrient concentration. These results are in harmony with those obtained by Ismail *et al.* (2014).

Table 7: Effect of soil and foliar application of NPK on N, P and K uptake (kg/feddan) by grains.

Soil application of NPK (A)	Foliar application of NPK (B)	N		P		K	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	15.69	15.66	4.61	4.49	6.45	6.73
	Twice times	19.70	19.83	6.17	5.96	8.30	8.63
	Three times	22.23	22.36	7.46	7.03	9.25	10.22
	Four times	24.96	25.26	8.82	8.42	11.10	11.71
Mean		20.64	20.78	6.77	8.63	8.78	9.32
50% of NPK Recommended rate (50% RR)	0.0	29.35	29.53	10.45	10.62	13.16	13.79
	Twice times	34.43	33.05	12.73	12.36	15.27	16.16
	Three times	40.87	40.96	15.26	14.96	18.31	19.63
	Four times	49.75	50.44	18.73	17.99	22.34	23.77
Mean		38.60	38.50	14.29	13.98	17.27	18.34
100% of NPK Recommended rate (100% RR)	0.0	50.23	51.33	19.93	19.42	23.82	24.39
	Twice times	52.07	52.11	21.36	20.37	26.40	26.11
	Three times	52.19	52.35	21.44	20.46	27.12	28.31
	Four times	52.75	53.46	22.36	21.63	28.96	29.78
Mean		51.81	52.31	21.27	20.47	26.58	27.15
Mean of foliar application	0.0	31.76	32.17	11.66	11.51	14.48	14.97
	Twice times	35.40	35.00	13.42	12.90	16.66	16.97
	Three times	38.43	38.56	14.72	14.15	18.26	19.39
	Four times	42.49	43.05	16.64	16.01	20.80	21.75
L. S. D. at 5%							
(A)		3.75	4.03	2.25	2.02	2.65	2.85
(B)		1.13	1.26	0.78	0.63	1.13	1.39
(A x B)		4.26	4.85	4.10	3.96	4.06	4.35

It is also noticed from the data presented in Tables 7, 8 and 9 that nutrients uptake in grains and/or straw were significantly increased by increasing the time of spraying. Spraying plants with 2% N, P and K solutions four times gave 35.5, 21.2 and 11.3; 46.3, 26.4 and 13.6; 30.8, 18.7 and 10.0%

increase in total N, P and K uptake over 0.0, two and three time treatments, respectively in the first season. Similar trends were obtained in the second season. This is due to foliar feeding of nutrient may actually promote root absorption of the same nutrient (Oosterhuis, 1998 and Soepardi, 1998) or other nutrients through improving root growth and increasing nutrients uptake (El-Fouly and El-Sayed, 1997).

Table 8: Effect of soil and foliar application of NPK on N, P and K uptake (kg/feddan) by straw.

Soil application of NPK (A)	Foliar application of NPK (B)	N		P		K	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	9.13	9.33	2.55	2.34	34.15	36.79
	Twice times	11.35	10.91	3.36	3.27	41.58	42.93
	Three times	13.70	12.76	3.95	3.76	47.96	46.55
	Four times	16.66	15.69	4.78	4.53	53.37	53.67
Mean		12.71	12.17	3.66	3.48	44.27	44.99
50% of NPK Recommended rate (50% RR)	0.0	17.92	18.37	4.76	4.61	58.91	61.49
	Twice times	20.73	20.81	6.21	5.82	65.16	66.92
	Three times	23.36	23.75	7.34	6.63	71.40	73.89
	Four times	27.01	28.06	8.26	8.56	81.25	85.67
Mean		22.26	22.75	6.64	6.41	69.18	71.99
100% of NPK Recommended rate (100% RR)	0.0	27.36	27.11	8.03	7.83	79.55	83.36
	Twice times	28.57	28.83	8.32	8.34	81.17	85.62
	Three times	29.76	29.84	9.27	9.31	82.66	86.27
	Four times	32.19	33.43	10.71	10.43	85.70	90.49
Mean		29.47	29.80	9.08	8.98	82.27	86.44
Mean of foliar application	0.0	18.14	18.27	5.11	4.93	57.54	60.55
	Twice times	20.22	20.18	5.96	5.81	62.64	65.16
	Three times	22.27	22.12	6.85	6.57	67.34	68.90
	Four times	25.29	25.73	7.92	7.84	73.44	72.05
L. S. D. at 5%							
(A)		3.36	3.76	1.34	1.19	7.38	8.67
(B)		0.65	0.77	0.26	0.27	1.16	1.38
(A x B)		6.59	7.06	3.08	3.16	8.94	10.16

The statistical analysis of the data in Tables 7, 8 and 9 reveal that nutrient uptake did not responded to the interaction between the two studied treatments. In general, the highest values of N, P and K uptake by grains and/or straw were recorded for the plants received 100% RR as soil application + N, P and K application as foliar spraying four times. Meanwhile, the plants without N, P and K as soil or foliar application exerted the low nutrients uptake.

CONCLUSION

Results presented have confirm the beneficial use of foliar N, P and K fertilization in wheat, which sprayed wheat plants with 2% of N, P and K solutions four times plus N, P and K at 50% RR gave quality and quantity of wheat production equal to those obtained when supplied the plants with 100% from its N, P and K recommended rates. This meaning that it could save about 50% RR of NPK fertilizers. Also, using foliar application under fertilized wheat plants with 100% from its recommended rates improve the quality of grains by increasing protein percentage.

Table 9: Effect of soil and foliar application of NPK on total N, P and K uptake (kg/feddan) by wheat plants.

Soil application of NPK (A)	Foliar application of NPK (B)	N		P		K	
		2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
0.0	0.0	24.75	24.91	7.25	6.89	40.63	43.39
	Twice times	31.17	30.82	9.60	9.31	49.72	51.51
	Three times	35.91	35.26	11.47	10.83	57.29	56.83
	Four times	41.58	40.96	13.58	12.91	64.38	65.41
Mean		33.35	32.99	10.48	8.99	53.01	54.29
50% of NPK Recommended rate (50% RR)	0.0	47.22	48.15	15.26	15.36	72.13	75.33
	Twice times	55.30	53.77	18.90	18.23	80.47	83.23
	Three times	64.21	64.82	22.63	21.61	89.56	90.25
	Four times	76.83	78.46	26.85	26.50	103.45	109.16
Mean		60.89	61.3	20.91	20.43	86.40	89.49
100% of NPK Recommended rate (100% RR)	0.0	77.44	78.41	27.79	27.11	103.16	107.86
	Twice times	80.57	80.79	29.75	28.93	107.66	111.65
	Three times	81.81	82.31	30.71	29.94	109.83	114.72
	Four times	84.03	86.72	33.19	32.01	114.58	120.11
Mean		80.96	82.06	30.36	29.50	108.81	113.59
Mean of foliar application	0.0	49.80	50.49	16.77	16.45	71.97	75.53
	Twice times	55.68	55.13	19.42	18.82	79.28	82.13
	Three times	60.64	60.80	21.60	20.79	85.56	87.27
	Four times	67.48	68.71	24.54	23.81	94.14	98.23
L. S. D. at 5%							
(A)		3.49	4.10	1.99	1.69	7.86	8.06
(B)		1.36	1.147	0.79	0.71	2.67	2.86
(A x B)		7.54	8.13	4.19	4.03	9.05	9.16

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تأثير الاضافة الارضية أو الرش الورقي بالمعدلات المختلفة من الاسمدة النيتروجينية والفوسفاتية والبوتاسية علي محصول القمح كما ونوعا

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أجريت تجربتان حقليتان بالمزرعة البحثية بمحطة البحوث الزراعية بسدس، مركز البحوث الزراعية، محافظة بني سويف، مصر لدراسة تأثير اضافة معدلات مختلفة من الاسمدة النيتروجينية والفوسفاتية والبوتاسية علي صورة اضافة ارضية او رش ورقي وتداخلاتهم علي محصول القمح كما ونوعا. تم استخدام ثلاث معدلات للتسميد الارضي (بدون، ٥٠%، ١٠٠% من الكمية الموصي بها لنبات القمح من الاسمدة النيتروجينية والفوسفاتية والبوتاسية) واربع مستويات من عدد مرات الرش الورقي (بدون، رش مرتان، رش ثلاث مرات، رش اربع مرات)، وكانت اهم النتائج المتحصل عليها هي:-

- ادي زيادة معدلات التسميد الارضي او الرش الورقي الي زيادة طول النبات ، الوزن الجاف للنبات وعدد السنابل في المتر المربع وعدد الحبوب في السنبلة ومحصول الحبوب والقش وتركيز وامتصاص عناصر النيتروجين والفوسفور والبوتاسيوم في الحبوب والقش والنسبة المئوية للبروتين في الحبوب.
- ادي رش عناصر النيتروجين والفوسفور والبوتاسيوم اربع مرات مع الاضافة الارضية لهذة العناصر بمعدل ٥٠% من المعدل الموصي به الي قيم للصفات السابقة متساوية معنويا مع التسميد الارضي للنيتروجين والفوسفور والبوتاسيوم بمعدل ١٠٠% من الموصي به ما يعني امكانية توفير ٥٠% من هذة الاسمدة بالرش الورقي اربع مرات.
- ادي زيادة التسميد الارضي او الورقي الي زيادة تدريجية لتركيز وامتصاص العناصر في الحبوب والقش وكذلك زيادة نسبة البروتين في الحبوب، مما يعني امكانية الاستفادة من التسميد الورقي مع الارضي بالمعدلات الموصي بها الي زيادة نوعية حبوب القمح بزيادة نسبة البروتين بها.
- استجابة وزن الالف حبة الي زيادة التسميد الارضي، بينما لم يتأثر بزيادة عدد مرات الرش الورقي.

* وتؤكد نتائج الدراسة علي فائدة استخدام الرش الورقي لعناصر النيتروجين والفوسفور والبوتاسيوم لنبات القمح، حيث ان الاضافة الارضية للاسمدة النيتروجينية والفوسفاتية والبوتاسية بمعدل ٥٠% من الموصي بها + رش نبات القمح بمحلول ٢% من الاسمدة النيتروجينية والفوسفاتية والبوتاسية اربع مرات اعطي قيم لانتاجية القمح كما ونوعا متساوية معنويا مع تلك التي انتجت باضافة تلك الاسمدة ارضيا بالمعدل الموصي بة. وهذا يعني امكانية توفير حوالي ٥٠% من كمية الاسمدة النيتروجينية والفوسفاتية والبوتاسية الموصي بها لنبات القمح، وكذلك يمكن زيادة جودة حبوب القمح من حيث زيادة نسبة البروتين بها باستخدام التسميد الورقي مع الاضافة الارضية بالمعدل الموصي به.