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INTEGRATED EFFECT OF UREA AND UREASE INHIBITOR ON WHEAT PRODUCTIVITY.

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ABSTRACT

A field experiment was conducted on a special farm near kafr El-sheikh, kafr El-sheikh governorate, during the winter season 2012 / 2013 to investigate the effect of urea fertilizer levels in the presence or absence of urease inhibitor thiophosphoric triamide (NBPT) on wheat plant. Six treatments were arranged in a split-block design, which were the simple possible combination between three levels of urea fertilizer i.e.50, 75 and 100kg N/fed for wheat plant as main plots and two treatments of (NBTP) (0 and 4% from the N-level), each treatment was replicated three times. Results indicated that; the average values of growth parameters, yield and its components and chemical composition of wheat plant were significantly increased as the level of N-fertilization was increased either in the presence or absence of urease inhibitor, but the rate of increases for the plants treated with (NBTP) were more than that obtained from the untreated plants. On the contrary of this trend, adding of N-levels in single form significantly increase the average values of nitrate and nitrite contents in wheat plant as the level of N-fertilization was increased while, such effect was sharply and significantly decreased due to an adding of (NBTP) in combination with the same levels of N-fertilization. The most suitable treatment which realized the highest yield of grain of wheat plant was connected with the plants treated with 100 kg N/fed combined with urease inhibitor.

INTRODUCTION

Wheat (Triticum aestivum) is one of the major cereal crops in Egypt. Local production of wheat is not sufficient to face the domestic consumption.

Nitrogen is an essential plant nutrient and key to maintaining higher yield production and worldwide economic viability of agricultural systems. Nitrogen is removed in large quantities by Livestock and harvested materials and is mobile and susceptible to gaseous losses and leaching.

Urea is the N source most widely used in agriculture worldwide (Heffer and Prud’homme, 2011). Urea is the primary solid nitrogen fertilizer in the market because of its high N content (46% N), Nitrogen loss through NH_3 volatilization is a primary concern when Urea is applied to surfaces of alkaline soil because Urea is readily hydrolyzed by urease enzyme, causing higher soil pH around the fertilizer granules (Chien *et al.*,2009). There is a need to improve the efficiency of urea-based fertilizers through new technologies and management approaches. One of the most promising approaches is to apply urea in combination with the urease inhibitor (N-(n-butyl) thiophosphoric triamide, nBTPT or NBPT) at low concentrations ranging from 0.01 to 0.5% (NBPT, w/w) (Sanz-Cobena *et al.*, 2008). Granular urea applications with NBPT have been reported by a number of researchers to be effective in delaying urea hydrolysis as well as increasing productivity under a range of cropping and pasture systems (Martin *et al.*, 2008)

A low N-response efficiency of granular urea shows that a large percentage of the applied fertilizer N is not being used for productive purposes and is potentially lost to recipient ecosystems(Howarth and Marino,2006).

Several products have been studied to minimize the loss of NH_3, including urease inhibitors (Chien *et al.*, 2009). Many organic and inorganic compounds have been tested as urease inhibitors (Kiss and Simihaian, 2002), but the best results have been obtained with the urea analogues, particularly N-(n-butyl) thiophosphate triamide (NBPT) (Watson, 2000), which strongly blocks three active sites of the urease molecule (Manunza *et al.*1999). NBPT has been tested in several countries with generally satisfactory results at low concentrations (Cantarella *et al.*, 2008). NH_3 lost to the atmosphere from applied urea also accelerates global warming through the indirect production of N_2O (Vander Gon and Bleeker, 2005).

The high pH induces gaseous N losses via NH_3 volatilization (Hayashi *et al.*, 2008). High NH_3 emission from soil lowers the efficiency of applied urea and has potentially negative environmental effects like acidification of soil and eutrophication of water if deposited on vulnerable recipient ecosystems (Howarth and Marino, 2006).

The majority of NH_3 losses occur in the first week after application. The most effective period of urease inhibition by NBPT is relatively short once the fertilizer is applied to the soil (up to 14 days [Trenkel, 2010] or even less [Cantarella *et al.*,2008]). Urea may be incorporated into the soil during this period through mechanical or water (rain or irrigation) means or move down the soil through diffusion thus eliminating or reducing NH3 volatilization losses (Dawar *et al.*, 2011).

The objective of this investigation aimed to evaluate the integrated effect of urea and urease inhibitor on the productivity of wheat plant.

MATERIALS AND METHODS

A field experiment was conducted using wheat plant (Triticum aestivum) Misr 2 variety during 2012 / 2013 season at private farm of kafr El-sheikh governorate, to study the influence of combined use of (urea) levels on wheat productivity, with or without the urease inhibitors N-(n-butyl) thiophosphoric triamide (NBPT). The experimental design was split plot design with three replicates for each treatment was used, Urea was applied at three levels (50, 75 and100 kg N/fed), with or without (NBPT) at the rate of 4% from applied N to the soil. Other agricultural practices were done according to the recommended for wheat plant by the ministry of agriculture.

Some physical and chemical properties of the experimental soil before planting as show in table 1. Soil samples were sieved and routine analysis in the beginning of the experiment was done according to Hesse (1971). Soil reaction pH in 1:2.5 soil-water suspensions and electrical conductivity (Ec), dS.m-1, at 24 C̊ in 1:5 soil extract were determined according to (Jackson, 1967). Available phosphorus was determined colorimetrically at wavelength of 660 n.m (Hesse, 1971). Available potassium was estimated by using flame photometer according to Jackson, (1967).Mechanical analysis was determined according to the international pipette method as described by Piper (1950). Samples of straw and grains were taken at harvest, dried at 70 ^{o}C till constant weight and grained to a fine powder and then 0.2 g was taken to wet digestion using a mixture of sulfuric and perchloric acids according to Peterburgski, (1986) to determine the percentage of total nitrogen which determined by Kjeldahl method as described by Hesse, (1971). Nitrate and nitrite were determined according to the method described by Singh (1988). Statistical analysis was done according to Gomez and Gomez 1982.

Table 1: Some physical and chemical properties of the experiment soil before planting.

Mechanical analysis %				Available (ppm)					pH	E.c ds.m^{-1}	Sp %	O.M %	$CaCO_3$ %
sand	Silt	Clay	Texture	N	p	K	NO_3^-	NH_4^+					
39.8	41.3	18.9	loamy	42.7	1.05	287.1	5.88	4.35	7.92	1.09	37.5	1.05	4.97

RESULTS AND DISCUSSION

Data presented in table 2 indicate the effect of urea levels and urease inhibitor as well as their interactions on N, P, K, NO_3-N and NO_2-N content of wheat plant foliage. It can be observed that the average values of N, P and k% were significantly increased as the level of N-fertilizer was increased either with or without urease inhibitor (NBPT), but the rate of increase for plants treated with (NBPT) was more than obtained from the untreated plants. On the other hand, the average values of nitrate and nitrite content were increased as the level of N-fertilizer was increased; adding (NBPT) combined with the same levels of urea sharply and significantly decreased the mean values of such traits as compared to the untreated plants.

Nitrogen contents increased due to the increase in the availability of this nutrient in the soil and results agree with those reported in the literature (Marino *et al.,* 2009). However, increased N content in the mass of the vegetative and total aerial parts is due to both the increased content and increased mass of the aerial part and grain yield. Similarly, results for grain N content reflect the behavior of grain yield and suggest increased nutrient export by the grains when applied N rates are highest.

Data in table 3 reveal that, the trend of the average values of the chemical composition of wheat plant foliage was reflected on parameters of straw. In this respect, the highest values of N, P and K% were realized for the plants treated with urea fertilizer at the rate of 100 kg N/fed in combination with (NBPT). but, The maximum increases of (NO_3^- and NO_2^-) were recorded by the application (75 kg N/fed), when were added (NBPT) There is a significant increase, The maximum increases of (N, P and K%) were recorded by the application (with (NBPT)) but, The maximum increases of (NO_3^- and NO_2^-) were recorded by the application of urea (without (NBPT)). The increases in (N, P and K %) were high significant. The maximum increases were recorded by the application (100N+ with (NBPT)). The increases in (NO_3^- and NO_2^-) were high significant, the maximum increases were recorded by the application (100 kg N/fed+ without (NBPT)).

Table: 2 Effect of urea levels, urease inhibitor and their combinations on nutrient content of wheat plant foliage

Treatment			N%	P%	K%	NO_3-N (mg.kg^{-1})	NO_2-N (mg.kg^{-1})
Urea	50 kg N/fed		3.58	0.470	4.05	23.67	0.94
	75 kg N/fed		4.11	0.530	4.53	27.13	1.09
	100 kg N/fed		4.16	0.530	4.56	28.20	1.14
	F. test		**	**	**	**	*
	LSD at 5%		0.04	0.011	0.06	0.30	0.02
Urease inhibitor	without		3.68	0.470	4.07	26.33	1.05
	With		4.22	0.540	4.67	11.18	0.45
	F. test		**	**	**	**	**
	LSD at 5%		0.02	0.003	0.02	0.28	0.03
Interaction	50 kg N/fed	without	3.26	0.424	3.68	23.67	0.94
		With	3.91	0.509	4.42	14.21	0.56
	75 kg N/fed	without	3.82	0.492	4.21	27.13	1.09
		With	4.40	0.567	4.84	10.85	0.44
	100 kg N/fed	without	3.96	0.507	4.33	28.20	1.14
		With	4.36	0.558	4.78	8.46	0.35
	F. test		**	**	**	**	**
	LSD at 5%		0.02	0.020	0.02	0.49	0.06

Growth analysis revealed a positive effect of NBPT addition to urea, especially in total plant dry matter, which is likely associated with increased N uptake (Bondada and Oosterhuis,2001).

Data in Table 4 show the nutrient content of wheat grain yield as affected by the application of different rates of (urea), with or without (NBPT) and their interaction. the (N, P and K%) and (NO_3^- and NO_2^-) of grain yield increase with increasing levels of urea, The maximum increases(N, P and K%) and (NO_3^- and NO_2^-) were recorded by the application(100 kg N/fed), when was added without (NBPT) and the increases were significant, The maximum increases in (N and P %) were recorded by the application (75 kg N/fed+ with (NBPT)). The maximum increase in (K %) was recorded by the application (100 kg N/fed +with (NBPT)), the increases in (NO_3^- and NO_2^-) were high significant, the maximum increases were recorded by the application (100 kg N/fed +without (NBPT)).

Increased grain yield for maize (Zea mays L.) was also observed when using NBPT with urea (Chien *et al.,* 2009). The increase reported by these authors was only 351 kg ha-1, which indicates that gains stimulated by urease inhibitors may be small.

Table3: Effect of urea levels, urease inhibitor and their combinations on nutrient content of wheat straw

Treatment			N%	P%	K%	NO_3-N (mg.kg^{-1})	NO_2-N (mg.kg^{-1})
Urea	50 kg N/fed		0.89	0.136	0.78	10.69	0.65
	75 kg N/fed		1.02	0.154	0.89	11.03	0.67
	100 kg N/fed		1.05	0.159	0.91	10.76	0.65
	F. test		**	*	**	N.S	N.S
	LSD at 5%		0.06	0.013	0.03	0.58	0.04
Urease inhibitor	without		0.93	0.142	0.81	15.92	0.96
	With		1.04	0.157	0.91	5.72	0.35
	F. test		**	**	**	**	**
	LSD at 5%		0.01	0.001	0.01	0.19	0.02
Interaction	50 kg N/fed	without	0.83	0.127	0.72	14.23	0.86
		With	0.96	0.146	0.84	7.14	0.43
	75 kg N/fed	without	0.97	0.147	0.85	16.33	0.99
		With	1.07	0.161	0.94	5.72	0.35
	100 kg N/fed	without	1.00	0.152	0.87	17.20	1.02
		With	1.09	0.165	0.95	4.31	0.27
	F. test		**	**	*	**	**
	LSD at 5%		0.02	0.020	0.02	0.32	0.02

Data in Table 5 show the yield parameter of wheat plants as affected by the application of different rates of (urea), with or without (NBPT) and their interaction. the (plant highest, number of spike and straw yield) increase with increasing levels of urea, The maximum increase was recorded by the application(75 kg N/fed), and The maximum increase of 1000 grain weigh and grain yield) was recorded by the application(100 kg N/fed), when was added (NBPT), The maximum increases(plant high, number of spike , straw yield, weigh of 1000 grain weigh and grain yield) were recorded by the application of urea (with (NBPT)).The maximum increase in (plant highest and straw yield) was recorded by the application (75 kg N/fed +with (NBPT)). But, the maximum increases (weigh of 1000 grain weigh and grain yield) were recorded by the application (100 kg N/fed +with (NBPT)). The increase in (number of spike) was a high significant, at the application (50 kg N/fed +with (NBPT)).

Height and shoot dry mass was increased because N contributes to plant vegetative growth, thus affecting the rates of leaf emergence and expansion, final leaf size, and stem elongation in cereals (Schroder *et al.*, 2000). Increases in the vegetative characteristics are beneficial because they represent reserves that will be used during grain filling.it can be concluded that the increasing dose of an N fertilizer increases the yield (Zaman *et al.*, 2010)

The higher urea concentration in plants treated with NBPT led us to consider that both leaf and soil ureases were inhibited during the initial days of the study, thereby allowing more urea to accumulate in the plant. This may explain the dose-dependent effect of NBPT on urea content observed by Watson and Miller (1996).

Table 4: Effect of urea levels, urease inhibitor and their combination on nutrient content of wheat Grain

Treatment			N%	P%	K%	NO_3-N (mg.kg^{-1})	NO_2-N (mg.kg^{-1})
Urea	50 kg N/fed		2.73	0.382	3.31	13.13	0.53
	75 kg N/fed		3.15	0.435	3.65	14.67	0.58
	100 kg N/fed		3.16	0.437	3.75	15.20	0.62
	F. test		**	**	**	**	**
	LSD at 5%		0.12	0.012	0.08	0.82	0.03
Urease inhibitor	without		2.74	0.380	3.25	14.33	0.58
	With		3.28	0.456	3.89	8.05	0.33
	F. test		**	**	**	**	**
	LSD at 5%		0.01	0.002	0.01	0.21	0.15
Interaction	50 kg N/fed	without	2.43	0.340	2.94	13.13	0.53
		With	3.04	0.425	3.68	9.21	0.37
	75 kg N/fed	without	2.86	0.395	3.32	14.67	0.58
		With	3.43	0.475	3.98	8.08	0.32
	100 kg N/fed	without	2.94	0.406	3.49	15.20	0.62
		With	3.38	0.469	4.02	6.87	0.28
	F. test		**	**	**	**	**
	LSD at 5%		0.02	0.020	0.02	0.36	0.02

Application of nitrogen fertilizers represents one of the highest input costs in agricultural systems. Adequate N must be available to the wheat plant at all phases of development. Shortage of N can result in reduced tillering, reduced head size, poor grain fill, reduced yields, and low grain protein content (Stewart *et al.* 2005).

Data in Table 6 show the available (N, P and k) of soil as affected by the application of different rates of (urea), with or without (NBPT) and their interaction. The available (N and K mg.kg^{-1}) of soil increase with increasing levels of (urea) with (NBPT), the maximum increases of available (N and K mg.kg^{-1}) were recorded by the application (100N+with (NBPT))**.** The maximum increase of available (P ppm) was recorded by the application (100N+without (NBPT)).

Both (NH_4^+ and NO_3^-) of soil were affected by the application of different rates of (urea), with or without (NBPT) and their interaction. The maximum increase of (NH_4^+) was recorded by the application (50N+with (NBPT)). The maximum increase of available (NO_3^-) was recorded by the application (100N+without (NBPT)).

Results indicated that wheat plants that received urea+NBPT had higher N recovery because NBPT minimizes NH3 volatilization (Gioacchini *et al.,* 2002); it therefore promotes higher N availability in the soil for plant absorption.

Gioacchini *et al.* (2002) reported that use of NBPT in silt loam and clay loam soils, reduced NH_3 volatilization
by 89% and 47%, respectively.

It is generally accepted that NH_3 volatilization problems result largely from the rapid enzymatic hydrolysis of urea to ammonium carbonate by soil urease (Harrison and Webb, 2001). Sanz-Cobena *et al.* (2008), who reported a reduction of 36% and 42% in the emitted NH_3, respectively. This reduction was associated with the slowdown in urease activity, promoting a decrease of NH_4^+ availability (Sanz-Cobena *et al.,* 2008).

Table5:Effect of urea levels, urease inhibitor and their combinations on yield parameter

Treatment			Plant high (cm)	Spike	Weigh. 1000 seed	Grain yield (kg/fed)	Straw yield (kg/fed)
Urea	50 kg N/fed		121	721	47	2467	3329
	75 kg N/fed		128	722	45	3467	4950
	100 kg N/fed		124	646	49	3517	4812
	F. test		n.s	n.s	n.s	*	*
	LSD at 5%		8.43	155	8.18	689.70	957.98
Urease inhibitor	without		116	647	44	2937	4068
	With		133	745	50	3364	4659
	F. test		**	**	**	**	**
	LSD at 5%		1.25	6.83	0.47	48.63	77.23
Interaction	50 kg N/fed	without	110	655	43	2243	3027
		With	132	786	51	2691	3631
	75 kg N/fed	without	120	675	42	3243	4630
		With	137	768	48	3691	5270
	100 kg N/fed	without	117	611	46	3323	4547
		With	130	681	52	3710	5076
	F. test		**	**	**	n.s	n.s
	LSD at 5%		2.158	11.84	0.82	84.23	133.8

From the results mentioned previously it could be concluded that, using of urea levels under investigation in single form without inhibitor significantly increased all investigated parameters(grain and straw yield, yield component and nutrient content of wheat plant) as the levels of N-fertilizer were increased. Adding urease inhibitor combined with N-fertilizer levels had a more pronounced effect on the average values of this parameter than the untreated plants. Such this effect had an adversely effect on the content of nitrate and nitrite of wheat plant organs; whereas adding (NBTP) sharply and significantly decreased the mean values. Thus, under the same condition of this study it can be recommended that the most suitable treatment for realizing the largest safe yield was happened due to an addition of urea at the level of 100 kg N/fed combined with urease inhibitors(NBTP).

Table6: Effect of urea levels, urease inhibitors and their combinations on available N, P, K, NH_4-N and NO_3-N in soil after wheat harvesting in $mg.kg^{-1}$

treatment		Av. N	Av. P	Av. K	NH_4-N	NO_3-N
50 kg N/fed	without	79.73	19.80	238.83	8.16	10.34
	With	87.70	18.82	262.72	11.41	7.25
75 kg N/fed	without	106.77	25.47	279.67	6.17	13.80
	With	117.54	24.22	307.63	8.65	9.67
100 kg N/fed	without	131.27	29.77	315.47	5.28	27.62
	With	144.42	28.34	347.01	7.44	19.33

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التاثير المتكامل لليوريا ومثبطات انزيم اليوريز علي انتاجية نبات القمح

كريم فكرى فودة

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تم إجراء تجربة حقلية في مزرعة خاصة بكفر الشيخ بمحافظة كفر الشيخ، خلال موسم شتاء 2012/2013 وذلك لدراسة التاثير المشترك لليوريا مع مثبط انزيم اليوريز وتأثيرهم المشترك علي إنتاجية القمح والمحتوي من بعض العناصر الغذائية وتيسر العناصر الغذائية بالتربة. ولقد إستخدم تصميم القطاعات المنشقة مرة واحدة مع 3 مكررات . تم إضافة اليوريا بمعدل (0 50 -75 -100) كجم نيتروجين /فدان. واضيف المثبط بمعدل (صفر ، بنسبة 4% من النيتروجين المضاف). وأشارت النتائج إلى زيادة معنوية في متوسط قيم معاملات النمو والمحصول و مكوناته و التركيب الكيميائي لنبات القمح بشكل ملحوظ بزيادة التسميد النيتروجيني سواء في وجود أو عدم وجود اليورياز ، وكان معدل زيادة النباتات المعاملة مع المثبط أكبر من النباتات الغير المعاملة . على العكس من هذا ، اضافة معدلات النيتروجين بمفردها أدت إلى زيادة في متوسط قيم النترات و النتريت في نبات القمح. ولكن مع اضافة المثبط إتضح انخفاض قيمهم مع نفس معدلات النيتروجين.وكان أعلي محصول للحبوب من نبات القمح مع المعاملة (100 كجم نيتروجين /فدان + انزيم اليوريز).

قام بتحكيم البحث

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