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Wheat Yield and Uptake of N, P and K as Affected by the Application of Nitrapyrin (Nitrification Inhibator)

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Abstract: Addition of inhibitor to urea or ammounium sulfate resulted in significant increase in the yields of grain and straw. Combination of low rates of N and inhibitor resulted in 27.2 percent yield increase using Urea and 29 percent increase of ammonium sulfate. Applying N in one dose combined with inhibitor gave higher yield increases. The inhibitor increased wheat grain yield much more than straw yield, especially at low N rates, with higher rates the opposite was noticed. N, P and K uptake seemed to be affected with N-rate, dose and also the application of the inhibitor.

Key words: Wheat yeald, application of Nitrapyrin

Introduction

Fertilizer nitrogen recovery is usually in the rang of 30 to 40 percent using conventional application methods and even with best agronomic practices seldom exceeds 60 to 65 percent (Craswell *et al*., 1981; Vlek and Byrenes, 1986). Fertilizer nitrogen is subject to a number of chemical, physical and biochemical mechanisms, which can result in significant losses of N from the soil-root zone. Losses occur principally through (i) leaching and runoff of nitrite (NO_2^-) and nitrate (NO_3^-), (ii) biological denitrification of both NO_2^- and NO_3^- and (iii) volatilization of ammonium (NH_3) from improper application of anhydrous or aqueous NH_3, and surface application of urea and N-sources containing ammonium (NH_4). The magnitude of this problem has simulated the interest of the fertilizer industry in the chemical and / or physical modification of conventional N fertilizer to minimize these losses (Allison, 1963). One approach involves the formation of ammonical fertilizers with certain chemicals to repress or inhibit nitrification. By maintaining fertilizer N in the NH_4 form for extended periods, fertilizer use efficiency might be increased through enhanced N-uptake.

The potentials of nitrification inhibitors are being evaluated in various parts of the world. The results are rather inconsistent. Some studies showed increased yields (Swezey and Turner, 1962; Selim *et al*., 1987; Hammed *et al*., 1994; Abou Seeda, 1997), others have reported no yield response to nitrification inhibitors (Boswell *et al*., 1976; Hendrickson *et al*., 1978); and still others have shown a response only under certain conditions (Touchton *et al*., 1978). Inverse effects have also been reported (Dibb and Welch, 1976).

Studies Under Egyptian conditions in the last decade indicated positive yield responses for certain inhibitors (Selim *et al*., 1987; Hammed *et al*., 1994; Abou Seeda, 1997). However, the effect of the predominance of either NH_4^+ or NO_3^- ions on the grows and yield of various crops under different N-fertilization conditions needs furthre investigation. Therefore, the objective of the present work was to evaluate the effect of the best inhibitor actually known, that is nitrapyrin (2 Chloro-6 "trichlormethyr Pyridine) on the N, P and K uptake and yield of wheat under different N fertilization conditions.

Materials and Methods

Field trials were carried out during the 1997/1998 season to investigate the effect of the addition of nitrapyrin nitrification inhibitor to different rates and doses of N-fertilizers on the N, P and K uptake and yield of wheat. The experiment was performed at the experimental farm of the National Research Center in El-Kanater in El-Oalubia Governorate, and designed as randomized complete block with three replicates. The soil had the following characteristics: pH 7.8; EC. 0.21 dSm^{-1} at 25°C; O.M. 1.23 percent; clay content 51.2 percent; silt content 30.59; sand content 16.9 percent; cation exchange capacity 42.3 meq/100 g soil; total nitrogen 0.15 percent; NH_4-N, 27 ppm; and NO_3-N, 7 ppm.

Nitrogen fertilization treatments comprised of two rates of either urea or ammonium sulfate without and with the addition of nitrapyrin (the active ingredient of N-serve. N-rates were 40 kg N/fed. as a low rate and 80 kg N/fed. as a high rate, also, N-fertilizers were applied at one or two doses. In case of two doses. The first was applied after seedling emergence and the second one was applied 3 weeks later. Nitrification inhibitor (*nitrapyrin*) was added at the rate of 0.23 kg/fed. mixed with fertilizers. A basal dose of 50 kg P_2O_5/fed. (in the form of superphosphate) was added to all plots before sowing and 50 kg K_2O/fed. (in the form of potassium sulfate) was added to all plots after two weeks from seedling emergence.

Studied crop: Winter wheat (*T. aestivum* L.) the experimental plot: 20 m^2 and the date of sowing was 3, December, 1997.

The above soil characteristics were determined according to the standard procedures as described by Cottenie *et al*. (1982). Total in plant soil available nitrogen of NH_4-N; NO_3-N was determined according to kjeldahl method described by Bremner and Mulvaney (1982). Available phosphorus and potassium were determined according to methods described by Black (1982). The randomized compete block analysis using *(NLSD)* was done according to Gomez and Gomez (1984).

Results and Discussion

Effect of nitrapyrin on grain and straw yields of wheat under different rates of N-fertilizers.

Data in Table 1 represent the yield of wheat as affected by different rates of N-fertilizers along with *nitrapyrin* regardless of the number of N-doses. Generally, the application of both rates of urea and ammonium sulfate, with or without inhibitor caused a highly significant increase in both grain and straw yields of wheat. The effect of inhibitor addition was pronounced with both rates of N-fertilizers where a highly significant increase in both grain and straw yields was obtained when compared to without inhibitor addition. Also, a significant increase was recorded for low rate of urea combined with inhibitor than the higher rate, where the percentage increase of the total yield of wheat was 27.2 percent and it was 24.7 percent for the other one as compared with urea without inhibitor addition.

It is of interest to point out that the effectiveness of the nitrification inhibitor (N-serve) was higher with the lower rate of urea than with the higher one. The enhancing effect of inhibitor addition combined

with lower rate of urea might be due to the increase of fertilizer use efficiency by decreasing N-losses more than in case of higher rate of it. This finding is in accordance with Selim *et al*. (1987), Hammed (1989) and Hammed *et al*. (1994).

A highly significant difference among the ammonium sulfate rate was obtained in their effects on the grain and straw yields of wheat. A highly significant increase was recorded for high rate of *AS* combined with inhibitor than the lower one, where the percentage increase of the total yield was 29 percent and it was 14.1 percent for the other one as compared with *AS* without inhibitor addition.

The results show that inhibiting nitrification had a positive effect on the yield of wheat when applying N-fertilizer at low rate for urea and high rate for ammonium sulfate.

Effect of nitrapyrin on grain and straw yields of wheat under different doses of N-fertilizers: Data in Table 1 show the effect of nitrification inhibitor on grain and straw yields of wheat under different N-doses regardless the N-fertilizers rates. Addition of both N-sources in two doses without inhibitor caused a slightly increase in both grain and straw yields of wheat when compared with their addition in one dose, while the effect of the studied inhibitor was more pronounced with addition of both urea and ammonium sulfate in one dose, a highly significant increase in both grain and straw yields was obtained when compared with their addition in two doses, where the percentage increase of the total yields was 14.5 and 21.3 percent for urea and ammonium sulfate, respectively.

Table 1 also show that grain/straw ratio was affected the addition nitrification inhibitor under different N-fertilizers, rates and doses. The addition of inhibitor to the lower rate of both urea and ammonium sulfate markedly increased grain/straw ratio compared to higher rate of both N-fertilizers combined with inhibitor. This means that addition of inhibitor to the lower rate of both urea and ammonium sulfate increased wheat grain yield much more than straw yield, this was more pronounced with urea fertilization, but the inhibitor with the higher rate of both urea and ammonium sulfate fertilization.

Effect of nitrapyrin on N-concentration and uptake by wheat plants under different rates of N-fertilizers: Data in Table 2 represent the N-concentration and uptake by wheat plants as affected by different n-rates along with nitrapyrin. Data revealed that application of both N-fertilizer sources with or without inhibitor caused a marked increase of N-concentration in both grain and straw yields of wheat. N-concentration in plant materials is shown to differ slightly from one treatment to another along with different N-rates, where application of higher rates of both N-sources gave an increase of N-concentration in both grains and straw of wheat comparing with the lower one.

The amount of N-taken up by plants differed widely from higher to lower rates of N-fertilizers combined with inhibitor, the application of higher rates of both N-fertilizer sources markedly increased the total N-uptake when compared with the lower ones. Urea fertilization was more pronounced than ammonium sulfate, where the percentage increase of the total n-uptake was 76 percent for higher rate of urea fertilization and it was 23.5 percent for ammonium sulfate as compared with lower rates.

Effect of nitrapyrin on N-concentration and uptake by wheat plants under different doses of N-fertilizers: Table 2 show that N-concentration in both grain and straw yields of wheat could be affected by number of doses and inhibitor addition. Application of urea as one dose combined with inhibitor markedly increased N-concentration of both grain and straw yields when compared to its application as two doses, while opposite result was obtained in case of *AS* fertilizers, application ammonium sulfate as two doses slightly increased N-concentration in both grain and straw yields when Compared to its application in one dose.

Calculation the N-amount taken up by one dose of urea contributed to the increase in N-uptake by almost 37.8% compared with two doses of urea, while the amount of N-taken up by plants seemed to have increased by only 8.4% due to the addition of the inhibitor to two doses of ammonium sulfate compared to one dose.

Generally, application of urea in one dose combined with inhibitor was more effective on N-concentration and uptake by plants than ammonium sulfate either in one dose or two doses.

N-recovery and Utilization efficiency: Recovery of applied N as affected by nitrification inhibitor is presented in Table 3. Data revealed that addition of inhibitor under different rates and doses of N-fertilizers caused a markedly increase N-recovery by plants and N-utilization efficiency comparing to treatments with inhibitor addition. Results, also indicate that addition of inhibitor with higher rates of both urea and ammonium sulfate increased N-recovery by wheat plants as compared with lower rates. N-recovery by plants increased from 153 to 375 for urea treatments and increased from 167 to 239 for ammonium sulfate. Data in Table 3 show the calculated apparent utilization efficiencies of different rate of N-

Table 1: Effect of nitrapyrinon grain and straw yields of wheat under different rates and doses of N-fertilizers

N Treatment (N rate)	No. of doses	Inh.	Grain yield	Straw yield	Total yield	Grain straw ratio
			----------(kg plot^{-1})----------			
Control (-)	-	-	8.88	10.59	19.47	0.84
Urea (Low)	1	-	12.86	14.39	27.25	0.89
Urea (Low)	1	+	12.86	19.17	34.66	0.81
Urea (High)	1	-	15.49	14.13	28.29	1.00
Urea (High)	1	+	14.16	17.50	35.28	1.02
Urea (High)	2	-	16.12	18.44	34.56	0.87
Urea (High)	2	+	14.40	21.67	38.07	0.76
AS (Low)	1	-	13.74	15.56	29.30	0.88
AS (Low)	1	+	15.58	17.84	33.42	0.87
AS (High)	1	-	13.54	15.40	28.94	0.88
AS (High)	1	+	16.90	20.43	37.33	0.83
AS (High)	2	-	15.23	20.49	35.72	0.74
AS (High)	2	+	15.29	23.20	38.49	0.66
LSD (0.05)			2.10	1.82	2.57	
LSD (0.01)			2.85	2.47	3.49	

Table 2: Effect of nitrification inhibitor (nitrapyrin) on N-concentration and uptake by wheat under different rates and doses of N-fertilizers

N treatment (N rate)	No. of doses	Inh,	N-concentration %		N-uptake (g plot^{-1})		
			Grain	Straw	Total uptake	Grain	Straw
Control (-)	-	-	1.16	0.34	139	103	36
Urea (Low)	1	-	1.26	0.41	221	162	59
Urea (Low)	1	+	1.44	0.34	192	223	69
Urea (High)	1	-	2.19	0.63	339	310	89
Urea (High)	1	+	2.30	0.60	514	409	105
Urea (High)	2	-	1.47	0.45	320	237	83
Urea (High)	2	+	1.72	0.42	373	282	91
AS (Low)	1	-	1.74	0.45	309	239	70
AS (Low)	1	+	1.54	0.37	306	240	66
AS (High)	1	-	1.89	0.50	333	256	77
AS (High)	1	+	1.68	0.46	378	284	94
AS (High)	2	-	1.82	2.48	381	280	101
AS (High)	2	+	1.82	0.59	410	273	137

Table 3: N-recovery and utilization efficiency (%) as affected by nitrification inhibitor within different N rates and doses

N treatment (N rate)	No. of doses	Inh.	N-recovery (G plot^{-1})	Utilization efficiency
Control (-)	-	-		
Urea (Low)	1	-	82.0	32.8
Urea (Low)	1	+	153.0	61.2
Urea (High)	1	-	100.0	40.0
Urea (High)	1	+	375.0	72.0
Urea (High)	2	-	181.0	36.0
Urea (High)	2	+	234.0	46.8
AS (Low)	1	-	170	68.0
AS (Low)	1	+	167	66.8
AS (High)	1	-	194	38.8
AS (High)	1	+	239	47.8
AS (High)	2	-	242	48.4
AS (High)	2	+	271	54.2

Added = 250g N plot^{-1} as low rate and 500 g N plot^{-1} as high rate.
*N recovery = Total N uptake (fertilizer) total N uptake (control)

$$\text{*N-utilization efficiency} = \frac{\text{N-recovery}}{\text{N-applied by fertilizer}} \times 100$$

applied combined with inhibitor. It was observed that, application of higher rates of urea fertilizer increased N-utilization efficiency to 75 percent, while the lower rates increased N-utilization efficiency to 61.2 percent. In other words application of lower rates of ammonium sulfate fertilizer increased N-utilization efficiency to 66.8 percent, while the higher rates increased N-utilization efficiency to 47.8 percent.

Calculation of N-recovery and utilization efficiency as affected by inhibitor addition under different N-doses in Table 3 revealed that application of urea in one dose combined with inhibitor gave a highest values of N-recovery by plants compared to application in two doses, N-recovery increased from 234 for two doses treatments to 375 for one dose treatments. Also, improvement in N-utilization efficiency was recorded in case of application of urea as one dose combined with inhibitor compared to their application as two doses. 29 percent increases was recorded for the abovementioned treatment. Data of adopted treatments along ammonium sulfate on N-recovery and utilization efficiency shows that a slight increase was recorded when AS applied in two doses. N-recovery increased from 239 for one dose to 271 for two doses. 6.2 percent increases of N-utilization efficiency was recorded for the abovementioned treatment.

Effect of nitrapyrin on P-concentration and uptake by wheat under different rates and doses of N-fertilizers: Data in Table 4 represent P-concentration and uptake by wheat as affected by inhibitor addition under different rates and doses of N-fertilizer. P-concentration in both grain and straw yield of wheat seemed to be affected by the N-rates and doses. Higher P-concentration and uptake was noticed with lower rate of urea than with the higher one, opposite results was noticed in case of ammonium sulfate

Table 4: Effect of nitrification inhibitor (nitrapyrin) on P-concentration and uptake by wheat under different rates and doses of N-fertilizers

N treatment (N rate)	No. of doses	Inh.	P-concentration %		P-uptake (g plot^{-1})		
			Grain	Straw	Total uptake	Grain	Grain
Control (-)	-	-	0.135	0.043	17	12	5
Urea (Low)	1	-	0.127	0.050	25	17	8
Urea (Low)	1	+	0.169	0.039	33	26	7
Urea (High)	1	-	0.136	0.055	27	19	8
Urea (High)	1	+	0.105	0.047	25	17	8
Urea (High)	2	-	0.132	0.044	29	21	8
Urea (High)	2	+	0.130	0.051	32	21	11
AS (Low)	1	-	0.118	0.037	22	16	6
AS (Low)	1	+	0.121	0.048	28	19	9
AS (High)	1	-	0.149	0.055	29	20	9
AS (High)	1	+	0.128	0.049	32	22	10
AS (High)	2	-	0.121	0.051	30	19	11
AS (High)	2	+	0.125	0.046	30	19	11

AS = Ammonium sulfate

Table 5: Effect of nitrification inhibitor (nitrapyrin) on K-concentration and uptake by wheat under different rates and doses of N-fertilizers.

N treatment (N rate)	No. of doses	Inh.	K-concentration %		K-uptake (g plot^{-1})		
			Grain	Straw	Total uptake	Grain	Straw
Control (-)	-	-	0.23	1.04	131	20	11
Urea (Low)	1	-	0.75	1.50	313	96	217
Urea (Low)	1	+	0.36	1.49	341	55	286
Urea (High)	1	-	0.24	2.01	318	34	284
Urea (High)	1	+	0.20	1.40	280	35	245
Urea (High)	2	-	0.20	1.76	356	32	324
Urea (High)	2	+	0.70	1.48	353	33	320
AS (Low)	1	-	0.24	1.75	304	32	272
AS (Low)	1	+	0.25	1.75	353	39	314
AS (High)	1	-	0.21	1.81	308	28	280
AS (High)	1	+	0.19	1.46	328	31	297
AS (High)	2	-	0.21	1.27	298	32	266
AS (High)	2	+	0.17	1.97	483	26	457

AS = Ammonium sulfate

fertilizer. Taking into consideration the number of N-doses, P-concentration and uptake was also influenced by the adopted treatments, urea application in two doses combined with inhibitor gave a slight increase in P-concentration and uptake than in one dose, while in case of *AS,* the trend was opposite. In addition, the amount of P-taken up by plants was more pronounced with ammonium sulfate fertilization than urea along the different N-rates and doses. Therefore it could be concluded that P-absorption was positively influenced by addition of inhibitor to ammonium sulfate fertilizer.

Ammonium nutrition again enhanced the absorption of phosphate promoting dry matter production and good developing of root system and also, due to no competition in absorption with the phosphate ions. These results are in agreement with those of Boratynski and Zietecka (1982).

Effect of nitrapyrin on K-concentration and uptake by wheat under different rates and doses of N-fertilizers: Data in Table 5 represent K-concentration and uptake as affected by inhibitor addition under different N-rates and doses. Potassium concentration in plant materials and their uptake seemed to be affected by adopted treatments. Addition of N-fertilizer in lower or in higher rates did not affect the pattern of K-concentration and uptake, since the difference in K-concentration and uptake were narrow, an increase in K-uptake was noticed when both n-sources were applied in two doses, ammonium sulfgate fertilization was more effective on K-uptake than urea fertilization. It seemed that the inhibitor provides more NH_4^+ ions in the soil which compete with the absorption of other cations specially K casing a decrease in their uptake. Cox and Reisenauer (1977), observed that intake of mineral cations in a dilute constant -composition water culture decreased by NH_4^+. Ammonium had a greater effect on the intake of divalent than of the monovalent cations. Mathers *et al*. (1982), reported similar effect of nitrapyrin (N-serve) especially when the N-source was $(NH_4)_2SO_4$. They added that nitrapyrin treatment decreased K-concentration and uptake.

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