J. King Saud Univ., Vol. **8**, *Agric. Sci.* (1), pp. 159-172, Riyadh (A.H. 1416 / 1996).

Nitrogen Management and Nitrapyrin Effects on Yield and N Recovery of Wheat

A.S. Modaihsh, F.M. Al-Romian, and M.O. Mahjob
Soil Science Department, College of Agriculture, King Saud University,
Riyadh, Saudi Arabia

(Received 12/1/1415; accepted for publication 6/8/1415)

Abstract. The influence of nitrification inhibitor (nitrapyrin), fertilizer nitrogen application rate, and nitrogen splitting were evaluated in a lysimeter experiment with wheat grown on a sandy loam (Torrifluvent) highly calcareous soil [292 g Kg^{-1} $CaCO_3$]. The effect of treatments on wheat yield, N uptake and N recovery was reported. Wheat yields were most significantly affected by the rate of applied N. Increasing fertilizer application rate from 50 to 150,250, and 350 kg N ha^{-1} resulted in 88, 139 and 166% increases in grain yield (G.Y) respectively. Neither nitrapyrin addition nor nitrogen splitting resulted in any significant increases in wheat yield. However, number of tillers (N.T) was significantly increased by addition of nitrapyrin. The nitrification inhibitor, therefore, did apparently conserve fertilizer N, but not enough to affect grain yield. Nitrapyrin did not result in any increases of N concentration in plants, whereas increasing the splitting of N to nine splits resulted in a significant increase in N concentration in wheat grains leaching losses of N were generally very small and constitute an insignificant path way for N losses [0.6-2.8%].

Introduction

The relatively large need of plants for nitrogen besides the limited ability of soils to supply it, cause nitrogen to be the most limiting nutrient for crop production. This is especially evident in arid and semi-arid regions of the world, as in Saudi Arabia where supplemental additions of nitrogen are usually required for successful crop production. The use of fertilizer N for crop production and the benefit it gives in increasing yield and quality is not without potential hazards to the environment. Nitrogen lost from the soil is also an economic loss for the farmer. Recently, there is a growing concern that fertilizer N should be used as efficient as possible to minimize economic loss and environmental pollution [1; 2].

Knowledge of the pathways of fertilizer N applied to crops is needed as a prerequisite for developing a good and efficient management system. Numerous studies in different parts of the world have been conducted on fertilizer N balance and efficiency [3, p. 229]. Since N uptake and efficiency are influenced by the specific conditions of the study, it is difficult to extrapolate results to areas with different climatic and soil conditions. Studies are therefore necessary to end up with recommendations that suit the prevailing conditions.

A greater efficiency of utilization of N may be accomplished by matching rate and time of application to crop needs. This goal may be achieved by selecting the optimum rate and time of application for the specific soil and plant under consideration [4]. Another approach to increase the efficiency of applied N in the soil may be through the use of some compounds that retard nitrification (nitrification inhibitors). Controlled nitrification of NH_4-N in the soil reduces the risk of nitrogen leaching. Additionally, the presence of NH_4-N in the soil together with NO_3-N enables better nutrition of most crops [5, p.345]. Both these goals can be served by applying nitrification inhibitors together with ammonium-forming fertilizer such as urea. This could provide management alternatives to minimize N loss and increase fertilizer use efficiency [6-8]. The nitrification inhibitor that received most attention in recent years is nitrapyrin [2-chloro-6 (trichloromethyl) pyridine]. The large number of literature on nitrification inhibitors [6, p.63-73; 7-9] during the last two decades is a testimony to the interest in this approach.

The objectives of this study are to determine the influence of nitrification inhibitor (nitrapyrin), time, and rate of nitrogen fertilizer application on yield, N uptake, and N use efficiency of wheat grown on calcareous soil under arid conditions.

Materials and Methods

The experiment was conducted on lysimeters at the College of Agriculture, King Saud University Educational Farm located in Riyadh. The lysimeters were constructed using steel lysimeters (containers) 58 cm inside diameter ($0.264m^2$ or 2.64×10^{-5} hectare) and 88 cm depth. It was equipped with drainage holes fitted at 5 cm from the bottom. The bottom was covered by concrete layer. A layer of sorted gravel was placed at the base of each lysimeter to facilitate drainage. A plastic jerry-cans 5*l* capacity were allotted to each lysimeter and placed at lower level to collect drainage water. A surface sandy loam (Torrifluvent) calcareous soil was brought from the College of Agriculture Experimental and Research farm at Deirab, 25 km southwest of Riyadh. Selected soil properties were determined by standard procedures. Sand, silt, and clay were 790,100, and 110g kg^{-1}. Organic matter, pH and $CaCO_3$ were 5g kg^{-1}

7.6, and 292g kg^{-1}. Available N, P, and K were 0.034, 0.025, 0.185g kg^{-1}. Lysimeters were filled up to 15 cm from the surface. Net soil depth was 50 cm. Treatments consisted of four N rates: 50, 150, 250, and 350 kg N ha^{-1} [low, medium, high, and very high], and two nitrification inhibitor [NI] rates of 0 and 2.24 kg ha^{-1}. Fertilizer N was splitted into three, six, and nine applications. Nitrogen was applied to soil as urea solution. Urea fertilization schedule is given in Table 1. Treatments were replicated three times and arranged in a completely randomized block design. Wheat [Trititcum aestivum L. var. Yecora Rojo] was planted at a rate of 150 kg ha^{-1} in each lysimeter. Fertilizers P, K and micronutrients were added as recommended (P_2O_5 175 Kg ha^{-1}, K_2O 100 Kg ha^{-1}). Irrigation with tap water was provided according to plant requirements. Wheat seedlings were thinned to 80, three weeks after planting. Micronutrients were added after thinning. Plant leaf samples were taken at head initiation and total nitrogen was determined in each sample. Five leachates were obtained during the growth season. NO_3-N and NH_4-N were determined in each leachate by Kjeldahl method [10, p. 1179]. At maturity the above ground parts were harvested from each lysimeter. Plants were oven-dried at 70°C for 48 hr, and dry weight was recorded. Total nitrogen was determined in plant material by digesting the plant material by perchloric-sulfuric acid mixture according to the method described by Page [11, p. 595-624]. Soil samples were obtained from each lysimeter at 25 and 50 cm depth for N analysis. The data obtained were statistically analyzed using ANOVA procedure and the differences among the means, were separated according to L.S.D method.

Table 1. Urea fertilization schedule in lysimeter experiment

Splitting dates	No. of doses	3 Splits	6 Splits	9 Splits
		% of the urea added		
14 Dec 1991	1	30	15	15
06 Jan 1991	2	--	15	15
01 Feb 1991	3	50	15	10
09 Feb 1991	4	--	--	10
16 Feb 1991	5	--	20	10
25 Feb 1991	6	--	--	10
29 Feb 1991	7	--	15	10
04 Mar 1991	8	20	20	10
08 Mar 1991	9	--	--	10

Results and Discussion

The analysis of variance given in (Table 2) shows that differences in grain yield (G.Y)., biological yield (B.Y), and number of tillers (N.T). are highly significant ($P \leqslant 0.01$) among nitrogen application rates. Neither nitrapyrin addition nor nitrogen splitting resulted in any significant increases in G.Y. or B.Y.. On the other hand, addition of nitrapyrin resulted in a significantly ($P \leqslant 0.01$) higher number of tillers.

Table 2. Summary of the analyses of variance for the effect of rate, splitting of urea nitrogen fertilizer and nitrapyrin on wheat grain yield (GY), no. of tillers (NT), and biological yield (BY)

S.O.V.	GY g lysimeter^{-1}	NT	BY g lysimeter^{-1}
Rate (R)	**	**	**
Nitrapyrin (NP)	N.S.	**	N.S.
Split (S)	N.S.	N.S.	*
R × NP	**	*	N.S.
R × S	**	N.S.	N.S.
NP × S	N.S.	N.S.	N.S.
R × NP × S	N.S.	N.S.	N.S.

* and ** significant at the 5% and 1% level of probability, respectively; N.S. = not significant.

Differences due to interactions among these treatments are not significant with the exception of those in grain yield due to the interaction between rate and splitting of nitrogen application (R×S) and differences in G.Y., B.Y., and N.T. due to the interaction between rate of nitrogen application and nitrapyrin (R×Np).

The mean yield (grain and biological) and number of tillers of the various treatments are presented in Fig. 1. Increasing fertilizer application rate from 50 kg N ha^{-1} to 150, 250, and 350 kg N ha^{-1} resulted in 88, 139, and 166% increases in grain yield, respectively. For biological yield the increases were in the order of 19, 44, and 78%. Biological yield at harvest increased due to nitrogen addition, but the rate of increase was less than that in grain yield. The high nitrogen levels applied in this study (150, 250, and 350 kg ha^{-1}) resulted in more substantial increases in grain yield than in vegetative growth. This implies a significant increase in the harvest index (0.41) when compared to the harvest index in the low nitrogen treatments (0.26).

Wheat yields were not significantly affected by nitrapyrin or splitting of N application to more than three splits (Table 2). Number of tillers were significantly

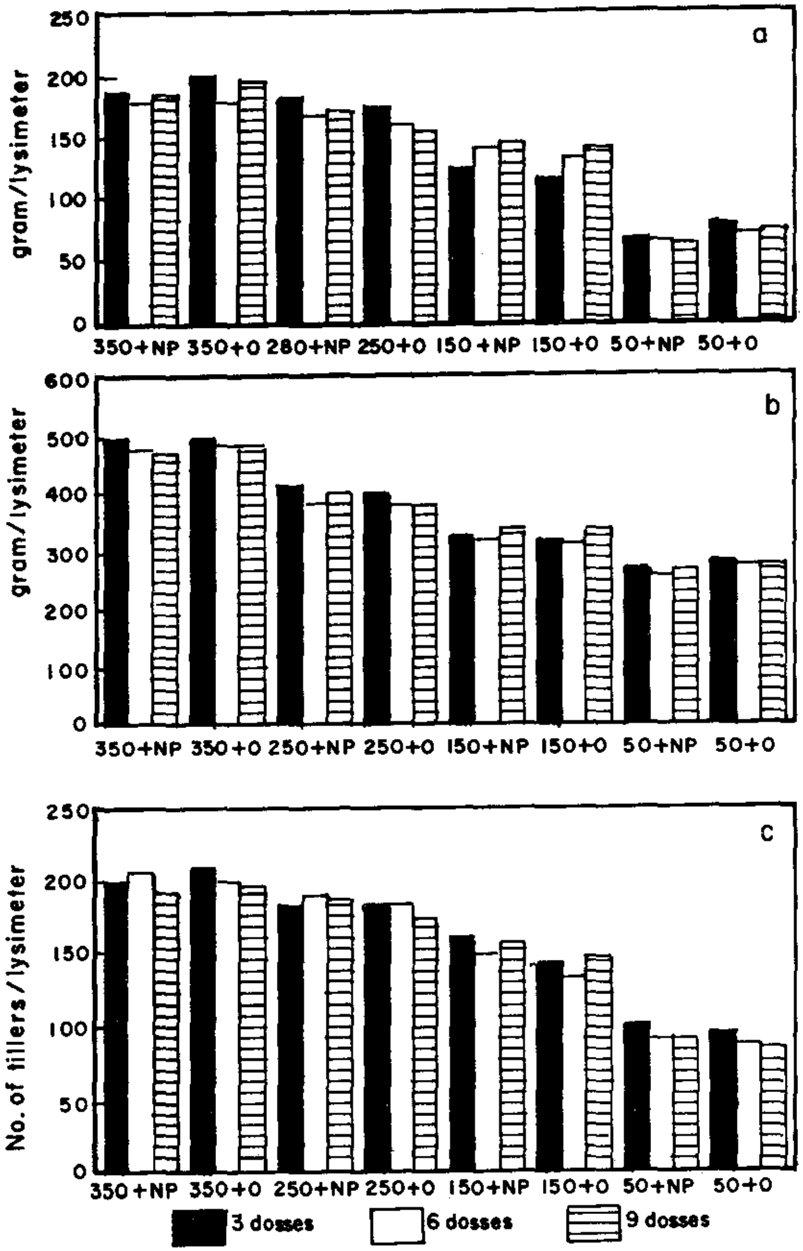

Fig. 1. Wheat grain yield (a), biological yield (b), and no. of tillers (c) as affected by the rate, splitting fo applied urea and the application of nitrapyrin .

increased by the addition of nitrapyrin. The nitrification inhibitor, therefore, apparently seems to conserve fertilizer N at the early stages of growth (tillering stage) but it had no effect on the grain yield.

Recently Bronson *et al.* [12] also showed that nitrification inhibitor Dicyandiamide (DCD) amendment to fall applied N for winter wheat did not affect the grain yield of wheat but they suggested that addition of nitrification inhibitor may help in reducing denitrification and leaching losses of N. On the other hand Shyilon *et al.* [13] found that treating N fertilizer with nitrapyrin increased wheat yield up to 32% above untreatd. Higher responses were always associated with climatic and soil conditions that favored soil N losses by denitrification and leaching. No yield benefit occurred from the use of inhibitors when applied N was not subjected to losses conditions. Nitrification inhibitors can only be effective in reducing leaching and denitrification losses [14]. In our study, leaching was very low and denitrification is expected to be low. Therefore, the ineffectiveness of nitrapyrin is not surprising.

Timely application of nitrogen to meet the need of plant has led to the adoption of splitting the amount of fertilizers to several doses. In the Kingdom of Saudi Arabia, the use of central pivot systems for irrigation has made splitting of N application economically feasible. However, in this experiment, splitting urea up to 9 splits did not result in any significant increase in yield of wheat (Table 2). A lack of significant increase in grain yield or biological yield confirms the fact that leaching has not constituted an important avenue of N loss [15]. In the light of the relatively higher number of splits even in the lower treatment (3 splits) and the wise portioning (30%-50%-20%) and timing of the applied N, this lack of response is expected.

Table 2 shows that there is a significant interaction between rate of applied N and nitrapyrin addition. This interaction was significant for grain yield ($P \leq 0.01$) and number of tillers ($P \leq 0.05$). The grain yield is significantly high only at the high nitrogen application rate (250 kg N ha^{-1}). However, the increase in number of tillers was only significant at 150 kg N ha^{-1} application rate.

In the current experiment, the interaction between rate and splitting of applied N was only significant for the grain yield. At the very high (350 kg N ha^{-1}) and high (250 kg N ha^{-1}) nitrogen rates, the 3 splits was superior to 9 splits, whereas in the medium (150 kg N ha^{-1}) nitrogen rate, the 9 splits become superior. A very important factor determining the yield response to urea splitting is the total supply of nitrogen (rate of application). As the response of cereal grain yield to nitrogen often reaches a stage of diminishing returns [16], it might be expected that the response to splitting would be reduced as availability via the high rates of application increased (as in the case of the very high and high rates treatments). A survey of 32 field trials in the United Kingdom [17, p. 239] suggested that foliar urea applied to wheat during and after anthesis only increased yield when previous nitrogen application to the soil had been sub-optimal for yield. Splitting higher application rates of N into 6 or 9 splits caused leaf scorch, as a result a significant decrease in the grain yield was obtained [17; 18, p. 301; 19, p. 151]. This was partly alleviated through reducing spray concentration in the lower rates. Some researchers [18, p. 301] suggested that the repeated damage to the leaves through spraying could have caused yield depression. Our results showed that using the rates commonly used in Saudi Arabia [250-350 kg N ha^{-1}], it is not advisable to apply urea nitrogen to the wheat plant in more than 3 splits. Further investigations are needed to determine the proper timing of application and the right dose to be applied at each time.

Effect of treatments on N content of wheat

The analysis of variance shows that differences in N concentration in wheat are highly significant ($P \leqslant 0.01$) among N application rates. The differences in N concentration in leaves and seeds, but not in shoots, are also highly significant among the split treatments. On the other hand, addition of nitrapyrin did not result in any significant difference in N content in the various parts of the plants. Differences due to interactions among these factors were significant only in those of N concentration in leaves and grains due to rate × splitting and for N concentration in leaves due to rate × splitting × nitrapyrin. (Table 3).

At heading, N concentration in leaves was not affected by splitting the very high rate (350 kg N ha^{-1}) treatment, whereas, in the high (250 kg N ha^{-1}) and medium (150 kg N ha^{-1}) rates treatments, 9 splits were superior to 6 and 3 splits. While in the low rate (50 kg N ha^{-1}) treatment, 6 splits was superior to 3 and 9 splits. On the other hand, N concentration in seeds was significantly higher in 9 splits treatment in both very high and high N application rates and the differences were not significant in the medium and low rates treatments.

The data presented in Table 3 show that the N concentration of wheat plant increased progressively and significantly ($P \leqslant 0.01$) with increasing rates of nitrogen fertilizer from 50 kg N ha^{-1} up to 350 kg N ha^{-1}. Also splitting the high rates into 9 splits resulted in increasing N in the leaves and seeds of wheat compared to those obtained with 3 splits treatment.

Although no significant increase in grain yield was obtained due to increasing the the number of splitting of added N, yet increasing the number of splits (9 splits) resulted in a significant increase in grain N concentration. It seems that increasing the

Table 3. The effect of rate, splitting of urea nitrogen fertilizer and nitrapyrin addition on wheat N concentration in leaves at heading (NH), N concentration in seeds (NG), and N concentration in shoots (NO)

Nitrogen rate	With NP	Splits	NH	NG	NO
kg N ha^{-1}				%	
50	Yes	3	2.06	1.26	0.20
50	Yes	6	2.11	1.23	0.21
50	Yes	9	1.90	1.29	0.19
50	No	3	1.86	1.08	0.20
50	No	6	2.17	1.22	0.19
50	No	9	1.99	1.19	0.18
mean			2.02	1.21	0.20
150	Yes	3	2.34	1.98	0.21
150	Yes	6	2.45	1.84	0.19
150	Yes	9	2.73	1.97	0.22
150	No	3	2.50	2.03	0.23
150	No	6	2.47	2.03	0.16
150	No	9	2.40	2.03	0.21
mean			2.48	1.98	0.20
250	Yes	3	2.58	2.08	0.37
250	Yes	6	2.58	2.23	0.42
250	Yes	9	2.96	2.31	0.43
250	No	3	2.35	2.17	0.37
250	No	6	2.57	2.19	0.41
250	No	9	2.91	2.26	0.40
mean			2.66	2.21	0.40
350	Yes	3	3.58	2.29	0.63
350	Yes	6	3.28	2.09	0.67
350	Yes	9	3.09	2.53	0.62
350	No	3	3.21	2.41	0.68
350	No	6	3.27	2.26	0.64
350	No	9	3.33	2.43	0.57
mean			3.29	2.34	0.63
LSD$_{(0.05)}$					
Rate (R)			0.09	0.08	0.032
Split (S)			0.07	0.07	NS
R × S			0.11	0.10	NS
R × nitrapyrin × S			0.21	NS	NS

number of splits have extended the period of addition of N. Thus part of the added N was supplied during and after anthesis. It is expected that this delayed application of N resulted in increasing grain N content. This confirms the fact that nitrogen accumulation in the grain continues even after dry weight reaches its maximum and this is also in line with the result of Borghi *et al.* [20]. The potential to increase grain protein through late-season N application has been demonstrated in a number of studies [21;22]. Increased grain N or crude protein content (% N × 5.7) is often desired due to the associated improvements in nutritive value of cereal feed crops [23, p.256] and increased seedling vigor in seed crops [24] and improves loaf baking characteristics [25]. Detailed experiments investigating the optimum timing for urea application (i.e., time of split application) showed that the optimum occurring at anthesis [25] or post anthesis [22]. Lower grain response due to delayed N spray is expected. This is because the plants at this stage, have had smaller green areas on one hand and nutrients translocation was about to be ceased on the other hand.

In the current experiment, addition of nitrapyrin did not result in any significant increase in N concentration of wheat plant. It is generally found that the use of nitrification inhibitor increases the total uptake of N by plants in situations where loss of N due to leaching and/or denitrification limits plant growth. However in case where N is not limiting plant growth and losses due to leaching and denitrification is minimal, retardation of nitrification may not affect the plant N composition [26]. Also, it has been generally reported that with plant species that prefer nitrate such as wheat, retardation of nitrification either decreases or has no effect on N uptake [27;28].

Effect of treatments on recovery of applied N

Analysis of variance of the obtained results demonstrates that the differences among treatments are highly significant ($P \leqslant 0.01$) for the rate of N application. Table 4 shows the percentage of N recovered in plant, soil and the N leached from plant-soil system. It also includes the percentage of N unaccounted for.

The percentage of N (NH_4 and NO_3), recovered in soil immediately after harvest of wheat for the soil depths (0-25 cm and 25-50 cm) (Table 4), increases significantly with fertilizer rate. The N remaining in the soil could be utilized by a following crop or converted to organic N, (N-immobilization) but under the condition prevailing in Saudi Arabia, it will be lost by volatilization. The results indicate that residual soil N after harvest did increase significantly from the low rate (50 kg N ha^{-1}) and the other rates. Whilst the differences were not significant between the medium (150 kg N ha^{-1}) and high (250 kg N ha^{-1}) N rates, and between the high and very high (350 kg N ha^{-1}) N rates. Chaney [29] found different results. He found that there were non significant

Table 4. The effect of rate, splitting of urea nitrogen fertilizer and nitrapyrin addition on wheat N uptake-g lysimeter^{-1}-(PU), N recovered in plant (RP), N recovered in soil (RS), N recovered in plant & soil (RPS), N leached (L), and N unaccounted for (UF)

Nitrogen rate	With Np	Splits	PU	RP	L	RS	RPS	UF
kg N ha^{-1}			g lysimeter^{-1}			%	of N recovered	
50	Yes	3	1.19	90.22	2.77	4.87	95.08	2.14
50	Yes	6	1.16	87.63	2.79	4.43	92.06	5.15
50	Yes	9	1.13	85.95	2.79	4.40	90.36	6.85
50	No	3	1.19	89.88	2.77	4.69	94.57	2.66
50	No	6	1.18	89.37	2.65	4.96	94.33	3.02
50	No	9	1.17	88.94	2.67	3.42	92.37	4.97
150	Yes	3	2.71	68.28	1.17	8.23	76.51	22.32
150	Yes	6	2.80	70.54	1.17	8.00	78.54	20.29
150	Yes	9	3.08	77.69	1.12	7.99	85.68	13.20
150	No	3	2.67	67.21	1.14	7.28	74.49	24.37
150	No	6	2.84	71.55	1.13	7.55	79.10	19.77
150	No	9	3.13	79.00	1.13	7.98	86.98	11.88
250	Yes	3	4.45	67.35	0.82	7.75	75.10	24.08
250	Yes	6	4.42	66.88	0.78	8.42	75.30	23.92
250	Yes	9	4.67	70.63	0.80	8.47	79.10	20.10
250	No	3	4.38	66.24	0.79	8.45	74.69	24.52
250	No	6	4.16	62.96	0.78	8.42	71.38	27.84
250	No	9	4.17	63.07	0.80	8.29	71.35	27.85
350	Yes	3	5.87	63.45	0.64	8.38	71.83	27.54
350	Yes	6	5.35	57.84	0.65	8.59	66.43	32.92
350	Yes	9	6.06	65.55	0.65	8.51	74.07	25.28
350	No	3	6.47	69.95	0.67	8.17	78.12	21.21
350	No	6	5.64	60.95	0.66	8.32	69.27	30.08
350	No	9	6.01	65.03	0.64	8.36	73.38	25.97
LSD$_{(0.05)}$								
Rate			0.23	4.00	0.04	0.67	3.97	3.9

increases in soil N up to the optimum fertilizer rate for yield but once the optimum was reached, further addition of fertilizer increased nitrate contents of the soils significantly. This indicates that in the current experiment up to the high rate, the optimum fertilizer rate for yield was not reached.

The recoveries in plant of added N were highest in the low and high rates treatments and were not affected by splitting or nitrapyrin addition. Unrecovered N which represents the gaseous losses of applied N is inversely proportional to the recovery percentage in plants. Contrary to several results [30] nitrification inhibitor did not increase the N recoveries in plants. This may be attributed to the lesser effect of the inhibitor on yield rather than on N content. The amounts of N leached were very small and constitute an insignificant pathway for N losses. Percentage of N leached ranged from 0.64-2.79%. Higher percentages were leached from the low application rate (50 kg N ha^{-1}) followed by medium application rate (150 kg N ha^{-1}). Generally, percentage of N leached is inversely proportional to the rate of N added [2].

Finally, possible mechanism for the loss of applied urea-N which was unaccounted for is ammonia volatilization and denitrification. Urea susceptibility to volatilization under a wide range of conditions is well recognized [31]. It is expected that N- urea volatilization constitutes a major part of the unaccounted for N losses.

Although intensive studies have been conducted to sustain efficient plant use of fertilizer N yet it is still relatively low. Inefficient use of N could burden higher costs for crop production and probably environmental pollution. Consequently much more research is needed to trace fertilizer N losses for the sake of efficient management particularly under arid conditions. It could be concluded that under this experimental condition, increasing fertilizer rate increased wheat grain yield. Neither nitrapyrin addition nor N splitting resulted in any significant increase in wheat yield. Leaching losses of N were generally very small and the magnitude of N losses through volatilization increased by increasing N rate more than 50 kg N ha^{-1}.

References

[1] Dowdel, R.J. and Webster, C.P. "A Lysimeter Study of the Fate of Fertilizer Nitrogen in Spring Carley Crops Grown on a Shallow Soil Overlying Chalk." *Journal of Soil Sci.*, 35, (1984), 184-190.

[2] Petrovic, A.M. "The Fate of Nitrogenous Fertilizers Applied to Turfgrass." *J. Environ. Qual.*, 19, No.1 (1990), 1-14.

[3] Boswell, F.C.; Meisinger, J.J., and Case, N.L. Production, Marketing, and Use of Nitrogen Fertilizers. In: OP. Engelstad (Ed.). *Fertilizer Technology and Use.* 3rd ed. (Madison, WI: SSSA, 1985.

[4] Spratt, E.D. "Effect of Ammonium and Nitrate Forms of Fertilizer and Their Time of Application on Utilization of N by Wheat." *Agron. J.*, 66, (1974), 57-61.

[5] Mengel, K. and Kirkby, E.A. *Principles of Plant Nutrition.* Bern. Switzerland: Int. Potash Inst. 1978.

[6] Meisinger, J.J.; Randall, G.W. and Vitosh, M.L. (Eds) *Nitrification Inhibitors- Potentials and Limitations.* USA Madison WI: ASA SSSA 1980.

[7] Sahrawat, K.L. and Keeney, D.R. "Effects of Nitrification Inhibitors on Chemical Composition of Plants." *J. Plant. Nutr.*, 7, (1984), 1251-1288.

[8] Walters, D.T. and Malzer, G.L. "Nitrogen Management and Nitrification Inhibitor Effects on Nitrogen-15 Urea: I Yield and Fertilizer Use Efficiency." *Soil. Sci. Soc. Am. J.*, 54, (1990), 115-122.

[9] Walters, D.T., and Malzer, G.L. "Nitrogen Management and Nitrification Inhibitor Effects on Nitrogen-15 Urea: II Nitrogen Leaching and Balance." *Soil Sci. Soc. Am. J.*, 54, (1990), 122-130.

[10] Bremner, J.M. Inorganic Forms of Nitrogen. In: C.A. Black, *et al.* (Ed.) *Methods of Soil Analysis Part 2 Agronomy 9.* Madison Wis.: Am. Soc. of Agron. Inc. 1965.

[11] Page, A.I. *Method of Soil Analysis.* (Part 2) Madison WI: ASA SSSA, 1982.

[12] Bronson, K.F.; Touchton, J.T.; Hauck, R.D., and Kelley, K.R. "Nitrogen- 15 Recovery in Winter Wheat as Affected by Application Timing and Dicyandiamide." *Soil Sci. Soc. Am. J.*, 55, (1991), 130-135.

[13] Shyilon, L.L.; Varsa, E.C.; Kapusta, G., and Mburu, D.N. "Effect of Etridiazol and Nitrapyrin Treated N Fertilizers on Soil Mineral N Status and Wheat Yields." *Agron. J.*, 76, (1984), 265-270.

[14] Mouchova, H. and Apltauer, J. "Effects of the Nitrification Inhibitor N-Serve on the Utilization of Fall-Applied Urea by Wheat." *Fert. Res.*, 4, (1983), 165-180.

[15] Singh-Bijay; Yadvinder-Singh; Khind, C.S., and Meelu, O.P. "Leaching Losses of Urea-N Applied to Permeable Soils Under Low Land Rice." *Fert. Res.* 28, (1991), 179-184.

[16] Wibberley, E.J. *Cereal Husbandry.* Ipswich: Farming Press, 1989.

[17] Dampney, P.M.R. "The Effect of Applications of N During Stem Extension and Grain Filling on the Quality of Wheat Grain Used for Breadmaking." In: *Aspects of Applied Biology.* 15 Cereal Quality Warwick: Association of Applied Biologists, 1987.

[18] Poulton, P.R.; L.V. Vaidynathan; D.S. Powlson, and D.S. Jenkinson. "Evaluation of the Benefit of Substituting Foliar Urea for Soil-Applied Nitrogen for Winter Wheat." In: G.F.J., Milford; P.S., Kettlewell; J.H., Orson; W.T.B., Thomas; P.E., Pritchard and C., Myram (Eds.) *Aspects of Applied Biology,* 25 Cereal Quality II Warkwick: Association of Applied Biologists, 1990.

[19] Sylvester-Bradley, R.P.; Dampney, M.R., and Murray, A.W.A. "The Response of Winter Wheat to Nitrogen." In: *The N Requirement of Cereals.* London: HMSO, 1984.

[20] Borghi, B.M.; Boggimi, C.G., and Ponga, N.E. "Kinetics of Dry Matter Accumulation and Composition Changes in Developing Bread Wheat." Kernel Z. Acker U. *Pflanzenbau.* 152, (1983), 224-237.

[21] Hucklesby, D.P.; Brown, C.M.; Howell, S.E., and Hageman Late, R.H. "Spring Applications of Nitrogen for Efficient Utilization and Enhanced Production of Grain and Grain Protein of Wheat." *Agron. J.* 63, (1971), 274-276.

[22] Pushman, F.M. and Bingham, J. "The Effects of Granular Nitrogen Fertilizer and a Foliar Spray of Urea on the Yield and Bread-Making Quality of Ten Winter Wheats." *J. Agric. Sci.*, 87, (1976), 281-292.

[23] Stoskopf, N.C. *Cereal Grain Crops.* Virginia Reston: Reston Publishing Company, Inc., 1985.

[24] Ayers, G.S.; Wert, V.F., and Reis, S.K. "The Relationship of Protein Fractions and Individual Proteins to Seedling Vigor in Wheat." *Ann. Bot.*, 40, (1976), 563-570.

[25] Finney, K.F.; Meyer, J.W.; Smith, F.W., and Fryer, H.C. "Effect of Foliar Spraying on Pawnee Wheat with Urea Solutions on Yield Protein Content and Protein Quality." *Agron. J.*, 49, (1957), 341-347.

[26] Sahrawat, K.L. "Control of Urea Hydrolysis and Nitrification in Soil by Chemicals-Prospects and Problems." *Plant Soil,* 57, (1980), 335-352.

[27] Cunningham R.K. "Cation-Anion Relationships in Crop Nutrition." *J. Agric. Sci.*, 63, (1964), 97-111.

[28] Nielsen, K.F.; Warder, F.G., and Hinman, W.C. "Effect of Chemical Inhibition of Nitrification on

Phosphorus Absorption by Wheat." *Can J. Soil Sci.*, 47, (1967), 65-71.

[29] Chaney, K. "Effect of Nitrogen Fertilizer Rate on Soil Nitrate Nitrogen Content After Harvesting Winter Wheat." *J. Agric. Sci.*, 114, (1990), 171-176.

[30] Freney, J.R.; Smith, C.J., and Mosier, A.R. "Effect of a New Nitrification Inhibitor (Wax coated Calcium Carbide) on Transformations and Recovery of Fertilizer Nitrogen by Irrigated Wheat." *Fert. Res.*, 32, (1992), 1-11.

[31] Fenn, L.B. and Hossner, L.R. "Ammonia Volatilization from Ammonium or Ammonium-Forming Nitrogen Fertilizers." *Adv. Soil Sci.*, 1, (1985), 123-169.

تأثير إضافة النيتروجين والنيترابيرين على محصول القمح ومحتواه من النيتروجين

عبدالله سعد المديهش، فهد محمد الرميان، ومحمد عثمان محجوب
قسم علوم التربة، كلية الزراعة، جامعة الملك سعود،
الرياض، المملكة العربية السعودية

(قُدم للنشر في ١٢/١/١٤١٥هـ؛ وقبل للنشر في ٦/٨/١٤١٥هـ)

ملخص البحث. قُوم كل من تأثير مثبط النترتة (النيترابيرين)، معدل وعدد جرعات النيتروجين المضاف في تجربة ليسميترات زرعت بالقمح في تربة جيرية (كربونات الكالسيوم ٢٩٪) ذات قوام طمي رملي. أظهرت النتائج أن محصول القمح تأثر معنويًا بمعدل إضافة السماد من ٥٠ إلى ١٥٠ و٢٥٠ و٣٥٠كجم نيتروجين/هكتار حيث أدت إلى زيادة في محصول الحبوب بلغت ٨٨, ١٣٩, ١٦٦٪ على التوالي.

لم تؤد إضافة النيتروجين أو زيادة عدد دفعات النيتروجين إلى ٩ دفعات إلى أي زيادة معنوية في محصول القمح في حين زاد عدد الأفرع زيادة معنوية نتيجة لإضافة النيترابيرين الأمر الذي يستنتج منه أن استخدام مثبط النترتة هذا قد يؤدي إلى رفع كفاءة السماد النيتروجيني بدرجة قد لا تكون كافية لزياد محصول الحبوب.

استخدام النيترابيرين لم يؤد لأية زيادة في تركيز النيتروجين في النبات في حين أدت زيادة دفعات النيتروجين المضاف إلى ٩ دفعات لزيادة معنوية في تركيز النيتروجين في حبوب القمح.

أظهرت الدراسة أن فقد النيتروجين بالغسيل في هذه التجربة كان قليلاً جدًا حيث لم يسهم إلا بالقدر الضئيل (٦ , ٠-٨ , ٢٪) في عملية فقد النيتروجين.