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EFFECT OF BALANCED NITROGEN FERTILIZATION ON WHEAT PRODUCTIVITY UNDER DRIP IRRIGATION SYSTEM

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Abstract

A field experiment was carried out at the Experimental Farm of Soils and Water Department (30° 3'19.49"N latitude, 31°19'10.19"E longitude), Faculty of Agriculture, Al-Azhar University, Cairo, Egypt during two successive winter seasons of 2018/2019 and 2019/2020. The study aimed to investigate the effect of balanced nitrogen fertilization at different ratios of NH_4^+:NO_3^- :T1 (0% : 100%), T2 (25% : 75%), T3 (50% : 50%), T4 (75% : 25%) and T5 (100% : 0%) according to the total nitrogen supplied (100 Kg N fed^{-1}) on the productivity and nutrient status of wheat plant (*Triticum aestivum*, L. *CV.* Giza 171). The results revalued that, the application of two nitrogen forms (T4 : 75 kg NH_4-N +25 kg NO_3-N) was preferred to increase yield parameters, nutritional status (NPK) and protein content in wheat grains compared to applying the individual forms of nitrogen, either NH_4^+ or NO_3^- . The relative increase of grain yield, 1000 grain weight, straw yield, biological yield, N, P, K and protein content for the first season at T4 were 36.91, 25.02, 28.89, 32.20, 89.00, 51.43, 64.46 and 88.96% as compared with the individual effect of NO_3-N (T1), where T4 recorded an increase of 3.58, 1.55, 1.75, 2.53, 1.07, 1.92, 1.53 and 1.03 % over the individual effect of NH_4-N (T5). It could be recommended that, the application of two nitrogen forms as a balanced nitrogen fertilization (T4) was preferred to increase the nutrient uptake as well as quantity and quality of wheat crop. Moreover, increasing the efficiency of nitrogen fertilizers and reducing environmental pollution could be achieved through balanced fertilization.

***Key words**:* Balanced nitrogen fertilization, Ammonium, Nitrate, wheat productivity.

Introduction

Nitrogen is one of the most important yield-limiting nutrients for normal plant growth and crop production in all agricultural regions of the world. Nitrogen is an essential constituent of proteins, nucleic acids, chlorophylls and many secondary metabolites. Many processes are affected by the deficiency of nitrogen, such as photosynthesis process and protein formation, where nitrogen is related with amino acids synthesis and protein formation (Mengel and Kirkby 2001). Nitrogen is the most important nutrient for the wheat plant due to clear effects on increasing the productivity of grain yield and protein content. Wheat is among the most responsive crops to the application of nitrogen fertilizers, especially in the soils suffering from insufficient nitrogen (Glass *et al*., 2002, Metwally, 2009). Therefore, the management of nitrogen fertilizers is a very important practice for increasing soil fertility and then the productivity of crops (Seadh, 2014).

Plants uptake nitrogen from the growth media in one of two ionic forms either NH_4^+ (ammonium) and/or NO_3^- (nitrate). Therefore, the total nitrogen absorbed consists of a combination of these two forms. Moreover, NH_4^+ or NO_3^- can affect the physiological and metabolic processes of plants, such as nutrient absorption, enzyme activity, photosynthesis rate, signaling pathways, and ultimately influence crop yield and plant growth (Guo *et al*., 2007 and Roosta *et al*., 2009).

The ratio of NH_4- N: NO_3- N represents a great important factor in balanced nutrition of plant with nitrogen and can affect the plant growth. The optimal growth of plant species requires a balanced ratio of nitrate to ammonium, where unbalanced forms of nitrogen (NH_4^+: NO_3^-) may be affect on the availability of some nutrients in the growth media through the pH changes around the roots of plant. Also, pH changes in the root environment due to imbalance in cation-anion absorption are minimized by the best ratio of NO_3^--N to NH_4^+-N. Many plant species grow best with a mixture of NH_4^+ and NO_3^-. On the other hand, the best ratio of ammonium and nitrate to be applied also varies with other factors such as growth stage, temperature, pH and soil properties (Forde and Clarkson 1999; Roosta and Schjoerring 2008; Roosta, 2014 and Bindraban *et al*., 215).

The effects of NH_4^+ and NO_3^- nutrition on plant growth have been studied; however, the results depend mainly on plant species. Under controlled growth conditions, nitrate can be absorbed more quickly by some plants, while ammonium may be preferred by other plants. Ammonium supply in the short - term is reported to improve the sink formation, either by increasing the level of photosynthates or specific phytohormones where the fruits, seeds, or tubers represent the main yield in these crops (Marschner, 1995 and Britto and Kronzucker 2002). The beneficial effect of NH_4-N on plant growth may be due to the lower energy consumption, compared with NO_3-N and to alterations in the phytohormone balance, where ammonium is directly integrated with carbon chain in the assimilation of nitrogen, without the need for reduction phases by enzymatic action, which positively reflects on nitrogen utilization efficiency (Sarasketa *et al*., 2014 and Bittsanszky *et al*., 2015). In most plant species, NH_4^+ absorbed by the roots is directly converted into amino acids within the roots, which cost less energy for both transport and assimilation of nitrogen (Escobar *et al*., 2006 and Zhong *et al*., 2014).

Nitrogen fertilization is an essential practice for the cultivation of wheat, especially in sandy soils which represent about 90% of the Egyptian soils. These soils are characterized by their poor physical, chemical properties and fertility status as well as their low capacity to retain water and their low supplying power for nutrients, which losses by leaching and volatilization. Therefore, there is an urgent necessity to apply different sources of organic fertilizers for this soil beside the usual fertilizers (Abdel-Fattah and Merwad 2015).

Among the various nitrogen fertilizers used in Egypt are the following: Urea, anhydrous ammonia, ammonium nitrate, ammonium sulphate and calcium nitrate. In a comparative study on the effect of some nitrogenous fertilizers on the growth, yield parameters and chemical composition of wheat plant grown in some soils of Egypt, there are positive effects were recorded for all fertilizers used on the characteristics of the wheat plant and the arrangement of nitrogen fertilizers was as follows: Ammonia gas < ammonium sulfate < ammonium nitrate < urea (Metwally, 2009).

Wheat (*Triticum aestivum*, L.) is one of the most important cereal crops used for human food and animal feed worldwide and especially in Egypt. Recently, several experiments were carried out to increase the wheat productivity to reduce the gap between Egyptian production and consumption via increasing the cultivated area, increasing wheat yield per unit area, reducing production costs (especially mineral nitrogen fertilizers), and find other alternatives (Kowsar *et al*., 2015). In Egypt, total production of cereal crops recorded 19.5 million tons in 2014 and wheat represents 8.8 million tons, while the imports of cereal crops reached 17.9 million tons, and wheat represents 10.5 million tons (FAO, 2015). In the season of 2017, the production of wheat crops diminished about -2 million tons (FAO, 2017). Therefore, the current study aims to investigate the effect of different ratios of ammonium and nitrate as balanced nitrogen fertilization on the productivity and nutrient status of the wheat plant (*Triticum aestivum*, L. *CV.* Giza 171) under drip irrigation system.

Materials and Methods

A field experiment was carried out on sandy soil at the Experimental Farm of Soils and Water Department (30° 3'19.49"N latitude, 31°19'10.19"E longitude), Faculty of Agriculture, Al-Azhar University, Cairo, Egypt during two successive winter seasons of 2018/2019 and 2019/ 2020. The current work aims to investigate the effect of different ratios of NH_4^+ : NO_3^- : T1 (0% : 100%), T2 (25% : 75%), T3 (50% : 50%), T4 (75% : 25%) and T5 (100% : 0%) based on the total nitrogen supplied 100 Kg N fed^{-1} as a recommended dose as well as T0 (control treatment), on the wheat productivity and some nutrient status (N, P and K) under drip irrigation system.

Soil samples (0-30 cm) of the field experiment were taken before cultivation, air dried, crushed and sieved through a 2.0 mm sieve for the determination of some physical and chemical properties for two growing seasons and presented in table 1.

Compost of rice mushroom straw (prepared by environment Department, Faculty of Agriculture) was mixed during soil preparation for cultivation at the rate of 4 ton f ed^{-1}. The compost of rice mushroom straw was added to improving soil properties, such as increasing water holding capacity (WHC) and save nutrients from lost especially nitrogen as well as the low content of nutrients. The composition of compost used in the experiment for two growing seasons is shown in table 2.

Soil and compost analysis were carried out as follows

Particle size distribution was carried out using the pipette method as described by Dewis and Freitas (1970). Organic carbon content in soil and compost was

Table 1. Some physical and chemical properties of the soil under study (mean of two seasons).

Practical size distribution				
Coarse sand (%)	**Fine sand (%)**	**Silt (%)**	**Clay (%)**	**Texture class**
49.84	25.41	14.70	10.05	sandy loam

Moisture content (%) at: FC	PWP	AW	pH	EC (ds m^{-1})	CEC (cmolc kg^{-1})	OC (%)	OM (%)	$CaCO_3$ (%)
12.55	4.63	7.92	7.92	1.79	3.00	0.24	0.41	2.11

Soluble icons (mmolc l^{-1})							
Cations				Anions			
Ca^{++}	Mg^{++}	Na^+	K^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
2.20	3.00	12.25	0.50	0.00	2.95	11.30	3.70

Available macronutrients (mg kg^{-1})		
N	P	K
35	8	50

FC: Field capacity; PWP: Permanent wilting point; AW: Available water; pH: 1:2.5 w/v soil water suspension; EC: Soil paste extract; CEC: Cation exchange capacity; OC: organic carbon and OM: organic matter.

Table 2: Some analysis of compost rice mushroom straw (mean of two seasons).

pH	**EC (ds m^{-1})**	**Moisture (%)**	**OM (%)**	**CEC (cmolc kg^{-1})**	**C/N ratio**
7.36	2.85	15	29.24	50.21	
Total macronutrient %					
C	N	P	K		
17	0.66	0.20	0.50		25.75

pH was determined in 1:10 w/v compost water suspension.
EC was determined in 1:10 w/v compost water extract.

determined using Walkley and Black method as described by Estefan *et al*., (2013) and organic matter content was calculated by multiplying OC% by 1.72. Electrical conductivity (EC) in soil water extract (1 : 2.5) and compost water extract (1 : 10) was determined by Electrical Conductivity meter (model WTW Series Cond 720); pH values of soil suspension (1 : 2.5) and compost suspension (1 : 10) were determined by using pH meter (model WTW Series pH 720). Total calcium carbonate in soil was determined using the calcimeter method according to Dewis and Freitas (1970). Soluble cations and anions were determined in soil extract (1 : 2.5) according to Estefan *et al*., (2013). Available NPK in soil, total N, P and K in compost and cation exchange capacity (CEC) of soil and compost were measured using laboratory tests as described by the Soil, (1996).

Wheat grains (*Triticum aestivum*, L. *CV.* Giza 171) were sown at the rate of 50 kg fed^{-1} on the 7th of November in the first season 2018/2019 and the second season 2019/2020, respectively. The plot area was 10.5 m^2 (3.5 m length and 3 m width) which represents 1/400 fed. Wheat plants were fertilized with the recommended fertilizers of nitrogen, phosphorus and potassium according to the recommendation of the Ministry of Agriculture. Phosphorus and potassium fertilizers were applied before cultivation as follows: 30 kg P_2O_5 fed^{-1} as calcium superphosphate (15% P_2O_5) and potassium was added at 50 kg K_2O as potassium sulphate (48 % K_2O). After three weeks from sowing, the treatments of nitrogen fertilizer were started. Nitrogen fertilizers were added by fertigation at the rate of 100 Kg N in four equal doses every ten days (after 21, 31, 41 and 51 days of sowing). Different sources of nitrogen fertilizers as urea (46% N), ammonium nitrate (33% N) and calcium nitrate (17% N) were used for different treatments of study. The treatments consisted of five proportions at different ratios of NH_4^+: NO_3^-: 0:100, 25 : 75; 50 : 50, 75 : 25,100 : 0 as well as control treatment as follows in table 3.

Table 3: Different treatments under the study.

Treat-ment	**Ratio of nitrogen forms** NH_4 (%)	NO_3 (%)	**Source and amount of nitrogen fertilizer fed^{-1}**
T0	0	0	nil
T1	0	100	588.25kg of calcium nitrate (17%N)
T2	25	75	54.35kg of urea (46 % N) + 441.2
			of calcium nitrate (17%N)
T3	50	50	303.034kg of ammonium nitrate (33 % N)
T4	75	25	163.05kg of urea (46 % N)+147.05kg
			of calcium nitrate (17%N)
T5	100	0	217.4 kg of urea (46 % N)

In both seasons of study, the treatments were arranged in a randomized complete block design with three replicates. Agricultural practices for growing wheat were carried out as recommended by the Ministry of Agriculture. At the harvest stage, 22th of April for two growing seasons, plants grown in one row were taken for each plot to measure and calculate the following parameters according to Fageria, *et al.,* (1996):

A- Yield parameters:

1-1000- grain weight (g).

2- Grain yield (kg fed^{-1}).

3- Straw yield

4- Biological yield = Grain yield + Straw yield

5- Harvest Index =

$$\frac{Grain\ yield\,(kg\ fed)^{-1}}{Bio\log ical\ yield\,(kg\ fed)^{-1}}$$

6- Yield efficiency =

$$\frac{Grain\ yield\ (kg\ fed)^{-1}}{Straw\ yield\ (kg\ fed)^{-1}} \times 100$$

7- Protein content *(%) = N (%) × 6.2s*

B- Plant analysis:

The sample of grain and straw from each treatment were grounded in a stainless-steel mill and taken for chemical analysis. Half gram of dry matter of grain and straw was wet digested using a mixture of sulphuric and perchloric acids ($HClO_4$+H_2SO_4) according to the procedure of Jones and Benton (2001). Macronutrients (NPK) were determined in acid digestive extract of grain and straw as well as the uptake N, P and K were calculated. All obtained results in both seasons were statistically analyzed as mean values for both seasons. The least significant difference (LSD) method was used to test the differences between treatment means at a 5% level of probability as described by Gomez and Gomez (1984).

Results and Discussion

Effect of different treatments on wheat yield parameters at seasons of 2018/2019 and 2019/2020

The data in table 4 shows the effect of different ratios of NH_4-N and NO_3-N according to the total nitrogen supplied on the yield parameters of wheat grown in sandy loam soil under the drip irrigation system at the two seasons of study. As illustrated in table 4, the addition of nitrogen fertilizers significantly increased the studied parameters of wheat yield for both two growing seasons as compared with control treatment. The highest significant values of grain yield, 1000 grain weight, straw yield, biological yield, harvest index and yield efficiency of wheat were 2170 (kg fed)$^{-1}$, 50.32 (g), 2900, 5070, 0.428 and 74.83 which recorded with T4 at the 1st growing season, while the lowest significant values under control treatment reached to 600, 30.13, 1100, 1700 , 0.353 and 54.55%, respectively in the 1st season. The same trend was found with the above parameters of wheat yield in the 2nd growing season. The relative increase of grain yield over control treatment was 164.17, 187.50, 216.67, 261.67 and 249.17 % for T1, T2, T3, T4 and T5 respectively at the 1st growing season. Moreover, the increases over control treatment recorded 166.67, 201.71, 233.33, 278.12 and 268.38 % for T1, T2, T3, T4 and T5 respectively in the 2nd season. These results could be supported with those obtained by Metwally, (2009) and Ghaderi-Daneshmand *et al*., (2012) they found that wheat crop is very responsive to the application of nitrogen fertilizers especially in soil suffering from insufficient nitrogen, where nitrogen is a limiting factor for plant growth of wheat.

Table 4: Effect of different treatments on wheat yield parameters at growing seasons of 2018/2019 and 2019/2020.

Treat-ment	Grain yield (kg/ fed.)	1000 grain weight (g)	Straw yield (kg/ fed.)	Biolo gical yield (kg/ fed.)	Har-vest Index	Yield effic-iency (%)
1st Season						
T0	600	30.13	1100	1700	0.353	54.55
T1	1585	40.25	2250	3835	0.413	70.44
T2	1725	43.36	2400	4125	0.418	71.88
T3	1900	46.21	2600	4500	0.422	73.08
T4	2170	50.32	2900	5070	0.428	74.83
T5	2095	49.55	2850	4945	0.424	73.51
LSD	95.02	2.01	100.20	180.13	0.010	1.40
2nd Season						
T0	585	31.00	1040	1625	0.360	56.25
T1	1560	40.62	2200	3760	0.415	70.91
T2	1765	43.11	2435	4200	0.420	72.48
T3	1950	47.00	2640	4590	0.425	73.86
T4	2212	51.02	2944	5156	0.429	75.14
T5	2155	50.60	2905	5060	0.426	74.18
LSD	110.5	1.95	110.33	195.20	0.011	1.05

The data in table 4 revealed also that grain yield, 1000 grain weight, straw yield, biological yield, harvest index and yield efficiency of wheat are significantly affected by different ratios of NH_4-N and NO_3-N for both two seasons of study. The results of the 1st growing season showed that, the gradual increase in the ratio of NH_4-N up to 100% (T5) with a decrease in NO_3-N caused an increase by about 32.18%, 23.11%, 26.67%, 28.94%, 2.66% and 4.36% for grain yield, 1000 grain weight, straw yield, biological yield, harvest index and yield efficiency, respectively, of wheat compared with applying NO_3-N alone at 100% (T1). On the other hand, there was no significant effect between T4 and T5 on the above parameters of wheat yield. The same trend was observed with the 2st season, where the relative increase of grain yield, 1000 grain weight, straw yield, biological yield, harvest index and yield efficiency of wheat recorded 38.14%, 24.57%, 32.05, 34.57%, 2.65% and 4.61with T5 comparing with T1, respectively. These results could be enhanced with those obtained by Sugar and Berzsenyi (2012) and Abdel Wahab *et al*., (2017) they found that increasing the proportion of NH_4-N based on the total nitrogen supplied by injection of anhydrous ammonia as a source of NH_4^+ led to increasing the yield parameters of wheat (number of spikes, 1000 grain weights, grain yield and straw yield). They explained that the application of nitrogen fertilizers in the ammonium form increased metabolic processes and the rate of physiological activities and consequently increased wheat yield with a good quality of grains.

Regarding the preference of some plants for nutrition with NH_4-N over NO_3-N, this advantage may be due to NH_4-N more readily to the assimilation of nitrogen than NO_3-N, where NH_4 absorbed is directly converted into amino acids and then process of protein synthesis, which cost less energy for both transport and assimilation of nitrogen, while some plant species may be lack to a nitrate reduction system to the assimilation of nitrogen (Escobar *et al*., 2006 and Zhong *et al*., 2014). Sarasketa *et al*., 2014 and Bittsanszky *et al*., (2015), they attributed the beneficial effect of NH_4-N to the lower energy consumption in the assimilation of nitrogen, where ammonium nitrogen form is directly incorporated into the carbon chain without the need for reduction by enzymatic action, while NO_3-N requires a nitrate reduction system. The yield parameters under the combined effect of NH_4: NO_3 ratios at T2, T3 and T4 were higher than the individual effect of NO_3 at T1. This effect can be interpretation according to Duan *et al*., (2007) who pointed out that, the regulation of nitrogen uptake and assimilation of nitrogen could be achieved by the mixing nitrogen supply (NH_4^+/ NO_3^-), which eventually positively reflected on the maximizing yield of rice and soybean plants. Furthermore, mixed NH_4^+/ NO_3^- fertilizers have an energy-saving effect not only on regulation of nitrogen uptake but also increase the solubility and availability of nutrients in the media of plant growth.

Table 5: Effect of different treatments on the content and uptake of N, P, K and protein content in wheat grains at seasons of 2018/2019 and 2019/2020.

Treat-ment	Content (%)			Uptake (kg fed^{-1})			Protein content (%)
	N	P	K	N	P	K	
	1st Season						
T0	0.62	0.12	0.71	3.72	0.72	4.26	3.88
T1	1.00	0.35	1.21	15.85	5.55	19.18	6.25
T2	1.31	0.40	1.42	22.60	6.90	24.50	8.19
T3	1.59	0.46	1.71	30.21	8.74	32.49	9.94
T4	1.89	0.53	1.99	41.01	11.50	43.18	11.81
T5	1.87	0.52	1.96	39.18	10.89	41.06	11.69
LSD	0.20	0.03	0.14	3.55	0.97	3.25	1.12
2nd Season							
T0	0.7	0.13	0.75	4.10	0.76	4.39	4.38
T1	1.02	0.32	1.20	15.91	4.99	18.72	6.38
T2	1.35	0.38	1.43	23.83	6.71	25.24	8.44
T3	1.62	0.45	1.70	31.59	8.78	33.15	10.13
T4	1.88	0.51	1.95	41.59	11.28	43.13	11.75
T5	1.85	0.5	1.93	39.87	10.78	41.59	11.56
LSD	0.18	0.04	0.17	3.11	1.00	3.00	1.25

The aforementioned results could point out to the importance of increasing the ratio of NH_4-N and decreasing the ratio of NO_3-N in the subject of the total supplied N, add to wheat plants, where assimilate NH_4^+ more readily than NO_3^-, owing to lack a completely functional nitrate-redacted system. The beneficial effect of using nitrate combined with ammonium may be attributed to the improvement of N uptake which reflected on plant growth and yield parameters. Also, the differences in the above parameters under the different N sources were mainly due to their variations in the availability on the other nutrients.

Effect of different treatments on the content and uptake of N, P, K and protein content in wheat grains at seasons of 2018/2019 and 2019/2020

The data in table 5 represent the effect of different nitrogen ratios according to the total nitrogen applied on the content and uptake of N, P, K and protein percentage in wheat grains at two growing seasons of study. The results indicated that the application of nitrogen fertilizer treatments (T1 up to T5), increased the content and uptake of N, P, K and protein content in wheat grains as compared with control treatment. The highest significant values of N, P, K and protein content in wheat grains for both growing seasons were recorded with the application of nitrogen at 75 Kg NH_4-N plus 25 Kg NO_3-N (T4); the values were 1.89, 0.53, 1.99 and 11.84% for the 1st growing season, while the values were 1.88, 0.51, 1.95 and 11.75% at the 2nd season for the content of N, P, K and protein, respectively. The lowest significant values of N, P, K and protein content in wheat grains for both seasons were obtained without application of nitrogen fertilizers (control treatment); the values were 0.62, 0.12, 0.71 and 3.88% in the 1st growing season, while the values were 0.70, 0.13, 0.75 and 4.38% at the 2nd season, respectively. There is a notable superiority for protein content in grains under the treatments of increasing levels of NH_4-N (T2, T3, T4 and T5) as compared with T1, this effect may be due to the beneficial and direct effect of ammonium form on amino acids and protein synthesis. In this concern, the levels of asparagine and glutamine in cell sap of crops may be affected by NH_4-N where plants supplied essentially with NH_4-N contains high amounts of asparagine and glutamine, where these polyamines are supposed to be used as a flower initiation messenger and then increase protein content (Roosta and Schjoerring 2007).

With regard to the results presented in Table 5 it is seen that, with an increase in the NH_4-N ratio and a decrease in NO_3-N, this led to an increase in the content and uptake of N, P and K as well as increasing the protein content in wheat grains. In the other words, based on the total N supplied, increasing the ratio of ammonium nitrogen on the expense of nitrate-nitrogen up to the treatment of T5 gave high values of N, P, K status and protein content in wheat grains with no significant difference between T4 and T5.

The combined treatment of 75 kg NH_4-N+25 kg NO_3-N (T4) gave the highest significant values of N, P, K and protein content, where the values recorded 1.89, 0.53, 1.99 and 11.84%, for the content of N, P, K and protein, respectively at the 1st growing season by about 89, 51.43, 64.46 and 88.96 % as compared with the application of 100 kg NO_3 (T1). Also, values of N, P, K and protein content were 1.88, 0.51, 1.95 and 11.75%, respectively for the 2nd season by about 84.31, 59.37, 62.50 and 84.17 % as compared with the application of 100 kg NO_3 (T1). These results could be supported with those obtained by Abdel Wahab *et al*., (2017) they attributed the increased NPK uptake and wheat grain content of protein under increasing NH_4-N versus decreasing NO_3-N to the remarkable increase in the availability of nutrients and consequently increasing plant growth and wheat grains weight. Also, they added that this may be due to the important role of nitrogen particularly NH_4-N in plant metabolism processes, roots growth and proliferation of plants which increase nutrients uptake. It is worth to mention that the use of nitrogen fertilizers in the ammonium form (NH_4-N), it is feasible to acidify the growing medium pH (Roosta and Schjoerring 2007), where NH_4 causes acidification by coupling of NH_4 absorption with the release of H+ by plant roots (Marschner, 1995). Conversely, NO_3 absorption increases the increasing medium solution pH (Mengel and Kirkby 2001). On the other hand, the sap in crops supplied essentially with ammonium contains high amounts of asparagine and glutamine in which these polyamines are supposed to be used as a flower initiation messenger (Roosta and Schjoerring 2007).

From the above results in Table 5 it can be concluded that the application of the two nitrogen forms (NH_4^+ and NO_3^-) at the rate of 75 kg NH_4-N +25 kg NO_3-N (T4) is still favorite to improve the uptake of N, P, K and protein content in wheat grains compared to applying the solitary form of nitrogen, either NO_3 at T1 or NH_4 at T5, with a significant superiority of the ammonium form compared to the nitrate form. The enhancement effect of 75 kg NH4-N +25 kg NO3-N (T4) may be due to the balanced supply of two nitrogen forms on regulation uptake of nitrogen and other nutrients which eventually reflected positively on plant growth and maximize crop yields, therefore, the balance supply between NO_3^- and NH_4^+ can serve as limiting factors for plant growth which are often used as wheat fertilizers to maximize crop yields (Luo *et al.*, 2013). There are many possible explanations for the superiority of NH_4 over NO_3 for increased nutrient uptake and plant growth. One of the most accepted explanations may be due to the nature of root morphology and the required form of nitrogen, where different root tissues require different amounts of NH_4^+ and NO_3^-, and a higher NH_4^+ concentration for protein synthesis is needed in the meristem zone. In most plant species, NH_4^+ absorbed by the roots is directly converted into amino acids within the roots, while nitrate reduction requires more energy demanding than the direct assimilation of NH_4^+ into amino acids, therefore NH_4^+ absorption requires less energy for the transport and the assimilation of nitrogen (Escobar *et al*., 2006 and Zhong *et al*., 2014).

Effect of different treatments on the content and uptake of N, P and K of wheat straw at seasons 2018/2019 and 2019/2020

Data presented in table 6 showed that the uptake and content of N, P and K in wheat straw were significantly increased by application nitrogen fertilizers treatments (T1, T2, T3, T4 and T5) as compared with control treatment. Status of N, P and K in wheat straw was significantly increased with the application of NH_4-N and decreasing with NO_3-N. Increasing the level of

Table 6: Effect of different treatments on the content and uptake of N, P and K of wheat straw at seasons of 2018/2019 and 2019/2020.

Treat-ment	Content (%)			Uptake (Kg/fed.)		
	N	P	K	N	P	K
	1st Season					
T0	0.20	0.04	0.50	2.20	0.44	5.50
T1	0.33	0.13	0.95	7.43	2.93	21.38
T2	0.46	0.16	1.11	11.04	3.84	26.64
T3	0.55	0.20	1.35	14.30	5.20	35.10
T4	0.65	0.24	1.55	18.85	6.96	44.95
T5	0.63	0.23	1.53	17.96	6.56	43.61
LSD	0.05	0.02	0.10	2.23	0.65	3.00
	2nd Season					
T0	0.19	0.05	0.55	1.98	0.52	5.72
T1	0.35	0.14	0.96	7.70	3.08	21.12
T2	0.42	0.18	1.14	10.23	4.38	27.86
T3	0.53	0.22	1.36	13.99	5.81	35.90
T4	0.63	0.26	1.56	18.55	7.65	45.93
T5	0.61	0.26	1.54	17.72	7.55	44.85
LSD	0.06	0.02	0.12	2.11	0.86	3.25

NH_4-N up to 100% (T5) gave high significant values of NPK status as compared with 100 % NO_3-N (T1) with a significant superiority of the combined effect of NH_4 and NO_3 at T4 on the individual effect of NH_4^+ at T5 or individual effect of NO_3 at T1. The cooperative effect of NH_4^+ and NO_3^- (T4) gave the highest significant values of NPK in two seasons. The values of NPK content of T4 were 0.65, 0.24 and 1.55 %, respectively, with an increase about 96.97, 84.62 and 63.16% as compared with T1 at the 1st growing season. The values of NPK content under the combined effect of NH_4^+ and NO_3^- (T4) reached 0.63, 0.26 and 1.56% by increasing about 80, 85.71 and 62.5% over the individual effect of NO_3 at T1 for the 2nd growing season. These results are in harmony with those obtained by Metwally, (2009) and Abdel Wahab *et al*., (2017) they attributed the increased uptake of nutrients by wheat straw under the application of anhydrous ammonia as a source of NH_4-N to the more availability of nutrients for the wheat plant. Furthermore, nitrogen application in the NH_4-N was more effective in increasing the quantity of nitrogen uptake in grains and generally more effective in increasing the quantity in straw.

Conclusion

On the basis of the above results it could be concluded that the most treatment which gave the highest significant values of all yield parameters and nutritional status namely (T4: 75 Kg NH_4-N+25 Kg NO_3-N). So that the response was by increasing the ratio of NH_4-N and decreasing the ratio of NO_3-N in relation to the total supplied N (100 kg N fed^{-1}), even so no significant effect was found between this treatment (T4) and (T5):100 Kg N as NH_4-N. Furthermore, wheat can assimilate NH_4 more readily than NO_3, because the plants lack a completely functional nitrate-redacted system. However, the plants which are supplied with ammonium contain high levels of asparagine and glutamine in cell sap of crops, where such polyamines are assumed to function as a messenger to flower initiation. On the other hand, the beneficial effect of using nitrate combined with ammonium may be attributed to the improving of N uptake which reflected on plant growth and yield parameters. Also, the differences in the above parameters under the different N sources were mainly due to their variations in the availability of N and other nutrients.

References

Abdel Wahab, M., M. Attia, A. Hassan and A. Salem (2017). Nitrate and Ammonium Balance in Fertilizing Wheat Grown on Sand Soil. *Journal of Soil Sciences and Agricultural Engineering,* **8(5):** 183-188.

Abdel-Fattah, M.K. and A.M.A. Merwad (2015). Effect of different sources of nitrogen fertilizers combined with vermiculite on productivity of wheat and availability of nitrogen in sandy soil in Egypt. *American Journal of Plant Nutrition and Fertilization Technology,* **5(2):** 50-60.

Bindraban, P.S., C. Dimkpa, L. Nagarajan, A. Roy and R. Rabbinge (2015). Revisiting fertilizers and fertilization strategies for improved nutrient uptake by plants. *Biology and Fertility of Soils,* **51(8):** 897-911.

Bittsanszky, A., K. Pilinszky, G. Gyulai and T. Komives (2015). Overcoming ammonium toxicity. *Plant Science,* **231:** 184-190.

Britto, D.T. and H.J. Kronzucker (2002). NH_4^+ toxicity in higher plants: a critical review. *Journal of plant physiology,* **159(6):** 567-584.

Dewis, J. and F. Freitas (1970). Physical and chemical methods of soil and water analysis. FAO, Rome, Soils Bulletin, (10).

Duan, Y.H., Y.L. Zhang, L.T. Ye, X.R. Fan, G.H. Xu and Q.R. Shen (2007). Responses of rice cultivars with different nitrogen use efficiency to partial nitrate nutrition. *Annals of Botany,* **99(6):** 1153-1160.

Escobar, M.A., D.A. Geisler and A.G. Rasmusson (2006). Reorganization of the alternative pathways of the Arabidopsis respiratory chain by nitrogen supply: opposing effects of ammonium and nitrate. *The Plant Journal,* **45(5):** 775-788.

Estefan, G., R. Sommer and J. Ryan (2013). Methods of soil, plant, and water analysis. A manual for the West Asia and North Africa region, 3.

Fageria, N.K., V.C. Baligar and C.A. Jonses (1996). Growth and mineral nutrition of field crops. Printed in the USA by Marcel Dekker.

FAO (2015). Wheat sector review. Economist, Investment Centre Division, FAO. Egypt.

FAO (2017). Giews country brief Egypt reference data 21 September.

Forde, B.G. and D.T. Clarkson (1999). Nitrate and ammonium nutrition of plants: Physiological and molecular perspectives. *In Advances in botanical research,* **30:** 1-90.

Ghaderi-Daneshmand, N., A. Bakhshandeh and M.R. Rostami (2012). Biofertilizer affects yield and yield components of wheat. *International Journal of Agriculture: Research and Review,* **2(6):** 699-704.

Glass, A.D., D.T. Britto, B.N. Kaiser, J.R. Kinghorn, H.J. Kronzucker, A. Kumar, M. Okamoto, S. Rawat, M.Y. Siddiqi, S.E. Unkles and J.J. Vidmar (2002). The regulation of nitrate and ammonium transport systems in plants. *Journal of Experimental Botany,* **53(370):** 855-864.

Gomez, K.A. and A.A. Gomez (1984). Statistical procedures for agricultural research. 2nd edition. John Wiley and Sonc, Inc., New York, 207-215.

Guo, S., Y. Zhou, Q. Shen and F. Zhang (2007). Effect of ammonium and nitrate nutrition on some physiological processes in higher plants-growth, photosynthesis, photorespiration, and water relations. *Plant Biology,* **9(1):** 21-29.

Jones, J. and J. Benton (2001). Laboratory guide for conducting soil tests and plant analysis. CRC press.þ

Kowsar Jan, M.V. Boswal and G. Singh (2015). Impact of bio-fertilizer and organic fertilizer on yield and yield parameters of bread wheat. *International Journal of Current Research,* **7(2):** 12388-12395.

Luo, J., J. Qin, F. He, H. Li, T. Liu, A. Polle, C. Peng and Z.B. Luo (2013). Net fluxes of ammonium and nitrate in association with H^+ fluxes in fine roots of Populus popularis. *Planta,* **237(4):** 919-931.

Marschner, H. (1995). Mineral nutrition of higher plants Academic Press New York. Mineral nutrition of higher plants. 2nd ed. Academic Press, New York.

Mengel, K. and E.A. Kirkby (2001). Principles of plant nutrition. 5th ed. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Metwally, A.M.E (2009). A chemical comparative studies between anhydrous ammonia injection, ammonium sulfate and urea in some soils and their effect on the chemical composition of wheat plant, M.Sc. Faculty of Science, Fayoum University.

Roosta, H.R. (2014). Effect of ammonium: nitrate ratios in the response of strawberry to alkalinity in hydroponics. *Journal of plant nutrition,* **37(10):** 1676-1689.

Roosta, H.R. and J.K. Schjoerring (2007). Effects of ammonium toxicity on nitrogen metabolism and elemental profile of cucumber plants. *Journal of Plant Nutrition,* **30(11):** 1933-1951.

Roosta, H.R. and J.K. Schjoerring (2008). Root carbon enrichment alleviates ammonium toxicity in cucumber plants. *Journal of Plant Nutrition,* **31(5):** 941-958.

Roosta, H.R., A. Sajjadinia, A. Rahimi and J.K. Schjoerring (2009). Responses of cucumber plant to NH_4^+ and NO_3^- nutrition: the relative addition rate technique vs. cultivation at constant nitrogen concentration. *Scientia Horticulturae,* **121(4):** 397-403.

Sarasketa, A., M.B. González-Moro, C. González-Murua and D. Marino (2014). Exploring ammonium tolerance in a large panel of Arabidopsis thaliana natural accessions. *Journal of experimental botany,* **65(20):** 6023-6033.

Seadh, A.K. (2014). Improvement of some wheat varieties productivity under organic and minerals fertilization Ph.D. (Agronomy), Fac. Agric., Mansoura University.

Soil, K. (1996). Survey Laboratory Methods Manual (No. 42, pp. 46-48). Soil Survey Investigations Report.

Sugar, E. and Z. Berzsenyi (2012). Effect of N fertilization on the dynamics of dry matter production and leaf area of wheat (*Triticiumaestavium* L.) varieties in different years. *Acta Agronomica Hungarica,* **60(4):** 385-396.

Zhong, Y., W. Yan, J. Chen and Z. Shangguan (2014). Net ammonium and nitrate fluxes in wheat roots under different environmental conditions as assessed by scanning ion-selective electrode technique. *Scientific reports,* **4(1):** 1-9.