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Critical Level Limitation of Nitrogen For Wheat Plants Cultivation in El-Gimmiza Area

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ABSTRACT

Wheat is an important Egyptian grain crop. Nitrogen have a major influence on wheat the productivity. The goal of N management program should be supplying enough N to achieve maximum profit from the crop. But any N not used by the wheat crop is potentially subjected to leaching, which pollutes groundwater and decreases the efficiency of N fertilization. The availability of Nitrogen affect by the soil properties, especially soil salinity, soil content of total calcium carbonate and particles size distribution of soil (soil texture). Also, some other important factors as soil-pH, soil organic matter content and cation exchange capacity of soil...etc. The aim of study to nitrogen critical level limitation of wheat crop under loamy soil through each of different nitrogen levels and obtained the maximum yield of production. Field experiment was carried out in El-Gimmiza Agricultural Researches Station Farm during winter season of 2012-2013 in Loamy soil. The experimental design was randomized complete blocks. Grain and straw yield for wheat crop were determined, soil available nitrogen was determined after harvesting. The obtained result observed that wheat grain plus straw yield was low at N_1-treatment (5586 kg fed^{-1}) and the highest one was at N_3-treatment (7294 kg fed^{-1}). Nitrogen critical level for wheat grain yield was N_3-treatment (60 kg N fed^{-1}). So, the nitrogen critical level for what grain yield is N_3-treatment (60 kg fed^{-1}). From the field experiment, the nitrogen critical level limitation for wheat crop yield is 60 kg N fed^{-1} under Egyptian environmental conditions for El-Gimmaza area such as soil moisture regime, soil temperature, biotic activity and soil pH.
keywords: Nitrogen Critical level, Loamy soil.

INTRODUCTION

Wheat is an important Egyptian grain crop having the nitrogen a major influence on the productivity levels. The goal of N management program should be supplying enough N to achieve maximum profit from the crop. But any N not used by the wheat crop is potentially subjected to leaching, which pollutes groundwater and decreases the efficiency of N fertilization. The total nitrogen of the earth is about 167 x10^{15} ton (Barker and Pilbeam, 2007). Ntrogen in soils, lakes, streams, sea bottoms, and living organisms is only about 0.02% of the total nitrogen of the earth (Barker and Pilbeam, 2007). Nitrogen is the essential inorganic nutrient required in the largest quantity by plants. Most plants are able to absorb either nitrate (NO_3^-) or ammonium (NH_4^+) or both. NH_4^+ as the sole source of nitrogen or in excess is deleterious to the growth of many plant species.

The availability of Nitrogen affect by the soil properties, especially soil salinity, soil content of total calcium carbonate and particles size distribution of soil (soil texture). Also, some other important factors as soil-pH, soil organic matter content and cation exchange capacity of soil …etc. The research on plant-soil interaction is focused on the processes that take place in the rhizosphere، the soil environment surrounding the root. Many of these processes can control plant growth، microbial infections, and nutrient uptake. (Roberto et al., 2007). Nutrient cycling is a key ecosystem function and essential for the conversion of nutrients to plant available forms. Cultivation and grazing affect N, P, K and S cycling in soils differently (Green et al., 2007).

The linear uptake of nitrogen from calcium nitrate applied at seeding at 0, 60,120 and 180mg Nkg^{-1}, soil resulted in widely different intercept and experimental control values in both high and low labile organic matter counterparts of a coarse sandy loam; the extrapolated control was less than the experimental value. Calculated and experimental values were not significantly different in a loamy sand and a loam (Figueiredo, 2009).

Ammonium and nitrate are the most important inorganic N forms readily available to plants. In loamy sand with EC_e 12.1 dS m^{-1}, no significant differences were found between NH_4^+ and NO_3^- nutrition for shoot biomass of wheat (Irshad et al., 2002). Also, compared to NH_4^+ and NO_3^- nutrition increased the plant uptake of Ca^{2+}, Mg^{2+}, K^+ and N and plant biomass under EC 10 dS m^{-1} induced using NaCl (Mahmood and Kaiser, 2003). El-Gharably, (2008) reported that, the lower root and shoot biomass and nutrient uptake with NH_4^+, compared to NO_3^- nutrition were attributed to plant toxicity with NH_4^+ when applied at 3-6 mM N. Ammonium, as a sole source of N applied at high concentrations, may be toxic for plants (Britto and Kronzucker, 2002). Nitrogen (an element required in large quantities for healthy plant growth) may be supplied either as a cation (ammonium - NH_4) or an anion (nitrate - NO_3), the ratio of these two forms of nitrogen in the nutrient solution can have large effects on both the rate and direction of pH changes with time. (World shopping, 2011). In the other study by Almodares et al., (2009) was carried out to evaluate the effects of four nitrogen treatments (50, 100, 150 and 200 Kg urea ha^{-1}) on biomass, crude protein, soluble carbohydrates and crude fiber contents in three fodders (corn, sweet sorghum and sweet sorghum bagasse) at the filed experimental station. The results showed the effects of nitrogen treatments and fodders on the above measurements were significant.

In many ecosystems, the importance of plant uptake of soil organic N in the field remains unclear (Jones, 1999; Hodge et al.، 2000 and Nasholm et al., 2009). It has been generally suggested that direct uptake of organic N is significant for plants in soils where inorganic N availability is very limited (Schimel and Bennett, 2004) or where soil concentration of amino acids is very high (Jones et al., 2005). In addition, various studies have found plant organic N uptake in ecosystems where amino-N is the dominant form of soluble soil N (Chapin et al., 1993; Nasholm et al., 1998; Nordin et al., 2001 and Bardgett et al., 2003). The relationship between soil N availability and plant N uptake, however, will depend on various factors, including soil interactions, plant-microbial competition, and mycorrhizal association (Persson et al., 2003 and Schimel and Bennett, 2004). Many studies on plant physiology, including those on N uptake, are based on hydroponically grown plants. However, caution is required to extrapolate results from these studies to soil–plant interactions so as to get better insights into mechanisms and processes occurring in the rhizosphere. Indeed, there are a number of ecologically crucial differences between a real soil and a nutrient solution: (1) water potential; (2) nutrient-patched vs. uniform distribution in the solution; (3) gas composition and concentration; (4) type, amount, and half-life of rhizodepositions; (5) abundance, activity, and diversity of microbial communities inhabiting the rhizosphere; and (6) symbiosis with fungi and bacteria (Badalucco and Paolo, 2007).

The aim of study to nitrogen critical level limitation of wheat crop under loamy soil through each of different nitrogen levels and obtained the maximum yield of production.

MATERIALS AND METHODS

A field experiment was carried out in El-Gimmiza Agricultural Researches Station Farm during winter season of 2012-2013 on loamy soil. Disturbed surface soil sample was collected in summer 2012 and 2013 and it's air dried, gently crushed and sieved through a 2 mm sieve. Fractions below 2 mm were subjected to chemical and physical analyses. Soil physical and chemical properties and also its content of available-N were carried out according to Black et al., (1965) and presented in Table 1.

Table (1): Some physical and chemical properties of the studied soil

Soluble cations ($meql^{-1}$)				Soluble anaions ($meql^{-1}$)				Texture Class			Texture Grade	SP	pH	EC dSm^{-1}
Mg^{2+}	Ca^{2+}	K^{+}	Na^{+}	SO_4^{2-}	HCO_3^{-}	CO_3^{2-}	Cl^{-}	Sand	Silt	Clay				
5.3	8.9	2.5	13.2	4.5	0.6	-	24.8	36.0	37.8	26.2	Loam	46.6	8.2	3.19

Nitrogen in soil was determined before cultivation (Native nitrogen), thus nitrogen treatments were carried out (Table, 2).

Table (2): Nitrogen experimental rate treatments and symbols

Treatments	Symbols	Nitrogen rates ($mg\ kg^{-1}$)
Control (without N-fertilizer)	N_0	zero
Treatment -2	N_1	300
Treatment -3	N_2	450
Treatment -4	N_3	600
Treatment -5	N_4	750
Treatment -6	N_5	900

*** Nitrogen fertilizer is ammonium nirate.**
Available nitrogen was determined in all soil samples digestion by perchloric acid and sulfuric acid using method of Kjeldahl as described by Page *et al.*, (1982).

Wheat crop was cultivated during November, 2012 and it's harvested during May, 2013. Soil was preparing and phosphorus and potassium fertilizers according to recommendation dose. Native nitrogen quantities were subtracted from nitrogen added in the treatments numbers 2-6, then the net nitrogen fertilizers were added to soil. Surface irrigation was used at the optimum of soil moisture at the period between irrigation. The experimental design was randomized complete blocks in the three replicates. Grain and straw yield for wheat crop were determined, soil content of available nitrogen was determined after harvesting. The relation between wheat grain and straw yield was studied using Minitab computer analytical programs to found nitrogen critical level based on newer important statically program according to El-Shazly (2013).

RESULTS AND DISCUSSIONS

Efficient N management program in wheat production can be attained by suitable evaluation of plant nutritional status. The definition of nitrogen critical level is the level of nitrogen in soil at which before or after it reduces with absorbed nitrogen and thus reduce the crop. Figure (1) observed that wheat grain yield was affected by nitrogen treatments for all replicates. The mean value of wheat grain yield was high at N_3-treatment (2464 kg fed^{-1}) and low at N_5-treatment (2002 kg fed^{-1}). Nitrogen critical level for wheat grain yield was N_3-treatment (60 kg N fed^{-1}). So, the nitrogen critical level for wheat grain yield is N_3-treatment (60 kg N fed^{-1}). Rasaei et al., (2012) concluded that, nitrogen is one of the elements in soil that is strongly influenced by water in the soil. But other parameters such as temperature can be effect on it.

Figure (2) observed that wheat straw yield was affected by nitrogen treatments for all replicates. The mean value of wheat straw yield was high at N_3-treatment (4830 kg fed^{-1}) and low at N_1-treatment (3556 kg fed^{-1}). Nitrogen critical level for wheat straw yield was N_3-treatment (60 kg N fed^{-1}). Wheat crop N requirement and the ability of the soil to supply N depends on a range of variables, including inorganic and organic N content of the soil, in-crop mineralisation, rate of nitrate leaching, rotation history and presence of yield limitations (such as root disease) and abiotic constraints such as salinity and sodicity (Fontes and Ronchi, 2012).

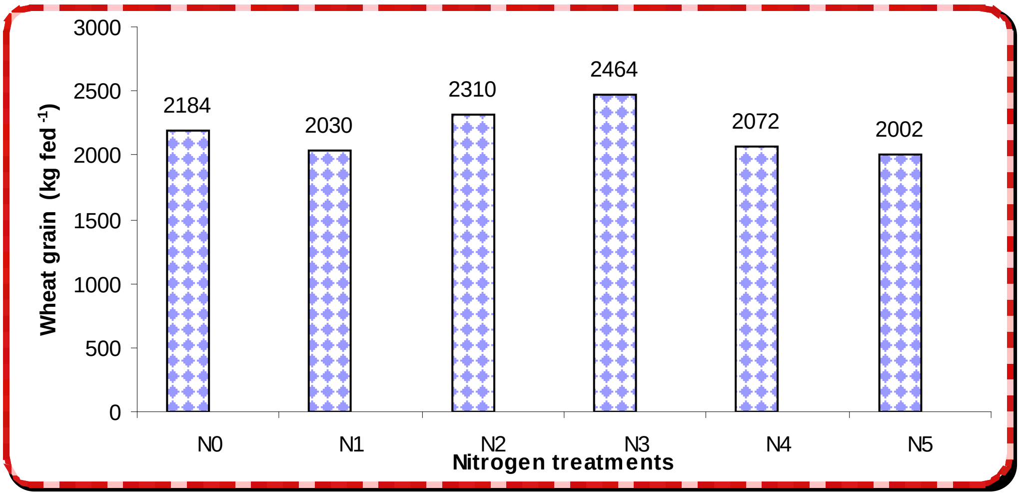

Figure (1): The relation between soil nitrogen treatments and wheat grain yield.

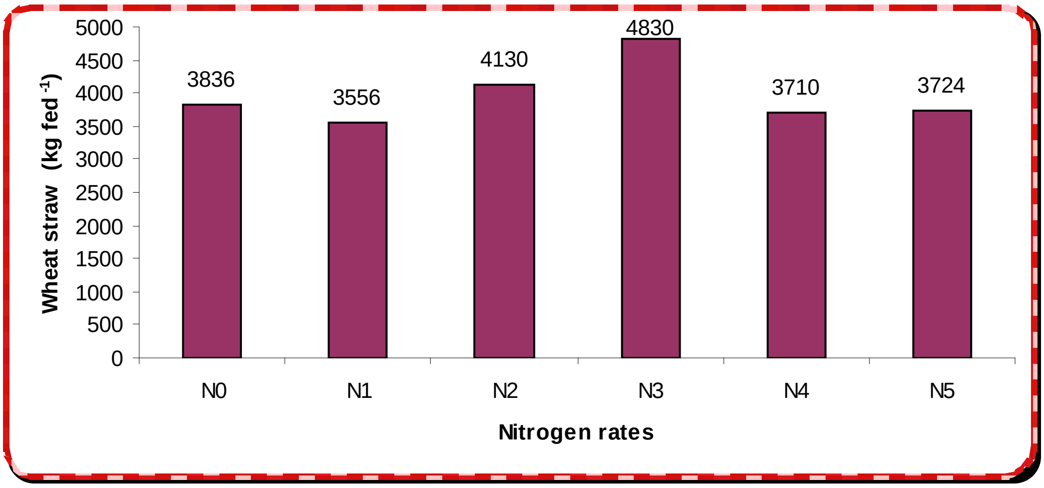

Figure (2): The relation between soil nitrogen treatments and wheat straw yield.

Nitrogen critical level limitation for wheat crop grain plus straw yield was studied and the result recorded in Table (3) and it's illustrated in Fig. (3). The obtained result observed that wheat grain plus straw yield was low at N_1-treatment (5586 kg fed^{-1}) and the highest one was at N_3-treatment (7294 kg fed^{-1}). Independently of the N index, the existence of values accepted as the critical N concentration is necessary to be used as a standard or reference. Usually, recommendation for critical values to evaluate N status are derived from wheat field survey and or field and greenhouse studies at soil and nutrient solution conditions in which wheat plant responses to a range of fertilizer rates are measured. Thus, nitrogen critical level limitation for wheat crop grain plus straw yield is N_3-treatment (60 kg fed^{-1}). Also, based on mean values of wheat grain plus straw yield, the treatments were take the following order: N_1(5586 kg fed^{-1}) < N_5 (5726 kg fed^{-1}) < N_4 (5782 kg fed^{-1}) < N_0 (6020 kg fed^{-1}) < N_2 (6440 kg fed^{-1}) <N_3 (7294 kg fed^{-1}). More recently information to farmers about N management has incorporated recognition that wheat has a varying demand for N throughout the season and N supply needs to match this demand (DPI, 2006). Correlations coefficients between soil nitrogen treatments and wheat grain, straw and grain plus straw yield were studied using Minitab statically analysis and the obtained result recorded in Table (4).

Table (3): Wheat grain plus straw yield mean values (Kg fed^{-1}) during 2012 – 2013 growth season

Treatment		grain	Straw	grain plus straw
N0	0	2184	3836	6020
N1	30	2030	3556	5586
N2	45	2310	4130	6440
N3	60	2464	4830	7294
N4	75	2072	3710	5782
N5	90	2002	3724	5726

Statically analysis use computer Maintab-programm of grains and straw yields of wheat plants in relation with added nitrogen fertilizer show that positive highly correlation coefficient relationship between N-treatments and each of wheat crop grain (R^2 = 94.7%), straw (R^2 = 97.2%) and grain plus straw yield (R^2 = 99.6%). These results are agree with obtained by those Ali et al., (2000); Abdel-Ghani and Bakry, (2005); Abd El-Hady et al., (2006) and Alamri and Mostafa, (2009) on they studied for different Egyptian soils.

To predict the wheat yield productivity on the basis of the N-treatment effect, available nitrogen was determined for all treatments and the obtained results observed in Fig. (4). Generally, available nitrogen increasing with increase nitrogen additive and positive correlation relationship (R^2= 75.8%) between nitrogen added and available nitrogen in soil (Fig. 3). Available nitrogen values ranged from 20 kg fed^{-1} at initial soil nitrogen content (N_0) to 40.6 kg fed^{-1} at the highest nitrogen treatment 90 kg fed^{-1} (N_5). This results are agree with obtained by El-Mleegy, (2007) and El-Shazly, (2013) on their studied on different Egyptian soils.

Table (4): Correlations coefficients between soil nitrogen treatments and wheat grain, straw and grain plus straw yield

	N-treatments	Grain	Straw
Grain Pearson correlation	-0.165		
P	0.755		
N	10		
Straw Pearson correlation	0.085	0.947**	
P	0.872	0.004	
N	10	10	
Grain plus straw Pearson correlation	0.016	0.972**	0.996**
P	0.977	0.001	0.000
N	10	10	10

***. correlation is significant at the 0.05 level (1-tailed)**
****. correlation is significant at the 0.01 level (1-tailed)**

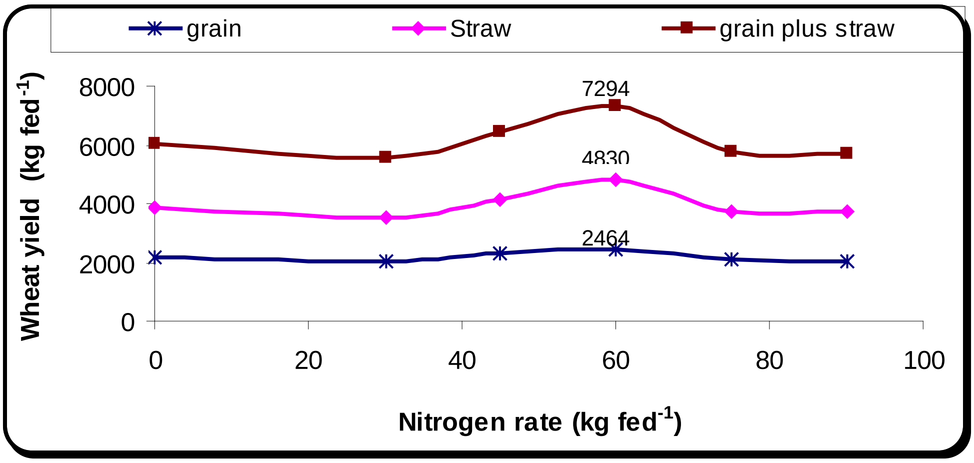

Figure (3): The relation between soil nitrogen rate and wheat yield.

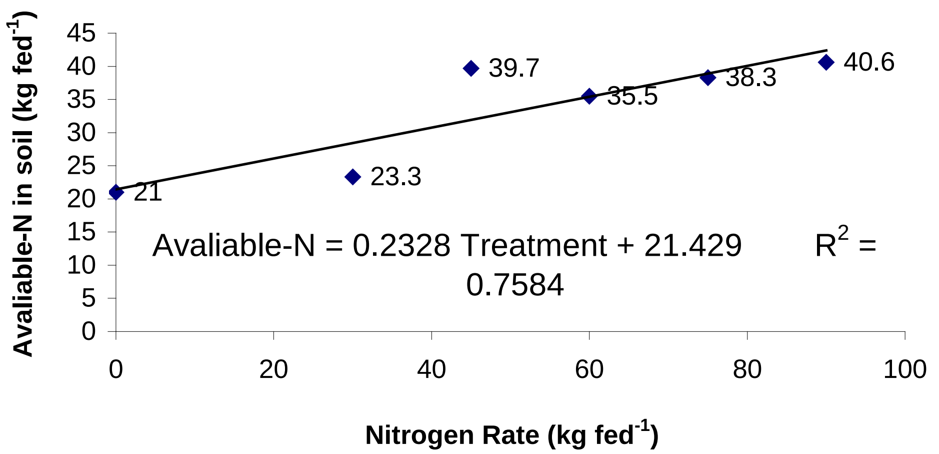

Figure (4): Prediction of soil available nitrogen based on nitrogen treatments for wheat crop.

CONCLUSION

From the field experiment, the nitrogen critical level limitation for wheat crop yield is 60 kg N fed^{-1} under Egyptian environmental conditions for El-Gimmiza area such as soil moisture regime, soil temperature, biotic activity and soil pH.

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تحديد الحد الحرج للنيتروجين لمحصول القمح لمنطقة الجميزة

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يعتبر القمح من محاصيل الحبوب المصرية الهامة. ويتأثر مستوى الإنتاج بشدة بعنصر النيتروجين. إن الهدف من إدارة برامج النيتروجين هو توفير إمداد كافي منه لتحقيق أقصى ربح من هذا المحصول ولكن أي إضافة زائدة للنتروجين لمحصول القمح قد تسبب تلوث المياه الجوفية بالغسيل وبالتالي تقل كفاءة التسميد الأزوتي وتتأثر صلاحية النيتروجين بخواص التربة وخاصة ملوحة التربة، المحتوى الكلي من كربونات الكالسيوم والتوزيع الحجمي للحبيبات (قوام الأرض) بالإضافة إلى بعض العوامل المهمة الأخرى مثل محتوى التربة من المادة العضوية والسعة التبادلية الكاتيونية. إن الهدف من هذه الدراسة هو تحديد المستوى الحرج لمحصول القمح من النيتروجين تحت ظروف الأراضي االلومية من خلال إضافة مستويات مختلفة من النيتروجين للحصول على أعلى إنتاجية ولذلك تم تنفيذ تجربة حقلية بمزرعة محطة البحوث الزراعية بالجميزة خلال الموسم الشتوي ٢٠١٢-٢٠١٣م وتم تصميم التجربة في قطاعات كاملة العشوائية وتم تقدير محصول الحبوب والقش للقمح، والنيتروجين الميسر في التربة بعد الحصاد ولقد أوضحت نتائج الدراسة أن إنتاجية الحبوب والقش كانت منخفضة عند المعاملة رقم ١ (٥٥٨٦ كجم/فدان) وأن أعلى إنتاجية كانت عند المعاملة رقم ٣ (٧٢٩٤ كجم/فدان). وكان المستوى الحرج لعنصر النيتروجين لإنتاج الحبوب والقش هو ٦٠ كجم نيتروجين/فدان في ظل الظروف البيئية المصرية لمنطقة الجميزة مثل مستوى رطوبة التربة، درجة حرارة التربة، النشاط الميكروبي ودرجة حموضة التربة.