Jahrestagung der Deutschen Bodenkundlichen Gesellschaft vom 07. bis 12. September 2013 in Rostock; Vorträge Kommission IV, Berichte der DBG (nicht begutachtete online-Publikation). www.dbges.de

Effect of different levels of NPK on wheat crop in North Delta

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Abstract

A balanced fertilization of NPK nutrients leads to increase soil fertility, anti soil nutrients depletion and also decrease nutrients losses to ground water and hence decrease its pollution. Therefore, a field experiment was conducted for two growing seasons on wheat in North Delta, Egypt. Different levels of nitrogen (0, 96, 192 and 288 kg N ha^{-1}), phosphorus (0 and 53 kg P_2O_5 ha^{-1}) and potassium (0 and 120 kg K_2O ha^{-1}) as well as 4 doses of N fertilizer were used. The objective of the present study was to investigate the effect of previous different levels of N, P and K fertilization and N fertilizer splitting on wheat yield and its components as well as uptake of N, P and K by wheat grain under different treatments. The results revealed that yield and its components were significantly affected by graded applied and splitting of N levels. The protein content in wheat grains was increased with increasing N levels up to 288 kg N ha^{-1} in presence of 53 kg P_2O_5 ha^{-1} as well as 120 kg K_2O ha^{-1}. The previous treatment recorded the highest values for protein content in wheat grains and total chlorophyll content.

Key words: *Wheat, nutrient uptake, chlorophyll content, North Delta, harvest index, N fertilizer splitting*

1. Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal and forage crop all over the world and it is considered the main food crop in Egypt as in many other countries of the world. Furthermore, wheat is considered the most important winter crop, because its grains are the main food for the urban and rural societies and its straw is a very important fodder for animal feed, especially during summer. The domestic wheat production in 2013 season was estimated by 8.7 million tones, whereas the Egyptian national consumption of wheat is about 17.7 million tons in 2013; there is a great gab between the consumption and production (**USDA, 2013**).

Egypt imports above five million tonnes of wheat grains. Unless domestic wheat production increases annually, the deficit will increase, due to the increase birth rate (2%) and present per capita consumption estimated by about 200 kg $year^{-1}$ (**USDA, 2013**). Increasing wheat production could be possible via two ways: horizontal expansion through increasing the cultivated area with wheat and vertical expansion through the development of new cultivars having the high potentiality and subsequently implementing the proper cultural practices (**Ragab 2011**).

Egypt utilizes fertilizers at an accelerating rate, due to various factors such as the increase in the cropped area, raising the rate of fertilizer application for various crops and the depletion of the High Dam. Consequently, Egypt is considered to be a heavy user of chemical fertilizers, especially N fertilizers then P and K fertilizers. Soil fertility continues to decline because of combined effects of increasing pressure for land use for crop production, inadequate compensation of nutrients exported and lack of nutrients management. Therefore, the objective of this study was to quantify the optimum doses of splitting N as well as the recommended combination of NPK fertilizers for wheat (cv. Sakha 93) production under North Delta region, Egypt.

2. Materials and Methods

Nitrogen fertilizer rate was split into four doses: the first dose (20%) at sowing, the 2nd dose (50%) before the 1st irrigation (27 days from sowing), the 3rd dose (20%) before the 2nd irrigation (56 days from sowing) and the 4th N dose (10%) was added at the 3rd irrigation (86 days from sowing). On the other hand, both of P and K fertilizers were applied during land preparation before planting. Soil samples were taken from the successive depths of 0-25 and 25-50 cm. The main plots were randomly assigned to nitrogen levels (0, 96, 192 and 288 kg N ha^{-1}), the subplots were represented by the two levels of phosphorus (0 and 53 kg P_2O_5 ha^{-1}) and the sub-sub plots were represented by the two levels of potassium (0 and 120 kg K_2O ha^{-1}). All agricultural practices of wheat crop such as: tillage, irrigation and fertilization were done in the experiment as practical by farmers.

Soil salinity and pH were 1.82 dS m^{-1} and 7.9, respectively for surface layer (0-25 cm). Plant samples were taken randomly at harvest to estimate the yield and its components as well as total chlorophyll content (**Kalra, 1998**), grain protein content and flag leaf area (cm^2). Soil samples were air-dried crushed and passed through 2.0 mm sieve for the chemical analyses according to **Page et al. (1982)**. All statistical data were performed using analysis of variance technique by mean of "**MSTAT**" computer software package (**Gomez and Gomez 1984)**. All calculations were made on a dry weight basis.

3. Results and Discussion

3.1 Yield and its components

At harvesting, one m^2 from each plot was selected and number of tillers per plant was recorded (from soil surface to the tip of the spike of the main stem), spike and plant length (cm), number of grain/spike and 1000 grains weight (g). The plants of each plot were harvested and the following characters were determined: grain yield (Mg ha^{-1}), harvest index, total chlorophyll content (mg kg^{-1} fw), grain protein content (%) and flag leaf area (cm^2). The chemical composition of wheat grain and NPK total uptake were also considered.

As shown in **Table 1**, in general, NPK at following level 192, 53 and 120 kg unit ha^{-1}, respectively recorded the highest values for previous parameters of wheat yield and its components with exception for grain yield. These results were in agreement with the data obtained by **Hegab (1994), Abd-Allah et al. (1999) and Ogunalela et al. (2000).**

3.2 NPK uptake by wheat grain

The addition of **N**-fertilizer increased **N** and **K** concentration and hence uptake of wheat plants at three physiological stages of growth (tillering, booting and maturity). Furthermore, the N concentration in grain and straw of wheat significantly increased by increased added N. N uptake by wheat straw was significantly increased (48.5 and 47.3 kg ha^{-1}) with increasing N-levels for the same treatment of $N_{288}P_{53}K_{120}$ in the first and second seasons, respectively (Data not tabulated). Similar results were reported by **Memon et al. (1988) and Kanani (1996).** Also, data indicated that this increase was more pronounced in the presence of phosphate and potassium fertilizers than its absence. Concerning potassium, it is an important factor for synthesis of amino acids and proteins from ammonium ions as well as for plants growing in solution enriched in ammonium ions that accumulate in them.

3.3 N-fertilizer splitting and wheat grain quality

It reported that, the grain and straw yields of wheat were much higher when splitting N to three equal doses than when splitting N to two equal doses or when it was applied in one dose **(Faizy *et* al. 1986a).** Also, the grain yield of wheat was higher when the nitrogen was split in to 4 than when split onto 3 or 2 doses **(Faizy *et* al. 1986b).** Data in **Tables 1 and 2** showed that, the protein content in wheat grain and total chlorophyll content were significantly increased by increasing N-level up to 288 kg N ha^{-1}. Also, the highest mean values were 13.8 % and 49.7 mg kg^{-1} fw for this treatment of $N_{288}P_{53}K_{120}$, respectively. These results agreed with those obtained by **El-Kholy (2000)**, **Abd El-Hadi (2004) and Amer (2005).** Splitting and timing of N fertilizer application is an important factor affecting the efficiency of fertilizer N because the interval between application and crop uptake determines the length of exposure of fertilizer N to loss processes such as leaching and denitrification. Therefore, timing N applications to reduce the chance of N losses through these processes can increase the efficiency of fertilizer N use and crop quality. Proper timing of nitrogen fertilizer applications to high yielding varieties might be another means in attempting to achieve high yield and high protein content **(McKenzie, 2010).** The beneficial effect of **K** on increased wheat yield is due mainly to higher kernel-weight, this striking effect of **K** on both grain yield and test weight results from increasing either the photosynthetic capacity or productive life of flag leaves, which accounts for up to 80% of grain filling. **K**-fertilization has a role in decreasing certain plant diseases and improving quality.

4. Conclusion

In general, it could be recommended that, the best treatment was NPK at following level 192, 53 and 120 kg unit ha^{-1}, respectively), which gave the highest production for wheat yield which indicate the importance of balance fertilization for this soil and wheat crop. It should be also splitted the N-fertilizer into 4 doses as mentioned in this work. On the other hand, it should be followed the balanced NPK fertilizer program to avoid leaching of N and P to ground water under North Delta region, Egypt.

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Table 1: Effect of different treatments of NPK-fertilizers on wheat yield and its components for 2nd season

Treatment	Grain yield (Mg ha^{-1})	Plant height (cm)	No. of grains per spike	Tillers no. per plant	Spike length (cm)	Weight of 1000 grains (g)	Flag leaf area (cm^2)	Protein in grain (%)
$N_0P_0K_0$	5.4 h	93.0 d	31.0 g	4.5 ef	8.5 h	39.2 h	18.4 h	7.2 g
$N_{96}P_0K_0$	9.3 ab	100.0 bcd	41.0 f	5.0 ef	15.0 def	51.2 de	45.0 f	8.0 fg
$N_{192}P_0K_0$	10.0 abc	99.7 bcd	69.0 cd	7.2 cd	15.7 cde	57.5 b	50.7 de	10.3 de
$N_{288}P_0K_0$	8.9 ef	106.0 ab	62.5 d	7.2 cd	16.0 cde	57.2 b	54.0 d	11.9 abcd
$N_0P_{53}K_0$	7.1 g	81.0 e	46.5 ef	3.7 f	12.5 g	47.5 f	33.6 g	11.3 bcd
$N_{96}P_{53}K_0$	9.6 abcd	96.0 cd	53.7 e	5.2 ef	14.2 efg	53.7 cd	42.0 f	8.8 efg
$N_{192}P_{53}K_0$	9.4 bcde	109.3 a	73.7 bc	8.7 abc	19.0 a	54.6 bc	55.0 d	10.9 bcde
$N_{288}P_{53}K_0$	9.3 cde	111.5 a	79.0 b	9.2 ab	19.0 a	48.6 ef	62.0 c	13.0 ab
$N_0P_0K_{120}$	8.9 def	93.2 d	52.0 e	4.0 ef	13.2 fg	43.6 g	22.9 h	9.9 def
$N_{96}P_0K_{120}$	9.7 abcd	104.0 abc	69.2 cd	5.7 de	16.5 bcd	48.1 f	46.3 ef	10.2 de
$N_{192}P_0K_{120}$	**10.4 a**	110.3 a	77.2 bc	9.7 ab	19.2 a	54.5 bc	63.0 c	12.0 abcd
$N_{288}P_0K_{120}$	9.7 ab	107.8 ab	89.5 a	9.2 ab	19.5 a	50.0 ef	65.6 bc	12.9 ab
$N_0P_{53}K_{120}$	6.7 g	84.0 e	63.0 d	3.7 f	15.5 cde	47.1 f	36.1 g	10.6 cde
$N_{96}P_{53}K_{120}$	8.2 f	102.8 abc	76.5 bc	8.0 bc	17.5 abc	49.0 ef	52.9 d	10.7 cde
$N_{192}P_{53}K_{120}$	**10.3 ab**	**110.5 a**	**97.0 a**	**10.5 a**	**19.0 a**	**61.7 a**	**71.4 a**	12.6 abc
$N_{288}P_{53}K_{120}$	9.4 bcde	104.8 ab	94.7 a	10.5 a	18.2 ab	60.5 a	69.9 ab	**13.8 a**

Table 2: Effect of different treatments of NPK fertilizers on total leaf chlorophyll content (mg kg^{-1} fw), harvest index (%), nutrient concentration and uptake by wheat **grain** for the 1st growing season

Treatment	Chlorophyll, mg kg^{-1} fw	Harvest index (%)	Nutrient concentration in grain (%)			Nutrient uptake by grain (kg ha^{-1})		
			N	P	K	N	P	K
$N_0P_0K_0$	28.6 f	52.3 e	1.11 h	0.31 h	0.30 b	16.6 i	4.3 k	3.8 i
$N_{96}P_0K_0$	32.8 e	54.5 cde	1.48 ef	0.39 cdef	0.34 b	65.5 f	10.1 h	11.5 f
$N_{192}P_0K_0$	40.3 c	62.2 ab	1.77 d	0.43 abc	0.27 b	92.6 e	15.6 f	21.4 c
$N_{288}P_0K_0$	45.6 b	57.7 bcde	2.04 bc	0.45 ab	0.37 b	107.0 d	21.4 e	27.4 b
$N_0P_{53}K_0$	28.4 f	52.8 de	1.31 g	0.34 fgh	0.31 b	25.7 h	5.0 jk	4.6 i
$N_{96}P_{53}K_0$	39.4 cd	59.2 abcd	1.57 e	0.37 efg	0.34 b	66.7 f	12.0 g	11.5 f
$N_{192}P_{53}K_0$	41.7 c	60.1 abc	1.81 d	0.46 a	0.36 b	100.6 d	24.2 d	21.4 c
$N_{288}P_{53}K_0$	45.2 b	57.0 bcde	2.03 c	**0.46 a**	0.35 b	116.9 c	26.6 c	27.4 b
$N_0P_0K_{120}$	30.7 ef	57.8 bcde	1.33 g	0.35 fgh	0.45 b	42.2 g	8.6 hi	5.5 h
$N_{96}P_0K_{120}$	36.2 d	**64.7 a**	1.76 d	0.38 def	0.48 b	73.4 f	15.4 f	14.4 e
$N_{192}P_0K_{120}$	41.5 c	60.8 abc	2.09 abc	0.43 abcd	0.52 b	116.9 c	20.6 e	22.1 c
$N_{288}P_0K_{120}$	45.6 b	60.2 abc	**2.15 a**	0.43 abcd	0.55 ab	125.3 b	28.6 b	29.0 a
$N_0P_{53}K_{120}$	36.3 d	56.3 bcde	1.47 f	0.32 gh	0.49 b	46.1 g	6.7 ij	6.7 g
$N_{96}P_{53}K_{120}$	39.4 cd	54.4 cde	1.82 d	0.40 bcde	0.52 b	85.7 e	12.9 g	15.6 d
$N_{192}P_{53}K_{120}$	47.4 ab	55.6 bcde	2.14 ab	0.45 ab	**0.56 a**	128.4 b	25.9 cd	22.1 c
$N_{288}P_{53}K_{120}$	**49.7 a**	55.2 cde	2.13 abc	0.41 abcde	0.55 ab	**172.3 a**	**35.5 a**	**29.0 a**

N_0, N_{96}, N_{192}, N_{288} = 0, 96, 192 and 288 kg N ha^{-1}, respectively
P_0, P_{53} = 0 and 53 kg P_2O_5 ha^{-1}, respectively K_0, K_{120} = 0 and 120 kg K_2O ha^{-1}, respectively
Means followed by the same letter in each column are not significantly different at 5% level using Duncan's Multiple Range Test (n= 4)