Soil-Based Technique for Managing Nitrogen Fertilization in Wheat in some Desert Soils at West Nile Delta, Egypt

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ABSTRACT

This paper proposed N fertilizer recommendation method for wheat grown in West Nile Delta, Egypt in order to obtain optimum yield at increased use efficiency of the applied fertilizer. The proposed method relies on target N uptake, indigenous soil N supply (ISN) and recovery efficiency of the applied N fertilizer (REN). The first season experiments (2015/2016) were conducted at five locations (El-Khatatba, South El-Tahrir, El-Bostan, North El-Tahrir and El-Nobaria). In these experiments, an increasing rate of N fertilizer from zero to 285 kg N ha^{-1} was applied in the tested plots. The maximum grain yield of wheat as computed from the generated quadratic function was 7286 kg ha^{-1} for maximum uptake of 268 kg N ha^{-1}. From the data of the first season, prediction equations of the ISN and REN were developed depending on soil organic matter, clay content and soil available N. The second season experiments (2016/2017) were conducted at four different locations (El-Khatatba, South El-Tahrir, El-Bostan and North El-Tahrir) in order to validate the established prescriptive equation (PE) against the general recommendation (GR) and farmer practice (FP). The PE successfully regulated the N fertilizer requirements according to soil test and target yield. For instance, the application rate at El-Bostan location as guided by the PE was 185 kg ha^{-1} gave a grain yield of 4423 kg ha^{-1} with a REN of 46.8 %. However, with 285 kg N fertilizer ha^{-1} as GR, the obtained grain yield was 5100 kg ha^{-1} with a REN of 35.6 %. On the other hand, the application rate at North El-Tahrir location as guided by the PE was 330 kg N fertilizer ha^{-1} resulted in 7490 kg ha^{-1} grain yield and 66.4 % REN. However, the GR gave 7100 kg ha^{-1} grain yield and 51.1 % REN. These results proved the inadequacy of the GR in getting high grain yield along with high use efficiency, and then considerable wastage of the applied N fertilizer are predicted. Unexpectedly, farmers showed a remarkable ability to increase or decrease N fertilizer rates according to soil status and projected yield due to experience. Nonetheless, the PE that developed in this study gives a scientific and reasonable basis to adjust N fertilizer rate depending on soil properties, and hence plant response to the applied N fertilizer.

Key words: N management, prescriptive equation, soil test crop response, wheat

INTRODUCTION

Nitrogen is the nutrient that most limits growth of cereals and N fertilizer is the key input in production. It is typically required in larger quantities than any other nutrient if farmers are to reap high yield. In Egypt, it is estimated that 247000 tons N were applied to wheat crop only in 2010/2011, representing 21.3 % of Egypt's N fertilizer consumption (Heffer, 2013). Although it is the determinant factor in cereal crop yield, N involves high energy-production costs and is, because of its mobility in the soil-plant-atmosphere system, easily dissipated in the environment if not properly applied (Mahler et al., 1994; Guillard et al., 1995; Ali, 2014; Ali et al., 2015). The inappropriate N management has detrimental effects on crop yield and the environment, and can aggravate disease and pest incidence (Bijay-Singh and Yadvinder-Singh, 2003; Fageria and Baligar, 2005). The N fertilizer recovery efficiency (REN) has been found to be around 44 % for wheat based on worldwide evaluation (Krupink et al., 2004). It means large quantity of N fertilizer is lost from the soil to the environment.

In majority of the cereal growing areas in Egypt, N recommendations are practiced as general recommendation (GR) for large areas. In this method, high quantity of the nutrient is applied to compensate for a possible low supply from the soil in any field and thus ensuring high crop yields. High crop yields can be obtained with the GR that involves fixed-rate method. However, the uniform adoption of GR does not ensure economy and efficiency of N fertilizer. In fact, the variation in soil fertility is not taken into account in this method, and there will be considerable wastage of fertilizer. Despite many years of research efforts, an accurate method for determining how much N fertilizer can be applied to intensively managed cereal crops to obtain high target yields, maintain adequate soil fertility and minimize environmental risk is still a debatable issue (Zhu, 2006; Robertson and Vitousek, 2009; Ali, 2014). Efficient N fertilizer management can be defined as managing N fertilizer so crop uses as much of the applied N as possible (Ferguson et al., 1994). The concept of "spoon feeding" N to the crop on an "as needed" basis (Schepers et al., 1995) is intended to enhance the efficiency of N fertilization and reduce the potential for environmental contamination.

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Decisions on N fertilizer applications require knowledge of the expected crop yield response to N. The latter is a function of crop N demand, indigenous N supply (ISN) from soil, and the fate of the N fertilizer applied as an efficiency factor. Most N fertilizer recommendations are based on empirical crop response functions derived from factorial N fertilizer trials conducted across different locations (Doberman et al., 2003), but the great spatial and temporal variations between and within fields in yield response to applied N has limited use of this method in practical N management (Schmidt et al., 2002; Mamo et al., 2003; Scharf et al., 2005; Miao et al., 2006). The difference in N responses is due to the variability of crop demand (Fiez et al., 1995) and soil N supply and N losses (Delin et al., 2005). The challenge in site-specific N management strategies is to develop methods that can quantitatively yet simply estimate optimum N rates to meet crop needs for specific locations. Yield-based fertilizer N recommendation is a commonly used method based on the mass balance approach. The optimum N rate is estimated as the total N content of the grain minus ISN (non-fertilizer sources) and adjusts for efficiencies in the ability of the crop to recover fertilizer N from the soil (Dobermann and Cassman, 2002). For this approach to be successful, the ISN must be estimated accurately on appropriate spatial scales (Dobermann et al., 2003).

Keeping up these issues, a scientific, reasonable and effective fertilizer recommendation method is necessary for the requirements of both high yield and friendly environment as well. Therefore, the present study was undertaken i) to develop soil test-based prescriptive technique that can be used to define N fertilizer requirements for wheat grown at West Nile Delta, and ii) to validate the developed equation at different locations compared with the general N fertilizer recommendation and farmer practice (FP).

MATERIALS AND METHODS

Experimental sites

Field experiments were conducted on wheat (*Triticum aestivum* L.) variety Sakha 93 during 2015/2016 and 2016/2017 seasons at different locations in West Nile Delta, Egypt. The first season experiments were carried out at five different locations (El-Khatatba, South El-Tahrir, El-Bostan, North El-Tahrir and El-Nobaria). In these experiments, an increasing rate of N fertilizer was applied in the tested plots in order to establish a prescriptive equation (PE) for defining N fertilizer rate for wheat. The second season experiments were conducted at four different locations (El-Khatatba, South El-Tahrir, El-Bostan and North El-Tahrir) in order to validate the established PE against the GR and FP. This area has relatively moderate temperatures, with highs usually not surpassing 31° C as average in the summer. Only 100–200 mm of rain falls during an average year, and most of this falls in the winter months. The maximum average of 34° C is recorded as the hottest temperatures in July and August. Winter temperatures are normally in the range of 9° C at nights to 19° C at days.

Initial soil samples were collected from the experimental plots, mixed, air-dried, ground, sieved (through a 2 mm sieve) and analyzed for soil physical and chemical characteristics and reported in Table (1). Soil texture was determined using the pipette method according to Page et al. (1982). The pH and electrical conductivity (EC) were measured in saturated soil paste and extract, respectively as described by Page et al. (1982). Soil organic matter was determined using the procedure of Walkely and Black as outlined by Page et al. (1982).

Table 1. The main physical and chemical characteristics of the topsoil (0-30 cm) samples in the experimental sites, West of Nile Delta, Egypt

	pH*	EC**, dS m^{-1}	OM, %	$CaCO_3$, %	CEC, $cmol_c$ kg^{-1}	Sand, %	Silt, %	Clay, %	Texture class	Avail. N, mg kg^{-1}	Avail. P, mg kg^{-1}	Avail. K, mg kg^{-1}
Establishment season												
El-Khatatba	7.64	1.18	1.5	6.7	7.7	79.92	10.56	9.52	LS	23	3.50	50
South El-Tahrir	7.55	1.35	1.7	7.6	8.5	75.59	12.52	11.89	SL	30	3.90	43
El-Bostan	7.97	0.48	0.4	1.8	0.5	98.05	1.23	0.72	S	9	2.86	17
North El-Tahrir	8.02	2.01	3.1	25.2	16.2	57.31	22.09	20.60	SCL	43	9.30	83
El-Nobaria	8.44	1.54	2.5	18.5	10.9	68.61	15.40	15.99	SL	40	8.40	80
Validation season												
El-Khatatba	7.44	1.51	2.3	3.2	8.7	78.95	11.63	9.42	SL	29	3.34	57
South El-Tahrir	7.69	1.21	1.4	5.0	4.2	83.70	10.14	6.16	LS	28	4.37	43
El-Bostan	7.74	0.98	1.0	3.8	2.8	87.39	8.36	4.25	S	16	3.14	27
North El-Tahrir	7.92	2.80	2.5	4.9	18.2	52.01	25.39	22.60	SCL	58	11.45	93

* pH in saturated soil paste. ** Electrical conductivity in saturated soil paste extract.

Total calcium carbonate content was measured using calcimeter according to Page et al. (1982). Available N was extracted by 2 *M* KCl solution according to Dahnke and Johnson (1990) and then determined by micro-Kjeldahl according to Page et al. (1982). Available P and K were extracted by 1 *M* NH_4HCO_3 in 0.005 *M* DTPA adjusted to a pH of 7.6 (Soltanpour, 1991) and P was determined colorimetrically using ascorbic acid and ammonium molybdate using spectrophotometer, and K was measured using flamephotometer (Page *et al.*,1982).

Experimental design

The experiments were laid out in a randomized complete block design with three replicates. The treatments in the first season consisted of N fertilizer levels of 0, 95, 167, 285 kg N ha^{-1} applied as ammonium nitrate (33.5 % N) in three equal split doses. The purpose of applying a range N fertilizer rate was to establish plots with different yield potentials and thus different total N uptake. The second season experiments were conducted in order to validate the established PE against the GR (285 kg N ha^{-1}) and FP (at three different parts in a farmer's field alongside the experiment).

Soil and crop management

Soil was ploughed twice, levelled and divided into 10 m^2 plots prior to sowing. The wheat seeds were sown during November by hand. At the time of sowing, phosphorus (as single superphosphate, 16 % P_2O_5) and potassium (as potassium sulfate, 48 % K_2O) were applied following the general recommendation. Weeds and diseases were controlled as needed.

Plant sampling and analysis

At maturity, wheat crop was harvested manually. Grain and straw were weighted from each plot in the field and samples were collected and dried in hot air oven at 70? C for three days and ground. For reporting, grain yields were adjusted to 14% moisture to standardize yield data (by multiplying oven dry grain yield with 1.14). The samples were wet digested in H_2SO_4 – H_2O_2 mixture and total N was determined by micro-Kjeldahl method (Kalra, 1997).

Calculations and statistical analysis

Regression analyses were performed using Statistical Product and Service Solutions (SPSS 18.0). The analysis of variance (ANOVA) was used to determine the effects of N treatments on the generated data. Least significant difference (LSD) was used to test the differences between means at probability < 0.05 as described by Gomez and Gomez (1984). The recovery efficiency of the applied N fertilizer was calculated as described by Cassman et al. (1998) as follows:

$$\text{REN, \%} = \frac{\mathbf{Nuf} - \mathbf{Nuz}}{\mathbf{Nap}} \times \mathbf{100}$$

where N_{uf} and N_{uz} are the total N uptake (total N uptake is the sum of N uptake in grain and straw, and N uptake in respective part is calculated by multiplying dry weight of yield with N concentration in percent divided by 100) in N fertilized and control plots (kg N ha^{-1}), respectively; N_{ap} is the amount of N fertilizer applied (kg N ha^{-1}).

RERSULTS AND DISCUSSION

Establishment of target N uptake

The increasing rate of N fertilizer treatments pooled from all sites generated a high degree quadratic function between grain yield and total N uptake (Fig. 1). By setting the first derivative of the quadratic equation to zero, the maximum grain yield was computed to be 7286 kg ha^{-1} for maximum uptake of 268 kg N ha^{-1}. Therefore, the target uptake of N (TUN) for which N fertilizer application level can be worked out to achieve the maximum yield in the algorithm being developed in this study is 268 kg N uptake ha^{-1}. This figure will be modified later according to target grain yields for economic considerations of the application rate of N fertilizer.

Prediction of the indigenous soil supply and recovery efficiency of N

Knowledge of the ISN can reflect the supply of N from the soil and can be used as guideline for fertilizer recommendation. In other words, the higher ISN means higher grain yield in control plots is attainable and consequently lower fertilizer is required to obtain maximum yield. Multiple regression was performed between N uptake in control plots and soil prosperities in order to predict the ISN. Data showed that the ISN can be predicted satisfactorily by soil organic matter, clay and available N contents in soil with R^2 value of 0.83 (Table2). Several studies indicated that ISN was an indicator of soil fertility and could be used to estimate fertilizer recommendation (Dobermann and Cassman, 2002; Dobermann et al., 2003; Cui *et al*., 2008). Soil organic matter playing a critical role in predicting ISN in this study, and has also been used previously for making fertilizer recommendations (Galvis-Spinola *et al*.,1998). For example, Soltanpour (1979) assumed that about 34 kg of available N would be mineralized per hectare for every 1 % soil organic matter. Likewise, the REN from N fertilized plots was regressed against soil properties, and data showed that soil organic matter and

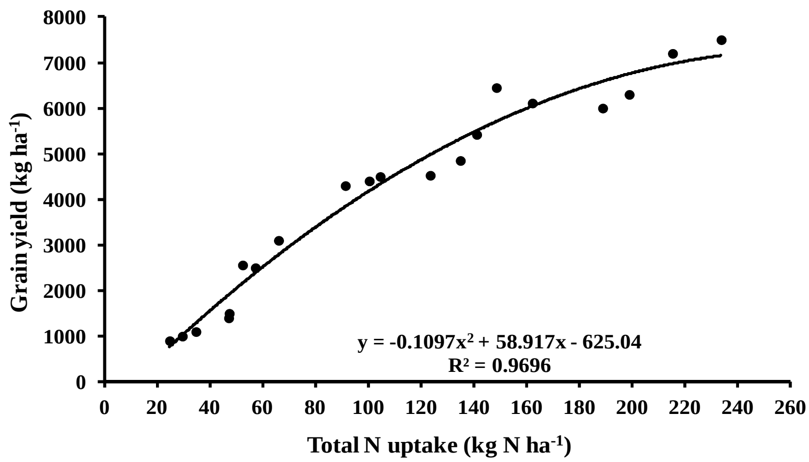

Fig. 1. Relationship between total N uptake and wheat grain yields

Table 2. Prediction regression equations of indigenous supply of N (ISN) and recovery efficiency of N (REN) for wheat grown at West Nile Delta

Regression equation	R^2
$ISN\ (N\ kg\ ha^{-1}) = 10.674 + 4.217 \times OM + 0.918 \times Clay + 0.212 \times Available \cdot N$	0.83
$REN\ (\%) = 27.261 + 3.248 \times OM + 1.309 \times Clay$	0.72

The overall findings of this research indicate that the differentiated yield response of wheat to N rate is linked directly to each crop's varying N total uptake and its use efficiency. The difference between TUN and ISN can reflect N requirement to be compensated to attain target yield. However, the difference in N uptake must be divided by REN as an efficiency factor under the assumption that some of the applied fertilizer will be lost (after dividing the percent value by 100). Summing up these findings, we can propose the PE that can be used to define the optimum N fertilizer rate using soil data as:

$$\text{N fertilizer rate (kg N ha}^{-1}) = \frac{TUN - ISN}{REN}$$

In other words, if the target grain yield is 7286 kg ha^{-1},this means the TUN is 268 kg N uptake ha^{-1}, and in such case the PE can be written as:

N fertilizer rate (kg N ha^{-1}) =

$$= \frac{268 - (10.674 + 4.217 \times OM + 0.918 \times Clay + 0.212 \times Available \cdot N)}{[(27.261 + 3.248 \times OM + 1.309 \times Clay) \div 100]}$$

clay contents were the best predictors under the conditions of this study with R2 value of 0.72 (Table 2).

It is pertinent to mention here that in case of low REN, the recommended rate of N fertilizer can be high in order to achieve maximum yield. Therefore, following the developed equation without modifying the target grain yield and then TUN can result in an uneconomical application rate. Accordingly, a criterion for defining target grain yield depending on the REN was proposed by the authors (Table 3). Subsequently, the TUN would be modified using Figure 1. Thus, the developed PE should be powerful because it shows that response to added N, which can differ from location to location, can be realized depending on soil data.

Table 3. The estimated target yield and total uptake of N (TUN) by wheat grown at West Nile Delta according to the predicted recovery efficiency of N (REN)

RE, %	Target yield, %	Target yield, kg ha^{-1}	TUN, kg ha^{-1}
30-35	50	3643	87
35-40	60	4372	102
40-45	70	5100	129
45-50	80	5829	153
50-60	90	6557	190
> 60	100	7286	268

Validation of the established prescriptive equation

In order to validate the performance of the developed PE, four different sites at West Delta have been selected to perform on-farm evaluation against FP and GR. The treatments consisted on the GR in the region (285 kg N ha^{-1}), FP following their experience and the PE as developed in this study. The data listed in

Table 4. The estimated N fertilizer recommendation rate for wheat grown at different locations in West Nile Delta according to soil test and target grain yield

	ISN*, kg N ha^{-1}	REN**, %	Target yield, kg ha^{-1}	TUN***, kg N ha^{-1}	N Fertilizer rate, kg N ha^{-1}
El-Khatatba	35.2	47.1	5829	153	250.4
South El-Tahrir	28.2	39.9	4372	102	185.2
El-Bostan	22.2	36.1	4372	102	221.3
North El-Tahrir	54.1	64.8	7286	268	329.9

* Indigenous supply of N. ** Recovery efficiency of N. *** Total uptake of N.

Table (4) show N fertilizer recommendation as guided by the PE.

In the experiment conducted in El-Khatatba, a total of 238 kg N ha^{-1} was applied by farmer, whereas 250 kg N ha^{-1} was applied as guided by the PE (Table 5). There was statistically similar grain yield between GR and PE treatments with values of 6267 and 6050 kg ha^{-1}, respectively. However, the FP gave grain yield statistically lower than the GR with a value of 5850 kg ha^{-1}. A similar trend was observed in total N uptake between treatments with the highest value of 168.6 kg N uptake ha^{-1} for GR, followed by PE treatment with a value of 162.7 kg N uptake ha^{-1} and FP treatment with a value of 157.4 kg N uptake ha^{-1}. Pertaining to REN, its values were 49.1, 48.3 and 49.3 % for GR, FP and PE treatments, respectively without significant differences.

In the experiment conducted in South El-Tahrir, a total of 190 kg N ha^{-1} was applied by farmer, whereas a total of 185 kg N ha^{-1} was applied as guided by the PE (Table 5). Results of FP and PE treatments gave statistically similar yield with values of 4423 and 4433 kg ha^{-1}, respectively. Both treatments were lower than the GR treatment that gave a value of 5100 kg ha^{-1} grain yield.

Table 5. Grain yield, total N uptake and recovery efficiency of N (REN) of wheat grown at different locations at West Nile Delta as guided by the prescriptive equation (PE), the general recommendation (GR) and farmer practice (FP)

	Total applied N fertilizer, kg ha^{-1}	Grain yield, kg ha^{-1}	Total N uptake, kg ha^{-1}	REN, %
		El-Khatatba		
Control	0	1060 c*	28.5 c	-
General recommendation	285	6267 a	168.6 a	49.1 a
Farmer practice	238	5850 b	157.4 b	48.3 a
Prescriptive equation	250	6050 ab	162.7 ab	49.3 a
LSD ($p < 0.05$)	-	238.4	6.4	NS
		South El-Tahrir		
Control	0	1333 c	35.9 c	-
General recommendation	285	5100 a	137.2 a	35.6 b
Farmer practice	190	4423 b	119.0 b	45.4 a
Prescriptive equation	185	4433 b	119.3 b	46.8 a
LSD ($p < 0.05$)	-	139.9	3.8	5.1
		El-Bostan		
Control	0	850 d	22.9 d	-
General recommendation	285	4850 a	130.5 a	37.8 ab
Farmer practice	180	3233 c	86.9 c	34.8 b
Prescriptive equation	221	4117 b	110.7 b	39.8 a
LSD ($p < 0.05$)	-	148.9	4.0	3.4
		North El-Tahrir		
Control		1483 c	45.3 c	-
General recommendation	285	7100 b	191.0 b	51.1 b
Farmer practice	310	7350 a	253.3 a	67.1 a
Prescriptive equation	330	7490 a	260.0 a	66.4 a
LSD ($p < 0.05$)	-	173.9	13.3	6.5

* Means followed by the same letter are not significantly different within the same column at the 0.05 level of probability by least significant difference test (LSD).

A similar trend was observed in total N uptake between treatments with the highest value of 137.2 kg N uptake ha^{-1} for GR, followed by PE treatment with a value of 119.3 kg N uptake ha^{-1} and FP treatment with a value of 119.0 kg N uptake ha^{-1}. However, FP and PE gave REN higher than the GR with values of 45.4 and 46.8 %, respectively compared with 35.6 % in GR.

In the experiment conducted in El-Bostan, a total of 180 kg N ha^{-1} was applied by farmer, whereas a total of 221 kg N ha^{-1} was applied as guided by the PE (Table 5). The GR resulted in the highest grain yield, followed by PE and FP with values of 4850, 3233 and 4117 kg ha^{-1}, respectively. The highest total N uptake was recorded in GR treatment with a value of 130.5 kg N uptake ha^{-1}, followed by PE and FP with values of 110.7 and 86.9 kg N uptake ha^{-1}, respectively. However, the highest REN was observed in PE treatment, followed by GR and FP with values of 39.8, 37.8 and 34.8 %, respectively.

Finally, in the experiment carried out in North El-Tahrir, a total of 310 kg N ha^{-1} was applied by farmer, and 330 kg N ha^{-1} as guided by PE (Table 5). The FP and PE gave statistically similar yield with values of 7350 and 7490 kg ha^{-1}, respectively, and higher than the yield obtained in the GR treatment with a value of 7100 kg ha^{-1}. The highest total N uptake was recorded in PE treatment with a value of 260 kg N uptake ha^{-1}, followed by FP treatment with a value of 253.3 kg N uptake ha^{-1} and then GR with a value of 191 kg N uptake ha^{-1}. However, FP and PE treatments gave statistically similar REN with values of 67.1 and 66.4 %, respectively, and followed by GR with a value of 51.1 %.

As expected, the PE successfully regulated the N fertilizer requirement according to soil test and target yield. For instance, in El-Bostan area with a relatively lower soil test, it was predicted that ISN is 22.2 kg N ha^{-1} and REN is 36.1 %. These data favored target grain yield to be 4372 kg ha^{-1} and thus TUN to be 102 kg N uptake ha^{-1}. Under these circumstances, the N fertilizer requirement was solved to be 221 kg N ha^{-1}. This is agreed with the findings of Cui *et al*. (2008) who reported that if the soil N pools are greatly low, it is very difficult to achieve high target yield and hence should be decreased. On the other hand, in North El-Tahrir area with a relatively higher soil test, it was predicted that ISN and REN are 54.1 kg N ha^{-1} and 64.8 %, respectively. These data directed the target grain yield to be 7286 kg ha^{-1} and then TUN to be 268 kg N uptake ha^{-1}. Therefore, the N fertilizer requirement turned out to be 323 kg N ha^{-1}. These findings are consistent with the finding of Fawy (2003) who reported that the attainable yield of wheat in coarse-textured soils like South El-Tahrir can be 5600 kg ha^{-1} with applying 260 kg N ha^{-1}, whereas in moderately fine-textured soils like North El-Tahrir the yield can be as high as 8300 kg ha^{-1} with applying the same amount of N fertilizer.

CONCLUSIONS

Foregoing results revealed that the existing GR of N fertilizer for wheat leads to excessive amounts of fertilizer that has an environmental impact and increase the cost of production. In the present investigation, a PE was developed based on TUN, ISN and REN. The first parameter can be obtained based on target grain yield, while the latters based on soil data. The developed method takes into account the variation in soil properties from location to location. The proposed equation [N fertilizer rate (kg N ha^{-1}) =

$$\frac{\text{Target uptake of N} - \text{indigenous N supply}}{\text{Recovery efficiency of N}}$$

was proved to be an effective and promising N fertilizer recommendation method against the GR in terms of REN and then the production costs. Surprisingly, farmers showed high ability to judge the optimum (or resemble) amounts of N fertilizer to be applied in their fields according to target yield and soil status based on experience. However, the PE that developed in this study gives a scientific basis to modify N fertilizer requirements for wheat grown at West Nile Delta.

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الملخص العربي

تقنية قائمة على التربة لإدارة التسميد النتروجيني للقمح في بعض الأراضي الصحراوية بغرب الدلتا، مصر

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تقترح تلك الدراسة طريقة لتحديد كمية النتروجين المناسبة للقمح النامي بمنطقة غرب الدلتا بمصر من أجل الحصول على محصول ملائم بكفاءة مرتفعة من السماد المستخدم. تعتمد الطريقة المقترحة على معرفة الكمية المستهدفة من النتروجين الممتص ومقدار إمداد التربة من النتروجين وكفاءة الاسترداد من السماد المضاف. تم إجراء تجربة حقلية في الموسم الأول عام ٢٠١٥/٢٠١٦ في خمس مواقع مختلفة بمنطقة غرب الدلتا (الخطاطبة وجنوب التحرير والبستان وشمال التحرير والنوبارية). تمت إضافة معدلات متزايدة من السماد النتروجيني من صفر الى ٢٨٥ كجم للهكتار من أجل بناء علاقة بين الكمية الممتصة من النتروجين ومحصول الحبوب. وكان أقصى محصول حبوب حسابياً هو ٧٢٨٦ كجم للهكتار لكمية امتصاص كلية قدرها ٢٦٨ كجم نتروجين للهكتار وذلك من خلال التحليل التفاضلي لمعادلة الدرجة الثانية. بناءً على نتائج الموسم الأول، تم إيجاد معادلات إنحدار مركب للتنبؤ بكمية النتروجين التي يمكن إمدادها من التربة دون تسميد كذلك كفاءة الاسترداد من السماد المضاف إعتماداً على المادة العضوية ونسبة الطين والنتروجين الميسر بالتربة. تم إجراء تجارب حقلية في الموسم الثاني (٢٠١٦/٢٠١٧) في أربعة مواقع (الخطاطبة وجنوب التحرير والبستان وشمال التحرير) من اجل تأكيد معادلة التوصيات السمادية التي تم تأسيسها في الموسم الاول وذلك في مقابل التوصيات العامة ومعاملة المزارع. أوضحت النتائج نجاح معادلة التوصيات في تنظيم معدل إضافة السماد النتروجيني بالإعتماد على تحليل التربة والمحصول المستهدف وبكفاءة عالية للسماد المضاف. فعلى سبيل المثال كان معدل إضافة السماد النتروجيني بمنطقة البستان بالإعتماد على معادلة التوصيات ١٨٥ كجم للهكتار والتي أعطت محصول حبوب قدره ٤٤٢٣ كجم للهكتار وكفاءة استرداد قدرها ٤٦.٨ %. في حين إضافة كمية سماد ٢٨٥ كجم للهكتار كتوصية عامة أعطت محصول حبوب قدره ٥١٠٠ كجم للهكتار بكفاءة استرداد قدرها ٣٥.٦ %. وكان معدل الإضافة في شمال التحرير معتمداً على معادلة التوصيات ٣٣٠ كجم للهكتار والذي أعطى محصول حبوب قدره ٧٤٩٠ كجم للهكتار بكفاءة استرداد قدرها ٦٦.٤ %؛ وأعطت التوصية العامة ٧١٠٠ كجم للهكتار محصول حبوب بكفاءة استرداد ٥١.١ %. تؤكد تلك النتائج عدم كفاية التوصيات العامة في الحصول على محصول عالي تحت كفاءة مرتفعة من السماد المستخدم، وبالتالي فقد كمية كبيرة من السماد المضاف. على غير المتوقع، فقد أظهر المزارع قدرة عالية على زيادة او خفض معدل إضافة السماد النتروجيني بناءً على الخبرة لطبيعة التربة والمحصول المستهدف، حيث تَحصّل في معظم المواقع على نتائج تقترب من معاملة معادلة التوصيات؛ الا ان معادلة التوصيات التي تم تأسيسها في تلك الدراسة تعطي أساس علمي ومنطقي لتعديل معدلات الإضافة بالإعتماد على خصائص التربة وبالتالي إمكانية إستجابة النبات للسماد المضاف بكفاءة عالية.