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POSSIBILITY OF AMMONIUM NITRATE APPLICATION TO FLOODED RICE SOILS

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ABSTRACT

The rice plant is capable of using both ammonium and nitrate forms of nitrogen, but fertilizers containing nitrate nitrogen are inefficient because nitrate is lost by leaching or denitrification in flooded rice soils. But, sometimes farmers are forced to use some fertilizers such as ammonium nitrate instead of urea for the second application of nitrogen fertilizer in flooded rice soils. A field experiment was carried out at Sakha Agricultural Research Station in 2014 and 2015 to know and understand the optimum way for ammonium nitrate utilization at the second dose of nitrogen application and compare the effects of N sources (ammonium nitrate and urea) at the second dose on yield components and yield of rice variety Giza 179 in experiment laid out in a Random Complete Block Design replicated thrice.

The two years data during 2014 and 2015 revealed that all the yield parameters, yield, nitrogen uptake and available nitrogen increased significantly with an application of T_1 {2/3 recommended as a urea (Basal application) + 1/3 of N recommended as urea onto drained soil then flooded immediately (Top dressing)}

These results were statistically at par in most parameter with that of treatment T_2 {(2/3 of recommended as a urea(Basal application) + 1/3 of recommended as ammonium nitrate in saturated soil then flooded immediately (Top dressing)}. The lowest values of yield and yield attributes were found when T_4 {2/3 recommended as a urea(Basal application) + 1/3 of recommended nitrogen as ammonium nitrate onto drained soil then flooded immediately (Top dressing)}.

The study recommended that in the case of having to use ammonium nitrate as a second dose of nitrogen fertilizer, it need to apply in saturated soil then irrigated immediately.

INTRODUCTION

More people depends on rice for their major feeding. Rice is very important for food security and economic. (FAO, 2003). During the last period the demand for rice has grown in Africa and is considered as one of the main strategic commodity crop for poverty reduction and food security. (FARA, 2009). Nitrogen is considered as the limiting factor nutrient for production in flooded rice soils (Samonte *et al*., 2006).

Nitrogen is one of three essential macronutrients for plant growth and yield. So, mineral N- fertilizers are widely used in agriculture all over the world and also, in Egypt, N- fertilizers are applied to meet the needs of the crop during the early growth stages and accumulate in the vegetative parts to be utilized for grain formation (Salem, 2006). Also, N- fertilizers has a vital role in the contents of N % of rice grains and N uptake by plants (Ebaid and Ghanem, 2000).

Nitrogen is important for fertilization to increase the yield, it is necessary to know the best source, good level and appropriate time of nitrogen for each variety beside its impact on components of yield and other agronomic characters, to obtain better knowledge for productive response (Chaturvedi, 2005; Manzoor *et al*., 2006; Salem, 2006; and Jan *et al*., 2010).Sources of nitrogen fertilizer, different levels and time of application play significant roles in determining fertilizer uptake (Jan *et al*., 2010). Sometimes farmers cannot get urea fertilizer to apply the second dose of nitrogen and they will be forced to use ammonium nitrate.

Therefore, this study was conducted to study the effect of urea and ammonium sulfate as a second dose on the yield, yield components of Giza 179 beside how to apply ammonium nitrate in flooded rice soil if you are forced to use it, also, how to maximize the N use efficiency from each source of Nitrogen.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Field Sakha agriculture Research Station Sakha, Kafrelsheikh during 2014 and 2015 seasons. The experiment consisted of one rice variety (Giza 179) and five fertilizer treatments viz., T_1 {2/3 of recommended nitrogen as a urea (Basal application) + 1/3 of recommended nitrogen as urea onto drained soil then flooded immediately (Top dressing)}, T_2 {(2/3 of recommended nitrogen as a urea(Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil then flooded immediately (Top dressing)}, T_3 (2/3 of recommended nitrogen as urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil then flooded 2 days later (Top dressing)), T_4 {2/3 of recommended nitrogen as a urea(Basal application) + 1/3 of recommended nitrogen as ammonium nitrate onto drained soil then flooded immediately (Top dressing)}, T_5 {2/3 of recommended nitrogen as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil (Top dressing)}. Nitrogen was applied at the rate of recommended rate 69 kg N fed^{-1}, unvarying dose of 15 kg P_2O_5 and 48 kg K_2O ha^{-1} before transplanting were applied to the plots. The nursery of rice variety GZ 179 was sown on 3rd and 7th of May during 2014 and 2015 seasons respectively. Seedlings of 30 days old were pull from the nursery beds carefully. Seedlings were transplanted with 3 plants/ hill in the well puddled experimental plots. The plot size was kept 3m x 4m ($12m^2$). Spacing’s were given 20 cm x 20 cm. All intercultural operations were done carefully.

Composite soil samples were collected before plowing the soil. Soil suspension for pH wasprepared and EC_e of the soil extraction (1:5) was prepared. Soil organic carbon (SOC) was analyzed by Walkley and Black method (Nelson and Sommers, 1982). Nitrogen phases were extracted with 2.0 M potassium chloride according to Page *et al*. (1982) and determined by microkjeldahl apparatus. The result is presented in Table 1.

Yield and its components (panicles number /hill, panicle length (cm) panicle weight (g), one thousand grain weight (g), number of filled grains/panicle, grain yield (tons/fed) and straw yield (tons/fed), were evaluated at harvest time.

The grain and straw yields were measured at maturity then adjusted to the grain moisture content of 14%. The N content of the rice crop, straw and grain samples were analyzed for total N to know the impact of N fertilization. Grain and straw were harvested. Grain and straw samples from each plot were separated. The samples were oven dried for 48 h at 70°C, then ground. Total nitrogen was analyzed using the kjeldahal method (Bremer and Mulvaney, 1982). The Duncan's multiple range tests (1995) was used to compare the means at 5% of significant.

Table 1: Physical and chemical properties of the experimental soil sites during the two cropping seasons of 2014 and 2015.

Soil characteristics	Seasons 2014	2015
Soil texture (%)	**Clay**	**Clay**
clay %	57.00	58.40
sand %	11.40	9.30
silt %	31.60	32.30
pH (1: 2.5 water suspension)	8.30	8.10
EC (dSm-1)	2.1	1.99
Cations (meq/L.)		
Ca+ +	5.2	4.9
Mg+ +	2.2	2.68
Na+	0.6	0.45
K+	13	11.87
Anions (meq/L.)		
HCO3-	3.80	2.50
Cl-	13.11	12.74
SO4- -	4.09	4.66
O.M. (%)	1.83	1.90
Available Mineral N(mg/kg)	39	42

RESULTS AND DISCUSSION

Number of panicles/hill:

Data in Table 2 shows that utilization of nitrogen as urea only for the first and second application increased the number of panicles as compared to the other treatments. Data shows that there are no significant differences between T_1{2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as urea onto drained soil and flooded immediately (Top dressing)}and T_2 {(2/3 of recommended as a urea(Basal application) + 1/3 of recommended as ammonium nitrate in saturated soil then flooded immediately (Top dressing)}in both seasons while the lowest number of panicles was found in T4{2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate onto drained soil and flooded immediately (Top dressing)}.

Nutrients availability and good plant growth may be contributed to increase the number of panicles/hill. It could be concluded that the increase in number of panicles. hill-1 resulted from increasing nitrogen may be due to stimulation effect of branches initiation which gave more panicles. $hill^{-1}$. These results are in quite agreement with those reported by Hemalatha *et al*, (2000)

Panicle length:

The highest panicle length was found in T_1{2/3 recommended as a urea (Basal application) + 1/3 kg N fed^{-1} as urea onto drained soil and flooded immediately (Top dressing)}, followed by T_2 {(2/3 recommended as urea(Basal application) +1/3 kg N fed^{-1} as ammonium nitrate in saturated soil and flooded immediately (Top dressing)}without any significant differences in both seasons and the lowest value of panicle length was found with T_4{2/3 recommended as a urea(Basal application)+1/3 of recommended nitrogen as ammonium nitrate onto drained soil and flooded immediately (Top dressing)}without any significant with T_3 (2/3 recommended as a urea (Basal application) +1/3 of recommended nitrogen as ammonium nitrate in saturated soil and flooded immediately 2 days latter (Top dressing)) and T_5 {2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil(Top dressing) in the first and second seasons (Table 2).

Nitrogen nutrient play role in panicle formation and elongation and for this role, panicle length increased with urea application. This increase of panicle length might be due to the favorable effect of N on rice plants and this encouraged the growth of rice plants and subsequently the excursion of panicle. These results are in agreement with those obtained by Idris and Matin (1990) and Naeem *et al*, (2012).

Panicle weight:

Panicle weight was significantly higher with urea only. Significant increase in panicle length may be result in significant increase in panicle weight (Tables 2). The urea and ammonium sulfate had difference in panicle weight. Different results were observed with, Chaturvedi (2005) who found highest grain weight panicle^{-1} with ammonium sulfate and lowest with urea.

Table 2: Panicles number. hill^{-1}, panicle length(cm), panicle weight(g) and one thousand grain weight(g) as affected by different nitrogen treatments in 2014 and 2015 seasons.

Treatment	2014				2015			
	No. of panicles/hill	Panicle Length(cm)	Panicle Weight(g)	1000-grain weight(g)	No. of panicle/hill	Panicle Length(cm)	Panicle Weight(g)	1000-grain weight(g)
T_1	25.20a	23.40a	4.850a	27.70a	25.40a	24.60a	5.200a	28.20a
T_2	24.00ab	22.20ab	4.330b	27.50a	24.20ab	23.40ab	4.730b	28.00ab
T_3	23.00bc	21.80b	4.310b	26.50ab	23.20bc	23.00b	4.710b	27.00abc
T_4	20.50d	21.10b	3.230d	24.50c	20.70d	22.20b	3.630d	25.00c
T_5	21.30cd	21.80b	3.540c	25.50bc	21.50cd	23.00b	3.940c	26.00bc

The lowest panicle weight was obtained with the application of the second dose of urea as ammonium nitrate apply onto drained soil and flooded immediately (T_3). This may be due to the shortage of available nitrogen under fertilization with ammonium nitrate due to losses by leaching and denitrification. Generally, grain weight is affected by environmental conditions during the process of grain filling (Kausar *et al.*, 1993).

Thousand grain weight:

One 1000-grain weight affected significantly by application of urea and ammonium sulfate as a second dose of nitrogen fertilizer. The highest value of 1000-grain weight (g) was found in T_1 (2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as a urea onto drained soil and flooded immediately (Top dressing) followed by T_2 (2/3 recommended as a urea(Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil then flooded immediately (Top dressing) without any significant differences in both seasons. and the lowest value of1000- grain weight was observed with T_4 {2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate onto drained soil then flooded immediately (Top dressing) (Table 2). The differences of width and length of the grains that were judged partly by genetic makeup of the variety play important role for the variation of 1000- grain. Increase in grain weight with T1 and T2 might be primarily due to improvement of the nitrogen use efficiency that increase the chlorophyll content of leaves which led to higher photosynthetic rate and ultimately plenty of photosynthates available during grain development. Similar finding have been reported by Bhowmick and Nayak (2000).

Number of filled grains panicle^{-1}:

Number of filled grains panicle^{-1} strongly influenced by urea and ammonium nitrate fertilizer (Table 3). Maxium number of filled grains panicle^{-1} was observed when (2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as urea onto drained soil and flooded immediately (top dressing) (T_1) was applied followed by T_2 {(2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil and flooded immediately (Top dressing)}while the lowest was in T_4{2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate onto drained soil then flooded immediately (Top dressing). Adequate supply of nitrogen contributed to grain formation, which probably increased number of filled grains panicle^{-1}. The present results confirmed by the results which obtained by Chander and Pandey (1996).

The trend in number of filled grains panicle^{-1} gave similar trend to panicle length, therefore this parameter might be influenced by the panicle length. The panicle length observed with the nitrogen fertilizer was compatible with Witt *et al*. (2007) findings they found that nitroge absorbed at sowing, tillering and panicle initiation stage in rice plant ensured a good number of panicles with increased number of spikelet panicle^{-1} that contribute to increase grain number panicle^{-1}.

Grain and straw yields:

It is important to notice that increase in panicle length, number of filled grains panicle^{-1}, 1000-grain weight caused the highest grain yield. The yield of rice mainly depends on the yield contributing parameters such as number of grains panicle^{-1} ,one thousand and grains weight. Also Physiological parameters play an important role on rice yield, which was supported by Cui-Jing *et al.* (2000). They observed that higher rice yield can achieve by increasing total dry matter.

Results in Table 3 showed that there was a significant impact on grain yield by the application of different urea and ammonium nitrate. The highest grain yield was observed in T_1 (69 kg N fed^{-1} as Urea) {2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as a urea (Top dressing)} which was statistically similar to T_2 2/3 recommended as Urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate in saturated soil then flooded immediately (top dressing)} without any significant differences in both seasons but the lowest grain yield was obtained from T_4 treatment (2/3 recommended as a urea (Basal application) + 1/3 of recommended nitrogen as ammonium nitrate onto drained soil and flooded immediately (top dressing)}. The increase in grain yield may be due to cumulative effect of more panicle length, number of filled grains and panicle weight with urea than ammonium nitrate. The increase in yield with nitrogen fertilizer as a urea only for the first and second application might be due to continuous supply of nitrogen to the soil solution to meet the required nutrients for physiological processes that help for improving the yield. Almost the same trend was found with rice straw. Reddy (2006) reported that application of nitrogen fertilizer as nitrates in the early stages of growth may be did not have any effect because nitrates may be lost by leaching or result to deleterious effects on the plant due to conversion of nitrate to nitrite.

Table 3: Number of filled grains/ panicle, grain and straw yields t.fed^{-1} as affected by different nitrogen treatments in 2014 and 2015 seasons.

Treatments	2014 No. of filled grains/panicle	2014 Grain yield t.fed^{-1}	2014 Straw yield t.fed^{-1}	2015 No. of filled grains/panicle	2015 Grain yield t.fed^{-1}	2015 Straw yield t.fed^{-1}
T_1	132.00a	4.536a	5.289a	136.00a	5.181a	5.973a
T_2	128.00b	4.468ab	5.216b	132.00ab	5.165a	5.853a
T_3	125.00c	4.309b	4.801c	129.00b	4.927b	5.640ab
T_4	110.00e	3.948c	4.283d	114.00d	3.753d	4.960c
T_5	115.00d	4.027c	4.620c	119.00c	4.013c	5.356bc

Nitrogen uptake

Figures 1 and 2 illustrate the treatments effect on the rice uptake. Among all treatments maximum increase in N uptake was found in T_1 (2/3 recommended as urea (Basal application) + 1/3 kg N fed^{-1}} followed by T_2 (2/3 recommended as a urea + 1/3 as a Ammonium nitrate in saturated soil and flooded immediately). This increase in nitrogen uptake might be due to the increase in yield production beside the reduction in nitrogen losses that help for increasing nitrogen absorption. Data also shows that T_4 (2/3 recommended as a urea + 1/3 of nitrogen as ammonium nitrate onto drained soil and flooded immediately) gave the lowest value of nitrogen uptake. This may be due to the losses of nitrogen by leaching. Also the increase in nitrogen uptake with urea as compared to ammonium nitrate may be due to the dominant of nitrogen form as ammonium with urea. Although NH_4^+ uptake requires less energy than that of NO_3, only a few plant species, such as rice, are capable of growing exclusively with NH_4^+ (Kronzucker *et al.*, 1999).

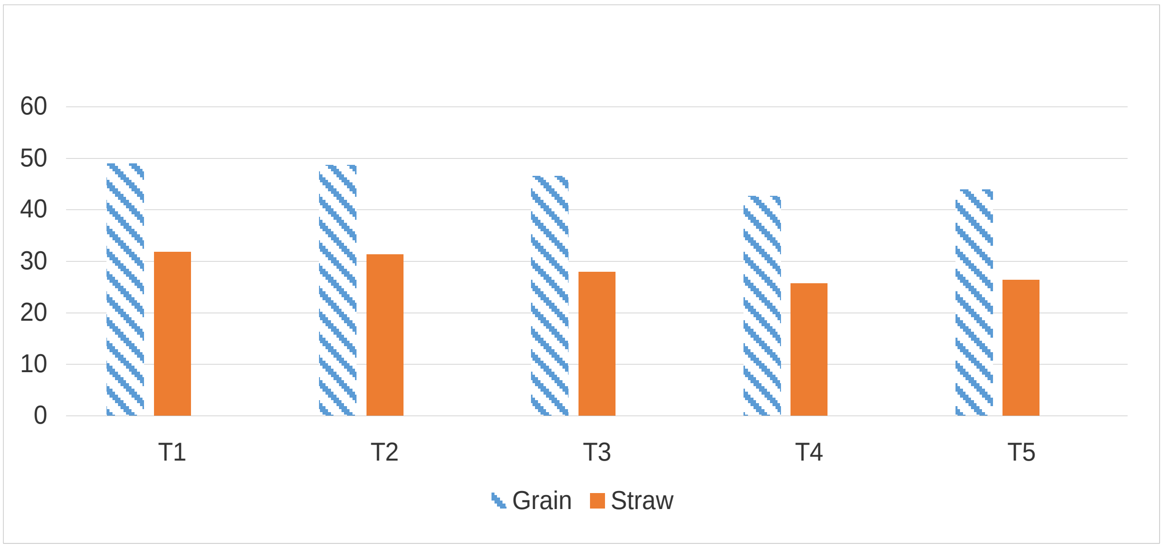

Fig 1: Nitrogen uptake by rice plant (kg/fed) as affected by the application of different nitrogen treatments at harvest in 2014 season.

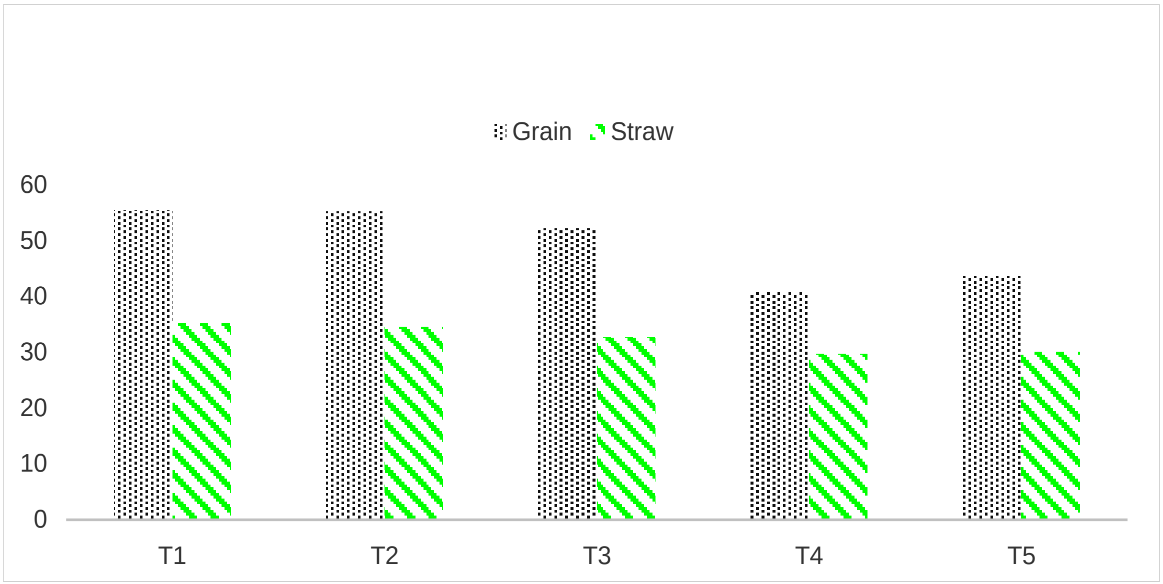

Fig 2: Nitrogen uptake by rice plant (kg/fed) as affected by the application of different nitrogen treatments at harvest in 2015 season.

Available nitrogen:

Data in Figures. 3 and 4 illustrate the effect of different nitrogen treatments on the kinetic changes of available nitrogen (NH_4^+ + NO_3^-) during the growing season. Data indicated that available soil nitrogen decreased continuously with crop growth, reaching the lowest level at harvest. Available soil nitrogen increased in all treatments to a peak after the second dose of nitrogen fertilizer (after 30 days from transplanting), then declined to the minimum at harvest.

Data also showed that, the highest value of available nitrogen after the second dose of nitrogen fertilizer resulted from T_1 (2/3 recommended as urea (Basal application) + 1/3 as urea} followed by T_2 (2/3 recommended as a urea + 1/3 as urea as Ammonium nitrate in saturated soil and flooded immediately). This might be due to addition the second dose of nitrogen as a urea in dry soil then irrigated directly or apply the second dose of nitrogen as ammonium nitrate in saturated soil then irrigated directly reduce the losses of nitrogen by volatilization and leaching. T_4 (2/3 recommended as a urea + 1/3 as ammonium nitrate onto drained soil then flooded immediately) gave the lowest value of available nitrogen . This might be due to the losses of nitrogen by leaching or denitification. Olfati *et al*. (2014) revealed that nitrate forms leach with water, whereas ammonium forms adsorbed to negatively charged soil clay lattice; so that ammonium forms leach less.

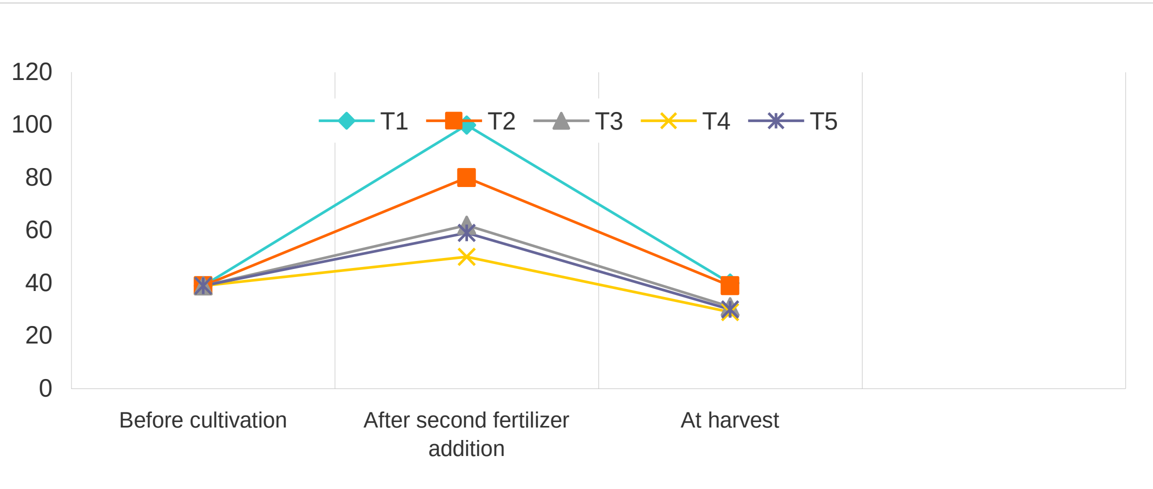

Fig 3: Means of available nitrogen (ppm) as affected by the application of different nitrogen treatments at different times in 2014 season.

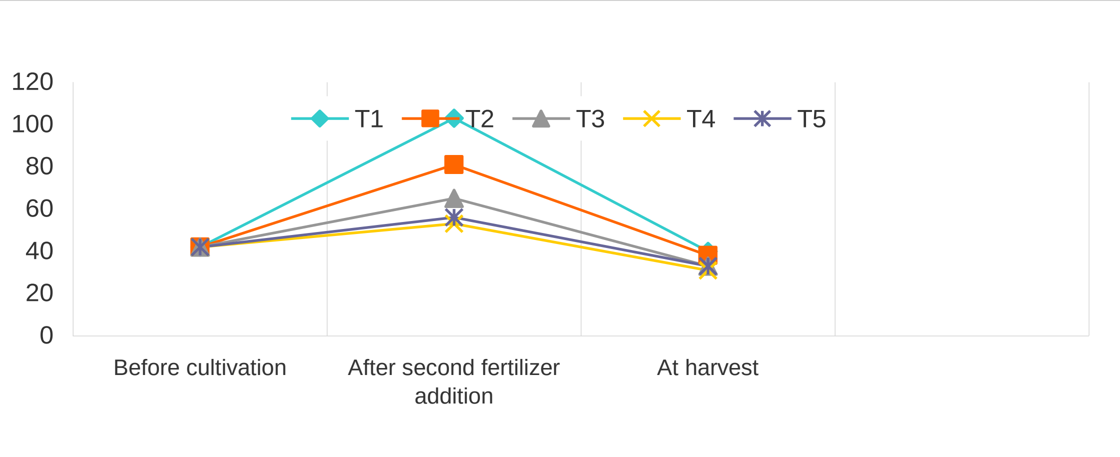

Fig 4: Means of available nitrogen (ppm) as affected by the application of different nitrogen treatments at different times in 2015 season.

CONCLUSION

The objective of the present study was to evaluate the best method to apply the second dose of nitrogen fertilizer as ammonium nitrate. In this study, it was found that if ammonium nitrate applied in saturated soil then irrigated directly, we can expect good yield closed to to the yield of urea fertilizer. Utilization of the right way for applying the fertilizer will increase nitrogen efficiency and reducing nitrogen losses. Great emphasis should be placed to reduce nitrogen losses and enhancing nitrogen efficiency. Nitrite and nitrate contribute in the formation of nitrogenous carcinogenic compound causing human gastric cancer.

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إمكانية استخدام سماد نترات الامونيوم في أراضي الأرز المغمورة

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إجريت تجربتان حقليتان في موسمي ٢٠١٤ , ٢٠١٥ فى مزرعة محطة البحوث الزراعية بسخا. وذلك بهدف دراسة الطريقة المثلي لاضافة سماد النيتروجين كنترات أمونيوم في حالة الضروره اليه كجرعة ثانية في اراضي الارز وذلك مقارنة باليوريا ومعرفة تأثير كل سماد منهما علي المحصول ومكوناته في التجربة التي صممت في قطاعات كاملة العشوائية مع زراعة صنف الارز جيزة ١٧٩. تم استخدام ٥ معاملات تمثلت في الاتي : ثلثي السماد التينروجيني الموصي به (يوريا) + ثلث الكمية (يوريا)في الارض التي تم صرفها ثم تم ريها مباشرة بعد الإضافة، ثلثي السماد التينروجيني الموصي به (يوريا) + ثلث الكمية (نترات الامونيوم)في الأرض المشبعة ثم تم ريها مباشرة بعد الإضافة، ثلثي السماد التينروجيني الموصي به (يوريا) + ثلث الكمية (نترات الامونيوم)في الأرض المشبعة ثم ريها بعد يومين من الإضافة، ثلثي السماد التينروجيني الموصي به (يوريا) + ثلث الكمية (نترات الامونيوم)في الأرض التي تم صرفها ثم تم ريها مباشرة بعد الإضافة، ثلثي السماد التينروجيني الموصي به (يوريا) + ثلث الكمية (نترات الامونيوم)في الأرض المشبعة .

اوضحت النتائج ان اضافة ثلثي كمية النيتروجين في صورة سماد اليوريا عند الزراعه ثم اضافة ثلث الكمية المتبقية كنترات امونيوم في الارض المشبعة ثم الري مباشرة أدي الي الحصول علي افضل النتائج في عدد السنابل/جوره ووزن الـ١٠٠٠ حبه ووزن السنبله والمحصول وكذا الممتص من النيتروجين والمتاح بالتربه وكانت النتائج متقاربه مع النتائج المتحصل عليها في حالة اضافة اليوريا كجرعة اولي وثانيه والتي اظهرت افضل النتائج بين كل المعاملات. واوضحت النتائج ايضا ان اضافة الجرعة الثانية في صورة نترات امونيوم في ارض تم صرفها ثم الري مباشرة بعد الأضافة أدى الى نقص المحصول مقارنة باضافة اليوريا فقط او اضافة ثلثي كمية النيتروجين في صورة سماد اليوريا عند الزراعه ثم اضافة ثلث الكمية المتبقية كسماد نترات امونيوم في الارض المشبعة ثم الري مباشرة .

لذا توصي الدراسة في حالة الاضطرار الي استخدام نترات الامونيوم كجرعه ثانيه من السماد النيتروجيني بضرورة اضافة سماد نترات أمونيوم في الارض المشبعة ثم الري مباشرة.