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Effect of Different Nitrogen Fertilizer Sources on Growth and Rice Yield Under Saline Sodic Soil Conditions

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ABSTRACT

Two filed experiments were conducted during 2015 and 2016 seasons at the Research Farm of El-Sirw Agricultural Research Station, Damietta Governorate, Egypt. The experiments were performed to study the response of Giza179 rice cultivar to eight nitrogen sources Viz; ammonium sulfate (AS), ammonium nitrate (AN), urea (U), Di-ammonium phosphate (DAP), mono ammonium phosphate(MAP), calcium ammonium nitrate (CAN), and calcium nitrate (CN) and potassium nitrate (KN) under saline sodic soil conditions. The experimental soil was clay with salinity level 7.5 and 7.3 dSm^{-1} and sodicity (ESP) level 41and 40% dSm^{-1} in 2015 and 2016 seasons, respectively. The experiment was performed in randomized complete block design and repeated four times. The main obtained results could be summarized as follows; The nitrogen source had significant differences on nutrients leaf contents (NPK), rice growth (leaf area index, dry mater production and chlorophyll content), yield attributes and grain yield in both seasons. Ammonium sulphate showed good and better regarding nitrogen leaf content, while, CAN and KN recorded the highest values of K leaf content. However, DAP and MAP recorded the highest values of P leaf content in both seasons. Ammonium sulphate recorded the highest values of studied growth traits while, the sources contain nitrate (AN, CAN, CN and KN) had the lowest values. The DAP and MAP were comparable regarding their favorable effect on rice growth occupying the second position after ammonium sulphate. The ammonium sulphate had high yield component giving high grain yield followed by DAP and then MAP. Generally, urea or ammonium nitrate as well as any sources contains nitrate is not efficient to apply it for rice under the same saline sodic soil conditions.

Keywords: Saline sodic soil, Rice, N sources**.**

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important crop after wheat. It is a staple food for nearly one half of the world population since most of them live in developing countries. Moreover, it is a very important cereal crop in Egypt for consumption and exportation, in which an important source for hard currency. In Egypt the total rice cultivated area is about 1.54 million fed which produce about 6.08 million tons of paddy rice (RRTC, 2014). Rice is mainly cultivated in the Northern Nile-Delta of Egypt, where, salt affected soils are prevailing. Furthermore, poor quality water is used as irrigation water in the target domain area about (30-35% of rice cultivated area) of salt affected soils. The area of saline soil is expected to increase in Egypt as a result of fresh water shortage and climate change. Rice under saline soil needs especial management rather than normal soil. Nitrogen (N) is usually the most yield-limiting nutrient in lowland rice production. Intensive agricultural production systems have increased the use of nitrogen fertilizer. Urea and ammonium sulfate are the two main sources of inorganic N fertilizer for lowland rice. Nitrogen content is an important criterion; however, other factors should also, be taken into consideration when choosing a fertilizer carrier. These factors include content of nutrients, chemical reactions in soil and nutrient availability to plants in soil. Recovery of N in crop plants is usually less than 50% worldwide (Fageria *et al.* 2010). Worldwide, N recovery efficiency for cereal production (rice, wheat, sorghum, millet, barley, corn, oat, and rye) is approximately 33%. Jan *et al.* (2010), and Fageria *et al.* (2011) Sekhar *et al.* (2014) found that maximum grain yield was obtained at 168 mg N kg^{-1} soil in form of ammonium sulfate and at 152 mg N kg^{-1} soil as urea. Maximum grain yield at average N rate (160 mg kg^{-1}) was 22% higher with the application of ammonium sulfate compared to urea. Rice yield components, N uptake and use efficiency were significantly and positively influenced with the increase of applied ammonium sulfate. Under saline soil conditions, Assefa *et al.* (2009), Fageria *et al.* (2010), Chien *et al.* (2011) and Zayed (2012) found that applied ammonium sulfate as nitrogen source significantly surpassed urea application regarding rice growth (LAI, dry matter, chlorophyll content), number of panicles, number of filled grains/panicle, thousand grain weight, panicle weight, grain and straw yields as well as harvest index. Furthermore, applying ammonium sulfate significantly reduced spikelet sterility resulted in heavy panicle and grains as well as high number of filled grains. The attempt was performed to find out the pertinent N sources under saline sodic soil conditions to fetch imperative rice grain yield.

MATERIALS AND METHODS

Two filed experiments were conducted during 2015 and 2016 seasons at the Research Farm of El-Sirw Agricultural Research Station, Damietta Governorate, Egypt. The experiments were performed to study the response of Giza 179 rice cultivars to various nitrogen sources Viz: AS- ammonium sulfate ($(NH4)_2SO_4$, 20% N), AN- ammonium nitrate (NH_4NO_3, 33%N), U- urea (N_2H_4CO, 46%N), DAP- di-ammonium phosphate ($(NH_4)_2$ HPO_4, 17%N), MAP- mono ammonium phosphate (NH_4 HPO_4, 18%N), CAN- calcium ammonium nitrate ($Ca(NH\ NO_3)_2$ 27%N), CN- calcium nitrate ($Ca(NO_3)_2$, 15%N) and KN- potassium nitrate (K_2NO_3 15%N). Representative soil samples were taken from the experimental sites then were analyzed to chemical soil prosperities followed the standard procedures by Cottenia *et al.* (1979) and Page *et al.* (1982) and the data are listed in Table 1.

The nursery was well fertilized with calcium super phosphate (15.5% P_2O_5) at the rate of 71.5 kg ha^{-1} on the dry soil before plaguing. After bundling zinc sulfate was applied at the rate of 23.8 kg ha^{-1}. Rice seeds of Giza 179 at the rate of 142.8 kg ha^{-1} were soaked, in running water, and incubated for 36 hours each to enhance germination then, pre-germinated seeds were manually broadcasted in the nursery. Weeds were chemically controlled using Saturn

(50%) at the rate of 4.75 liters ha^{-1} dissolved in 200 liters of water which sprayed using Knapsack sprayer seven days after sowing. The rice seeds were sown in nursery bed on April, 25th, in the two seasons of study. The previous crop was Egyptian clover (*Trifolium alexandrinum*, L) in the two seasons of study. The permanent filed soil was well prepared. Calcium super phosphate (15.5% P_2O_5) and potassium sulfate (48% K_2O) were applied in the dry soil before flooding. When the recommended P and K fertilizers were applied, the amounts present combined with some nitrogen sources were deemed to be cut from the recommended rates. The recommended nitrogen rate of 165 kg ha^{-1} for rice under saline soil was applied. Thirty days old seedling was transplanted 20 cm row-to-row, 3-4 seedlings hill^{-1} with 20 cm hill to hill. Each plot included ten rows with five-meter length, (area 10 m^2). The other usual agricultural practices of growing rice were performed as the recommendation of Ministry of Agricultural and Land Reclamation.

Table 1. Chemical soil prosperities of the experimental sites during 2015 and 2016 seasons.

season	pH	ESP	EC dSm^{-1}	Cation meq L^{-1}				Anion meq L^{-1}		
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	SO$_4^{-}$	Cl–	3HCO
2015	8.0	0.41	7.5	24.0	20.0	31	0.30	32.0	40	11
2016	7.9	0.40	7.3	24.0	20.0	29	0.31	30.0	43	12

At heading stage, plant samples (five hills), were randomly taken from each plot to estimate the following characteristics; heading date, Leaf area index, chlorophyll content, dry matter weight, Leaf nitrogen, phosphorous and potassium contents were measured in taken plant samples. Plant height (cm) was measured from the soil surface up to the tallest panicle tip for each plant, however, number of tillers hill^{-1} was estimated. Nutrient rice leaf contents were analyzed according to Yoshida *et al.* (1976). At harvest, ten main panicles were randomly taken to determine the grain yield attributes; i.e., number of panicles hill^{-1}, panicle length (cm), panicle weight (g), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, and 1000-grain weight (g). The grain and straw yields, of six inner rows for each sub plot, were determined and converted into t ha^{-1}, based on 14% moisture content.

All the data collected were subjected to analysis of variance according to (Gomez and Gomez 1984). Treatment means were compared by Duncan's multiple range test (Duncan, 1955). All statistical analysis was performed using analysis of variance technique by means of "COSTAT" computer software package.

RESULTS AND DISCUSSION

1-Nutrients rice leaf contents:

Data allied in Table 2 revealed that the tested nitrogen sources differed significantly regarding the leaf content of the three measured nutrients (NPK), since the nutrient rice leaf contents varied in their response to nitrogen fertilizer sources. It as observed that ammonium sulphate showed good and better regarding nitrogen leaf content in both season. In this concern, Urea and DAP forms were comparable to Ammonium sulphate regarding nitrogen content in both study seasons. Calcium ammonium nitrate came after the above mentioned nitrogen sources in its effect on N% of rice leaf. However, potassium nitrate and ammonium nitrate gave the lowest values of N% in rice leaf in both seasons. The N sources corresponding to high N% in rice leaf might be improved soil proprieties and induced such soil reclamation in the soil reflected nitrogen availability and its uptake.

Table 2. Nutrients leaf content (NPK) of rice as affected by different N sources under saline sodic soil in 2015 and 2016 seasons.

Nitrogen source	N%		P%		K%	
	2015	2016	2015	2016	2015	2016
AS	2.73a	2.61a	0.171ab	0.173ab	1.89cd	1.79cd
AN	2.37c	2.35c	0.153b	0.159b	1.58e	1.53e
U	2.66a	2.59a	0.154b	0.151b	1.79d	1.72d
CAN	2.40b	2.51ab	0.132.c	0.128c	2.18a	2.18a
DAP	2.61a	2.6a	0.192a	0.196a	1.92bc	1.95bc
CN	2.22c	2.17c	0.136c	0.137abc	2. 18b	2.15b
MAP	2.51b	2.45b	0.197a	0.199a	1.90c	1.93c
KN	2.32c	2.20c	0.167b	0.163b	2.38a	2.34a
F test	**	**	**	**	*	**

In a column, means followed by a common letters are not significantly different at 5 % level according to DMRT.

The other N forms failed to increase N% that owing to its high nitrogen losses under submerged conditions. Regarding P % in rice leaf, great variation in rice leaf P content was due to various nitrogen forms in this study and that was hold true in both seasons. The nitrogen sources contain phosphate nutrient (DAP and MAP) exerted high P content of rice leaf followed by ammonium sulphate and calcium ammonium nitrate (Table 2). The favorable effect of forms containing phosphate contributed to increase the P availability of soil solution. With respect to response of K leaf content to varying N forms, the form containing potassium (KN) also, elevated K leaf content followed by calcium ammonium nitrate sulphate. Potassium nitrate gave the highest values of leaf content in both seasons without any significant differences with those recorded by calcium ammonium nitrate. Mono- and di-ammonium phosphate came in the last order regarding its effect on K leaf content. The ammonium sulphate occupied the fourth rank that might be due to its high NH_4 content restricted K uptake. Similar findings have been reported by Fageria *et al.* (2010), Zayed (2012) and Sekhar *et al.* (2014).

2-Growth characteristics:

Data in Tables (3 and 4) showed that nitrogen sources had a significant difference on all the studied traits in both seasons. Ammonium sulfate gave the highest values of leaf area index and came in the second rank for dry matter production. At the same time, di-ammonium phosphate produced the highest dry matter in both seasons that might be due to its efficiency to increase adenosine-triphosphate (ATP) compound resulted in higher activity of metabolism and differentiating as well as dry matter production. Calcium ammonium nitrate gave the highest values of chlorophyll content in both seasons that could be attributed to enhancing plant pigment formation by increasing Mg and N uptake as result of decreasing Na^+ and improving rice growth. As previously mentioned applying different sources on nitrogen increased the various nutrients such as NPK that might alleviate the harmful effect of salt, elevate it growth and tolerance. From going discussion, the improved previous mentioned items by studied N forms, particularly ammonium sulphate reflected tillers number since ammonium sulphate gave the highest values of it and tallest plants in both seasons.

Table 3. Leaf area index, dray matter and chlorophyll content of rice as affected by different N sources under saline sodic soil in 2015 and 2016 seasons.

Nitrogen	Leaf area index		Dray matter (g m^{-2})		Chlorophyll content	
source	2015	2016	2015	2016	2015	2016
AS	6.05a	5.75a	48.00ab	46.27ab	42.47bc	41.10cd
AN	3.59d	3.44d	33.9c	33.9c	44.08ab	42.80ab
U	5.29b	5.06b	41.53bc	40.3bc	43.34ab	42.20abc
CAN	3.67d	3.31d	44.17abc	42.77abc	44.63a	43.33a
DAP	4.27c	5.14c	50.5a	48.9a	41.40c	40.20d
CN	3.59d	3.43d	38.87bc	42.2abc	42.84bc	41.46bcd
MAP	4.64c	4.18c	39.27bc	37.13bc	44.01ab	42.73ab
KN	3.00e	2.94e	35.67c	34.43bc	42.81bc	41.56bcd
F test	**	**	**	**	*	**

In a column, means followed by a common letters are not significantly different at 5 % level according to DMRT.

Regarding the flowering date, it was significantly affected by various investigated nitrogen sources in both seasons of study (Table 4). It was marked that nitrogen sources containing phosphorous significantly shortened the period from sowing to heading date that might due to phosphorous in the term of DAP and MAP accelerated fluorine hormones that fasten heading panicle exertion and flowering. The rest of N forms were at par regarding flowering date. The current data are in good harmony with those reported by Fageria *et al.* **(**2010), Zayed (2012) and Sekhar *et al.* (2014).

Table 4. Some growth traits of rice as affected by different N sources under saline sodic soil in 2015 and 2016 seasons

Nitrogen	Flowering (day)		Plant height (cm)		Number of tillers $hill^{-1}$	
source	2015	2016	2015	2016	2015	2016
AS	90.32a	92.16a	97.08a	96.66a	24.82a	23.41a
AN	90.81a	92.66a	76.32e	80.08cd	16.78de	15.83de
U	90.32a	92.16a	85.84cd	85.41bc	20.37bc	19.21bc
CAN	90.32a	92.16a	85.34cd	84.91bc	18.02cde	17.00cde
DAP	85.98c	87.73c	89.10bc	87.91b	21.82b	20.58b
CN	90.65a	92.5a	80.48de	75.91d	18.99bcd	17.91bcd
MAP	86.83b	88.60b	93.38ab	92.91a	19.43bcd	18.33bcd
KN	90.32a	92.16a	83.19d	82.75bc	15.61e	14.73e
F test	*	**	**	**	*	**

In a column, means followed by a common letters are not significantly different at 5 % level according to DMRT.

3-Yield components

Data listed in Table (5 and 6) showed that the tested nitrogen sources markedly affected all yield components, (number of panicles, panicle length, panicle weight, number of filled grains $panicle^{-1}$, number of unfilled grains, panicle weight, 1000-grain weight) in 2015 and 2016 seasons. The data related to above-mentioned traits came to confirm the superiority of ammonium sulphate since it gave the highest values of yield components in both seasons. Di-ammonium phosphate and mono-ammonium phosphate came immediately after ammonium sulfate in this concern and urea form recorded third order. CAN showed reasonable amount to some extent in the issue. Ammonium sulphate possessed the lowest values of unfilled grains $panicle^{-1}$, while, the ammonium nitrate had the highest values of unfilled grains $panicle^{-1}$.

On the other hand, the lowest values of all above-mentioned traits were recorded by potassium and calcium nitrate or/ and ammonium nitrate among the nitrogen sources in 2015 and 2016 seasons (Tables, 5 and 6). The advantages of ammonium sulfate mainly as source for both of nitrogen and sulfur assimilated might have played a vital role in growth and development of rice plants because of their active role in plant metabolic processes. Also, application of ammonium sulfate might improve soil physical and chemical proprieties, under current saline soil with high pH which, in turn, resulted in improving nutrients availability, low pH and bulk density leading to increase rice salt tolerance, improve rice growth, proper yield components and subsequently high grain yield. Also, ammonium had ability to increase soil aggregates resulted in improving system of soil drainage. Losses happened from nitrogen under sodic condition is more from urea but it is less from ammonium for that can deemed as one of the beneficial effect of ammonium sulphate. Sulfur in exciting in ammonium sulphate is playing district role in amino acids formation that could increase rice salinity tolerance. Sulfur bridge formed under sodic soil protect cytoplasmic protein from degradation that might be boosted rice slat tolerance and its survival, as well as improving rice growth, resulted in higher grain yield components. As previously seen ammonium sulfate showed its favorability in most of studied traits in both seasons that are mainly contributed to the readily soluble nature of the former. Regarding the benefit effect of DAP or MAP that might be due the present of phosphate which increase the availability of P in saline sodic soil relieving its deficiency reflected nucleic acids and ATP formation a resulted in higher growth rate and well yield components. Furthermore, the role of nitrogen present in DAP and MAP at the form of NH_4 that plant can take without more energy for reduction, saving energy and converted it directly to amino acids. The excessive of P in soil solution reduced rice plant chloride uptake and keep them healthy. The low effective of urea under saline sodic soil might be due to nitrogen losses via volatilization. The failure of forms involving NO3 such as KN (KNO_3), AN (NH_4NO_3) and so on that is probably due to nitrogen losses by NO_3 leaching under submerged saline sodic soil. The form of CAN had a reasonable improvement in rice growth and yield components that because Ca remediation and removing Na present in saline sodic soil. Similar findings were reported by Assefa *et al.* (2009), Chien *et al.* (2011), Zayed *et al.* (2012) and Sekhar *et al* (2014).

Table 5. Some yield components of rice as affected by different N sources under saline sodic soil in 2015 and 2016 seasons.

Nitrogen source	Number of panicles hill^{-1} 2015	Number of panicles hill^{-1} 2016	Panicle length (cm) 2015	Panicle length (cm) 2016	Panicle weight (g) 2015	Panicle weight (g) 2016
AS	23.42a	22.09a	18.53a	18.53a	3.59a	3.40a
AN	15.30de	14.43de	16.00cd	16.33bcd	2.92bc	2.77bc
U	18.92bc	17.85bc	17.66abc	17.71abc	2.56cd	2.42cd
CAN	16.55cde	15.61cde	16.23cd	16.90a-d	2.77bcd	2.62bcd
DAP	20.38b	19.23b	16.80bcd	16.13cd	3.18ab	3.14cd
CN	17.53bcd	16.54bcd	18.00ab	18.00ab	2.52cd	2.39cd
MAP	17.98bcd	16.96bcd	17.90ab	18.08ab	3.09b	2.93b
KN	14.12e	13.32e	15.80d	15.80d	2.31d	2.18d
F test	**	**	**	**	**	**

In a column, means followed by a common letters are not significantly different at 5 % level according to DMRT.

Table 6. Some yield components of rice as affected by different N sources under saline sodic soil in 2015 and 2016 seasons.

Nitrogen source	1000-grain weight (g) 2015	1000-grain weight (g) 2016	Filled grains panicle^{-1} 2015	Filled grains panicle^{-1} 2016	Unfilled grains panicle^{-1} 2015	Unfilled grains panicle^{-1} 2016
AS	28.21a	27.96a	106.16a	97.40a	15.31c	13.33c
AN	24.48d	24.23d	83.56c	76.66c	30.85a	28.00a
U	27.51a	27.26a	94.90b	87.06b	18.04bc	15.66c
CAN	25.38c	25.13c	99.91b	91.66b	20.85b	18.01bc
DAP	26.61b	26.36b	105.29a	96.60a	18.50bc	16.00bc
CN	28.35a	28.10a	83.56c	76.66c	32.45a	29.60a
MAP	27.61a	27.36a	100.1b	91.80b	22.71b	19.86b
KN	24.18d	23.93d	85.31c	78.26c	29.51a	26.66a
F test	**	**	**	**	*	**

In a column, means followed by a common letters are not significantly different at 5 % level according to DMRT.

4-Yields

Data in Table (7) indicate that various nitrogen sources had pronounced effect on rice yields (grain and straw yields) as well as harvest index in couple study seasons.

Table 7. Yields of rice as affected by different N sources under saline sodic soil in 2015 and 2016 seasons.

Nitrogen sources	Grain yield (t ha^{-1}) 2015	Grain yield (t ha^{-1}) 2016	Straw yield (t ha^{-1}) 2015	Straw yield (t ha^{-1}) 2016	Harvest index 2015	Harvest index 2016
AS	6.94a	6.73a	7.99a	7.83a	0.465a	0.463a
AN	4.52d	4.39d	6.12c	6.00c	0.425b	0.422b
U	6.31b	6.13b	7.24abc	7.58ab	0.468a	0.465a
CAN	5.55c	5.39c	6.61bc	6.72abc	0.456ab	0.454a
DAP	6.80ab	6.60ab	7.82ab	7.66ab	0.465a	0.462a
CN	5.27c	5.12c	6.85abc	6.18c	0.436ab	0.433ab
MAP	6.28b	6.10b	7.73ab	7.10abc	0.448ab	0.445ab
KN	5.45c	5.29c	6.31c	6.48bc	0.463a	0.433ab
F test	**	**	**	**	*	*

In a column, means followed by a common letters are not significantly different at 5 % level according to DMRT.

Interestingly, ammonium sulphate is being the superior N form, whereas, it gave the maximum values of rice grain yield, straw yield and harvest index in both seasons of study. Urea occupied the second order after ammonium sulphate and DAP come in the third rank followed by MAP. It was clear that applying ammonium sulphate as N form had high affinity to increase dry matter partitioning and improve rice grain filling in terms of panicle characteristics resulted in more grain yield against straw yield. The latter advantage of usage of ammonium sulphate and urea as well as DAP and MAP under saline sodic soil enable plants to produce high harvest index in the terms of economic yield. On contrary, the forms containing NO_3 produced the lowest yields in both seasons (Table7). The obtained high yield with ammonium sulphate are attributed to their beneficial in improving nutrient plant content rice growth , yield attributes and main yield components. Several authors such as Fageria *et al.* (2010**),** Zayed (2012) and Sekhar et al (2014) reported similar findings.

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تأثير مصادر مختلفة من السماد النيتروجينى على نمو ومحصول الأرز تحت ظروف الأرض الملحيه الصوديه

بسيوني عبد الرازق زايد ، وائل حمدي الكلاوي ، محمد محمد عبدالحميد و اميرة محمد عكاشه
قسم بحوث الأرز – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – مصر

أجريت تجربتان حقليتان بالمزرعة البحثية بمحطة بحوث السرو الزراعيه بدمياط مصر خلال موسمي ٢٠١٥و٢٠١٦م. بهدف دراسة استجابة صف الارز جيزه ١٧٩ لمصادر مختلفه السماد النيتروجيني وهي كبريتات الامونيوم (٢٠% ن)، نترات النشادر(٣٣.٥% ن), اليوريا (٤٦% ن)، ثنائي فوسفات الامونيوم (١٨% ن)، واحادي فوسفات الامونيوم (١٨% ن)، نترات الامونيوم الكالسوميه (٢٧% ن)، ونترات الكالسيوم (١٥% ن)، ونترات البوتاسيوم (١٥% ن): وكانت التربه التي اقيمت بها التجربه طينيه ومستوى الملوحه بها ٧.٥ و٧.٣ديسم والصوديه كانت ٤١ و ٤٠% في موسمي الدراسة ٢٠١٥ و٢٠١٦ م. وقد استخدم تصميم القطاعات الكامله العشوائيه في أربعة مكررات.وقد تم تقدير صفات النمو و المحصول و مكوناته. ويمكن تلخيص اهم النتائج المتحصل عليها كالاتي:كان لمصادر السماد النيتروجيني تاثيرمعنوي على محتوي النبات من بعض العناصر (NPK) وصفات النمو (دليل مساحة الأوراق والوزن الجاف ومحتوى الكلوروفيل وعدد الفروع وطول النبات) ومحصول الحبوب ومكوناته في كلا موسمي الدراسه حيث اظهرت النتائج ان مصادر النيتروجين اختلفت معنويا في تاثيرها علي محتوي النبات من العناصر المقدرة وهي النيتروجين والفسفور والبوتاسيوم حيث أعطي المصدر النيتروجيني سلفات الامونيوم أعلي محتوي ورقي للنتروجين وكلا من ثنائي فوسفات الامونيوم واحادي فوسفات الامونيوم أعلي محتوي فسفوري ونترات البوتاسيوم أعلي محتوي بوتاسي. وفي نفس الوقت فقد أعطت سلفات الامونيوم أعلي القيم لصفات النمو وأعلى محصول و مكوناته في كلا موسمي الدراسه. كما وجد ان ثنائي فوسفات الامونيوم و احادي فسفات الامونيوم تلت في أفضليتها سلفات الامونيوم . أوضحت النتائج أن أي مصدر نيتروجيني يحتوي علي النترات سواء كان منفردا او مع الامونيوم مثل نترات النشادر او نترات الكالسيوم او نترات البوتاسيوم لم تظهر أي كفاءه عاليه في تحسين النمو او المحصول كما كان مفترضا. وتوصى هذه الدراسة بزراعة الأرز فى مثل هذه الأراضى مع إضافة سلفات الأمونيوم كمصدر للسماد النيتروجينى لإعطاء أعلى محصول من الأرز.