EFFECTS OF TWO NITROGEN FERTILIZERS ON WATER QUALITY AND HYBRID TILAPIA PERFORMANCE IN FISH FARMS

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EFFECTS OF TWO NITROGEN FERTILIZERS ON WATER QUALITY AND HYBRID TILAPIA PERFORMANCE IN FISH FARMS

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ABSTRACT

The purpose of the present study was to compare the effect of urea and ammonium nitrate (AN) as nitrogen fertilizer sources with mono superphosphate (MSP) on water quality and the productive performance of hybrid tilapia fish in outdoor fish ponds. This work was conducted for 86 days using six 1000 m2- earthen ponds to evaluate three treatments with two replicates each. Ponds were divided into three groups, the 1st didn't receive any fertilizers (control), while the 2nd received 17.2 kg urea + 33.2 kg MSP /fed./week, and the 3rd received 24.2 kg ammonium nitrate + 33.2 kg MSP /fed./week. Tilapia hybrid fry (*Oreochromis niloticus x Oreochromis aureus*) were stocked with an average initial weight of 1.5 g with stocking rate of 1.5 fish/m^2. Random fish samples (45 fish/pond) were taken monthly throughout the experimental period and individual body weight were recorded for each sample. Water samples were weekly taken for physical, chemical and biological analyses. Dissolved oxygen, pH, SD, total ammonia nitrogen (TAN), NO_2, NO_3 total alkalinity, total hardness, total phosphorus, orthophosphate, and chlorophyll "a" were determined. There were no significant differences between Urea+MSP and AN+MSP treatments in all water quality parameters except for orthophosphate which were higher in AN+MSP than Urea+MSP dissolved oxygen and chlorophyll "a" which were higher in the Urea+MSP than AN+MSP. Results revealed that AN+MSP treatment had an average individual weight of 99.09 g/fish vs. 96.01 g/fish for Urea+MSP then 62.35 g/ fish for control and total fish yield of 514.98 kg/fed., 495.32 kg/fed. and 150.52 kg/fed for the three treatments respectively). AN+MSP treatment achieved slightly higher utilization efficiency and fertilization cost than Urea+MSP. Urea+MSP treatment achieved higher relative rank of 298 comparing to 263 for AN+MSP.

INTRODUCTION

Aquaculture is considered an important source of fish production for meeting the world's increasing demand for animal protein. Today, more than half of the world's population depends on fish as a principal source of animal protein, so the demand for fish is expanding rapidly throughout the world. In addition to its high nutritional value and its top rank among all other protein sources, either from plants or animals; fish is easily digestible, so fish production should be increased in developing countries to meet the demand of the increasing population. Tilapia one of the most common fish in Egypt as well as all world countries and it is the main cultured fish species in Egypt, contributing 43.5% of farmed fish production and 24% of total fisheries production (GAFRD 2007).

Nile tilapia (*Oreochromis niloticus*) is one of the widely farmed tilapia species in tropical countries. This is because they feed low in food chain and also consume a wide variety of materials. Production in developing countries occurs mainly in semi-intensive ponds, where cheap feed supplements and fertilizers are applied to produce low-cost fish (Waidbacher, et al., 2006).

Knud Hansen and Batterson (1994) reported that the principal reason of fertilizing aquaculture ponds is to increase phytoplankton activity to produce natural food for cultured fish species.

Nitrogen plays an important role in the dynamics of aquaculture systems due to its dual role, in various forms as a nutrient and toxicant (Burford and Lorenzen 2004, El shafai et al., 2004). Urea quickly hydrolyzes to ammonia nitrogen in water, and ammonium salts dissolve to provide water with ammonia nitrogen which is the preferred source of nitrogen for phytoplankton (Wetzel 2001). However, there are disadvantages to ammonia nitrogen where it nitrified to nitrate, and this process consumes a considerable amount of dissolved oxygen and produces hydrogen ions that neutralize alkalinity and depress pH (Tepe and Boyd, 2001).

Abdalla *et al.* (1996) pointed out that nitrogen fertilizer applications usually produce an increase in total ammonia nitrogen (TAN). In pond's water TAN is present primarily as ammonium ion (NH_4) and as un–ionized ammonia (NH_3) the latter form is toxic to many aquatic organisms, especially fish.

The present study was aimed to compare the effect of urea and ammonium nitrate as nitrogen fertilizer sources with mono superphosphate on water quality and the productive performance of tilapia fish.

MATERIALS AND METHODS

Six experimental earthen ponds (1000 m^2 each) with the same approximately average depth of 1.25 m located at the Central Laboratory for Aquaculture Research (CLAR), Abbassa, Sharkia governorate, Egypt, were used to perform this study.

Urea (46% N), Ammonium nitrate (AN, 33% N) and mono superphosphate (MSP, 15.5% P_2O_5) were used as inorganic fertilizers in this study, all of these fertilizers were added after being dissolved in an amount of the same pond water that it will apply in, then the liquid mixture of water and fertilizer was spread over the water surface. Artificial fish feed (25% crude protein) with 3% of fish biomass was applied in all experimental treatments along the experimental period.

The experiment included three treatments. The first one was the control, where no fertilizers were added. The second was the addition of urea plus mono superphosphate (Urea+MSP) and the third was the addition of ammonium nitrate plus mono superphosphate (AN+MSP) as shown in table 1. All fertilizers were added to maintain the same concentration of nitrogen from both nitrogen fertilizers (urea and A. nitrate) and phosphorus from mono superphosphate in all fertilized ponds.

Table (1) Amounts of fertilizers (kg/fed/week) with nutrient percentages added to all ponds

Item	Control	Urea+MSP	AN+MSP
Urea (46% N)	-----	17.2	-----
A. nitrate (33% N)	-----	-----	24.2
Mono superphosphate (15.5% P_2O_5, 6.77% P)	-----	33.2	33.2
Total nitrogen (N)	-----	7.91	7.99
Total phosphorus (P)	-----	2.25	2.25

Pond water level was maintained at a constant depth of 100 cm, water losses through evaporation and seepage were compensated through adjusted irrigation gate from a water channel, ponds were randomly allocated to the three experimental treatments (control, Urea+MSP and AN+MSP treatments), each with two replicates.

Tilapia hybrid fry (*Oreochromis niloticus x Oreochromis aureus*) of about 1.5 ± 0.5 g initial weight were purchased from Abbassa fish hatchery (5 km from CLAR) then fish were acclimated to pond conditions by holding the closed fish bags in the same pond in which the experimental work was to be carried out for at least 30 minutes, the bags were opened and fish started to swim freely out of bags, each pond was cultivated with 1500 fish fry (1.5 fish/m^2). The experiment lasted for 86 days.

Water samples from each pond were taken weekly at 9 o 'clock using the column sampler (Boyd, 1990) "which allow collecting of water sample from the whole water column" from five spots from each pond then all of these five subsamples were mixed in a plastic bucket then one liter of this mixture considered a representative water sample. Then the following water quality parameters were measured, water temperature (°C), dissolved oxygen (DO), pH, Secchi disk (SD), total ammonia nitrogen (TAN), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), total alkalinity (T.Alk.), total hardness (TH), total phosphorus (TP), orthophosphate (OP) and chlorophyll "a". Temperature and dissolved oxygen were measured using dissolved oxygen meter model YSI 57. Values of pH were assessed by Hach comparison apparatus following the method described by APHA (1985). Total alkalinity, total hardness and total phosphorus concentration were measured according to APHA (1985). TAN was measured by Hach comparison method (APHA 1970).

Chlorophyll "a" was determined photometrically according to Vollenweider (1969**)** by using spectrophotometer (model Milton Roy 21D).

Fish samples were taken monthly to adjust feeding rates and to observe fish growth, samples were collected at early morning using a drawling net. Fish sample from each pond was counted and weighed, and then average individual weights were calculated.

Statistical analysis was performed using one-way analysis of variance (one-way ANOVA) and Duncan's multiple range test to determine differences among treatments.

Means at significance level of ($P \leq 0.05$) considered significant all statistical evaluations were carried out using the Statistical Analyses System package (SAS, 2009)

RESULTS AND DISCUSSION

Water quality

Data presented in Table (2) show that there was no significant effect on water temperature among the three treatments during the experimental period whereas the concentration of dissolved oxygen (DO) in ammonium nitrate and urea were significantly lower than the control. The significant decrease in oxygen concentration in the AN+MSP and Urea+MSP treatments are due to (as shown later in table, 2) their higher fish biomass (514.9 kg/feddan and 495.32 kg/feddan, respectively) than that obtained in the control group (150.5 kg/ feddan).

Values of pH in the AN+MSP and Urea+MSP treatments were significantly higher than the control as a result of removing CO_2 by phytoplankton cells (expressed as chlorophyll a) which were higher in both fertilizer treatments 281.98 and 207.96 µg/l in the Urea+MSP and AN+MSP respectively, than in control 125.89 µg/l. Same results were obtained for total alkalinity (T.Alk.), total hardness (TH) and Secchi disk (SD) which were significantly lower in AN+MSP and Urea+MSP treatments than control, which could be described by the same reason mentioned for pH. Ibrahim (2001) reported that phytoplankton require carbon (C) in the form of carbon dioxide (CO_2) or in any other forms.

The higher values ($p<0.05$) of TAN, nitrate and nitrite in AN+MSP and Urea+MSP treatments than control may attributed to the using of urea and ammonia nitrate as nitrogen sources in both treatments, as well as the release of more ammonia from the grown fish in both treatments as a result of the bigger fish biomass in both treatments than control (as shown in table, 2).

Table (2): Limnological characteristics (means ± SE) of pond waters treated with the three different treatments through the experimental period.

Parameters	Treatment		
	Control	Urea+MSP	AN+MSP
Temp. (^oC)	27.7 ± 0.17	27.7 ± 0.15	27.6 ± 0.15
DO (mg/l)	6.33a ± 0.08	5.81b ± 0.18	5.33c ± 0.18
pH	8.6b ± 0.04	9.1a ± 0.05	9.2a ± 0.06
SD (cm)	12.8a ± 0.37	10.5b ± 0.35	10.2b ± 0.37
TAN (mg/l)	0.58b ± 0.01	0.70a ± 0.01	0.71a ± 0.01
NO_2 (mg/l)	0.039b ± 0.003	0.054a ± 0.003	0.054a ± 0.005
NO_3 (mg/l)	0.352b ± 0.043	0.463a ± 0.037	0.451a ± 0.054
T.Alk. (mg/l)	190.8a ± 2.6	155.0b ± 2.71	160.21b ± 3.2
T.H. (mg/l)	150.27a ± 2.28	128.0b ± 2.64	128.1b± 3.01
T.P. (mg/l)	0.522b ± 0.03	1.014a ± 0.06	1.025a ± 0.04
O.P. (mg/l)	0.102c ± 0.005	0.173b ± 0.011	0.216a ± 0.017
Chl. “a” (µg/l)	125.89c ± 7.96	281.98a ± 29.8	207.96b ± 16.38

Means in the same row with different letters are significantly different (P≤0.05).

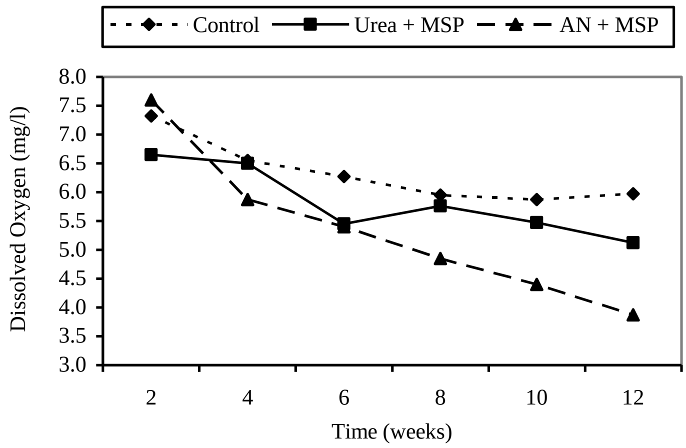

Figure (1) Dissolved oxygen fluctuation in the three treatments throughout the experimental period

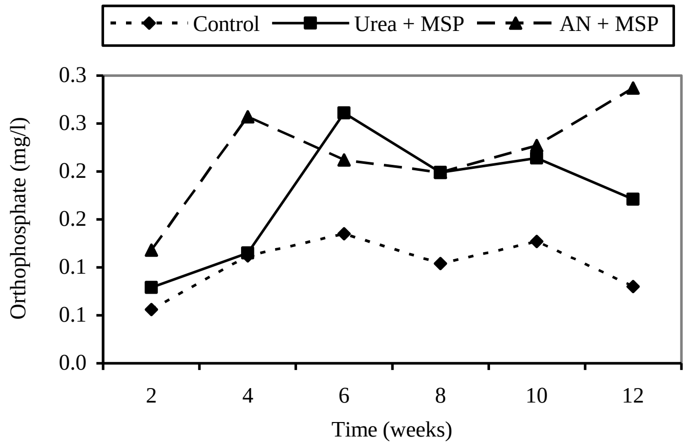

Figure (2) Orthophosphate fluctuation in the three treatments throughout the experimental period

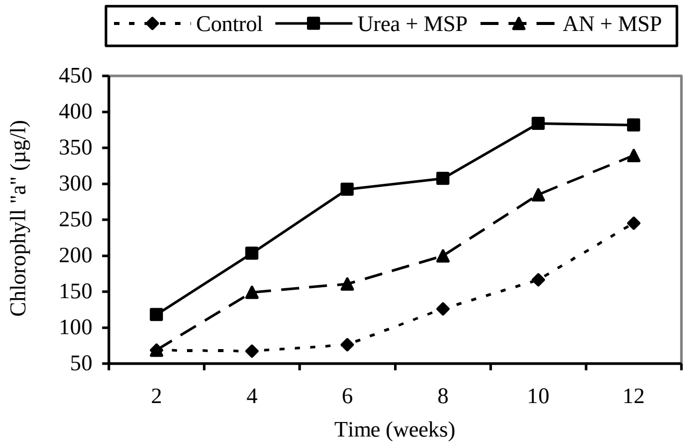

Figure (3) Chlorophyll “a” fluctuation in the three treatments throughout the experimental period

Moreover the higher ($p<0.05$) total phosphorus (TP) and orthophosphate concentrations (OP) of AN+MSP and Urea+MSP treatments may possibly related to the addition of mono super phosphate in both treatments. All water quality parameters were not significantly differed in both fertilization treatments (Urea+MSP and AN+MSP) except for dissolved oxygen (Fig. 1), orthophosphate (Fig. 2) and Chlorophyll “a” (Fig. 3), where, DO was higher in the urea treatment than that in the nitrate treatment which could explained by increasing fish biomass in nitrate treatment (514.98 kg/fed) comparing to urea treatment (495.32 kg/fed, although not significant, Pawar et al., 2009 and EL-Khaldi, 2010). OP had significant higher concentrations in the AN+MSP treatment (0.216 mg/l) than Urea+MSP (0.173 mg/l), while Chlorophyll "a" which follow this order Urea+MSP, AN+MSP and control (281.98, 207.96 and 125.89 µg/l respectively) which maybe explained by the availability of the nutrients (P and N) in the AN+MSP (El-Mashjary and Ali, 2010) and Urea+MSP treatments and the higher grazing rate in AN+MSP treatment than that in the Urea+MSP treatment.

Fish performance

As indicated in Table (3) AN+MSP and Urea+MSP ponds had significantly higher total net fish yield, total net daily gain and net average individual weight, (504.69 and 485.78 kg/fed., 5.86 and 5.64 kg/fed./day 99.09 and 96.01 g,) which were higher than control ponds (140.68 kg/fed., 1.64 kg/fed./day and 62.35 g,). These may due to: 1) the increase of natural food in the two fertilization treatments than in the control treatment, 2) higher releasing rate of phosphorus and nitrogen from Urea+MSP and AN+MSP fertilizers and 3) improved water chemical, physical conditions and as much as abundance of phytoplankton (higher chlorophyll "a" concentration) which enhance zooplankton and ultimately enhance fish growth (Jacob and culver, 2010). Fish performance parameters showing no significant differences between both fertilization treatments (Urea+MSP) and AN+MSP). Although they were slightly higher in the side of AN+MSP treatment.

Fertilizer utilization efficiency

The best fertilizer is that fertilizer which not only produces a greater fish production, but produces a greater fish production using smaller units, in order to maintain the environment. This could be measured by calculating the fertilizer

Table (3) Effect of the three different treatments on hybrid tilapia growth performance (means ± SE) throughout 86-growout experiment.

Parameters	Treatment		
	Control	Urea+MSP	AN+MSP
Total initial fish weight (kg/fed)	9.84 ± 0.21	9.54 ± 0.30	10.26 ± 0.39
Total fish yield (kg/fed.)	150.52b ± 11.1	495.32a ±13.8	514.98a ± 9.01
Total net fish yield (kg/fed.)	140.68b ±11.2	485.78a ± 13.3	504.69a ± 8.90
Survival percentage (%)	40.17b ± 1.04	85.76a ± 1.27	86.59a ± 1.37
Total net daily gain kg/fed./ day)	1.64 b ± 0.09	5.64a ± 0.19	5.86a ± 0.15
Net average individual weight	62.35b ± 3.74	96.01a ± 6.72	99.09a ± 11.35

Means in the same row with different letters are significantly different (P≤0.05).

Table (4) Means of nutrient utilization efficiencies and total costs for urea and ammonium nitrate plus mono superphosphate for 86 days growout period.

Parameter	Urea+MSP	AN+MSP
Urea-N utilization efficiency		
kg fish / 1 kg urea-N	5.12	-----
*% urea-N incorporated into fish biomass**	11.67	-----
A. nitrate-N utilization efficiency		
kg fish / 1 kg a. nitrate-N	-----	5.26
% a. nitrate-N incorporated into fish biomass	-----	12.00
MSP-P utilization efficiency		
kg fish / 1 kg MSP-P	17.99	18.69
% MSP-P incorporated into fish biomass	10.36	10.77
Total fertilizer cost (LE/Fed)	267.26	294.43
Total fertilizer cost LE/kg fish	0.55	0.58

*Assumes a tilapia composition of 9.5%N, 2.4% P, and 76% water (Tan, 1971).

utilization efficiency (Ibrahim and Nagdi, 2006). AN+MSP treatment had slightly higher N utilization efficiency than that in the Urea+MSP treatment (Table 4) with an average of 5.12 and 5.26 kg of tilapia produced per kg of N added and 11.67% and 12.00% of N fertilization incorporated into fish biomass for both treatments respectively. Similar results were obtained for P utilization efficiency with an average of 17.99 and 18.69 kg of tilapia produced per kg of P added and 10.36% and 10.77% of P fertilization incorporated into fish biomass for Urea+MSP and AN+MSP treatments respectively.

On the other hand total fertilizer cost was also higher in the AN+MSP treatment (294.43 LE/Fed) than Urea+MSP treatment (267.26 LE/Fed), and total fertilizer cost per kg fish was 0.55 and 0.58 LE/kg fish for the Urea+MSP and AN+MSP treatment respectively.

Relative rank

The best fertilizer is that fertilizer which increases the desired variables (e.g. Net fish yield (NFY), DO, nitrate, available phosphorus, Chl “a” etc.) and decreases the undesired variables (e.g. TAN, fertilizer cost, fertilizer cost per kg fish produced, amount of fertilizers used etc.) in another words any fertilizers to be recommended should produces a higher production with the minimum environmental impact.

Table (5) Ranking of values for some studied variables that affecting the decision of using one of the two treatments, the highest value was considered as 100 the other values were computed as related to 100 (overall average).

Variable	Urea+MSP	AN+MSP
Net Fish Yield	96.25	100
Dissolved oxygen	100	91.74
NO3	100	97.41
OP	80.09	100
Chl "a"	100	73.96
N incorporated into fish biomass	97.25	100
P incorporated into fish biomass	96.19	100
Positive subtotal	670	663
TAN	-98.59	-100
Fertilizer cost	-90.55	-100
Fertilizer cost / kg Fish	-94.83	-100
Fertilizer amount	-87.80	-100
Negative subtotal	-372	-400
Relative rank	**298**	**263**

(+) sign is given to the desired variables (wanted to increased)

(-) sign is given to the undesired variables (wanted to decreased)

Table (5) presents a nonparametric analysis of the two fertilization treatments based on their relative ranks for some variables measured in this study with an ultimate goal of choosing one of them depending on their ranks following this manner, the highest rank of 100 is given to the treatment that gave the highest mean and the other were computed relative to 100 (as percent). (+) sign is given to the variables desired to increase then by adding together a positive subtotal will obtained, and (-) sign is given to the variables desired to decrease then by adding together a negative subtotal will obtained then the general relative rank of treatments could be obtained by subtracting negative subtotal from positive subtotal, therefore the better treatment is that treatment with the highest relative rank.

As presented in table (5) the Urea+MSP treatment had the highest relative rank of 298 compared to 263 that accrued by AN+MSP treatment.

Recommended nitrogen fertilizer

It seems that ammonium nitrate produced higher fish production than urea when mixed separately with MSP, but with more precise view, it could found that, this higher production comes from higher fertilizer units which will have more impact on the environment furthermore it will be more expensive. Therefore, on the light of the above results of water quality, fish performance, and fertilizer utilization efficiency, it is recommended to use urea as a source of nitrogen as a mixture with mono superphosphate as a source of phosphorus, with the same rates used in this study.

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تأثير استخدام الأسمدة النيتروجينية على البيئة المائية والأداء الأنتاجي لأسماك البلطى الهجين في المزارع السمكية

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المستخلص

تهدف الدراسة لمعرفة تأثير نترات الأمونيوم واليوريا كمصدر للسماد النيتروجيني مع وجود سماد السوبر فوسفات الأحادي واثر ذلك على جودة المياه وأداء أسماك البلطى الهجين (إناث بلطى نيلى X ذكور بلطى أوريا). تم تنفيذ الدراسة باستخدام أحواض ترابية بمساحة متساوية (١٠٠٠متر٢) بالمعمل المركزي لبحوث الثروة السمكية بالعباسة لمدة ٨٦ يوم ، تم توزيع عدد ثلاث معاملات ومثلت كل معاملة في مكررتين. تم تقسيم الأحواض الى ثلاث معاملات الأولى (كنترول) لم يتم تسميدها أما المجموعة الثانية (اليوريا + السوبر فوسفات الأحادي) فقد تم تسميدها بـ ١٧,٢ كجم يوريا / فدان/ أسبوع+ ٣٣,٢ كجم سوبر فوسفات الأحادي/ فدان/ أسبوع والمجموعة الثالثة (نترات الأمونيوم + السوبر فوسفات الأحادي) فقد تم تسميدها بـ ٢٤,٢ كجم نترات الأمونيوم/ فدان/ أسبوع +٣٣,٢ كجم سوبر فوسفات الأحادي/ فدان/ أسبوع.

أخذت عينات عشوائية من الأسماك كل شهر على مدار الدراسة لأخذ الأوزان . أخذت عينات من الماء أسبوعيا للتحاليل الفيزيائية و الكيمائية و البيولوجية . تم قياس تركيز الأكسجين الذائب، الأس الهيدروجيني، قرص الشفافية، نيتروجين الأمونيا الكلى، النيتريت، النترات، القلوية الكلية، العسر الكلى، الفوسفور الكلى، الفوسفور الذائب و الكلوروفيل أ. لم يكن هناك فروق معنوية بين معاملتى اليوريا ونترات الأمونيوم فى مقاييس جودة المياه إلا فى تركيز الأكسجين الذائب حيث كان أقل فى معاملة النترات عنه فى معاملة اليوريا ورجع ذلك لزيادة المستهلك منه فى معاملة النترات نتيجة زيادة محصول الأسماك فيها عنه فى معاملة اليوريا. كذلك قل تركيز الكلوروفيل "أ" فى معاملة النترات لزيادة معدل رعى الأسماك عنه فى معاملة اليوريا وزاد تركيز الفوسفور الذائب فى معاملة النترات عن معاملة اليوريا.

دلت النتائج على أنه كان متوسط الوزن الفردى للأسماك ٩٩,٠٩ جم/سمكة فى معاملة نترات الأمونيوم وكان 96.01 جم/سمكة فى معاملة اليوريا أما الكنترول فكان أقلهم (٦٢,٣٥ جم/سمكة) وكذلك الأنتاج الكلى للأسماك (٥١٤,٩٨، ٤٩٥,٣٢ و ١٥٠,٥٢ كجم/فدان للمعاملات الثالثة على الترتيب. كما أظهرت معاملة نترات الأمونيا ارتفاع طفيف فى معدل كفاءة استخدام الأسمدة وتكاليف التسميد عنه فى معاملة اليوريا. وحققت معاملة اليوريا ترتيب نسبى أعلى (٢٩٨) مقارنة ب معاملة نترات الأمونيا (٢٦٣).