Journal of Environment Protection and Sustainable Development
Vol. 1, No. 3, 2015, pp. 121-125
http://www.aiscience.org/journal/jepsd

Nitrogen Use Efficiency of Okra (*Abelmoschus esculentus* (L.) Moench) in Sandy Regosol Amended with Locally Available Organic Manures and Urea Integrations

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Abstract

Since green revolution, over usage of chemical fertilizers became predominate with the concern of food security for the growing population. This indiscriminate usage causes malignant effects on soil fertility especially in sandy regosols where the leaching of nutrients particularly nitrogen causing yield losses as well as environmental and health defects. A pot experiment was carried out at Eastern University, Sri Lanka to evaluate the nitrogen use efficiency, nitrogen uptake and yield of okra (*Abelmoschus esculentus* (L.) Moench) in sandy regosolusing variety EUOK - 2. The treatment combinations were laid out in Completely Randomized Design and there were thirteen treatments with four replicates. In this experiment poultry manure, farmyard manure, *Leucaena* (Ipilipil) leaves and paddy straw were used as organic nitrogen sources and urea as the inorganic nitrogen source. The organic manures were evaluated solely and in combination with urea at the rate of 50% and 100% from each in weight basis. These all treatments were tested with control with no organic or inorganic nitrogen sources and were evaluated among themselves also. Significantly highest nitrogen uptake and pod yield were registered in application of sole poultry manure. Nitrogen use efficiency expressed as agronomic nitrogen use efficiency (NUE-AE) and physiological nitrogen use efficiency (NUE-PE) were registered in application of sole farmyard manure and *Leucaena* leaves respectively. So sole poultry manure, farmyard manure and *Leucaena* leaves can be suggested to the farmers especially for the cultivation of okra on sandy regosol in order to obtain the best yield and indirectly minimizethe use of synthetic fertilizers.

Keywords

Okra, Organic Manure, Pod Yield, Nitrogen Uptake, Nitrogen Use Efficiency

Received: April 8, 2015 / Accepted: May 1, 2015 / Published online: May 28, 2015

1. Introduction

Limitations in food supply for a large population and the harmful effects of inorganic fertilizers on the environment are major threats in agricultural science. As a consequence, scientists and researchers are seen arguing in favour of organic fertilizers as the best solution to increase fertilizer use efficiency and nutrient retention.

Generally excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield (Stewart *et al*., 2005). However, chemical fertilizers alone generate several deleterious effects to the environment and human health and they should be replenished in every cultivation season because, the synthetic nitrogen, phosphorus and potassium fertilizer is rapidly lost by either evaporation or by leaching in drainage water and it causes dangerous environmental pollution (Aisha *et al*., 2007). Indiscriminate use of these inorganic fertilizers also leads to

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nutrient imbalance in soil and causing ill-effects on soil properties.

Among the nutrients supplied by the synthetic fertilizers, Nitrogen is the essential element for plant growth and it is the nutrient, taken up in largest amount by plants. 85 – 90 million metric tons of nitrogenous fertilizers are added to soil worldwide annually (Good *et al*., 2004). Nitrogen losses are observed in every type of soil and management of such losses should always be a top priority when considering the study of nitrogen supply to crops (Salazar *et al*., 2011). Bawatharani*et al*. (2010) stated that loss of nitrogen through leaching and threat of ground water contamination is higher in sandy regosol.

Knowledge about the integrated use of organic material with chemical fertilizers and use of organic manures instead of synthetic fertilizer could enable the development of new agricultural approaches for improving nitrogen management and contribute to developing models of sustainable agriculture (Saez *et al*., 2012). These approaches would provide new information for increasing the nitrogen use efficiency (NUE) in plants. Lin *et al*. (2010) stated that addition of organic manure to soil, increase soil microbial biomass and microbial community diversity and also improve the physico-chemical properties of soil consequently increase their fertility and fertilizers use efficiency as a final goal.

Only 30 to 40% of the nitrogen being absorbed by the crop from the applied nitrogen fertilizer and the rest lost through leaching, volatilization, denitrification, soil erosion and microbial consumption (Glass, 2003). Improved nitrogen use efficiency (NUE) could result in the capture of a greater proportion of the applied nitrogen while still maintaining crop yield targets, or more efficient use of the nitrogen captured so that crop yields are maintained even when the nitrogen supply is reduced (Brauer and Shelp, 2010) and these scenarios would cause lower requirements for applied nitrogen and thus, reduce fertilizer costs and the environment pollution (MacDonald *et al*., 2013). Optimal use of nitrogen improves dry matter, especially the economic parts of the plant (i.e., flowers and fruits) and a crop's nitrogen supply should be synchronized to its demand. Increasing the nitrogen use efficiency for nitrogenous fertilizers decrease the NO_3^-(nitrate ion) hazards to environment. Improving nitrogen use efficiency (NUE) of crop plants is thus of key importance.

The main emphasis here to determine the impact of organic nitrogen sources and their integrations with inorganic nitrogen source on the nitrogen use efficiency and yield of local okra cultivar (EUOK-2).

2. Materials and Methods

2.1. Description of Experimental Site

A pot culture experiment was laid out during the period of 10th of March to 15th of July, 2014 at Eastern University, Sri Lanka which is located in low country, dry zone (DL_2 agro ecological zone) in the latitude of 70^{0}43' N and the longitude of 81^0 42' E.

2.2. Description of Soil and Organic Manure Used in the Experiment

The soil used in this study was sandy regosol. It belongs to great group of Tropofluvents according to the USDA soil taxonomy (De Alwis and Panabokke, 1972).Organic manures used in this experiment were Poultry manure, Farmyard manure, *Leucaena leucocephala* and Paddy straw and the total nitrogen content of these were 3.12%, 0.76%, 3.04% and 0.61% respectively.

2.3. Treatments and Experimental Design

The evaluation of the organic nitrogen sources were done solely and in combination with the inorganic nitrogen source, urea at the rate of 50% and 100% from each in weight basis. All the treatments were evaluated in comparison with the control. The treatment combinations were laid out in Completely Randomized Design and there were thirteen treatments with four replicates. Poultry manure, farmyard manure, *Leucaena* green leaves and paddy straw were used at the rate of 10 tons/ha in sole organic manure treatments and urea was applied according to the fertilizer recommendation of Department of Agriculture, Sri Lanka as 300 kg/ha. Other major nutrients P_2O_5 and K_2O were applied at the rate of 200 kg/ha and 150 kg/ha by Triple Superphosphate and Muriate of Potash respectively. The treatments were,

T1-Control

T2-Poultry manure (PM)

T3-Farmyard manure (FYM)

T4-*Leucaena* leaves (LL)

T5-Paddy straw (S)

T6-50% PM + 50% urea

T7-50% FYM + 50% urea

T8-50% LL + 50% urea

T9-50% S + 50% urea

T10-100% PM + 100% urea

T11-100% FYM + 100% urea

T12-100% LL + 100% urea

T13-100% S + 100% urea.

2.4. Planting

A bulk soil sample was collected from an area where cultivation was not previously carried out at 0-20 cm depth. The collected soil sample was processed and air dried for a day. The air dried soil was sieved (2mm mesh sieve) to avoid the soil heterogeneity. Each polyethylene bag was filled with 14 kg processed soil.According to the treatments, organic manure was incorporated in to the soil two weeks prior to the planting.Five pre-treated seeds were sown in each bag and two weeks after germination, one plant per bag was maintained.

2.5. Measurements

2.5.1. Manure Analysis

Manures were analysed initially to find out the nitrogen content and the total nitrogen contents were determined by Micro kjeldhal method (Jackson, 1973)

2.5.2. Plant Analysis

Total nitrogen in plant parts were determined by Micro kjeldhal method.

2.5.3. Yield

Pods of okra were harvested at the maturity and fresh weight of the pods was taken.

2.6. Calculations

2.6.1. Total Nitrogen Uptake

Total nitrogen uptake was calculated using the following formulae:

$$\text{Nitrogen uptake} = \text{NC x DM}$$

NC - Nitrogen concentration in total plant

DM - Total plant dry matter

2.6.2. Nitrogen Use Efficiency (NUE)

Nitrogen Use Efficiency expressed as Agronomic Efficiency (NUE-AE) and Physiological Efficiency (NUE-PE) was calculated using the following formulas:

$$\text{NUE} - \text{AE} = \frac{\text{Y}f - \text{Yo}}{\text{p}}$$

$$\text{NUE} - \text{PE} = \frac{\text{Y}f - \text{Yo}}{Puf - Puo}$$

Y*f*- Yield of fertilized crops

Y*o*- Yield of unfertilized crops

P- Rate of fertilizer applied

P*uf*- N uptake in fertilized crops

P*uo*- N uptake in unfertilized crops

2.7. Analysis of Results

Data collected were subjected to analysis of variance (ANOVA) using SAS 9.1 version statistical software package and mean comparison was performed within treatments using Tukey test at 5% significant level for precise and easy interpretation of results of this experiment.

3. Result and Discussion

3.1. Pod Yield of Okra

Table 1. Effect of Nitrogen Sources on Pod Yield of Okra

Treatments	Pod yield (kg/ha)
T1	01.04 ± 0.01 d
T2	19.27 ± 0.11 a
T3	06.15 ± 0.29 c
T4	13.61 ± 0.27 b
T5	01.18 ± 0.01 d
T6	11.17 ± 0.03 b
T7	06.09 ± 0.65 c
T8	06.05 ± 0.76 c
T9	02.00 ± 0.55 d
T10	11.29 ± 0.11 b
T11	06.75 ± 0.40 c
T12	11.94 ± 1.04 b
T13	03.25 ± 0.01 d
F test	*

The value represents mean ± Standard Error of replicates
* represents significant at 5% level of probability. Mean values in a column followed by the same letter(s) within treatment group are not significantly different at 5% level of significance by Tukey Test.

Application of 100% poultry manure recorded significantly ($P<0.05$) highest pod yield.The reason for the highest yield from sole source of poultry manure may be due to higher nutrient availability and uptake from the manure added soil. Akande*et al*. (2010) stated that organic manures can be used to provide nutrition to okra and attain yields that are generally comparable to that obtained with mixtures of organic and mineral fertilizer. The maximum pod yield was followed by sole *Leucaena* green leaves and 100% *Leucaena* green leaves integrated with 100% urea.It was found the direct mineralization of nitrogen from the *Leucaena* leaves attributed to the release of maximum 92% nitrogen within 30 days (Pandey *et al*., 2006) and reduces the losses and increase the uptake of nutrients thus increase the yield of crops. It was noted that among the organic manures sole paddy straw and its integrations with urea gave lower yield. This may be due to higher amount of immobilized nitrogen than other treatments. Yield obtained from control treatment was ranked last. This may be due to the unavailability of nutrients.

3.2. Nitrogen Uptake of Okra

Table 2. Effect of Nitrogen Sources on Nitrogen Uptake of Okra

Treatment	Nitrogen Uptake (g/kg)
T1	10.37 ± 0.12 m
T2	76.62 ± 0.37 a
T3	30.91 ± 0.59 i
T4	62.88 ± 0.12 c
T5	20.89 ± 0.11 l
T6	45.05 ± 0.50 e
T7	38.37 ± 0.12 g
T8	41.77 ± 0.22 f
T9	24.22 ± 0.27 k
T10	72.77 ± 0.22 b
T11	34.75 ± 0.25 h
T12	55.66 ± 0.34 d
T13	27.94 ± 0.05 j
F test	*

The value represents mean ± Standard Error of replicates
* represents significant at 5% level of probability Mean values in a column followed by the same letter(s) within treatment group are not significantly different at 5% level of significance by Tukey Test.

Sole application of poultry manure gave the highest nitrogen uptake while the control gave the lowest. The observations are in accordance with Opara and Asiegbu (1996) who reported that poultry manure application can increase the nitrogen uptake. The highest nitrogen uptakewas followed by poultry manure with 100% urea and this may be due to rapid decomposition of poultry manure (Amanullah *et al*., 2010) and increased availability of nitrogen. Sole poultry manure and its integration with 100% urea followed by sole *Leucaena* green leaves, which showed a positive response to nitrogen uptake. It was ascertained that incorporation of *Leucaena* green leaves to the soil two weeks before planting could produce available ammonium - nitrogen in soil which is comparable with the ammonium - nitrogen that is originating from the mineral nitrogen level recommended by the Sri Lankan Department of Agriculture, i.e. 88 kg N/ha (Zoysa*et al*.,1989). Lower nitrogen uptake was obtained in sole paddy straw treatment. This may be due to slow decomposition, because of its fibrous nature and immobilization of nitrogen of sole paddy straw which has a higher C:N ratio. This was supported by Herath*et al*. (2004).

3.3. Nitrogen Use Efficiency of Okra

3.3.1. Agronomic Nitrogen Use Efficiency (NUE- AE) in Okra

Significantly highest nitrogen use efficiency expressed as agronomic efficiency (NUE-AE) of applied nutrient was with sole application of farmyard manure.This may be due to the availability of sufficient quantity and effective form of nitrogen just on a time at a right amount thus optimize the nitrogen use efficiency.The next highest value was registered in sole poultry manure application as it improves the physical properties (Agbede*et al*., 2008) and chemical properties of soil (Amanullah *et al*.,2010) consequently increase the yield of crop. Evidently efficiency at paddy straw was very low and this may be due to the slow rate decomposition of paddy straw and slow release of nitrogen to the soil.

Table 3. Effect of Nitrogen Sources Agronomic Nitrogen Use Efficiency of Okra

Treatment	Agronomic nitrogen use efficiency (kg/kg)
T1	-
T2	58.39 ± 0.35 b
T3	68.10 ± 0.82 a
T4	41.31 ± 0.89 d
T5	02.21 ± 0.08 g
T6	46.99 ± 0.85 c
T7	47.09 ± 1.08 c
T8	22.62 ± 0.44 d
T9	09.54 ± 0.99 f
T10	22.76 ± 0.25 e
T11	26.63 ± 0.87 e
T12	24.63 ± 1.35 e
T13	11.05 ± 0.05 f
F test	*

The value represents mean ± Standard Error of replicates
* represents significant at 5% level of probability. Mean values in a column followed by the same letter(s) within treatment group are not significantly different at 5% level of significance by Tukey Test.

3.3.2. Physiological Nitrogen Use Efficiency (NUE-PE) in Okra

Table 4. Effect of Nitrogen Sources on Physiological Nitrogen Use Efficiency of Okra

Treatment	Physiological Nitrogen use efficiency (kg/kg)
T1	-
T2	78.54 ± 1.41 b
T3	71.47 ± 0.48 c
T4	84.27 ± 0.58 a
T5	07.40 ± 0.23 i
T6	45.59 ± 0.51 f
T7	59.44 ± 0.45 d
T8	53.92 ± 0.94 e
T9	25.23 ± 0.26 g
T10	18.95 ± 0.39 h
T11	44.90 ± 0.52 f
T12	43.31 ± 0.59 f
T13	24.73 ± 0.05 g
F test	*

The value represents mean ± Standard Error of replicates
* represents significant at 5% level of probability. Mean values in a column followed by the same letter(s) within treatment group are not significantly different at 5% level of significance by Tukey Test.

The highest physiological nitrogen use efficiency was in *Leucaena* green leaves application. Since *Leucaena* was incorporated two weeks before planting, it could be said that a mineralization period of two weeks was adequate to produce available ammonium - nitrogen to cope with the nitrogen requirement of okra crop consequently increase the physiological nitrogen use efficiency. These results were found to be in agreement with those of Zoysa *et al.* (1989).The next highest value was registered in sole poultry manure application. Boateng *et al*. (2006) stated that poultry manure application registered over 53% increase of nitrogen level in the soil, and exchangeable cations increase with manure application which might be the reason for higher physiological nitrogen use efficiency. The lowest physiological nitrogen use efficiency was in sole paddy straw application and this may be due to the low availability of nitrogen from paddy straw which might not be synchronized with the need of crop.

4. Conclusions

The present study was conducted to find out the possibilities in minimizing the usage of synthetic fertilizers and increasing the utilization of locally available organic manures. Significantly highest nitrogen uptake and yield were registered in application of sole poultry manure. Nitrogen use efficiency expressed as agronomic nitrogen use efficiency (NUE-AE) and physiological nitrogen use efficiency (NUE-PE) were registered in application of sole farmyard manure and *Leucaena* leaves respectively.

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