J. Agric. Sci. Mansoura Univ., 28(5): 4131 - 4140, 2003

EFFECTS OF APPLICATION METHOD AND NITROGEN FORMS ON RICE YIELD

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ABSTRACT

Laboratory and pot experiments were conducted to evaluate the effectiveness of organic matter in combination with urea under surface and subsurface condition on rice yield production. Results revealed that application of organic matter decreased the volatilization of ammonia. Subsurface condition was more effective in reducing N-loss than surface one. It was noticed that O.M. addition stimulate the grain yield for both surface and subsurface circumstances. Maximum yield was obtained at equal rate of N from inorganic and organic sources. Data also indicated that surface application gave higher grain/straw ratio as compared to the surface one. Application of organic matter increased the nitrogen content in rice grain as compared with urea alone. Increasing ratios between organic matter and urea gradually increased the N-content in rice grain.

Deep placement of urea combined with organic matter increased P and K content for both grain and straw as compared with surface application. The highest values of the residual-N were observed at equal doses of urea nitrogen and organic matter. Deep placement was better than surface application on the residual nitrogen, content in soil.

Keywords : Organic matter, urea, surface, deep placement, NH_3 volatilization, N, P and K content in rice plant.

INTRODUCTION

Rice is very responsive to nitrogen fertilization, and high-yield potential of modern varities can not be realized without adequate N supply to the plant during the entire growing season. The behaviour of N in flooded soils is markedly different from its behaviour in drained soils that receive atmospheric oxygen. Flooding the soil can affect the fate of added-N as well as native soil-N, and must be taken into consideration in the nitrogen fertilization of lowland rice (Abou Seeda 1997, Fillery *et al.*, 1986). The unique reactions undergone by N in flooded soils result in a considerable loss of applied N fertilizer. Alternative N fertilizer managements are needed to increase productivity and N use efficiency in rice lowland (Savant and De Datta 1982). Application of organic N may reduce the amount of fertilizer-N required for optimum crop yield. Understanding the release of N fraction from organic matter may also reduce the potential of ground water pollution.

The effectiveness of N in organic matter in compared to that of fertilizer is variable but ranged between 30-60% (*Smith and Chambers,1992*). The objective of this research was to study the efficiency of organic matter as a nitrogen source to reduce the amount of inorganic nitrogen fertilizer required for optimum rice yield production.

MATERIALS AND METHODS

Greenhouse experiment :

This study was performed at the Soil and Water Res. N.R.C. Cairo, Egypt. Pot experiments were carried out and designed as randomized complete block with three replicates in plastic pots (40cm height, 25cm in diameter) The investigated soil is characterized by pH 7.63, EC 0.16 dSm^{-1}. $CaCO_3$ 1.0%, OM 0.32%, total nitrogen 0.034%. clay content 46.5%, silt content 34.8% and sand content 18.70% The organic matter characterized by O.C. 42.5%, T.N 3.52% and C/N ratio 12.07. Nitrogen fertilizer as (urea) was combined with chicken manure at the rate of 60mgN/kg soil which was added as surface and subsurface application.The treatments were as follows:

	Chicken manure (mgN/kg soil)	Urea (mgN/kg soil)
1-	60	0
2-	40	20
3-	20	40
4-	30	30
5-	0	60

Phosphorus and potassium were applied at a rate of $50P_2O_5$ and $40K_2O$mg/kg soil as super phosphate and potassium sulphate, respectively, Fe, Mn, Zn and Cu were applied at a rate 5, 5, 5 and 2.5 mg/kg soil as Fe-EDDHA and sulphate compound respectively. Five rice seedlings (21 day old V. Giza 171) were transplanted and kept under continuous flooding system through the growth period. At maturity, the plant parts were harvested and separated into grains and straw. Dry weight was recorded, ground and prepared for analysis. Total N in plant and soil available nitrogen. (NH_4+NO_3)-N were determined by Kjeldahl method as described by *Bremner and Mulvaney (1982)*. Agronomic and physiological efficiencies were calculated as described by *Buresh et al. (1988) and Hammad et al., (1994)*.

Laboratory experiment :

Ammonia volatilization :

Ammonia collection system described by *Abou Seeda (1997)* was used for this study. Two hundred grams of air dried soil were treated with the previous treatments as described later at surface and subsurface application. Nitrogen was applied at a rate of (200 mgN) from both sources, placed in volatilization conical flask and sealed after fertilizer. The moisture content was maintained under flooding condition. Sweep air was trapped in (2% H_3BO_3), volatilized NH_3 was determined after 3,7,14,28, 42 and 56 days of incubation by titration with 0.01 M H_2SO_4 as described by *Black (1982)*.

RESULTS AND DISCUSSION

Ammonia volatilization :

The NH_3 volatilization during the incubation period is presented in Fig. (1), from which one can assumed that surface application of urea stimulated the N-loss through the volatilization of ammonia as compared with the subsurface. It was noticed that during the incubation period the volatilized-NH_3 gradually increased. Results reveal that the highest amounts of volatilized NH_3 were recorded at 28 days of incubation, after that time this fraction was gradually decreased until the end of the incubation. However deep placement of urea fertilizer decrease the loss of nitrogen through minimizing the volatilized NH_3 during the incubation time. The reduction in volatilized NH_3 was ranged between (22-37%). *Cao et al., (1984)* reported that deep placement reduced the NH_3-loss. Results obtained by Schnier *et al.,* (1988) and Abou Seeda (1997) found that the unique reduction undergone by N-flooded soils resulted in a considerable loss of applied N-fertilizer. They also reported that alternative N-fertilizer management practices are needed to increase productivity and N-efficiency in rice Lowland. Several researchers reported that subsurface placement of the N-fertilizer into anaerobic soil zone has been proposed as possible method to improve the utilization of N-fertilizer by rice plants (DeDatta 1986 and Norman *et al.*, 1989). This method is intended to minimize N losses due to NH_3-volatilization as well as losses via nitrification-denitrification reaction (Patrick *et al.*, 1985) and Abou Seeda *et al.*, (1997).

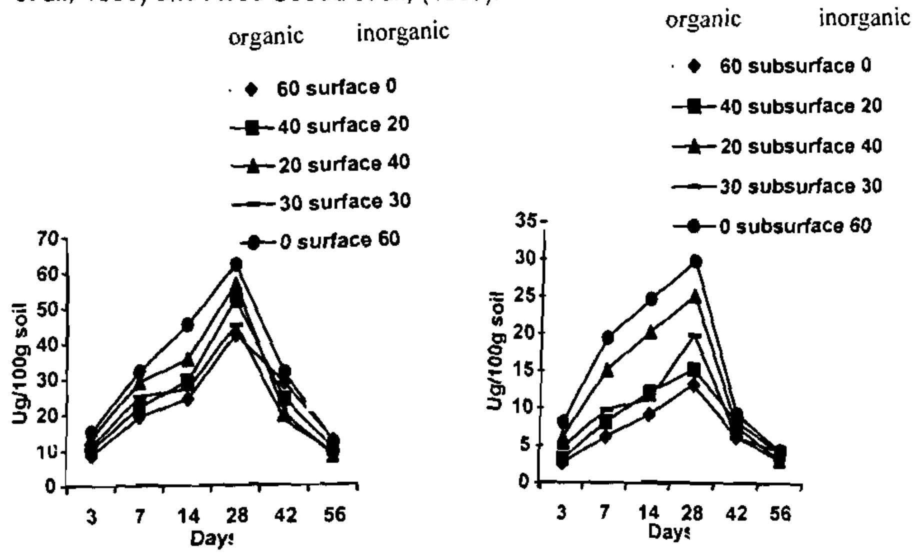

Fig. (1) : Ammonia volatilization as affected by source of nitrogen and method of application

Results reveal that application of urea combined with organic matter slightly reduced the volatilized NH_3 particularly during the first period of incubation. Addition of 20mgNkg^{-1} as organic matters and 40mgNkg soil^{-1} as urea markedly decreased the NH_3 volatilized as compared with applied urea alone. Increasing source of organic-N stimulated a reduction of NH_3 volatilized either in surface or subsurface application. Organic matter had more effective for reducing the ammonia volatilization. Reddy and Patrick, (1986) and Abou Seeda (1994), stated that nitrogen losses due to nitrification denitrification reaction can be prevented in case of increasing the O_2 demand in the root zone by increasing the organic matter content of the soil, maintaining inorganic N in form NH_4^+ and deep placement of the fertilizer added. These are some of the potential management strategies that can be used to prevent N-losses for rice field. It was noticed that application of 50% inorganic-N + 50% organic-N decreased volatilization of NH_3. This phenomenon may be explained by the role of organic materials particularly in rice field. Abou Seeda (1997) Abou Seeda *et al.*, (1994) and El-Aila *et al.* (1996) reported that organic matter breakdown proceeds at slower rate particularly in submerged soil as compared with drained soil. They found out the slower rate of decomposition taking place in flooded soil which might be expected to retard the release of N, this process may regulate as well as prevent N-loss.

Biological experiment :

Rice yield production as affected by urea, organic matter and method of application :

Effects of surface and deep placement of urea combined with organic matter on the grain and straw yield of rice plant are presented in Table (1). Deep placement caused a highly significant increase in grain yield as compared with surface one. It was noticed that application of organic matter as a source of N stimulated the grain yield for both surface and deep placement. Under surface application of urea combined with organic matter at equal rate (30mgN/kg) the grain yield was increased by about 24% as compared with organic matter alone. Organic matter application caused an increase in the grains by about 54% and 49% as compared with urea alone for surface and deep placement respectively. Such differences between surface and deep placement could be explained by the observation of Abou Seeda *et al., (1994)*, they stated that thinly oxidized layer may reduced the loss of nitrogen and the presence of organic matter may play an important part for the thickness of aerobic layer which is a function of balance between optimum supply and consumption of oxygen. They also reported that the buffering action of soil due to organic matter addition in soil resulted in a remarkable decrease in the loss of nitrogen and furthermore increase the N-use efficiency.

Increasing the organic matter gradually increased the grain yield of rice particularly under subsurface application. Maximum yield of rice was obtained at equal rate of nitrogen derived from urea and organic matter (30mgN/kg soil). The increases were about 38% and 50% as compared with either organic matter or urea respectively, under deep placement. The role of organic matter under subsurface application was more pronounced than surface application. This phenomenon may be explained by the pathway of the organic material particularly in rice field, flood soil greatly differ from drained soil in mineralization and immobilization reaction of N. One of the major differences is the rate of organic matter decomposition, organic matter break down proceeds at slower rate in submerged soil as compared with a drained soil. The slower rate of decomposition taking place in flooded soil, might be expected to retard the release of the nitrogen.

The low requirement of the *anaerobic organisms* for N causes organically bound, N to be released to rice crop earlier in the growing season under deep placement than surface application. This *readily release of* NH_4 from anaerobically decomosing organic matter partially responsible for the good response of rice to added organic matter (Abou Seeda *et al.*, 1994). Similar trends for straw yield production were observed. From the above mentioned results, improving of grain and straw yield production as the results of applied urea combined with organic matter under surface and subsurface application may be attributed to better growth under favourable physical, chemical and biochemical condition and can be related to the effect of organic matter which containing a considerable amounts of nitrogen and other nutrient elements for plant growth. Similar results were obtained by Arafat *et al.* (1997), Kathiresan *et al.*, (1993).

Table (1): Grain and straw yield ($g.pot^{-1}$) as affected by urea combined with organic matter and method of application

Organic	Inorganic	Yield g pot –1		Grain/	Agronomic	Physiological
(mgNkg^{-1} soil)		Grain	Straw	straw ratio	efficiency	efficiency
Surface						
60	0	62.71	75.11	0.83	57.9	3.92
40	20	69.65	86.43	0.80	69.5	3.58
20	40	65.72	80.22	0.82	63.0	4.7
30	30	78.20	93.65	0.84	83.8	5.27
0	60	40.67	60.22	0.68	21.2	3.50
Subsurface						
60	0	65.41	80.51	0.81	62.4	2.67
40	20	76.36	43.62	0.82	80.73	3.49
20	40	70.33	86.72	0.81	70.68	3.59
30	30	90.34	106.40	0.85	104.03	3.30
0	60	60.41	76.82	0.78	54.15	3.60
0	0	27.92	45.12	0.62	0.0	0.0
L.S.D.	**5%**	**3.14**	**5.25**			

Grain/straw ratio, agronomic and physical efficienies :

Table (1) show that grain/straw ratio, agronomic and physiological efficiencies can be affected by urea combination with organic matter under surface and subsurface conditions. Results reveal that application treatments increased the grain/straw ratio as compared with the control one. Surface application gave a higher grain/straw ratio of (0.84) at equal doses of nitrogen from the studied inorganic and organic forms. Whereas application of different treatments particularly under subsurface condition gave the maximum grain/straw ratio of (0.85) as compared with the surface application. Similar results were obtained by DeDatta *et al.*, (1988).

Agronomic efficiency (grain yield increase per unit of N-applied obtained from the treatments) is presented in Table (1). Data observed that application of organic nitrogen and its combination with urea under subsurface application increased agronomic efficiency. It was observed that application of urea combined at equally doses of N-sources gave the highest value of agronomic efficiency as compared with the same treatment under surface condition. Average increase was about 24% between surface and subsurface.

The physiological efficiency (grain yield increase per unit of N-taken up above the zero-N control treatment) was used to assess whether the effect of inorganic nitrogen (urea) and its combination with organic nitrogen (organic matter). Results reveal that physiological efficiency was affected by the treatment. It was noticed that physiological efficiency increased under surface condition particularly at equally rate of nitrogen from urea combined with organic matter.

Plant composition :

Effect of urea and its combination with organic matter under surface and subsurface condition on the content of NPK content (mg pot $^{-1}$) in grain and raw of rice plant are shown in Table (2). It was noticed that application of organic matter as a source of nitrogen stimulates the nitrogen content for both surface and subsurface condition. Surface application of organic matter alone increased the nitrogen content by about 71% as compared with urea treatment alone. Increasing ratios between urea and organic matter gradually increased the N-content in the grain. Highest nitrogen content in the grain of rice was obtained from the combination of urea and organic matter at a rate of 30/30 mgN/kg soil. Average of increase were about 145% and 43% as compared with urea and organic matter alone. This phenomenon could be explained by the fact that organic matter occomodate substantial amount of organic nitrogen which can plant absorbed it through the mineralization mechanisms during the growing season. The release of NH_4^+ from anaerobically decomposing of the organic matter is partially responsible for the good response of rice to added organic matter. Similar trend was observed by DeDatta (1995) and Dickman *et al.*, (1993). The magnitude variation of N-uptake with respect to the above mentioned treatment was very clear.

Deep placement improved the N-use efficiency by rice plant during the growing reason. Application of organic matter increased the N-content in grain by about 12% as compared with surface application. Maximum value of N-content in grain was noticed at equate doses of nitrogen from urea and organic matter. An average result was about 25% as compared with the same treatment under surface application. Similar trends were observed in straw. Abou Seeda *et al.*, (1994) stated that rice straw incorporation and N injected at 15cm at deep placement could reduce N-loss due to preventing upward diffusion of NH_4-N^{15} from the botton portion of the core to the overlying flood water, because of the high C/N ratio of the rice straw, any N^{15} diffused will be readily immobilized.

Phosphorous and potassium content (mg pot $^{-1}$) in both grain and straw of rice plants are shown in Table(2). Data revealed that deep placement of urea combined with organic matter caused an increase in P and K content for both grain and straw of rice plants as compared with surface application. Results also reveal that equal portions of applied N from urea and organic matter gave the highest values of P and K content in both grains and straw as compared with other treatments. This indicates that the efficiency of phosphorous and other nutrients was positively affected by both N-fertilization and organic matter, which may increase the root distribution and furthermore the yield production of rice. The pronounced increase in NPK content in grain and straw of rice plants could be explained by the positive effect of organic matters on improving the nutritional status of rice plant and also due to higher mineralization of organic matter. Numerous authors have reported about the effectiveness of organic matters (Craswell *et al.*, 1981 ; Cao *et al.* 1984; Abou Seeda (1997) and El-Alia (1997).

Table (2) : Effect of urea and its combination with organic matter under surface and subsurface condition on the content of NPK (mg pot $^{-1}$)in grain and straw of rice plant

Organic (mgNkg^{-1} soil)	Inorganic	grain mg/pot			Straw mg/pot		
		N	P	K	N	P	K
Surface							
60	0	1254.2	188.1	1442.3	600.8	225.3	901.3
40	20	1532.3	250.7	1741.2	743.6	276.5	1080.3
20	40	1170.12	183.8	1577.2	681.8	248.6	1002.7
30	30	1798.6	516.1	2033.2	842.9	337.1	1217.4
0	60	732.06	162.6	845.0	391.4	108.3	632.3
Subsurface							
60	0	1406.3	215.8	1569.8	644.0	281.7	966.0
40	20	1756.2	413.0	1985.3	795.7	365.1	1170.2
20	40	1547.2	374.1	1758.2	693.7	277.5	1040.6
30	30	2258.5	650.4	2529.5	1064.0	446.8	1489.6
0	60	1268.61	289.9	1389.4	576.1	145.9	453.2
0	0	368.5	80.9	451.9	248.1	54.1	234.6

Residual available –N (NH^+_4 +NO^-_3) - N in soil :

The residual-N contents of NH_4-N and NO_3-N in soil after the harvesting of rice yield are presented in Table (3). Results reveal that deep placement resulted in a remarkable increase of the residual nitrogen as compared to surface application. It was noticed that surface application of organic matter stimulates the residual-N (NH_4 + NO_3)-N, an average increase was about 51% as compared with urea alone. Highest values of the residual –N were observed at an equal doses of nitrogen form urea and organic matter (30 + 30mgN/kg). An average increase was about 100% as compared with urea alone under the same condition. However an average increase of the organic matter under deep placement as compared to surface application was about 14%.

It can be noticed that deep placement at equal doses of nitrogen derived from urea and organic matter (30mgN/kg) gradually increase the residual N. Results reveal that increasing of the residual nitrogen was about 36% and 85% for organic matter and urea alone respectively. It was also noticed that deep placement was more effective than surface application by about 15% particularly, at the equal doses of nitrogen from urea and organic matter.

Table (3) : Soil available nitrogen (mg kg soil $^{-1}$)as affected by urea and its combination with organic matter under surface and subsurface condition

Organic Inorganic (mgNkg^{-1} soil)		Available-N (mgNkg^{-1} soil)		
		NH4-N	NO3-N	(NH4+NO3) - N
Surface				
60	0	62.13	20.31	82.44
40	20	75.69	25.18	100.87
20	40	66.33	22.19	88.52
30	30	81.42	29.1	110.52
0	60	42.13	12.13	54.26
Subsurface				
60 subsurface	0	68.50	26.33	93.83
40 subsurface	20	83.73	30.41	114.14
20 subsurface	40	72.80	26.15	98.95
30 subsurface	30	95.19	32.16	127.35
0 subsurface	60	52.61	16.11	68.72
0 subsurface	0	23.12	15.43	38.55

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تأثير طرق الإضافة وصور النيتروجين على نبات الأرز

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يعتبر سماد اليوريا من أكثر الأسمدة الأزوتية استخداما فى أراضى الأرز بمصر ولزيادة كفاءة استخدام اليوريا يتطلب ذلك فهم معرفة سلوك اليوريا تحت الظروف الغدقة.

أجريت تجربة معملية وأخرى زراعية فى أصص لدراسة أثر خلط الأسمدة العضوية بسماد اليوريا تحت ظروف الإضافات السطحية وتحت السطحية على نبات الأرز النامى حيث تشير النتائج إلى:

- إضافة المادة العضوية أدت إلى تقليل تطاير الأمونيا سواء أكان تحت الظروف السطحية أو تحت السطحية بالمقارنة بسماد اليوريا المضاف إلا أن الإضافات تحت السطحية كان لها دور فعال فى خفض تطاير اليوريا وذلك إذا ما قورنت بالإضافات السطحية.
- أظهرت النتائج أيضا أن أعلى محصول تم الحصول عليه كان تحت معدل متساوى من النتروجين المضاف (٣٠ ملليجرام نيتروجين من اليوريا + ٣٠ ملليجرام نيتروجين من المادة العضوية لكل كم تربة)، كما أنه تم الحصول على أعلى محصول تحت الظروف التحت سطحية (Subsurface condition) بالمقارنة بظروف الإضافة السطحية (surface condition) .
- إضافة المادة العضوية أدت إلى زيادة النيتروجين الكلى فى كل من الحبوب، والقش إذا ما قورنت بإضافة اليوريا فقط. كما أن أعلى قيمة للنيتروجين وجدت تحت المستوى المتساوى من كل من اليوريا + المادة العضوية وخاصة تحت الظروف Subsurface condition بالمقارنة Surface condition .
- أدى خلط المادة العضوية واليوريا إلى زيادة المحتوى الكلى من البوتاسيوم والفوسفور وإن كميتهما تزداد تحت المستوى المتساوى من كل من اليوريا والمادة العضوية.
- أظهرت النتائج أن الإضافات تحت السطح (Subsurface condition) بمعدل متساوى من كل من اليوريا والمادة العضوية أدت إلى زيادة النيتروجين المتبقى فى الأرض بعد الحصاد مما يعكس زيادة دور المادة العضوية فى زيادة المحتوى الغذائى من العناصر الغذائية إذا ما قورنت بسماد اليوريا المضاف وحده فقط.