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Effect of Application of Slow-Released Nitrogen Fertilizer Using Waste Paper Slurry on the Growth and Yield of Rice and Chemical Properties of Soil

Jun-Ho Back* and Bok-Jin Kim*

ABSTRACT

The aim of this study was to investigate the effects of slow-released nitrogen fertilizer(SRNF) on the growth and yield of rice. SRNF produced from wasted paper was applied to a clay loam paddy field comparing to urea fertilized field and only P-and K-fertilized field. Some agronomic components like as growth development and yield component were observed and physico-chemical properties of the soils were analyzed. Plant height and tiller numbers per hill showed higher in rice plant treated with SRNF than in one treated with urea at the early grow stage whereas they appeared to be all much the same at the end of growth stage. While the chlorophyll content in SRNF-treated rice shoot was higher than in urea-treated one, the photosynthetic activity in urea-treated rice shoot was slightly higher than in SRNF-treated rice. In harvested grain, the nitrogen content was higher than in SRNF treated rice than in urea treated rice, but in straws the content was less. At the harvesting stage, nitrogen uptake in grains was about 4% higher in SRNF-treated rice than in urea treated rice whereas in straws rather 20% lower. The N efficiency in SRNF treated rice was lower than in urea treated rice. In the soils treated with SRNF, pH, organic matter and phosphorus were higher than in the soils treated with urea. Total N content in SRNF treated soil was lower after experiment than in urea treated soil.

Key words : Slow-released N fertilizer(SRNF), Growth, Yield, Nitrogen uptake, Nitrogen efficiency, Chlorophyll content, Photosynthetic activity.

Introduction

In Korea, rice is a major crop, and its cultivation area is 55% of total agricultural fields. Now, our concern is to develop the competitive power for rice production under WTO(Korean Society of Rice Research, 1996). In this context, a few technical aspects were proposed to sustain the agricultural environment such as slow-released fertilizer. When quick-acting fertilizer is supplied to cultivate rice in the early stage of growth, blast and lodge are frequently induced. Thus, most of farmers have habitually supplied through 4 times split application of fertilizer.(Lee, 1996; Lee et.al, 1995). Namely the fertilization were performed in amounts of 50, 20, 20 and 10% of total fertilizer at the stages of basal, tillering, panicle induction and ripening, respectively. Various attempts were carried

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out to develop slow-released nitrogen fertilizer(SRNF) for the last half a century(Black and Giesecke, 1923; Lunt, 1971). Ureas and other urea form fertilizers as SRNF also had been applied to turf grasses, garden trees and upland crops. Albeit these forms are relatively inexpensive, they have a disadvantage in the quality regulation and the application to paddy field(Seong, et. al. 1990)

On the other hand, it was reported that paper waste sludge like as news papers, magazines and packing boxes was produced over one million ton. Wood industrial factories have reused them as raw material for the production of fiberboard. Chang et.al.(1992a, b) have studied on the utilization of ripening sludge fertilizers mixed with sawdust, hog manure and urea to recycle the paper waste slurry containing over 60% organic matters. Allan(1991, 1992) and Bailey et. al(1994) have also tried to improve the utility through an infiltration technique of organic matter and synthetic resin into fibrous cell wall. In this study, we report that urea could be incorporated into waste paper fibers and thereafter slowly released to soils and degraded to be optimal condition to uptake for crops. Furthermore, we have improved a SRNF using waste paper slurry.

Materials and Methods

1. Materials

Fig.1 shows the production process of SRNF. Briefly, wasted papers were mixed to obtain pure pulp slurry in 1 to 2% alum($Al_2SO_4 \cdot 18H_2O$) solution at 30 to 40℃ using a defibrator. After fibers were produced from ink-removed pulp slurry in 12in×12in deckle box, they were dried at 100 ±5℃ in a dry oven. Urea saturated solution was fully impregnated to fiberboards and then dried at 75±5℃ in a dry oven. The resulted fertilizer materials were finally manufactured under 100psi at 50℃ through a thermal press and then uniformally sliced.

N-content of trial product, SRNF was 26%. The N-dissoluting rate this product in water at 30℃ for 24hr was 6 about 60% which was higher value than Korean Standards for Fertilizer Regulation. Rice(*Oryza sativa* var. Ilmi) was cultivated in the field of Yeungnam University. The physico-chemical properties of soil before experiment was shown in table1.It appeared to be clay loam soil with low fertility.

2. Treatments

Fifteenkg soils were filled in pots(1/2000a). Total fertilization amounts of N-P_2O_5-K_2O were 15-9-11kg per 10a. Nitrogen was omitted in the control pot(None-N). Only P_2O_5 and K_2O were suppled as the basal dressing fertilization. Urea and SRNF were used as the N-fertilizers. The fertilization were performed in amounts of 50, 20, 20 and 10% of total fertilizer through 4 times split applications, i.e. basal, tillering, panicle induction and ripening, respectively.

SRNF were supplied only as a basal fertilizer. Rice seeds were sawn at May 10th 1999 and two seedlings per hill transplanted at June 20th 1999. The experimental plot was completely randomed design in 8 replicates.

3. Observations and measurements

The growth analysis was carried out in terms of 10 days at the early stage and of 5 days after the middle stage. Chlorophyll contents was measured 40 days after transplanting. Chlorophyll analysis was performed by Yoshida' s method(1972). Briefly, 1g leaves(fresh weight) were grinded with mortar in 80% acetone. After dilution with 80% acetone and filtration with filter paper(Whatman No. 42) in Buchner funnel, the diluted filtrates were filled to

Table 1. Physico-chemical properties of soil before experiment

Texture	pH (1:5)	O.M. g kg^{-1}	T-N (%)	Av. P_2O_5 (mg kg^{-1})	C.E.C. (cmol$^+$ kg^{-1})	Ex. cation(cmol$^+$ kg^{-1})		
						Ca	Mg	K
Clay loam	5.6	13.1	0.14	45	8.7	4.61	0.24	0.11

100ml and their absorbances were observed at 645 and 663 nm using a spectrophotometer(Milton Roy Spectronic 401). The photosynthetic activity in middle leaves was measured with a portable photosynthesis system(LI-6200, LI-COR) between a.m. 10 and 12 O' clock. The measurements were twice performed. The heading date, culm length, panicle length, grain yield and yield components were analyzed by the "Standard Method for Agricultural Experiments" (RDA. 1983). The sampled plant parts were dried at 80℃ and pulverized. Total N-contents were measured by micro-Kjeldahl method. After 0.5g pulverized samples were dissolved in 10ml digesting solution($HClO_4$:H_2SO_4:H_2O=18:1:11), P_2O_5 was quantitatively analyzed by vanadate method and K, Ca and Mg were done using a atom absorption sphectrophotometer(RDA, 1997).

The N-uptake rate and N-efficiency(%) were calculated by equations, N-concentration × dry weight and {(N-content in plants of N-treated plot - N-content in plants of untreated control plot) ÷ N-content of treated fertilizer × 100}, respectively. Soils were air-dried and sieved through 2mm size. Each pH, organic matter, available phosphate and total nitrogen were analyzed by pH meter, Tyurin-, Lancaster- and Kjeldahl methods, respectively. After extraction in 1N-NH_4OAc solution, exchangeable K, Ca and Mg were measured using a atom absorption spectrophotometer (Varian spectra).

The water dissoluting N was collected in a 500ml plastic cylinder in which 10g SRNF were put and mixed 300ml with distilled water. The water was sampled 24hr after reservation at 30℃ in water bath. After filtration, the N-contents were measured by Kjeldahl method.

Results and Discussions

1. Shoot length, tillering number, chlorophyll content and photosynthetic activity

Figure1. shows the changes in the shoot length and number of tillers per hill. It appeared that SRNF had an stimulating effect on shoot growth at the early growth stage but similar to urea-treated plants after the middle growth stage. The number of tillers per hill was not affected by N-form of fertilizers. The maximum tillering stage in untreated(None-N) rice plant in was faster than N-treated one. The maximum tillering number in None-N rice plant was, however, extremely reduced. The tillering number in SRNF-treated rice plant was more increased than urea-treated one upto 50 days after transplanting, developing

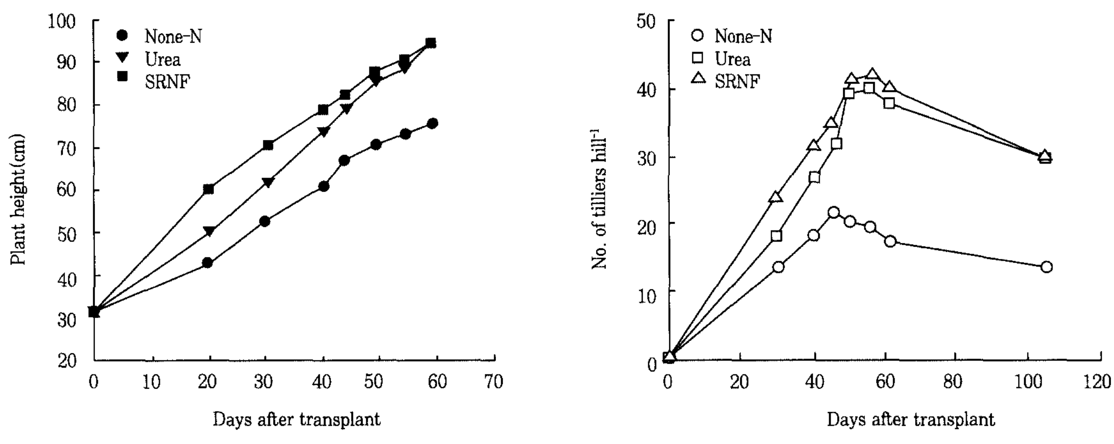

Fig. 1. Changes in the plant height and number of tillers per hill of rice treated with slow-released N fertilizer using waste paper(SRNF).

Table 2. Total chlorophyll content and photosynthetic activity in the leaves of rice treated with slow-released N fertilizer using waste paper(SRNF) at 40 days after transplanting

Treatment	Total chlorophyll content ($mg\ g^{-1}$ fw)	Photosyntheotic activity ($mg\ CO_2\ dm^{-2}\ hr^{-1}$)
None-N	1.41 b*	17.31 b
Urea	3.20 a	22.75 a
SRNF	3.57 a	20.71 a

* Means within a column followed by the same letter are not significantly different at the 5% level by the Duncan's New Multiple Range Test (DNMRT)

almost same numbers after the maximum tillering stage. We would determine that the growth of rice plants in SRNF-treated plot was faster than other ones because of high dissoluting rate of N in SRNF-treated soils.

The chlorophyll content and photosynthetic activity were seen in table2. The chlorophyll content in SRNF-treated rice shoot was 0.37mg^{-1} g fresh weight higher than in urea-treated one whereas the photosynthetic activity in urea-treated rice shoot(22.75mg $CO_2dm^{-2}\ hr^{-1}$) was slightly higher than in SRNF-treated rice shoot(20.71mg $CO_2dm^{-2}\ hr^{-1}$). However, these values were not statistically different in the significant level of 5% such as Cheong's observation(1995).

2. Tillering stage, culm, panicle-length, grain yield and yield component

Some agronomic characteristics were investigated(table3). The heading date in plants of urea-treated plot(August 27th) was one day faster than one in plants of SRNF-treated plot whereas culm- and panicle-length in SRNF-treated plot were longer than in urea-treated plot. However, it was not statistically different in the significant level of 5%.

Although the percent ripened grain in SRNF-treated rice plants was 0.4% lower than in urea-treated rice plants, the grain yield in SRNF-treated rice plants was reversely 3.7g pot^{-1} higher than in urea-treated ones. This phenomenon was resulted from higher number of tillers per hill and of caryopses per panicle, corresponding to Cheong et.al's report(1995) that SRNF had exhibited on positive effect on the development of panicle and caryopsis.

3. Chemical components, N-uptake and N-efficiency

Table4 shows the chemical components in the grains and straws harvested from SRNF or urea-treated rice. The contents of all chemical components in the grain from SRNF-treated rice were higher than in other treatment exclusive with P_2O_5 whereas the contents of total nitrogen and CaO in straws were lower than others. Interestingly, total N-content in grains from SRNF-treated rice was slightly higher than others but, the one straws was less. It might be derived of relatively fast dissoluting rate of SRNF at early

Table 3. Heading date, culm and panicle length, yield in brown rice and yield components of rice

Treatment	Heading date	Culm length(cm)	Panicle length (cm)	No. of panicles $plant^{-1}$	No. of spike-lets $planicle^{-1}$	Ripened grains (%)	1000-grain wt.(g)	Brown rice yield(g pot^{-1})
None-N	8.26	64.3b*	16.3b	13.8b	78b	63.3b	17.5b	37.5b
Urea	8.27	72.6a	20.6a	30.0a	110a	79.9a	20.2a	68.3a
SRNF	8.26	78.8a	20.8a	30.3a	112a	79.5a	20.8a	72.0a

* is the same as in Table 2.

Table 4. Chemical components in the grain and straw of rice treated with slow-released N fertilizer using waste paper(SRNF) at harvest (Unit : %)

Treatment	Grain					Straw				
	T-N	P_2O_5	K_2O	CaO	MgO	T-N	P_2O_5	K_2O	CaO	MgO
None-N	0.59	0.74	1.30	0.22	0.23	0.28	0.39	3.86	0.59	0.27
Urea	1.19	0.84	1.50	0.30	0.27	1.26	0.45	3.91	0.75	0.50
SRNF	1.20	0.82	1.59	0.31	0.30	1.13	0.45	4.03	0.68	0.52

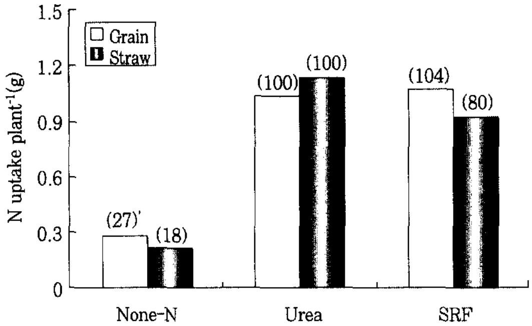

Fig. 2. Nitrogen uptake per plant in the grain and straw of rice treated with slow-released N fertilizer using waste paper(SRNF) at harvest.

* ( ) : Index

growth stage resulting in deficient supply at late growth stage. It should be indicated that the growth period of rice is relatively longer than other crops. The aspects of N uptake were shown in Fig.2. The N uptake in the straws of SRNF treated rice was 20% less than in one of urea treated rice.

The N uptake in the grains of SRNF treated rice, however, was 4% higher than in one of urea treated rice, suggesting that the releasing rate of SRNF was faster than that of urea.'

Table5 indicates the N efficiency at the harvesting stage. The N efficiency of SRNF treated rice(42.8%) was lower than of urea treated rice, corresponding to the results by Wada et.al(1991) that slow released fertilizer had an enhancing effect on total N content at early growth stage of rice and on N efficiency.

Table 5. Nitrogen efficiency of urea and slow released N fertilizer using waste paper(SRF) at harvest

Treatment	Nitrogen efficiency (%)
Urea	48.3
SRF	42.8

4. Chemical properties in soils after experiment

Table6 shows the chemical properties in soils after experiment. The soils treated with SRNF contained higher pH, organic matter, phosphate but CEC and the contents of exchangeable cations(Ca, Mg, K) were similar to them in the soils treated with urea.

Total N-content in the soils treated with SRNF was lower than in the soils with urea in which nitrogen was maintained upto the late growth stage derived of 4 times split application.

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Table 6. Soil chemical properties treated with slow-released N fertilizer using waste paper(SRF) after harvest

Texture	pH (1:5)	O.M. (g kg-1)	T-N (%)	Av. P_2O_5 (mg kg-1)	C.E.C. (cmol+ kg-1)	Ex. cation(cmol+ kg-1) Ca	Mg	K
None-N	6.1	6.8	0.13	0.13	6.2	4.30	0.22	0.11
Urea	5.6	9.1	0.14	0.14	6.6	4.71	0.22	0.07
SRNF	5.9	14.8	0.13	0.13	6.5	4.57	0.22	0.08

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Effects of Applicatin of Slow-Released Nitrogen Fertilizer(SRF) Using Waste Paper Slurry on the Growth and Yield of Rice and Chemical Properties of Soil

Jun-Ho Back* and Bok-Jin Kim*,

폐지섬유를 이용한 완효성 요소비료 시용이 벼의 생육, 수량 및 토양에 미치는 영향

백준호* · 김복진*

폐지섬유를 이용한 완효성 요소비료(시제품)의 벼에 대한 실용화 가능성을 검토하기 위하여 pot시험으로 무질소구, 요소구(대조구), 시제품구 처리에 벼(일미벼)를 공시하여 생육, 엽록소 함량 및 광합성능력, 수량 및 수량구성요소, 식물체중 무기성분 함량, 질소이용율, 토양의 이화학성 등을 조사하였다.

초장과 분얼수는 생육초기에 시제품구가 요소구보다 다소 증가하였으나, 생육후기에는 비슷한 경향을 보였다. 이앙 후 40일의 엽록소 함량은 시제품구에서 요소구보다 다소 높았으나, 광합성능력은 요소구보다 낮았다. 수량 및 수량구성요소는 시제품구보와 요소구간에 통계적인 유의성은 없었으나, 시제품구가 요소구보다 다소 높았다.

수확기에 식물체중 전질소함량은 시제품구가 요소구보다 정조에서는 높았으나, 짚에서는 낮았다. 수확기의 질소흡수량은 시제품구가 요소구보다 정조에서 4% 높았으나, 짚에서는 20% 낮았으며, 질소이용율은 시제품구가 요소구보다 약간 낮았다. 시험 후 토양중 전질소 함량은 시제품구가 요소구보다 낮았다.

Key words : Slow-released N fertilizer(SRNF), Growth, Yield, Nitrogen uptake, Nitrogen efficiency, Chlorophyll content, Photosynthetic activity.

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