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Efficiency of Soil and Fertilizer Nitrogen in Relation to Rice Variety and Application Time, Using ^{15}N Labeled Fertilizer[1].

V. ^{15}N Point application in fields.

Hoon Park[2], Sung Kyun Mok[2] and Sun Jong Seok

Institute of Agricultural Sciences, Office of Rural Development, Suweon, Korea 170

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重窒素를 利用한 水稻品種 및 施用時期에 따른 土壤 및 施肥 窒素의 効率[1]

V 圃場에서 ^{15}N의 局地施用

朴 薰[2]·睦 盛 均[2]·石 順 鍾

農業技術研究所 水原

抄 錄

農家圃場(13個所)에서 重窒素肥料試驗結果 80%의 圃場에서 利用率은 減法의 경우가 標識法의 경우보다 높았으며 肥料窒素에 依한 土壤窒素吸收가 助張된 것을 나타낸다. 이 두 方法의 값은 圃場間에 類似한 傾向을 보였다. 黃皮尿素와 局地施用은 施肥効率(施肥窒素當增收量, Fe)을 分施의 15에서 23으로 增大시켰는 데 이는 利用率(Eu)을 29에서 50으로 增大시킨 때문이며 吸收施肥窒素効率(Ef)은 50에서 46으로 감소하는 傾向을 보였다. 統一系의 多收穫能은 吸收施肥窒素効率, 轉移率 및 土壤窒素選好指數(施肥窒素吸收增加量에 對한 土壤窒素吸收增加量의 比 PI)가 큰데 기인한 것 같다.

일련의 本 研究는 施肥體系下의 收量은 利用率과 吸收施肥窒素効率의 積인 施肥効率에 依存하며 肥料의 形態나 施肥時期 및 方法 等 施肥管理는 主로 利用率을 增大시키고 利用率의 限界는 品種 特性에 主로 基因하는 吸收施肥窒素効率에 依하여 調整됨을 보였다.

Introduction

Slow-release nitrogen fertilizers, such as sulfur coated urea(SCU) and isobutylenediurea(IBDU) were developed for saving labor and energy, decreasing environmental pollution and better

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2) Present address: Korea Ginseng & Tobacco Research Institute(韓國人蔘煙草研究所) 112 Ini-Dong, Chongro-Ku, Seoul

productivity by continuous optimum nitrogen supply to plants. Energy crisis in 1974 increased fertilizer price and stimulated researches increasing productivity under tight supplies of fertilizer. The concept of nitrogen efficiency was much developed in rice since 1974[3,6~10]. These concepts, however, were not much tested for the fertilizer experiment such as application methods and forms in various fields. Point application of urea showed similar effect in yield comparing with SCU[4]. Point application as ball fertilizer of urea may be cheaper than SCU. In this study nitrogen efficiency was investigated in case of point application and broadcasting by using ^{15}N labelled fertilizer in 13 fields of NPK simple trials that were carried out countrywide[5]. Effect of urea and ammonium sulfate on yield were also assessed.

Materials and Methods

Experimental sites: Thirteen fields were selected from 32 fields in which N,P,K simple trials were carried out using both Tongil and local varieties in 1977[5]. Soils included newly opened hillyland, saline and sandy soils with normal soils.

Treatments: ^{15}N labelled urea(5 atom %) was applied to 4-plants plot isolated by plastic plates in 222 plot for 4-time split broadcasting application by puddling to 5cm depth. In one of 022 plot($3 \times 4 = 12m^2$) urea was applied as point application(108 hills) and ammonium sulfate to the other half at 30% reduced rate of 222. Ammonium sulfate point application was carried out for the comparison with urea and for the possible correction of the effect of ^{15}N labelled ammonium sulfate used instead of labelled urea. Thus the point application plot of isolated by plastic plate was made in ^{14}N ammonium sulfate plot of this point application. Specific efforts were made to minimize probable error[1,11]. Appropriate amount for 4 hills of ammonium sulfate(labelled or not) and urea was pu tinto half cut thin mail envelope and then wrapped. The wrapped fertilizer was burried in 5cm depth at the center of 4 hills. All hills are belong only once to a 4 hill unit for fertilizer supply. Sulfur coated urea(TVA) was also tested at 30% reduced rate of 222(It was 20% reduced rate in all other fields except 13 fileds caryring out ^{15}N ammonium sulfate experiment). N2 level was 16kg per Tongil and 12 KgN per 10a for the local. Phosphorus(P_2O_5) and Potash(K_2O) of 2 level were 8Kg for Tongil and 6 for the local.

Sampling and ^{15}N analysis: Soil samples(top and subsoil) and plant samples are analysed according the standard methods of Institute of Agricultural Sciences[12]. Pooled samples were made of three hills for straw and grain ground by vibrational mill and subjected to ^{15}N analysis[2].

Results and Discussion

Soil chemical characteristics were shown in Table 1. Except newly opened hilly soil, Songjeong series, all other soils were relatively high in organic matter content. The yield in this hilly soil was 200 and 242 Kg/10a for the local and Tongil on no-fertilizer plot but 659 and 787 with SCU. It was 628 and 68_Kg/10a respectively in 522 treatment.

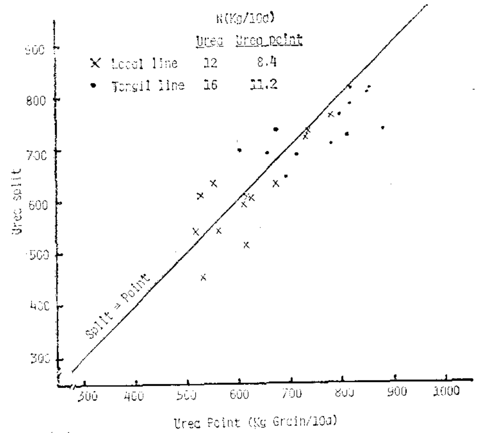

Fig. 1. Relationships between yield(kg/10a) with urea split(4 times) and point application of 70% nitrogen(1977).

Table 1. Soil chemical characteristics of ^{15}N experimental fields

Province	Soil series		pH (%)	OM (%)	P (ppm)	Exch. (me/100g) Ca	Mg	K	SiO_2 (ppm)
Gyeongi	*Mangyeong*	T	5.6	2.34	69	2.70	2.19	0.05	71
		S	6.9	0.17	11	4.51	3.19	0.05	113
	Jeonbug	T	5.9	2.64	175	2.81	0.43	0.07	87
		S	6.3	2.17	41	3.85	0.62	0.09	105
Gangweon	*Gyuam*	T	5.9	2.64	175	2.81	0.43	0.07	87
		S	6.3	2.17	41	3.85	0.62	0.09	105
Chnngnam	*Pyeongtaeg*	T	5.8	3.14	78	3.15	0.73	0.13	159
		S	5.7	3.17	48	3.32	0.85	0.08	69
	Sachon	T	5.5	3.59	95	2.48	0.54	0.08	71
		S	6.3	3.34	40	3.08	1.01	0.05	115
	Yeompo	T	5.7	3.69	26	5.37	1.42	0.10	76
		S	6.3	3.00	19	4.59	1.35	0.07	93
Jeonbug	*Songjeong*	T	5.5	0.21	4	0.83	0.96	0.13	136
		S	5.3	0.17	4	0.77	0.98	0.14	155
	Chunpo	T	5.7	2.97	62	4.51	1.16	0.17	97
		S	5.9	1.76	11	4.95	2.15	0.09	129
Jeonnam	*Hwadong*	T	5.1	2.03	62	4.32	1.84	0.43	154
		S	5.5	1.72	39	4.29	2.19	0.27	215
	Jisan	T	5.7	1.52	92	3.43	1.33	0.76	157
		S	5.8	1.59	46	3.55	1.41	0.23	147
Gyeongbug	*Sinheung*	T	5.6	1.66	67	2.63	0.79	0.20	75
		S	5.7	1.55	38	3.88	0.84	0.10	86
Gyeongnam	*Yuga*	T	5.5	1.93	56	3.88	1.40	0.13	77
		S	6.1	1.93	74	3.85	1.62	0.08	103
	Gangseo	T	4.8	1.52	89	1.84	0.52	0.17	38
		S	4.9	0.69	60	1.77	0.48	0.11	38

T: topsoil S: subsoil

The mean of yield, harvest index, fertilization efficiency of 13 fields with SCU, ammonium sulfate and urea point application was shown in comparison with 220 fertilizer, 222 and maximum yield plots in Table 2.

Highest yield was shown in point applications. Point application was better than SCU. High yield of SCU and point application seems to be due to higher fertilization efficiency(Fe). Fe was higher by 9 to 10 than that of 4-time split application. Even in maximum yield plot Fe increased slightly.

Point application increased number of tillers per hill and plant height than SCU did(Table 2). Plant height in two varieties and number of tiller per hill in the local were smaller in SCU than in 222 plot. This indicates that SCU supplies nitrogen more in the later stage while point application still supplies in the early stage of growth. Yield trend among fields with 4-time split was similar to that with point application (Fig. 1). This result again indicates fertilizer

Table 2. Yield and fertilization efficiency(Fe) with various nitrogen application methods(mean of 13, 1977)

	Fn (N kg/10a)	Yield (kg/10a)	Yield Index	Fe Yield kg/kg	HI	At harvest	
						No. tiller/hill	Plant height
Local line							
0 0 0	0	443	72	—	40	11.0	72.2
2 2 2*	12	612	100	13.9	46	13.5	85.9
SCU(TVA)	8.4	639	103	22.0	47	14.0	80.5
U.P.	8.4	631	103	22.3	49	14.7	89.6
A.P	8.4	657	107	25.9	49	14.3	91.9
Max. Yield**	17	683	112	17.1	48		
Tongil ilne							
0 0 0	0	500	68	—	54	11.7	64.3
2 2 2	16	738	100	15.1	53	14.5	64.5
SCU	11.2	757	103	21.9	54	14.8	63.5
U.P	11.2	771	104	24.1	57	16.1	80.7
A.P	11.2	770	104	24.1	57	16.2	70.0
Max. yield	22	825	112	15.5	56		

* 4 split, U.P or A.P; urea or ammonium sulfate point application(5cm depth)
** Maximum yield did not include point application, HI: Harvest index

Table 3. Fertilization efficiency(Eu), and absorbed fertilizer nitrogen efficiency(Ef) in split and point application(mean of 13, 1977)

		Yield	Nt	Nf	Ns	Eu(%)		(T%)	Ef	Fe	HI
		(kg/10a)				Difference	¹⁵N				
0 0 0	Local	443	4.64	—	—	—	—	63.4	—	—	40
	Tongil	500	5.68	—	—	—	—	65.2	—	—	54
2 2 2*	Local	612	9.36	3.45	5.91	36.3	28.0	61.9	47.3	13.9	46
	Tongil	738	11.37	4.87	6.50	37.5	30.4	69.2	52.7	15.1	53
Point	Local	657	10.25	4.24	6.10	65.7	51.2	62.3	45.8	23.4	49
	Tongil	770	12.30	5.47	6.83	58.9	48.8	67.4	46.8	23.2	57
(70% of 222)											

* N for Tongil line 16kg/10a, for local line 12kg, potash(K_2O) and phosphorus(P_2O_5) were 8kg/10a for Tongil line and 6kg for local line. Nt: Total nitrogen taken up, ¹⁵N: N from fertilizer, Ns: N from soil T: Nitrogen partition to grain, HI: Harvest index.

application method seems to be very limited for the increase of field productivity and for the change of production system.

Super-granular urea(2g and 4g per granule made in TVA) was applied as point application at higher nitrogen level than SCU in one field and resulted in higher yield(no data showed) suggesting that optimum rate will be much higher in point application. The large granular urea may be much more economically feasible than SCU. Yield increase by 3 to 7% with 30% reduced rate of fertilizer suggests that saving nitrogen fertilizer is highly possible for practical use in the near future. There was specially high response to ammonium sulfate in certain field indicating that long term use of urea must

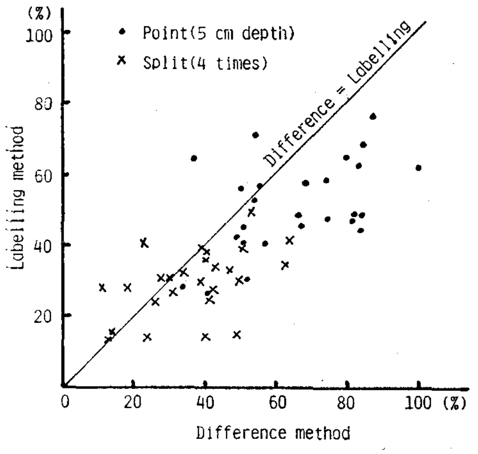

Fig. 2. Comparison of fertilizer use efficiency by different method and labeled nitrogen method in point(70% N of split) and split application(1977).

be reconsidered.

The uptake of fertilizer and soil nitrogen, use efficiency, absorbed fertilizer nitrogen efficiency were shown in Table 3. Tongil showed higher uptake not only of fertilizer nitrogen but also of soil nitrogen. Point application increased uptake of both fertilizer and soil nitrogen.

Use efficiency of fertilizer nitrogen in two methods was greater in Tongil and in point application. Use efficiency calculated by difference method tended to be greater than that calculated by the labelling method(Fig. 2) especially in point application that showed higher value of Eu. This fact indicates that the more the fertilizer nitrogen is used efficiently the larger the uptake amount of soil nitrogen.

Efficiency of soil nitrogen uptake could be measured by the ratio of the increment of soil nitrogen to the increment of fertilizer nitrogen in plants($\Delta Ns/\Delta Nf$) rather than $\Delta Ns/\Delta Nf$ [10] From Table 3($\Delta Ns/\Delta Nf$)$\times$100 was 55 for Tongil and 24 for the local. This parameter may be called soil nitrogen preference index(PI) and could be used as a criterion for saving fertilizer nitrogen.

In the fields(less than 20% fo total number of fields) with higher use efficiency by ^{15}N method the luxuary absorption of fertilizer may occur probably due to dense root development to the area of fertilizer nitrogen applied. The interaction of indi genous nitrogen of soil and fertilizer nitrogen may be implicated in the difference of the efficiency between difference and labelling methods. Translocation efficiency of *nitrogen to grain(T) was greater in Tongil* but similar between application methods(Table 3).

Scatter diagram of Eu, Ef and Fe were shown is Fig. 3, 4 and 5. Point application predominantly increased use efficiency(Eu) but it affected little and rather tended to decrease a little the absorbed fertilizer nitrogen efficiency(Ef). Thus point application increased Fe through greater contribution of Eu.

This fact strongly indicates that fertilizer application methods improve only use efficiency for higher fertilization efficiency. It also means that absorbed fertilizer nitrogen efficiency depend much on varietal improvement. In Table 3 average Ef was higher in Tongil than in the local varieties. Above results are well accordance with the fact that high yield in soils depends more on Eu while high yield in varieties depends more on Ef[7,8]. Thus the limitation of Eu imp-

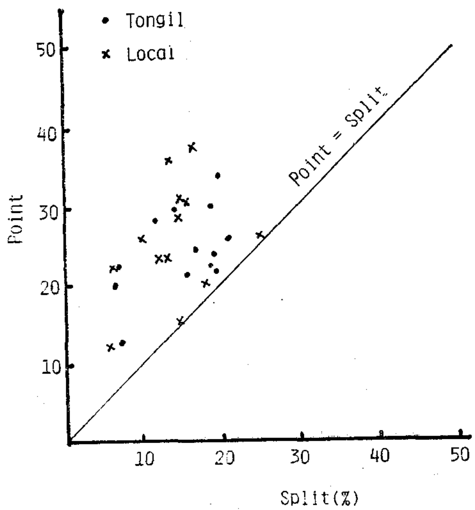

Fig. 3. Scatter diagram of nitrogen use efficiency in point application(30% reduced rate) and 4-time split application of urea with two rice lines(1977).

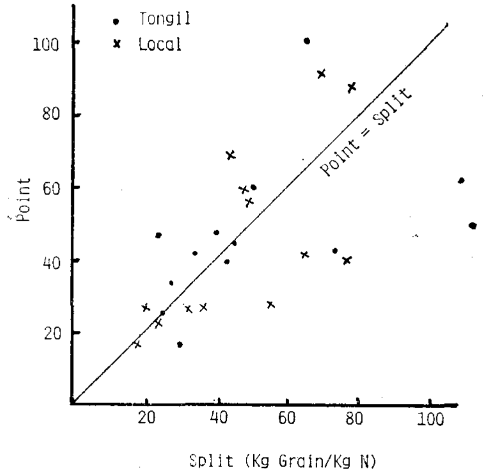

Fig. 4. Scatter diagram of absorbed fertilizer nitrogen efficiency(kg grain/kg N) in point application(30% reduced rate) and 4-time split application of urea with two rice lines(1977).

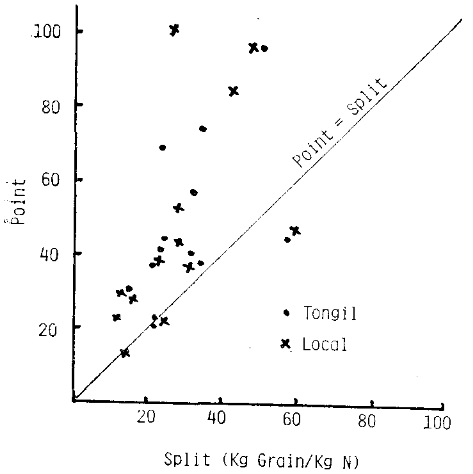

Fig. 5. Scatter diagram of fertilization efficiency in point application(30% reduced rate) and 4-time split application of urea with two rice lines(1977).

rovement will be controlled by Ef. It may be the partial answer to the question why the 30% increased rate with SCU over that of maximum yield with split application can not give any considerable yield increment though the 30% reduced rate gives the same or slightly higher yield.

Abstract

From ^{15}N labelled nitrogen experiments on 13 fields use efficiency by difference method was higher than that by labelling method in 80% of fields tested indicating augmentation of soil nitrogen uptake by fertilizer nitrogen. Both methods showed very similar trend among fields. Sulfur coated urea(SCU) and point application increased fertilization efficiency(yield increment per fertilizer nitrogen applied, Fe) to 23 from 15 of split application through the increase of fertilizer use efficiency from 29(Eu) to 50 but tended to decrease efficiency of absorbed fertilizer nitrogen(yield increment per nitrogen derived from fertilizer, Ef) from 50. to 46

High yielding capacity of Tongil line appears to be attributed to the higher Ef, translocation efficiency and soil nitrogen preference index(soil nitrogen increment in plant per the increment of fertilizer nitrogen in plant, PI).

This studies confirmed that yield under fertilizer application system depends on Fe which is the multiplication of Eu and Ef and that the improvement of fertilizer management(form, application method and time) increases principally Eu, the limit of which is controlled by Ef that is attributed mainly to varietal characteristics.

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