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KP 110

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ABSTRACT

USE OF *Azolla* AS A NITROGEN SOURCE FOR LOWLAND RICE. A four-year experiment has been carried out to study the possibility of using *Azolla* as a nitrogen source for lowland rice. The work done in the first year of the experiment which was conducted in the wet season (WS) and the dry season (DS) of 1984/1985, was to evaluate whether *Azolla* could really increase rice yield. In the second year of the experiment done in the WS and DS of 1985/1986, N-derived from *Azolla* (N-dfA) and N-derived from urea (N-dfU) in rice plant were determined. The third year work done in the WS and DS of 1986/1987 was conducted to see to what extend *Azolla* could be applied in the field in terms of kg N/ha as a N-source for rice. While the last year of the experiment was devoted to study the N-balance of *Azolla* and urea, which was done in the DS of 1988/1989. Results of the experiments show that *Azolla* has the same ability as urea to increase rice production. There was no difference in total N-uptake by rice treated either with *Azolla*, or urea, or *Azolla* interacted with urea. By increasing the *Azolla* level its N recovery will decrease. The same phenomenon was also found for urea. Another interesting fact is that an *Azolla* cover in the rice field could promote N-uptake from urea.

ABSTRAK

PENGGUNAAN *Azolla* SEBAGAI SUMBER N BAGI PADI SAWAH. Telah dilakukan penelitian selama empat tahun berturut-turut mengenai kemungkinan penggunaan *Azolla* sebagai sumber N bagi padi sawah. Pekerjaan pada tahun pertama yang dilakukan pada musim tanam penghujan (MTP) dan musim tanam

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kemarau (MTK) 1984/1985 ialah untuk menilai apakah *Azolla* benar-benar mampu menaikkan produksi padi. Percobaan tahun kedua yang dilakukan pada MTP dan MTK 1985/1986 ialah untuk menentukan berapa besar N-berasal dari *Azolla* (N-bdA) sekaligus dibandingkan dengan N-berasal dari urea (N-bdU), yang ditemukan pada tanaman padi. Tahun ketiga dari penelitian ini, yang percobaannya dilakukan pada MTP dan MTK 1986/1987 ialah untuk mengamati sampai seberapa jauh takaran N-bdA dapat diterapkan di lapangan, yang hasilnya dibandingkan dengan N-bdU. Tahun terakhir penelitian ini dititikberatkan pada penyusunan neraca N-bdA dan N-bdU. Hasil penelitian empat tahun ini menunjukkan bahwa *Azolla* mempunyai kemampuan yang setara dengan urea untuk meningkatkan produksi padi. Selain itu tidak ada perbedaan antara serapan N-total bdA dan serapan N-total bdU, atau dengan *Azolla* yang diinteraksikan dengan urea. Meningkatnya takaran N-bdA akan menurunkan kandungan N-bdA yang ditemukan kembali pada tanaman padi. Hal yang serupa ditemukan juga pada urea. Adanya hamparan *Azolla* di sawah akan meningkatkan penyerapan N-bdU oleh tanaman padi.

INTRODUCTION

The ability of *Azolla* to fix N_2 from the air has been established by many researchers. This trait of *Azolla* in building up its nitrogen content could be used as an N source for many purposes, such as for lowland rice to increase rice production. This possibility has been studied in different countries (1-3). Such studies are very important because the results have shown that *Azolla* has the possibility to replace a part of chemical fertilizers usually used for lowland rice. In some extreme cases such as for remote areas, it could be used as a sole N fertilizer source.

In Indonesia the common rate of N used for lowland rice range from 60 to 90 kg N/ha. In several agricultural

areas, the rate used is up to 150 kg N/ha or more. A report by SUMANTRI (4) in one of the most prominent newspaper in Indonesia "Kompas" said that in four provinces in Java, the rate of fertilizer used is 279.22 - 340.65 kg Urea/ha. With such fertilizer rate, the rice yield range only from 4.42 to 4.97 t/ha. The lack of response to chemical fertilizer shown by these data could be attributed to the satiated condition of the soil, caused by using high rates of chemical fertilizers for long periods. Over-using chemical fertilizers was also brought forward by the President of Indonesia Mr. Soeharto in his speech at the opening of an N-fertilizer plant. He warned the farmers to use fertilizers cautiously and not to overuse it (5).

In connection with the above statements, especially for Indonesia, may be *Azolla* can be used to improve soil conditions by reducing chemical N fertilizers rate and replace it by *Azolla*. Another advantage of using *Azolla* as an N source is that it could be used in remote areas, where no chemical fertilizers are available due to lack of transportation.

This paper reports the work done under FAO/IAEA Coordinated Research Programme on Isotopic Studies of Nitrogen Fixation and Nitrogen Cycling in *Azolla* and Blue-Green Algae, RC No. 39271SD for four years to study the

possibility of using *Azolla* as an N source for lowland rice.

MATERIALS AND METHODS

Influence of N Source on Rice Production (1984/1985). Field experiments were conducted in Bogor, West Java. The date of seeding, transplanting, and harvesting are presented in Table 1.

Table 1. The dates of seeding, transplanting, and harvesting of the four year experiment

YEAR	Date of		
	Seeding	Transplanting	Harvesting
1984/1985			
wet season (WS)	Nov. 6, 1984	Nov. 27, 1984	March 10, 1985
dry season (DS)	May 20, 1985	June 11, 1985	Sept. 23, 1985
1986/1987			
wet season (WS)	Dec. 9, 1985	Jan 2, 1986	April 15, 1986
dry season (DS)	June 9, 1985	June 30, 1986	Oct. 1, 1986
1987/1988			
dry season (DS)	May 22, 1987	June 15, 1987	Sept. 7, 1987
wet season (WS)	Nov.15, 1987	Dec. 7, 1987	March 14, 1987
1988/1989			
dry season (DS)	May 25, 1988	June 14, 1988	Sept. 13, 1988

Note : After each experiment a residual experiment was carried out

Plots size, plant distance, and variety used are described in Table 2.

All the treatments performed in the field experiments are shown in Table 3. In these experiments, *Azolla* was applied at a rate of 36 and 72 kg N/ha, at different times, i.e. before and after transplanting. Only labelled urea was used in these experiments while the *Azolla* used was un-labelled.

Table 2. Experiment site, plot size, plant distance, and rice variety used in the four year field experiment

1984/1985	
- experimental site	: Bogor, 250 m above sea level
- plot size :	
* yield plot	: 5 m x 1.60 m
* isotope plot	: 1.60 m x 1.20 m
- plant distance	: 20 cm x 20 cm
- rice variety	: Atomita I
1985/1986	
- experimental site	: Bogor, 250 m above sea level
- plot size :	
* yield plot	: 5 m x 4 m
* isotope plot	: 1 m x 1 m
- plant distance	: 20 cm x 20 cm
- rice variety	: IR-36
1987/1988	
- experimental size	: Pusaka Negara, 5 m above sea level
- plot size :	
* yield plot	: 3 m x 3 m
* isotope plot	: 1 m x 1 m
- plant distance	: 20 cm x 20 cm
- rice variety	: IR-64
1988/1989	
- experimental size	: Bogor, 250 m above sea level
- plot size :	
* yield plot	: 5 m x 4 m
* isotope plot	: 0.8 m x 0.6 m
- plant distance	: 20 cm x 20 cm
- rice variety	: IR-64

Note : both experimental sites, Bogor and Pusaka Negara are located in West Java

The main parameter observed was rice production expressed in dry weight of grain and straw.

Interaction of N Source (1986-1987). These field experiments were done in Bogor. Date of seeding, planting, and harvesting are presented in Table 1. In Table 2 data for plot size, plant distance, and rice variety used are given. Here *Azolla* was applied at 60 kg N/ha in two splits, but this rate could not be achieved in the field. The rates applied were usually less than 60 kg N/ha. Labelled *Azolla* and urea were used in these field experiments. The labelling of *Azolla* was done in the field. It was done by growing *Azolla* in plots with a 3 m X 3 m size and, into these plots labelled urea was added. The labelled *Azolla* was washed, mixed and drain before incorporation. The treatments conducted in these experiments are presented in Table 4. The parameter used was the nitrogen yield.

Effect of N Sources Rate on N-Recovery (1987/1988). Field experiments were done at Pusaka Negara, West Java. Date for seeding etc, and plot size etc are referred in Tables 1 and 2, while the treatments are described in Table 5. Here *Azolla* used ranged from 28.0 to 117.2 kg N/ha, while rate of urea was from 30 to 120 kg N/ha. The same labelling method was used as in the experiment 1986/

1987, and the labelling was done in the field. Parameter applied was N-recovery of N efficiency of *Azolla* and urea.

^{15}N Balance Experiments (1988/1989). Field experiments were done at Bogor. The date of seeding etc, and plot size etc. are presented in Tables 1 and 2. The treatments done in this experiment are described in Table 6. The rate of *Azolla* applied was 200 g fresh weight/m^2 when used with urea, while urea was applied at a rate of 30 and 60 kg N/ha. Labelled *Azolla* was applied at a rate of 33.3 kg N/ha.

The method of labelling *Azolla* in the field was by growing *Azolla* in 1/3 part of the experiment plot. After ^{15}N labelled urea was applied to the *Azolla* cover, it was left to grow for 12 days. After this time period *Azolla* was expanded to 1/2 part of the experiment plot. To this *Azolla* cover, more ^{15}N labelled urea was added. After the second addition of ^{15}N labelled urea, the *Azolla* cover was left to grow for 15 days. At the end of the 15 days growing period, the *Azolla* was let to expand to the whole experiment plot. The whole labelled *Azolla* cover was incorporated into the soil. The main parameter here was to establish an N-balance of rice applied with *Azolla* or urea.

Azolla. *Azolla* used for all the experiment was *Azolla* pinnata obtained from the National Biology Institute,

Bogor, Indonesia. The percentage of total-N and the atom excess of *Azolla* used are presented in Tables 7 and 8.

Harvest. For all the experiments done the rice plants were cut at 3 cm above the soil surface. Panicle was separated from straw and dried at 60°C for 48 hours.

Total-N was determined by Kjeldahl method. For the experiments receiving ^{15}N, the atom excess of the plant parts were determined using a JASCO NIA-1 emission spectrometer.

RESULTS AND DISCUSSION

Influence of N-Source on Rice Production (1984/1985). From these experiments it was clearly shown that *Azolla* has the same ability as urea to increase rice production (Table 9). The increase of rice production by *Azolla* as compared to the control, was observed in the dry season (DS) as well as in the wet season (WS) experiment. Especially for the DS experiment, from the data obtained it was revealed that *Azolla* at a lower N-rate gave more rice production than urea applied at higher N-rate (Table 9).

By these experiments it was proven that *Azolla* could be used as a single N-source or interacted with urea to increase rice production. Similar fact has also been reported by many research workers as mentioned before.

Interaction of N-Source (1986/1987). For these field experiments, discussion will be focused on the nitrogen yield of rice. Data in Table 10 show that the highest N-yield is for treatment NU-3. For *Azolla* alone and *Azolla* interacted with urea, the nitrogen yield were quite low, particularly in the WS. This might be due to the *Azolla* N-rate applied, which in general was lower than the N-rate of urea, while for the DS, the difference was not so much (Table 4). This is probably because of the nearly equal N-rate application of *Azolla* and urea (Table 4). The difficulty in applying *Azolla* at N-rates exactly the same as urea, has lso been reported by ESKEW and KOVACS (6).

Data in Table 11 show that, there is no difference in total-N uptake between *Azolla*, urea, or *Azolla* interacted with urea. Only for treatment NU-3, there is a quite high total N-uptake. But for this treatment, labelled urea was used twice i.e., at transplanting and at maximum tillering, while for the other treatments, labelled *Azolla* or urea was only applied once, at transplanting or at maximum tillering. Expressed in mg N/9 hills, total N-uptake dfU was higher. This is due to the higher nitrogen yield as presented in Table 10.

In the WS, there were still differences between treatments on N-recovery in grain, straw, and plant. The high-

est N-recovery was obtained by *Azolla* when interacted with urea/NAU (Table 12). In the DS, there were no differences in N-recovery in the grain, straw, and plant. The higher N-recovery from *Azolla* can be used as an indicator that rice plant can use N-dfA better than N-dfU. Another possibility is that more N-dfU is lost than N-dfA from the soil, leaving less N-dfU available for rice compared with N-dfA.

Effect of N-Source Rates on N-Recovery (1987/1988). In these field experiments, it is obvious that N-rate of *Azolla* is always lower than that of urea (Table 5). Despite of this fact, the N-dfA was higher than N-dfU (Table 13). This might mean that as an N-source, *Azolla* is used more efficiently than urea. Another interesting point is that with the increase of N-source rates either *Azolla* or urea, the N-recovery decreased.

^{15}N Balance Experiments (1988/1989). Data presented in Table 14 show that the lowest N-uptake by rice was for treatment 30 NU (T). This happened when urea was applied without an *Azolla* cover. But when urea was applied at a later time, i.e. two weeks after transplanting, the N-uptake increased (Table 14). An increase of N-uptake was also observed when the N rate of urea was increased. However N-uptake dfA was not too high compared to N-uptake

An interesting fact is that N-uptake dfU could increase when there is an *Azolla* cover. Total N-uptake in roots were higher in those located at 0-10 cm depth than in deeper roots. For total N in the soil, apparently more N left in 0-10 cm soil layer than in deeper layer (Table 14).

The highest N-recovery percentage in plants were given by treatment A (T1) + 30 NU (wat), while for *Azolla* as a single source represented by treatment NA (T), the N-recovery was also quite high (Table 15). For the root and soil, the highest N-recovery was given by the treatment where *Azolla* was used as a single N source NA(T) (Table 15). The highest total N-recovery was also from the *Azolla* treatment NA (T), while the lowest N-recovery was given by the treatment where urea was applied at transplanting at a rate of 60 kg N/ha (60 NUL(T)) (Table 15)

CONCLUSIONS

From this four-year experiment, the following conclusions could be forwarded i.e.:

- *Azolla* has the same ability as urea to increase rice yield
- Total N-uptake dfA generally is lower than that dfU. This might be due to the lower N-rates of *Azolla* applied compared to that of urea

- It is difficult to reach high N rates from *Azolla* which is equal to that of urea, especially for rates higher than 60 kg N/ha
- The higher the N rates of *Azolla* and urea used the lower the percentage of N-recovery
- An *Azolla* cover in the rice field can increase N-uptake dfU.

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Table 3. Treatments carried out in the field experiments, 1984/1985

Code of treatment	
1. ON	Control, no nitrogen
2. 30 NU	30 kg N/ha urea applied as a basal fertilizer, broadcasted and incorporated
3. 60 NU	60 kg N/ha urea applied in three splits, 30 kg N/ha before transplanting, 15 kg N/ha three weeks after transplanting, and 15 kg N/ha 25 days before heading
4. 90 NU	90 kg N/ha urea applied in two splits, 60 kg N/ha before transplanting, and 30 kg N/ha 25 days before heading
5. 30NU + 36NA (1)	30 kg N/ha urea and 1.5 kg fresh weight/m^2 *Azolla* (equal to 36 kgN/ha) are simultaneously incorporated into the soil as basal fertilizer. *Azolla* was planted in the treatment plot. If *Azolla* has nor reach the quantity of 1.5 kg fresh weight/m^2, the deficit was added from outside the treatment plot.
6. 30NU + 36NA (2)	30 kg N/ha urea applied as a basal fertilizer, and *Azolla* was added three weeks after transplanting by incorporation into the soil, at the rate as in treatment 5. The same step as in treatment 5 was taken when *Azolla* has not reached the required quantity
7. 72 NA (1)	After reaching full cover, *Azolla* was incorporated into the soil before transplanting. After transplanting *Azolla* inoculation was repeated in the treatment plot. The second incorporation of *Azolla* was carried out at 25 days before heading. The first and second incorporation of *Azolla* was at the same rate as in treatment 5, and the same step was taken as in treatment 5 when Azolla has not reached the required quantity.
8. 72 NA (2)	After reaching full cover, *Azolla* grown after transplanting was incorporated into the soil. Directly after the first incorporation *Azolla* was reinoculated to reach full cover. The second incorporation of *Azolla* was carried out at 25 days before heading. Both incorporation of *Azolla* were done at a rate equal to treatment 5, and the same step as in treatment 5 was taken when *Azolla* has not reached the required quantity.

Notes : - ^{15}N labelled urea was used only in the isotope plots
- no labelled *Azolla* was used in the isotope plots
- the same treatments were carried out for the isotope plots as well as for the yield plots

Table 4. Treatments of field experiments, 1986/1987

Wet Season				Dry Season				Code of treatment
Azolla		Urea		Azolla		Urea		
t	mt	t	mt	t	mt	t	mt	
kg N/ha								
Isotope plot								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ON
28.3*	27.2	0.0	0.0	30.0*	23.7	0.0	0.0	NA-1
29.0	21.4*	0.0	0.0	29.0	31.1*	0.0	0.0	NA-2
0.0	0.0	30.0*	30.0	0.0	0.0	30.0*	30.0	NU-1
0.0	0.0	30.0	30.0*	0.0	0.0	30.0	30.0*	NU-2
0.0	0.0	40.0*	20.0*	0.0	0.0	40.0*	20.0*	NU-3
0.0	21.4*	30.0	0.0	0.0	31.1*	30.0	0.0	NAU
Yield plot								
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ON
29.0	27.2	0.0	0.0	27.8	23.7	0.0	0.0	NA-Y
0.0	0.0	30.0	30.0	0.0	0.0	30.0	30.0	NU-Y1
0.0	0.0	40.0	20.0	0.0	0.0	40.0	20.0	NU-Y2
0.0	27.2	30.0	0.0	0.0	23.7	30.0	0.0	NAU-Y

Notes : - t = Azolla and urea applied at transplanting
- mt = Azolla and urea applied at maximum tillering
- * = labelled Azolla or urea used

Table 5. Treatments of field experiment 1987/1988

DS		WS		Code of treatments
Azolla	Urea	*Azolla*	Urea	
kg N/ha				
Isotope plot				
0.0	0.0	0.0	0.0	ON
28.0	0.0	29.3	0.0	A1
56.0	0.0	58.6	0.0	A2
84.0	0.0	87.9	0.0	A3
112.0	0.0	117.2	0.0	A4
0.0	30.0	0.0	30.0	U1
0.0	60.0	0.0	60.0	U2
0.0	90.0	0.0	90.0	U3
0.0	120.0	0.0	120.0	U4
Yield plot				
0.0	0.0	0.0	0.0	ONY
22.72	0.0	27.82	0.0	A1Y
45.44	0.0	55.64	0.0	A2Y
68.16	0.0	83.46	0.0	A3Y
90.88	0.0	111.28	0.0	A4Y
0.0	30.0	0.0	30.0	U1Y
0.0	60.0	0.0	60.0	U2Y
0.0	90.0	0.0	90.0	U3Y
0.0	120.0	0.0	120.0	U4Y

Notes : - each rate of *Azolla* and urea was applied in two splits, i.e., the first half was added at transplanting and the other half at one month after transplanting
- labelled *Azolla* and urea were used in the isotope plots

Table 6. Treatments of field experiment 1988/1989

Codes of treatments	
ON	Control, no nitrogen
30 NU(T)	30 kg N/ha urea, incorporated at transplanting, without *Azolla* inoculation
30 NU(T) + A(T)	30 kg N/ha urea, incorporated at transplanting, with *Azolla* inoculation but not incorporated
NA(T)	33.3 and 30.4 kg N/ha *Azolla*, incorporated at transplanting, in the isotope and yield plots respectively
A(T) + 30 NU(wat)	*Azolla* inoculated at transplanting, at a rate of 200 g fresh weight/m^2, but not incorporated into the soil. 30 kg N/ha urea was added at 2 weeks after transplanting
A(T1) + 30 NU(wat)	The same treatment as in treatment 5 was carried out, but in this treatment *Azolla* was incorporated into the soil at 4 weeks after transplanting. Further *Azolla* growth was allowed but not incorporated
30 NU (wat)	30 kg N/ha urea, added into the flood water at the same time as in treatment 5, without *Azolla* inoculation
60 NU (T)	60 kg N/ha urea, incorporated at transplanting, without *Azolla* inoculation
A(T)	*Azolla* inoculated at transplanting, at rate of 200 g fresh weight/m^2, but not incorporated and no addition of urea

Notes :
- treatments number 1 to 9 were all applied in the isotope and yield plots
- ^{15}N labelled urea and Azolla were only used in the isotope plots
- in the isotope plots ^{15}N labelled urea was used for treatments 2, 3, 5, 6, 7, 8, and for treatment 4 ^{15}N labelled *Azolla* was used
- for treatment 9, unlabelled *Azolla* was used in the isotope as well as in the yield plots

Table 7 Percentage of total-N of *Azolla* during the four year experiments

	N-total			
	WS		DS	
	..... %			
1984/1985	3.720*		3.800*	
1985/1986	T	MT	T	MT
- unlabelled	3.80**	3.08**	3.85**	3.76**
- labelled	4.08**	4.20**	4.24**	4.16**
1987/1988				
- unlabelled	3.127***	3.450***	3.307***	3.326***
- labelled	3.586***	3.902***	3.637***	3.667***
1988/1989	12 d		15 d	
- unlabelled	4.1994****		4.2569****	
- labelled	4.2972****		4.5510****	

WS = Wet Season, DS = Dry Season, T = *Azolla* applied at transplanting, MT = *Azolla* applied at maximum tillering, 12 d = 12 days after *Azolla* inoculation, 15 d = 15 days after *Azolla* inoculation
* = mean from 4 replicates, ** = mean from 10 replicates, *** = mean from 8 replicates, **** = mean from 4 replicates

Table 8 Percentage of atom excess of labelled *Azolla* during the experiments

	Atom Excess	
	WS	DS
	..... %	
1984/1985	-	-
1986/1987		
T	3.56**	4.22**
MT	3.42**	3.46**
1987/1988		
T	1.2254***	2.4437***
MT	1.4316***	2.6833***
1988/1989		
15 d	-	12.0376****

Notes : all the abbreviations and signs mentioned in this table are indentical to that of Table 7

Table 9 Influence of N-source on rice production

Treatments	Dry Season		Wet Season	
	GR	ST	GR	ST
	..... kg/ha			
1. ON	3153	3675	3085	3637
2. 30 NU	4038	4124	3391	4377
3. 60 NU	4139	4059	3722	4539
4. 90 NU	4889	4841	3608	4592
5. 30NU + 36NA(1)	4266	4129	3884	4690
6. 30NU + 36NA(1)	3863	4263	3655	4896
7. 72 NA (1)	4918	5185	3603	4386
8. 72 NA (2)	4943	4551	3726	4351
LSD 5%	642	ns	ns	625
CV (%)	10.21	10.40	14.45	9.59

Notes : GR = Grain, ST = Straw, * = mean of four replications LSD= Least Significant Difference, CV = Coefficient of Variation, ns = not significant

Table 10 Effect of *Azolla*, urea, and *Azolla* + urea on nitrogen yield

Treatments	Wet Season			Dry Season		
	GR	ST	PL	GR	ST	PL
	..... mg N/9 hills					
ON	1242*	407	1649	1271	551	1822
NA-1	1587	511	2098	2055	742	2797
NA-2	1448	502	1950	2103	789	2892
NU-1	1903	574	2477	2155	791	2946
NU-2	1861	545	2406	2271	767	3030
NU-3	2048	552	2600	2313	867	3180
NAU	1727	477	2204	2242	655	2897
LSD 5%	371	ns	438	346	139	364
CV (%)	15	20	13	11	13	9

Notes : GR = Grain, ST = Straw, PL = Plant = Grain + Straw, * = mean of four replications, LSD = Least Significant Difference, CV = Coefficient of Variation, ns = not significant

Table 15 Effect of *Azolla*, urea, and *Azolla*+urea on N-recovery

Treatments	Plant			Roots			Soil			
	GR	ST	PL	(0-10 cm)	(> 11 cm)	Total	(0-10 cm)	(> 11 cm)	Total	Grand Total
	..... %									
1. ON	-	-	-	-	-	-	-	-	-	-
2. 30 NU(T)	25.11*	11.50	36.61	2.01	0.18	2.19	30.64	2.88	33.02	71.82
3. 30 NU(T) + A(T)	32.04	11.51	43.55	1.75	0.13	1.88	25.09	0.58	25.67	71.10
4. NA(T)	36.16	20.64	56.80	3.86	0.19	4.05	30.83	3.60	34.33	94.35
5. A(T) + 30 NU (wat)	41.51	17.96	59.47	2.40	0.18	2.58	23.64	0.49	24.13	86.18
6. A(T1) + 30 NU (wat)	39.64	23.27	62.91	2.35	0.17	2.39	23.68	1.35	25.34	90.63
7. 30 NU (wat)	39.54	20.09	59.63	2.36	0.21	2.57	10.27	3.85	14.07	76.20
8. 60 NU (T)	25.27	10.09	35.36	1.51	0.06	1.57	8.42	2.81	11.23	48.15
9. A (T)	-	-	-	-	-	-	-	-	-	-
LSD 5%	9.69	5.72	13.30	0.98	ns	0.98	7.08	1.69	7.86	12.80
CV (%)	20	24	18	30	43	28	22	53	23	12

Notes : - N-recovery = recovery from labelled *Azolla* or urea
- GR = Grain, ST = Straw, PL = Plant, * = mean from four replications
LSD = Least Significant Difference, CV = Coefficient of Variation, ns = not significant