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ABSTRACT

COMPARING AZOLLA-N WITH UREA-N ON THEIR ABILITY TO INCREASE RICE YIELD USING ^{15}N LABELLED AZOLLA AND UREA. A series of experiments have been carried out in the dry season (DS) of 1986/1987 and the wet season (WS) of 1987/1988, to compare the ability of Azolla-N with urea-N in increasing rice yield. All these experiments were field experiments conducted at the Experiment Station of the Institue for Food Crops Development, Sukamandi, West Java. The treatments done in these experiments were, (1) source of N with two levels, namely from Azolla and urea, (2) rates of N applied with five levels i.e. 0, 30, 60, 90, and 120 kg N/ha, (3) interaction between the two treatments. A randomized block design was carried out and all treatments were replicated four times. Parameters observed were, (1) total yield expressed in total yield of grain and straw, (2) total-N yield expressed in total-N yield of grain and straw, (3) percentage of N-derived from Azolla (N-dfA)and N-derived from urea (N-dfU), (4) N yield dfA and dfU and (5)percentage of N recovery dfA and dfU. Results showed that there was no difference between the ability of Azolla-N and urea-N in increasing rice yield. Apparently, Azolla-N was used more by the rice plants than urea-N especially for lower rates, such as, 30 and 60 kg N/ha.

ABSTRAK

MEMBANDINGKAN KEMAMPUAN N-AZOLLA DENGAN N-UREA DALAM MENINGKATKAN HASIL PADI MENGGUNAKAN AZOLLA DAN UREA BERTANDA ^{15}N. Suatu rangkaian percobaan telah dilakukan dalam musim kemarau (MK) 1986/1987 dan musim penghujan (MP) 1987/1988, untuk membandingkan kemampuan N-Azolla dengan N-urea dalam meningkatkan hasil padi. Semua percobaan ini merupakan percobaan lapangan, dan dilaksanakan di Kebun Percobaan Pusat Penelitian Tanaman Pangan, Sukamandi, Jawa Barat. Perlakuan yang diterapkan dalam percobaan ini ialah, (1) sumber N dengan dua tingkat yaitu Azolla dan urea, (2) takaran N dengan lima tingkat yaitu 0, 30, 60, 90

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dan 120 kg N/ha, (3) interaksi antara kedua perlakuan ini. Percobaan tersebut menggunakan rancangan acak kelompok, setiap perlakuan diulang empat kali. Parameter yang diamati, ialah (1) hasil total yang dinyatakan dalam bobot kering gabah dan jerami, (2) hasil N-total gabah dan jerami, (3) persentase N-berasal dari Azolla (N-bdA) dan N-berasal dari urea (N-bdU), (4) hasil N-bdA dan N-bdU, dan (5) persentase N-bdA dan N-bdU yang ditemukan kembali. Hasil percobaan ini menunjukkan bahwa tidak ditemukan perbedaan antara kemampuan Azolla dan urea dalam hal menaikkan hasil tanaman padi. Tampaknya tanaman padi lebih banyak menggunakan N-Azolla daripada N-urea, terutama pada takaran yang lebih rendah yaitu 30 dan 60 kg N/ha.

INTRODUCTION

According to ZIFFERICO (1), nitrogen and phosphorus have been demonstrated in many studies to be the most important elements which influence crop yields. Apparently this is one of the main reasons why an increase rate of fertilizer N and P have been advocated to meet the growing demand for food. On the other hand, plenty of studies have also shown that most of the fertilizer applied is wasted. This is due to the fact that plants are capable to take up only a portion of the applied fertilizer in the year of application, while a lot being lost through several processes (1). This fact combined with other facts such as the price of fertilizer which will increase years ahead, have to be taken into consideration in recommending the fertilizer rate, especially for farmers in developing countries.

The utilization of cheaper alternatives of supplements of fertilizers have to be introduced. For rice, a promising and a cheap source of N is the water fern Azolla. Azolla is considered as a promising source of N because of its ability in fixing atmospheric N. This is due to the presence of a nitrogen fixing cyanobiant occurring

in special leaf cavities of the Azolla leaf, and is able to contribute considerably to the nitrogen status of the soil (2). Further, BECKING (2) mentioned that for unlimited growth of Azolla, a input of 300- 600 kg N/ha could be introduced to the ecosystem.

All these facts have been able to increase interest about the ability of Azolla as an alternative source of N or as a supplement of N. From our previous experiments (3 - 5) it was found that Azolla alone or in combination with urea was able to increase rice yield in terms of grain and straw dry weight.

Based on these facts, field experiments were set up to compare the ability of Azolla as N-source with urea to increase rice yield, using several rates of N ranging from 0 kg N/ha to 120 kg N/ha.

MATERIAL AND METHODS

Plant Material and Date of the Experiments. Two field experiments have been conducted using rice, variety IR-46 at the Experiment Station of the Institute for Food Crops Research and Development, Sukamandi, West Java. The dates of seeding, planting and harvesting are described in Table 1.

Table 1. Dates of seeding, planting and harvesting of rice in the experiments.

Season	Date of		
	Seeding	Planting	Harvesting
Dry Season (DS)	22 - 5 - 1987	15 - 6 - 1987	1 - 9 - 1987
Wet Season (WS)	15 - 11 - 1987	7 - 12 - 1987	14 - 3 - 1987

Treatments of the Experiments. The treatments given were (1) sources of N, with two levels, Azolla pinnata and urea, (2) N rates of the two N-sources namely 0, 30, 60, 90 and 120 kg N/ha, and (3) interaction between the two treatments. All treatments were replicated four times. Azolla-N and urea-N were applied twice. First half of the N rate was applied at planting time and the next half was given at maximum tillering. For Azolla-N, the Azolla was burried ± 5 cm into the soil, while urea was broadcasted between the plant rows. P and K were applied as basal dressing at planting time at a rate of 60 kg P_2O_5/ha and 30 kg K_2O/ha, respectively.

Labelled Azolla, Labelled Urea and Total-N of Azolla. To gain ^{15}N-labelled Azolla, special plots for Azolla were set up. Fifteen days before application, the Azolla in these plots were labelled with ^{15}N ammonium sulphate, which has a 20% atom excess (a.e.). The a.e. of the Azolla ^{15}N-labelled in the dry season, for application at planting time and maximum tillering were at an average of 2.448 and 2.638%, respectively. For wet season, the a.e. values for application at planting time and maximum tillering were at an average of 1.225 and 1.432%, respectively. These values were an average of ten replicates.

The percentage of total-N of the labelled Azolla and unlabelled Azolla in the DS were 4.117 and 3.910% at planting time, 3.667 and 3.670% at maximum tillering, respectively. While for the WS these values were, 3.586 and 3.127, 3.902 and 3.450 respectively. All these values were an average of ten replicates.

Experimental Plots. The size of isotope plots where labelled Azolla and urea were used was 1 x 1 m^2 and was further referred as isotope plots. For the yield plots, the size was 3 x 3 m^2. In these plots, unlabelled Azolla and urea were used. These plots are further referred as yield plots.

Rates of Azolla Applied. As mentioned before, the rates of Azolla and urea applied was in the range of 0 kg N/ha to 120 kg N/ha. But in fact it was difficult to apply Azolla within this range. In general the rates of Azolla applied were lower than that of urea as described in Table 2.

Table 2. Total N rate applied at planting time and maximum tillering as carried out in the field.

Isotope plots				Yield plots		
Azolla		Urea		Azolla		Urea
..... kg N/ha						
dry season						
A1	28.00	N1	30.00	A1	22.72	N2	30.00
A2	56.00	N2	60.00	A2	43.44	N2	60.00
A3	84.00	N3	90.00	A3	68.16	N3	90.00
A4	112.00	N4	120.00	A4	90.88	N4	120.00
wet season						
A1	29.33	N1	30.00	A1	27.22	N1	30.00
A2	58.66	N2	60.00	A2	53.99	N2	60.00
A3	82.99	N3	90.00	A3	83.17	N3	90.00
A4	117.32	N4	120.00	A4	110.89	N4	120.00

Statistical Analysis. To compare the difference between Azolla-N and urea-N in rice, an analysis of variance was carried out to analyse the data obtained following the methods of GOMEZ and GOMEZ (6).

Parameters Observed. Parameters observed were

1. rice yield expressed in dry weight for grain and straw
2. total-N yield of rice expressed in total-N of grain straw and biomass
3. percentage of N-derived from Azolla (N-dfA) and N-derived from urea (N-dfU) of grain and straw
4. N-yield dfA and dfU in grain, straw and biomass
5. percentage of N-recovery dfA and dfU in grain, straw and biomass.

For parameters (1) and (2) the data used were only from the yield plots, mentioned in Tables 2 and 5. And for the parameters (3), (4) and (5), the data used were from the isotope plots (Tables 6, 7 and 8).

RESULTS AND DISCUSSION

Rice Yield. Rice yield is expressed in dry weight of grain and straw. Figs. 1 and 2 showed the grain dry weight in the DS and WS. These figures presented that urea-N gave better grain weight increase than Azolla-N with increasing N rates. In spite of this Table 3 showed that only in the dry season significant difference between Azolla-N and urea-N ($P < 0.05$) was found in their ability to increase grain dry weight. But it must be taken into consideration that especially for the N rates starting from 60 kg N/ha to 120 kg N/ha the Azolla-N rates applied were always lower than that of urea-N rates (Table 2). Based on this, it could be suggested that if the rates of Azolla-N and urea-N were at the same level there would be no differences between Azolla-N and urea-N in increasing dry weight of grain and

straw. As expected, increasing N rates either from Azolla or urea significantly increase grain dry weight.

However, Figs. 1 and 2 show that grain dry weight in the WS was higher than in the DS. In general yield of rice is expected to be higher in the DS than in the WS. This can be explained by statement in that in the DS the radiation intensity is higher than in the WS, resulting in higher yield.

Total-N Yield. Total-N yield is expressed in total-N yield of grain, straw and biomass and is derived from dry weight times percentage of total-N. Percentage of total-N for grain and straw is presented in Table 5. Azolla-N and urea-N are capable to increase total-N yield of grain, straw and biomass in the DS as well as in the WS (Figs. 5 - 10). There is no difference in the ability of Azolla-N and urea-N to increase total N-yield of all the components observed (Tables 6 and 7) The increase of N rate resulted in the increase of N-yield. But this increase is only due to the increase of dry weight, and not to the incerase of the percentage of total-N. It was found that increasing N rate did not influence the percentage of total-N of grain and straw (Table 5). But there are several investigators who have assured that Azolla could increase percentage of total-N. In our case, probably the rice variety itself which responds to N rate only by increasing dry weight but no by increasing percentage of total-N, although the increase of dry weight in turn can increase N-yield. The response of the rice variety to increasing N rate which is, only to dry weight but not total-N percentage, is the reason why in the WS the total-N yield

of all the components is higher than in the DS. From the data observed for total-N yield, the most prominent result is that Azolla-N and urea-N were able to increase total-N yield by increasing dry weight of grain, straw and biomass, but did not increase percentage of total-N

Percentage of N-dfA and N-dfU. Fig. 11 shows that for the DS as well as for the WS, at high N-rates i.e. 90 and 120 kg N/ha, the percentage of N-dfU is always higher than that of N-dfA. While for lower rates, i.e. 30 and 60 kg N/ha, the percentage of N-dfA is higher than N-dfU. This might be due to the lower application of Azolla-N compared to urea-N. Another reason is probably by applying Azolla-N, N from other sources such as from soil is pushed up. In general the percentage of N-dfA and N-dfU in grain is always a little lower than that found in straw (Fig.11). Does this mean that the rice plant used prefers to distribute N from other sources to the grain than from Azolla or urea is a question which is interesting to be answered by further studies. Another interesting fact is that at low N-rate application (30 kg N/ha) the N-dfA is much higher than N-dfU. Apparently at low N rates most of the urea-N applied is lost, resulting in low percentage of N-dfU in grain and straw.

Total N-dfA and Total N-dfU. Total N-dfA and total N-dfU is calculated from total N-yield time percentage of N-dfA/N-dfU (Fig. 12). Fig. 12 also shows that at higher rates of Azolla-N and Urea-N application total N-dfU is higher than total N-dfA. While for the lower N rates (30 and 60 kg N/ha) the opposite is revealed, showing higher total N-dfA compared to total-N-dfU. In spite of this, it was found from

statistical calculation that there was no significant differences in the ability of Azolla and urea in the contribution of total N-dfA and total N-dfU in all plant parameters observed (Tables 8 and 9). Total N-dfA and total N-dfU increased when the N-rates were increased. This of course be related to the facts that with increasing N-rates, both total -N and percentage of N-dfA and N-dfU will increase too in grain and straw.

Percentage of N-recovery. Percentage of N-recovery is the efficiency of the utilization of N sources by the plant in its components. In this case the N sources were Azolla and urea.

Fig. 13 shows, that especially for Azolla at the lower rates of N application e.g. 30 and 60 kg N/ha, the percentage of N-recovery displayed by Azolla is very high compared to urea. The low N-recovery dfU at lower rates might be due to losses of the urea-N, since urea-N is easily lost in submerged conditions. While with increasing N rates, the percentage of N-recovery for both sources are quiet the same (Table 10). Either for Azolla-N or urea-N the increasing rate of N will cause a decrease in the percentage of N-recovery. This probably mean that with increasing N rates of Azolla and urea, the plant is able to explore other N sources, resulting a decrease in percentage of N-recovery (dfA and dfU).

CONCLUSIONS

From the experiments conducted it was shown that there was no significant difference between Azolla-N and urea-N in their ability to increase yield in terms of grain and straw dry weight and total-N. By increasing N rates, the values of all parameters applied increase too. For Azolla-N, the optimal rates were 30 and 60 kg N/ha for the percentage of N-dfA and N-recovery compared to urea. The most important observation especially at the yield plots was that at higher N rates (90 and 120 kg N/ha) where although the actual application rates of Azolla were much lower than those of urea results obtained showed no no difference between the rice yield caused by application of Azolla compared with urea. It should be taken into consideration that for high N rates, when using Azolla it is quiet difficult to reach the same N-rates as when urea is used.

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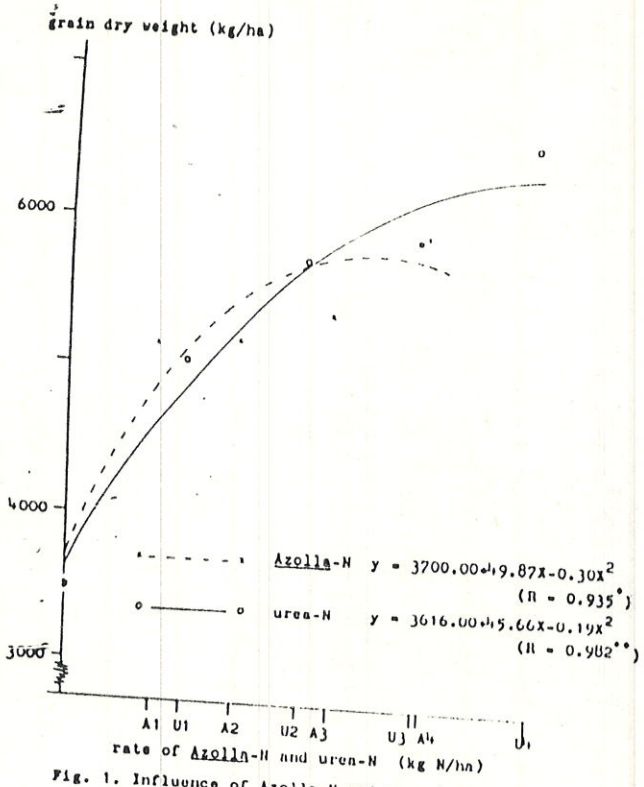

Fig. 1. Influence of Azolla-N and urea-N on grain dry weight (dry season)

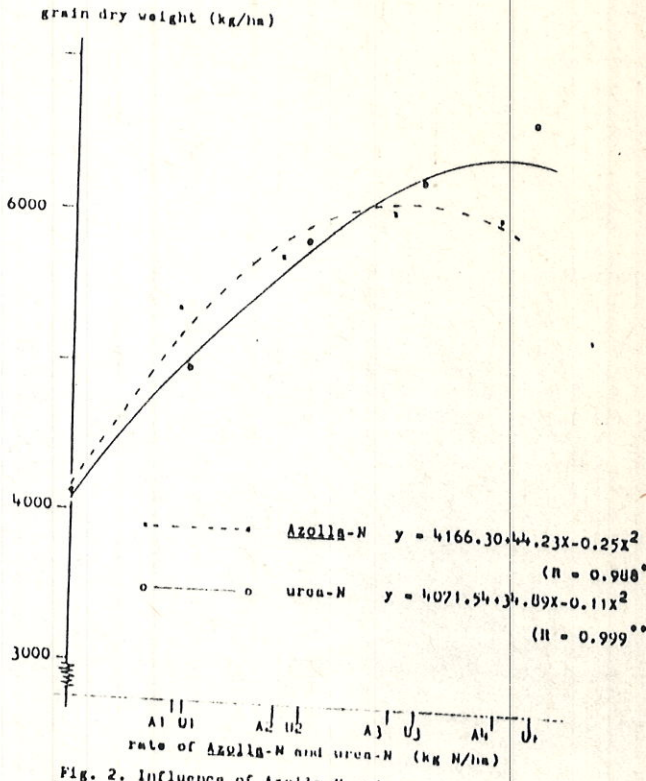

Fig. 2. Influence of Azolla-N and urea-N on grain dry weight (wet season)

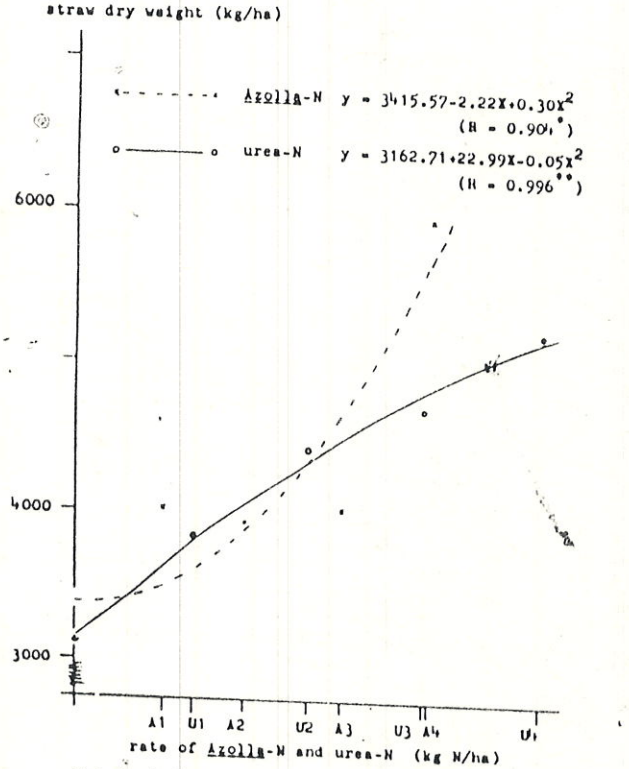

Fig. 3. Influence of Azolla-N and urea-N on straw dry weight (dry season)

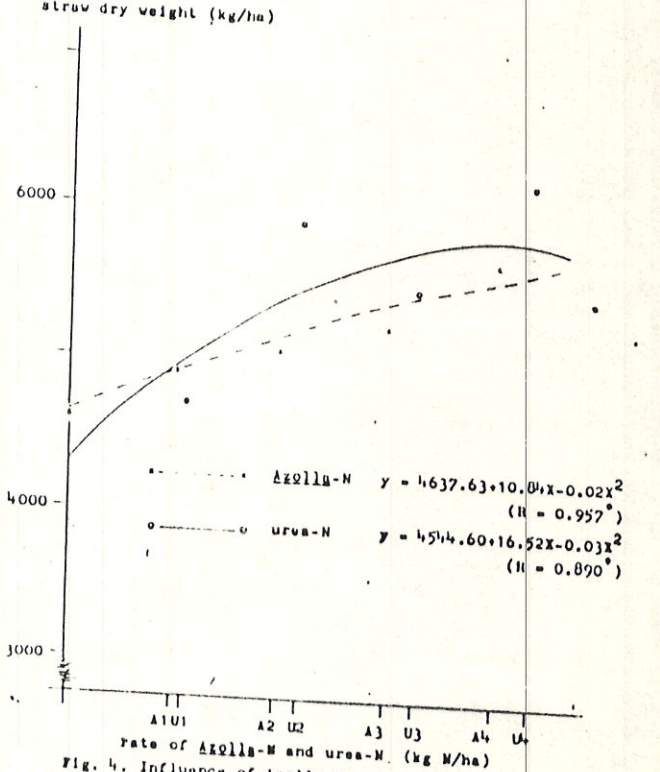

Fig. 4. Influence of Azolla-N and urea-N on straw dry weight (wet season)

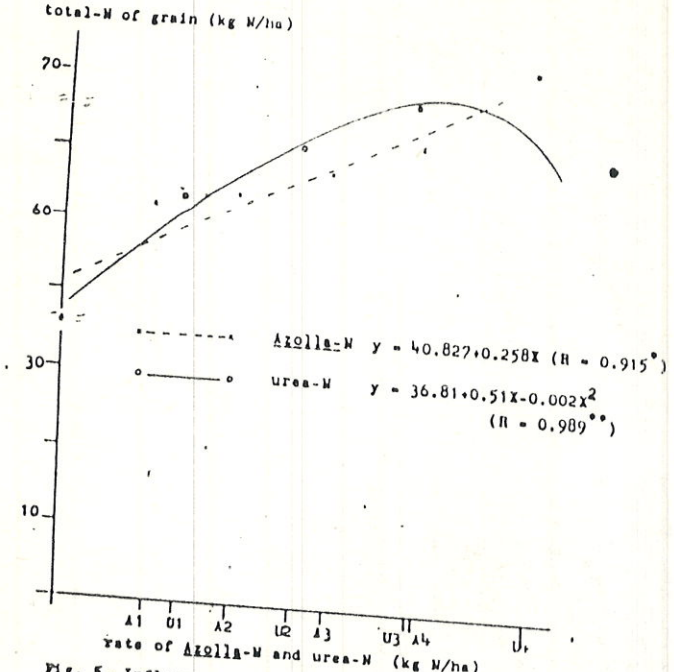

Fig. 5. Influence of Azolla-N and urea-N on total-N of grain (dry season)

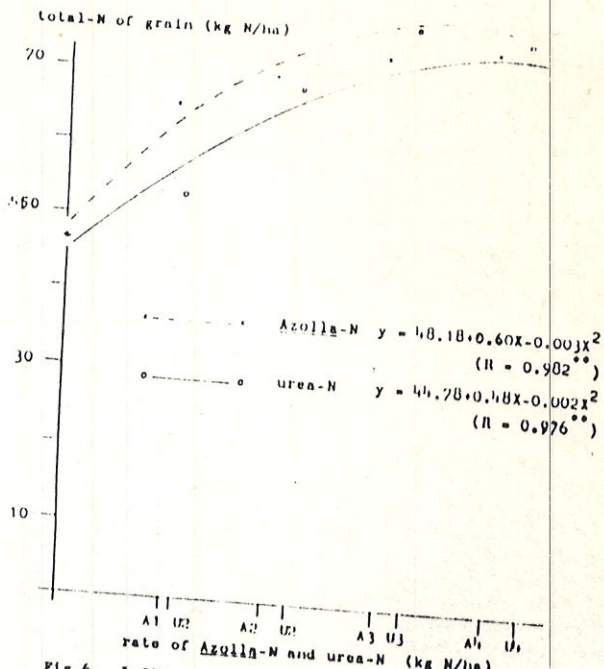

Fig.6. Influence of Azolla-N and urea-N on total-N of grain (dry season)

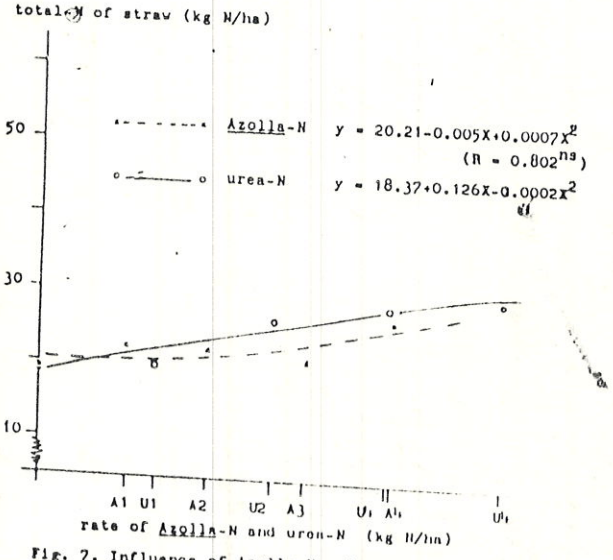

Fig. 7. Influence of Azolla-N and urea-N on total-N of straw (dry season)

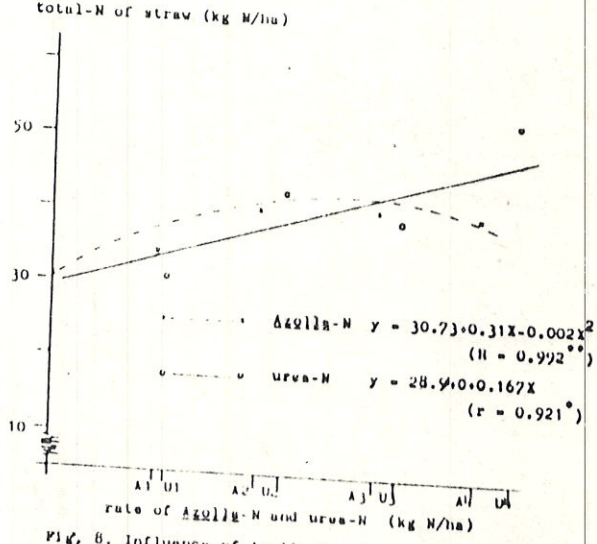

Fig. 8. Influence of Azolla-N and urea-N on total-N of straw (wet season)

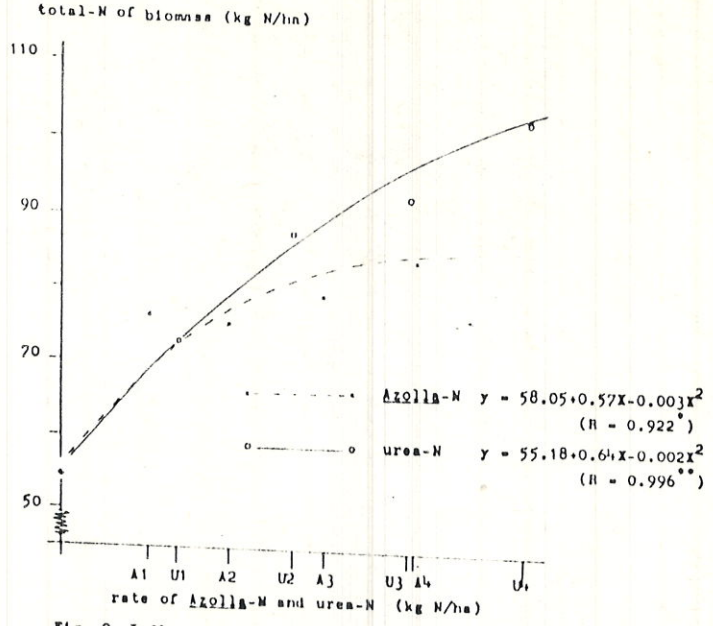

Fig. 9. Influence of Azolla-N and urea-N on total-N of biomass (dry season)

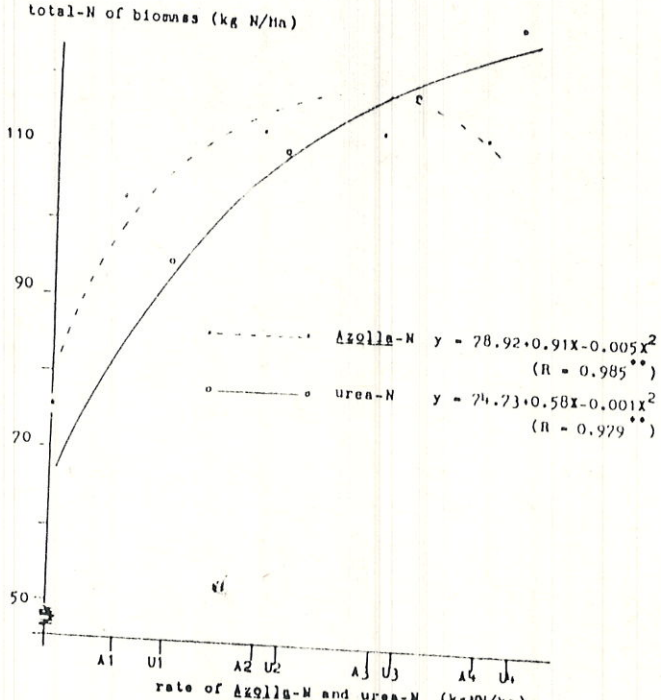

Fig. 10. Influence of Azolla-N and urea-N on total-N of biomass (wet season)

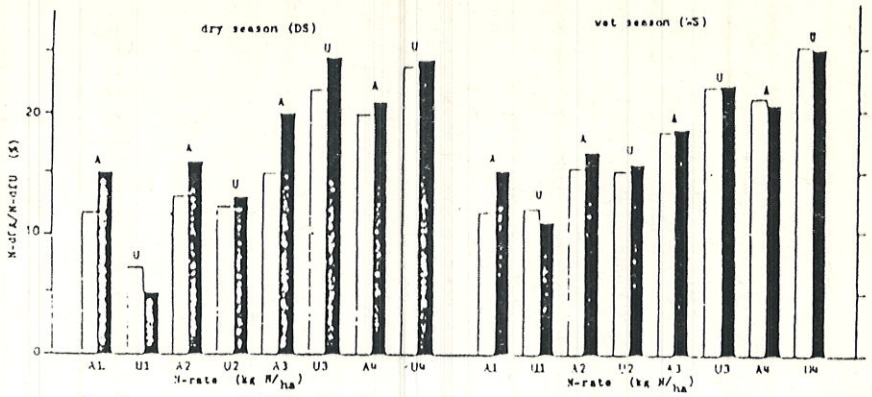

Fig. 11. Percentage of N-dfA and N-dfU in grain (▢) and straw (■) as influenced by Azolla (A) and urea (U)

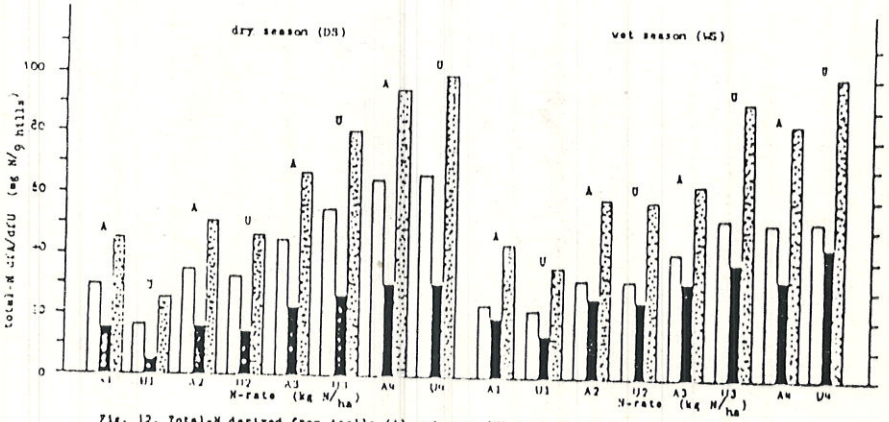

Fig. 12. Total-N derived from Azolla (A) and urea (U) in grain (▢), straw (■) and biomass (▣)

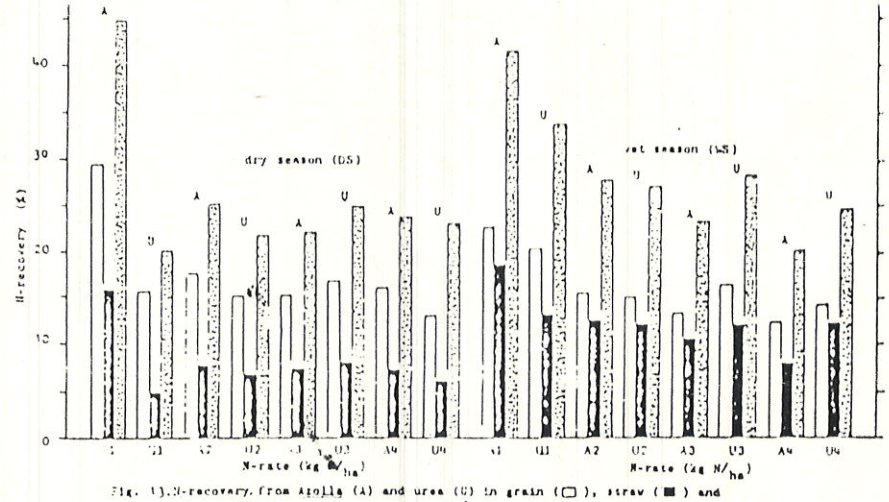

Fig. 13. N-recovery from Azolla (A) and urea (U) in grain (▢), straw (■) and biomass (▣)

Table 3. Dry weight of rice as influenced by *Azolla* and urea application (yield plots)

	N-rate						N-rate					
	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S
	DS						WS					
	Grain kg/ha											
A	3484	5153	5190	5379	5935	5028	4082	5385	5724	6040	6032	5453
U	3484	5068	5725	5908	6553	5348	4082	4975	5829	6263	6663	5562
Ro-N	3484	5111	5458	5644	6244	----	4082	5180	5777	6153	6348	----
LSD (5%)	S=245	N=549	Int.=ns				S=ns	N=292	Int.=ns			
CV (%)	7.30						5.17					
	Straw kg/ha											
A	3145	4037	3938	4045	5954	4224	4622	4899	5321	5249	5699	5158
U	3145	3816	4438	4707	5235	4268	4622	4706	5902	5501	6212	5389
Ro-N	3145	3927	4188	4376	5595	----	4622	4803	5612	5375	5956	----
LSD (5%)	S=317	N=650	Int.=ns				S=ns	N=393	Int.=ns			
CV (%)	9.87						7.27					

A = *Azolla* U = urea S = difference between sources N = differences between N-rate Int. = interaction between SxN DS = dry season WS = wet season LSD = least significant difference CV = coefficient of variation

Table 4. Dry weight of rice as influenced by *Azolla* and urea application (isotope plots)

	N-rate						N-rate					
	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S
	DS						WS					
	Grain											
	mg/9 hills											
A	189	247	251	275	281	249	161	196	199	204	218	195
U	189	210	246	273	281	240	161	184	195	219	227	197
Ro-N	189	229	249	274	281	---	161	190	197	212	223	---
LSD (5%)	S=ns	N=34	Int.=ns				S=ns	N=21	Int.=ns			
CV (%)	13.88						10.34					
	Straw											
	mg/9 hills											
A	149	171	156	194	224	179	150	193	199	223	214	196
U	149	160	169	173	189	168	150	173	219	236	230	200
Ro-N	149	166	163	184	207	---	150	183	209	230	217	---
LSD (5%)	S=ns	N=50	Int.=ns				S=ns	N=35	Int.=ns			
CV (%)	16.67						17.20					

A = *Azolla* U = urea S = difference between sources N = differences between N-rate Int. = interaction between SxN DS = dry season WS = wet season LSD = least significant difference CV = coefficient of variation

Table 5. Percentage of total-N of grain and straw in the dry season

Codes of N-rate*	Isotope Plots		Yield Plots	
	Azolla	Urea	Azolla	Urea
	%			
	Grain			
A1 1.05	N2 1.06	A2 1.03	N2 1.04	
A2 1.06	N3 1.07	A3 1.04	N3 1.08	
A3 1.09	N4 1.07	A4 1.08	N4 1.10	
A4 1.13	N5 1.12	A5 1.05	N5 1.12	
	Straw			
A1 0.60	N2 0.64	A2 0.61	N2 0.61	
A2 0.60	N3 0.64	A3 0.59	N3 0.62	
A3 0.60	N4 0.63	A4 0.61	N4 0.63	
A4 0.64	N5 0.63	A5 0.64	N5 0.63	

* for the actual N-rate see table .
** each value is a mean of 4 replicates

Percentage of total N of grain and straw in the wet season

Codes of N-rate*	Isotope Plots		Yield Plots	
	Azolla	Urea	Azolla	Urea
	%			
	Grain			
A1 1.07	N2 1.04	A2 1.21	N2 1.18	
A2 1.06	N3 1.13	A3 1.21	N3 1.17	
A3 1.12	N4 1.13	A4 1.21	N4 1.23	
A4 1.12	N5 1.11	A5 1.23	N5 1.14	
	Straw			
A1 0.76	N2 0.75	A2 0.79	N2 0.66	
A2 0.79	N3 0.77	A3 0.77	N3 0.73	
A3 0.79	N4 0.74	A4 0.78	N4 0.72	
A4 0.76	N5 0.81	A5 0.69	N5 0.82	

* for the actual N-rate see table 7
** each value is a mean of 4 replicates

Table 6. Total-N of grain, straw and biomass as influenced by *Azolla* and urea application (yield plots)

	N-rate						N-rate					
	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S
	DS						WS					
Grain	kg N/ha											
A	35.68	52.23	54.26	57.98	62.21	52.47	46.75	65.15	69.53	72.84	74.08	65.67
U	35.68	52.53	61.80	65.01	73.35	57.67	46.75	53.42	68.13	77.07	75.70	64.21
Ro-N	35.68	52.38	58.03	61.50	67.78	-----	46.75	59.29	68.83	74.93	74.89	-----
LSD (5%)	S=3.31	N=7.43	Int.=ns				S=ns	N=4.71	Int.=6.77			
CV (%)	9.29						7.08					
Straw	kg N/ha											
A	19.07	22.79	21.05	21.25	26.71	22.17	30.36	38.38	41.02	41.15	39.06	38.00
U	19.07	20.20	26.17	28.24	29.92	24.72	30.36	31.09	42.50	39.75	51.10	38.96
Ro-N	19.07	21.50	23.61	24.75	28.32	-----	30.36	34.74	41.76	40.45	45.08	-----
LSD (5%)	S=1.88	N=2.98	Int.=4.21				S=ns	N=4.53	Int.=6.41			
CV (%)	12.37						11.33					
Biomassa	kg N/ha											
A	54.75	76.52	75.31	79.23	88.92	74.77	77.11	103.11	110.55	113.99	113.14	103.63
U	54.75	72.73	87.97	93.25	103.27	82.93	77.11	84.51	110.64	116.82	126.93	109.18
Ro-N	54.75	74.66	81.64	86.24	96.10	-----	77.11	94.02	110.60	115.41	119.99	------
LSD (5%)	S=4.09	N=6.48	Int.=9.16				S=ns	N=8.26	Int.=11.68			
CV (%)	8.03						7.68					

A = *Azolla* U = urea S = difference between sources N = differences between N-rate
Int. = interaction between SxN DS = dry season WS = wet season LSD = least significant difference CV = coefficient of variation

Table 7. Total-N of grain, straw and biomass as influenced by *Azolla* and urea application (isotope plots)

	N-rate						N-rate					
	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S	0	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S
	DS						WS					
Grain												
	mg N/9 hills						mg N/9 hills					
A	1999	2577	2679	2990	3232	2696	1671	2088	2106	2272	2449	2117
U	1999	2400	2636	2930	3131	2619	1671	1962	2168	2427	2510	2138
Ro-N	1999	2489	2658	2960	3182	----	1671	2000	2137	2350	2480	----
LSD (5%)	S=ns	N=353	Int.=ns				S=ns	N=261	Int.=ns			
CV (%)	12.96						11.96					
Straw												
	mg N/9 hills						mg N/9 hills					
A	931	1014	937	1140	1424	1089	1136	1302	1572	1750	1614	1475
U	931	1021	1085	1081	1241	1072	1136	1309	1683	1759	1792	1536
Ro-N	931	1018	1011	1111	1333	----	1136	1306	1628	1755	1717	----
LSD (5%)	S=ns	N=185	Int.=ns				S=ns	N=316	Int.=ns			
CV (%)	16.74						20.80					
Biomassa												
	mg N/9 hills						mg N/9 hills					
A	2930	3591	3616	4130	4656	3785	2807	3390	3679	4022	4063	3542
U	2930	3421	3721	4010	4372	3691	2807	3221	3851	4186	4302	3673
Ro-N	2930	3506	3669	4070	4514	----	2807	3306	3765	4104	4183	----
LSD (5%)	S=ns	N=439	Int.=ns				S=ns	N=420	Int.=ns			
CV (%)	11.39						11.27					

A = *Azolla* U = urea S = difference between sources N = differences between N-rate Int. = interaction between SxN DS = dry season WS = wet season LSD = least significant difference CV = coefficient of variation

Table 8. Percentage of N-dfA and N-dfU of rice as influenced by *Azolla* and urea application (%)

	N-rate					N-rate				
	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S
	DS					WS				
	Grain									
	%									
A	11.53	12.83	14.78	19.69	14.72	11.40	15.31	18.30	21.07	16.52
U	6.90	12.09	21.81	23.59	16.10	11.67	15.08	21.89	25.07	19.43
Ro-N	9.22	12.49	18.30	21.64	-----	11.35	15.20	20.09	23.07	-----
LSD (5%)	S=ns N=3.21 Int.=4.54					S=1.67 N=2.37 Int.=ns				
CV (%)	20.01					13.06				
	Straw									
	%									
A	14.99	15.81	19.89	20.85	17.39	15.08	16.81	18.41	20.52	19.71
U	4.80	12.84	24.24	24.38	16.57	10.70	15.47	22.03	24.96	18.29
Ro-N	9.90	14.33	22.07	22.62	-----	12.89	16.14	20.22	22.74	-----
LSD (5%)	S=ns N=2.78 Int.=3.93					S=1.67 N=2.37 Int.=ns				
CV (%)	15.60					10.73				

A = *Azolla* U = urea S = difference between sources N = differences between N-rate Int. = interaction between SxN DS = dry season WS = wet season LSD = least significant difference CV = coefficient of variation

Table 9. Total-N dfA and dfU of rice as influenced by *Azolla* and urea application

	N-rate					N-rate				
	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S	A1/N1	A2/N2	A3/N3	A4/N4	Ro-S
	DS					WS				
Grain	mg N/9 hills									
A	297	352	444	649	436	239	322	418	517	374
U	167	321	543	663	423	223	326	530	627	427
Ro-N	231	337	494	656	---	231	324	444	572	---
LSD (5%)	S=ns		N=130	Int.=ns		S=49		N=70	Int.=ns	
CV (%)	29.38					16.88				
Straw	mg N/9 hills									
A	152	152	226	301	301	196	264	322	332	279
U	150	146	261	309	192	140	257	388	447	308
Ro-N	101	149	244	305	---	168	261	355	390	---
LSD (5%)	S=ns		N=54	Int.=77		S=ns		N=ns	Int.=88	
CV (%)	26.53					20.37				
Biomassa	mg N/9 hills									
A	449	504	669	950	643	435	586	740	849	653
U	216	467	804	992	620	363	583	917	1074	734
Ro-N	333	489	737	971	---	---	399	585	962	---
LSD (5%)	S=ns		N=135	Int.=ns		S=64		N=91	Int.=129	
CV (%)	20.64					12.67				

A = *Azolla* U = urea S = difference between sources N = differences between N-rate Int. = interaction between SxN DS = dry season WS = wet season LSD = least significant difference V = coefficient of variation

Table 10. Recovery of N fert/N-*Azolla* of rough grain, straw, and plant Isotope Plots-R3

Treatments	r. grain	straw	plant
	..... %		
Dry Season			
A1 2.08 N-A	29.49	15.05	44.55
A2 5.60 N-A	17.47	7.52	24.99
A3 8.40 N-A	14.67	7.46	22.13
A4 11.20 N-A	16.10	7.46	23.56
U1 3.00 N-U	15.35	4.51	19.86
U2 6.00 N-U	14.87	6.74	21.61
U3 9.00 N-U	16.75	8.05	24.85
U4 12.00 N-U	12.84	6.05	22.98
L S D 5%			
- N-source	3.62	1.33	4.13
- N-rates	5.72	2.10	6.52
- interaction	8.09	2.97	9.22
C V (%)	32	26	25
Wet Season			
A1 2.93 N-A	22.66	18.54	41.20
A2 5.86 N-A	15.25	12.47	27.72
A3 8.79 N-A	13.17	10.16	23.33
A4 11.72 N-A	12.24	7.84	20.08
U1 3.00 N-U	20.65	12.89	33.54
U2 6.00 N-U	15.11	11.89	27.00
U3 9.00 N-U	16.35	11.96	28.31
U4 12.00 N-U	14.48	10.34	24.82
L S D 5%			
- N-source	ns	ns	ns
- N-rates	3.59	2.30	3.94
- interaction	ns	3.25	5.57
C V (%)	21	18	13

N-A = N-*Azolla* N-U = N-urea