(DAS) for May and Dec sown crops and at 57 DAS for the Jun crop.

S. aculeata and *S. rostrum* had similar performance irrespective of date of sowing (Table 1, 2). The May-sown crop performed best (May is the most appropriate time for growing a green manure crop to fit local rice-based cropping systems). The Jun-sown crop had reduced plant height and less biomass production. The Dec crops had very poor growth. □

Biofertilizer efficiency in lowland rice

S. Jeyaraman and S. Purushothaman, Agricultural College and Research Institute. Tamil Nadu Agricultural University, Madurai 625104, India

We studied the efficiency of blue-green algae, Azospirillum, and azolla alone and with 50, 75, and 100 kg N/ha during wet and dry seasons 1986-87. Treatments were in a randomized block design with three replications.

Azospirillum lipoferum at 10^8 cells/g inoculant was inoculated at 1 kg/ha by seedling root dip for 20 min. A composite culture of blue-green algae was applied in the soil at 10 kg/ha 10 d after transplanting (DT). *Azolla pinnata* was established as dual crop at 1 t/ha 10 DT and the azolla mat incorporated at 20 d and 40 d.

Effect of biofertilizers on grain yield. Madurai, India, 1986-87.

Treatment	Grain yield (t/ha)	
	Kharif (CO 37)	Rabi (IR20)
100 kg N/ha alone	5.9	4.2
75 kg N/ha alone	5.7	6.0
50 kg N/ha alone	5.0	3.8
75 kg N/ha + blue-green algae	6.2	4.5
75 kg N/ha + azolla	5.9	4.5
75 kg N/ha + Azospirillum	6.4	4.5
50 kg N/ha + blue-green algae	5.6	4.0
50 kg N/ha + azolla	5.2	4.1
50 kg N/ha + Azospirillum	5.9	4.0
Blue-green algae alone	4.8	3.2
Azolla alone	4.6	3.3
Azospirillum alone	4.9	3.3
No fertilizer control	4.1	2.8
LSD (0.05)	0.5	0.3

Azospirillum with 75 kg N/ ha influenced grain yield the most, with a significant increase in wet season rice and a dry season yield comparable to that with 100 kg N/ha (see table). In both seasons, yields with blue-green algae and 75 kg N/ ha or dual cropping of azolla, and that with Azospirillum with 50 kg N/ ha were comparable with yield with 100 kg N/ha. □

Effect of Azospirillum biofertilizer on rice yield

S. Rajagopalan and M. Rangaswamy, Rice Research Station, Ambasamudram 627401, Tamil Nadu, India

We compared the effect of Azospirillum biofertilizer with that of organic manure at various levels of N during kharif (Jun-Sep) and rabi (Oct-Feb) 1986-87. Test varieties were IR50 in kharif and IR20 in rabi. The experiment was laid out in a split-plot design with three replications.

Soil was a sandy loam with pH 6.8, EC 0.43 dS/m, and 297-40-153 kg available NPK/ha. Farmyard manure

Table 1. Productive tillers and grain yield with organic manure and Azospirillum application at 4 N levels.[a] Tamil Nadu, India, 1986 kharif.

Treatment	Productive tillers (no./m^2)					Grain yield (t/ha)				
	No N	49 kg N/ha	73 kg N/ha	98 kg N/ha	Mean	No N	49 kg N/ha	73 kg N/ha	98 kg N/ha	Mean
Control	487	531	549	566	533	3.2	3.8	3.9	4.1	3.8
5 t FYM/ha	501	544	556	572	543	3.3	3.7	4.0	4.4	3.9
Azospirillum (nursery + main field)	535	550	556	564	551	3.3	3.9	4.1	4.2	3.8
FYM + Azospirillum	489	521	550	576	534	3.2	3.8	4.1	4.5	3.9
Mean	503	536	553	569		3.3	3.8	4.0	4.3	

	LSD (tillers)	LSD (grain yield)
FYM × Azospirillum	ns	ns
Levels of N	25	0.2
FYM × Azospirillum × N level	ns	ns

[a]N applied per soil test recommendation, with 98 kg N/ha = 100% N.

Table 2. Productive tillers and grain yield as influenced by organic manure and Azospirillum at 4 N levels.[a] Tamil Nadu, 1986 rabi.

Treatment	Productive tillers (no./m^2)					Grain yield (t/ha)				
	No N	49 kg N/ha	73 kg N/ha	98 kg N/ha	Mean	No N	49 kg N/ha	73 kg N/ha	98 kg N/ha	Mean
Control	334	357	378	406	369	2.9	3.6	3.9	4.1	3.6
5 t FYM/ha	335	367	373	385	365	2.7	3.7	4.1	3.9	3.6
Azospirillum (seed + nursery + root dip + main field)	351	370	364	453	385	3.1	4.0	4.0	4.4	3.9
FYM + Azospirillum	380	367	392	454	398	3.0	3.8	4.0	4.6	3.9
Mean	350	365	377	425		2.9	3.8	4.0	4.3	

	LSD (tillers)	LSD (grain yield)
FYM × Azospirillum	21	ns
Levels of N	16	0.1
FYM × Azospirillum × N level	32	0.3

[a]N applied per soil test recommendation, with 98 kg N/ha = 100% N.

(FYM) was applied at 5 t dry weight/ ha in the main field. It contained 0.56% N, 0.13% P, and 0.75% K.

Azospirillum was applied at 2 kg/800 m^2 to the nursery area and 2 kg/ha to the main field during 1986 kharif (total 4 kg). In 1986 rabi, Azospirillum was applied 1 kg to seeds needed for 1 ha, 1 kg/ 800 m^2 to the nursery, 2 kg/800 m^2 as seedling root dip, and 2 kg/ ha to the main field (total 6 kg). Soil application to both nursery and main field was done by mixing 2 kg peat-based inoculant with 25 kg powdered FYM and 25 kg soil. This was uniformly broadcast in the nursery at sowing and in the main field at transplanting. P and K were applied per soil test recommendation to all treatments. For all 4 treatment levels, N was applied as 59% basal and 50% in 2 equal splits at active tillering and panicle initiation.

During kharif, the main effect of biofertilizer and organic manure was not significant individually or in combination, but levels of N in the subplots were significant. Application of 98 kg N/ ha gave significantly higher grain yield than other treatments and 30% higher than control (Table 1). Productive tillers/m^2 was also significant for N level.

During rabi, the interaction of N level, organic manure, and biofertilizer application was significant for productive tillers and for grain yield. Combined application of organic manure, Azospirillum, and 100% recommended N resulted in significantly higher yield, on par with 100% N with Azospirillum (Table 2). The more pronounced effect of Azospirillum during rabi than during kharif may be due to its combined application to seed, soil, and roots. □

Screening azolla strains for shading tolerance

T. Kröck and J. Alkämper, Wissenschuftliches Zentrum Tropeninstitut, D-6300 Giessen (F.G.R.); and I. Watanabe, Soil Microbiology Department, IRRI

In dual culture with rice, azolla growth is limited by light deficiency due to rice canopy shading. Beginning 30-40 d after transplanting, the rice crop severely suppresses azolla growth. With azolla strains tolerant of shading, biomass production could be improved and growth prolonged.

We screened 12 azolla strains for shading tolerance in a pot experiment. Azolla was inoculated at 1.4 g fresh weight/ pot (197 g fresh weight/ m^2) in 10-cm-diameter beakers and grown on soil-water culture. Triplephosphate was applied weekly. Light intensities of 50% and 15% were attained by shading beakers with green nylon screens (control was left unshaded), with 3 replications. Biomass of azolla was determined every 5 d for 5 wk, and days to biomass doubling computed for the period from inoculation to maximum biomass. Azolla N content at the end of the experiment was determined by micro-Kjeldahl method.

Tested azolla strains did not differ much in tolerance for shading (see table). Strains with the best growth without shading (*A. caroliniana* #310, #311; *A. mexicana* #202; *A. microphylla* #401) also were the best strains with shading. Some strains were particularly well adapted or poorly adapted to shading. *A. microphylla* #417 and *A. caroliniana* #301 were less affected by shading; *A. pinnata* var. *pin.* #49 and #58 were much more affected. *A. filiculoides* #107 obviously was not adapted to tropical conditions and did not grow well.

The N content of the two strains that performed best (*A. caroliniana* #301, *A. mexicana* #202) was increased by shading. □

Effects of light intensity (100%, 50%, 15%) on growth and N content of 12 azolla strains. Pot experiment, IRRI, 1985.

Azolla strain	Accession no.	Maximum biomass[a] (g fresh wt/pot)			Doubling time (d)			N content (% N in dry wt)		
		100	50	15	100	50	15	100	50	15
A. pinnata var. imbricata	5	10.07 def	8.53 cd	6.05 b	7.78	10.82	13.26	3.69	3.29	3.34
A. pinnata var. imbricata	49	11.66 bcd	8.01 de	4.71 cd	9.18	8.80	16.37	3.33	3.20	3.33
A. pinnata var. imbricata	58	9.21 efg	6.69 ef	3.62 d	8.33	9.87	20.37	3.52	3.37	3.81
A. filiculoides	107	7.38 gh	5.10 f	1.58 e	14.98	14.95	28.12	4.32	4.61	[b]
A. mexicana	202	12.18 bc	13.29 a	7.89 a	8.99	8.63	11.27	4.01	4.17	4.55
A. caroliniana	301	6.76 h	7.94 de	4.17 cd	9.89	11.23	19.33	3.49	3.57	3.47
A. caroliniana	310	15.08 a	14.44 a	8.35 a	8.20	8.38	10.91	3.99	4.16	4.64
A. caroliniana	311	13.28 ab	13.30 a	7.59 a	8.63	8.64	11.83	4.30	4.01	4.04
A. microphylla	401	11.76 bcd	10.80 b	7.57 a	7.37	9.58	9.08	4.94	4.89	4.91
A. microphylla	417	8.18 fgh	9.96 bc	5.43 bc	8.71	9.91	14.46	4.45	4.51	4.26
A. microphylla	418	11.15 cde	9.36 bcd	5.38 bc	7.40	8.06	11.82	4.60	4.35	4.47
A. pinnata var. pinnata	701	9.53 ef	8.58 cd	5.00 bc	8.11	10.74	12.20	3.91	3.24	3.51
LSD (0.05)		1.94	1.71	1.33						

[a]In a column, means followed by a common letter are not significantly ent by DMRT at the 5% level. [b]Not enough material for analysis.

*The **International Rice Research Newsletter** is mailed free to individuals and institutions engaged in rice research and training. For further information, write IRRI, Communication and Publications Dept., Division R, P. O. Box 933, Manila, Philppines,*