Soil fertility, Productivity and Economics of Low land Rice as influenced by Incorporation of N-fixing Tree Leaves

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Abstracts

The prunnings of trees in agro-forestry and farm fences generate a good amount of foliage and twigs that are very rich in essential plant nutrients. If this biomass can be recycled to crop production, this would be a boon to the resource poor farmers of the region. The field experiments were conducted in *kharif* seasons of 2003, 2004 and 2005 at low land farm of the ICAR Research Complex for NEH Region, Umiam, Meghalaya (950m msl) to study the effect of N-fixing tree leaves incorporation on growth, yield and productivity of lowland rice. The soil of the experimental field was low in available P (6.95 kg/ha), medium in N (277 kg/ha) and high in K (258 kg/ha). The pH and organic carbon content of the soil was 5.1 and 2.86 %, respectively. Five tree leaves viz., *Erythrina indica, Acacia auriculiformis, Alnus nepalensis, Parkia roxburghii* and *Casia siamea* were applied @ 10t/ha on fresh weight basis. These were compared with recommended NPK (80:60:40kg/ha) and control under RBD and replicated thrice. In the first year growth, yield attributes and yield (4.82 t/ha) were highest with recommended NPK followed by *Erythrina* leaves. In the second year of experimentation (2004) also, all the growth, yield attributes and yield (5.08 t/ha) were highest with recommended NPK followed by the incorporation of *Erythrina* biomass@10t/ha (4.83 t/ha). However, these values were at par with those of Parkia, *Acacia* and *Casia*. In the third year of experimentation i.e., 2005 most of the tree leaves surpassed the recommended NPK in terms of growth and yield attributes and yield except alder leaves. The highest growth, yield attributes and yield in the third year (2005) were observed with incorporation of *Erythrina* leaves (5.67t/ha) that were however, at par with all other leaves and recommended NPK (5.13t/ha). The nutrient removal followed almost the similar trend as that of grain yield and biomass production. There was significant improvement in the available N and P status of the soil. The available K and micro nutrient status was not much influenced by the different treatments. The highest net return was recorded with recommended NPK (Rs. 19, 077/ha) followed by the incorporation of *Erythrina* biomass (Rs.14, 144/ha). Therefore, utilization of biomass from prunnings of MPTs were recommended for improving productivity and soil health.

Key words: Rice, N-fixing tree leaves, Productivity, soil fertility, Nutrient uptake, income

Introduction and objectives

Agriculture is the basic livelihood of people in North East. Rice is the major staple food of the region. Rice is generally cultivated without any fertilizer and manure. The farmers of the region in general and hill farmers in particular have common apathy towards use of fertilizer. In some cases low level (5t/ha) of manure is applied. Rice is also cultivated in hill slopes under shifting cultivation without any inputs. As a result the productivity of rice in the region is very low (1.6 t/ha). The region is still in deficit of about 1 million tone of rice. Rice productivity can be increased substantially by recycling the available resources within the farm to the soil. To mention a few on-farm resources that can increase rice yield are incorporation of weeds, forest litter, leaves and twigs from pruning and lopping of trees on bund or around the field. The availability of such green biomass are specially plenty under agroforestry systems, as the MPTs are regularly pruned/lopped to avoid shading of under story crops. These biomass are other wise left unutilized some times even burnt. But in most cases these are very rich in essential nutrients. If the available biomass in and around the farm can be effectively recycled in crop production, the productivity of crops and soil health can be maintained to a great extent. The importance of effective recycling of on and off farm resources for organic rice cultivation in the region is also stated by Tripathy *et.al* (2007).

Green manure is the best organic option available in rice culture for meeting the crop requirement of N in a safe and sustainable manner. When organic matter like green manure, is applied to the field, during the process of its decomposition, organic acids are produced that promote the solubilization of soil nutrients (such as phosphorus), making it more available to plants (Rasal et al. 1988). Uyovbisere and Elemo (2002) aslo studied the use of tree leaves incorporation in crop production and reported higher yield and nutrient uptake of maize due to application of neem leaves. Tree leaves specially those from leguminous species could be the ideal utilizable organic materials for recycling in crop production (Bhardwaj and Gaur, 1985). Decomposition of these materials are very fast and 50 % of nutrients are released within a month for the crop use. Chaphale and Badole (1999) reported significant improvement in soil physico-chemical properties of soil due to addition of *Glyricidia* foliage. Threre was significant improvement in soil organic carbon content, total N and available N duie to addition of *Glyricidia* foliage. Higher soil nutrient availability and grain yield of crops due to application of *Leucaena leucocephala* over FYM and vermicomposting was also reported by several other workers **(**Bellakki and Badanur., 1993; Durgude and Patil, 1997). Lehria *et al*. (2003) used 15t subabul (*Leucanea leucocephala*) leaves with 25% N in maize under dry land condition and reported significantly higher grain yield of maize over recommended NPK alone. He also observed marked residual effect on succeeding crop due to application of green leaf manure to previous crop. Increase in nutrient uptake of crops due to application of green manure and green leaf manure was reported by Singh *et. al*. (2004). Murthy *et al*. (1990) found that the incorporation of siris (*Albizia lebbeck*) (4.7% N), neem (2.6% N) and subabul (3.2% N) leaves improved the available and total N status of soil over control (no incorporation)

Keeping this background in mind, a field experiment was undertaken to study the effect of N-fixing tree leaves incorporation on productivity of lowland rice.

Materials and Methods

The field experiments were conducted in *kharif* seasons of 2003, 2004 and 2005, respectively at low land farm of the ICAR Research Complex for NEH Region, Umim, Meghalaya (950m msl) to study the effect of N-fixing tree leaves incorporation on growth, yield and productivity of lowland rice. The seven treatments consisted of T1: *Erythrina indica* fresh leaves and twigs@10t/ha, T2: Alder (*Alnus nepalensis*) fresh leaves and twigs@10t/ha, T3: Tree bean (*Parkia roxburghii*) fresh leaves and twigs@10t/ha,T4: Acacia (*Acacia auriculiformis*) fresh leaves and twigs@10t/ha,T5: Cassia (*Cassia siamea*) fresh leaves and twigs@10t/ha,T6: Recommended NPK (80: 60:40 kg/ha) and T7: Control (No fertilizer and manure) were replicated thrice under a randomized block design experiment (RBD). The soil of the experimental field was low in available P (6.95 kg/ha), medium in N (277 kg/ha) and high in K (258 kg/ha). The pH and organic carbon content of the soil was 5.1 and 2.86 %, respectively. All the tree leaves were applied 20 days ahead of transplanting to the main field and incorporated along with spading/ trampling. Rice variety Sahsarang 1 was transplanted in the first week of July at a spacing of 20 x 15 cm. The growth and yield data were collected at harvest. The post harvest soil samples were collected for analyzing macro and micro nutrient status. All the leaves were analysed for their nutrient and moisture content. In the first year, only yield data were collected. From second year onwards all the relevant data were collected.

For pest and disease control a common dose of neem cake was applied to the soil @ 250kg/ha. Two sprays of neem oil (2ml/lt) were given at panicle initiation and heading stage to prevent pest and disease problems. Two hand weeding were given at 25 and 45DAT. Observations on growth and yield attributes were recorded as per schedule. The post harvest data on total biomass, grain yield, test weight etc were recorded. The data collected were analyzed as per standard statistical method applicable for the experiment under consideration.

Weather parameters

The Details of temperature, rainfall and humidity during the experimental seasons i.e. June to November (2004-05) are given in table. In 2003, the minimum and maximum temperature ranges between 11.7 to 20.8 and 22.8 to 28.3^{0}C,respectively and a total rainfall of 1995mm was received during the cropping season. The rainfall received during the year 2004 and 2005 were 2276.8 mm and 1190 mm, respectively.

Table. Mean monthly weather parameters during the crop season (2004-05)

Month	Temperature (^{0}C)				Rainfall (mm)		RH (%)	
	Max		Min		2004	2005	2004	2005
	2004	2005	2004	2005				
June	26.9	27.5	19.7	19.7	432.2	343.7	85.6	86.5
July	25.9	29.4	20.0	21.0	747.3	171.1	89.8	83.4
August	29.0	29.7	20.5	20.3	189.8	197.1	85.9	82.6
September	25.9	27.8	19.3	19.0	263.4	390.7	88.4	86.5
October	24.7	27.4	15.4	15.6	584.5	234.0	86.8	83.7
November	23.4	23.5	11.5	12.8	59.6	50.7	79.9	82.0

Results

There was marked variation in the nutrient composition of different leaves used in the experiment (Table 1). The N content varies from 2.24 % with alder to as high as 3.24 with Erythrina. The *Accacia* biomass also contained an appreciable amount of nitrogen (3.19%).The highest P and K content was also recorded with Erythrina biomass. The same biomass also had maximum moisture content (71%). This showed that the Erythrina leaves are more succulent. Most of the leaves contained 65-70% moisture, indicating that only one third of their fresh weight are real biomass and this justifies the use of 10 t/ha of fresh biomass.

Table.1 Nutriment composition (%) of different tree leaves and twigs used in the experiment

Tree leaves & twigs	N	P	K	Moisture	OC
Erythrina	3.24	0.47	1.54	71.62	18.82
Alder	2.24	0.41	1.37	66.22	16.88
Tree bean	2.54	0.40	1.52	69.28	16.88
Acacia	3.19	0.43	1.36	65.37	14.14
Cassia	2.50	0.39	1.17	65.80	17.34

Growth and yield attributes:

The incorporation of different tree leaves had significant effect on growth and yield attributes of rice (Table. 2, 3 &4). In the second year of experimentation (2004), all the growth attributes viz., height, tillers/m2, biomass, root length and root volume and yield attributes viz., panicles/m2, grains/panicle, test weight etc. all were highest with recommended NPK followed by the incorporation of *Erythrina* biomass@10t/ha. However, these values were at par with those of *Parkia*, *Acacia* and *Casia*. In the third year of experimentation i.e., 2005 the trend was completely different. Most of the tree leaves surpassed the recommended NPK in terms of growth and yield attributes except alder leaves. The highest growth and yield attributes in the third year (2005) were observed with incorporation of Erythrina leaves that were however, at par with all other leaves and recommended NPK. The performance of rice with recommended NPK in the third year was slightly lesser than the incorporation of tree leaves except alder leaves that recorded lowest values of growth and yield attributes among all the leaves and recommended NPK. The control plot recorded the lowest values of growth and yield attributes in all the three years of experimentation.

Table. 2. Effect of N-fixing tree leaves incorporation on growth attributes of low land rice

Treatments	Total Biomass (t/ha)			Total tillers/m2		Plant height (cm)	
	2003	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Erythrina @ 10 t/ha	11.03	11.95	13.44	246	285.3	86.63	91.21
Alder @10 t/ha	9.16	10.21	11.12	242.3	246.6	81.63	86.40
Tree bean @10 t/ha	10.34	11.25	12.40	223.0	268.0	85.02	86.93
Acacia @10 t/ha	9.74	11.56	12.80	242	284.0	85.2	90.83
Casia @10 t/ha	9.82	11.43	13.20	244.7	283.7	84.97	89.0
NPK (Rec.NPK)	11.69	12.42	12.18	256.3	256.0	87.77	87.3
Control	6.98	7.88	8.30	175.0	228.0	77.67	83.16
Sem	0.56	0.52	0.64	12.16	15.19	1.64	2.00
CD (P=0.05)	1.71	1.63	1.96	37.4	46.8	5.03	6.14

Table.3. Effect of N-fixing Tree Leaves Incorporation on root activity, leaf area index and weed biomass of Low Land Rice

Treatments	Root length (cm)		Root volume (cc/hill)		lAI	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**
Erythrina @ 10 t/ha	18.96	21.54	43.56	72.32	1.95	2.02
Alder @10 t/ha	18.30	19.10	37.83	40.62	1.62	1.77
Tree bean @10 t/ha	18.52	20.67	39.50	52.42	1.86	1.90
Acacia @10 t/ha	18.63	19.95	41.68	70.50	1.90	2.02
Casia @10 t/ha	19.55	19.25	42.37	66.30	1.86	2.04
NPK (Rec.NPK)	19.67	19.92	45.80	47.79	1.78	1.80
Control	16.97	18.31	31.26	37.36	1.46	1.48
Sem	0.89	1.16	1.58	4.63	-	-
CD (P=0.05)	2.73	3.56	4.85	14.21	-	-

Table.4. Effect of N-fixing Tree Leaves Incorporation on yield attributes of Low Land Rice

Treatments	Effective panicles/m^2		Panicles/hill		Effective grains/panicle		Test weight	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Erythrina @ 10 t/ha	211.3	251.3	8.33	9.53	162.7	185.2	23.67	24.66
Alder @10 t/ha	183.0	231.7	7.46	7.54	153.4	165.6	23.30	23.44
Tree bean @10 t/ha	198.0	244.7	7.73	8.33	156.5	174.8	23.41	24.45
Acacia @10 t/ha	206.7	252.0	8.27	8.93	160.3	174.4	23.70	24.28
Casia @10 t/ha	203.7	248.7	8.10	8.17	157.7	173.1	23.58	24.59
NPK (Rec.NPK)	227.7	235.0	8.53	7.75	168.9	169.2	23.76	23.83
Control	161.0	201.3	6.2	6.40	146.3	151.5	22.69	23.31
Sem	17.1	16.12	0.55	0.46	7.81	2.98	0.36	0.36
CD	52.49	49.48	1.68	1.41	23.97	9.15	1.11	1.11

Yield

The results revealed that tree leaves incorporation had significant effect on grain and yield of rice (Table.2). In the first year, highest grain yield was recorded with NPK (4.82t/ha) followed by incorporation of *Erythrina* (4.48t/ha) and *Parkia* leaves (4.13 t/ha). In the following year ie., 2004., though the trend remained almost same, the gap between yield obtained with NPK (5.08t/ha) and tree leaves incorporation reduced. Surprisingly, in the third year (2005), all the tree leaves except alder surpassed the grain yield level that was obtained with recommended NPK (5.13t/ha). Significantly highest grain yield of rice in third year was recorded with incorporation of *Erythrina* leaves (5.67t/ha) that remained at par with all other leaves except alder (4.67t/ha). Similar trend was observed with respect to straw and total biomass yield. Such positive effect of tree leaves incorporation like *Leucaena leucocephala* (Durgude and Patil, 1997), *Azadiricta spp*. (Murthy *et.al*.1990) and Alder (Alnus nepalensis) and *Eupatorium odoratum* (Das *et. al.* 2007) on improved productivity were reported by several researchers. The result indicated that green leaf manuring with N-fixing tree leaves left marked residual effect and therefore improved productivity level due to cumulative effect. Comparatively lesser rainfall along with high temperature and lower humidity in 2005 might have helped in giving better productivity as indicated from the weather data.

The harvest index remained unaffected by different treatments. The harvest index remained unaffected by different treatments. Such positive effect of tree leaves incorporation like *Leucaena leucocephala* (Durgude and Patil, 1997), *Azadiracta sp* (Uyobisere and Elemo, 2002) and Alder (*Alnus nepalensis*) and *Eupatorium odoratum* (Das, *et.al*.2007) were reported by several researchers.

Table. 4. Effect of N-fixing tree leaves & twigs incorporation on grain and straw yield of low land rice

Treatments	Grain Yield (t/ha)			Straw Yield (t/ha)			H.I		
	2003	**2004**	**2005**	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**

Erythrina @ 10 t/ha	4.48	4.83	5.67	6.55	7.12	7.77	40.68	40.46	42.14
Alder @10 t/ha	3.50	4.10	4.67	5.66	6.11	6.45	38.18	39.91	42.09
Tree bean @10 t/ha	4.13	4.40	5.24	6.20	6.85	7.16	39.90	39.92	42.27
Acacia @10 t/ha	3.92	4.66	5.30	5.83	6.90	7.49	40.37	40.31	41.45
Casia @10 t/ha	3.99	4.55	5.58	5.83	6.69	7.46	40.71	40.46	42.27
NPK (Rec.NPK)	4.82	5.08	5.13	6.88	7.34	7.05	41.28	40.93	42.06
Control	2.80	3.13	3.35	4.18	4.75	5.04	40.39	39.72	40.30
Sem	0.19	0.15	0.25	0.39	0.33	0.36	0.97	0.86	0.78
CD (P=0.05)	0..58	0.46	0.77	1.19	1.02	1.19	NS	NS	NS

Nutrient concentration and uptake

The nutrient (NPK) concentration in grain and straw of rice were analyzed (Table). The different treatment influenced the nutrient content to a lesser extent. However, the uptake was significantly influenced by the incorporation of tree leaves and NPK. The nutrient removal followed almost the similar trend as that of grain yield and biomass production. Therefore, the highest nutrient removal in the third year was observed with incorporation of Erythrina biomass. The other biomass incorporation recorded the nutrient removal at par with each other. Control plot recorded the lowest uptake values. Higher nutrient availability due to application of green leaf manures like *Glyricidia, L. leucocephala , A, Albizia lebbek* etc. were also reported by several other workers (Bellakkki and Badanur, 1993; Durgude and Patil, 1997 and Murthy and Badole, 1999)

Table.10. Nutrient content (%) of rice and straw grain as influenced by N- fixing tree leaves incorporation

Treat ments	Nutrient content in grains (%)						Nutrient content in straw (%)					
	N		P		**K**		N		P		**K**	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
T1	1.33	1.39	0.29	0.31	2.59	2.87	0.65	0.70	0.20	0.22	3.51	3.55
T2	1.20	1.26	0.27	0.26	2.37	2.67	0.59	0.60	0.16	0.17	3.47	3.49
T3	1.20	1.30	0.28	0.29	2.71	2.70	0.63	0.63	0.19	0.20	3.48	3.50
T4	1.30	1.32	0.27	0.30	2.72	2.75	0.64	0.68	0.20	0.20	3.48	3.52
T5	1.30	1.31	0.27	0.29	2.70	2.73	0.63	0.63	0.09	0.19	3.50	3.52
T6	1.20	1.30	0.26	0.26	2.72	2.73	0.60	0.63	0.18	0.18	3.51	3.51
T7	1.20	1.22	0.23	0.23	2.37	2.38	0.54	0.57	0.18	0.17	3.43	3.45

Post harvest soil fertility

At the harvest, soil samples were analyzed for macro and micro nutrient (Table.). From second year onwards, all the tree leaves showed positive effect on the available soil nutrient status. There was significant improvement in the available N and P status of the soil. The available K status was not much influenced by the different treatments. The different treatment though improved the micro nutrient status of the soil could not achieve the level of significance. Higher nutrient availability due to application of green leaf manures like *Glyricidia, Leucaena leucocephala*, *Albizia lebbek* etc. were reported by numerous workers (Bellaki and Badanur, 1993; Durgude and Patil, 1997., Chaphale and Badole,1999 and Murthy *et.al.* 1990). Murthy et.al. (1990) also found that the incorporation of siris (*Albizia lebbeck*) (4.75 N), neem (2.6 %N) and subabul 93.2% N) leaves improved the available and total N status of soil. The mineralization of nutrients specially N from green manure biomass might had been rapid and was available throughout the crop growth period. In wet seeded rice, green manure incorporation makes adequate N available at the critical satage of 58-80 DAS, enabling better nutrient uptake and higher yield (Joseph et.al.2002). During the process of organic matter decomposition, organic acidas are produced that promote the solubilization of soil nutrients (such as phosphorus) making it more available to plants (Rasal *et.al.*1988)

Table. 8. Soil fertility as influenced by N- fixing tree leaves and twigs incorporation.

Treatments	Organic carbon (%)		Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Erythrina @ 10 t/ha	2.68	2.85	320.1	323.3	12.18	13.06	292.7	294
Alder @10 t/ha	2.65	2.76	295.3	309.7	9.42	11.72	296.0	295
Tree bean @10 t/ha	2.60	2.71	288.7	314.1	10.67	12.85	271.4	282
Acacia @10 t/ha	2.75	2.88	299.3	307.5	11.20	12.31	274.8	278
Casia @10 t/ha	2.63	2.82	317.8	322.5	12.37	13.20	280.2	298
NPK (Rec.NPK)	2.59	2.61	281.0		8.56	10.25	273.9	277
Control	2.51	2.50	269.4	270.7	7.39	7.20	253.8	265
Sem			13.54	18.27	0.85	1.31	11.66	10.38
CD (P=0.05)			41.73	56.31	2.62	4.03	35.94	32.00
Initial value	2.86		277		6.95		257.8	

Table .9. Soil micronutrient status (ppm) as influenced by N- fixing tree leaves incorporation

Treatments	Fe		Mn		Zn		Cu	
	2004	**2005**	**2004**	**2005**	**2004**	**2005**	**2004**	**2005**
Erythrina @ 10 t/ha	1.48	1.51	0.50	0.55	0.05	0.04	0.17	0.18
Alder @10 t/ha	1.65	1.85	0.53	0.58	0.04	0.05	0.15	0.15
Tree bean @10 t/ha	1.25	1.32	0.65	0.65	0.04	0.04	0.21	0.21
Acacia @10 t/ha	1.22	1.23	0.70	0.73	0.04	0.05	0.18	0.20
Casia @10	1.38	1.41	0.64	0.63	0.04	0.04	0.15	0.16

t/ha								
NPK (Rec.NPK)	1.85	0.85	0.61	0.61	0.04	0.04	0.15	0.13
Control	0.92	0.97	0.39	0.40	0.03	0.04	0.10	0.09
Initial	1.11		0.38		0.04		0.14	
Sem	0.12	0.14	0.04	0.04	0.005	0.005	0.023	0.023
CD (P=0.05)	0.38	0.43	0.12	0.12	0.016	0.015	0.08	0.07

Economics:

Unlike grain yield, the net return was highest with recommended NPK (Rs.19077/ha) followed by the incorporation of *Erythrina* (Rs.15144/ha) and *Casia* (Rs.13378/ha) leaves. The return per rupee invested also followed the similar trend. The low net return with incorporation of tree leaves are mainly due to higher labour cost required for collection, incorporation etc. However, if family labour is involved and ignored from economics, the incorporation of tree leaves would be beneficial. Moreover, if the improvement in soil physico-chemical and biological properties are considered, the incorporation of tree leaves would be much more beneficial compared to the inorganic means.

Table. 12. **Economics of treatments (Based on three years average)**

Treatments	Mean grain yield (t/ha)	Mean straw yield (t/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Return/rupee invested
Erythrina @ 10 t/ha	4.99	7.15	16,940	32,084	15,144	1.89
Alder @10 t/ha	4.09	6.07	16,350	25,822	9,472	1.58
Tree bean @10 t/ha	4.56	6.74	16,560	29,381	12,821	1.77
Acacia @10 t/ha	4.63	6.74	16,780	29,802	13,022	1.78
Casia @10 t/ha	4.71	6.66	16,880	30,258	13,378	1.79
NPK (Rec.NPK)	5.01	7.09	13,110	32,187	19,077	2.45
Control	3.09	4.66	10,360	19,937	9,577	1.92

Therefore it could be recommended that the application of tree leaves specially the leaves and biomass from N fixing species would not only improve the productivity and income but would also maintain the soil health. In north east where a lot of biomass mainly from trees are available could effectively be recycled in organic rice production.

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