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Addition of some tree leaf litters in forest soil and their effect on the growth, yield and nutrient uptake by red amaranth

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Abstract: A pot experiment was conducted in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during January to April 2007 to examine the growth, yield and nutrient uptake by red amaranth and chemical changes in post harvest soil amended with four tree leaf litters viz. *Teak, Eucalyptus, Sal* and *Acacia* at the rate of 20 t ha^{-1}. A chemical fertilizer treatment at the recommended dose along with a control was included for comparison. The experiment was laid out in completely randomized design with three replications. The application of different tree leaf litters and chemical fertilizers significantly influenced most of all the parameters studied except Ca and Mg contents. The highest values of most of the parameters were recorded from the plant treated with chemical fertilizers whereas plant diameter, dry matter weight, S, Fe contents and the entire nutrient uptake were maximum in plants amended with *Teak* leaf litters. Changes in soil pH, organic matter, N and P contents were significant due to the addition of different tree leaf litters but no significant difference was observed in K content and the highest values were recorded from the soil amended with same leaf litter. Among the leaf litters, *Teak* exhibited the best performance in most of the cases whereas *Eucalyptus* showed a good result in some cases. Thus, the overall result suggests that red amaranth can be cultivated in soil treated with chemical fertilizer as well as *Teak* and *Eucalyptus* leaf litters for higher yield and the addition of leaf litters is required to maintain and improve the soil fertility and productivity.
Key words: Leaf litters, Yield, Nutrient uptake, Red amaranth.

Introduction

Litter plays a fundamental role in the nutrient turnover and in the transfer of energy between plants and soil, the source of the nutrient being accumulated in the upper most layers of the soil (Singh, 1971). Nutrients may be released from litter by leaching or mineralization (Swift *et al.,* 1979). The rate of nutrients release depends on several factors such as chemical composition, structural nature of the litter and microbial population (Seasted, 1984). Rangtia evergreen forest of Sherpur plays an important role in both ecological and economic terms of Bangladesh. This forest helps us to restore the productivity and is also the source of a variety of products. Sal, Teak, Acacia, Garjan, Eucalyptus, Koroi and Mahogoni are the major tree species of this forest. A lot of leaf litters and twigs are fallen on the ground soil every year which play a vital role to enrich the forest soil organic matter content and are naturally decomposed and released nutrients for forest plants. These forest tree leaf litters can be applied as an organic amendment for the production of agricultural crops in the surrounding areas of the forest.

Red amaranth (*Amaranthus tricolor* L.) is one of the popular, tasty and nutritious leafy vegetable in our country but unfortunately the production of this popular vegetable is very low according to our demand. The production of this vegetable should be increased to meet up our increasing demand. The unused forest leaf litters can be used as an organic amendment in the nearby forest site for vegetable cultivation which play a vital role for boosting up the plant growth and ultimately increase the yield. Hence, the prevailing situation underscores the need for a research to study the effect of forest tree leaf litter addition on the growth, yield nutrient uptake by red amaranth.

Materials and Methods

To study the response of red amaranth to leaf litters addition in forest soil, a pot experiment was carried out in the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during January to April 2007. Silt loam soil (0-15 cm) was collected from the Rangtia sal forest of Jhenaigati upazila under Sherpur district. Soils were air dried, ground and sieved through a 2 mm sieve to remove plant residues and other extraneous materials and mixed thoroughly and finally 8.5 kg soil was poured into each earthen pot. The soil had the following properties: pH 4.92, organic matter 1.25%, total N 0.062%, exchangeable K 0.16 cmol kg^{-1}, available P, S, Ca and Mg contents were 5.28, 10.66, 42.20 and 48.00 μg g^{-1}, respectively. *Teak* (*Tectona grandis*), *Eucalyptus* (*Eucalyptus camaldulensis*), *Sal* (*Shorea robusta*) and *Acacia* (*Acacia auriculiformis*) litters were collected from different locations of Rangtia sal forest. These litters were washed, sun dried followed by oven drying at 60^0C for 48 hours, ground in a grinding mill and applied @ 20 t ha^{-1}. The chemical constituents of litters used in this experiment have been presented in Table 1. A chemical fertilizer along with a control was used as treatment for comparison. Urea, TSP, MOP and gypsum were applied according to the fertilizer recommendation guide (BARC, 2005). One-third amount of urea and full dose of other fertilizers were applied one day before sowing. The rest part of urea was applied at 10 and 20 days after sowing. Ground leaf litters were mixed thoroughly with the soil and saturated with water for 30 days before sowing for their well decomposition. Approximately 20 to 30 seeds of red amaranth cv. BARI Lal Shak-1 were sown in each pot following completely randomized design with three replications and finally 8 plants were kept in each pot for harvesting. Adequate soil moisture content was maintained by the addition of distilled water regularly. Fully matured crops were harvested at 40 days after sowing and soil samples from each pot were collected for chemical analyses to evaluate the residual effect of the leaf litters in soil. Soil and plant nutrients were analyzed following the standard methods (Page *et al.*, 1982). Analysis of variance was done with the help of computer package MSTAT developed by Russel (1986) and the mean differences of the treatments were adjudged by LSD test.

Table 1. The chemical constituents of leaf litters used in the experiment

Leaf litter	Organic Carbon (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
Teak	52.39	1.32	0.24	0.93	1.70	0.66	0.13
Eucalyptus	50.22	1.17	0.18	1.15	1.54	0.55	0.11
Sal	44.35	0.98	0.13	0.75	1.00	0.33	0.08
Acacia	47.81	1.03	0.15	0.81	1.17	0.47	0.07

Results and Discussion

Effect of tree leaf litters on the growth and leaf yield of red amaranth

Plant height: Application of different tree leaf litters and fertilizer significantly influenced the plant height of red amaranth. The tallest plant (32.67 cm) was identified from the pot treated with chemical fertilizer which was identical with the plant height obtained from the pot amended with *Teak* litter and the shortest plant (21.00 cm) was recorded from *Sal* litter treatments (Table 2). Among the leaf litters of different trees, *Teak* leaf litter was superior to other leaf litters for producing taller plants. Yamazaki and Roppongi (1990) studied the effect of soybean meal (SM), composted pig manure (PM) and composted cattle dung mixed with sawdust (CMS), applied singly or with chemical fertilizer, on the plant height of leafy vegetables such as spinach and lettuce, cabbage and concluded that all those amendments significantly increased the height of those vegetables as compared to control.

Plant diameter: Significant variation was observed in plant diameter of red amaranth due to different leaf litters addition and chemical fertilization (Table 2). The highest (0.573 cm) and the lowest (0.480 cm) plant diameter were recorded from the pot treated with *Teak* litter and control pot, respectively. *Teak*, *Eucalyptus* and *Acacia* produced statistically identical plant diameter recorded from chemical fertilizer treated plants.

Number of leaves: Different tree leaf litters significantly influenced the number of leaves of red amaranth. The highest number of leaves (17.00) was recorded from chemically fertilized pot which was identical with the leaf number obtained from those pots treated with *Teak* and *Eucalyptus* litters and significantly different from other leaf litters including control. The lowest number of leaves (11.00) was counted from the pot which was neither fertilized nor amended with any leaf litters (Table 2). Maharudrappa *et al.* (2000) conducted an experiment to observe the effect of Teak, Acacia, Eucalyptus and Casuarina leaf litters in soil, who reported that application of leaf litters significantly increased the number of leaves of indian spinach and lettuce and the highest values were obtained from Teak litter amended soil.

Fresh yield: The effect of different tree leaf litters on fresh yield of red amaranth was significant. Among the treatments, the highest (112.0 g) and the lowest (77.33 g) yields were recorded from the pots treated with chemical fertilizer and *Sal* leaf litter, respectively. Whereas Teak, Eucalyptus and Acacia showed yield as 105.33, 94.67 and 80 g, respectively (Table 2). Among the leaf litters of different trees, *Teak* litter was superior to other litters for producing higher yield of red amaranth which was statistically identical with the yield of chemical fertilizer treated pot. Anez and Espinoza (2003) conducted a field experiment to evaluate the effect of manure, compost, leaf litters and chemical fertilizer for the production of lettuces and cabbages, who reported that productivity, were significantly and independently affected by the treatments. The addition of leaf litter to the soil may be an alternative to chemical fertilizers to obtain an excellent red amaranth harvest.

Dry matter yield: Application of different tree leaf litters and chemical fertilizer significantly influenced the dry matter yield of red amaranth. The highest dry matter yield (8.93 g) was observed in pot amended with *Teak* leaf litter which was identical with the weight obtained from the chemically fertilized plant and the lowest dry matter yield (4.48 g) was recorded from the pot which was neither treated with chemical fertilizer nor amended with any leaf litters (Table 2). The results showed that *Teak* leaf litter was superior to others for producing higher dry matter yield.

Table 2. Effect of different tree leaf litters and chemical fertilizer on the growth and yield of red amaranth cv. BARI Lal shak-1

Treatments	Plant Height (cm)	Plant diameter (cm)	Leaves plant^{-1} (No.)	Fresh yield pot^{-1} (g)	Dry matter yield pot^{-1} (g)
Control	22.67	0.480	12.00	80.00	4.48
Teak	30.67	0.573	15.00	105.30	8.93
Sal	21.00	0.510	11.00	77.33	5.25
Eucalyptus	28.17	0.536	13.33	94.67	6.18
Acacia	26.00	0.533	12.33	89.00	4.53
Chemical fertilizer	32.67	0.553	17.00	112.00	7.12
LSD (0.05)	4.07	0.039	3.84	14.34	2.52

Effect of tree leaf litters on nutrient contents and their uptake by red amaranth

Nitrogen: The effect of different leaf litters on N content of red amaranth was significant (Table 3). The N content varied from 0.79 to 1.06%. The maximum (1.06%) and minimum (0.79%) N contents were obtained from the plant treated with chemical fertilizer and *Sal* litter, respectively. The results showed that N content in *Teak* and *Eucalyptus* litter treated plants were statistically identical with that of chemical fertilizer. The C: N ratio of *Sal* litter was higher than others because the decomposition rate and nutrient release was slower. This might be one of the reasons that the nutrient contents of *Sal* litter were lower than others.

Nitrogen uptake by red amaranth was significantly influenced by the application of different tree leaf litters and chemical fertilizer. The highest uptake (86.59 mg pot^{-1}) was calculated from the plant amended with *Teak* litter and the lowest uptake (36.40 mg pot^{-1}) was found from the plant under control treatment.

Phosphorus: Different leaf litters significantly influenced the content of P in red amaranth (Table 3). The maximum (0.92%) and minimum (0.52%) P contents were obtained from the plant treated with chemical fertilizer and control, respectively. The results indicated that P content in *Teak* and *Eucalyptus* leaf litter amended plant was identical with chemical fertilizer treated plants. It appears that leaf litter may be an alternative to chemical fertilizers to obtain an excellent red amaranth harvest.

Significant variation was observed in P uptake by red amaranth by application of different leaf litters. The P uptake varied from 23.90 to 66.08 mg pot^{-1} where the maximum and minimum uptakes were recorded from the plant treated with *Teak* litter and control plants, respectively as shown in Table 3. The results revealed that P uptake of chemical fertilizer and *Eucalyptus* treated plants were identical with that of *Teak* litter amended plants.

Potassium: Potassium content of red amaranth was significantly influenced due to the application of different leaf litters and chemical fertilizers (Table 3). The highest content (0.96%) was recorded from the chemically fertilized plant which was identical with *Teak* litter amended plant and significantly different from other litters including control. The lowest content (0.50%) was obtained from the untreated control plant.

Application of different tree leaf litters and chemical fertilizers had a significant influence on the K uptake by red amaranth. The highest (71.40 mg pot^{-1}) uptake was calculated from the *Teak* leaf litter treated plant which was identical with chemically fertilized plant and the lowest uptake (22.52 mg pot^{-1}) was recorded from the plant which was neither treated with any leaf litter nor chemical fertilizer.

Calcium: The effect of different leaf litters on Ca content in red amaranth was not significant (Table 4). The amount of Ca content varied from 0.53 to 0.75%. The maximum (0.75%) and minimum (0.53%) Ca contents were obtained from the plant treated with chemical fertilizer and control, respectively.

Calcium uptake by red amaranth was significantly influenced by application of different leaf litters. The highest uptake (58.03 mg pot^{-1}) was recorded from the plant treated with chemical fertilizer which was identical with *Teak* litter amended plant. The lowest uptake (23.99 mg pot^{-1}) was recorded from the untreated plant.

Magnesium: No significant difference in Mg content of red amaranth was observed due to the application of leaf litters and chemical fertilizers. The maximum (0.91%) and minimum (0.70%) contents were obtained from the plant treated with chemical fertilizer and control, respectively (Table 4).

Application of different tree leaf litters significantly influenced the uptake of Mg by red amaranth where the highest (70.0 mg pot^{-1}) and lowest (30.13 mg pot^{-1}) uptake were recorded from the chemically fertilized and control treatment, respectively. The uptake obtained from the *Teak* litter was identical with chemical fertilizer.

Sulphur: The effect of different leaf litters on S content of red amaranth was significant (Table 4). The amount of S content varied from 0.15 to 0.26%. The maximum and minimum S contents were obtained from the plant treated with *Teak* and *Sal* leaf litter treated plants, respectively. The results reflected that S content of chemically fertilized plants was identical with that of *Teak* leaf litter treated plants.

Addition of different tree leaf litters significantly influenced the S uptake by red amaranth. The highest uptake (20.29 mg pot^{-1}) was calculated from the plant treated with *Teak* leaf litter which was identical with the uptake obtained from chemical fertilizer treated plant and the lowest uptake (8.18 mg pot^{-1}) was recorded from untreated plants.

Iron: Significant variation in Fe content of red amaranth was observed due to different leaf litters application (Table 4). The highest (14.70 µg g^{-1}) content was found from the plant treated with *Teak* litters which was identical with that of chemically fertilized plant. The lowest content (6.68 µg g^{-1}) was recorded from the plant which was not treated with any leaf litters or chemical fertilizer.

Iron uptake by red amaranth was significantly influenced by application of different leaf litters. The uptake was highest (0.93 µg pot^{-1}) in *Teak* litter amended plant which was identical with that of *Eucalyptus* and chemical fertilizer treated plant and the lowest (0.39 µg pot^{-1}) uptake was calculated from the untreated plant.

Effect of tree leaf litters on the chemical properties of post harvest soil

Soil pH: The changes in pH value for application of different tree leaf litters and chemical fertilizers have been presented in Table 5. The results showed that application of different leaf litters significantly decreased soil acidity where the highest pH value (5.72) was recorded from soil amended with *Teak* litter followed by pH values 5.20, 5.40, 5.42 recorded from *Acacia*, *Sal*, *Eucalyptus* litter treated soil, respectively. The lowest value (4.92) was recorded from the control treated pot. The addition of organic residues had a considerable effect on increase of soil pH value. Issac and Nair (2002) also reported that litter addition increased soil pH.

Table 3. Effect of different tree leaf litters and chemical fertilizer on N, P and K contents and their uptake by red amaranth

Treatments	Nitrogen		Phosphorus		Potassium	
	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})
Control	0.79	36.40	0.52	23.90	0.50	22.52
Teak	0.99	86.59	0.83	70.35	0.88	71.40
Sal	0.83	43.90	0.73	39.02	0.75	40.14
Eucalyptus	0.95	62.09	0.79	51.89	0.79	54.67
Acacia	0.85	38.16	0.74	33.23	0.77	35.51
Chemical fertilizer	1.06	75.94	0.92	66.08	0.96	70.93
LSD (0.05)	0.12	32.27	0.12	20.65	0.12	26.08

Table 4. Effect of different tree leaf litters and chemical fertilizer on Ca, Mg, S and Fe contents and their uptake by red amaranth

Treatments	Calcium		Magnesium		Sulphur		Iron	
	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})	Content (µg g^{-1})	Uptake (µg pot^{-1})
Control	0.53	23.99	0.70	30.13	0.17	8.18	6.68	0.39
Teak	0.71	51.05	0.84	65.46	0.26	20.29	14.70	0.93
Sal	0.51	27.15	0.72	37.86	0.15	8.21	7.99	0.70
Eucalyptus	0.63	45.93	0.78	52.18	0.22	16.14	8.99	0.92
Acacia	0.59	26.20	0.75	33.77	0.18	8.33	10.32	0.89
Chemical fertilizer	0.75	58.03	0.91	70.00	0.23	16.98	13.00	0.69
LSD (0.05)	0.26	21.19	0.27	21.60	0.09	9.45	5.93	0.09

Organic matter: Significant variation in organic matter content was recorded due to application of different leaf litters in soil. The highest organic matter (2.62%) was recorded from soil amended with *Teak* litter which was identical with the content obtained from the *Eucalyptus* and *Acacia* litter treated soil. The lowest organic matter (1.13%) was obtained from the soil which was not treated with chemical fertilizer or any leaf litters (Table 5). This result indicated that leaf litters was superior to chemical fertilizer for increasing organic matter in soil. Thus the findings of our study was in agreement with that of Issac and Nair (2002) who reported that application of tree leaf litters significantly increased soil organic matter content as compared to control.

Total N: Addition of different tree leaf litters significantly influenced soil N content as reported in Table 5. The highest N (0.097%) content was recorded from soil amended with *Teak* leaf litter which was identical with N content obtained from *Acacia* and *Eucalyptus* litters treated soil and the content was lowest (0.061%) in untreated control soil. Litter addition improved nitrogen nutrient pool in soil as reported by Issac and Nair (2002). This result indicated that leaf litters was superior to chemical fertilizer for increasing nitrogen level in soil. Maharudrappa *et al.* (2000) conducted an experiment to observe the effect of *Teak*, *Acacia*, *Eucalyptus* and *Casuarina* leaf litters addition in soil, who reported that N content was higher in *Teak* leaf amended soil compared to other leaf litters.

Table 5. Effect of different leaf litters and chemical fertilizer on the chemical properties of post harvest soil

Treatments	pH	Organic matter (%)	Total N (%)	Available P ($\mu g\ g^{-1}$ soil)	Exchangeable K (cmol kg^{-1} soil)
Control	4.92	1.13	0.061	5.28	0.30
Teak	5.72	2.62	0.097	9.85	0.41
Sal	5.40	1.97	0.069	7.30	0.33
Eucalyptus	5.42	2.37	0.089	8.67	0.40
Acacia	5.20	2.13	0.087	8.13	0.39
Chemical fertilizer	4.93	1.21	0.067	6.21	0.32
LSD (0.05)	1.10	0.85	0.013	1.25	0.13

Available P: The results showed that application of different leaf litters significantly increased available P content in soil where the highest value (9.85 $\mu g\ g^{-1}$) was recorded from soil treated with *Teak* leaf litter followed by available P contents recorded from *Sal*, *Acacia* and *Eucalyptus* leaf litter treated soil, respectively. The lowest content (5.28 $\mu g\ g^{-1}$) was recorded from the control soil (Table 5). This result reflected that leaf litters was superior to chemical fertilizer for increasing available P level in soil. Dutta and Agrawal (2001) studied with litter fall and leaf litter decomposition and nutrient dynamics of plant species namely *Acacia auriculiformis*, *Cassia siamea*, *Casuarina equisetifolia*, *Eucalyptus hybrid* and *Gravelia pteridifolia* growing on mine soil. Litters of different plant species showed significant variations in P concentrations in soil.

Exchangeable K: Difference in exchangeable K content of soil was not significant due to addition of different leaf litters. The maximum K content (0.41 $\mu g\ g^{-1}$) was detected from soil amended with *Teak* leaf litter and the minimum K content (0.30 $\mu g\ g^{-1}$) was recorded from the untreated control soil (Table 5). Nevzat *et al.* (2003) examined the effects of pine *(Pinus taeda L.)* needle litter addition on soil nutrient contents, who reported that concentration of K in the soil was increased two to three folds.

Conclusion: The overall result suggests that the addition of *Teak* and *Eucalyptus* leaf litters to the soil may be an alternative to chemical fertilizers to obtain an excellent red amaranth harvest and to maintain and improve the soil fertility and productivity.

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