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Impact Of Teak Leaf Litter Addition On Yield Of *Kasturi Bhindi* And Soil Fertility Under Teak Based Agroforestry System

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ABSTRACT

An experiment was conducted to see the impact of teak leaf litter addition on yield of *Kasturi Bhindi* at Agroforestry Research Farm, College of Agriculture, Nagpur. The experiment was laid out in Randomized Block Design (RBD) with ten treatments consisting of various levels of teak leaf litter combined with cow dung and bio-decomposer. The study revealed that the teak leaf litter and cow dung addition along with PDKV bio-decomposer significantly affected the yield of *Kasturi bhindi*. Treatment of 5 t ha^{-1} teak leaf litter + cow dung @ 50% teak leaf litter + bio-decomposer (T_7)recorded significantly higher fresh and dry foliage yield (139.02 q ha^{-1} and 20.34 q ha^{-1}) as well as seed yield (18.91 q ha^{-1}). The lowest values for EC were recorded with T_4 teak leaf litter @ 7.5 t ha^{-1} EC (0.11 dS m^{-1}) after the harvest of the *Kasturi bhindi*. The highest organic carbon (6.53 g kg^{-1}) was recorded with application of 7.5 t ha^{-1} teak leaf litter in treatment T_4 while available N, P (17.89 kg ha^{-1}) and K (359.14 kg ha^{-1}) were recorded higher in T_7 with application of teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer. The population of bacteria after harvest of crop ranged from 84.36 × 106 cfu g^{-1} to 86.88 × 106 cfu g^{-1}. Significantly highest count of fungi was recorded in treatment T_{10} with application of teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter (15.18 × 105 cfu g^{-1}). The study revels that incorporation of teak leaf litter, cow dung and bio-decomposer may increase yield of *Kasturi Bhindi* as well as soil fertility.

Key Words:

Actinomycetes, Availability of nutrients, Bacteria, Fungi population, Teak, *Kasturi Bhindi*

INTRODUCTION

Kasturi bhindi (*Abelmoschus moschatus* Medic.) popularly known as musk mallow yields scented seed possessing an aroma similar to that of musk (*kasturi*) obtained from the Musk-deer (*Moschatus moschifera*) and valued for its volatile oil. Leaf litter is an important component of tree cropping system. This is because it builds up the forest floor and creates a layer of nutrient and litter on the soil. The role of litter as a pool of plant nutrients has long been recognized. It is well established that litter decomposition is positively associated with soil and litter nutrient concentrations (Wood et al. 2006). *Tectona grandis* is considered to be an important tree species in the western parts of India. The total area with this species is approximately 10.5 ha, planted mostly by forest persons. Litter fall of teak is the primary mechanism for transfer of plant detritus from above-ground parts of trees to the soil surface. Decomposition of this detritus provides the main source of energy and nutrients for soil and litter organisms, and is a major pathway for the recycling of nutrients to the plant community (Charley and Richards 1983).

The interactive and sequential processes of litter fall, its decomposition and subsequent mineralization are essential in sustaining a dynamic agriculture ecosystem. This is important because the availability of nutrients and plant uptake depends upon the re-absorption and re-translocation of the nutrients before leaf fall and subsequently on decomposition and mineralization of the organic matter. Plant litter decomposition is the process of biological disintegration of litter during which mineralization of complex organic compounds into simple inorganic forms. It includes leaching, break up by fauna, transformation of organic matter by micro organisms and transfer of organic and mineral compounds to the soil (Loranger et al. 2002). Cow dung harbours a rich microbial diversity, containing different species of bacteria (*Bacillus*spp., *Corynebacterium* spp. and *Lactobacillus* spp.), protozoa and yeast (*Saccharomyces* and *Candida*) (Nene 1999, Randhawa and Kullar 2011) and also acts as a conditioner for soil (Garg and Kaushik 2005 and Be´langer et al. 2014).

The present study was conducted to study the effect of teak leaf litter addition on yield of *Kasturi Bhindi* and soil fertility under Teak Based Agroforestry System.

MATERIAL AND METHODS

The field investigation was conducted in the year 2016-17 at Agroforestry Research Farm, College of Agriculture, Nagpur. The experiment was laid out in Randomized Block Design (RBD) and the treatments were replicated thrice. Ten treatments consist of various levels of teak leaf litter combined with cow dung and bio-decomposer. The experimental site where experiment was conducted is a teak plantation of year 1991. The teak was planted at 2 m distance (tree to tree) and 12 m row to row spacing. Teak leaf litter required for the experiment was obtained from teak plantation of Agroforestry research farm. During late winter *i.e.* in the month of February litter fall of teak starts. The teak leaf litter was then collected from surface and was dumped in pit where it was crushed. The teak leaf litter samples were then analyzed for nutrient content. From the result it was observed that C:N ratio of teak leaf litter is 30.40 which is narrower. Anonymus (2011) concluded that, understanding C:N ratios of crop residues and other material applied to the soil is important to manage soil cover and crop nutrient recycling , providing quality habitat for soil micro organisms.

The soil under experimental area is light textured soil with good drainage. In order to study the nitrogen mineralization soil samples up to 0-15 cm depth were collected at 30, 60 and 90 DAS of *Kasturi Bhindi*. Standard methods for analysis of soil and plant samples were applied. pH of soil was determined using pH meter with 1:2.5 soil water suspension while EC was determined from same sample using Conductivity meter (Jackson 1967). Wet Oxidation method of Walkley and Black 1934 was employed for estimating organic matter content of soil and available Nitrogen was estimated by alkaline potassium permanganate method using microprocessor based automatic distillation system (Subbiah and Asija 1956). Available phosphorus was determined by olsen's method where as available potassium was determined by neutral normal ammonium acetate method using flame photometer (Jackson 1967). Fungi, Bacteria and Actinomycetes population was determined by using Dilution plate technique (Dhingra and Sindair 1993).

RESULTS AND DISCUSSION

Litter and cow dung quality

Teak leaf litter required for the experiment was obtained from teak plantation of Agroforestry Research Farm. Cow dung was procured from Dairy Section, College of Agriculture, Nagpur. Nutrient content of teak leaf litter and cow dung used in the study is as following

Residues	OC %	N%	C:N	P%	K %
Cow dung slurry	47.68	0.50	25.00	0.40	0.50
Teak litter	37.70	1.24	30.40	0.38	0.46

From above data it was found that, teak leaf litter contains higher proportion of nitrogen compared with cow dung. C:N ratio of cow dung and teak leaf litter was narrower.

Fresh and dry matter yield

The effect of teak leaf litter addition on fresh and dry matter yield of *Kasturi Bhindi* was found significant. The values of fresh weight of ranged from 107.88 q ha^{-1} to 139.02 q ha^{-1}. While, dry matter yield ranged from 15.78 q ha^{-1} to 20.34 q ha^{-1}. Significantly higher foliage yield (139.02 q ha^{-1} and 20.34 q ha^{-1}) was recorded in treatment T_7 where 5 t ha^{-1} teak leaf litter + cow dung @ 50% teak leaf litter + bio-decomposer were added. The second best treatment was T_8 fertilized with teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter, which recorded 137.28 q ha^{-1} fresh matter and 20.08q ha^{-1} dry matter yield. Treatment T_7 recorded about 23% more fresh weight than control plot and dry matter 23.58% over control plot.

It was observed that, treatment T_8, T_9 and T_3 were at par with treatment T_7. Though T_3 recorded 2.02% fresh and dry foliage yield than control it is found significant. The overall decreasing trend of dry matter yield is $T_7 > T_8 > T_9 > T_3 > T_5 > T_{10} > T_4 > T_2 > T_6 > T_1$.

Table 1. Effect of teak leaf litter addition on foliage and seed yield (q ha^{-1}) of *Abelmoschus moschatus*

	Treatment	Fresh Yield	Dry Yield	Seed Yield
T_1	Absolute control	107.88	15.78	16.14
T_2	Teak leaf litter @ 2.5 t ha^{-1}	110.56	16.17	16.49
T_3	Teak leaf litter @ 5 t ha^{-1}	136.22	19.93	16.95
T_4	Teak leaf litter @ 7.5 t ha^{-1}	124.00	16.68	16.78
T_5	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio-decomposer	133.06	19.46	17.38
T_6	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	121.90	17.83	17.41
T_7	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	139.02	20.34	18.91
T_8	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter	137.28	20.08	17.76
T_9	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	136.78	20.01	17.52
T_{10}	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	125.53	18.36	17.28
SE(m) $\pm$		1.227	0.178	0.19
CD at 5%		3.576	0.574	0.57

The highest yield in T_7 treatment might be because of increase availability of nutrients through decomposition of teak leaf litter. Rahman et. al. (2014) also confirmed that application of 5 t ha^{-1} cow dung increased the leaf yield of *tulsi* and *pudina* significantly. The results are in conformity with Sarkar et. al. 2010, who reported that, addition of different forest tree leaf litters influenced dry weight of plants. Chowdhury 2007 also reported the similar finding in red amaranthus.

Seed yield

The data (table 1) was recorded on seed yield and compared statistically for significance. It was observed that, the effect of teak leaf litter addition significantly influenced seed yield. The lowest seed yield was recorded in control plot T_1 (16.95 q ha^{-1}), while the highest seed yield (18.91 q ha^{-1}) was recorded in T_7 which was significantly superior among all the treatments. T_8 recorded second highest seed yield per hectare (17.76 q ha^{-1}). Application of teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter+ bio- decomposer recorded 18.53% increased seed yield over control.

The highest seed yield in T_7 treatment might be as a result of higher production of dry matter. The increased foliage or dry matter might have resulted in higher photosynthesis enhancing the fruiting and thereby increasing seed yield. All this might be due to the fact that the teak leaf litter which was having narrow C:N ratio might have decomposed faster and made availability of major nutrients which are actively involved in vital process ultimately resulted in higher seed yield. The results confirm the findings of Yadav et.al. 2013 in ashwagandha.

Residual Soil Fertility

pH and EC

Effect of teak leaf litter addition of soil pH and EC was found non-significant and ranged from 7.01 to 7.17 for pH and 0.119 to 0.129 dS m^{-1} for EC (Table 2). Teak leaf litter @ 5 tha^{-1} recorded higher values of pH (7.17) while, the lowest values were recorded with T_4 teak leaf litter @ 7.5 tha^{-1} EC (0.117 dSm^{-1}) after the harvest of *Abelmoschus moschatus*. The lowest values in these treatments might be due to formation of organic acids which might resulted in lowering the pH values of soil. Alexander et al. 1981 stated pH value is a measure of soil reaction and any drastic change in pH value indicates drastic change in soil environment. As pH value increases, acidity decreases and vice versa. Issac and Nair (2002) reported 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

The lowest values were recorded with T_4 teak leaf litter @ 7.5 tha^{-1} EC (0.117 dSm^{-1}) after the harvest of the *Kasturi bhindi*. High level of teak leaf litter resulted in fast decomposition might have resulted in lowering EC level in this treatment. Naugraiya and Puri (2001) studied chemical characteristics of the entisols before and after 7.5 years of silvipasture system and found improvement in these properties in the plantation site; compared to without tree plantation. E.C. of the soil increased with time and was 0.29 dSm^{-1}.

Organic carbon

The organic carbon content of composite soil sample before sowing was 6.21 g kg^{-1} which was moderately high. After harvest of *kasturi bhindi* there was significant change in organic carbon content and value for organic carbon ranged from 6.45 g kg^{-1} to 6.53 g kg^{-1}. The highest organic carbon was recorded in T_4 while, the lowest organic carbon was recorded in T_1. T_9 and T_8 recorded second highest organic carbon content (6.55g kg^{-1}) (Fig. 1). Treatment T_4 supplied with 7.5 t ha^{-1} teak leaf litter might resulted in accumulation of highest organic carbon as the amount of litter added was highest and also contain organic carbon.

Treatment T_4 recorded 6.07% and 2.49% increased organic carbon compared to initial and control respectively. Over all analysis regarding organic carbon shows that, there is increase in organic carbon content with addition of organic residues in all the treatments. Treatment T_5, T_6, T_7, T_8, T_9, and T_{10} found at par with treatment T_4 in increasing organic carbon content in soil. Treatment T_5 with application of teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio-decomposer increased organic carbon content in soil which was found statistically significant over other treatments. The cow dung and decomposer might have increased the decomposition rate and thereby added carbon to soil.

Dinakaran and Krishnayya (2010) recorded increased soil organic matter in afforested areas under teak, bamboo and mixed vegetation and observed that the increase being greatest under teak plantations.

Table 2. Effect of teak leaf litter addition on chemical properties of soil

	Treatments	Chemical Properties	
		pH	EC (dS m^{-1})
T_1	Absolute control	7.08	0.119
T_2	Teak leaf litter @ 2.5 t ha^{-1}	7.02	0.129
T_3	Teak leaf litter @ 5 t ha^{-1}	7.17	0.123
T_4	Teak leaf litter @ 7.5 t ha^{-1}	7.07	0.117
T_5	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio-decomposer	7.01	0.122
T_6	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	7.04	0.119
T_7	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	7.05	0.123
T_8	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter	7.07	0.123
T_9	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	7.07	0.122
T_{10}	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	7.01	0.119
SE(m) ±		0.04	0.001
CD at 5%		--	--
Initial value		7.10	0.120

Available nutrient status of soil

The availability of nutrients in all treatment combinations was significantly influenced by addition of different teak leaf litter levels. The significantly higher availability of nitrogen, phosphorous and potassium was recorded in treatment T_7 with application of teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter (Table 3).

Availability of nitrogen in treatment T_5, T_8 and T_9 were at par with T_7. Treatment T_5 recorded only 1.33% less available nitrogen than T_7 and found statistically significant over other treatments. These results are in close agreement with Surekha et al. 2004 who reported that litter addition provides a steady supply of carbon and energy for microorganisms and cause increasing microbial biomass pool thereby increasing soil respiration rate which help to enhance availability of N in soil. Chowdhury et al. (2008) also observed increase availability of N with addition of teak leaf litter. Issac and Nair (2002) studies confirm the findings.

There was 16.16 % increase in available phosphorous in soil after harvest of *Kasturi Bhindi*. It was observed that T_7 recorded 14.48 % increased P availability compared control plot. Treatment T_5 and T_8 found at par with treatment T_7 regarding availability of phosphorous in soil after harvest of crop. Treatment T_5 with application of teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio-decomposer recorded 17.61 kg ha^{-1} P which was 1.57 % lesser than T_7 and 13.12 % more than control plot. The microbial activities and root excaudate might have contributed in less fixation and thus making P available for plant use. These results are in conformity with Sarkar et. al. 2010 who, reported highest available phosphorous in the soil with teak leaf litter. Majumdar et. al. (2004) also observed the high available phosphorous content in agroforestry systems.

Table 3. Effect of teak leaf litter addition on available nutrient status (kg ha^{-1}) of soil

	Treatments	N	P	K
T_1	Absolute control	277.52	15.30	341.02
T_2	Teak leaf litter @ 2.5 t ha^{-1}	288.79	16.30	348.02
T_3	Teak leaf litter @ 5 t ha^{-1}	288.79	16.30	352.14
T_4	Teak leaf litter @ 7.5 t ha^{-1}	289.56	16.55	352.45
T_5	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio-decomposer	290.12	17.61	349.44
T_6	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	285.45	17.15	358.72
T_7	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	294.02	17.89	359.14
T_8	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter	292.86	17.76	358.45
T_9	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	289.75	17.54	357.14
T_{10}	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	287.25	17.35	358.14
SE(m) $\pm$		1.44	0.112	1.364
CD at 5%		4.32	0.336	4.09
Initial value		270	15.00	340.21

In all there was 5.17% increment in availability of potassium compared over initial values. Treatment T_6, T_8 $T_9$and T_{10} found statistically at par with T_7 treatment. Treatment T_6 recorded 358.72 kg ha^{-1} availability of potassium, which was second best superior treatment. Probable reason behind increasing of K availability maximum in this treatment might be addition of teak leaf litter and its mineralization resulting in solubilization of fixed K increasing the availability of K is soil.

Harry et al. (2002) also confirmed that, high potassium removal in absence of potassium addition has resulted in drastic reduction of available potassium. Fouly (2015) confirmed the findings. Laskowski et al. Garkoti (1999) conducted a study on the nutrient release of woody litter in three forests on high altitudinal zones of central Himalaya and reported that potassium was released most rapidly.

Microbial Population

The population of actinomycetes, bacteria and fungi in all treatment combinations were significantly influenced by application of teak leaf litter level. Significantly higher colonies of actinomycetes were recorded in treatment T_9 whereas, the highest count of bacteria was recorded in treatment T_7. Significantly highest count of fungi was recorded in treatment T_{10} (15.18 $\times$ 10^5 cfu g^{-1}) (Table 4). Lowest availability of actinomycetes, bacteria and fungi was recorded in control plot which didn't receive any source of nutrient.

Sudhakaran et al. 2013 also found increased population of actinomycetes in soil in organic farming system that in conventional farming system. Same findings were confirmed by Gajda et al. 2000. Soil microbial community composition in terms of actinomycetes, bacteria and fungi counts was significantly affected by litter treatment. In particular quantity of total bacteria was higher in leaf litter mixed plots than control plots (Xiao et. al. 2016).

Table 4. Effect of teak leaf litter addition on actinomycetes population (10^4cfu g^{-1}) in soil

	Treatments	A (10^4 cfu g^{-1})	B (10^6 cfu g^{-1})	F (10^5 cfu g^{-1})
T_1	Absolute control	22.36	84.36	11.49
T_2	Teak leaf litter @ 2.5 t ha^{-1}	22.93	86.55	12.95
T_3	Teak leaf litter @ 5 t ha^{-1}	23.27	85.42	13.70
T_4	Teak leaf litter @ 7.5 t ha^{-1}	24.16	84.68	14.75
T_5	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio-decomposer	24.67	86.54	12.31
T_6	Teak leaf litter @ 2.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	23.72	85.71	12.51
T_7	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	24.11	86.88	13.20
T_8	Teak leaf litter @ 5 t ha^{-1} + cow dung @ 50% of teak leaf litter	24.02	84.62	13.55
T_9	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter + bio- decomposer	24.94	86.14	13.33
T_{10}	Teak leaf litter @ 7.5 t ha^{-1} + cow dung @ 50% of teak leaf litter	24.5	86.75	15.18
SE(m) $\pm$		0.06	0.088	0.064
CD at 5%		0.183	0.264	0.192

The lowest count of fungi was recorded in control plot which didn't receive any source of nutrient. The highest colony count of fungi in T_{10} might be attributed to dead food material available from teak leaf litter. The narrow C:N ratio of teak leaf litter might responsible for easy decomposition and thus resulted in providing food material to microbes indirectly increasing their population in soil. Badole (2000) reported maximum microbial population (actinomycetes, fungi and bacteria) with application of organic manures.

It was observed that, the treatments where cow dung was applied along with teak leaf litter gave higher colony count of fungi, actinomycetes and bacteria compared to teak leaf litter alone. This might be because, cow dung contains diverse group of microorganisms such which makes them suitable for microbial degradation (Umanu et al. 2013). All these findings indicate that cow dung can supply nutrients and energy required for microbial growth.

CONCLUSION

It is concluded that, teak leaf litter, cow dung and bio-decomposer have a great impact on microbial populations. The study indicates that there is increase in yield due to incorporation of teak leaf litter along with cow dung and bio-decomposer. It is found that addition of dead organic matter in the form of teak leaf litter and cow dung has shown more availability of nutrients and also aids in increasing microbial populations than use of any source alone.

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