The role of forest in supplying soil nutrients in agricultural production system in the mid hills of Nepal

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Forest litter is one of the major sources of soil nutrients in the hills of Nepal. Litter is collected and placed for animal bedding or in some cases they are spread directly into field. The direct benefits have not been measured in crop field, despite its major role in the agricultural production system. However, the extent of exact input of litter and their fertilizing ability under different forest system in Nepal has not been studied. This study aims at investigating the annual forest litter and major soil nutrient yield from different forest types found in Rupa and Begnash Lake area in the midhills of Western Nepal. This paper also endeavours to examine the quantity of forest litter produced under six different forest category, nutrient yields for agriculture from the forest litter from different forests and discusses the significance of the forest litter in replenishing soil fertility in the middle mountains of Nepal in the light of existing knowledge base.

Key words: Forests, forest litter, soil nutrients, nutrient yield

Forests transfer plant nutrients through the leaf, bark and roots into the soil the degree of which varies with condition of forests and species composition. Forest is the principal source of leaf litters and lopped green foliage that are used for feed, bedding and composting of herbaceous animal species. This material when mixed with animal excreta yields high quality organic compost manure, which forms the principal source of soil nutrient for hill agricultural system. An estimated 2 to 3 tons of leaf litter is used as fertilizer by each household in the mid hills, and that an estimated 50% of the forest litter is removed annually from the forest (Mahat 1987).

Forest litter is an active important component of soil heterotrophic system. The forest floor represents organic material on the soil surface including floor vegetation and litter in different stages of decomposition. In the terrestrial ecosystem a major portion of energy fixed by the plants flows its way to the soil in the form of dead organic matter. The plant debris establishes a link in energy and nutrient transfer between autotrophic and heterotrophic components. Thus forest litter is an active and important component of soil heterotrophic system (Rout and Gupta 1988). Rates of addition of organic matter to soils under tropical rain forest are reported to be very high as much as 10.4 t/ha/year (Rout and Gupta 1988). Proctor (1984) gave a figure of 8.3 t/ha/year based on more than 100 determinations. Pirazizy and Singh (1992) observed an annual litter fall of 654503 kg/ha, 14502 kg/ha and 77173 kg/ha from conifer forest, sub-alpine, and Oak forest respectively. The Nitrogen (N) Phosphorus (P) and Potash (K) content from different forest types of litter fall are 6970 kg/ha of N, 3197 kg/ha of P and 2249 kg/ha of K from conifer forest and 9241 kg/ha of N, 462 kg/ha of P and 5766 kg/ha of K from Oak forest which can be considered higher level of nutrients in the forest soil. Leaf litter yield varies from 4 - 25 metric tons/ha/year depending on the forest conditions (Pirazizy and Singh 1992). Pirazizy (1993) reported that 6970 kg/ha of N, 3197 kg/ha of P and 2249 kg/ha of K is added to soil from conifer forest in India. In soil, the amount of organic matter available at anytime is the result of the rate of addition and loss of litter. Singh (1988) reported a removal of 10.79 ton/ha of K and 338 kg/ha of ash when the pine needles were removed from the forest, which also changed the physical property of soils.

Forest litter is one of the major sources of soil nutrients in the hills of Nepal. Litter is collected and placed for animal bedding or in some cases they are spread directly into field. The direct benefits have not been measured in crop field, despite its major

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contributions in the agricultural production system, which is used traditionally. The farmers collect forest litter that either mixed with animal manure or as animal bedding material that is ultimately used fertilizer. This is an important traditional innovation for recharging soil nutrients in the agricultural land. However, the extent of exact input of litter and their fertilizing ability under different forest system in Nepal has not been studied. This study is designed to understand the annual forest litter and major soil nutrient yield from different forest types found in Rupa and Begnash Lake area in the midhills of Western Nepal. This paper examines the quantity of forest litter produced under six different forest category, nutrient yields for agriculture from the forest litter from different forests and discusses the significance of the forest litter in replenishing soil fertility in the middle mountains of Nepal in the light of existing knowledge base.

Methodology

In order to estimate the forest litter production and nutrient accumulation under different forest types, a study was carried out in Begnash and Rupa lake watershed area in Pokhara Valley. Forest litter and its quantity collected by households in a year were determined using questionnaire survey. Each forest types were identified through onsite visit during major leaf shedding seasons and the total forest area was calculated based on the information on the recent land use map produced from the Department of Topography. Their canopy height was estimated using clinometer. Litter samples of different forest types were taken.

Forest litter was collected from 6 different forest types (*Sal dominated, Katush dominated, Chilaune dominated, Degraded, Mixed and Regenerated*) using 1 m x 1 m quadrates from 18 forest sites in the study area. For the laboratory examination litter samples from eighteen sampling sites were identified in each forest categories. Each site was divided into 5 parts using measuring tape. 1 m x 1 m quadrate was then prepared. In each site, 1 m x 1 m quadrate at five places (4 in the corner and one from the middle) was laid down. Litter from each quadrate area was taken and weighed in a pen balance. Average weight of 5 samples from each part was taken. The average yield from 6 different forest types were thus calculated and statistically analyzed. As leaf shedding varies with forest types, different time was followed (March–April and Oct–Dec) for sampling. This sampling procedure was also carried out in second year. After the estimation of litter yield, litter samples were taken, weighed and put into the plastic bag with sample description for laboratory analysis. Samples were analyzed at Pakhribas and Khumaltar Laboratory.

Results and discussion

Table 1 (A, B, C, D, E, and F) shows the leaf litter yield of different forest types. The mean annual litter yield/m^2 for different forest categories was calculated which is shown in Table 2. The average yield/m^2 was then converted into yield per hectare and is shown in Table 3. The average litter yield per hectare of forest area is 7272 Kg/ha. The litter yield was higher in mixed forest followed by Sal dominated, regenerated, Katush dominated, Chilaune dominated and degraded forest. The mean yield in degraded forest was 2430 Kg/ha/year.

Laboratory analysis results of litter samples taken for nutrient content are presented in Table 4. Katush dominated forest system had higher nitrogen (N) content than the other nutrient categories.

Based on the nutrient content of different forest category samples, total nutrient yield per hectare of each forest categories is calculated (Table 5). There was a significantly high nutrient yield in mixed forest than the other categories followed by Katush, Chilaune, regenerated and Sal forest.

Table 1: Mean annual litter yield under different forest system

Forest system	Yield kg/m2/year	N
Sal dominated	0.819 ± 0.294	23
Katush dominated	0.780 ± 0.252	9
Chilaune dominated	0.751 ± 0.158	14
Degraded forest	0.243 ± 0.102	8
Mixed forest	0.982± 0.267	5
Regenerated forest	0.810 ± 0.151	3

Table 2: Annual litter yield under different forest system

S.N.	Forest type	Mean yield (Ton/ha)
A	Sal dominated forest	8.190
B	Katush dominated forest	7.580
C	Chilaune dominated forest	7.510
D	Degraded forest	2.430
E	Mixed forest	9.820
F	Regenerated forest	8.100
	Mean yield	7.272 ±2.51

Table 3: Nutrient content of forest litter under different forest type

Chemical Parameter	A (N=10)	B (N=10)	C (N=10)	D (N=3))	E (N=5)	F (N=3)	Mean yield
Nitrogen %	7.7	12.63	10.50	4.20	11.2	8.45	9.11
P_2O_5 %	0.22	1.30	1.40	0.23	1.50	0.54	0.865
K_2O %	0.66	2.50	0.80	0.53	2.10	1.52	1.351
OM %	97.60	97.5	97.8	87.60	98.0	96.60	95.85
DM %	93.00	93.3	93.0	94.00	93.0	94.00	93.33

A = Sal dominated, B = Katush dominated, C = Chilaune dominated, D = Degraded, E = Mixed (no pine), F = Regenerated

From the Table 1 it appears that in terms of litter yield, mixed forest (except pine) has significantly higher yields (P<'05) than the Sal and regenerated forest system, Katush dominated and Chilaune dominated system. There was significantly low yield from the Degraded forest. While the nutrient content of different forest type is considered, Katush dominated system has significantly (P<. 05) higher nitrogen than Sal dominated, Chilaune dominated, degraded and regenerated forest category. While the overall nutrient composition is considered, mixed forest has significantly higher nutrient yield compared to all the forest categories.

Yield data from the above were converted into per hectare of yield and shown in Table 2. The highest litter yield is found from mixed forest followed by Sal, Regenerated, Katush, Chilaune and degraded forest respectively.

While the nutrient content of forest litter is considered (Table 3), each forest category recharges the following amount of soil nutrients in the system (Table 4).

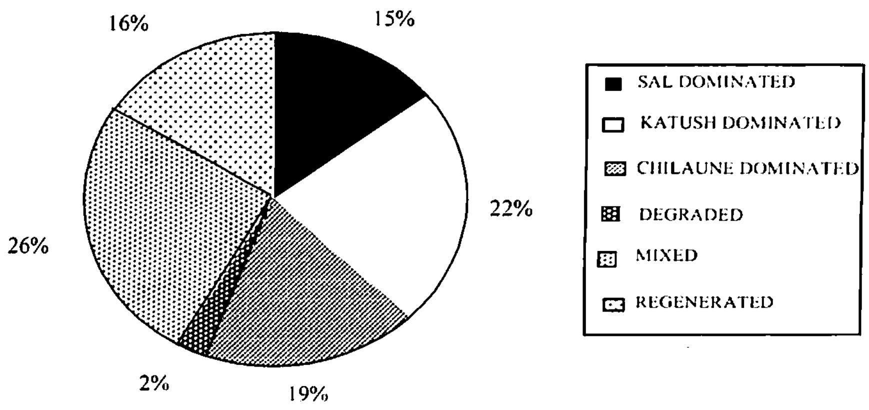
The litter and nutrient yield data from the above tables were synchronized and the estimated nutrient yield per hectare per year under different forest system was calculated (Table 4).

From the Table 4, it is apparent that the highest yield of soil nutrient emanates from the mixed forest. Such a significant nutrient yield in the forest of watershed area is not fully utilized in the agricultural production system. Only about 7% of leaf litter is collected and

Table 4: Annual nutrient yield kg/ha of forest under different systems

Chemical parameter	Sal dominated	Katush dominated	Chilaune dominated	Degraded	Mixed	Regenerated	Mean yield kg/ha
Nitrogen	631	957	789	102	1100	684	710.5±346
P_2O_5	18	98	105	6	147	44	69.6±55.5
K_2O	54	190	60	6	206	123	106.5±80
OM	7993	7390	7344	2129	9623	7614	7015±2539

Fig 1 : Percent annual nutrient yield from different forest types



decomposed on the farm. Major proportion of forest litter is still left uncollected and thus major quantity of chemical nutrient is recharged within the forest system of which some is eroded and leached down during rainy season.

The capacity of a soil to supply nutrients to plants is influenced by its physio-chemical and biological properties. Since the magnitude of these properties in all the soils is not the same, they differ in their capacity to supply nutrients to plants. Considering the above nutritional status it can be assumed that forest soils in the watershed area are rich in nutrient supply. Evidences like heavy eutrophication of wetland sites and water bodies (Rupa Lake and part of Begnash Lake) due to heavy leaching of nutrients from the adjoining forest areas and the general health status of the forest stand support the above statement.

From the results of this study it is evidenced that a highly significant quantity of soil nutrient is being produced from the forest litter. The question on how much of this is actually used into the agricultural system has not been answered. In order to understand the amount used into the farmland, a survey was conducted in the study area. The result is presented in Table 5.

Table 5: Quantity of litter used in agriculture system in the watershed area

S.N.		Forest types						
		A	B	C	D	E	F	Total
1	Percentage of households collecting leaf litter (%) (a)	5	5	9.5	10.5	15	0.5	45.5%
2	Quantity collected kg/ha/year/hh (b)	500	800	700	100	1000	500	3600
3	Total number of household collecting leaf litter (c)	200	200	380	20	600	20	1420
4	Total quantity of leaf collection (b x c) for agriculture t/year	100	160	266	2	600	10	1138

A=Sal dominated, B= Katush dominated, C= Chilaune dominated, D= Degraded, E= Mixed without pines), F= Regenerated

Table 6: Use of organic fertilizer from forest resource

Chemical parameter	Total yield from leaf litter (ton)	Percent used agriculture (%)	Total used in the agriculture (ton)
N2	1404	7 %	98
P2O5	133	7 %	9.31
K2O	208	7%	14.56
OM	14931	7 %	1034

Table 5 summarizes the quantity of forest litter used in agriculture system. In the entire watershed area, only 35% of the surveyed households actually collect leaf litter to use it as fertilizer. Some households (10.5 %) collect litter from the degraded forest, causing further impoverishment of forests. Such collection is due to nearness of degraded forest from the settlement. The major collection is from mixed forest (15%) followed by *Schima* dominated forest (9.5%). With respect to the quantity of leaf litter collection, highest collection was from mixed forest (1000 Kg) and lowest from degraded forest (100 kg). In the entire watershed area, only 1420 household do collect forest litter.

While considering the total forest area of 2120 ha in the watershed, the average annual litter production (7.272 metric ton/ha total forest area of the watershed) comes to 15417 tones equivalent to 1404 ton N, 133 ton P_2O_5, and 208 ton of K_2O and 14931 ton organic matter is produced. Out of this only 7% of the total litter, 1079 tone is utilized. The quantity of nutrients used is shown in the Table 6.

From the above table it appears that 98 t N_2, 9.3 t P_2O_5, 14.6 t K_2O and 1034 t of organic manure is drawn from forest area to the agriculture system directly. Despite traditional innovation of recharging soil nutrients from the forest litter, only an estimated 7% is actually utilized for agriculture production system. Rest of the nutrients are either leached down to lower river basins, some are recharged within the forest area while considerable quantities is being washed down to the river during monsoon rain. The farmers in the form of floodwater trap some of it.

The major problem for not being able to use such a vast nutrient resource for fertilizing agriculture field and at the same time retaining within the forest was reported to be (a) due to lack of working labor force in time (b) some of the forest litter are not decomposed readily and therefore termite, ants and rats are attracted in the crop field which hinders and reduces the crop production.

Conclusion

The findings of this study questions the findings of the earlier workers who reported that the increased use of forest litter in farm land is interfering with natural forest nutrient cycle which is leading to long term declines in soil fertility and productivity. In this study the leaf litter production and nutrient yield is estimated from two years, if the accumulation of decomposed litter under different forest types over a period of time is considered, the cumulative effect will be much higher. It therefore appears that forest areas within the watershed do not have the soil fertility crises at the current use level. There seems to be a tremendous potential for the management of forest litter to use as cheap and sustainable fertilizer source.

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Annex 1: Litter yield under different forest system

(A) Sal dominant forest system

Sample No.	Location	Crown density (%)	Yield kg/m²
1.	Saldanda	70	1.185
2.	Saldanda	50	0.700
3.	Saldanda	70	1.000
4.	Lamaswara	40	0.450
5.	Banpokhari	60	0.780
6.	Kandel Tundo	50	1.540
7.	Salghari	70	1.200
8.	Deepako danda	60	0.750
9.	Lamshi	70	0.980
10.	Raniban	55	0.650
11.	Bharpale	65	0.780
12.	Kattaseko Pakho	45	0.700
13.	Rato danda	50	0.800
14.	Rato danda	70	0.900
15.	Besarekopakho	70	1.200
16.	Saldanda	80	0.730
17.	Saldanda	40	0.660
18.	Rato Tundo	70	1.070
19.	Dopahare	70	1.110
20.	Bhirpani	40	0.620
21.	Kattaseke Pakho	50	0.650
22.	Jimire	45	0.780
23.	Chhatinpakha	40	0.620

Mean yield = 0.819 ± 0.294

(B) Katush dominant forest system

Sample no.	Location	Crown density (%)	Yield kg/m²
1.	Lamaswara	40	0.650
2.	Chhare	30	0.320
3.	Chhare	60	0.760
4.	Simle Tari	70	0.820
5.	Syankhuydi ban	70	0.590
6.	Syankhuydi ban	60	0.970
7.	Kandel Tundo	50	0.820
8.	Dopehere	70	1.280
9.	Kataseko Pakho	50	0.620

Mean yield = 0.758 ± 0.252

(C) Chilaune dominant forest system

Sample no.	Location	Crown density (%)	Yield kg/m²
1.	Bimirekumo	40	0.640
2.	Ghatako Pakho	40	0.570
3.	Rato Tundo	65	0.720
4.	Dophare	65	0.950
5.	Rato Mato	50	0.650
6.	Bhirapani	45	0.700
7.	Sanopahadhi	60	0.840
8.	Sunarbari	50	0.720
9.	Bharpale	60	0.730
10.	Dharapani	50	0.650
11.	Dharepakho	45	0.700
12.	Samapakho	55	1.210
13.	Jimire	45	0.820
14.	Satadobato	40	0.620

Mean yield = 0.751 ± 0.158

D) Degraded forest system

Sample no.	Location	Crown density (%)	Yield kg/m²
1.	Lamaswara	20	0.290
2.	Simle Tari	15	0.270
3.	Kandel Tundo	>20	0.290
4.	Raniban	>15	0.250
5.	Panhileko Ban	>15	0.200
6.	Bharapale	20	0.250
7.	Charapako	15	0.210
8.	Samapakho	>20	0.190

Mean yield = 0.243 ± 0.102

(E) Mixed forest system

Sample no.	Location	Crown density (%)	Yield kg/m²
1.	Kandel Tundo	50	1.540
2.	Kalomudo	65	0.830
3.	Lamishi	60	0.780
4.	Bhangra	70	0.980
5.	Bhirchouk	55	0.820

Mean yield = 0.982 ± 0.267

(F) Regenerated forest system

Sample no.	Location	Crown density (%)	Yield kg/m²
	Kalimati	30	0.630
	Majhikuna	60	1.000
	Begnas	60	0.800

Mean yield = 0.982 ± 0.267