first and second year was observed in system 5. The initial available potassium status decreased under all systems without exception.

Nutrient balance

Available nitrogen status at the end of the second year registered an increase under all systems with higher increase under system 6 (Table 3). which might have resulted either from the lesser uptake by cotton crop (Venugopal, 1978) or higher addition of residues by cotton crop or both. Considering computed balance, however. except in system 6 which indicated a gain, in all other systems there was a net loss. Even in annual crop cycles, several workers have reported positive nitrogen balance (Sarker *et al.*, 1989; Except systems 4 and 6 where there was an increase in available phosphorus, in all other systems there was depletion. But applying the yardstick of computed balance, a net loss in this nutrient was indicated by all systems.

Measured by the parameter of computer balance, maximum removal was seen in system 4 and 6 but these were the two systems which exhibited minimum loss of potassium. The quardruple cropping system 4 involving two pulse crops not only enriched the soil but also produced higher economic produce.

Inclusion of legume in the cropping systems results in higher soil nitrogen and higher uptake of phosphorus. As that of legume, cotton in the systems too resulted in higher soil available nitrogen which might be because of lesser uptake by cotton crop or higher addition of residues by cotton or both. The systems possessing cotton component found to leave more phosphorus from deeper soil zone with its deep root system. The systems involving pulses left higher potassium in the soil because of comparatively lesser uptake of potassium by these component crops.

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LEAF LITTER ACCUMULATION AND MINERALISATION PATTERN OF HILLY SOILS

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ABSTRACT

To study the leaf litter accumulation and mineralisation pattern under different vegetational ecosystem, experiments were conducted at the Horticultural Research Station, Kodaikanal during January, 1992 to June, 1992. Plantations of eucalyptus, acecia (both evergreen), apple (deciduous) and pine (coniferous) were selected for the field experiment. The leaf litters were quantified monthly and these were further used in computation of nutrient addition to the system. An incubation study was also conducted using the leaf litter to investigate the mineralisation pattern by observing the C/N ratio. The results revealed that the leaf litter accumulation was appreciable under pine plantation followed by eucalyptus, while a low accumulation was observed in apple and acacia plantations. The accumulation of leaf litter resulted in soil fertility improvement as quantified by the enrichment of nutrients. Owing to their resistant nature, the pine needles mineralised very slowly as compared to the other leaf litters under the climatic conditions in the hills.

KEY WORDS : Leaf litter, Accumulation, Mineralisation, Hilly Soils.

Organic matter addition in a soil system plays a decisive role in maintaining both physical and chemical properties. The leaf fall in the hill soil system has yet another benefit of soil conservation by conserving soil moisture. Samraj *et al.* (1982) while stressing the need of soil and water conservation in the hill soils of peninsular India indicated that forest vegetation has a great influence on forest soils. They estimated that the leaf litter accumulation in forest vegetation to be as much as 2000 kg/ha/year while Venkatraman *et al.* (1983) reported an average return of leaf litter to the soil was 108-314 kg/ha/month. An addition of leaf litter of 2170/kg/ha year had been reported in the man-made blue gum and black wattle forest by Bhimaya (1989). The significance of soil N in crop production was apparent due to the fact that 60-80 per cent of N absorbed by crops was derived from native pool. Leaf litter addition resulted in build up of soil N. Mineralisation, a biological oxidation process depending upon temperature, is a slow process in the hill soils of Kodaikanal. As such, lack of quantification of organic matter accumulation and mineralisation pattern present a serious lacuna in the existing knowledge and hence the present study.

MATERIALS AND METHODS

An experiment was conducted at the Horticultural Research Station, Kodaikanal during January - June, 1992 to study the accumulation of leaf litters under the angiospermic evergreen plantations of eucalptus (*Eucalyptus globulus*) and acacia (*Acacia decurrena*), coniferous everngreen plantation of pine (*Pinus patula*) and deciduous apple plantation. The leaf litter accumulations were quantified by collecting the leaf litters in a fixed monitoring plot of 2 x 2 m. At the end of the every month, the fallen leaves in the monitoring plots were collected and weighed. Composite samples of individual leaf litter were analysed (Table 1) for the major nutrient contents. (Piper, 1966). The computation of nutrient additions to the ecosystem was done by multiplying the litter accumulation with nutrient contents. The leaf litter accumulation and the nutrient addition were presented in Table 2.

A separate incubation study was carried out during the 3rd week of January, 1992 as a pot experiment. Pots were filled with 10 kg of soil, collected from fields of respective plantations. Separate sets of pots were kept to replicate the samples. The leaf litters of eucalyptus, acacia, apple and pine were incorporated at the rate of 100 g/10 kg soil. The initial soils (Table 1) and immediately after incorporation were analysed for their properties (Jackson, 1973). The incubated soils were analysed for organic C and total N at bimonthly intervals and the computation of C/N ratio was done at every stage.

RESULTS AND DISCUSSION

The results (Table 2) revealed that the cumulative leaf fall was higher (2124 kg/ha) in the confierous evergreen pine ecosystem than in evergreen eucalyptus (1392 kg/ha) and acacia (720 kg/ha). The decidous apple plantation had the lowest magnitude of leaf fall. The pine and eucalyptus owing to their good canopy and heavy and continuous fall of leaves had apparently contributed for the high accumulation of litter. Similar results were earlier reported (Venkatraman *et al.*, 1983; Kannan, 1990).

The addition of major nutrients to the soils was also in the order of total leaf fall, the coniferous pine followed by eucalyptus, acacia and apple. The quantity of added N through leaf fall was higher than that of P and K. This observation was in line with the observations of Dinakaran (1982). The quantum of P addition was the least as compared to N and K and this was quite obvious from the fact that P content was low in leaf materials.

Table 1. Initial soil and leaf analysis.

Vegetation	Content in leaves (%)			Soil properties		Total (%)		
	N	P	K	Org. C(%)	CEC me/100	N	P	K
Apple	1.25	0.07	0.55	2.65	11.15	0.238	0.216	0.115
Eucalyptus	1.65	0.09	0.55	3.26	10.54	0.269	0.212	0.104
Acacia	1.25	0.09	0.60	2.73	10.94	0.218	0.234	0.132
Pine	1.30	0.25	0.60	3.09	10.45	0.194	0.305	0.126

Table 2. Monthly accumulation of leaf litter and nutrients.

Months	Plantations	Leaf litter accumulation (kg/ha)	Nutrient Addition kg/ha		
			N	P	K
Jan. '92	Apple	Nil	1.20	-	-
	Eucalyptus	70	12.0	0.06	0.40
	Acacia	45	1.60	0.04	0.27
	Pine	90	1.20	0.23	0.54
	Mean	51	0.75	0.08	0.30
	SD	39	0.57	0.10	0.23
Feb. '92	Apple	Nil	-	-	-
	Eucalyptus	290	4.80	0.26	1.60
	Acacia	100	1.30	0.09	0.60
	Pine	295	3.80	0.74	1.80
	Mean	171	2.50	0.27	1.00
	SD	146	2.20	0.33	0.80
Mar. '92	Apple	Nil	-	-	-
	Eucalyptus	260	4.30	0.23	1.40
	Acacia	50	0.70	0.05	0.30
	Pine	200	2.60	0.50	1.20
	Mean	128	1.90	0.20	0.73
	SD	123	1.90	0.23	0.68
April '92	Apple	60	0.75	0.04	0.33
	Eucalyptus	305	5.00	0.28	1.70
	Acacia	140	1.80	0.12	0.84
	Pine	470	6.10	0.20	2.80
	Mean	244	3.41	0.41	1.42
	SD	182	2.54	0.54	1.08
May. '92	Apple	75	0.93	0.05	0.41
	Eucalyptus	258	4.30	0.23	1.40
	Acacia	200	2.50	0.18	1.20
	Pine	590	7.70	0.50	3.50
	Mean	281	3.86	0.49	1.63
	SD	220	2.90	0.68	1.32
June. '92	Apple	45	0.56	0.03	0.25
	Eucalyptus	210	3.50	0.19	1.20
	Acacia	185	2.30	0.17	1.10
	Pine	480	6.20	0.20	2.90
	Mean	230	3.14	0.40	1.36
	SD	182	2.37	0.53	1.11
Total	Apple	180	2.28	0.12	4.02
	Eucalyptus	1392	22.98	1.26	7.68
	Acacia	720	9.00	0.66	4.32
	Pine	2124	27.60	5.34	12.72
	Mean	1104	15.47	1.85	7.19
	SD	842	11.82	2.38	4.05

Interestingly the pine leaves added about 5 kg/ha of P within six months. This again was due to its habit of continuous leaf shedding and inherently high P content (0.25%) of the needles. Higher addition of P through pine needless was earlier reported by Kannan (1990). The monthly addition of leaf litters on an average varied between 30-350 kg adding 0.4 to 4.6 kg N, less than one Kg of P and upto 2 kg of K per month. In general, the nutrient addition always depended upon the quantum of leaf fall.

Table 3. Organic C and total content in leaf litter under incubation (mean of 3 replication).

Vegetation	Organic carbon (%)	Total N %	C/N ratio
Just after incubation			
Apple	3.53	0.201	17.54
Eucalyptus	4.53	0.276	16.41
Acacia	4.04	0.226	17.88
Pine	4.20	0.246	17.07
Mean	4.08	0.237	17.22
March '92			
Apple	3.06	0.228	15.80
Eucalyptus	3.36	0.207	16.20
Acacia	3.62	0.226	16.00
Pine	3.36	0.206	16.25
Mean	3.35	0.217	16.06
May '92			
Apple	2.81	0.216	13.00
Eucalyptus	3.06	0.219	14.00
Acacia	2.43	0.180	13.50
Pine	2.76	0.193	15.33
Mean	2.77	0.202	13.96
CD at 5%			
Stages (S)	0.29	0.005	
Plantations (P)	0.34	0.006	
S X P	0.34	0.006	

Studies on mineralisation (Table 3) revealed that the organic C content which ranged from 2.43% to 4.53%, decreased from 4.08% in January, 3.35% in March and 2.77% in May indicating the progressive decomposition. The C degradation in a linear fashion for progressive days of incubation had been reported by Maeda and Shiga (1978). The C degradation was again reflected in the changes in C/N ratio which had dropped from 17.22 to 13.96%. The organic C of the samples of the incubated apple leaves showed a low value while that of eucalyptus and pine recorded high organic carbon content at all the stages of analysis. This fact might well be attributed to the native difference of species, the proportion of non-humic and humic substances and the resistance to microbial action (Kanwar, 1976; Russel, 1976). The total N content was also found to be reduced at the end of 5th month. It was quite evident that even the slow mineralisation as prevalent under this cool climatic condition, could cause reduction in total N content of the soil due to continuous mineralisation. The C/N ratio which fluctuated between 16.41 to 17.88 during the start of the experiment, narrowed after 3 months (between 15.82 to 16.25) and further reduced after 5 months (13.00 - 15.33). During the end of March and May the pine incubated soil showed higher C/N ratio being 1.74 from the start of the experiment) indicating the nature of resistance of leaf to the ammonifiers. This again was in contrast to the high rate of mineralisation in the instance of apple leaves, which showed a decreases of 4.54 in the C/N ratio. The mineralisation rate as observed from the C/N ratio at progressive stages of incubation clearly indicated the lowering of C/N ratio as the days advanced. The C/N ratio was getting narrowed to 2 to 4 units and this fall was comparatively steep for apple leaves. The mineralisation was low in the case of pine and also eucalyptus litter. The observation confirmed that the different species involved in the experiment had variable to mineralisation.

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