EUCALYPTS DILEMMA : A CLARIFICATION THEREOF

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Introduction

The mounting controversy over replacement of indigenous tree species with extensive eucalypts plantings vis-a-vis views of environmentalists and foresters and that of layman's dilemma calls for a review of scientific work done so far for this species. There is no doubt about the production and growth rate superiority of the species on the short-term rotation basis. To be able to conserve the environment in its totality, congenial to the human inhabitation, requires the sound understanding of such man-made ecosystems in terms of in-put and out-put of energy and materials, which are handled by four functional processes : photosynthesis, herbivory, carnivory and decomposition and these are being affected and effected the abiotic environment. Too many failed to understand that ecology is the study of interrelationship of organisms and their environment and that human beings must be included among the organisms so studied (Smith, 1980).

Of the many issues, about the eucalypts planting and their effects on the local environment and human well being, water and material regulation and organic matter production needs urgent attention of the foresters and of environment conscious people, to educate the general public. Right or wrong conceptions about eucalypts planting can then be evaluated in its right perception. As such no plant and life-form is useless as far as the totality of the ecosystem is concerned. Thus use and abuse of eucalypts would also depend upon the activities of forest managers and land use planners. In the forth-coming lines salient findings, of sal growing in its natural zone and where the eucalypts have been planted in some of the areas of the state of Uttar Pradesh, and elsewhere, with regard to the organic matter and materials strategies operates in these ecosystems have been described.

Biomass and Productivity

The equivalent biomass and productivity realised in eucalypts is definitely higher even at the early ages compared to the indigenous as well as other exotic tree species planted in the similar areas (Table 1). This enhanced biomass and rate of production is probably expression of genetical form of eucalypts and of the inherent site property which had otherwise, developed under different land use (local forests).

Therefore it is difficult, if not impossible, to compare the biomass and production rate of eucalypts with those of other tree species stands and hence it would be difficult to conclude that eucalypts potentiality have an edge over the naturally growing tree species. If this is clear then one may not likely to get the similar amount of biomass and rate of production year in and year out. A close examination of the data on biomass set in Tables 2 and 3 sugest: that eucalypts have not yet acclimatised with the prevailing environmental conditions of the region as it shown violent oscillations (Odum, 1983) while natural sal recc.us a gradual progress. Somewhat similar trends in growth is also seen for eucalypts grown in Australia (Table 3). Further, it may also be noted that the biomass which have been realised at 7 years of age in India is generally higher than that of 10 years of age in Australia. Thus, low production in Australia has been attributed to the combined effect of fire, insects and pathogens and low fertility of soils, particularly of phosphorus (Cromer *et al.* 1976).

As far as the contribution of root biomass to the above ground is concerned it is 26% in case of sal whereas 18% in

Table 1

Above ground distribution of nutrients (kg/ha) in some forest ecosystems of comparable biomass (t/ha)

Forest ecosystem	Age (yrs.)	Biomass (t/ha)	Nutrients (kg/ha) N	P	K	Ca	Mg	Source
Tectona grandis	38	130	370	108	331	973	128	Kaul *et al.* (1979)
Shorea robusta (Coppiced)	21	104	521	52	200	572	117	Kaul *et al.* (1979)
Shorea robusta	43	132	452	64	103	513	131	Negi (1984)
Shorea robusta	47	163	438	79	202	643	164	Negi (1984)
E. globulus	10	143	909	55	193	861	99	Negi & Sharma(19
E. hybrid	13	145	406	95	286	984	157	Negi (1984)
E. hybrid	16	165	453	106	315	1017	69	Negi (1984)
E. hybrid	17	129	365	85	258	893	140	Negi (1984)
Pinus roxburghii	44	145	336	29	101	288	77	Kaul *et al.* (1981)

Table 2

Total biomass (kg/ha) in Shorea robusta and Eucalyptus hybrid at different ages in East Dehra Dun Division (Source: Negi, 1984)

Shorea robusta		*Eucalyptus hybrid*	
Age (yrs.)	Total biomass	Age (yrs.)	Total biomass
22	69281	5	68434
36	144601	6	67788
43	166495	7	52569
47	206507	8	71756
52	168500	9	64406
91	230228	10	141540
93	250400	12	178539
33 (Coppiced)	423135	13	172118
55 (Plantation)	444247	14	137800
		16	194656
		17	153234

Eucalyptus hybrid (Negi, 1984). Plants with large root biomass are more effective competitors for water and nutrients and can withstand the adverse conditions of the environment (Smith, 1980). The undergrowth in eucalypts stands is generally of *Lantana camara* whereas in sal stands it mainly consists of species like *Mallotus philippensis*, *Milletia auriculata*, *Clerodendrum infortunatum* and *Murraya coenigii* etc. It has been observed that under eucalypts plantations the undergrowth biomass varies from 6 to 9 t/ha whereas in sal it is between 4 to 6 t/ha. The higher biomass is due to almost complete penetration of light through eucalypts canopy coupled with the mortality of trees with the advancement of age (Negi, 1984) and also the soil fertility and texture irrespective of the allelopathic effect of eucalypts (Del Morale and Muller, 1970).

Table 3

Biomass estimates of some Eucalyptus ecosystems in India and Australia

Species	Age (yrs.)	Total biomass (t/ha)	Source
	INDIA		
Eucalyptus hybrid (U.P.)	5	68.4	George, 1977
E. hybrid (U.P.)	10	141.6	
E. hybrid (U.P.)	12	178.5	Negi, 1984
	16	194.6	
E. hybrid (T.N.)	7	55.1	Negi & Sharma, 1985
	8	52.2	
	9	135.5	
	7(Coppiced)	162.2	
E. tereticornis	5	81.1	Singh & Sharma, 1976
	9	196.7	
E. globulus	5	38.1	Negi *et al.*, 1984
	7	142.7	
	9	139.0	
	16	220.4	
	AUSTRALIA		
E. grandis	2	18.3	Bradstock, 1981
	5	53.2	
	12	196.7	
	27	94.0	
E. globulus	4 (Unfertilised	6.3	Cromer *et al.* 1976
	4 (Fertilised)	30.3	
E. globulus	9.5	30.0	Cromer & Williams, 1982
E. grandis	10	32.0	Wise & Pitman, 1981
E. laevopinea	10	112.0	
E. maculata	10	121.0	
E. saligna	10	162.0	
E. sieberi	10	110.0	
E. viminalis	10	115.0	

Eucalypts is an evergreen species, bears the foliage all times of year. The age of the leaves supposed to be more than one-and-a-half years. Evergreenness is the most consistently observed characteristics of species from infertile habitats are traits that reduce annual nutrient requirement principally through increased leaf longevity and low relative growth rate (Chapin 1980). Evergreens become increasingly predominent on infertile soils, particularly on low-phosphorus soils (Al-Mufti *et al.*, 1977 ; Beadle 1954 & 1966 ; Loveless 1961 & 1962; Monk, 1966 ; Small, 1972 and Webber, 1978). Several advantage of increased leaf longevity in nutrient poor sites have been suggested. These leaves provide greater photosynthetic carbon return per unit nitrogen allocated to the leaves than deciduous leaves (Mooney, 1972; Reader, 1978; Schlesinger and Chabot, 1977). The characteristics in terms of advantage and disadvantage of evergreen leaves have been reviewed by Chapin (1980). Evergreen leaf provide a deciduous leaves in equable climates, where photosynthesis is possible during the most of the year (Mooney, 1972) and is the obvious reason why eucalypts grow faster in tropical and sub-tropical regions. Further, Mutch (1970) has showed that the litter, in fire-dependent forests, compared with that in fire-independent burns faster and more completely fire replaces bactarial and fungal decomposition as the agent degrading litter and permitting the recycling of its mineral content. This point requires investigations as to how the litter of eucalypts decomposes here in Indian conditions and mineralization takes place to reply the controversy raised about this tree species growing. The organic matter returns in an ecosystem is considered to be the essential process by which the essential nutrient and matter is recycled in a system (Ebermayer, 1876; Muller, 1887). Therefore the extent of litter accumulation and its decomposition could be detrimental to the ecosystem development (Odum, 1983).

The amounts of litter accumulation and decomposition depends upon the climatic conditions as well as of the quality of this resource (Bray & Gorham, 1964; Nye, 1961).

The litter collected under eucalypts is generally lower than the sal and pine and greater than teak though it has higher importance value Index than sal. This is probably due to the longevity of the eucalypts leaves as has been described above. The larger amount of litter in case of pines has been due to the presence of other tree associated in pine stand (Pande & Sharma, unpublished). They have shown synchronization in leaf fall with the environmental conditions in case of sal, teak and pine, while eucalypts show a bimodal pattern of leaf fall. The first high peak was recorded in the months of October-November and second one during the months of April-May. The first peak has been attributed to the genetical make-up of the plant (internal factors) on the basis of correspondance of peak (October-November) with that of eucalypts growing in Australia which occurs during the months of January-February (Bray & Gorham, 1964), while second peak in their studies was attributed to environmental stress of the region as it corresponds with the rest of the species though sal records maximum leaf fall a month earlier than rest of the species. The synchronizing peak, in all the species, during March to May will have added advantage of getting decomposed in time and would also depend on the substrate quality. Whereas, eucalypts leaf litter would lag behind as it has highest peak in leaf fall during October-November and also contain water soluble thoxins (del Morale *et al.*, 1970). This bimodal pattern of leaf fall in eucalypts will have detrimental effect in mineralization to the forest soil. This view finds support from their data on leaf litter disappearance represented on per cent per day basis. Leaf-litter disappearance rate was recorded lowest in eucalypts and highest in sal. The synchonizing leaf fall pattern in case of sal also finds support from their data on the amounts of leaf fall and respective nutrient concentration which fallowed the significant negative correlation while in case of eucalypts it was non-significant and partially significant for the rest of the species studied for certain nutrient concentration.

Nutrient strategy

On an average the nutrient concentration in eucalypts is generally higher compared to the sal. The overall differences were noticeable specially for N, K and Ca but not for P and Mg (Negi, 1984). It will be worthwhile to analyse the efficiency of redistribution of nutrients in order to understand the nutrients strategy from abscising leaves (Table 4) which is generally high for eucalypts compared to sal. The withdrawal percentage for phosphorus was also higher compared to sal. Attiwill (1980) reported that the withdrawal percentage at P in *Eucalyptus obliqua* was nearly 60% in abscised leaves. This indicates that eucalypts have conservational affinity for phosphorus and lend support for higher production in Indian soil (Negi *loc. cit.*). This has been further confirmed from the data on nutrient accumulation in the above ground biomass which was higher in case of eucalypts. The amount of nutrients return through litter fall and their subsequent decay which is slow in case of eucalypts would not enrich the soil to the extent of other deciduous ones and in the course of time eucalypts likely to leave the soil infertile with the present land utilisation and forest management practices. Further a valid comparison of eucalypts can be made with other forest ecosystems having comparable biomass for their nutrient drain as a result of harvesting the above ground tree components. A perusal of Table 1 reveals that the amounts of nutrient drain is definitely higher in eucalypts on whole tree utilization basis.

As discussed above it can be inferred that internal cycling of nutrients (within tree components) is well developed in eucalypts with a poorly developed external cycling (litter fall and canopy wash etc.). Thus eucalypts conserve more nutrients to produce equable biomass (Table 1) and will be lost upon as result of harvesting the ecosystems.

Why Eucalypts ?

In an ecosystem, man-made or natural, between and within, interplay amongst components is a reality and a homeostatic adjustment develop through the course of evolutionary time. The decomposer compartment is well developed and coordinated with physical and biotic climate in a mature system and where larger part of energy goes to the maintenance of the system and lower fraction, to the net primary production. Production is the out-come of different components interaction in an ecosystem. One may be propted *to ask, why then production* is higher in eucalypts than the natural forest of the region? The obvious answer to the query lies in bettering of our understanding in the natural ecosystems. High production of eucalypts is the realized fraction of the potentiality of the forest soil which was under different land use prior to the plantations.

Table 4

The concentration of various elements (% on oven dry weight basis) in green foliage (F), litterfall (L) and withdrawal % (W) of nutrients

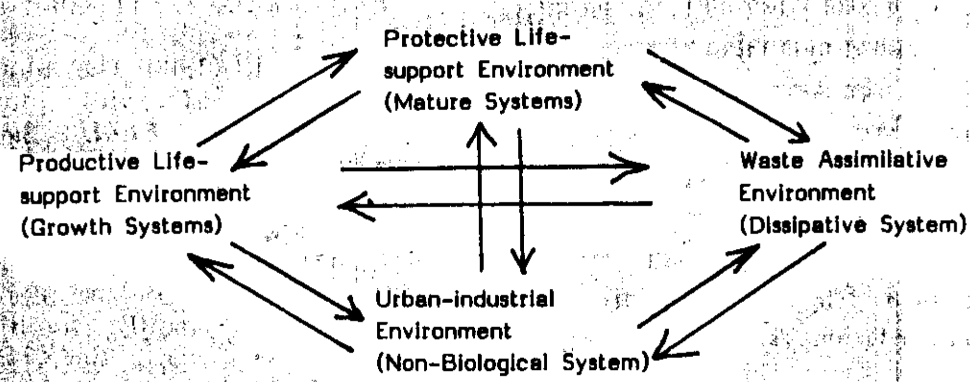
Species		N	P	K	Ca	Mg
Shorea robusta	F	1.64	0.19	0.48	0.87	0.27
	L	1.15	0.18	0.34	1.35	0.15
	W%	30	5	29	-55	44
Eucalyptus hybrid	F	1.88	0.16	1.04	1.47	0.295
	L	1.11	0.06	0.54	1.24	0.160
	W%	41	63	48	16	46

Source : Negi, 1984

Besides biomass accumulation and material cycles, ecosystems are rich in information net-works comprising physical and chemical communication flows that connects all parts and steer or regulate the system as a whole. An ecosystem considered as cybarnetic in nature where the control depends on feedback, which occurs when part of the out-put fedback as in-put (Odum *loc. cit.*). The balanced positive and negative fedback determines the control and stability of an ecosystem. After having understood the intricacy of the system it is possible to analyse the raised controversy. Eucalypts maximises the potentiality of the forest land and passes little information in the form of energy to the counter component which are essential for running up of the ecosystems and thus eucalypts shows oscillations in its realised production and developes poor cybornates in the plantation ecosystem. In other words the total gross production in eucalypts and regional vegetation may remain the same as per the potentiality of the forest land is concerned but the allocation of this gross would be different. In case of eucalypts greater amount of energy (biomass) goes to the net primary production compartment. In all stable systems the bulk of net primary production is shed as litter. This component thus enters the decomposition sub-systems as dead organic matter or detritus. This detritus is broken down by the combined action of decomposer community which utilizes energy and other nutrients for their own growth (Swift *et al.*, 1979). Within the ecosystem the decomposition subsystem performs two major function the mineralization and formation of soil organic matter. To maintain production plants must have continuing access to essential nutrients. The bimodal peak in eucalypts leaf fall is not in correspondence with the climatic condition of the region and hence will show differences in their decay than the local ecosystems. Also the low decay constant of eucalypts leaf will tend to spoil the potentiality of the forest floor as litter decomposition is supposed to be fertility index of the forest floor. Organism not only adapt to the physical environment in the sense of tolerating it, but also use the natural periodicities in the physical environment to time their activities and to "programme" their life histories so they can benefit from favourable conditions. This control is weekly developed in eucalypts as it is evident from the leaf fall, and production data. Thus, in nut shell it can be said, on long-term basis, it would not be beneficial to grow eucalypts perpetually for sustained growth on the same land as it would impaire the fertility of the forest floor for the reasons detailed above. The principles of ecosystem development has greater relevance to the human ecology because developmental trend involves contrast with the human goal of maximum production and protection. Recognising the ecological basis for this conflict between human and nature is a first step in establishing rational policies for managing the environment. Since it is impossible to maximise for conflicting uses in the same system, two possible solution to the dilemma suggest themselves. We can continually compromise between quantity of yield and quality of living space or we can deliberately compartmentalize the landscape to maintain both highly productive and predominantly protective types as separate units subject to different management strategies.

To be able to utilise the principles of ecosystem development relating to the landscape as a whole a compartment modal has been suggested by Odum (1983) depicting three types of environment that constitute the life-support systems for the fourth compartment the urban-industrial heterotrophic system. The human productive "environment" comprises early successional or growth-type ecosystems such as croplands, pastures, tree plantations and intensively managed forest that provide food, fiber, fuel, fodder and fertilizer. Nature ecosystems such as old growth forests, climax grasslands and oceans are more protective than productive. The third category of natural or emi-natural ecosystems the urban-industrial and agriculture including manmade systems and other strongly impacted environments. All these components interact continually in terms of in-put and out-put as depicted below.

In the end it can be concluded that it is not easy to set the clock back but early realization of the facts about successive eucalypts plantings must be analysed judiciously so that damage to the site productivity can be minimised. This can be done through adopting better land management practices.



Adapted from Odum (1983)

Summary

The paper summarises the impact of plantation forestry in general with special reference to Eucalyptus plantation - a much talked about issue of the day. To be able to conserve the environment congenial to the human inhabitation require the fuller understanding of man-made ecosystem in terms of in-put and out-put in totality. Of the many environmental factors which influences the human environment, in the present writeup, a possible role of nutrient dynamics has been detailed out. However, it is not easy to set the clock back but early realisation of the facts must be analysed in its right perspectives to save the humankind.

युकेलिप्टस विडम्बना – एक स्पष्टीकरण

एस० सी० शर्मा व जे० डी० एस० नेगी

सारांश

यह अभिपत्र रोपवन वानिकी का सामान्यत: और युकेलिप्टस रोपवनों के विशेष संदर्भ में, जो आजकल विवाद का मुद्दा बना हुआ है, प्रभाव का सारांश प्रस्तुत करता है। मानव आवास के लिए हितकारी पर्यावरण बनाए रखने के लिए धन निवेश, धन प्राप्ति के रूप में पूरी तरह मानव निर्मित परिस्थिति - संहति को भलीभांति समझ लेना आवश्यक है। मानव पर्यावरण पर प्रभाव डालने वाले बहुत सारे कारकों में से, इस लेख में पोष्याहार गतिका की भूमिका को विस्तार से बताया गया है। यह तो ठीक है कि क्रम को उलटना आसान नहीं है फिर भी मानवता को बचाने के लिए तथ्यों के *निहितार्थों को सही परिप्रेक्ष्य में* शीघ्र समझकर विश्लेषित करना चाहिए।

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