Leaflet No.1/84-85

Government of the Union of Myanmar
Ministry of Forestry
Forest Department
Forest Research Institute

Environmental Impact of Eucalyptus plantations with Special Reference to *E.camaldulensis*

U Sein Thet, UMehm Ko Ko Gyi, U Thein Kywe
and
U Htun Lynn
Forest Research Institute
February 1985

ယူကလစ်စိုက်ခင်းများကြောင့် ပတ်ဝန်းကျင်ပြောင်းလဲမှုကို စူးစမ်းလေ့လာခြင်း

ဦးစိန်သက်၊ B.Sc. (For.) (Rgn.), M.Sc. (ANU)၊ ဌာနမှူး
ဦးမင်းကိုကိုကြီး၊ B.Sc. (For.)(Rgn.), M.Sc. (ANU)၊ ဌာနမှူး
ဦးသိန်းကြွယ်၊ M.Sc. (Rgn.)၊ သုတေသနမှူး
နှင့်
ဦးထွန်းလင်း M.Econ. (Stats) ၊ လက်ထောက်ညွှန်ကြားရေးမှူး
သစ်တောသုတေသနဌာန၊ ရေဆင်း

စာတမ်းအကျဉ်းချုပ်

ယူကလစ်စိုက်ခင်းများသည် အပင်အငွေ့ပျံခြင်း၊ ရေငွေ့ပျံခြင်းများပြား၍ ပတ်ဝန်းကျင်ပြောင်းလဲမှုကို ဖြစ်ပေါ်စေသည်ဟု မြန်မာပြည်တွင် သံသယအမျိုးမျိုးဖြစ်ပေါ်လျှက် ရှိပါသည်။ စူးစမ်းလေ့လာမှုများကို မှော်ဘီ၊ တောင်ငူ၊ ရေတာရှည်၊ သာစည်၊ မိတ္ထီလာ၊ ကျောက်ပန်းတောင်းနှင့် မေမြို့ မြို့နယ်များရှိ ယူကလစ်စိုက်ခင်းနှင့် ၎င်းတို့နှင့် ဆက်စပ်လျက်ရှိသည့် အခြားသစ်မျိုးများစိုက်ခင်း၊ သဘာဝတောနှင့် ကွင်းပြင်နေရာများတွင် နွေ၊ မိုး၊ ဆောင်း သုံးရာသီတွင် လေအပူချိန်၊ စိုထိုင်းဆ၊ အပေါ်ယံမြေအပူချိန်၊ မြေချဉ်ငံဓါတ်၊ မြေအစိုဓါတ်နှင့်သစ်သားအစိုဓါတ်စသည့် စမ်းသပ်မှုများ ပြုလုပ်၍ တွေ့ရှိချက်များကို နှိုင်းယှဉ်သုံးသပ်ဆွေးနွေးတင်ပြထားပါသည်။

Environmental Impact of Eucalyptus plantations with Special Reference to *E.camaldulensis*

U Sein Thet, B.Sc. (For.) (Rgn.), M.Sc. (ANU), Head of Division
U Mehm Ko Ko Gyi, B.Sc. (For.)(Rgn.), M.Sc. (ANU), Head of Division
U Thein Kywe, M.Sc. (Rgn.), Research Officer
and
U Htun Lynn, M.Econ. (Stats), Assistant Director
Forest Research Institute, Yezin

Abstract

Ecological consequences including the loss of moisture through evapotranspiration from Eucalyptus plantations has been a controversial issue in Burma. Studies of air temperature, humidity, surface soil moisture, acidity and temperature, and moisture content of Eucalyptus plantations and adjoining plantations of other species, natural forest and open areas were carried out in Hmawbi, Toungoo, Yedashe, Thazi, Meiktila, Kyaukpadaung and Maymyo Townships. The data obtained during wet season and dry season are presented and discussed.

Contents

1. Introduction

Eucalyptus are usually regarded as Australian trees. The great majority of the many species and subspecies are endemic to the Australian continent and closely adjacent islands. About 90 percent of the whole complex of the Australian vegetation is dominated by the genus Eucalyptus. From the information given to FAO, commercial eucalyptus plantations now cover about 4 million hectares in 58 countries and areas including Australia. Another 50 have trial planting or ornamental planting (FAO).

The name *Eucalyptus camaldulensis* was given in honour of the Count of Camaldali who had grown the tree successfully in his garden near Naples in Italy since 1822. The synonym *E. rostrata* is still in use and was preferred by Forestry Abstracts as recently as 1967. In Southern Australia the common name is red gum or river red gum, probably due to the rich red-brown colour of the heartwood and Kino (gum), its occurrence along watercourses, and to the nature of the bark. But in Central and Northern, the name ghost gum probably resulted from the whiteness of the bark (CSIRO, 1975).

E. camaldulensis is the most widely distributed eucalypt of mainland Australia and occurs in all states except Tasmania. It is confined chiefly to inland rivers and flood plains where the mean annual rainfall is less than 650 mm. The natural stands are harvested for sawnwood, railway sleepers and charcoal. It has been widely planted overseas and about 500,000 ha. have been established. The main characteristics which have been responsible for its success as an exotic species are: (a) rapid growth on poor sites with low rainfall, (b) ability to coppice readily, (c) ability to tolerate periodic waterlogging and some soil salinity, and (d) the usefulness of the wood for a range of purposes. The main use of *E. camaldulensis* has been for fuel, charcoal, posts and poles. It is used in Spain, Portugal and Morocco for pulp. In Argentina, Israel, Mexico and Spain, it is used for hardboard and particle board. It is not often sawn except for special purposes such as flooring blocks. It is widely planted for shade, shelter and amenity purposes. (CSIRO 1978).

Eucalyptus plantations were first introduced in Burma in 1922, in trial and ornamental plantings. To meet the demand for poles, posts, firewood, charcoal and sawntimber by peasants and workers, the Forest Department began large-scale plantings in 1967. About 17580 hectares of Eucalyptus had been planted in Burma by 1980 (See Appendix I).

Unfortunately there is a mistaken belief in Burma that Eucalyptus plantations cause loss of soil water and serious ecological consequences. This fallacy has been a controversial issue in Burma. So a study was undertaken in an existing Eucalyptus plantation, in an adjoining plantation, in natural stands of native species, and in open areas to obtain data to assess the effect of Eucalyptus plantations on soil water and other environmental factors.

2. Literature Review

As no data on the rate of loss of moisture through evapotranspiration for *E. camaldulensis* and other species under Burma climatic condition are available, literature from similar areas was reviewed.

A study in a five-year-old Eucalyptus hybrid plantation in Beliatere Range of Bankura District. of West Bengal, India, from October 1970 to October 1971 had found that out of the effective rainfall of 1147.2 mm, the site lost 1136 mm or 99.04% through evapotranspiration leaving 0.06% to augment the soil water storage. He concluded that E.hybrid plantation did not deplete the moisture reserve in the area, but has contributed little to the reserve (Benerjee). A study of the water balance in pines and eucalyptus from October 1968 to April 1971 at Lidsdale, New South Wales, found that there was no significant differences between

the sums of evaporation from the soil and transpiration of the trees under Eucalyptus or pine forests (Smith, Watson & Pilgrim).

In 1978 a brief survey of the information available on the effects of Eucalyptus plantation with particular reference to water relation and soil nutrition was made. The authors stated that beneficial effects out-weighed any possible adverse effects and complaints regarding the adverse effects of Eucalyptus plantations on water supply were rather exaggerated (Ghosh *et.al*). A study in 1967 investigated the comparative water balances of a 9-12 years old plantation of *E. camaldulensis* and a near-by clearing at Ilanot, in the Central Coastal Plain of Israel. The conclusion was that under conditions where soil moisture recharge by incident rainfall limits evapotranspiration, there is no evidence of an adverse hydrological effect by *E.camaldulensis* plantations (Karschon and Heth). In 1973 a study of the water relationship of *E.camaldulensis* leaves on three sites with contrasting soil moisture status was made in Israel. It was found that in the summer, when the evaporative power of the atmosphere is at its peak, the transpiration rate and its daily course are controlled by soil water availability when soil water supply is unlimited. The course of transpiration and other ecophysiological factors follows that of the climatic parameters, i.e. transpiration is controlled by the evaporative power of the atmosphere. Under conditions of limited soil water supply, however, physiological factors act to restrict water loss by transpiration (Kaplan).

In 1981 a study of the water balances in forests in Victoria, Australia was conducted. The movement of precipitation in a forest, as through fall, stemflow, canopy interception, forest floor interception, and forest floor leachate was estimated from measurements made in two Eucalyptus forest types *E.regans* and *E.obliqua* and *a Pinus radiata* plantation in the Maroondah watershed. It suggested that replacement of dry sclerophyll Eucalyptus forests with pine will lead to declines in water yield unless the pines are heavily thinned, but that the generality of declining water yield in uncertain (Feller).

Interception and transpiration losses from Eucalyptus and coniferous forest systems were reviewed by Dunin and Mackay, to compare evaporative losses by the different communities. Interception losses from the coniferous forest under normal management were greater than those from the Eucalypt forest due mainly to the larger leaf area associated with conifers. The difference in interception loss was estimated as being equivalent to about 10 percent of annual rainfall. A model of vapour loss from *P. radiata* was developed to stimulate the consequence of converting eucalypt forest to pine plantaions. In two case studies at Lidsdale and Batemans Bay, N.S.W. it was concluded that, increased vapour loss from pine over eucalypt communities was an estimated 35-100 mm per year.

Nshubemuki and Somi presented a brief survey of some of the available information about the effects of some Eucalyptus species on the major components of the hydrological cycle. They stated that claims regarding the adverse effects of Eucalyptus stands on water supply seem to be exaggerated and that suitable Eucalyptus provenances can be planted in Tanzania without fears of a decrease in local water supply (Nshubemuki and Somi).

Mathur and Raj (1980) studied the depletion of groundwater by Eucalyptus plantation by measuring groundwater table fluctuations occuring under *E. globulus* plantation. A series of piezometric holes were driven along a hill slope, covering low- lying and high level area of a small (8.1 ha) watershed planted with *E.globulus* (blue-gum) and in part covered with grassland and native Shola at Osamund, Wonlockdowns Reserved Forest in the Niligris, India. They found that groundwater table levels are much below the general rooting zone (2 m) of Eucalyptus except in the low-lying areas, indicating that Eucalyptus does not tap groundwater table during dry season, i.e. December to March.

Studies conducted by Forest Research Institute and College, Dehra Dun, showed that water consumed per gram of dry matter produced was only 1.41 mm per gram by Eucalyptus

as against 2.59 mm per gram by rosewood (*Dalbergia latifolia*) and 3.87 mm per gram by chir (*Pinus roxburghii*). This indicates that Eucalyptus produces more wood with a less water. Studies in Israel have also shown that evapotranspiration from *E. camaldulensis* is low and slightly higher than bare land which shows that Eucalyptus do not transpire large quantities of water. Investigations carried out in Israel on interception of rainfall by a 7-year-old *E. camaldulensis* plantation indicated that only about 14-15% of the total rainfall is lost as interception by Eucalyptus trees. Similar results were obtained at the Forest Research Institute, Dehra Dun, which when compared to chir, Teak (*Tectona grandis*) or Sal (*Shorea robusta*) forests showed that rainfall availability to soil in Eucalyptus plantation is much more than with native species. Recent studies in Gujarat indicated that soil p^H improved from 8.5 to 8 in a single rotation of five years of Eucalyptus. Under certain conditions Eucalyptus has the added advantage of improving soil (Shukla).

Karschon, Director, Ilanot Forestry Research Station, Israel, reported that obviously the higher water consumption of eucalypt is paid for by its rapid growth and high production. There are no restraints in Israel regarding planting of eucalypt because of water considerations. There is no other species of comparable growth rate and sites suitable for other species used in reforestation in Israel, which are not suitable for Eucalyptus, and vice-versa. Eucalyptus is, however, not favoured as windbreaks because of root competition and repeated root pruning (by heavy equipment) is required. He concluded that he would not be afraid of soil moisture losses by evapotranspiration of Eucalyptus in Burma, taking into account the large impact, the high biomass production could have on Socio-economic progress in the countryside, particularly in the dry zone. As always, the alternatives to growing Eucalyptus has to be evaluated (food crops, animal husbandry) but if the requirement is to grow timber or biomass for energy (including domestic fuel) there is little doubt that water consumption by itself should not be the decisive factor, since in dry areas, with soil moisture recharge by direct rainfall limiting evapotranspiration, Eucalyptus does not adversely effect water resources (Karschon).

3. Materials and Methods

Two sites one at heavy rainfall area (Hmawbi plantation site, Hmawbi Township, Rangoon Division), and another in the dry zone area (Yupartaung plantation site, Thazi Township, Mandalay Division) were selected. Weather houses were installed in the Eucalyptus plantation, in nearby native species plantation and one in open area. At Hmawbi site the native species selected was Pyinkado (*Xylia dolabriformis*). At the Yupartaung site a Sha (*Acacia catechu*) plantation of the same age as the *E. camaldulensis* plantation was selected.

Temperatures and Relative humidity readings at each weather house, were recorded five times a day from 1-11-80 to 30-6-82 (Plate 1.)

Acidity, temperature and moisture content of surface soils, under Eucalyptus plantation and native species forests, were collected during two wet seasons (September 1980 and October 1981) and two dry seasons (February 1981 and February 1982). Measurements were made in the dryzone and in heavy rainfall areas including, Pyinmana (Naung Oo township), Mondaing (Meiktilia township), Popa (Kyaukpadaung township), Yupartaung (Thazi township), Sakangyi (Maymyo township), Thandaung (Thandaung township), and Hmawbi (Hmawbi township) plantation sites. For surface soil temperatures a Taylor thermometer was used, while for acidity and moisture content of surface soil, a pocket soil moisture/p^H meter was used (Plate 2.). Average values were calculated for the two seasons and the results were compared.

For moisture content determination, Eucalyptus and other native species in nearby plantations in Maymyo and Popa were collected and studied during February 1981 to May 1982. Kyun (*Tectona grandis* Linn.f.), Thitya (*Shorea oblongifolia* Thw.) and Cherry (*Prunus ceradoides* D.Don.) were found close to *E. camaldulensis* in the Maymyo area. Kyaungdauk (*Pajanelia rheedii* DC.), Mayanin (*Acrocarpus fraxinifolius* Wight) and Thadi (*Protium serrata* Engler.) were located in the Popa area.

To study the effect of Eucalyptus growing in proximity to other vegetation, comparisons were made of the understory in natural forests, and in Eucalyptus plantations. Another study involved comparison of paddy grown under Eucalyptus plantation and paddy grown in the open.

Two 2-acre plots were selected at Ah-mut-gyi-gon in Yedashe township, one in a seven-year-old *E. camaldulensis* plantation spaced 15' x 15' and the other in the open. Paddy was grown and harvested from the two areas and the volume of yield determined.

Authentication of the plant specimens and wood samples was performed at the Wood Anatomy Research Section Forest Research Institute at Yezin. A collection of wood samples from fixed part the tree bole of uniform size and shape was made for all species. The samples were weighed immediately after collection and then dried in a laboratory oven at 105°C until a constant weight was achieved. From this data the moisture content of the samples was determined. The procedure was carried out both in summer and winter and the results compared.

PLATE 1. Weather Recording Station, at *Acacia catechu* plantation, Yupartaung Site.

PLATE 2. Surface Soil, Moisture and Temperature determination. (Note- Forest litter accumulation)

PLATE 3. Well-stocked undergrowth in 8 years old *E.camaldulensis* plantation at Yupartaung

PLATE 4. Vigorous undergrowth in 10 years old *E. camaldulensis* plantation at Popa

PLATE 5. Paddy cultivation under thinned 6 years old *E. camaldulensis* plantation at Kengtong Soil Conservation Farm, Shan State

PLATE 6. Animal fodder collection from one year old *E. camaldulensis* plantation, at Pyinma, Naung Oo, Mandalay Division

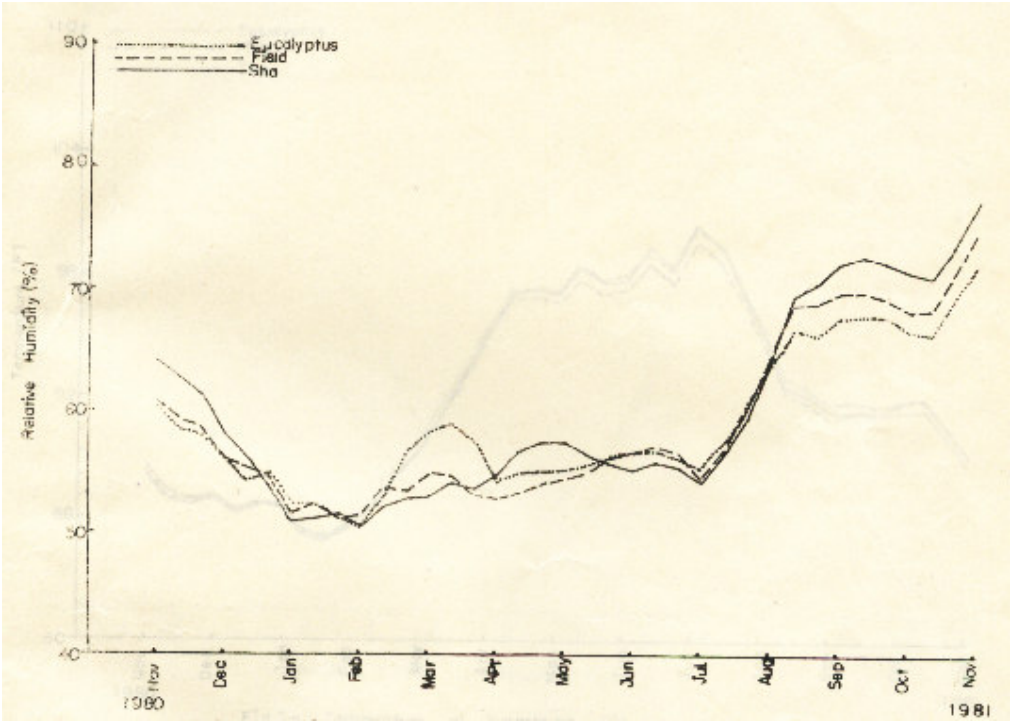

Fig.1 – Relative Humidity at Yupartaung Site.

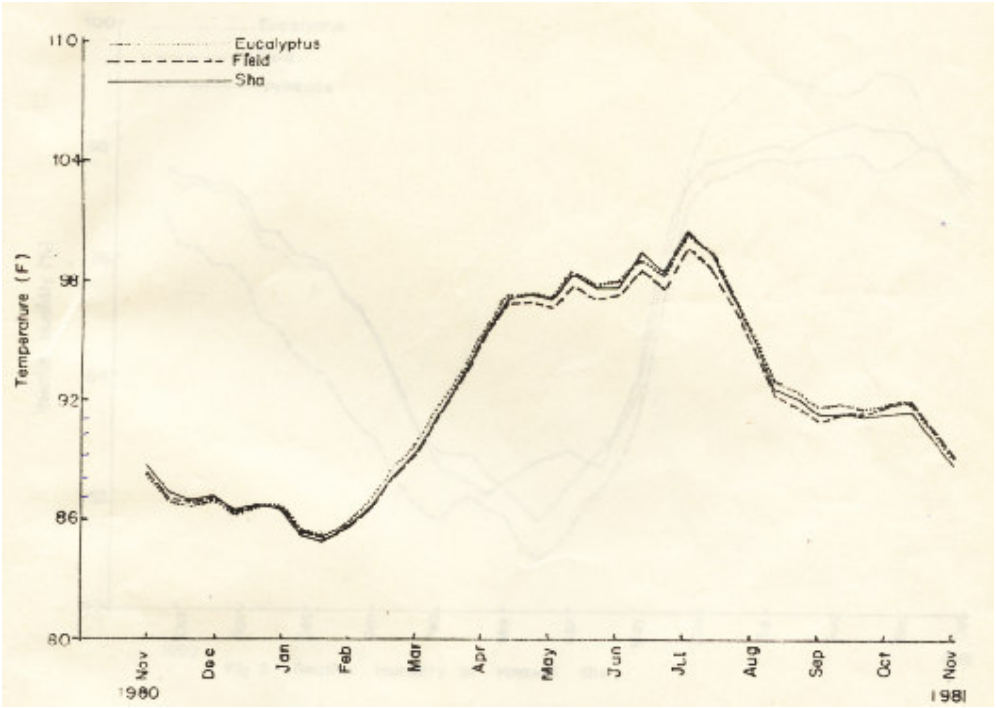

Fig 2 – Temperature at Yupartaung Site

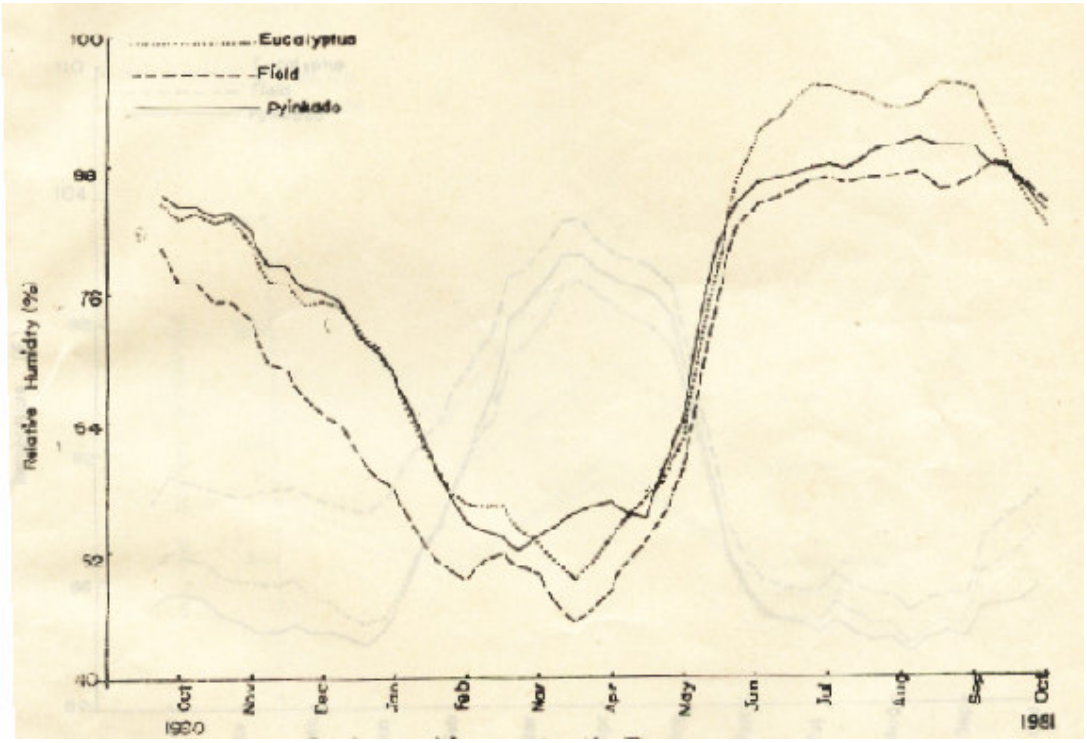

Fig3. Relatively Humidity at Hmawbi Site

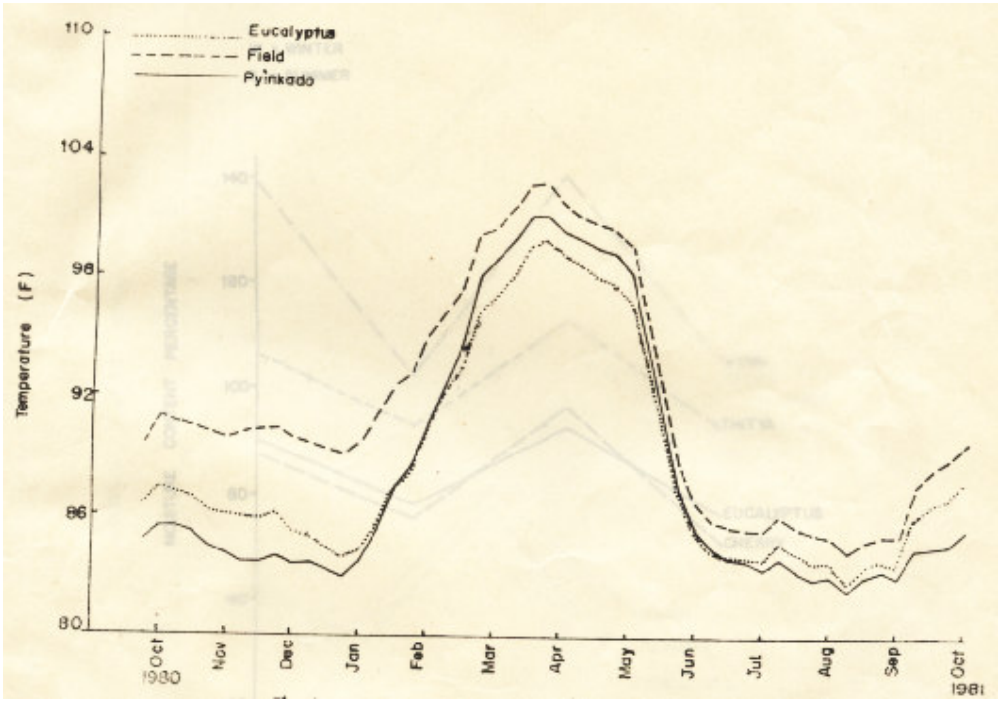

Fig 4. Temperature at Hmawbi Site

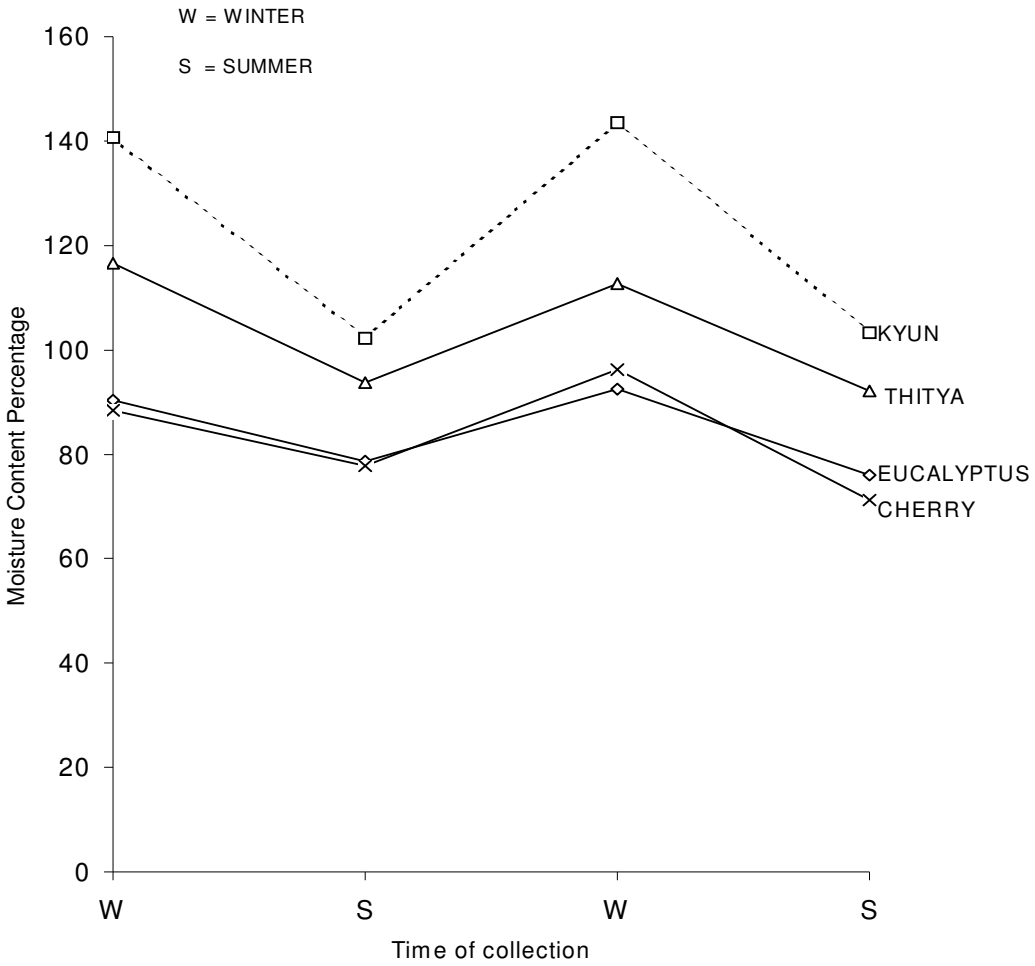

Fig. 5 The graphic representation of moisture content percentage and time of collection of different species in Maymyo area

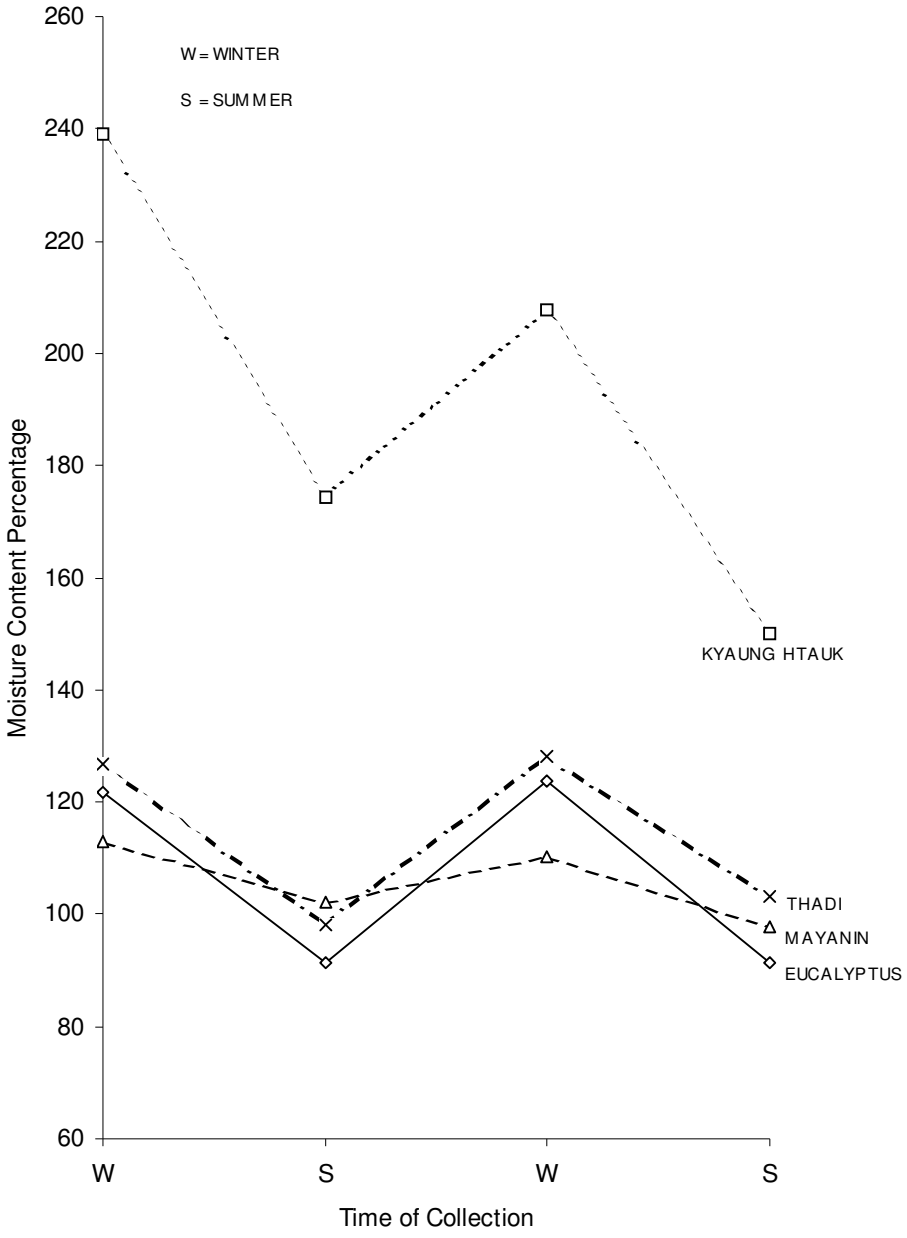

Fig. 6 The graphic representation of moisture content percentage and time of collection of different species in Popa area

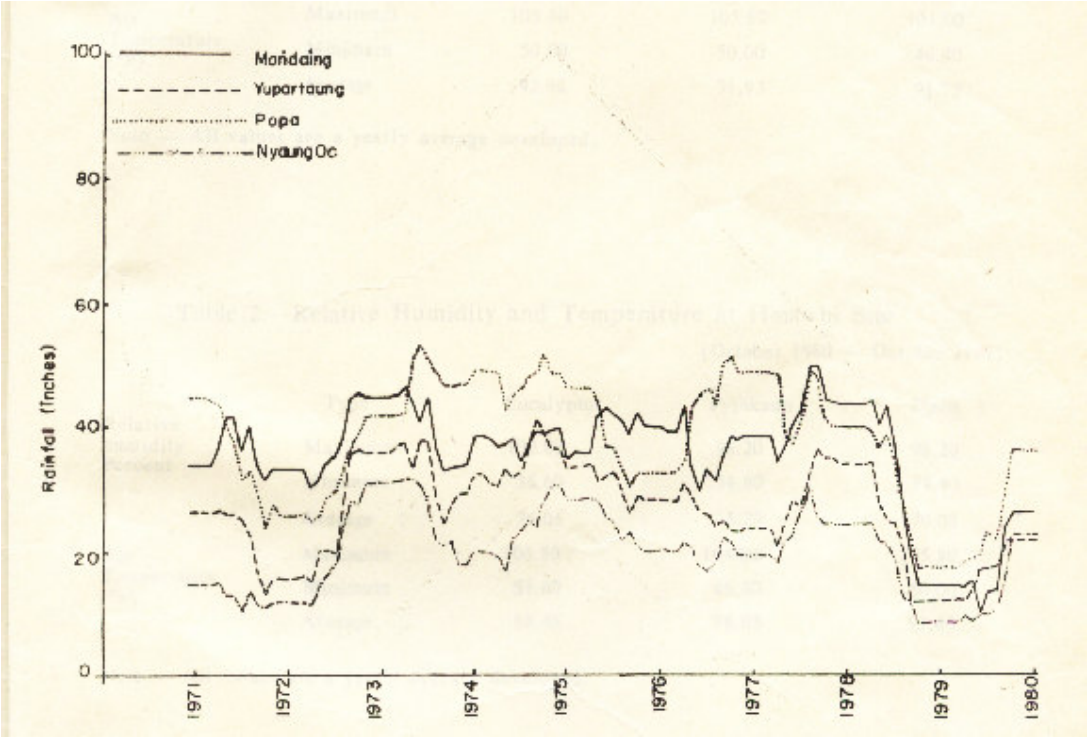

Fig 7. Rainfall Distribution at different Sites

4. Results

Maximum, minimum and average values of the relative humidity and air temperature for one complete year under Eucalyptus plantation, the native species plantation and the open areas at Hmawbi and Yupartaung sites are presented in Table 1 and 2. Monthly average values are shown in Appendix II.

Graphical representation of the average values for humidity and temperature, under the Eucalyptus, the native species and the open area, for Hmawbi and Yupartaung sites are shown in Figures 1 to 4.

Acidity, moisture content and temperature of surface soil, under the Eucalyptus and the native species of the different study sites, for the dry season and wet season are presented in Table 3 and 4.

The comparisons of moisture content of Eucalyptus and other native species (Kyun, Thitya, Cherry) in Maymyo area is shown in Table 5, and in Table 6, comparison between Eucalyptus, Kyaungdauk, Mayanin and Thadi in Popa area is presented. The relationship between moisture content (in percentage) of different species and time of collection in different weathers (Summer and Winter) are shown as graphic representation in Figures 5 and 6.

Within the study area, it was found that there was an extensive volume of forest biomass as undergrowth and litter fall under the Eucalyptus plantation, compared to nearby natural forest (Plates 2, 3 and 4).

Paddy harvesting under a thinned Eucalyptus plantation in a moderate rainfall area, and collection of grasses from young Eucalyptus plantation area for animal fodder, are shown in (Plates 5 and 6).

Paddy grown under a seven-year- old *E. camaldulensis* yielded 48 baskets 2 $^{1}/_{2}$ pyi, while paddy grown in the open yielded 47 baskets 11 pyi.

5. Discussion

Rainfall distribution in the dry zone at four different stations; two of which located very close to the *E. camaldulensis* plantation (Yupartaung and Popa), and the other two, located more than ten miles away (Mondaing and Nyaung Oo), followed the same pattern in the years 1970 to 1980 (See Fig 7). This indicated that there was no adverse effect on rainfall intensity due to Eucalyptus plantations in the Dryzone area.

At the Hmawbi study site (high rainfall) although the average temperature was higher in the Eucalyptus plantation than the Pyinkado plantation, it was not significantly different. But the average temperature in both the Eucalyptus and Pyinkado areas was significantly lower than that of the open area. In case of the low rainfall area (Yupartaung), the average temperature in Eucalyptus was higher than that of both the Sha plantation and the open area, but not significantly different. (Appendix III). Average relative humidity in the Eucalyptus plantation was higher than in the Pyinkado plantation and lower than that in the Sha plantation, but not significantly different. As expected, the relative humidity in all types of forest was significantly higher than that of the open area, the data indicates that Eucalyptus plantations do not have an adverse effect on relative humidity.

There was no indication of difference in surface soil moisture content between the Eucalyptus plantations and native species. Examination of surface soil temperature showed that temperature under Eucalyptus was lower than that of native species, but the differences were not significant.

According to Shukla, soil p^{H} improved from 8.5 to 8 in a single rotation of five years of Eucalyptus. Within the study area, soil acidity was favourable under Eucalyptus compared to native species at most of the study sites (Table 3 and 4) which indicates that *E. camaldulensis* is a suitable species to improve the Dryzone alkaline soils of Burma.

It was found that water absorption of *E. camaldulensis*, as shown by soil moisture percent, was not more than the other native species in reference to the difference in weather and location. In general the absorption was as expected in a fast- growing plantation.

6. Conclusion

Those studies have shown that in both heavy rainfall and low rainfall (Dryzone) areas, there is no adverse effect due to Eucalyptus plantations in comparison with native tree plantations in climatic factors of temperature, relative humidity, soil moisture, and ground water absorption. In the same way wood moisture content and ground biomass litter production showed no adverse effects.

Comparison of plantations versus open areas indicate that tree cover provides a tempering effect to reduce the soil temperature and increase the relative humidity and soil surface moisture. The presence of leaf litter and dense overhead canopy provide an additional modifying effect on rainfall impact thus reducing erosional forces.

Fast growing plantations of all species draw moisture from the soil to produce woody material. Comparison of Eucalyptus versus pine plantations demonstrated that pine species required more moisture than Eucalyptus unless the pine was restricted by heavy thinning.

Paddy grown under Eucalyptus plantations produced similar yields to paddy grown in the open. Finally Eucalyptus plantations serve to modify soil acidity through reducing soil p^H.

It can be concluded that Eucalyptus plantations do not by themselves have an adverse environmental impact when planted on proper sites. The benefits gained in tree growth and wood production far outweigh the amount of water consumed. In fact, the great number of Eucalyptus species available with a variety of growth characteristics and planting site requirements increases the forester's range of choices in prescribing the best species for a particular location to achieve optimum growth.

The Forest Department has an annual plantation program goal of approximately 90,000 acres for commercial, industrial and domestic use. This includes plantations for domestic fuelwood production and protection forests to reduce soil erosion. These plantations will be established in sites that are many and varied, as for instance in the dryzone where rainfall can be as low as ten inches per year, and soil can be so poor that even the most essential mineral elements are lacking. Eucalyptus species have been found to be most successful even in very arid areas.

Table 1. Relative Humidity and Temperature at Yupartaung Site (November 1980-November 1981)

	Type	Eucalyptus Plantation	Sha Plantation	Open Area
Relative humidity Percent	Maximum	90.00	91.00	91.00
	Minimum	36.75	38.67	40.25
	Average	59.08	60.22	59.21
Air Temperature (°F)	Maximum	105.80	105.80	104.00
	Minimum	50.00	50.00	46.40
	Average	92.02	91.93	91.72

Note-All values are a yearly average developed.

Table 2. Relative Humidity and Temperature at Hmawbi Site (October 1980- October 1981)

	Type	Eucalyptus Plantation	Sha Plantation	Open Area
Relative humidity Percent	Maximum	100.00	98.20	96.20
	Minimum	36.60	38.80	34.40
	Average	76.05	75.29	70.08
Air Temperature (°F)	Maximum	105.80	104.00	105.80
	Minimum	51.80	46.40	50.00
	Average	88.46	88.03	91.40

Note-All values are a yearly average developed.

Table 3. Acidity, Moisture Percent and Temperature of Surface Soil, under Eucalyptus and Native Species of Study Sites for Dry Season

Site	Acidity(p^H)		Moisture (%)		Temperature (°F)	
	Eu.	Nat.	Eu.	Nat.	Eu.	Nat.
Pyinma	7.0	6.9	5	10	87	87
Mondaing	7.0	7.0	5	10	79	80
Popa	6.9	7.0	25	18	65	68
Yupartaung	6.9	7.0	5	5	80	84
Maymyo	6.8	6.9	13	16	63	62
Thantaung	6.8	6.9	26	5	68	70
Hmawbi	6.8	7.0	15	10	72	72

Table 4. Acidity, Moisture Percent and Temperature of Surface Soil, under Eucalyptus and Native Species of Study Sites for Wet Season

Site	Acidity(p^H)		Moisture (%)		Temperature (°F)	
	Eu.	Nat.	Eu.	Nat.	Eu.	Nat.
Pyinma	6.3	6.2	82	79	84	88
Mondaing	5.6	6.3	100	100	76	78
Popa	5.6	5.5	100	100	75	74
Yupartaung	6.3	6.6	48	33	84	82
Maymyo	6.3	6.0	59	70	72	73
Thantaung	6.2	6.4	76	42	79	78
Hmawbi	5.8	6.3	50	43	79	78

Eu. – Eucalyptus Plantation
Nat. – Native Species, Natural Forest or Plantation

Table 5. Comparison of Moisture content of Eucalyptus of and Native Species in Maymyo Area

Species	Wood Moisture Content Percent			
	Winter(1981)	Summer(1981)	Winter(1982)	Summer(1982)
Eucalyptus	90.38	78.60	92.44	76.01
Kyun	140.77	102.21	143.50	103.27
Thitya	116.52	93.69	112.64	92.15
Cherry	88.40	77.78	96.20	71.17

Table 6. Comparison of Moisture content of Eucalyptus of and Native Species in Popa Area

Species	Wood Moisture Content Percent			
	Winter(1981)	**Summer(1981)**	**Winter(1982)**	**Summer(1982)**
Eucalyptus	101.77	72.52	105. 76	71.30
Kyaungdauk	239.06	174.36	207.65	150.08
Mayanin	96.05	81.31	93.26	77.85
Thadi	106.80	78.03	106.28	83.11

Appendix I.

Eucalyptus Plantation Areas in Burma

(Acres)

State/ Division Year	Kachin	Karen	Mon	Arakan	Shan	Sagaing	Pegu	Magwe	Rangoon	Mandalay	Irrawady	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1922												
1934					42					556		598
1963										5		5
1966										9		9
1967										30		30
1968										75		75
1969	5	5			100				5	122		237
1970			5	4	140	5	227		10	1036		1477
1971					244	217	471	4	50	1037		2023
1972	5				705	1614	456	177	200	1939	50	5146
1973	50				563	475	402	343	200	1043	119	3195
1974	50				650	1337	60	150	50	2352	155	4804
1975	50			5	640	848	298	350	125	1599	205	4120
1976	50				580	320	353	300	125	1610	155	3493
1977					790	240	250	400	175	2215	200	4270
1978			50		795	300	152	500	300	2392	300	4789
1979			300		2300	400	200	600	500	3500	700	8500
1980							150			500		650
Grand Total	210	5	355	9	7549	5756	3069	2824	1740	20020	1884	43421

Source: – Forest Plantation in Burma
Forest Department, Rangoon, Burma (March – 1981)

Appendix II.

Monthly, Relative Humidity and Temperature at Yupartaung and Hmawbi Sites

Month			Yupartaung						Hmawbi					
			R.H.(%)			Temp.(°F)			R.H.(%)			Temp.(°F)		
			Eu.	Sh.	Op.	Eu.	Sh.	Op.	Eu.	Po	Op	Eu.	Po	Op
1980		Max.	75	85	75	91	91	91	96	96	84	90	89	93
	Nov.	Mi.	47	53	43	57	57	55	74	73	62	66	66	66
		Av.	59	64	61	77	76	77	8.3	83	75	78	77	80
		Max.	63	73	64	90	90	50	89	85	75	90	91	93
	Dec.	Mi.	39	41	40	54	52	52	69	66	59	61	61	59
		Av.	54	56	56	73	72	72	75	76	63	76	75	78
1981		Max.	67	59	70	93	91	91	75	78	62	90	90	95
	Jan.	Min.	37	39	43	50	46	46	49	48	43	52	46	52
		Av.	50	51	51	71	70	70	66	67	56	73	73	76
		Max.	75	69	67	97	97	97	66	65	60	97	99	100
	Feb.	Min.	48	39	45	52	50	50	47	43	38	52	52	50
		Av.	57	55	54	74	75	72	56	55	50	76	76	77
		Max.	65	78	66	100	90	100	66	67	61	102	102	105
	Mar.	Min.	42	38	41	57	55	55	37	39	35	63	61	63
		Av.	54	57	54	81	81	80	51	54	47	83	82	85
		Max.	77	80	74	106	106	104	73	71	68	106	104	106
	Apr.	Min.	43	44	44	66	64	64	41	45	34	68	68	68
		Av.	57	55	57	86	86	83	55	55	61	87	87	87
		Max.	88	86	86	104	104	102	96	94	90	100	102	104
	May	Min.	49	48	45	73	75	73	47	48	46	73	75	75
		Av.	59	60	62	88	88	88	75	74	71	83	86	86
		Max.	79	84	81	97	99	97	100	98	92	88	88	91
	Jun	Min.	55	58	55	73	73	73	84	78	75	73	73	73
		Av.	68	72	70	88	84	84	94	87	85	80	81	81
		Max.	87	91	87	95	95	97	100	94	90	88	88	90
	Jul.	Min.	56	54	57	73	73	73	89	83	78	73	73	73
		Av.	69	74	71	84	82	84	94	89	87	80	80	81
		Max.	90	87	91	95	93	93	100	98	90	90	88	91
	Aug.	Min.	61	61	62	73	73	73	89	84	76	73	73	75
		Av.	69	74	73	83	83	84	96	90	86	80	85	81
		Max.	79	85	84	99	99	99	94	92	90	93	90	95
	Sept.	Min.	55	54	53	73	73	73	71	72	71	73	73	73
		Av.	65	68	66	85	84	84	84	85	79	82	81	83
		Max.	83	87	83	93	93	93	84	87	90	90	88	97
	Oct.	Min.	59	63	59	72	72	72	65	64	71	73	73	72
		Av.	71	73	79	82	81	81	75	78	81	81	80	83

Eu – Eucalypt **Po – Pyinkado**
Sh – Sha **Op- Open**

Appendix III

Comparison of Relative Humidity and Temperature between Sites

Parameters	Sites		Dry Season (Jan-May)	"t" values Wet Season (Jun-Dec.)	Whole Year (Jan-Dec)
Hmawbi					
Relative Humidity	Eu	Vs Pyinkado	-0.4326	1.6520	1.4025
`	Eu	Vs Open	8.2270**	4.7960**	7.4647**
`	Pyinkado	Vs Open	5.4618**	4.1479**	6.5261**
Temperature	Eu	Vs Pyinkado	-0.2434	3.5347**	1.6550
`	Eu	Vs Open	-2.9500**	-5.4776**	-5.8215**
`	Pyinkado	Vs Open	-1.6400	-9.4630**	-5.4525**
Yupartaung					
Relative Humidity	Eu	Vs Sha	-0.7532	-1.2181	-1.4430
`	Eu	Vs Open	1.2011	-2.5810*	-0.4966
`	Sha	Vs Open	2.9202**	0.2377	1.2607
Temperature	Eu	Vs Sha	2.0589*	1.5045	0.6647
`	Eu	Vs Open	0.8384	1.7329	1.5054
`	Sha	Vs Open	0.4096**	-0.290	2.8150**

* - Significantly different at 0.05 level
** - Significantly different at 0.01 level
df is 56 in all cases

References

1. Benerjii, A.K. (1972): Evapo-transpiration from a young Eucalyptus hybrid plantation of West Bengal. Symposium paper on Man Made Forests. In India. June 8-10, 1972.
2. CSIRO (1975): An annotated bibliography of Genetic Variation in *Eucalyptus camaldulensis*, compiled by K.G. Eldridge. Tropical Forestry Papers No. 8. pp59
3. CSIRO (1978): Eucalyptus for Wood Production. Ed. by W.E Hillis and A.G. Brown. CSIRO Australia. pp 434.
4. Dunin, F.X., Mackay, S.M. (1982); Evaporation of Eucalyptus and Coniferous Forest Communities Symposium Paper on Forest Hydrology. Melbourne, May 11-13, 1982.
5. FAO (1979): Eucalyptus for planting FAO, Forestry Series No.11, Rome, pp 677.
6. Feller, M.C. (1981): Water balances in *Eucalyptus regnans*. *E. obliqua* and *Pinus radiata* Forests in Victoria. Aust. For. 44(3), 153-161.
7. Ghosh, R.C., Kaul, O.M, Subba Rao, B.K. (1978): Some aspects water relation and nutrition in Eucalyptus Pantation. Indian Forester, 104 (7), 517-524.
8. Kaplan, J.(1973): The ecology of *Eucalyptus camaldulensis* Dehn in Israel. Ph.D. Thesis, Hebrew University, Jerusalem.
9. Karschon, R. (1980): Personal Correspondence.
10. Karschon, R., Heth, D. (1967): The Water Balance of a Plantation of *Eucalyptus camaldulensis* Dehn. Reprint from Contributions on Eucalyptus in Israel, III, 1967.
11. Mathur, H.N., Francis Hilary Raj, S.(1981): Ground Water Regime Under Blue-Gum at Osamund Nilgiris Initial Observations. Indian Forester, 106(8), 547-553.
12. Nshubemuki, L., Somi, F.G. R.(1979): Water used by the Eucalyptus-Observation and Probable Exaggerations. Silviculture Technical Note No.44
13. Shukla, S.K. (1980): Eucalyptus for planting. Extension series No.4, Forest Research Institute & College, Dehra Dun. 14. Smith, M. K., Watson K. K. and Pilgrim, D.H. (1974): A comparative study of the hydrology of radiata pine and Eucalypt Forests at Lidsdale, New South Wales. Inst. Eng. Aust. CE 16(1), 82-86.
14. Smith, M. K., Watson K. K. and Pilgrim, D.H. (1974): A comparative study of the hydrology of radiata pine and Eucalypt Forests at Lidsdale, New South Wales. Inst. Eng. Aust. CE 16(1), 82-86.