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On the Growth of Three Species of *Eucalypts* in Japan

Morishige HARADA

I. Introduction

The *Eucalypt* was imported into Japan for the first time when a Japanese steamer visited Australia in 1891, and Japanese bamboos were sent to Australia in exchange for it. Later, *Eucalypt* seeds were brought into Japan by foreigners and Japanese who returned from Australia. *Eucalypts* have been planted as single trees in gardens of government offices, schools, shrines, parks and private residences, or as street trees in the warmer districts of Japan, and at present forest trees of *Eucalypts* are scarcely found in the mountain regions of Japan except for a few examples mentioned below.

According to the investigation by the Japan Forestry Agency in 1953, the species of *Eucalypts* found in Japan are as follows:

1. *E. citriodora*
2. *E. corynocalyx*
3. *E. ficifolia*
4. *E. gunni*
5. *E. globulus*
6. *E. polyanthemos*
7. *E. robusta*
8. *E. rostrata*
9. *E. rudis*
10. *E. saligna*
11. *E. sideroxylon*
12. *E. tereticornis*
13. *E. viminalis*

The north limit of the growth of *Eucalypts* in Japan is Ibaragi, Gunma and Ishikawa Prefectures, and *Eucalypts* grow in the zone south of this limit, including Shizuoka, Hyogo, Kochi and Fukuoka Prefectures that are relatively warmer districts in Japan. *Eucalypts* grow vigorously as single trees at level lands in these districts. The total number of meridian and old trees of *Eucalypts* is 2,255 and the greater part of these are *E. globulus*.

Eucalypt plantations in monutainous regions are found only in Fukuoka and Kochi Prefectures, and the results of growing are very poor as seen by the following table.

Plantation	Species of *Euc.*	Age of trees	No. of trees	Average height	Average diameter
		yrs.		m	cm
Kasuya *Enc.* Forest (Fukuoka)	*E. globulus*	17	292	7.98	6.83
Shimato Camphor Co. (Kochi)	*E. globusus*	38	200	15.0	36.0

According to the development of the pulp industry and the shortage of lumber in the world, *Eucalypts* have come to be used profitably as pulp material. Thus, *Eucalypts* of rapid growth have attracted the attention for afforestation, as the need of sufficient supply of lumber is keenly felt in Japan.

Importing *Eucalypts* from Australia, thirty countries in the world have examined *Eucalypts* as the useful plants, and some of the countries have been growing *Eucalypts* on a commercial basis. The author planted in mountain regions 15 species of young plants of *Eucalypts* grown from the seeds forwarded from Mr. G. J. RODGER. Among them *E. dalrympleana*, *E. fastigata*, *E. rostrata* and *E. tereticornis* have grown well in the past year. Therefore, the studies were made on the growth habit and future prospect of the latter three species, excepting *E. dalrympleana* which must be studied into further at a higher mountain.

The author expresses his hearty gratitude to Mr. G. J. RODGER who furnished him with the useful seeds of these *Eucalypts* for his study in 1954, to Dr. M. R. JACOBS, of Australia, and PROF. SHIOYA of Kyushu University who have given him useful literatures on *Eucalypts* that were related with his research in 1956, to the Forestry Agency of Japan that subsidized for his study in 1955, and to PROF. SATO of Kyushu University who has helped his studies in *Eucalypts*.

II. Objects and Methods of Experiment

In Australia, more than 600 species of *Eucalypts* grow and most of them are utilized in various ways. It should be most important for Japan, if *Eucalypt* forests are successfully established in the mountain regions of Japan and the economic significance of it is determined, even if with one species only. Twenty-nine countries of the world, aside from Australia, have already set about the afforestation of *Eucalypts*, and some of them have placed it on a commercial basis. It is the hope of the author that if many species of *Eucalypts* are tested at mountain regions of Japan and promising species are selected and planted at suitable places of mountain areas, the afforestation of *Eucalypts* will prove successful in Japan.

The author carried out the test at Arahira (2.2 acres), Takatsuji (0.5 acre), Shogatani I (0.8 acre), Shogatani II (0.6 acre) in the Kasuya Experimental Forest attached to Kyushu University, and at a heap of coal mine waste outside of the Experimental Forest. Fifteen species of *Eucalypts* planted in these places were *E. cinerea*, *E. dalrympleana*, *E. fastigata*, *E. globulus*, *E. grandis*, *E. gummifera*, *E. maculata*, *E. melliodora*, *E. pauciflora*, *E. pilularis*, *E. punctata*, *E. robusta*, *E. rostrata*, *E. tereticornis* and *E. viminalis*.

A total of 2,457 *Eucalypts* were planted in a period from November 1954 to May 1955.

The climate and topography of each plantation and the physical and chemical properties of the soil were investigated. The Simple Soil Testing Instrument was used in the chemical test. The factors of the chemical examination were pH of the soil, nitrogen, effective phospate, effective potassium and phosphate absorbing power. Further, the damages caused by the cold, the percentage of withered plants, and the average growths of *E. fastigata*, *E. rostrata* and *E. tereticornis* which seemed to be promising were studied, and a review was made of the growths of the three species, with reference to Australian literatures.

III. Results of Experiments

The author investigated for a year the growth of young plants of *Eucalypts* germinated from 15 species of seeds, among which *E. fastigata*, *E. rostrata* and *E. tereticornis* proved promising. The conditions of the plantations and the state of growth of *Eucalypts* in the Kasuya Experimental Forest attached to Kyushu University are treated in this report.

E. fastigata

(A) Latitudes of Plantations

1) Arahira (High Land): 33°37′ N

2) Shogatani I (1st Division): 33°38′ N

(B) Altitudes and Climate

1) Temperatures

Plantation	Altitude	January			July		
		Min.	Max.	Abs. Max.	Min.	Max.	Abs. Max,
	cm	°C	°C	°C	°C	°C	°C
Arahira (HL)	240	0.3	7.9	−3.5	22.2	30.5	33.5
Shogatani I (1D)	61	1.2	8.8	−2.6	23.1	31.4	34.4

2) Rainfall

Average annual precipitation: 1565 mm

Average number of rainy days per year: 155

3) Frost and Snow

Frost: Average number of days per year: 43

Snow: Average number of days per year: 15

(C) Topography and Conditions of Forest before Planting

1) Arahira (HL)

Eastern slope of a higher mountain of 240 m above sea level;

average dip 35°; not very sunny but well-drained. Pine trees and broad-leaved trees had been cut down in 1950, and the land had been covered with grass and shrub before planting. The parent materials are various, but especially hornblende and serpentine are dominant.

2) Shogatani I (1D)

Lower hill of 61 m above sea level, the plantation is a level land on the ridge; sunny and well-drained. This area had been cultivated after pine trees had been cut down in 1950 and therefore, it is relatively fertile. Parent materials are various, but mudstone dominates.

(D) Physical and Chemical Properties of Soils

1) Arahira (HL)

Colour: black or pale black at 0–50 cm in depth. Type of soil: pebble soil. Humus: contained at 0–50 cm in depth. The longitudinal section of soil layer: granular structure with some nodules of hornblende and serpentine. Viscosity of soil is low at 0–20 cm in depth, but high below 20 cm. pH: 4.7 at 0–50 cm in depth. Ammonia-type nitrogen: rather scarce; caustic-type nitrogen: rich. Phosphate absorbing power: strong. Effective phosphate and effective potassium: extremely scarce.

2) Shogatani I (1D)

Colour: dark brown or brown at 0–50 cm in depth. Type of soil: clayey soil with small pebbles of mudstone. Humus: contained at 0–20 cm in depth, but nil below 20 cm. The longitudinal section of soil layer: powdery or granular structure with small pebbles of mudstone. Vicosity of soil: moderate at 0–20 cm in depth and strong at 20–50 cm in depth. pH: 4.3 at 0–50 cm in depth. Ammonia-type nitrogen: rich; caustic-type nitrogen: lacking at 0–50 cm in depth. Phosphate absorbing power: strong. Effective phosphate and effective potassium: extremely scarce.

(E) Growth Habit of *E. fastigata*

1) Damage caused by the cold

No damage was caused by the cold on the young plants of *E. fastigata* at both the plantations of Arahira (HL) and Shogatani I (1D). This species is very strong against the cold in Japan as in Australia.

2) Percentage of Withered Plants in a Year after Planting

The percentages of withered plants of *E. fastigata* were 37.2 % at the plantation of Arahira (HL) and 8 % at Shogatani I (1D). The reason why the percentage was so high at Arahira (HL) does not seem to be connected with the cold, but it seems to be due mainly to the fact that the soil had very little moisture holding ability. Most of these withered young plants were found in the dry season of summer.

3) Growth of *E. fastigata*

Height of tree and diameter near the root

Plantation	Height of tree			Average growth in length	Diameter near root
	Max.	Min.	Mean		
	cm	cm	cm	cm	cm
Arahira (HL)	100.0	6.0	58.8	50.8	0.45
Shogatani I (1D)	179.0	25.0	115.9	107.9	1.83

Remarks: 1. Date of sowing: May 29,1954
2. Date of planting: February 10,1955 / March 9, 1955
3. Date of survey: January 24, 1956

Judging from the data mentioned above, the growth of *E. fastigata* at Arahira Height is slow as compared with that at the lower ground of Shogatani I (1D). The difference of growth seems rather to be due to the difference in the physical characteristics of the soils than to the difference in the altitudes of these plantations in the Kasuya Experimental Forest in Japan, for this species grows well on the heights of low temperatures in Australia.

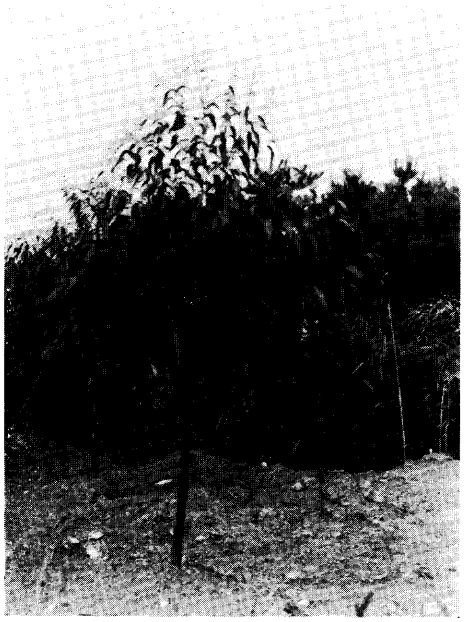

Fig. 1 Growth of *E. fastigata* at Shogatani I
Height of tree: 2.30 m
Diameter near root: 4.2 cm
Photographed on: July 14, 1956

E. rostrata

(A) Latitudes of Plantations

1) Arahira (HL): 33°37′N
2) Arahira (LL): 33°37′N
3) Takatsuji (1D): 33°38′N
4) Shogatani I (3D): 33°38′N
5) Shogatani II (1D): 33°38′N

Notes:
HL—High Land
LL—Low Land
1D—1st Division
3D—3rd Division

(B) Altitudes and Climate

1) Temperatures

Plantation	Altitude	January			July		
		Min.	Max.	Abs. Min.	Min.	Max.	Abs. Max.
	m	°C	°C	°C	°C	°C	°C
Arahira (HL)	240	0.3	7.9	−3.5	22.2	30.5	33.5
Arahira (LL)	110	1.0	8.6	−3.0	22.9	31.2	34.2
Takatsuji (1D)	85	1.1	8.7	−2.7	23.0	31.3	34.3
Shogatani I (3D)	61	1.2	8.8	−2.6	23.1	31.4	34.4
Shogatani II (1D)	70	1.2	8.8	−2.6	23.1	31.4	34.4

2) Rainfall, Frost and Snow

The rainfall, frost and snow at Arahira (LL), Takatsuji (1D) and Shogatani II (1D) are similar to those at Arahira (HL) and Shogatani I as mentioned above.

(C) Topography and Conditions of Forest before Planting

1) Arahira (HL)

As mentioned above.

2) Arahira (LL)

Plain on a hill, 110 m above sea level; this ground is along a mountain stream, and was covered with thick growth of broad-leaved trees a few years before. This ground is of poor drainage and unsunny, but not inundated with water except at the flood time. The parent materials are various and especially the hornblende and serpentine are dominant.

3) Takatsuji (1D)

This area is surrounded by the forest consisting of many pine trees aged 40 years on three sides, east, south and north. This division is a plain on a hill, 85 m above sea level, where bamboos grew thick a few years before. The ground is sufficiently moist, but not flooded. The parent materials are various, but mostly mudstone.

4) Shogatani I (3D)

A slope of lower hill, 61 m above sea level, facing towards east; average dip 15°. Both drainage and sunniness are fairly good. Pine trees and miscanthus grew thick before planting. The parent materials are sedimentary rocks, especially shale and mudstone.

5) Shogatani II (1D)

This plantation is divided into two, the, slope of a lower hill, 70 m above sea level, and the plain on a hill, 60 m above sea level. The former faces north and drains well, but is not very sunny. The latter is sufficiently moist and is flooded in the rainy season. This plantation had been covered with miscanthus before *E. rostrata* was planted. The parent materials are various, but especially sandstone.

(D) Physical and Chemical Properties of Soils

1) Arahira (HL)

As mentioned above.

2) Arahira (LL)

Colour: Black or dark brown at 0–50 cm in depth. Type of soil: clayey soil. Humus: rich at 0–50 cm in depth. The longitudinal section of soil layer: powdery at 0–10 cm in depth and granular structure with some nodules of hornblende and serpentine at 10–50 cm in depth. Viscosity of soil: moderate at 0–10 cm in depth and high below 20 cm.

pH: 5.2 at 0–50 cm in depth. Ammonia-type nitrogen: contained; caustic type nitrogen: lacking. Phosphate absorbing power: fairly strong. Effective phosphate and effective potassium: extremely scarce.

3) Takatsuji (1D)

Colour: dark brown or brown at 0–50 cm. Type of soil: clayey soil. Humus: contained at 0–10 cm in depth and nil at 10–50 cm. Longitudinal section of soil layer: powdery or granular structure with some nodules of mudstone. Viscosity of soil: high.

pH: 4.4 at 0–50 cm in depth. Ammonia type nitrogen: contained at 0–50 cm in depth, and caustic-type nitrogen: contained. Phosphate absorbing power: fairly strong. Effective phosphate: rich at 0–50 cm in depth, and effective potassium: extremely scarce at 0–50 cm in depth.

4) Shogatani I (3D)

Colour: brown at 0–50 cm in depth. Type of soil: clayey soil at 0–50 cm in depth. Humus: lacking at 0–50 cm in depth. Longitudinal section of soil layer: granular structure at 0–50 cm in depth. Viscosity of soil: high. Pebbles in soil: very abundant at 0–30 cm, and pebbly soil at 30–50 cm.

pH: 4.2 at 0–50 cm in depth. Nitrogen: lacking. Phosphate absorbing power: strong. Effective phosphate and effective potassium: extremely scarce at 0–50 cm in depth.

5) Shogatani II (1D)

Colour: dark brown or brown at 0–50 cm in depth. Type of soil: clayey soil or loam. Humus: contained in some degree at 0–50 cm in depth. Longitudinal section of soil layer: granular structure with pebbles of sandstone or mudstone in some degree. Viscosity of soil: high at 0–50 cm in depth.

pH: 5.2 at 0–50 cm in depth. Ammonia- and caustic-type nitrogen: contained at 0–50 cm in depth. Phosphate absorbing power: moderate at 0–50 cm in depth. Effective phosphate and effective potassium: extremely scarce.

(E) Growth Habit of *E. rostrata*

1) Damage Caused by the Cold and Percentage of Withered Plants in a Year after Planting

The percentage of damages by the cold was high, but the damages were only on sprouts and leaves and not on stems. Therefore, no bad effect was caused on the growth of young plants.

The percentage of withered plants was relatively small, and no great difference was found among the growths at various heights of hills and mountain areas.

The damages by the cold and the percentages of withered plants in a year after planting were as follows:

Plantation	Altitude	Percentage of damages on sprouts and leaves	Percentage of withered plants
	m	%	%
Arahira (HL)	240	70	18
Arahira (LL)	110	20	1.8
Takatsuji (1D)	85	60	16.1
Shogatani I (3D)	61	58	10.7
Shogatani II (1D)	70	55	12.8

2) Growth of *E. rostrata*

In Japan there are five plantations of *E. rostrata* in the Kasuya Experimental Forest attached to Kyushu University. The highest plantation is 240 m and the lowest 61 m above sea level. Investigations were made into the climate, topography, conditions of the forest before planting and the characteristics of the soil of these plantations. Judging from the results of the investigations, the growth of *E. rostrata* was generally good at each plantation. This seems to indicate that the planting limit in Japan is as wide as the limit of spontaneous growth of *E. rostrata* in Australia.

The height of trees and the diameter near the root were as follows:

Plantation	Altitude	Height of tree			Average growth in length	Diameter near root.
		Max.	Min.	Mean		
	m	cm	cm	cm	cm	cm
Arahira (HL)	240	121.5	37.0	64.9	60.9	0.5
Arahira (LL)	110	183.0	19.0	94.8	87.8	0.6
Takatsuji (1 D)	85	182.0	20.4	68.5	60.5	0.6
Shogatani I (3 D)	61	118.0	15.0	54.0	46.0	0.6
Shogatani II (1 D)	70	164.3	76.5	106.9	99.9	0.5

Remarks: 1. Date of sowing: August 2, 1954

2. Date of planting: November 1954 March 1955

3. Date of survey: October 1955 November 1955

4. Number of *E. rostrata* surveyed

Arahira (HL): 226
Arahira (LL): 110
Takatsuji (1 D): 101
Shogatani I (3 D): 100
Shogatani II (1 D): 261

Fig. 2 Growth of *E. rostrata* at Takatsuji (1D)
Height of tree: 3.19 m
Diameter ner roaot: 3.2 cm
Photographed on: July 12, 1956

E. tereticornis

(A) Latitudes of Plantation

1) Arahira (HL): 33°37′

2) Takatsuji (3D): 33°38′

(B) Altitudes and Climate

1) Temperatures

As mentioned before.

2) Rainfall, Frost and Snow

As mentioned before.

(C) Topography and Conditions of Forest before Planting

1) Arahira (HL)

As mentioned before.

2) Takatsuji (3D)

Mildly sloped area on the hillside; well-drained. This plot had been farmed until a few years before, and the soil is somewhat fertile. The parent materials are various sedimentary rocks, especially shale and mudstone.

(D) Physical and Chemical Properties of Soils

1) Arahira (HL)

As mentioned before.

2) Takatsuji (3D)

Colour: Dark brown or brown at 0–50 cm in depth. Type of soil: clayey soil. Humus: contained at 0–20 cm in depth. The longitudinal section of soillayer: granular structure with some nodules of shale and mudstone at 0–20 cm in depth. Viscosity of soil: high at 0–50 cm in depth.

pH: 4.4 at 0–50 cm in depth. Ammonia- and caustic-type nitrogen: contained at 0–50 cm in depth. Phosphate absorbing power: strong at 0–50 cm in depth. Effective phosphate and effective potassium: extremely scarce at 0–50 cm in depth.

(E) Growth Habit of *E. tercticornis*

1) Damage Caused by the Cold and Percentage of Withered Plants in a Year after Planting

This species suffered the heaviest damage by the cold among the three species studied. The damages, however, were on the parts of sprouts and leaves and not on the stem, and therefore no harm was done on the growth of the young plants. The percentage of withered plants increases in proportion to the altitudes in the Kasuya Experimental Forest. So this

species is not suitable for planting at high lands in Japan. The damages by the cold and the percentage of withered plants in a year after planting were as follows:

Plantation	Altitude	Percentage of damage by the cold	Percentage of withered plants
	m	%	%
Nursery	50	84.2	1.5
Arahira (HL)	240	94.0	38.5
Takatsuji (3 D)	85	90.0	3.4

2) Growth of *E. tereticornis*

The growth of *E. tereticornis* is poorer in proportion to the height of the plantation, and so the planting of *E. tereticornis* does not seem to succeed at high places in Japan. The growth of *E. tereticornis* was as shown in the following table:

Plantation	altitude	Height of tree			Average growth in lengh	Diameter near root
		Max.	Min.	Mean		
	m	cm	cm	cm	cm	cm
Nursery	50	180.0	120.0	152.0	112.0	2.0
Arahira (HL)	240	95.2	21.0	53.8	26.8	0.5
TaKatsuji (3 D)	85	207.0	20.0	116.7	82.7	1.3

Remarks: 1. Date of sowing: May 2, 1954
2. Date of planting:
Arahira (HL): February 28, 1954
Takatsuji (3 D): November 16, 1954
3. Date of survey: November 10, 1955

IV. Considerations

E. dalrympleana, *E. fastigata*, *E. rostrata* and *E. tereticornis* among the 15 sepcies of *Eucalypts* planted experimentally in mountain and hill regions in Japan seem to be promising for future growing, but *E. dalrympleana* has some points which need further study at higher places. Therefore, studies were made on the climate, topography, type of soil, of the places where the three species, except *E. dalrympleana*, were planted, and further on one year's growth of these species. Considerations are made of the relation between the growth of these species and the conditions of the environment, referring to the Australian literatures.

Fig. 3 Growth of *E. tereticornis* at Takatsuji (3D)

Height of tree: 3.45 m
Diameter near root: 4.6 cm
Photographed on: July 14, 1956

Fig. 4 *E. dalrympleana* is extremely resistant to the cold.

Height of tree: 3.54 m
Diameter near root: 3.4 cm
Photographed on: July 24, 1956
Plantation: Shogatani I

E. fastigata

Comparison of the climatic conditions at the districts in Australia where this species grown naturally and the plantations in the Kasuya Experimental Forest in Japan are made in Table I.

Table I

	Australia		Japan	
	Gurnang (N. S. W)	Crookwell (N. W. W)	Arahira	Shogatani
Latitude	30°S	37°30'S	33°37'N	33°38'N
Altitude	1197 m	882 m	240 m	61 m
Temperature				
Max. in summer	24.0°C	26.0°C	30.5°C	31.4°C
Min. in Wintar	— 2.0°C	— 1.0°C	0.3°C	1.2°C
Painfall				
Mean annual	760 mm	1016 mm	1565 mm	
No. of days	80	120	155	
Frost				
Average no. of days per year	108.9	72.7	43	
Snow				
Average no. of days per year	Occasional snow falls	moderate	15	

Both the maximum temperature in summer and the minimum temperature in winter in Japan are higher than those in Australia, the differences being some 2°C in winter and some 6°C in summer. For each 100 m rise in altitude, the temperature goes down by 0.5 °C. According to this calculation, a temperature fall of 2 °C is equivalent to 400 m rise in altitude; in other words, judging from the minimum temperature, *E. fastigata* can be planted at 640 m above sea lovel. The maximum temperature in summer becomes 28.5 °C at 640 m altitude, and it is 4.0 °C higher than the maximum temperature in Australia. Generally speaking, the amount of rainfall in Japan is greater than that in Australia (Refer to Table I.), and it is supposed that *E. fastigata* can grow at high mountains in Japan, so long as the moisture is held in the soil.

The growth of *E. fastigata* at Arahira (HL) was not so good as at Shogatani I (1D) in the Kasuya Experimental Forest. It is the author's opinion that the main cause of this is the lack of moisture-holding ability of the soil as described before. Since this *E. fastigata* has the strong resistivity against the cold, if suitable places where there is not excessive dryness is selected, it would be possible to make a forest of this species of *Eucalypt* in Japan.

According to the Australian literatures, *E. fastigata*:

1) prefers valleys and slopes of mountain areas, edges of level lands, and elevated hilly regions;
2) prefers south-east aspects where the exposure to the sun is not so oxcessive in summer;
3) prefers loamy soils, especially those resulting from granite, but dislikes sterile clay from sandstone and very heavy clay;
4) requires that the soil is moist but well-drained, and a little clay is contained in it.

If proper attention is paid to the above-mentioned conditions, *E. fastigata* will prove to be one of the useful species of *Eucalypts* that can be raised successfully in mountain regions in Japan.

Note: Chief uses of *E. fashigata*: Light structure and interior finishing materials.

E. rostrata

Though there are differences in the minimum temperature, the amount of rainfall and the number of days of frost and snow in a year between Australia and Japan, the places where *E. rostrata* grows in both the countries have some similarities of the climatic factor. Comparison of the climatic conditions at the places in Australia where this plant grows naturally with those at the plantations in the Kasuya Experimental Forest is made as follows:

Table II

	Australia		Japan	
	Hamilton (V)	Deniliquin (N. S. W)	Arahira	Shogatani
Latitude	15°58′S		33°37′N	33°38′N
Altitude	185 m	93 m	240 m	61 m
Temperature				
Max. in summer	25.5 °C	32.5 °C	30.5 °C	31.4 °C
Min. in winter	4.0 °C	3.5 °C	0.3 °C	1.2 °C
Absolute min.	— 5.0 °C	— 3.0 °C	— 3.5 C	— 2.6 °C
Rainfall				
Mean annual	225–640 mm		1,565 mm	
No. of days	40–150		155	
Frost				
Average no. of days per year	13—4		43	
Snow				
Average no. of days per year	Nil		15	

When the Australian literatures are referred to, *E. rostrata* has some advantages over *E. globulus* and *E. robusta* in planting. The advantages are as follows:

1) *E. rostrata* grows extensively in flooded plains, and exceptionally in South Australia, it grows on the slope of a hill as high as 303 m, or at higher places in Mt. Lofty Ranges and in the Flinders Ranges of South Australia, and in the tropics the species grows at places as high as 606 m.
2) *E. rostrata* forms forests in the savannah.
3) This species is able to fight for its existence and withstand adverse conditions for a long time, and grows thick by the parental tree even in the dry climate.
4) *E. rostrata* grows on poorly drained flats which are wet for several months of the year.
5) In the areas of scanty rainfall, e.g. 200–300 mm, this species grows by flood or by getting much water.
6) *E. rostrata* shows resistance against severe frost in winter, but it grows also in frost-free areas.
7) *E. rostrata* generally grows in the soil with high pH, and it can resist and grow in alkaline soils, too.

The growth of *E. rostrata* in a year after planting was very good at the five plantations in the Kasuya Experimental Forest, and besides, the growth of *E. rostrata* at the Itoda Experimental Plot and the Kuhara Experimental Plot of the Fukuoka Forestry Experimental Station was as good as that in the Kasuya Experimental Forest. The results are tabulated in the following.

(I) Itoda Experimental Plot (Itoda, Tagawa City, Fukuoka Pref.)

(A) General

1) Altitude: 110–120 m

2) Dip and direction: Dip: 3°–9°
Direction: N 40°–45° E

3) Parent material: limestone

4) Soil: clayey soil

5) Temperatures: 25-year average
Max. temperature: 21.4 °C
Min. temperature: 10.7 °C

(B) Growth of *E. rostrata*

Unit: cm

Division	Percentage of withered plants	Height of tree			Diameter near root
		Max.	Min.	Mean	
Not fertilized (tilled)	2.5 %	127.0	28.0	93.0	0.73
Not fertilized (Not tilled)	13.1	112.0	23.0	41.4	0.46

Remarks: Date of planting: October 1954
Date of survey: October 1955

(II) Kuhara Experimental Plot (Kuhara, Kasuyagun, Fukuoka Pref.)

(A) General

1) Altitude: 140–160 m

2) Dip and direction: Dip: 21°–28°
Direction: S 20° E

3) Parent materials: various, especially glimmer slate

4) Soil: loamy soil

5) Temperatures: similar to those at the Kasuya Experimental Forest.

(B) Growth of *E. rostrata*

Division	Percentage of withered plants	Height of tree			Diameter near root
		Max.	Min.	mean	
		cm	cm	cm	cm
Foot of mountain (not fertilized)	5.0 %	141.5	19.0	52.8	0.55
Halfway up mountain (not fertilized)	1.0	158.0	22.0	35.8	0.93

Remarks: Dete of planting: March 29, 1955
Date of survey: Spetember 13, 1955

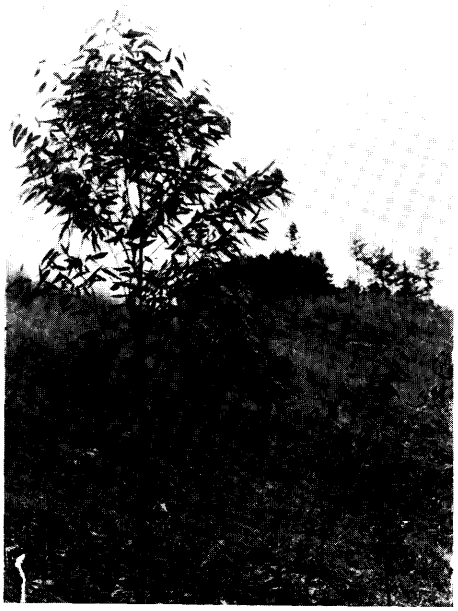

Fig. 5 *E. rostrata* at the Kuhara Experimental Plot attached to the Fukuoka Forestry Experimental Station

Photographed on: May 23, 1956

(III) Coalmine Waste Heap Experimental Plot (Sasaguri Town, Kasuyagun, Fukuoka Pref.)

(A) General

1) Altitude: 50-61 m
2) Dip and direction: Dip: 26°
   Direction: west
3) Parent material: shale
4) Soil: Poor soil dug out from the coal mine
5) Temperatures: similar to those at the Kasuya Experimental Forest.

(B) Growth of *E. rostrata*

1) Manuring: The earth near the root was tilled and manured with solid fertilizer.
2) Percentage of withered plants: Nil
3) Height of tree and diameter near the root

Height of tree			Average growth in length	Diameter near root
Max.	Min.	Mean		
155.0	89.5	120.0	70.8	1.0

Remarks: Date of planting: april—May 1955
Date of survey: November 1955

E. rostrata was the most successful among the 15 species which were planted in the Kasuya Experimental Forest, and also it showed fine growth at the test areas of the Fukuoka Prefectural Forestry Experimental Station and the Coalmine Waste Heap Experimental Plot. The percentage of withered plants of *E.rostrata* was small at mountain areas and *E. rostrata* grows at any place from low land to high altitude, and even in the poorly drained flat land and relatively dry areas. Especially, it can grow generally in comparatively poor soil of high pH. Therefore, it is supposed that *E. rostrata* is the species most suitable to mountain regions of Japan.

Note: Chief uses of *E. rostrata*: Paper pulp, post, timber, fencing, mine timber.

E. tereticornis

As shown by Table III, there are some similarities between the climatic conditions of the natural growth of this species in Australia and those of the plantations in the Kasuya Experimental Forest in Japan.

Table III

	Australia		Japan	
	Taree (N. S. W)	Gympie (Q)	Arahira (HL)	Takatsuji (3D)
Latitude	15 °S	38 °S	33°37 'N	33°38 'N
Altitude	9 m	90 m	240 m	85 m
Temperature				
Max. in sunmmer	29.0 °C	31.0 °C	30.5 °C	31.0 °C
Min. in winter	6.0 °C	5.5 °C	0.3 °C	1.3 °C
Rainfall				
Mean annual	510 mm	1520 mm	1560 mm	
No. of days	60	150	155	
Frost				
Averag no. of days per year	0	3	43	
Snow				
Average no. of days per year	Nil		15	

As mentioned before, the maximum temperature in summer at the Kasuya Experimental Forest in Japan is more or less similar to that in Australia, but the minimum temperature in winter at the former is lower than that of the latter. Therefore, the number of days of frost and snow in a year in Japan is greater than that in Australia. Consequently, at the Kasuya Experimental Forest, young plants of *E. tereticornis* had sprouts and leaves damaged by the cold, but the stems were not damaged, and the growth was good as described before.

The essential conditions of topography and soil for planting *E. tereticornis* in the mountain regions in Japan are, according to the Australian literatures, as follows:

1) In dry inland it grows at the lower slopes of hills, and in Queensland, at mountain slopes and plateaus.
2) Sandy loam and moisture are necessary, but the area must not be water-logged.
3) This species grows in a fairly wide range of good soils, but it dislikes acid soils.
4) The parent materials of soils are various, but the soils originated mostly from sedimentary rocks.
5) Subsoil must be clay; this species does not like dry shallow soils.

The growth of *E. tereticornis* at the Kuhara Experimental Plot attached to the Fukuoka Forestry Experimental Station was as good as that in the Kasuya Experimental Forest. The growth of *E. tereticornis* in the first year was as follows:

Division	Percentage of withered plants	Height of tree			Diameter near root
		Max.	Min.	Mean	
Foot of mountain (not fertilized)	3.0%	138.0	33.0	57.1	0.61
Halfway up mountain (not fertilized)	3.0%	125.0	20.0	63.6	0.12

Remarks: Date of planting: March — April 1955
Date of survey: September 14, 1955

Judging from the above-mentioned, the author believes that if *E. tereticornis* is planted at suitable places of hills lower than 100 m in Fukuoka Prefecture, the afforestation will be successful.

Note: Chief uses of *E. tereticornis*: Heavy structure, building scantling, Piles, mining timber, paving blocks, maul, sleeper and paper pulp.

V. Summary

1) Though all the plantations are of acid soil, the growth of the three species, *E. fastigata*, *E. rostrata* and *E. tereticornis* is good.
2) Even in the soils of mountainous areas and hills where effective phosphate and effective potassium are extremely lacking, the growth of the three species is good, if some nitrogen is contained in the soil.
3) The growth of the three species is good at plantations where the subsoil has some clay, has the moisture holding ability, is well-drained, and is somewhat moist but not water-logged.
4) The growth of the three species is good at plantations where the upper soil layer consists of the powdery structure and the lower soil layer of the granular structure with some nodules of the parent materials.
5) In spite of the minimum temperature of 0.3°C and the absolute minimum temperature of −3.5°C in winter, *E. fastigata* was not damaged by the cold at all, and a part of sprouts and leaves of *E. rostrata* and *E. tereticornis* was injured. Especially, *E. tereticornis* suffered the most damages at the plantation where the minimum temperature was 1.1°C and the absolute minimum temperature −2.7°C in winter. The two species have grown normally, because there was no harm done to the stems.
6) Height of trees and diameter near the root

Species	Plantation	Altiude (m)	Abs. min. temp. (C)	Height of tree			Growth length a year (cm)	inDia. in near root (cm)
				Max. (cm)	Min. (cm)	Mean (cm)		
E. fastigata	Arahira (HL)	240	−3.5°	100	6.0	48.8	50.8	0.45
	Shogatani I	61	−2.6	179	25.0	115.9	107.9	1.85
E. rostrata	Arahira (LL)	110	−3.0	183	19.0	34.8	87.8	0.6
	Takatsuji (1D)	85	−2.7	182	20.4	68.5	60.5	0.6
E. tereticornis	Arahira (HL)	240	−3.5	95.2	21.0	53.8	26.8	0.5
	Takatsuji (3 D)	85	−2.7	207.0	20.0	116.7	82.7	1.3

Remarks: Date of sowing: May—August 1954
Date of planting: November 1954—April 1955
Date of survey: October—November 1955

7) It seems that *E. fastigata* can be planted at high mountain areas over 300 m high above sea level, *E. tereticornis* from the sea-level to 100 m altitude, and *E. rostrata* from the sea-level to 300 m altitude. Especially, *E. rostrata* is the most suitable *Eucalypt* species for planting in mountain regions or hills in Japan.

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Résumé

(El español)

La crecencia de *E. fastigata*, *E. rostrata* y tereticornis de quince especies de eucaliptos que he plantado en Kasuya Experimental Foresta concerniente a Kyushu Universidad me parece a tener el futuro expectable. Por eso, describo sobre la crecencia de las plantas jovenas de tres especies de eucaliptos sobre dichos.

1) Las tierras de las plantaciones y la crecencia de tres especies de eucalipto.

Aunque las plantaciones sean acidas, tres especies de eucaliptos han indicado las buenas. Aún en tal caso de que la tierra de la plantacien carece mucho el fosfato válido y el potasio válide, si la tierra contenga algún nitrógeno, la crecencia de tres especies de eucalipto esté bien.

Si el superior parte del lecho de la tierra consista de la estructura polvera y el bajéro parte consista de la estructura de la granoso con

las pedrejones escasos en arcilla, la tierra puede cargar la humedad, y además es superior por desaguar. Por eso, la crecencia de tres especies de eucaliptos ha indicado generalmente los buenos resultados.

2) La temperatura de las plantaciounes y el daño por el frío.

Aunque la más baja temperatura en invierno de la plantación de *E. fastigata* es-té 0.3 °C y la muchisimo baja temp. −3.5 °C, esta planta apenas es danado por frío. Las maś bajas temps. de dos plantaciones de *E. rostrata* y *E. tereticornis* estén 1.0 °C y 0.3 °C, las muchisimo bajas temps. −2.6 °C y −3.5 °C. En este caso, uno partido de botónes y hojas de estas plantas han recibido el dano por frío, pero como estos troncos no fueron dañado, dos especies pudieron hacer la normal crecencia.

3) Las plantaciones y la percentaje de plantas secas.

La percentaje de plantas secas de *E. fastigata* es 37.2 % en Arahira (tierra alta), 8 % en Shogatani 1, la de *E. rostrata* es 1.8 % en Arahira (tierra baja), 16.1 % en Takatsuji y la de *E. tereticornis* es 38.5 % en Arahira (tierra alta), 3.4 % en Takatsuji.

4) Las plantaciones y el estado de la crecencia.

Especies	Plantacion	Alt. (m)	Más baja temp. en invierno (c)	Muchismo alta temp. en verano (c)	Med. altura de arbol (cm)	Dia. de pro,x. raíz (cm)
E. fastigata	Arahira (t. a)	240	− 3.5 °	33.5 °	58.8	0.45
	Shogatani (I)	61	− 2.6 °	34.4 °	115.9	1.85
E. rostrata	Arahira (t. b)	100	− 3.0 °	34.2 °	34.8	0.6
	Takatsuji	85	− 2.7 °	34.3 °	68.5	0.6
E. tereticornis	Arahira (t. b)	240	− 3.5 °	33.5 °	53.8	0.5
	Takatsuji	85	− 2.7 °	34.3 °	116.7	1.3

Nota:

(1) Cantidad de lluvia: 1565 (mm) (Med. año)
(2) Núm. días lluviales: 156 (por año)
(3) Núm. días de escarcha: 43 (Por año)
(4) Núm. días de nieve: 15 (Por año)
(5) Mesde la siemra: 5,1954 8,1954
(6) Mes de la plantacion: 11,1954 4,1955
(7) Mes de la investigación: 10,1955 11,1955

5) Altitud de la plantación que me parece satisfacer la plantación de tres especies de eucaliptos en japón.

Suponeo que podamos plantar *E. fastigata* sobre montaña alta de más 300 m. *E. teresticornis* sobre altitudes desde nível de mar hasta 100 m y *E. rostrata* desde nível de mar hasta 300 m, y *E. rostrata* sea de tres especies especialmente la más satisfactoria a plantar sobre la montana y la colina en japón.