TARC Report

Comparative Response of Five Lines of *Leucaena leucocephala* to Soil pH

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Introduction

Leucaena growing extensively in a feral state on basic soil of coral origin in the South-Western Islands of Japan seems to be originated from shrubby, low yielding Hawaiian type, and its growing ability in acid soils may be limited[6]. The present experiment aimed at estimating comparative forage value and tolerance to soil acidity of a native and 5 introduced lines of leucaena.

Materials and methods

The experiment (started in May 1981) was done on Red-yellow soil (pH ca. 5.0) of the Ishigaki Island,* using 5 newly introduced lines; K-8, Piracicaba, Campina Grande, Cunningham, Peru, and a line growing in the Ishigaki Island (designated as Ishigaki), at five liming levels (0, 3, 6, 10, and 15 t/ha). Lime was applied at rates increasing from 0 t at one end of the field to 15 t/ha at the other end so as to produce a pH-gradient in the surface 20 cm soil, with two replications with opposite lime gradient directions. In addition, fused phosphate and potassium chloride were applied at 750 and 200 kg/ha, respectively. *Rhizobium* inoculant was supplied from Australia (Arthur & Yates Co. Pty. Ltd.).

After treating the seeds with hot water (80°C)[1] and *Rhizobium* inoculant, each line was seeded in five rows at right angle to the lime gradient, with 40 cm inter-row spaces. The intra-row space was ca. 5 cm.

After 4 months, plant sample was harvested from the center row of each line at the height of 10 cm above the ground surface. The plants were separated into forage (leaves plus green soft portions of stem) and stem fractions.

Total N in the forage fraction was determined by Kjeldahl method and *in vitro* dry matter digestibility (IVDMD) by the modified method of Goto and Minson[5]. Two soil cores (10 cm diameter × 20 cm depth) were taken from the central area of each plot and mixed together to measure soil pH (soil : water= 1 : 1).

Results

Due to an unknown factor, germination of Ishigaki, Cunningham and K-8 was poor in several plots in one of the two pH gradient fields. Therefore, plant data obtained there were omitted for data analysis.

1) Dry matter yield

Fig. 1 shows yield responses to the soil pH of the six lines of leucaena. Although significant increase in total dry matter production due to liming occured in all the lines tested, optimal pH levels for maximizing plant growth varied with lines: Peru, Ishikagi, K-8 and Cunningham recorded the maximum yield at around pH 7 while Piracicaba and Campina Grande at around pH 6.5.

The soil pH range required for higher total

* 24° 25′N, 124° 10′E. Annual mean temperature and rainfall: 23.7°C and 2100 mm

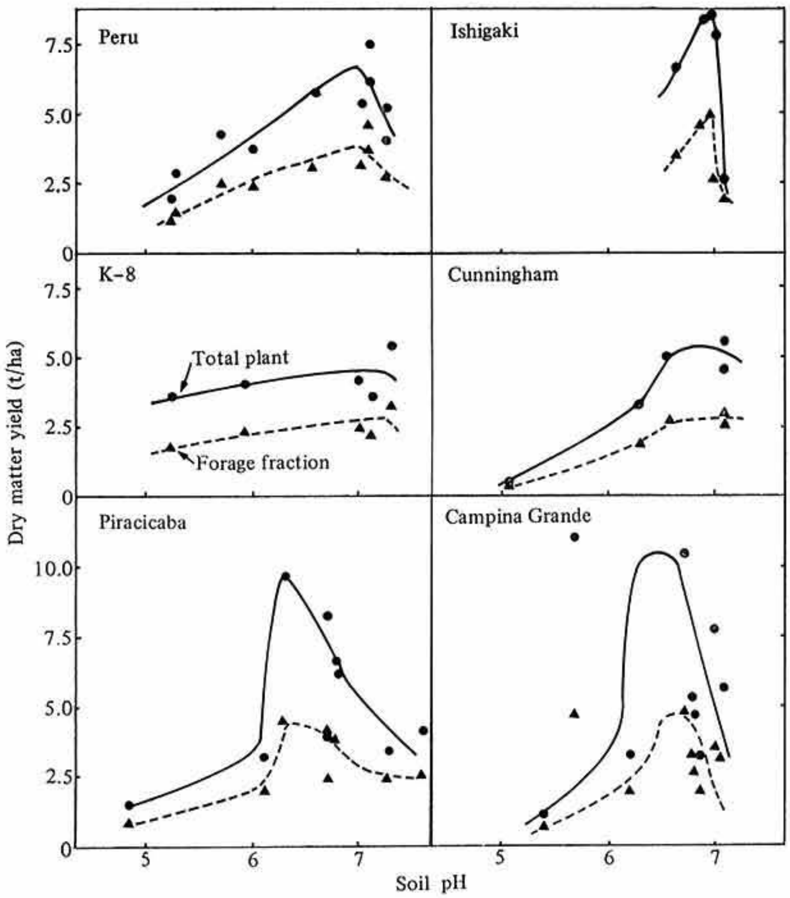

Fig. 1. Responses of total dry matter yield and forage fraction yield against soil pH, four months after sowing

dry matter production appeared to be very narrow in Ishigaki, while it is wide in K-8, and intermediate in others. As compared with other lines, K-8 maintained a higher yield level in lower soil pH, possibly indicating its adaptability to acid soil.

The maximum total dry matter yield at optimal soil pH differed among the lines; higher in Piracicaba and Campina Grande, followed by Ishigaki and Peru and then by K-8 and Cunningham.

The yield of forage fraction paralleled the total dry matter because percent forage fraction was not significantly different among the lines except Campina Grande, which showed somewhat lower value than the others (Table 1).

Table 1. Percent forage fraction of six lines of *Leucaena leucocephla*

Lines of leucaena	Percent forage fraction*
Peru	59.6 ± 4.4
K-8	58.3 ± 5.3
Piracicaba	58.5 ± 7.2
Ishigaki	61.4 ± 9.8
Cunningham	58.1 ± 6.3
Campina Grande	54.5 ± 6.8

* Mean value obtained from plants growing at various soil pH

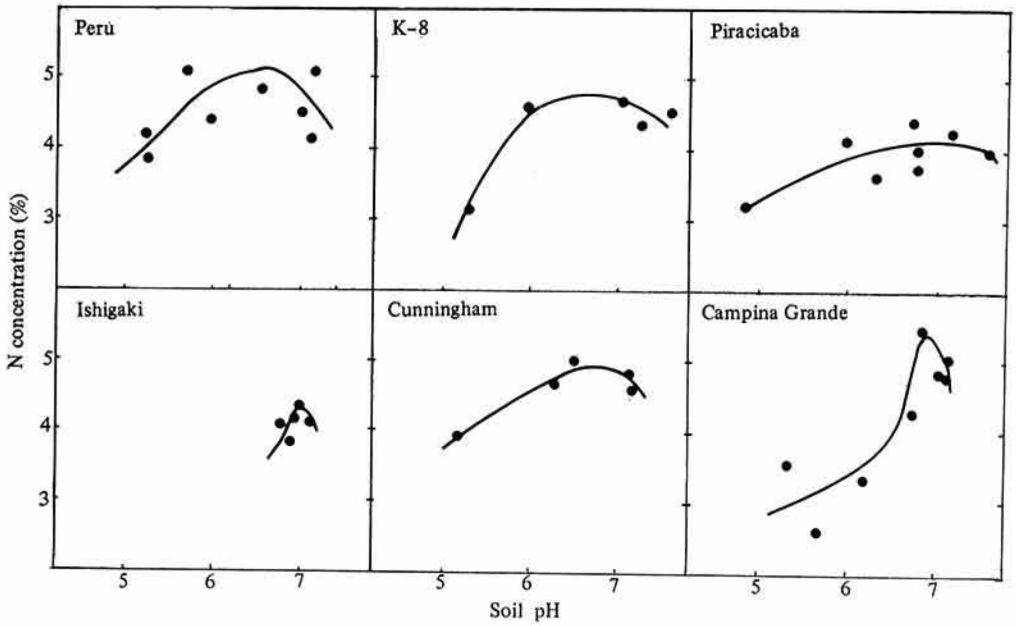

Fig. 2. Percent N in the forage fraction in relation to soil pH

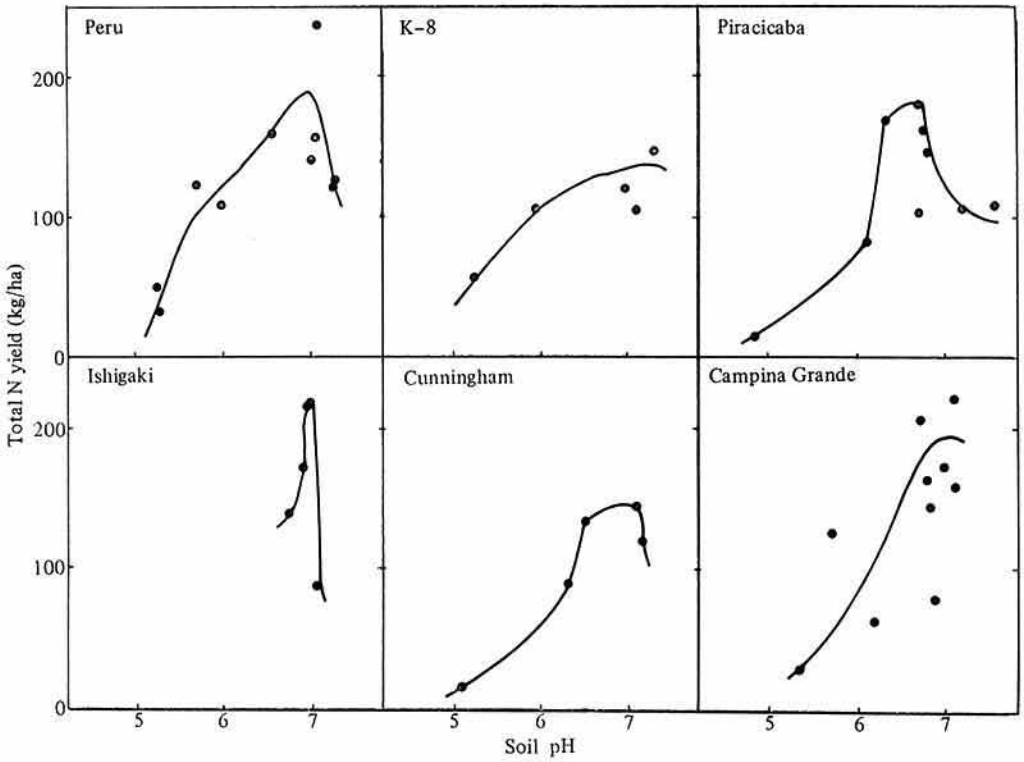

Fig. 3. Response of forage N against soil pH, four months after sowing

Table 2. Yield of digestible dry matter (kg/ha) and *in vitro* dry matter digestibility (%) of the forage fraction of six lines of ***Leucaena leucocephala***

Soil pH *1	Peru *2 *3	Cunningham	Campina Grande	Piracicaba	K-8	Ishigaki *4
5.15 ± 0.18	683.7 (57.9)	222.5 (59.0)	405.0 (50.3)	431.3 (47.8)	970.0 (55.2)	[6.62] 866.3 (52.7)
6.05 ± 0.21	1466.3 (59.6)	1061.3 (56.4)	920.0 (48.6)	1032.5 (52.9)	1216.3 (53.1)	[6.89] 1167.5 (54.9)
6.75 ± 0.17	1713.3 (55.2)	1603.8 (60.2)	920.0 (48.1)	1253.8 (52.8)	1462.5 (58.9)	[6.72] 1225.0 (51.6)
7.10 ± 0.18	1527.5 (56.5)	1800.0 (59.0)	1563.8 (50.0)	2058.8 (53.2)	1626.3 (51.8)	[6.95] 1348.8 (54.7)
7.11 ± 0.05	1731.3 (55.5)	1478.8 (57.6)	1538.8 (57.3)	1368.8 (53.6)	1276.3 (55.6)	[17.05] 505.0 (51.6)
mean IVDMD	(56.1 ± 2.7)	(58.4 ± 1.3)	(51.2 ± 3.4)	(54.0 ± 3.8)	(54.9 ± 2.4)	(53.1 ± 1.4)

*1) Mean ± S.E. Rate of liming aws 0, 3, 6, 10 and 15 ton/ha, in that order from the top
*2) Digestible dry matter
*3) *In vitro* dry matter digestibility (%)
*4) Soil pH in Ishigaki plots shown separately because it was significantly higher than other plots

2) Forage nitrogen

The percent N in the forage fraction (Fig. 2) showed more or less parallel patterns to the response curves of total dry matter yield. This may indicate the main beneficial influence of liming on growth was due to increased biological N_2-fixation.

The percent N tended to be higher in Peru, Cunningham, Campina Grande and K-8 than in Piracicaba and Ishigaki. The higher percent N associated with higher dry matter production made more distinct the differences in total forage nitrogen yield between lower and higher soil pH levels (Fig. 3).

3) Digestible dry matter yields

IVDMD did not change much with soil pH, except a few instances showing lower values probably due to sampling error.

Although IVDMD at each pH level tended to be higher in Peru and Cunningham, intermediate in Piracicaba, K-8, and Ishigaki, and lower in Campina Grande (Table 2), the patterns of digestible dry matter yield of forage fraction appeared to follow the response of total dry matter yield against soil pH.

Discussion

Although percentage and IVDMD of the forage fraction were fairly constant throughout the pH range, total plant production and N concentration in the forage were considerably increased by liming but very heavy liming depressed both parameters.

The increased plant growth and N concentration might have been caused at least partly by an improved N_2-fixation, because suboptimal calcium content in soil is known to reduce N_2-fixation[2] and legume may have the same range of tolerance to liming as expected in a variety of other plants not dependent on N_2-fixation[9].

The depression in plant growth and forage N concentration at very high lime levels might be explained by deficiencies of micronutrients[3,4,10,11] and phosphate[10] induced by heavy liming.

The different values of optimal soil pH for different lines may show the different ability of lines to grow at various soil pH, since they were inoculated with the same *rhizobium* strain.

Percent forage fraction of Ishigaki was a little higher than other lines, because soft, green portion of stems showing lower N concentration and IVDMD than leaves was more included in the forage fraction. Thus, percent N and IVDMD of the forage fraction decreased in Ishigaki. Lower percent forage fraction and lower IVDMD of Campina Grande are supposed to be due to the nature of this line, because N concentration in the forage fraction was not higher than other lines.

Three major soils of agricultural importance in the South-Western islands of Japan are Red-Yellow soils, Reddish-Brown soils of coral origin, and Calcareous Regosols[7,8], showing approximate pH ranges 4.2–5.8, 5.5–7.1 and 6.8–7.5, respectively. Leucaena (Ishigaki) is growing vigorously on a part of Reddish-Brown soils with higher pH, extending on the coastal line, and on Calcareous Regosols but none on Red-Yellow soils of the inner area except road sides which received abundant coral sands. This distribution can be explained by the result of this experiment.

Similarly, Peru, and Cunningham are also considered to be suitable for Calcareous Regosols and a part of Reddish-Brown soils with higher soil pH. As the yield of Ishigaki drops sharply at soil pH above 7.1 and below 6.5 and both N concentration and IVDMD of the forage appeared to be lower, either Peru or Cunningham may be more suitable for forage resources on these soils.

Campina Grande and Piracicaba will express their potential on the most of Reddish-Brown soils having pH value between 6.3 and 6.8. They will grow better than Peru and Cunningham even on Red-Yellow soils without heavy liming. Piracicaba may be better than Campina Grande which has lower percentage and IVDMD of forage.

In spite of relatively lower yield at soil pH above 6, K-8 appeared to be better than other lines at pH below 6, indicating less liming required for its normal growth on Red-Yellow soils. This is particularly important because this type of soil covers about 55% of the total area of South-Western Islands and 90% of it is still waiting for agricultural utilization[10].

Summary

The optimal soil pH for maximizing dry matter yields of leucaena lines was around 6.5 for Piracicaba and Campina Grande, and around 7.0 for Peru, Ishigaki, K-8, and Cumningham.

The range of the optimal soil pH was very narrow for Ishigaki, but contrastingly wide for K-8, indicating its ability to grow well in acid soil.

Both forage N and digestible dry matter yields were in parallel to the dry matter yields as percent N and IVDMD in the forage fraction were not different with the lines tested.

These results indicate that Ishigaki, Peru, and Cunningham are suitable for growing on Calcareous Regosols, Campina Grande and Piracicaba on Reddish Brown soils and K-8 on Red-Yellow soils of the South-Western Islands of Japan.

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