YIELD CHARACTERISTICS IN THREE BRED LINES OF THE LEGUME *LEUCAENA LEUCOCEPHALA*

E. M. HUTTON* AND W. M. BEATTIE†

ABSTRACT

Yield and associated characters in three bred lines of leucaena, Guatemala × Peru (Line 3) and Peru × Hawaii (Lines 5 and 27A), were compared with those of cv. Peru in two experiments at the Lansdown Experiment Station near Townsville.

In the first experiment in a 14-month growing period trees were cut off 15 cm above ground in three complete harvests and the material separated into edible dry matter (EDM) and wood DM. The total EDM yield of Line 3 was 1900 kg/ha which was 27% higher than that of Peru. Mimosine levels were similar in line 3 and Peru.

In the second experiment trees grown undisturbed for 16 months were plucked for edible material in 5 harvest periods during the subsequent 12 months. Total EDM production of line 3 was 7840 kg/ha which was 49% greater than that of Peru.

The study showed that increased EDM production in leucaena was obtained by breeding. This was associated with greater wood production but it is necessary to retain a well branched habit as found in Peru.

INTRODUCTION

Leucaena (*L. leucocephala*) is one of the most promising tropical grazing legumes (Hutton 1970) in spite of its tree-like habit and difficulties it can cause in cattle and other animals because of its mimosine content (Hegarty *et al.* 1964). On well-drained soils in environments ranging from the wet tropics to the drier tropics and sub-tropics, it can provide palatable high protein forage throughout the year and give high levels of milk production (Stobbs 1972) and liveweight gain (Jones 1973) in grazing cattle. Peru and El Salvador are the two leucaena cultivars available in Australia, and of these Peru is preferred because of its higher yield of edible dry matter (Hutton and Bonner 1960).

A study of the main leucaena introductions available in Australia defined the differences between them and showed they were self-pollinated (Hutton and Gray 1959). The Hawaii type is relatively short and bushy, early flowering and low yielding; the taller types are late flowering and high yielding, and those like Guatemala have sparse basal branching and those like Peru strong basal branching. A breeding programme to combine high branching density and high forage yield was initiated in 1956-57 at the CSIRO Samford Pasture Research Station (an. rainfall 1034 mm) in the subtropics of southern Queensland. The inheritance patterns in characters involved in yield have been reported by Gray (1967a, b, c) who found that erect habit was dominant over bushy habit and absence of strong basal branching was dominant over its presence. In this work, agronomic assessment and selection for yield in the progenies commenced principally in the F_4 generation.

The research on Gray's bred lines was transferred from Samford to the CSIRO Lansdown Research Station in the dry tropics near Townsville, Queensland (Lat. 19.5°S) because repeated frosting at Samford in the dry season prevented adequate expression of differences in yield and other characters. In three preliminary trials planted from 1967 to 1970 at Lansdown a comparative study of yield and branching was made in 28 of the bred lines and the parents. This enabled selection of three bred

* C.S.I.R.O., Division of Tropical Crops and Pastures, Cunningham Laboratory, Mill Road, St. Lucia, Qld. 4067.

† C.S.I.R.O., Division of Tropical Crops and Pastures, Davies Laboratory, Private Bag, Townsville, Qld. 4810.

lines with apparently superior forage yield. The studies reported in this paper concern two experiments comparing these 3 elite lines and Peru. The aim was to evaluate yielding ability and associated characters and assess whether breeding had resulted in any new leucaena line agronomically superior to Peru.

MATERIALS AND METHODS

The leucaena lines used in this study included the control cv. Peru and three bred lines viz. Guatemala × Peru-Line 3 (F_4) and Peru × Hawaii-Lines 5 (F_5) and 27A (F_7); by the F_4 generation selections had a high degree of stability. The experimental area was established in January 1971 on a yellow-red podzolic soil (Northcote Dy/Dr 3.42) at the CSIRO Lansdown Research Station near Townsville, and the work continued until June 1973. During the experiments the annual rainfall at the site was 1018 mm in 1971, 1339 mm in 1972 and 930 mm in 1973 with distribution as shown in Table 1. The area received 375 kg superphosphate/ha at establishment and an annual maintenance application of 125 kg/ha of molybdenized superphosphate. Biloela buffel grass was used as the associate species and was sown between the rows of young trees 6 weeks after transplanting.

Leucaena seeds were immersed in hot water at 80°C for 4 minutes to overcome hardseededness. After inoculation with Rhizobium strain CB81, the seed was planted in peat jiffy pots and the seedlings grown until ready for the field. The seedlings were transplanted 0.5 m apart within rows 2.0 m apart and the rows of each line extended the length of the experimental area. There were 4 randomized replicates of each of the 4 lines, a replicate consisting of two rows each of 96 trees. With guard rows there was a total of 3264 trees in the experimental area which occupied 0.32 ha. The area was used for two experiments, the first involving complete harvesting of trees, and the second plucking edible material from the framework of established trees. To cope with possible high tree to tree variation from environmental factors, a relatively large number of trees were sampled and in the second experiment two tree blocks were selected and each harvested separately in a harvest period.

(1) *Experiment* 1: *Complete harvests of trees cut* 15 *cm above ground*

In the first experiment two separate blocks of 12 trees were selected in each row at a predetermined randomized position which was the same in all rows of the area. At the start of the experiment trees averaged 1 m high. The selected blocks were harvested in September and December 1971, and again in March 1972. For these harvests a replicate of a line consisted of 48 trees. At a harvest, the edible material usually eaten by cattle viz. (a) Leaf and stem (up to 6 mm diam.) and (b) Green pods, was plucked off each tree to obtain dry matter yields and the crude protein and phosphorus contents. Then on each tree, the main stem length was measured from ground level to the top and the number of branches counted. Finally, the selected blocks of trees were cut off at a height of 15 cm above ground and all the woody material harvested and oven dried. At the end of this experiment, which involved a growing time of 14 months, the trees regrew vigorously and developed a typical framework.

(2) *Experiment* 2: *Harvests of edible material from framework of uncut trees*

In the second experiment, another two sets of blocks of 12 trees were selected in the uncut trees of each row at a predetermined randomized position similar in all rows. At this stage the trees averaged 2 m high and their growth had been uninterrupted for 16 months. In the subsequent 12 months the edible material viz. leaf-stem and green pods was then plucked off the blocks of trees during 5 harvest periods. The harvest periods, separated by intervals of a month, were May-June 1972, August-September 1972, November-December 1972, February-March 1973, and May-June 1973. In each row the first block of trees was harvested at the beginning of a period and the second at the end of the particular period. The mean EDM yields for the

TABLE 1

Monthly rainfall Lansdown Research Station during the experimental period.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
1971	99	199	140	47	15	32	12	53	—	57	37	327	1018
1972	886	168	226	—	9	25	—	—	—	—	18	7	1339
1973	195	110	169	27	—	8	—	4	66	43	54	254	930

Mean rainfall—864 mm.

different harvest periods were used for the comparative results in Fig. 2. This experiment covered a total growing time of 2½ years.

RESULTS

(1) *Experiment* 1

(*a*) *EDM and Wood DM production*

Figure 1 presents the mean yields of edible dry matter (EDM) and wood dry matter. Yield differences were significant at the March 1972 harvest and in total dry matter. Green pods contributed to the EDM only at the September 1971 harvest. As the experiment was planted in January 1971 a growing time of about 14 months with above average rainfall (vide Table 1) was involved. The dry season September and December 1971 harvests were small compared with the wet season harvest in March 1972.

At the March 1972 harvest, EDM production of lines 3 and 27A was significantly greater than that of line 5 and Peru. Total EDM yields followed a similar pattern, line 3 (1900 kg/ha) exceeding Peru (1500 kg/ha) by 27%.

Wood DM yields of the March 1972 harvest and the totals followed similar trends. In March 1972 line 27A had a wood yield similar to that of line 3, and both had significantly greater yields than line 5 and Peru. Total wood yield of line 27A was 2020 kg/ha, similar to that of line 3, and their total yields were significantly greater than those of line 5 and the lowest yielder Peru with 1480 kg/ha.

The mean for height of the main stem was 1.1 metres, for the number of branches per tree 5.5, and for the EDM:wood DM ratio 1:1.1 with no significant difference in these values between the bred lines and Peru. However line 3 and 27A tended to be the tallest and Peru tended to have the highest proportion of EDM to wood DM.

(*b*) *Chemical analysis of EDM*

The mean value for crude protein was 22.3% and that for phosphorus 0.22% with no significant difference between the bred lines and Peru. The crude protein is overestimated by about 3% because of the mimosine content of the EDM. There have been no real differences in mimosine levels between the bred lines and Peru whether the trees were being harvested completely or by plucking. Line 3 and Peru have been analysed at different times during the year and their mimosine levels were similar and varied from 13% to 16% (Hegarty, pers. comm.).

(2) *Experiment* 2

Fig. 2 shows the EDM yields for 5 harvests periods and the total EDM yields. The EDM obtained would have been available to mature cattle as at the start of the experiment the trees averaged 2 m high and at the end had not increased significantly in height. Significant differences were obtained in EDM yields for the harvest periods May-June 1972, February-March 1973, and May-June 1973 and also in total EDM production. Green pod EDM contributed only to the first and fourth harvest periods. The relatively high EDM yield for the first period tended to reflect accumulated summer herbage rather than that grown in the dry conditions of April-June 1972 (vide Table 1).

As shown in Fig. 2 the ranking order of lines for yield in the first and fourth harvest periods and in total EDM is 3 >27A >5 >Peru with most yield differences being significant. Line 3 was consistently and significantly the highest yielder even at the fifth harvest. The total EDM production by line 3 of 7840 kg/ha was 49% higher than Peru's 5250 kg/ha.

DISCUSSION

The breeding programme cited in this paper is the only one which has aimed at increasing EDM in *L. leucocephala*. It was successful as evidenced by the results of our experiments in north Queensland's dry tropics with three bred lines, which in

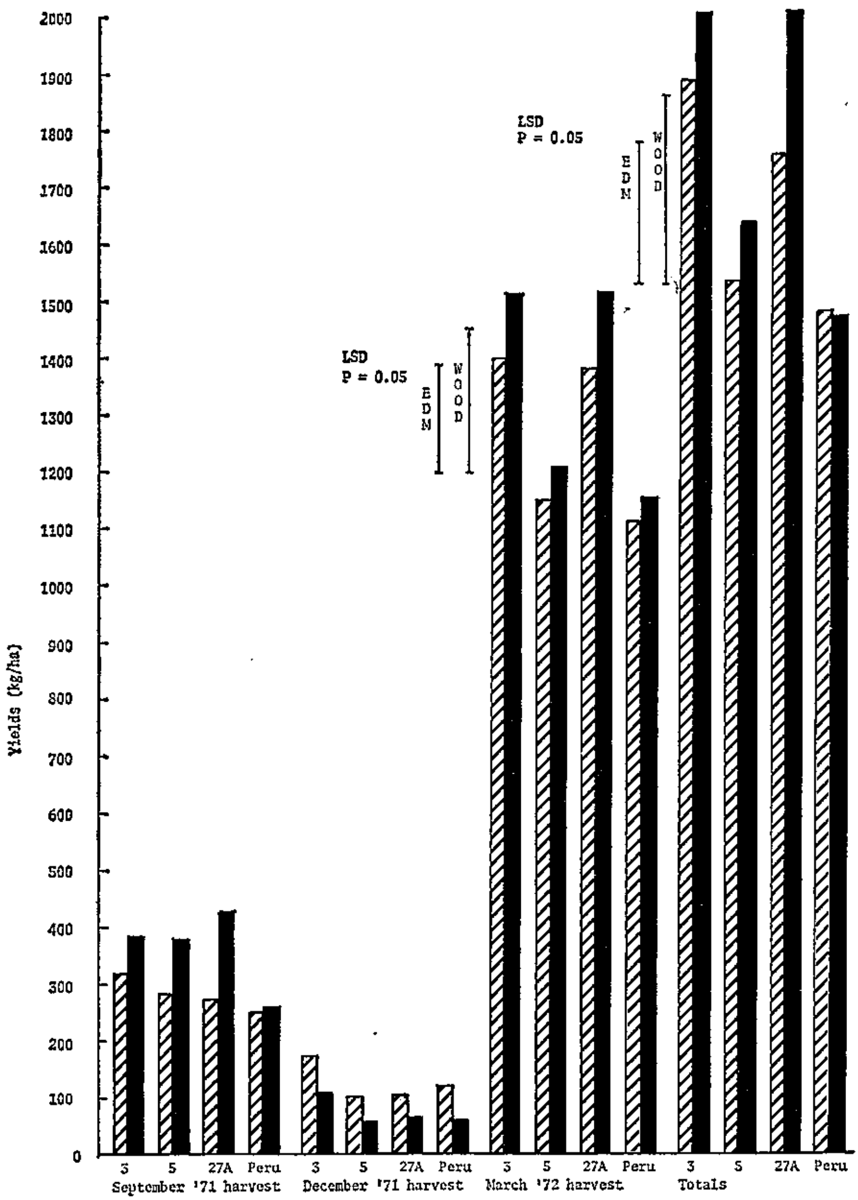

FIGURE 1

Mean yields of EDM (▨) and wood DM (■) of 3 bred lines of Leucaena and cv. Peru at 3 harvests in which trees were cut 15 cm above ground.

preliminary trials, had higher potential yields of EDM than any of the three parents. Line 3 was consistently more productive than cv. Peru, being significantly better in those harvests when growth was most active and having more potential than Peru to provide some green high protein cattle forage in the dry season from May onwards (vide Fig. 2). Line 3's total EDM production from uncut trees of 7840 kg/ha was 49% greater than Peru's yield and can be considered very satisfactory in the Lansdown environment. On a 12 months basis (2nd to 5th harvest periods incl., Fig. 2) EDM yield of uncut trees was 5460 kg/ha for line 3 and 3820 kg/ha for Peru; Peru gave 3 times more EDM than this at Samford (Hutton and Bonner 1960). Line 3 has shown superiority over Peru at Samford (R. J. Jones, pers. comm.) and in other environments. It is apparent that Line 3 can be considered as an alternative to Peru so is being registered as cv. Cunningham with a view to its release for commercial use. Of the other two bred lines, 27A was almost as productive as 3 and usually gave significantly higher EDM yields than Peru.

Comparison of the results in Figs. 1 and 2 (which were obtained in different periods) indicates that in the Lansdown environment with a long dry season (Table 1) complete harvesting is a severe process and could markedly reduce EDM yields. Plucking forage from intact tree frameworks gave almost three times more annual EDM production than complete harvests but this difference is exaggerated as the intact trees were almost a year older than those completely harvested. In Hawaii with

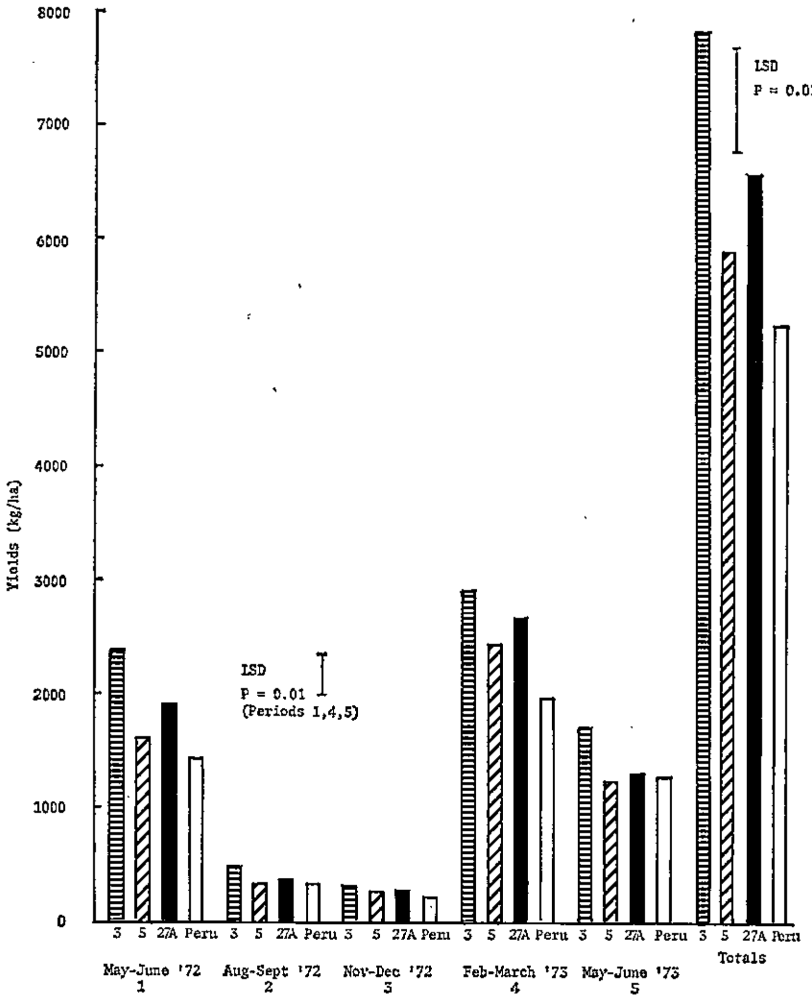

FIGURE 2

Mean yields of EDM of 3 bred lines of Leucaena and cv. Peru from plucking uncut trees in 5 harvest periods.

a favourable tropical climate and annual rainfall of 1500 mm, Takahashi and Ripperton (1949) obtained annual forage dry matter yields of 20,000-22,000 kg/ha from Leucaena with a series of complete harvests in which plots were cut 8 cm from the ground.

In the trees subjected to severe and complete harvesting relatively high levels of crude protein and phosphorus were maintained in the EDM of the bred lines and Peru. This augurs well for the nutrition of cattle grazing intact trees subjected to less stress. There was no difference in mimosine levels between the bred lines and Peru whether the trees were harvested completely or by plucking. It is apparent that low mimosine levels in commercial cultivars of *L. leucocephala* will only be achieved by a different approach to breeding such as the use of interspecific crossing (Gonzalez *et al.* 1967).

Among leucaena lines wood DM yields can be regarded as an index of vigour and these tended to follow a similar pattern to EDM yields (Fig. 1). Without a substantial woody framework a leucaena line would not have the potential to produce large numbers of buds and high yields of EDM. At the March 1972 harvest and in total (Fig. 1), lines 3 and 27A gave significantly the highest wood DM yields and 5 and Peru the lowest. On the basis of total yields, the production of EDM relative to wood tended to be more efficient in 3 than in 27A with Peru the most efficient. As indicated, there was no significant difference between the bred lines and Peru in number of branches per tree although 3 and 27A tended to be the tallest. It seems that to breed leucaena lines with higher yields of EDM than Peru it is necessary to combine a well-branched habit like Peru with more woody growth. Yield of EDM would also be increased if it were possible to incorporate more efficient production of EDM relative to wood in new bred lines.

The results from our study show that increased EDM in leucaena is possible by breeding. Gray's programme (Gray 1967a, b, c) gave bred lines like 3 which combined the vigour and high wood production of Guatemala with the branching habit and leafiness of Peru. Since these ecotypes originated from geographically separated areas, it is likely that new gene interactions leading to transgressive segregates with increased vigour (Verne 1964) could have been involved in this cross.

ACKNOWLEDGEMENTS

Thanks are due to Mr. S. G. Gray (formerly of this Division) for breeding the leucaena lines used in this study and Mr. J. B. F. Field (Division of Mathematics and Statistics) for the statistical analysis of the results.

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