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FORAGE PRODUCTION OF SOME LESSER-KNOWN LEUCAENA SPECIES GROWN ON ACID SOIL

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ABSTRACT

Leucaena leucocephala leaves are nutritious and palatable for ruminants. However, the plant is poorly adapted on acid soil, water logged, and susceptible to psyllid (*Heteropsylla cubana*). Leucaena favours soils with pH >5. It performs best on calcareous soils. This study aimed to evaluate adaptability of several *Leucaena* species on acid soils. The study was conducted at the experimental field in Ciawi, Bogor, altitude 500 m above sea level, rainfall 1500-2000 mm year^{-1}, on Latosol soil with pH 5.2. *Leucaena* species evaluated were *L. leucocephala* K28, *L. leucocephala* (local type), *Leucaena* KX2 hybrid, *L. collinsii*, *L. trichandra*, and *L. diversifolia*. Experiment was designed in a randomized complete block, four replications. All the seedlings were grown in the nursery for 2.5 months before being transplanted to the field. The plants were grown in row plots of 5 m x 1 m with planting distance 0.5 m and spacing between row plot was 3 m. One unit replicate was 5 m x 21 m. In wet season, the plants were pruned at 50 cm height every 3 months, whilst in dry season pruning was done every 5 months. Parameter measured were plant regrowth and forage production (edible part and non-edible part of the plant), as well as N and P content of the edible part. The result showed that *Leucaena* KX2 hybrid was superior to other leucaenas. Regrowth of KX2 hybrid was the fastest and produced highest forage. The highest fresh weight forage production for 1 year (four times harvests), i.e. 33.93 t ha^{-1} year^{-1} equal to 12.48 t ha^{-1} year^{-1} of dry weight, was obtained from *Leucaena* KX2 hybrid, whereas the lowest was produced by *L. diversifolia*, i.e. 3.12 t ha^{-1} year^{-1} of fresh weight or 1.01 t ha^{-1} year^{-1} of dry weight. Production of non-edible part followed the pattern of production of edible part. N and P content in the edible part of all *Leucaena* species did not show any significant difference except for *L. trichandra* which contained the lowest. This study implies that *Leucaena* KX2 hybrid is adaptable to acid soil; therefore it can be grown in wider areas throughout Indonesia.

[***Keywords***: Leucaena, forage production, acid soils]

INTRODUCTION

Leucaena leucocephala is a multipurpose tree legume, originally from Central America and Mexico. The plant is the most productive tree legume species, especially in tropical area. *L. leucocephala* was introduced to Indonesia in the 18th century, in the forest gardens of Java. It was traditionally used as source of fuel wood and forage (Wiersum 1982).

As forage, leaves of *L. leucocephala* are very palatable for animal especially ruminants, have high biomass productivity and digestibility, and contain high crude protein and mineral (Jones 1979). The plant contains low crude fiber and tannin which promotes protein by-pass. Leucaena used as feed supplement with basal diet grass and waste of agricultural product will increase animal intake and improve digestibility (Norton 1994).

Leucaena species contain many secondary plant metabolites (Lowry *et al*. 1984), one of them which affects nutritive value is mimosine. Mimosine may be metabolized to DHP (3-hydroxy-4 (1H)-pyridone) in leaf tissue and in the rumen. In ruminants adapted to leucaena consumption, specialised rumen bacteria may degrade DHP further to harmless compound. Therefore it is possible to inoculate ruminants with DHP degrading organisms to overcome mimosine toxic effects (Jones and Lowry 1984; Panhwar 2005).

Amongst other constraints, *L. leucocephala* is poorly adapted on acid soil, cool temperature and frost, water logged, and susceptible to psyllid (*Heteropsylla cubana*) attack. The psyllid outbreak in 1986 in eastern parts of Indonesia, especially in Amarasi, East Nusa Tenggara damaged significant loss to the plant which caused great stress on the cattle fattening system. Psyllid reduced leucaena productivity by 25-50% (Piggin and Parera 1987). In Amarasi, cattle are prominently tethered and fed under a cut and carry system based on *L. leucocephala* as forage. Therefore, cattle productivity is very high and the cattle industry has the potential to be sustainable.

Many efforts have been done to overcome the psyllid problems such as by introducing psyllid predator, selection and hybridization of *L. leucocephala* resistant to psyllid, and selection of *Leucaen*a adaptable to cool temperature and acid soil. The first notable interspecific hybrids were reported from hybridization of *L. leucocephala* x *L. pulverulenta* in Indonesia (Sorensson *et al*. 1994). This interspecific hybrid formed as a result of cross-pollination by bees. However, the hybrid was low seed production and susceptible to psyllid. Significant

finding was shown by *Leucaena* KX2 hybrid which was produced from hybridization between *L. leucocephala* and *L. pallida*, where *L. pallida* was highly resistant to psyllid and have high seedling vigor (Sorensson 1995) and faster seedling establishment (Sorensson *et al*. 1994). A new cultivar (*L. leucocephala* cv Tarramba) and the *Leucaena* KX2 hybrid have been introduced to West Timor to overcome the psyllid problem (Nulik *et al*. 2004), since the KX2 hybrid has consistently outyielded than others, and cultivar Tarramba was second best leucaena in producing forages after KX2 hybrid. As additional information, so far a seed production orchard has been established at Naibonat, East Nusa Tenggara (University of Queensland 2003). Some farmers have been planted cultivar Tarramba for commercial seed production (pers. comm. and author observation). The experiment was aimed to study the adaptability of several lesser-known *Leucaena* spesies on acid soil.

MATERIALS AND METHODS

An experiment was conducted at the experimental field of the Indonesian Animal Production Research Institute, Ciawi, Bogor. The soil is Latosol with soil pH 5-2, rainfall 1500-2000 mm year^{-1} (Table 1), and altitude of the site is 500 m above sea level. Six species of Leucaena evaluated were *Leucaena leucocephala* K28, *L. leucocephala* (local type), *Leucaena* KX2 hybrid, *L. collinsii*, *L. trichandra*, and *L. diversifolia*. Experiment was designed in randomized complete block, and each treatment was replicated four times. One unit replicate was 5 m x 21 m.

All the seedlings were grown in the nursery for 2.5 months before being transplanted to the field. The plants were grown in row plots of 5 m with planting distance within row 0.5 m and spacing between row plots was 3 m. In wet season, the plants were pruned at 50 cm height every 3 months, whilst in dry season pruning was done every 5 months. Parameter measured were plant regrowth and forage production (edible part and non-edible part of the plant). N and P content of the edible part was analysed by autoanalyzer. Population of plant per ha was 6667, therefore the production of forage per ha was population of plant x production of forage per plant.

RESULTS AND DISCUSSION

Plant Growth

The early plant height was measured at establishment period and their regrowth at harvest time (Table 2). The result showed that *Leucaena* KX2 hybrid had the fastest establishment compared to other leucaenas. This KX2 hybrid was resulted from hibridisation of *L. leucocephala* K636 dan *L. pallida* K748. The main reason for making interspecific hibridisation is to transfer useful genes from one species to another species that lack of those genes. The faster regrowth of KX2 hybrid could have been taken from *L. pallida* character, as *L. leucocephala* have very slow establishment, while *L. pallida* is known to have high seedling vigor (Sorensson *et al*. 1994) and high resistance to psyllid. This character will have strong affect on the ability and speed of its regrowth. Regrowth of KX2 hybrid is consistently faster than other species of *Leucaena* during the experiment.

Forage Production

Forage production of six *Leucaena* varied and this variation occurred during the experiment. At the first

Table 1. Monthly rainfall and number of raining days at Ciawi experiment garden field, Bogor, West Java.

Month	2002		2003		2004	
	Rainfall (mm)	Number of raining days	Rainfall (mm)	Number of raining days	Rainfall (mm)	Number of raining days
January	769	28	168	133	633	22
February	408	24	571	25	470	26
March	427	24	204	18	277	18
April	323	17	343	16	345	16
May	334	11	255	13	372	16
June	119	9	56	9	69	5
July	284	11	43	2	124	10
August	123	5	385	7	1	1
September	62	5	361	11	224	19
October	182	7	467	20	240	15
November	316	17	267	16	480	24
December	246	11	517	26	311	18

Table 2. Average of early plant height and regrowth of six *Leucaena* species grown on acid soil, Ciawi experimental field, Bogor, West Java.

Species	Plant height before harvest period (cm) at 10-month old	Regrowth (cm) after harvest			
		Harvest 1	Harvest 2	Harvest 3	Harvest 4
L. leucocephala K28	125.84	113.20	94.27	46.69	70.00
L. leucocephala	103.63	107.32	73.85	43.51	78.05
L. leucocephala KX2 hybrid	301.04	263.75	204.02	223.13	255.96
L. collinsii	154.00	117.50	61.53	47.96	78.83
L. trichandra	152.71	104.50	88.64	38.33	88.33
L. diversifolia	116.29	73.47	60.13	13.84	41.55

harvest, *Leucaena* KX2 hybrid produced significantly the highest fresh and dry edible (forage) which was 888.33 g per tree equivalent to 5.92 t^{-1} ha^{-1} of fresh weight. The lowest production was obtained by *L. diversifolia* (112.19 g per $tree^{-1}$ equivalent to 0.75 t ha^{-1} fresh weight) and *L. leucocephala* (113.21 g per tree equivalent to 0.75 t ha^{-1}), but those two species were not significantly different with *L. leucocephala* K28, *L. collinsii* and *L. trichandra* (Table 3). At the second harvest, forage production increased for all leucaenas, but the highest production which was 1433 g per tree equivalent to 9.55 t ha^{-1} was from *Leucaena* KX2 hybrid (Table 4).

Even though production of *Leucaena* KX2 hybrid decreased after each harvest, the plant produced the highest forage production compared to other. The lowest forage production was consistently obtained by *L. diversifolia* (Table 5).

Forage production of *L. trichandra* increased about 50% but it was not significantly different with *L. leucocephala* K28, *L. leucocephala,* and *L. collinsii*. *Leucaena* KX2 hybrid still significantly produced the highest forage. Production of all species, except *Leucaena* KX2 hybrid declined at fourth harvest (Table 6). This was due to seasonal reason, coincided with dry season (Table 1) as the fourth harvest was done in October 2003. In fact at fourth harvest, the cutting interval was longer which was 5 months (Table 7). The result indicates high adaptability of *Leucaena* KX2 hybrid in dry season. Therefore, the

Table 3. Average forage production of six *Leucaena* species at 10-month old.

Species	Forage production[1]			
	Fresh weight		Dry weight	
	g $tree^{-1}$	t ha^{-1}	g $tree^{-1}$	t ha^{-1}
L. leucocephala K28	148.87b	0.99	50.94b	0.34
L. leucecephala	113.21b	0.75	43.34b	0.29
Leucaena KX2 hybrid	888.33a	5.92	349.12a	2.33
L. collinsii	166.50b	1.11	59.77b	0.40
L. trichandra	195.70b	1.30	73.98b	0.49
L. diversifolia	112.19b	0.75	37.41b	0.25

[1]Plant population was 6667 plant ha^{-1} (planting space 0.5 m x 30 m).

Numbers in the same column followed with the same letter are not significantly different at P<0.05.

Table 4. Average forage production of six *Leucaena* species at 13.5-month-old.

Species	Forage production			
	Fresh weight		Dry weight	
	g $tree^{-1}$	t ha^{-1}	g $tree^{-1}$	t ha^{-1}
L. leucocephala K28	166.44b	1.11	47.97b	0.32
L. leucecephala	238.81b	1.59	71.26b	0.47
Leucaena KX2 hybrid	1433.00	9.55	511.32a	3.41
L. collinsii	268.50b	1.79	89.67b	0.60
L. trichandra	267.50b	1.78	96.12b	0.64
L. diversifolia	155.07b	1.03	51.03b	0.34

Numbers in the same column followed with the same letter are not significantly different at P<0.05.

Table 5. Average forage production of six *Leucaena* species at 16.5-month old.

Species	Forage production			
	Fresh weight		Dry weight	
	g $tree^{-1}$	t ha^{-1}	g $tree^{-1}$	t ha^{-1}
L. leucocephala K28	222.39bc	1.48	69.23bc	0.46
L. leucecephala	212.98bc	1.42	51.79bc	0.34
Leucaena KX2 hybrid	1240.18a	8.27	431.58a	2.88
L. collinsii	229.75bc	1.53	63.00bc	0.42
L. trichandra	445.00b	2.97	175.66bb	1.17
L. diversifolia	158.15c	1.05	46.37c	0.31

Numbers in the same column followed with the same letter are not significantly different at P<0.05.

Table 6. Average forage production of six *Leucaena* species at 21.5-month old.

Species	Forage production			
	Fresh weight		Dry weight	
	g tree^{-1}	t ha^{-1}	g tree^{-1}	t ha^{-1}
L. leucocephala K28	117.50	0.78	46.41	0.31
L. leucecephala	146.43	0.98	48.92	0.33
Leucaena KX2 hybrid	1528.04	10.19	579.15	3.86
L. collinsii	108.96	0.73	43.69	0.29
L. trichandra	286.67	1.91	113.81	0.76
L. diversifolia	43.49	0.29	16.38	0.11

Table 7. Average forage production of six *Leucaena* species at 26.5-month old.

Species	Forage production			
	Fresh weight		Dry weight	
	g tree^{-1}	t ha^{-1}	g tree^{-1}	t ha^{-1}
L. leucocephala K28	117.31c	0.78	46.34c	0.31
L. leucecephala	122.81c	0.82	41.02c	0.27
Leucaena KX2 hybrid	1633.70a	10.89	550.90a	3.67
L. collinsii	106.58c	0.71	42.74c	0.28
L. trichandra	610.83b	4.07	242.50b	1.62
L. diversifolia	100.37c	0.67	37.84c	0.25

Numbers in the same column followed with the same letter are not significantly different at P<0.05.

plant may be suitable to be developed in eastern parts of Indonesia which have drier climate condition. Table 7 shows the forage production at fifth harvest, which was the third year of the experiment. *Leucaena* KX2 hybrid still produced the highest forage compared to other species of *Leucaena*.

Figure 1 shows the fluctuation of forage dry weight from first to fifth harvest. In general, *Leucaena* KX2 hybrid produced 5-10 times forage than the other species (Table 8), which means that this cultivar is the most superior.

The significantly highest forage production during 1 year period (two seasons or first to fourth harvest) was obtained by *Leucaena* KX2 hybrid which was 33.93 t ha^{-1} of fresh weight or 12.48 t ha^{-1} of dry weight. This production was achieved with plant population of 6667 tree ha^{-1}. This result was higher than previous report where it was only 20 t ha^{-1} with plant population of 50,000 tree ha^{-1} (Winrock International 1997). In Brisbane Australia, KX2 hybrid yielded more total above-ground biomass and edible dry forage than the other species (Castillo *et al.* 1994). The lowest forage production was obtained by *L. diversifolia* which was 3.12 t ha^{-1} of fresh weight or 1.01 t ha^{-1} of dry weight. *Leucaena* KX2 hybrid has also shown their superiority on alkaline limestone soil, black alluvial of West Timor (Nulik *et al.* 2004); fertile volcanic soil of Lombok, West Nusa Tenggara (Panjaitan unpubl.). Non-edible part production showed similar pattern with edible part production. *Leucaena* KX2 hybrid produced the highest stem (Fig. 2).

Some *Leucaena* hybrid is seedless such as *Leucaena* KX2 hybrid. The population of the next generation would segregate when seed is used in multiplication (Sorensson 1989 *in* Sorensson *et al.* 1994). Therefore, vegetative multiplication is an alternative way to overcome this problem. The success of using vegetative multiplication depends on many factors such as selected plant materials and environmental condition for growth (Sun *et al.* 1998).

The biomass productivity of *Leucaena* species varies. Some species produced outstanding biomass; they may provide low yield of leaf for forage than wood and vice versa (Table 9).

The percentage of nitrogen in the leaf was not significantly different among the leucaenas (Table 10), which means that protein content in the leaf would also be no different among them (percentage of protein content is calculated by multiplying percentage of nitrogen content with 6.25). Therefore, all the *Leucaena*

Table 8. Total forage production of several *Leucaena* species from five time harvests.

Species	Fresh weight (t ha^{-1} year^{-1})	Dry weight (t ha^{-1} year^{-1})	Fresh weight (t ha^{-1} per 5 time harvests)	Dry weight (t ha^{-1} per 5 time harvests)
L. leucocephala K28	4.36	1.43	5.14	1.74
L. leucecephala	4.74	1.43	5.56	1.70
Leucaena KX2 hybrid	33.93	12.48	44.82	16.15
L. collinsii	5.16	1.71	5.87	1.99
L. trichandra	7.96	3.06	12.03	4.68
L. diversifolia	3.12	1.01	3.79	1.26

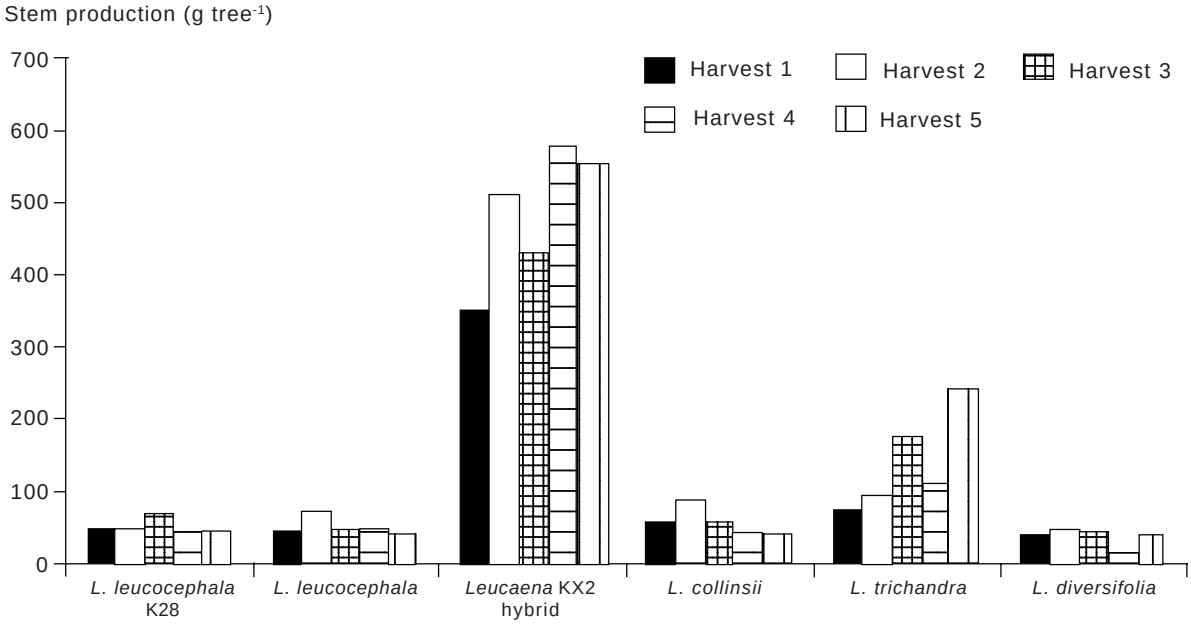

Fig. 1. Forage production of six *Leucaena* species from five time harvests.

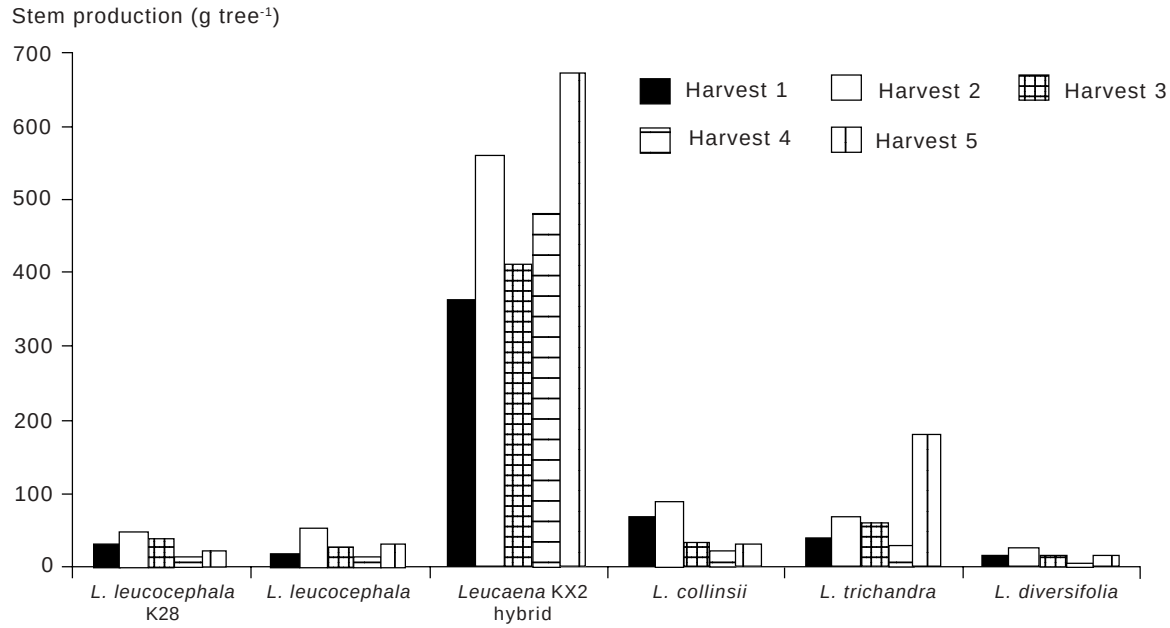

Fig. 2. Stem production of six *Leucaena* species from five time harvests.

Table 9. Leaf and stem ratio of six *Leucaena* species.

Species	Leaf and stem ratio per tree				
	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5
L. leucocephala K28	2.01	1.16	1.73	2.96	1.88
L. leucocephala	2.60	1.61	1.99	3.56	1.47
Leucaena KX2 hybrid	0.91	1.01	1.12	1.06	0.94
L. collinsii	1.60	1.07	1.87	1.60	1.27
L. trichandra	1.28	1.35	2.30	2.98	1.38
L. diversifolia	1.86	1.89	2.36	2.92	2.78

Table 10. Percentage of N and P content in the leaves of six *Leucaena* species.

Species	N (% dry matter)	P (% dry matter)
L. leucocephala K28	3.85a	0.28ab
L. leucocephala	4.10a	0.29ab
Leucaena KX2 hybrid	3.61a	0.24bc
L. collinsii	3.99a	0.24bc
L. trichandra	2.88b	0.20c
L. diversifolia	3.99a	0.30a

Numbers in the same column followed with the same letter are not significantly different at P<0.05.

species studied are comparable.in term of their protein content. This study implies that *Leucaena* KX2 hybrid is adaptable to acid soil; therefore it can be grown in wider areas throughout Indonesia.

CONCLUSION

Leucaena KX2 hybrid was superior to other species of *Leucaena*. This hybrid produced the highest forage all the year long which means that this hybrid can provide forage in both seasons. Regrowth of KX2 hybrid was the fastest and forage production was the highest. The highest fresh weight forage production for 1 year (four times harvests) was 33.93 t ha^{-1} equal to 12.48 t ha^{-1} of dry weight, and the lowest was produced by *L. diversifolia* which was 3.12 t ha^{-1} of fresh weight or 1.01 t ha^{-1} of dry weight. Production of non-edible part (stem) followed the pattern of production of edible part. N and P contents of the edible part (forage) did not differ with other leucaenas.

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