Effect of Leucaena Row Spacing and Cutting Intensity on the Growth of Leucaena and Three Associated Grasses in Thailand

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ABSTRACT : An experiment was conducted at Suwanvajokkasikit Research Station, Pakchong, Nakornratchasima, Thailand, to determine the yield and quality of three different grass cultivars intercropped with leucaena (*Leucaena leucocephala*). The treatments consisted of three grass cultivars (ruzi, dwarf napier and Taiwan A25) as the main plots, planted between leucaena at three row spacings (1, 2 and 4 m width) as the sub plots and leucaena cutting height (10 and 25 cm above ground levels) as sub-sub-plots. Dwarf napier consistently produced more dry matter than Taiwan A25 or ruzi and Taiwan A25 outyielded ruzi. Leucaena yield was highest in the ruzi plot and lowest in the dwarf napier plot. However, yields of grass plus leucaena were highest in the dwarf napier plot and were lowest in the ruzi plots. The difference was due mainly to the grass components. Increasing the spacing between rows of leucaena resulted in a lower leucaena yield but the reverse was true for the grasses. Cutting of leucaena at 10 cm above ground levels depressed yields of leucaena but did not affect the associated grasses. In terms of herbage quality, it was found that the crude protein of leaves and stems of the dwarf napier and Taiwan A25 were higher than that of the ruzi grass. Leucaena gave higher levels of crude protein than all grasses. The phosphorus and potassium levels of all grasses were higher than leucaena. ADF levels were higher in the grasses than in the legumes. Nutrient contents in the leaves and stems of grasses and leucaena were not affected by leucaena spacing and cutting height.
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Key Words : Row Spacing, Leucaena, Ruzi, Dwarf napier, Taiwan A25, Tropical Grasses

INTRODUCTION

Currently, native pasture is the most important source of forage for animals in Thailand. The quantity and quality of these pastures depends primarily on the natural soil fertility, season of the year and the species grown (Horne and Stur, 1997). Native pastures commonly grow along the roadside, on idle land and on communal grazing land. The productivity and quality of native pastures has been improved by oversowing with tropical legumes. Thus, oversowing legume into native pastures became the most common form of pasture development in the north and northeast of Thailand during 1980-1990 (Manidool, 1990). However, the need for land for cash cropping has lead to a significant reduction in grazing land for farming (Unguro, 1999) and hence a severe decline in the area of oversown native pasture available for animal production. As a consequence the reduced area of native pasture has been overgrazed, animal liveweights have declined, and the more desirable plant species significantly declined and were replaced by weeds.

Most Thai farmers who have pastures grow para, ruzi, guinea or napier grass as a mono culture (Tudsri and Sawadipanich, 1993), although their quality rapidly declines with age (Milford and Minson, 1966). Thus, grass/legume mixed pastures have been recommended but few have been able to retain the legume component and maintain long-term production (Wongsuwan and Watkin, 1990; Hare et al., 1999). Grass/legume pastures using tree legumes instead of the herbaceous species have successfully retained the legume (Tudsri et al., 1999). Dry matter yield from these mixtures was equal to that from grass alone, but of much higher quality due to the retention of the legume and the optimum cutting interval of these mixed pastures depended on the type of associated grasses (Tudsri et al., 1999). For example, for ruzi and napier cv. Taiwan A25 a cutting interval of 40 days was recommended but for dwarf napier/leucaena this was only 30 days (Tudsri et al., 1999). There were no deaths of leucaena plants in these experiment with the contribution of the legume to the total dry matter yield being from 10-26%.

Retention of the legume component is important since animal production is closely related to the legume proportion in the pasture (Norman, 1970). Nyaata et al. (1998) reported that to obtain the desired ratio of 30% legume and 70% napier, one or two rows of leucaena to one row of napier grass should be used. The species of associated grass can also affect leucaena yield (Tudsri et al., 1999) and may vary according to the plant spacing. Thus, the present experiment was conducted to examine the effect of grass species, leucaena row spacing and cutting height on the growth of leucaena and the associated grass species. The grass species used in this study were ruzi (*Brachiaria ruziziensis*), dwarf napier and Taiwan A25 (both *Pennisestum purpureum*). For leucaena (*Leucaena leucocephala*) the cultivar Ivory coast which is now widespread throughout Thailand was used.

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MATERIALS AND METHODS

The experiment was conducted on a sandy clay loam soil at the Suwanvajokkasikit Research Station, Pakchong, approximately 150 km northeast of Bangkok (Long 101° 19 E, lat 14 38′ N, altitude 388 a.s.l). Rainfall was measured on the farm, approximately 200 m from the trial site. Soil of the experimental area is classified as a moderate reddish brown lateritic with a pH 6.5. The chemical content of the soil at top 0-15 cm was 65 ppm available P (Bray II), 125 ppm K and 2.10% organic matter. A randomized split-split-plot design with three replications was used. The sub-sub-plot size was 5×4 m. The main plots consisted of three tropical grasses : ruzi, dwarf napier and Taiwan A25 planted between rows of leucaena, leucaena tree spacings of 1, 2 and 4 m width were the sub-plots and leucaena cutting height (10 and 25 cm) were the sub-sub-plots.

The area was ploughed and cultivated before sowing on January 15, 1994. Leucaena, dwarf napier and Taiwan A25 were planted in small plots prior to transplanting into the experimental area when the plants were 4-5 weeks old. Leucaena was transplanted into rows 1, 2 and 4 m apart (50 cm within row), and the two grasses transplanted between the leucaena rows at 50×50 cm spacing (between and within row, respectively), creating 1, 3, 7 rows of grass between the leucaena rows with 2 rows of grasses as the border. Ruzi grass, however, was sown as seed (60% germination), in 50 cm rows at 12 kg/ha. An initial fertiliser dressing of 15-15-15 (N:P:K) at 300 kg/ha was applied at sowing with further annual applications at the same rate in 1995 and 1996. The area was cut by using cutting machine to 10 cm for grasses, and 10 or 25 cm according to the treatment for leucaena by hand on April 21, 1994. This date was taken as day 0, and the cutting intervals of 30 days commenced from that date (except in the first harvest June 1994 which carried out 40 days after cutting) and continued until August 10, 1996. Thus, 7, 12 and 8 harvests were carried out in 1994, 1995 and 1996, respectively.

Grass dry matter yields were measured with four quadrats 100×50 cm^2 cut by hand shears to 10 cm in each plot. Ten plants of Leucaena were also cut at 10 or 25 cm depending on the treatment to measure the dry matter yield. A 500 g. subsample was separated into leaf and stem components. Each compoment was dried at 80°C for 72 h and dry weight recorded. The dry leaf and stem subsamples were analyed for N (October 1994, January, April, July, October 1995 and April 1996) to calculate crude protein levels (% N×6.25), and also for % P (April, July and October 1995 and April 1996) and % K (April and July 1995 and April 1996) by using Technicon Autoanalyser. The average of each nutrient was calculated. ADF contents were determined according to Van Soest system only one occasion in April 1996 for the 10 cm cutting height treatment for both grass and legume. After each sampling cut, the remaining pasture was cut according to the treatments and the forage removed.

For statistical analysis, a split-split plot design was used and difference tested for significance to $p<0.05$.

RESULTS

Rainfall

In the first year (1994), the rainfall was evenly distributed in the wet season (table 1). Little rainfall was recorded during the dry, cooler period from October 1994-February 1995. Rain began to fall in March 1995 and continued for two months after which dry conditions were again experienced during June and July 1995. However, a substantial amount of rainfall was recorded in August, September and October (1995) before the commencement of a dry cool period from November 1995 to January 1996. Rainfall commenced in February 1996 and continued until the end of the experiment on August 10, 1996.

Grass production

The total dry matter yield of the grasses compared over the 3 years are given in table 2. Dwarf napier grass significantly (p=0.05) out–yielded both Taiwan A25 and ruzi. Taiwan A25 also significantly out–yielded ruzi. The superiority of dwarf napier over the other grasses was evident in the first year, significance in the second and third years. Ruzi yielded poorly throughout the experiment.

Grass yield of the three plant cultivars progressively increased as the row spacing of leucaena increased with 2 m and 4 m spacing producing significantly more grass than 1 m spacings (table 2). Leucaena cutting height had no effect on the associated grass yields. There was no significant

Table 1. Rainfall (mm) at the Suwanvajokkasikit Research Station, Pakchong, Nakornratchasima during the study and the long term average

Month	1994	1995	1996	Average[1]
Jan	8	2	0	11
Feb	15	15	55	19
Mar	68	68	38	63
Apr	80	149	127	87
May	180	259	175	151
Jun	171	19	103	99
Jul	100	65	167	107
Aug	202	167	137	144
Sep	152	375	394	222
Oct	46	186	154	165
Nov	10	9	199	36
Dec	0	0	0	6
Total	1,032	1,314	1,546	1,110

[1] Average 1972-1996.

Table 2. Effect of grass species and leucaena spacing and cutting height on total annual dry matter yields (tones/ha)

	Grass	Leucaena	Total
1994			
A. Grass species			
ruzi	$11.36^{b,1}$	1.69^{a}	13.05^{b}
dwarf napier	13.33^{a}	1.24^{b}	14.57^{a}
Taiwan A25	12.51^{a}	1.01^{c}	13.52^{b}
B. Leucaena spacing (m)			
1	10.66^{b}	2.32^{a}	12.98
2	13.36^{a}	1.09^{b}	14.45
4	13.47^{a}	0.64^{c}	14.11
C. Cutting height (cm)			
10	12.53	1.36	13.89
25	12.16	1.31	13.47
1995			
A. Grass species			
Ruzi	5.95^{c}	2.47^{a}	8.42^{c}
dwarf napier	12.14^{a}	1.58^{b}	13.72^{a}
Taiwan A25	8.74^{b}	1.87^{b}	10.61^{b}
B. Leucaena spacing (m)			
1	7.14^{b}	3.53^{a}	10.67
2	9.56^{a}	1.58^{b}	11.14
4	10.44^{a}	0.81^{c}	11.25
C. Cutting height (cm)			
10	9.38	1.56^{b}	10.94
25	8.34	2.13^{a}	10.47
1996			
A. Grass species			
Ruzi	5.39^{c}	2.22^{a}	7.61^{b}
dwarf napier	11.01^{a}	1.16^{b}	12.17^{a}
Taiwan A25	9.26^{b}	1.62^{b}	10.88^{a}
B. Leucaena spacing (m)			
1	6.41^{b}	2.86^{a}	9.27
2	9.19^{a}	1.44^{b}	10.63
4	10.18^{a}	0.67^{c}	10.83
C. Cutting height (cm)			
10	8.21	1.39^{b}	9.60
25	8.43	2.07^{a}	10.51
Total (1994 -1996)			
A. Grass species			
Ruzi	$22.70^{c,1}$	6.38^{a}	29.08^{c}
dwarf napier	36.48^{a}	3.98^{b}	40.46^{a}
Taiwan A25	30.51^{b}	4.50^{b}	35.01^{b}
B. Leucaena spacing (m)			
1	24.21^{b}	8.71^{a}	32.92
2	32.11^{a}	4.11^{b}	36.22
4	34.09^{a}	2.12^{c}	36.21
C. Cutting height (cm)			
10	30.12	4.31^{b}	34.43
25	28.93	5.51^{a}	34.44

[1] Within columns for each main effect and year, means followed by the different letters are significantly different ($p<0.05$).

interaction between grass species and leucaena row spacing or cutting height.

The lowest dry matter yields were recorded between October and February which represents the normal dry and cool period in Thailand (figure 1).

Leucaena production

Leucaena yield in the ruzi plot was consistently the highest than when grown with dwarf napier or Taiwan A25. The leucaena yield differences associate with the later two grasses. however. was not significantly different (table 2).

In contrast to grass yields. leucaena yields in the three grass plots decreased as the leucaena row spacing increased (table 2). Cutting of leucaena at 10 cm above ground levels significantly reduced yields of leucaena. Leucaena growth in all grass plots was most greatest during the wet season (May–September) and least during the cool and dry period from October to February (figure 1). In general. there was no significant interaction between grass species and leucaena row spacing or cutting height.

Total (grass+leucaena)

The total dry matter yield was highest in the dwarf napier plots. and lowest in the ruzi plots while those containing Taiwan A25 were intermediate. Leucaena row spacing and cutting height had no effect on total dry matter yield.

Chemical compositions

Dwarf napier and Taiwan A25 recorded markedly higher crude protein percent. especially in the leaf, than ruzi grass. In contrast the crude protein content of leucaena in all grass plots showed similar levels in both leaf and stem (table 3). However. leucaena showed much higher crude protein contents. especially in leaves. than did the grasses. There were no effect of leucaena row spacing on crude protein content of grasses and leucaena.

The phosphorus and potassium percentage in the associated grasses showed much higher levels than leucaena for both stem and leaf. The ADF percentage figures showed differences between the grasses and leucaena. Although the stem fraction in both species was consequently higher in ADF% than the leaf. the ADF% of the leucaena leaf was noticeably lower than that of the grass but the ADF in the leucaena stem was noticeably higher than that of the grass stem component (table 3).

DISCUSSION

Leucaena production was adversely affected by intercropping with dwarf napier and Taiwan A25 while ruzi grass had the least effect, as was reported earlier by Tudsri et al. (1999). Ruzi is a stoloniferous grass with a low growing habit while Taiwan A25 is tall with low leaf production and dwarf napier a more leafy bunch grass

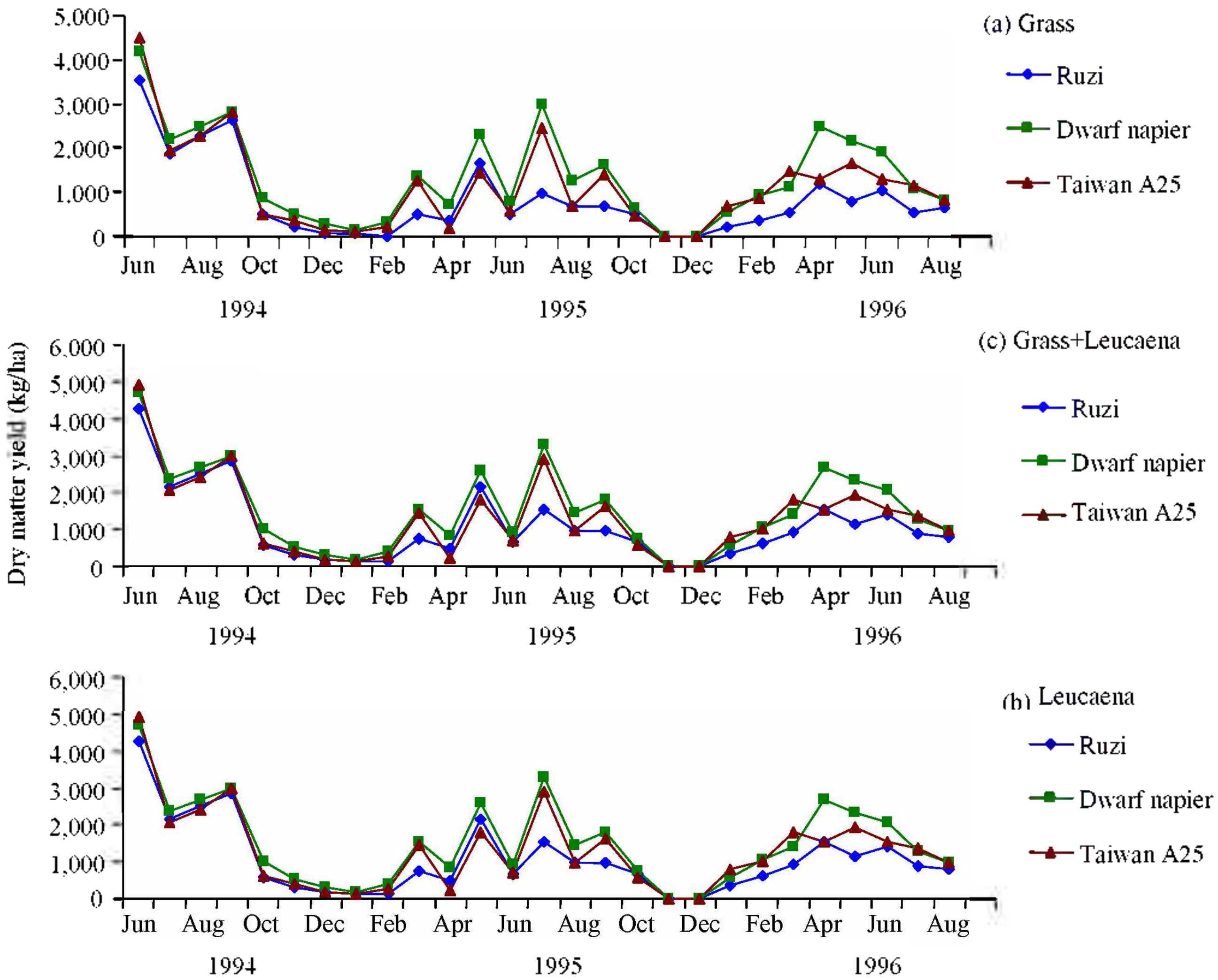

Figure 1. Total dry matter yield of grass(a), leucaena(b) and grass+leucaena(c) from each cutting during Jun 1994-Aug 1996.

species (Kaewkunya, 1997). It is likely that these different growth habits affected competition between species especially for light, as adequate nutrients were applied and soil moisture was plentiful during the rainy season. However, as earlier found by Tudsri et al. (1999) the total dry matter yield (grass+leucaena) was highest in the dwarf napier plots due to the vigour of the grass component (table 2).

This experiment also showed that there was a marked effect of leucaena row spacing on grass and leucana yield. Increasing the leucaena row spacing from 1 m to 4 m depressed leucaena yield by 53-76% but increased the grass yield by 33-41%. As a result, the total dry matter yield (grass+leucaena) differences between the row spacing treatments were not significant, although the wider spacing (2 and 4 m) produced 10% more total dry matter yield than did the narrower spacing (1 m). Nevertheless, the narrow spacing of 1 m was more advantageous in terms of legume contribution to total pasture production than the wider spacing. For example, the narrow spacing of leucaena provided average of 27% legume dry matter and 73% grass dry matter over the three years of the trial while the wider spacings (2 and 4 m) provided only 11 and 6% legume dry matter respectively.

Dairy cows producing 15 kg milk per day need about 13% crude protein in their diet, which can be obtained through a ration of 30% legume and 70% grass (Nyaata et al., 1998). Evans (1970) has shown that liveweight performance of beef cattle was linearly related to the legume content up to approximately 40% legume. Norman (1970) has also shown that there is a linear relationship between liveweight gain and the proportion of Townsville stylo (*Stylosanthes humilis*) in native pasture, for a legume content up to 75%. Tudsri et al. (2001) demonstrated that pastures containing 12-13% leucaena can support milk yield of 14 kg/hd/d for at least 100 days of lactation under grazing conditions. Thus, one or two rows of leucaena to one row of grass could produce the desired

Table 3. Effect of grass species, leucaena spacing and cutting height on the chemical composition of the grasses and legume (% dry weight)

	Grass		Leucaena		Grass		Leucaena	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
	Crude protein (%)				Potassium (%)			
A. Grass								
Ruzi	11.48[b,1]	7.43[b]	26.55	11.08	3.07	3.33	2.18	2.46
Dwarf napier	14.31[a]	10.56[a]	25.34	11.30	3.64	4.87	1.94	2.20
Taiwan A25	13.78[a]	8.85[b]	24.89	11.00	3.79	4.07	1.90	2.15
B. Row spacing (m)								
1	13.43	9.09	25.33	11.42	3.46	3.91	2.02	2.26
2	13.52	8.89	25.97	10.85	3.59	3.99	2.01	2.30
4	12.65	8.94	26.10	11.00	3.46	4.01	1.99	2.30
C. Cutting height (cm)								
10	13.07	9.01	25.82	10.79	4.10	3.95	1.99	2.22
25	13.33	8.88	25.74	11.21	3.57	4.00	2.02	2.23
	Phosphorus (%)				ADF (%)[2]			
A. Grass								
Ruzi	0.58	0.43	0.22	0.21	44.6	50.2	39.0	61.8
Dwarf napier	0.45	0.54	0.22	0.23	42.4	49.9	36.9	62.6
Taiwan A25	0.51	0.55	0.23	0.22	45.3	49.0	33.8	63.6
B. Row spacing (m)								
1	0.55	0.48	0.24	0.23	45.4	50.4	36.1	63.1
2	0.49	0.51	0.22	0.21	45.0	50.2	37.1	63.0
4	0.50	0.54	0.21	0.22	43.9	49.0	36.1	61.4
C. Cutting height (cm)								
10	0.47	0.55	0.21	0.19	-	-	-	-
25	0.46	0.48	0.21	0.19	-	-	-	-

[1] Within columns for each main effect, means followed by different letter are significantly different ($p<0.05$).
[2] No statistical analysis, determined only at 10 cm cutting height treatment for April, 1996 harvest.

ration. The wider row spacing (more than 2 m) is not recommended due to low legume content. This result agrees with Nyaata et al. (1998) who found that the 1:1 or 2:1 combination between leucaena and napier was the most suitable in Kenya.

Hard cutting of leucaena at 10 cm above ground levels depressed yield of leucaena relative to the lax cutting (25 cm). The superior regrowth ability of the lax cutting treatment may be related to the greater amount of food reserved available for regrowth (Humphreys, 1978) and the greater number of growing points (Gutteridge and Whiteman, 1975; Kessler and Shelton, 1980). Furthermore, the deleterious competitive effect from the associated grasses may lead to further restriction on leucaene regowth and hence low yield in the hard cutting treatment.

The results of this study showed that the crude protein contents were similar for dwarf napier and Taiwan A25 but both were much higher than for ruzi that has reported earlier by Tudsri et al. (1999). However, the levels of crude protein content of all three grasses were above the 7% critical level for animal intake (Milford and Minson, 1966). Leucaena showed a higher crude protein concentration than the grasses which highlights the importance of this legume in the pasture and in the diet. The beneficial effect of leucaena inclusion with poor quality grass was previously demonstrated by Tudsri et al. (2001).

In terms of phosphorus content of both the grass and the leucaena they showed adequate levels (0.20%, NRC, 1984) for the requirement of beef cattle. However, for dairy cattle only the grass component showed adequate levels to meet their requirement. Phosphorus content in our study showed lower levels than those reported by Holm (1973).

Potassium content of leucaena was low when compared to the grass species in the study (table 3). However, all levels recorded were adequate to meet the daily K requirement of dairy and beef cattle.

The ADF in the stem of leucaena was higher than in the grasses but the reverse was true for the leaf indicating the high nutritional values of this legume to the grass species. Leaf is the first part to be selected by the grazing animal (Whiteman, 1980) which, with its lower ADF percentage, is more beneficial to the animal.

As mentioned earlier, most Thai dairy farmers grow ruzi or common napier (Tudsri and Sawadipanich, 1993) of which quality rapidly declines with age. Hence, growing of leucaena with these grasses can result in sustainable mixed pasture production in Thailand. However, in order to achieve good establishment of the legume it is important to grow the appropriate associated grasses, plant the leucaena in 1-2 m rows and cutting to 25 cm. A low growing habit grass is more beneficial in terms of legume contribution than the leafy bunch grass. Lax cutting of leucaena must be recommended while a cutting interval of 30 days has been recommended for dwarf napier/leucaena and 40 days for ruzi and Taiwan A25 (Tudsri et al., 1999). However, it should be noted that leucaena only grow well on fertile, well drained soils. Most farmers in the northeast Thailand grow pasture on poor acid sandy soils on which leucaena does not grow well. Therefore, care must be taken when applying these results to those poor acid sandy soils and the research need to be also carried out on such areas.

CONCLUSION

The finding from this study suggest that integrating leucaena tree legume with dwarf napier produces higher quantities of quality fodder than the current species, ruzi grass. Even though leucaena production was adversely affected by intercropping with dwarf napier this combination produced the most dry matter. Leucaena row spacing should not more than 2 m width for intercropping with grasses and lax cutting of leucaena plants at 25 cm above ground levels is recommended. In terms of herbage quality, it was found that dwarf napier showed a greater quality than Taiwan A25 and ruzi grasses. Leucaena produced higher levels of crude protein but was lower in phosphorus, potassium and ADF than the grasses.

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