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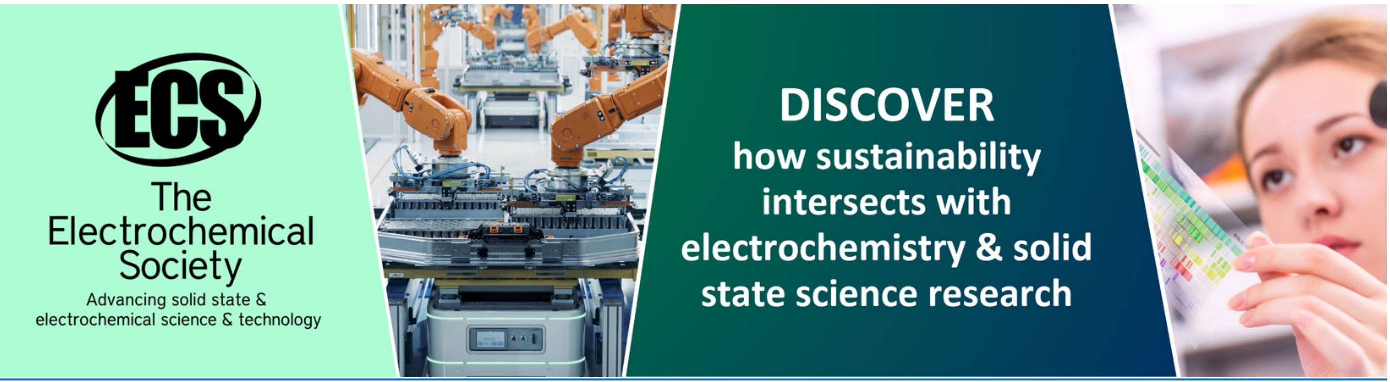
To cite this article: I G N Jelantik *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **888** 012061



Effect of different pasture legumes on growth profile and forage production of the selected native pasture grasses mix at different growth stages

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Abstract. The present experiment aimed to investigate the effect of introducing different pasture legumes on the growth profile and forage production of the selected native pasture grass species at different stages of growth. In a completely randomized design with 5 treatments and 5 replications, the mixture of *Sorghum plumosum* (SP) and *Bothriochloa pertusa* (BP) was introduced respectively with one of the forage legumes ie. *Alysicarpus vaginalis* (AV), *Pueraria phasoloides* (PP), *Desmodium incanum* (DI), and *Clitoria ternatea* (CT). Growth profile and forage production were measured at 40, 60, and 80 days after planting. Results showed that CT and PP significantly improved the growth and DM production of SP and suppressed ($P<0.05$) the growth of *BP* during the early vegetative stage but did not during the late vegetative stage. Introduction of legumes reduced ($P<0.05$) DM production of *SP* and the total forage production but improved ($P<0.001$) the DM production of *B. pertusa* as well as a leaf:stem ratio of both types of grass at the generative stage. PP had the highest ($P<0.05$) contribution of legumes to the total DM forage production during early and vegetative stages, meanwhile AV and DI during the generative stage. In conclusion, the introduction of forage legumes did not improve the DM production of both grass species but modify their growth profile toward a better quality as shown by increased leaf:stem ratio. *P. phasoloides* provide the highest foliage during the vegetative stage and *A. vaginalis* and *D. incanum* during the generative stage.

1. Introduction

Native pasture is the predominant source of forages for ruminants in The Province of Nusa Tenggara Timur which is one of the biggest cattle producers in Indonesia. A total of more than 800 thousand hectares of native pastures and about 89.4% of cattle population reaching 1,188,982 heads in 2020 [1] are gazing or tethered on the available native pastures. Those pastures, however, have been highly degraded due to uncontrol or free grazing practices for a long time. Those pastures are far overgrazed particularly during the dry season [2,3]. In this situation, pastures can lose productive and nutritious forage species [4] and consequently reduces the productivity of those native pastures, especially when occurring in semiarid areas [5]. The available native pastures are currently dominated by low-quality grass species with low forage production potential. In addition, the presence of pasture legumes is low, i.e. as low as 2.65 % [6] to 7.10 % [7]. Therefore, it is urgent those pastures are restored and their forage production should be increased if ruminant production is expected to increase.

Pasture improvement is commonly done through a combination of forage species since mixed pastures commonly have higher biomass yield and nutritive value than pure stands [8]. More species in a mixture and higher yield variation among species mixture increases the effect of diversity which is required to reach transgressive overyielding [9]. Complex mixtures produce more DM yield evenly throughout the growing season than simple mixtures [8]. Therefore, selecting among indigenous grass species is a very important step to improve native pasture production and quality. The selection of a species to reach higher biomass yield along with another species depends on the strength of interspecific competition between the selected species [10]. With regards to this, selecting at least two indigenous grass species which have a contrast growth profile and production capacity is perhaps the first important step. In this case, the combination of *S. plumosum* which is a perennial grass species with erected tussock [11] with *B. pertusa*, a perennial rhizomatous grass, may be the best choice. *S. plumosum* is a dominant grass in NTT and has a high DM yield as well as a good nutritive value [12]. Meanwhile, *B. pertusa* is considered native to south-East Asia and it has a high growth rate after rain and resistant to grazing [13].

To improve the quality of pasture, pasture legumes must be included. It was observed that the cumulative yield, CP, and in-vitro dry matter (DM) digestibility of mixtures were higher than grass monocultures and this was accompanied by improved seasonal yield distribution [14]. However, virtually no study was conducted on the response of the mixture between *S. plumosum* and *B. pertusa* on the inclusion of different species of forage legumes. Therefore, this study aims to investigate the effect of intercropping indigenous forage legumes into the mixture of *S. plumosum* and *B. pertusa* on the growth and yield of both types of grass as well as the total dry matter yield.

2. Materials and methods

2.1. Study site

The experiment was conducted during the growing season from December 2019 to June 2020 in inceptisol soil at Penfui (10° 05'S and 123° 52' E at an altitude of 10 a.s.l.), Kupang District, The Province of East Nusa Tenggara (ENT), Indonesia. The soil type found in the area is a deep (50-60 cm) vertisol with average pH of 7.7. The soil parent materials are derived from marine origin, which is essentially dominated by calcium carbonate. Annual rainfall in the area is approximately 1,500 mm/year and the mean relative humidity ranges from 62 to 97% (ENT-AIAT Automatic Weather Station).

2.2. Land preparation and experimental design

A 15 x 30 m^2 land was prepared for the experiment and it was cleared manually and plowed. As many as 25 plots of 2 x 2 m^2 were prepared and the distance between plots was about 60 cm. Seedlings of *S. plumosum* and *B. pertusa* were collected from the surrounding area about two weeks after the first rain during the rainy season. Three seedlings were planted into the plots at a 40x40 cm planting distance. One week later, seedlings of the selected forage legumes, i.e *Alysicarpus vaginalis*, *Clitoria ternatea*, *Desmodium incanum*, and *Pueraria phasoloides* were planted at similar planting distance in the respective plots which were selected randomly. The experimental design was a completely randomized design with 5 treatments and 5 replications. The treatments were the mixture of SP and BP without any legume (CO) or respectively intercropped with *Alysicarpus vaginalis* (AV), *Clitoria ternatea* (CT), *Desmodium incanum* (DI) and *Pueraria phasoloides* (PP). No irrigation and fertilization were applied but weedling was conducted during the first 20 days after planting. All plots were homogenized four weeks after planting by cutting grasses at 10 cm and legumes at 20 cm above the ground.

2.3. Measurement and forage sampling

Measurement and forage harvesting were done at 40, 60, and 80 days after the homogenization. The number of plants per tiller for both species of grasses was counted at 5 tillers selected randomly in a 1 x 1 m sub-plot for each plot. Morphological parameters such as plant height and leaf dimension were measured from 10 plants that were randomly selected from the sub-plot. To estimate the DM yield of both species of grasses, legumes, and the total yield, all plants in the sub-plot were cut 5 cm above the ground. Each grass species and legume were separated and weighed. The harvested species were then separated for leaf and stem and samples were taken from each part. A sub-sample was taken for DM determination and the rest were and were dried in an oven at 65 °C for 72 h before chemical analysis.

2.4. Statistical analysis
All data collected were analyzed using Proc. Anova by employing SPSS 23.

3. Results and discussion

3.1. The effect of intercropping forage legumes at the early vegetative stage (40 days)
Intercropping with forage legumes to a specific species of grass which is grown monoculture or to the mixture of some grasses generally improves the growth and DM production as well as the quality of the harvested herbage [15]. It seems, however, that different legumes have a different effects on the grass morphological development measured at different physiological stages. As presented in Table 1, at the beginning of the vegetative stage ie. measured at 40 days after sowing, the positive effect of legumes on the growth of *S. plumosum* and *B. pertusa* was only obtained with *Pueraria phasoloides*. The number of plants per tiller, plant height, and leaf dimension was higher when both species of grasses were inter-sowed with *P. phasoloides* compared to other legumes. Tillering has a close relationship with forage DM yield [16], therefore it is understood when an increase of DM production of SP but not BP with CT and PP inter sowing was also observed. Moreover, since PP produced the highest biomass compared to other legumes, the total DM herbage production was highest in the grass mix inter-sowed with *P. phasoloides*. This indicates that *P. phasoloides* is the best legume for the grass-legumes mix combination at the early vegetative stage.

The positive effect of intercropping legumes into grass mixture is commonly exerted through the nitrogen fixation occurring in the root noodle by rhizobium thereby increasing the soil nitrogen availability [15]. However, this may not occur in the early growth stage since the root nodule perhaps has not fully developed yet [17]. Hence, another factor may be responsible for the observed positive effect such as providing shade or canopy which improved the soil biology which in turn improves the efficiency of N transfer and utilization by grass or other crops [15]. *P. phasoloides* is a trilling legume that grew very fast at the beginning of the vegetative stage. In the present experiment, it has the highest rate of stem development and more leaves (P <0.05) compared to other legumes. It, therefore, provided sufficient shade for the grass mix. Shaded soil has a moderate temperature so that a large number of fauna such as earthworms can play a role in changing the fallen leaves to increase the soil nitrogen content [18]. Moreover, shade can cause the companion grass to absorb nitrogen efficiently. Wong and Wilson [19] reported that in shaded conditions grass can absorb soil nitrogen higher than land without shade.

Table 1. The effect of inter-sowing different forage legumes on the morphological characteristics measured at 40 days after planting.

Variables	Treaatment					SEM	P-value
	CO	AV	CT	DI	PP		
S. plumosum							
- no. tiller	32.45^{ab}	39.04^{b}	31.70^{ab}	27.19^{a}	37.10^{ab}	3.083	0.106
- Height (cm)	73.14^{a}	74.76^{a}	72.99^{a}	138.88^{b}	70.68^{a}	3.577	<0.001
- no. leaves	5.075^{a}	5.325^{a}	5.125^{a}	9.156^{b}	5.100^{a}	0.276	<0.001
- Leaf length (cm)	54.04	54.16	54.04	49.99	53.94	2.096	0.573
- Leaf wide (cm)	1.945	2.248	3.503	1.955	2.358	0.544	0.284
B. pertusa							
- No. tiller	20.44	16.80	23.75	18.25	28.60	6.308	0.694
- Height (cm)	107.71^{b}	86.97^{ab}	86.15^{ab}	130.21^{c}	84.39^{a}	7.153	0.001

- no. leaves	16.98^{a}	12.60^{a}	16.24^{a}	27.77^{b}	14.50^{a}	2.676	0.010
- Leaf length (cm)	19.75	20.65	19.24	17.89	18.30	0.862	0.211
- Leaf wide(cm)	0.763	0.743	0.765	0.718	0.733	0.026	0.663
Legume							
- Height (cm)		33.70^{a}	49.97^{a}	78.18^{b}	142.29^{c}	6.655	<0.001
- no. leaves		67.05^{a}	94.19^{a}	78.21^{a}	219.40^{b}	15.936	<0.001
- Leaf length (cm)		2.600^{a}	3.823^{a}	8.536^{b}	7.656^{b}	0.590	<0.001
- Leaf wide (cm)		2.082^{a}	2.374^{a}	5.847^{b}	6.360^{b}	0.216	<0.001
-no. branch		6.506^{a}	24.47^{a}	29.55^{a}	94.45^{b}	7.253	<0.001

Values bearing different superscripts differ significantly (P<0.05).

Meanwhile, other legumes particularly *D. incanum* significantly reduced (P<0.05) the height of *B. pertusa* but it does not affect the height of *S. plumosum*. Inter-sowing with DA also reduced herbage DM production of both *S. plumosum* and *B. pertusa* and therefore the total DM production. This finding is also reported by Souza [20] who found a reduction in forage DM yield in the grass-legume mix compared to monoculture. The suppressing effect of introducing legumes to the growth of the companion grass occurs commonly due to the competition for soil nutrients and/or solar energy [20]. Although grasses, in general, are considered superior in utilizing soil nutrients due to root structure, in poor soil nutrient availability the competition may reach a level to affect the growth of grasses [15].

Table 2. The effect of inter-sowing different forage legumes on the forage dry matter yield harvested at 40 days after planting.

Variables	Treaatment					SEM	*P-value*
	CO	AV	CT	DI	PP		
Grass :							
S. plumosum							
- Stem	125.35^{ab}	88.67^{a}	259.35^{c}	106.60^{a}	183.56^{b}	24.30	0.001
- Leaves	292.10^{bc}	219.38^{b}	384.91^{d}	68.58^{a}	325.04^{cd}	27.82	<0.001
-Total	417.44^{bc}	308.04^{ab}	644.26^{d}	175.18^{a}	508.59^{cd}	49.73	<0.001
- LSR	2.773^{c}	2.530^{c}	1.483^{ab}	0.680^{a}	1.913^{bc}	0.316	0002
B. pertusa							
- Stem	37.54	48.10	43.09	29.98	40.46	7.458	0.534
- Leaves	58.75^{b}	51.06^{b}	62.62^{b}	19.89^{a}	56.85^{b}	9.469	0.039
-Total	96.29^{ab}	99.17^{ab}	105.70^{b}	49.87^{a}	97.31^{ab}	16.57	0.171
- LSR	1.536^{c}	1.146^{b}	1.439^{c}	0.668^{a}	1.415^{c}	0.081	<0.001
Legume							
- Stem		18.51^{a}	37.43^{b}	20.73^{ab}	59.79^{c}	5.673	0.001
- Leaves		40.79^{b}	51.58^{b}	16.05^{a}	84.73^{c}	5.910	<0.001
-Total		59.29^{ab}	89.01^{b}	36.78^{a}	144.52^{c}	11.42	<0.001
- LSR		2.263^{c}	1.389^{b}	0.799^{a}	1.460^{b}	0.111	<0.001
Total DM Production	513.74^{b}	466.50^{b}	838.97^{c}	261.84^{a}	750.42^{c}	61.05	<0.001
P_SP	82.77^{b}	66.41^{a}	76.24^{b}	66.99^{a}	67.84^{a}	2.271	<0.001
P_BP	17.23^{ab}	20.78^{b}	12.89^{a}	18.98^{b}	13.10^{a}	1.704	0.017
P_Legum		12.81^{a}	10.87^{a}	14.04^{a}	19.06^{b}	1.082	0.001

Values bearing different superscripts differ significantly (P<0.05)
LSR : leaf:stem ratio
P_SP : the percentage of dry matter yield of *S. plumosum* in the total DM production
P_BP : the percentage of dry matter yield of *B. Pertusa* in the total DM production
P_Legum : the percentage of dry matter yield of different legumes in the total DM production

3.2. Effect of intercropping forage legumes at late vegetative stage (60 days)

Table 3 shows the effect of inter-sowing different legume species varying in the growth pattern of *S. plumosum* and *B. pertusa* at the late vegetative stage (at 60 days). The number of tillers was not affected by inter-sowing with legumes but the height and the number of leaves per plant declined in SP when inter-showed with DA and in BP when inter-sowed with CT. It seems that the competition between grass and DA in utilizing soil nutrients continued to occur and this was responsible for the depressing effect on their growth.

For the case that the negative effect of CT on the height and the number of leaves of BP was perhaps due to CT provide shade to BP but not to SP. Shade is known to reduce leaf and its dimension, but the ability to utilize solar radiation is increasing with shading [21]. This compensation often maintains the DM production under shading [21].

Table 3. The effect of forage legumes on the agronomic characteristics measured at 60 days.

Variables	Treatment					SEM	*P-value*
	CO	AV	CT	DI	PP		
S. plumosum							
- no. tiller	36.10	31.20	30.00	26.55	28.35	3.108	0.296
- Height (cm)	180.80^{b}	171.24^{b}	178.61^{b}	137.96^{a}	184.26^{b}	6.999	0.002
- no. leaves	14.20^{b}	13.20^{b}	12.90^{b}	9.175^{a}	12.40^{b}	0.641	0.001
- Leaf length (cm)	53.55	51.34	48.55	5.51	51.13	2.233	0.639
- Leaf wide (cm)	1.960	1.805	1.855	1.980	1.845	0.096	0.644
B. pertusa							
- No. tussock	12.50	14.60	14.45	18.25	14.90	2.493	0.607
- Height (cm)	155.01^{b}	123.65^{a}	126.72^{a}	128.83^{ab}	129.41^{ab}	8.431	0.112
- no. leaves	57.95^{c}	54.25^{bc}	41.55^{abc}	26.80^{a}	35.05^{ab}	6.454	0.020
- Leaf length (cm)	16.67^{a}	16.65^{a}	16.70^{a}	10.02^{ab}	19.16^{b}	0.669	0.064
- Leaf wide (cm)	0.700	0.650	0.678	0.720	0.710	0.669	0.244
Legume							
- No. tiller		1.686^{c}	1.675^{c}	1.037^{a}	1.406^{b}	0.080	<0.001
- Height (cm)		89.95^{a}	131.41^{ab}	88.87^{a}	155.86^{b}	16.95	0.041
- no. leaves		164.14	172.65	10.6.39	215.33	43.56	0.403
- Leaf length (cm)		4.138^{a}	3.466^{a}	7.922^{b}	4.081^{a}	0.580	0.01
- Leaf wide (cm)		1.856^{a}	1.898^{a}	5.907^{b}	2.721^{a}	0.504	<0.001
- no. branch		21.74	34.28	29.59	11.21	6.627	0.127

DM herbage production of both species of grasses and the total DM production was unaffected by legume inter-sowing. At this age, a positive effect of legume intercropping is expected. Sturludottir [22] reported the DM yield of grass and legume mixture was 15% higher than the most productive monoculture. Similarly, Finn et al. [23] found higher DM yield when grass and legumes are mixed. It seems that the lack of positive effect of legumes may be related to the proportion of legumes was still low. In the present experiment, the proportion of legume herbage to the total DM yield varied between 10.4 to 16.7%. Meanwhile, it has been suggested that legume components of 35 to 50% in mixtures are needed for sustained optimum forage yields [24].

At this age, *P. phaseoloides* continued to contribute the highest proportion (P<0.05) to the total DM herbage production. Higher legume proportion in the DM yield is particularly beneficial to increase the quality of pasture. Legumes in general have much higher CP and mineral content compared to tropical grass. The foliage of forage legumes often contains CP between 16 to 20% [15]. Meanwhile, tropical grass at the late vegetative stage contains much less, i.e. in the range between 5.4 to 13.8% [25].

Table 4. The effect of inter-sowing different forage legumes on the forage dry matter yield (g/m^2) harvested at 60 days after planting.

Variables	Treaatment					SEM	*P-value*
	CO	AV	CT	DI	PP		
Grass :							
S. *plumosum*							
- Stem	761.17	449.39	695.44	396.23	525.10	109.34	0.136
- Leaves	387.79	362.18	340.89	261.39	321.39	50.81	0.495
-Total	1148.96	811.57	1036.34	657.62	846.48	148.79	0.204
- LSR	0.512	0.823	0.592	0.678	0.625	0.107	0.358
B. pertusa							
- Stem	157.43^b	99.96^a	93.30^a	111.54^{ab}	99.74^a	16.70	0.092
- Leaves	75.60	79.03	67.27	74.84	62.63	10.51	0.800
-Total	233.03	177.99	160.58	186.34	162.37	25.33	0.298
- LSR	0.490	0.811	0.842	0.667	0.624	0.114	0.288
Legume							
- Stem		82.04^a	70.58^a	76.84^a	126.14^b	11.11	0.016
- Leaves		65.78	44.65	60.39	76.13	10.23	0.230
-Total		147.82^{ab}	115.23^a	137.23^a	202.28^b	19.54	0.047
- LSR		0.814	0.639	0.797	0.605	0104	0.399
Total DM Production	1381.98	1137.38	1312.15	981.23	1211.12	166.36	0.499
P_SP	83.18	71.51^{ab}	76.27^{bc}	67.02^a	69.89^{ab}	2.815	0.009
P_BP	16.83^{ab}	15.37^{ab}	13.26^a	19.00^b	13.40^a	1.423	0061
P_Legum		13.11^{ab}	10.48^a	14.03^{ab}	16.71^c	1.771	0.152

Values bearing different superscripts within a similar row differ significantly (P<0.05)
LSR : leaf:stem ratio
P_SP : the percentage of dry matter yield of *S. plumosum* in the total DM production
P_BP : the percentage of dry matter yield of *B. Pertusa* in the total DM production
P_Legum : the percentage of dry matter yield of different legumes in the total DM production

3.3. *Effect of intercropping forage legumes at generative stage (80 days)*

The effect of forage legumes on the morphological profile of *S. plumosum* and *B. perusa* measured at 80 days after sowing is presented in Table 5. The number of tillers in *S. plumosum* was lower (P<0.05) in the legumes inter-sown particularly with *A. vaginalis* and *D. incanum*. However, no effect of intersowing with those legumes on the number of tillers in *B. pertusa*. This occurs due to competition of soil nutrients or light with those legumes which grows substantially during this phase and become dense. The number of tillers is a more important parameter that affects biomass yield compared to plant height [26] hence, DM yield may be affected by the two legumes.

Table 5. The effect of forage legumes on the agronomic characteristics measured at 80 days.

Variables	Treatment					SEM	*P-value*
	CO	AV	CT	DI	PP		
Grass :							
S. plumosum							
- no. tiller	32.70^c	27.20^{ab}	35.15^c	23.30^a	30.10^{bc}	1.629	0.001
- Height (cm)	225.37	234.54	227.28	219.87	226.70	5.932	0.554
- no. leaves	21.15^{ab}	22.90^b	19.93^{ab}	18.38^a	21.53^{ab}	1.053	0.075
- Leaf length (cm)	46.86	52.64	48.54	50.07	47.14	1.570	0.107
- Leaf wide (cm)	1.790^a	1.968^b	1.700^a	1.835^{ab}	1.945^b	0.043	0.003
B. pertusa							
- No. tiller	10.70	13.06	10.37	15.00	10.52	1.701	0.270
- Height (cm)	120.21	139.19	125.83	138.39	129.78	8.760	0.507
- no. leaves	63.30	73.75	45.62	66.55	67.43	7.701	0.164

- Leaf length (cm)	15.20^{ab}	16.85^{b}	18.07^{b}	18.20^{b}	13.20^{a}	0.939	0.007
- Leaf wide (cm)	0.560^{a}	0.613^{ab}	0.658^{b}	0.680^{b}	0.544^{a}	0.024	0.004
Legume							
- No. tiller		1.550^{ab}	1.738^{b}	1.242^{a}	1.292^{a}	0.120	0.042
- Height (cm)		75.329^{a}	134.383^{b}	118.30^{b}	223.63^{c}	7.922	<0.001
- no. leaves		165.84^{b}	149.15^{b}	64.63^{a}	102.60^{ab}	22.24	0.029
- Leaf length (cm)		3.378^{a}	3.405^{a}	7.567^{b}	6.558^{b}	0.368	<0.001
- Leaf wide (cm)		2.162^{a}	1.867^{a}	5.064^{b}	5.315^{b}	0.233	<0.001
- no. branch		18.14^{a}	30.93^{a}	30.29^{a}	99.88^{b}	6.219	<0.001

Values bearing different superscripts within a similar row differ significantly (P<0.05)

DM herbage production of SP was reduced with all legumes but LSR was improved by AV. Meanwhile, DM herbage production of *B. pertusa* was unaffected (P>0.05) by legumes inter-sowing. However, LSR of DM produced was increased with AV and reduced with CT. All legumes produced a comparative amount of DM, however, the degree of leafiness differed significantly (P<0.05) among legumes. LSR was highest in AV and followed by DA, CT, and PP respectively. The total DM production tended to decline with legume inter-sowing. However, the total DM contribution of CT was the highest and PP was the lowest.

Table 6. The effect of inter-sowing different forage legumes on the forage dry matter yield harvested at 80 days after planting.

DM yield (g/m^2)	Treatment					SEM	*P-value*
	CO	AV	CT	DI	PP		
Grass :							
S.plumosum							
- Stem	1395.3^{a}	640.5^{a}	799.0^{a}	832.4^{a}	789.2^{a}	110.7	0.002
- Leaves	484.3^{c}	337.3^{b}	229.5^{ab}	277.4^{ab}	224.9^{a}	34.58	<0.001
-Total	1879.6^{b}	977.8^{a}	1028.5^{a}	1109.8^{a}	1014.14^{a}	135.9	0.001
- LSR	0.352^{a}	0.526^{b}	0.293^{a}	0.329^{a}	0.304^{a}	0.028	<0.001
B. pertusa							
- Stem	87.92^{a}	111.2^{ab}	128.5^{ab}	145.6^{ab}	156.4^{b}	18.62	0.124
- Leaves	40.13^{a}	66.44^{ab}	43.21^{ab}	64.82^{ab}	76.64^{b}	10.84	0.127
-Total	128.05^{a}	177.63^{ab}	171.68^{ab}	210.45^{ab}	233.07^{b}	28.54	0.150
- LSR	0.460^{b}	0.592^{c}	0.345^{a}	0.448^{ab}	0.479^{b}	0.036	0.005
Legume							
- Stem		128.9	128.2	160.2	131.6	18.71	0.584
- Leaves		70.16^{b}	38.00^{a}	63.06^{b}	39.46^{a}	5.683	0.003
-Total		199.1	166.2	223.2	171.1	23.67	0.333
- LSR		0.541^{c}	0.302^{a}	0.395^{b}	0.319^{a}	0.023	<0.001
Total DM Production	2007.7^{b}	1354.5^{a}	1366.4^{a}	1543.5^{ab}	1418.3^{a}	182.4	0.114
P_SP	93.64^{c}	72.31^{a}	75.06^{b}	71.44^{a}	71.48^{a}	0.798	<0.001
P_BP	6.361^{a}	13.05^{b}	12.86^{b}	13.66^{b}	16.45^{c}	0.645	<0.001
P_Legum		14.64^{b}	12.14^{a}	14.91^{b}	12.08^{a}	0.629	0.009

Values bearing different superscripts differ significantly (P<0.05)
LSR : leaf:stem ratio
P_SP : the percentage of dry matter yield of *S. plumosum* in the total DM production
P_BP : the percentage of dry matter yield of *B. Pertusa* in the total DM production
P_Legum : the percentage of dry matter yield of different legumes in the total DM production

The contribution of legumes to the total forage production changed when plants were harvested at 80 days of age. At that age, *A. vaginalis* and *D. incanum* had the highest contribution. These changes indicate the growth pattern of the two legume species which grows rapidly at the end of the rainy season. Meanwhile, DM yield of PP was the lowest. This was mostly due to the fallen leaf as it reaches the generative stage. This fallen leaf may provide litter and it is decomposed it will increase the soil nutrients. Legume litter has higher quality, faster decay, and nutrient release which improve the efficiency of soil nutrients [27].

4. Conclusion

Based on the results of morphological development and forage production, it can be concluded that the positive effect of the introduction of legume in pastures dominated by *S. plumosum* and *B. pertusa* is at the beginning of the vegetative period. Meanwhile, the contribution of legume to total forage production was highest by *C. ternatea* and *P. phasolides* in the lead up to the generative phase and by A. vaginalis and *D. incanum* in the generative phase. These changes indicate changes in forage quality that could result from this combination of cropping.

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