Growth components and Yield of *Brachiaria ruziziensis* (Congo grass) and *Centrosema pascuorum* (Centro) Mixtures as Influenced by Mixture Ratios, Phosphorus Levels and Stage of Harvest

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Abstract
This study was conducted during the 2017 and 2018 rainy season at the Crop Production Research farm, Abubakar Tafawa Balewa University, Bauchi to determine the effects of plant mixture ratios in Brachiaria ruziziensis and Centrosema pascuorum (100% Sole B. ruziziensis, 75%B.R:25%C.P, 50%B.R:50%C.P, 25%B.R:75%C.P and 100% Sole C. pascuorum)and phosphorus fertilizer (SSP) levels (0, 100 and 150kg/ha). The experiment was in a split-plot design with 5x3 factorial arrangement in which the mixture ratios constituted the main plots while phosphorus (SSP) levels constituted the sub treatments. Number of plants per stand ranged from 6.11 in 25%B.R:75%C.P to 9.56 in 100% B. ruziziensis and 2.89 in 75%B.R:25%C.P to 11.11 in 50%B.R:50%C.P. The highest plant height for B. ruziziensis was obtained in 25%B.R:75%C.P (38.0). Similarly, 25%B.R:75%C.P mixture had highest plant height for C. pascuorum (45.11). However, tiller per branch per m^2 ranged from 57.60 in 25%B.R:75%C.P to 190.9 in 100 B. ruziziensis and 32.9 in 75%B.R:25%C.P to 257.90 in 100 C. pascuorum. The mean values indicated that mixture ratios and phosphorus (SSP) levels significantly ($P<0.05$) increased plant height and tiller numbers in B. ruziziensis and C. pascuorum mixtures and 75%B.R:25%C.P mixture, 150kg/ha Single Super Phosphate fertilization and sampling period at week 8 had the best plant height and tiller per branch.

Introduction
Sources of cheaper alternative forages of high quality for ruminant livestock production have been a subject of research in recent years especially for small scale livestock producers in tropics. One of the logical approaches to alleviate the fast deterioration of pasture in the derived savanna is its improvement by incorporating forage legumes into natural grass sward to form grass-legume mixed pasture (Akingbade *et al*. 2004). Grass legume mixtures are usually superior to either pure stands of grass or legume, both in herbage yield and quality and ease of utilization. Congo grass (*Brachiaria ruziziensis*) is recommended for its vigorous growth in the tropical regions but achieving a balanced grass and legume mixed stands requires consideration of the interactions existing between the grass and legume species, which can in turn be manipulated by the relative seed proportions and the pattern in which they are planted (Hadji, 2000). Centro (*Centrosema pascuorum*) is a vigorous, trailing, twining and climbing perennial herb with trifoliate leaves and is fairly drought tolerant. *Centrosema pascuorum* is a legume species of high potential as fodder crop because of its high biomass production compared to other forage legumes. Like other nitrogen (N) fixing legumes, *Centrosema pascuorum* (Centurion) is a soil improver and its association with grass in mixtures is beneficial to grass yields making nitrogen (N) fertilizer not

necessary (Castillo *et al.*, 2003). Continuous use of inorganic fertilizers could eventually damage the soil by increasing soil acidity (Akinlade *et al.*, 2002). This study investigated the effect of mixture ratios, phosphorus fertilizer levels and stage of harvest on the yields and quality of *B. ruziziensis* and *C. pascuorum* mixtures in Bauchi.

Material and methods

Experimental Site

The experiment was conducted at the Crop Production Research Farm, Abubakar Tafawa Balewa University, Gubi Campus, Bauchi State. Bauchi falls within the Northern Guinea Savanna Ecological Zone with annual rainfall of between 1000mm and 1300mm per annum. Effective rainy season starts from April ends in late September or early October (Ovimap, 2016). The experimental soil is a loamy sand soil.

Table 1: Temperature, Relative humidity and Rainfall distribution for 2017 and 2018 in Bauchi

	Max. Temp (^{0}C)		**Relative Humidity (%)**		**Rainfall (mm)**	
Months	2017	2018	2017	2018	2017	2018
April	36.7	37.0	21.4	23.6	55.7	59.2
May	33.7	34.1	47.9	49.2	160.6	137.3
June	31.5	31.0	55.2	57.0	187.9	162.6
July	30.5	29.9	63.2	62.3	199.6	167.5
August	31.3	30.2	71.3	69.2	237.6	235.0
September	31.9	31.4	67.6	70.1	281.2	302.7
October	33.4	31.9	61.2	65.5	91.7	87.8
Total	228.7	225.5	387.8	396.9	1236.7	1252.1
Mean	32.7	32.2	55.4	56.7	102.8	104.3

Source: BSADP, 2017

Experimental layout, Pasture establishment

Mean of the two growing seasons of 2017 and 2018 was used as data for analysis in this study. A total plot area of 0.1ha (54mx36m) was used for the field trial, *B. ruziziensis* and *C. pascuorum* was planted as sole crops and at different mix ratios. The experiment was laid out in a Split plot design with factorial arrangement (5x3) consisting of five (5) treatment plots of grass-legume mixtures planted in rows 1m apart. The Treatment mixtures (**Treatment 1**: 100% sole *B. ruziziensis*, **Treatment 2**: 75% *B. ruziziensis*-25% *C. pascuorum*, **Treatment 3**: 50% *B. ruziziensis*-50% *C. pascuorum*, **Treatment 4**: 25% *B. ruziziensis*-75% *C. pascuorum* and **Treatment 5**: 100% sole *C. pascuorum*) constituted main plots and each main plot of grass-legume mixtures was further subdivided into three (3) sub-plots (17mx6m) of phosphorus fertilizer (SSP) levels (0, 100 and 150kg/ha). *B. ruziziensis* was planted in one row and *C. pascuorum* planted in next row simultaneously, both were planted in a row mixture of 1:1. Seeds of *B. ruziziensis and C. pascuorum* were measured and planted in row at a spacing of 50 cm between plant stands and at 2cm depth. Phosphorus fertilizer (SSP) was applied to the plants (at 0, 100 and 150 kg/ha) in the experimental plots as band placement at week 2 and week 5 after seedling emergence, respectively as full dose.

Data Collection and Procedures

Establishment count and field germination (%)

Seedling emergence was monitored from four (4) days after sowing, data on crop phenology such as number of plants per stand, plant height and number of tillers per branch/m^2 were measured at 4, 6 and 8 weeks after sowing. Seedling count was carried out 14 days after sowing to determine the number of plants per

stand within 1m x 1m quadrat. The plant height was measured using a meter rule from the ground to the tip of the flag leaf. The estimation of tiller numbers was carried out by counting the number of tillers per plant within a $1m^2$ quadrat thrown randomly.

Statistical Analysis

Data collected from the field trial were statistically analyzed using the procedures for experiments in a Split plot design (SAS, 2005). Data were subjected to Analysis of variance (ANOVA) using General Linear Model (GLM) of (SAS, 2005) while Duncan's Multiple Range Test (DMRT) was used to determine significant difference between treatment means.

Results and Discussion

Effect of mixture ratio, phosphorus level on plant establishment in *B. ruziziensis* and *C. pascuorum* mixtures

Table 2 shows the mean values for number of plant per stand for *B. ruziziensis* in the mixture ranged from 6.11 in 25%B.R:75%C.P to 9.56 in 100% sole *B. ruziziensis*. The result showed significant difference ($P<0.05$) in the mean values for number of plant per stand across treatments for *B. ruziziensis* except for 100% sole *B. ruziziensis* (9.56) and 75%B.R:25%C.P (9.33) which were statistically similar with each other ($P>0.05$). The mean values for number of plants per stand for *B. ruziziensis* and *C. Pascuorum* at different phosphorus levels is shown in Table 2. Number of plants per stand in *B. ruziziensis* was highest in treatments that received 150 kg/ha of phosphorus fertilizer (7.47) without significant difference ($P>0.05$) across treatments. The number of plants per stand for *B. ruziziensis* at different weeks after emergence was highest (11.56) at week 8, 11.33 was recorded at week 4 while week 6 was 10.80 and values were not significantly ($P>0.05$). Mean values for the number of plants per stand for *C. pascuorum* in the mixtures were not significantly ($P>0.05$) different and increased from 8.27 in week 4 and 6 to 8.33 at week 8.

The number of plants per stand after establishment for *B. ruziziensis* was observed to be lower as level of *C. pascuorum* increased in the mixture. Level of phosphorus fertilization and stage of growth did not show significant observable effect on the number of plants per stand. The number of plants per stand is an indication of the seed germination and seedling emergence in a plot. The germination test carried out prior to the commencement of this study indicated that seed of *B. ruziziensis* and *C. pascuorum* were viable which led to good number of plants per stand as was obtained in this study. *B. ruziziensis* in this study had more plants per stand than *C. pascuorum* and could be as a result of smaller and lighter seed in *B. ruziziensis* compared to seeds of *C. pascuorum* whose seeds are heavier and bulkier. Smaller seeds of *B. ruziziensis* indicate that weighted *B. ruziziensis* seeds will contain more seeds than its corresponding weighted equivalent of *C. pascuorum* seeds (Sani *et al*., 2015).

Table 2: Growth components of *B. ruziziensis* and *C. pascuorum* mixtures as affected mixture ratios, phosphorus levels

	No of Plant/Stand		Plant height (cm)		Tiller/Branch/M^2	
Treatments	**Brachiaria**	**Centrosema**	**Brachiaria**	**Centrosema**	**Brachiaria**	**Centrosema**
Mixture ratios (%)						
100% *B. ruziziensis*	9.56^{a}	-	23.33^{c}	-	190.9^{a}	-
75%B.R:25%C.P	9.33^{a}	2.89^{c}	28.22^{b}	29.28^{d}	87.80^{c}	32.9^{d}
50%B.R:50%C.P	8.89^{b}	11.11^{a}	29.39^{b}	37.72^{b}	107.6^{b}	184.00^{c}
25%B.R:75%C.P	6.11^{c}	6.89^{b}	38.00^{a}	45.11^{a}	57.60^{d}	188.20^{b}
100% *C. pascuorum*	-	6.67^{b}	-	36.11^{c}	-	257.90^{a}
SEM	0.044	0.025	0.085	0.062	0.259	0.244
Phosphorus levels (kg/ha)						
0	7.33	5.20^{b}	23.20^{b}	23.87^{c}	81.10	100.7^{c}
100	7.33	5.33^{b}	23.43^{b}	31.40^{b}	116.4^{b}	121.5^{b}
150	7.47	6.00^{a}	24.73^{a}	33.67^{a}	129.5^{a}	175.6^{a}

SEM	0.125	0.210	0.103	0.127	0.157	0.284
Sampling period (weeks)						
4	11.33	8.27	27.57^{c}	29.13^{c}	61.2^{c}	115.7^{c}
6	10.80	8.27	30.33^{b}	35.43^{b}	92.8^{b}	135.2^{b}
8	11.56	8.33	33.47^{a}	44.37^{a}	146.9^{a}	146.9^{a}
SEM	0.201	0.097	0.093	0.172	0.253	0.382
Interaction						
M x P	NS	**	**	**	**	**

$^{a, b, c}$= Means in the same row with different superscripts are significantly different (P<0.05), *= P<0.05, **= P<0.01, **NS**= Not significant, **P**= Phosphorus levels, **M**= Mixture ratios, **SEM**= Standard error of mean.

Effect of mixture ratio, phosphorus levels on plant height and tiller number in B. ruziziensis and C. pascuorum mixture

Table 2 above showed that plant height for *B. ruziziensis* and *C. pascuorum* in sole stand and mixtures increased significantly (P<0.05) across treatment as level of *C. pascuorum* increased in mixture. Similar increase in plant height was observed as phosphorus level and weeks increased. Plant height recorded highest value at 25%B.R:75%C.P for *B. ruziziensis* (38.0 cm) and *C. pascuorum* (45.0 cm) and was similar to the finding of Kusvuran *et al.* (2014) who obtained highest value for plant height at 80%HR:20%AR in a related study with Hungarian vetch and Annual rye grass at different mixtures. Factors like plant species, sowing ratio, soil climate and environmental conditions also influence plant height. Increase in plant height of *B. ruziziensis* in the mixtures as *C. pascuorum* increased could be due to increased nodulation and nitrogen fixation to the soil by *C. pascuorum* which influenced plant height in *B. ruziziensis*. Plant height were highest for *B. ruziziensis* (24.73 cm) and *C. pascuorum* (33.67 cm) at 150 kg/ha of phosphorus fertilizer and agrees with the finding of Suleiman (2006) who reported that application of phosphorus in relative quantity play a vital role in plant growth and all plant require phosphorus for growth and development in significantly large quantities. Also, Erman *et al.* (2009) reported increased plant height, number of branches shoot dry weight, number of pods, seed and biomass yield of inoculated *Pisum sativum* with phosphorus application. Table 2, showed the number of tillers per culm/m^2 was highest in treatment with 100% sole *B. ruziziensis*. This could be attributed to 100% sole *B. ruziziensis* having no competition from *C. pascuorum* coupled with its vigorous growth with an erect pattern. It correlates with the fact that as *C. pascuorum* increased in the mixture, tillers in *B. ruziziensis* decreased, which consequently resulted in lower number of tillers per plant for *B. ruziziensis* in the mixture. Tillering indicates the ability or potential of grasses to produce vegetative forage yield. The number of tillers per plant/m^2 in this study increase as the level of phosphorus increases, tiller number was less at early stage of growth for both specie but subsequently increased as the weeks increased which indicated that plant age had an effect on the number of tillers in plants.

Conclusion and recommendation

Treatment with 25%B.R:75%C.P forage mixture, fertilized with 150kg/ha SSP at week 8 sampling period had the better plant height and tiller per branch/m^2 and hence, recommended for optimum forage growth

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