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FORAGE YIELD POTENTIAL OF DOUBLE-RED MAIZE (*ZEA MAYS* L.) INTERCROPPED WITH TEPHROSIA (*TEPHROSIA BRACTEOLATA* GUILL AND PERR.) IN SHIKA NORTHERN GUINEA SAVANNAH

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ABSTRACT

The study was conducted to evaluate the agronomic potential of Double-red maize intercropped with *Tephrosia bracteolata* at the Breeder Seed Unit of National Animal Production Research Institute Shika, Zaria. The experiment was laid out in a 6×2×3 factorial arrangement in Randomized Complete Block Design (RCBD) with three replicates, which consists of four intercropping pattern (1:1, 1:2, 2:1 and 2:2 maize/*T. bracteolata* intra-row ratio) with sole maize and sole *T. bracteolata*, two plant spacing (25×60cm and 50×60cm) and three replications. Seedling emergence averaged 74.85% for maize and 79.35% for *T. bracteolata.* Plant height, number of leaves per plant and leaf area index (LAI) of maize and *T. bracteolata* and number of branches of *T. bracteolata* were significantly (P<0.05) affected by intercropping. There was no significant (p>0.05) effect of plant spacing on all growth components except plant height and LAI of maize. Plant height, number leaves per plant and LAI were significantly (P<0.05) affected by age of plant. The highest plant height (169.13cm), number of leaves per plant (12.00) and LAI (2.63) of maize were obtained at 12WAS. Fresh and dry matter yields were significantly (P<0.05) affected by intercropping pattern. The highest fresh forage yield (26.47 and 28.94t/ha) and dry matter yield (6.17 and 5.90t/ha) of maize and *T. bracteolata,* respectively were observed in sole treatments. Maize grain yield and land equivalent ratio were significantly (P<0.05) affected by intercropping. The highest value of 3.04t/ha for maize grain was recorded in sole maize treatment while the highest Land Equivalent Ratio LERs (1.50and 1.39) were recorded in 1:1 and 2:1 maize/*T. bracteolata* mixtures, respectively. Interactions significantly (P<0.05) affected only *T. bracteolata* forages. The study showed that among all intercropped mixtures, the 1:1 maize/*T. bracteolata* was preferable according to forage yield and maize grain yield than other intercropped mixtures. Plant spacing of 25×60cm had better nutrient compositions for maize forage. Intercropping Double-red maize with *T. bracteolata* in 1:1 intra-row ratio at plant spacing of 25×60cm is hereby recommended for smallholder farmers and livestock owners in Shika, Northern Guinea Savanna of Nigeria.

INTRODUCTION

Tephrosia bracteolata is a tropical shrub-like legume which produces seeds, leaves and stem which are useful in feeding animals in either fresh or conserved fodder (Ishiaku *et al*., 2015). Legume forage have reported to have the ability to fix atmospheric nitrogen in symbiosis with rhizobium bacteria lodge in their root (Bamikole *et al*., 2004; Odedire and Babayemi, 2016) which is made available to the companion plant in the process of nutrient uptake. Therefore, intercropping it with grass is a means of improving productivity compared to

monoculture, without any additional investment; cost of fertility of a companion cereal crop can be reduced through the activities of nitrogen fixation by legume (Abubakar *et al*., *2006*). The benefit of cereal-legumes association can be experienced, among others, in terms of enhanced dry matter yield, nitrogen content of herbage, animal intake of forage and animal productivity. Furthermore, it is attractive strategy to smallholder farmers for increasing land labour utilization per unit of area of available land though intensification of land use (Seran and Brintha, 2010).

Maize (*Zea mays*) is an important cereal crop in Nigeria. It is used as a main source of diet by many people in both rural and urban areas (Iken and Amusa, 2004). The common crop combinations in intercropping systems of this region are cereal-legume, particularly maize-cowpea, maize-soybean, maize-pigeonpea, maize-groundnuts, maize-beans, sorghum-cowpea, millet-groundnuts, maize-lablab, S*orghum almun*-lablab (Rees, 1986; Hassan *et al*., 2014; Amole *et al*., 2015; Ishiaku, 2016). However, there is scantiness of information on the productivity of maize intercrop with *T. bracteolata* and thus it is imperative to explore the possibility of integrating these crops in the Northern Guinea savannah of Nigeria. The objective of this study was to determine the forage yield potential and quality of *T. bracteolata* intercropped with Double-red maize in Shika, Northern Guinea savannah of Nigeria.

MATERIALS AND METHODS

Description of the Experimental Site

The study was conducted at the Experimental Farm of the Feeds and Nutrition Research Programme, National Animal Production Research Institute, Shika during the 2016 rainy season. Shika is located on latitude 11^0 12'W and longitude 07^0 33'E, with an altitude 660m above sea level, along Zaria-Funtua Road in the Northern Guinea Savannah zone of Nigeria (Ovimap, 2016). The climate of the study area is characterized by a defined wet and dry season. Wet season starts from April to early May and ends in late September to early October while the dry season last from October to April. The total annual rainfall ranges from 748.6-1156.7 mm with long term average of 1058.60mm with a maximum air temperature of 35^0C in May and minimum air temperature of 11.15^0C in December/January and relative humidity of approximately 75% (IAR, 2016).

Meteorological data of the experimental site

Weather observations at Shika and environs during the experimental period in 2016 are represented in (Table 1). The maximum and minimum air temperatures 32.27^oC and 22.65^oC respectively were recorded for the months of May to October during the rainy days which were slightly similar to the previous records. The total annual rainfall of 1049.90mm with an average of 209.18mm was recorded in 2016. Total number of rain days in Shika, was 61 days for 2016. A mean relative humidity of 73.33% and mean sunshine 7 hours was observed.

Table 1: Weather observations at IAR and environs during the experimental period

Months	Max. Air Temp (^{0}C)	Min. Air Temp (^{0}C)	Rainfall (mm)	Relative Humidity (%)	Sunshine (Hours)
May	35.16	24.16	81.30(6)	66.39	7.83
June	31.40	23.20	133.30(14)	75.50	7.12
July	30.84	22.94	218.40(10)	80.39	5.90
August	30.55	21.90	268.80(16)	81.94	6.68
September	32.46	25.45	344.10(15)	77.28	6.31
October	33.23	18.23	-	58.45	8.16
Total	-	-	1045.90(61)	439.95	42.00
Mean	32.27	22.65	209.18(12)	73.33	7.00

Number of rainy days is in parenthesis, Source: IAR, 2016

Soil samples of the Experimental Site

Soil samples were collected from the experimental site with the aid of a Soil auger at 4 corners and centre of the plots to the depths of 0-15cm and 15-30cm. Samples collected were mixed thoroughly and representative samples were taken for soil analysis before the commencement of the experiment. The soil samples were then analysed for physical and chemical properties **(**texture, particle size, total nitrogen, total carbon, phosphorus, soil pH, cations exchange capacity (CEC)). The analysis was carried out at the Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Experimental layout, design and treatments

A total land area of 29.5m × 11m (0.0325ha) was used for the experiment. The field was prepared by ploughing, harrowing with tractor drawn implements and ridged with two (2) Work bulls to provide clean seedbeds and to enhance better plant germination. The experimental field was divided into 3 main blocks each (3m × 29.5m) and was separated by 1m apart. Each block was sub-divided into 12 sub-plots (3m × 2m) at 0.5m apart. The experiment was laid out in a randomized complete block design (RCBD) with split-plot arrangement of 6x2x3 consisting of six treatments (maize intercropped with *T. bracteolata* in an intra row at 1:1, 1:2, 2:1 and 2:2 ratio, Sole maize and Sole *T. bracteolata* were used as controls), two plant spacing (25×60cm and 50×60cm) and three replications.

Experimental materials and agronomic study:

Tephrosia (*Tephrosia bracteolata* Perr. and Guil.) seeds were obtained from the Feeds and Nutrition Research Programme, National Animal Production Research Institute Shika, Zaria, while double-red maize (*Zea mays* L.) seeds from Kaduna State Agricultural and Development Program (KSADP), Kaduna, Kaduna State.

Seeds of *T. bracteolata* and maize were planted on ridges at 2cm depth using recommended seed rate of 10kg/ha (Ishiaku *et al*., 2015) and 20kg/ha, respectively. *Tephrosia bracteolata* seeds were scarified in boiled water for 8 minutes. Both maize and *T. bracteolata* seeds were sown at the same time by hand at a spacing of 25×60cm and 50×60cm and the planting took place when rain was established on 20th July, 2016. Weedings were done manually with hoes at 3 and 6 weeks after

sowing. Plants were thinned to 2 plants per stand after the first weeding and a uniform dose of fertilizer (120N:60P:60K kg/ha) per hectare was applied in two splits, immediately after first and second weeding to control any variation that could be due to soil fertility.

PARAMETERS MEASURED

Growth parameters and percentage field germination

Data on crop phenology was measured at 6, 8, 10 and 12 weeks after sowing. Three (3) plants from the two middle rows were randomly sampled per plot and tagged for the measurements of various agronomic parameters using the standard procedure as reported by Tarawali *et al*. (1995).

Plant height, branch number, leaf number and leaf area index

The plants height was measured using a meter rule from the ground to the tip of the flag leaf for maize. The estimation of branch numbers was carried out by counting the number of branches per plant at 6, 8, 10 and 12 weeks after sowing (WAS). The number of leaves per plant was obtained by counting the number of leaves per plant and the average number of leaves is recorded. Leaf length of the plants was estimated by measuring from the tip of the leaf to the base of the ligule with the aid of tape rule from 3 randomly selected plant stands per plot. Leaf width was determined by measuring the length of leaf half way or midpoint of the leaf gives the leaf width with the aid of 30cm meter rule on 5 randomly selected plants stands per plot. Leaf area index was calculated as the ratio of leaf area to the area of ground cover at 6, 8, 10 and 12 WAS, respectively. Leaf area was calculated by multiplying the length of the leaf by its width and a factor of 0.75 as described by Adesoji *et al*. (2013).

$$LAI = \frac{\text{Leaf area per plant (cm)} \times 0.75}{\text{Area of ground cover per plant (cm)}}$$

Determination of forage yield of Double-red maize and *T. bracteolata,* and seed yield of Double-red maize in t/ha:

Forage yield was determined by harvesting the fresh forage within each sub-plot within one $1m^2$ quadrat at a height of 15cm above the ground level at 14 weeks after sowing using a hand sickle. The harvested fresh wet forage materials were weighed and a known weight of sub samples (200 grams) was oven dried at 65^0C for 48 hours and reweighed to estimate dry matter yield (DWss) at the animal science laboratory, Faculty of Agriculture, Ahmadu Bello University, Zaria. Dry matter yield (t/ha) was calculated using formula below as reported by Tarawali *et al*. (1995).

$$\text{Dry matter (t/ha)} = (\text{Total FW} \times (\text{DWss/FWss})) \times 10$$

Where: Total FW = Total fresh weight from 1 m^2 in (g), DWss = Dry weight of the sub-sample in (g), FWss = Fresh weight of the sub-sample in (g)

The cobs were harvested manually from each plot, dried thoroughly and the seeds separated from their cobs by beating with wooden stick. Seed weight was recorded and computed to t/ha.

Determination of Land equivalent ratio (LER):

The benefit of planting spacing and the effect of competition between two species in the experiment was calculated by land equivalent ratio. LER verifies the effectiveness of intercropping for using the resource of the environment compare to sole cropping.

The LER was calculated as reported by Lelmel (2013)

$$\text{Total LER} = \text{IYM/SYM} + \text{IYT/SYT} = LER_{maize} + LER_{tephrosia}$$

Where:

SYM =Sole yield of maize

IYM= Intercropped yield of maize

IYT= Intercropped yield of *T. bracteolata*

SYT= Sole yield of *T. bracteolata*

$LER_{tephroia}$ represent the partial *T. bracteolata* equivalence

LER_{maize} represents the partial equivalence for maize

The value indicates advantage through intercropping when the value of LERt is greater than one and a disadvantage is through intercropping when value is less than one and no effect when the value equals one.

Chemical analysis

Samples of forage materials harvested were taken to laboratory for chemical analysis. The dried samples of forage were ground using a simple mill and passed through 1-2mm sieve. Proximate analysis was carried out to determine Nitrogen (N) for crude protein determination (N×6.25), crude fibre (CF), Ether Extract (EE), Nitrogen Free Extract (NFE) and ash content according to the procedure described by AOAC (2005). Neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) were determined by method of Van-Soest *et al.* (1991). Mineral contents (Sodium, Calcium, Potassium, and Phosphorus) were determined by the standard laboratory procedure of AOAC (2005) using the atomic absorption spectrophotometer.

Statistical Analysis

In experiment I, data on growth components were analysed using repeated measures of Analysis of Variance (ANOVA) and forage yield, proximate composition, fibre fractions and minerals were analysed using General Linear Model Procedure (Proc. GLM) of SAS (2005). Significant ($P<0.05$) differences among treatment means were compared by using Duncan Multiple Range Test (Duncan, 1955) of the SAS package.

Experimental Model

$Y_{ijk} = \mu + A_i + B_j + (A*B)_{ij} + E_{ijk}$

Where:

Y_{ijk} = is the record of observations for dependent variables

μ= is the population mean

A_i = effect of intercropping/treatments (i = 1, 2, 3, 4, 5 and 6)

B_j = effect of spacing (j = 25cm and 50cm)

$(A*B)_{ij}$ = effect of intercropping by spacing

E_{ijk} = random error assumed to be normally and independently distributed

RESULTS

Soil characteristics of the Experimental Site

Table 2 provides information on the physiochemical characteristics of the composite soil sample taken from 0-15cm and 15-30cm depth of the Experimental Site. The soil consists of 16.00-16.20% clay, 29.60-30.00% silt and 54.00-54.20% sand. The organic carbon was between 0.62 - 0.67%. The pH values were 4.8 and 4.7 for 0-15cm and 15-30cm, respectively. This shows that the soil of this Experimental Site is acidic in nature. The soil of the experimental site was low in total nitrogen (0.18-0.19%) and available phosphorus was 23.28% at 0-15cm and 22.01% at 15-30cm, respectively. The exchangeable cations present in the soil consist of Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} needed for plants growth and development. Also the soil has cation exchange capacity, exchangeable acidity and electrical conductivity of 8.70cmol/kg, 0.80Cmol/kg and 0.070dsm, respectively.

Table 2: Soil physical and chemical properties of the experimental site

	Soil dept	
Physical properties	**0-15cm**	**15-30cm**
Particle size (%)		
Clay	16.00	16.20
Silt	30.00	29.60
Sand	54.00	54.20
Textural class	Sandy loam	Sandy loam
Chemical properties		
PH (0.01MCaCl)	4.8	4.7
Total Nitrogen (%)	0.175	0.190
Organic Carbon (%)	0.67	0.62
Phosphorus (ppm)	23.28	22.01
Exchangeable bases (Cmol/Kg):		
Ca^{++}	4.0	3.91
Mg^{++}	1.50	1.43
K^{+}	0.64	0.62
Na^{+}	0.32	0.31

Growth component of double-red maize planted sole and intercropped with *T. bracteolata*

Table 3 shows the effect of intercropping, plant spacing and age of maturity on maize growth component and maize/*T. bracteolata* intercrop.

Table 3: Effect of intercropping, plant spacing, age of plant and their interactions on plant height, number of leaves and Leaf Area Index (LAI) of maize and maize/ *T. bracteolata* intercropped

Treatments	Plant height (cm)	No. of leaves per plant	Leaf Area Index
S. Maize	119.76^{c}	9.77^{b}	2.88^{a}
1:1	126.67^{bc}	10.14^{b}	2.37^{b}
1:2	130.66^{abc}	9.71^{b}	2.12^{b}
2:1	140.28^{a}	10.73^{ab}	2.80^{a}
2:2	133.50^{ab}	10.88^{a}	2.59^{ab}
SEM	6.79*	0.33*	0.17*
Spacing			
25×60cm	132.29^{a}	10.28	2.60^{a}
50×60cm	127.96^{b}	10.20	1.37^{b}
SEM	16.95*	0.82^{NS}	0.43*
Weeks after planting			
6	61.52^{c}	9.33^{c}	1.06^{c}
8	123.15^{b}	9.90^{c}	1.97^{b}
10	165.86^{a}	11.00^{b}	2.29^{a}
12	169.13^{a}	12.00^{a}	2.63^{a}
SEM	8.48*	0.41*	0.22*
Interaction			
P×S	0.7087	0.5326	0.0069
S×W	0.9753	0.7028	0.2484
W×P	0.9508	0.1802	0.1407
P×S×W	0.9993	0.3311	0.1729

^{abc}means with different superscripts within columns differed significantly (P<0.05), * = significant at 5% level of significant, NS = not significant, S. = sole, P= planting pattern, S=spacing,W= weeks after sowing, SEM= standard error of mean, 1:1 = 1maize :1 *T. bracteolata*, 1:2 = 1maize:2 *T. bracteolata*, 2:1 = 2maize:1 *T. bracteolata*, 2:2 = 2maize:2*T. bracteolata*,

The effect of intercropping on growth components

Intercropping significantly (P<0.05) affected plant height and leaf area index (LAI). The highest plant height values of 140.28 and 133.50cm were recorded in 2:1 and 2:2 maize-*T. bracteolata* intercrops, respectively, while the lowest (119.76cm) was recorded in sole-maize treatment. Leaf area index of (2.88 and 2.80) were significantly (P<0.05) higher in sole maize and 2:2 maize-tephrosia intercropped respectively. The least values (2.37 and 2.12) were observed in 1:1 maize-*T. bracteolata* and 1:2 maize- *T. bracteolata* intercrop, respectively. However, intercropping does not significantly (P>0.05) affects the number of leaves per plant.

Effect of plant spacing on growth components

Plant spacing significantly (P<0.05) affected the plant height and leaf area index. The highest plant height of 132.29cm was obtained at 25×60cm plant spacing, which was significantly (P<0.05) higher than 127.96cm recorded with 50×60cm. The leaf area index was significantly (P<0.05) higher in spacing of 25×60cm compared to spacing of 50×60cm. There was no significant (P>0.05) effects of plant spacing on the number of leaves per plant.

Effect of stages of maturity on growth components

Plant height, number of leaves per plant and leaf area index increased significantly (P<0.05) as the age of plant increased from 6 to 12 weeks after sowing (WAS). There were 63.63%, 22.25% and 59.70% increase in plant height, number of leaves per plant and leaf area index (LAI), respectively as the age of plant increased up to 12weeks. The plant height and LAI were similar at 10 and 12WAS. The same trend was observed in number of leaves per plant at 6 and 8WAS. All interactions were not significant (P>0.05) except interaction between planting pattern and plant spacing which had significant effect on leaf area index of *T. bracteolata* plants.

Fresh and dry matter yields

Table 4 shows the effect of intercropping and plant spacing on fresh and dry matter yield of maize, *T. bracteolata* and maize- *T. bracteolata* intercropped.

Effect of intercropping

Intercropping was observed to significantly (P<0.05) affected the fresh and dry matter of both the plant species. The highest fresh and dry matter yields of maize (26.47tones/hectare (t/ha) and 6.17t/ha DM) obtained in sole maize were significantly higher than the intercrop plots. Similarly, it was observed that the fresh and dry matter yields of sole *T. bracteolata* (28.93t/ha and 5.90t/ha DM) were significantly higher than the intercropped plots. There was no significant (P>0.05) effect of plant spacing observed in fresh and dry matter yields of maize and *T. bracteolata*.

Table 4: Effects of intercropping and plant spacing on fresh and dry matter yields of Double-red maize, *T. bracteolata* and maize-*T. bracteolata* intercropped

Treatments	Fresh forage yield (t/ha)			Dry forage yield (t/ha)		
	Maize	*T. bracteolata*	Total	Maize	*T. bracteolata*	Total
S. Maize	26.47[a]	-	26.47	6.17[a]	-	6.17
S. Tephrosia	-	28.93[a]	28.93	-	5.90[a]	5.90
1:1	21.98[b]	15.80[b]	37.78	4.28[b]	3.80 [b]	8.80
1:2	15.70[c]	14.50[b]	30.20	3.10[d]	3. 39[b]	6.49
2:1	16.07[c]	11.13[c]	27.20	4.72[b]	2.83[c]	7.55
2:2	17.07[c]	11.33[c]	28.40	3.67[c]	2.85[c]	6.52
SEM	1.74[*]	2.20[*]		0.47[*]	0.48[*]	
Spacing						
25×60cm	23.0	18.32		5.79	3.99	
50×60cm	16.76	14.53		4.13	3.66	
SEM	4.34[NS]	5.49[NS]		1.17[NS]	1.21[NS]	
Interaction						
P× S	0.7864	0.9925		0.2915	0.6538	

[abc] means with different superscripts within columns differed significantly ($p<0.05$), * = significant at 5% level of significant, NS= not significant, S. = sole, P=planting pattern, S=spacing, SEM=standard error of mean, 1:1= 1maize :1 *T. bracteolata*, 1:2 =1maize: 2, 2:1= 2maize: 1 *T. bracteolata*, 2:2=2maize:2 *T. bracteolata*

Maize grain yield and total land equivalent ratio (LER)

Table 5 provides information on the effects of intercropping and plant spacing on maize grain yield and LER.

Intercropping significantly ($P<0.05$) affected maize grain yield and total LER. Sole maize plots produced the highest ($P<0.05$) maize grain yield (3.04t/ha) while the least was recorded in 1:2 maize-*T. bracteolata* intercropped plots. The LER values of (1.50 and 1.39) for 1:1 and 2:1 maize-*T. bracteolata* intercrops, respectively were significantly ($P<0.05$) higher than the other treatments. However, the mean LERs of all intercrops in this experimental were greater than one (1.0) which means that there was 50%, 39%, 25% and 15% intercrop advantage in 1:1, 2:1, 1:2 and 2:2 maize-*T. bracteolata* mixtures, respectively than the average of the pure stands. The results of this finding also showed that maize grain yield and total LER were not significantly affected by plant spacing. There were also not significant interaction effects of intercropping and plant spacing on maize grain yield and total land equivalent ratio.

Table 5: Effect of intercropping and plant spacing on Double-red maize grain yield and total land equivalent ratio

Treatments	Maize Grain yield (t/ha)	Total land equivalent ratio (LER)
S. Maize	3.04[a]	1.00[c]
S. Tephrosia	-	1.00[c]
1:1	2.35[b]	1.50[a]
1:2	1.43[c]	1.25[baa]
2:1	2.14[b]	1.39[a]
2:2	1.92[bc]	1.15[b]
SEM	0.27*	0.07*
Spacing		
25×60cm	2.54	1.28
50×60cm	1.93	1.19
SEM	0.68 [NS]	0.11[NS]
Interaction		
P×S	0.9304	0.9017

[abc] means with different superscripts within columns differed significantly (P<0.05), * = significant at 5% level of signicant, NS=not significant, S. = sole, P= planting pattern, S=spacing, SEM=standard error of mean, 1:1= 1maize :1 *T. bracteolata* ratio, 1:2 =1maize: 2 *T. bracteolata* ratio, 2:1= 2maize: 1 *T. bracteolata* ratio, 2:2=2maize:2 *T. bracteolata* ratio

DISCUSSION

Growth components of double-red maize planted sole and intercropped with *T. bracteolata*.

The lowest plant height of 119.76% was obtained in sole maize compared to intercrop treatments (Table 3). The higher plant height in the intercrop treatments could be due to nodulation and nitrogen fixation ability of the *T. bracteolata* which is utilized by the maize component. This was in an agreement with the findings of Ishiaku (2016) who noted an increase in plant height of *Sorghum almum* intercropped with *Lablab prupreus*; Amjad *et al*. (2014) also observed increase in plant heights of corn when intercropped with *Vigna unguiculata* and *Glycine max* than the sole crops. Plant height (161.13cm) of maize observed at 12WAS in this finding was higher than what Hassan *et al*. (2014) recorded at 12WAS. The higher plant height and number of leaves per plant recorded in 1:2 and 2:2 maize/*T. bracteolata* mixtures suggests a greater contribution of *T. bracteolata* probably through the rhizobium nodulation, mainly nitrogen as compared to other treatments. The leaf area index for maize reported in this study (1.06-2.88) were similar to (1.600-3.00) reported by Hassan *et al*. (2014) in a study under irrigation. A significant reduction in leaf area index in 1:1 and 1:2 maize/ *T. bracteolata* mixtures were

observed when compared with the sole maize treatment. This might be due to competition between plant species for both above-ground for light and belowground for water and soil nutrients (Corre-hellou and Crozat, (2007). This is in conformity with the findings of Ishiaku (2016) who recorded a lower leaf area index for *Sorghum almum* intercropped as compared to sole cropping. Additionally, the reductions in leaf area index of maize under intercropping have been reported by many researchers (Matusso *et al*., 2012; Thobatsi, 2009; Bilalis *et al*., 2005).

The similarity in LAI of maize between 2:1 maize/*T. bracteolata,* 2:2 maize/*T. bracteolate* and the sole maize correspond with the result of Filho (2000) who did not find any significant differences in LAI between sole maize and maize intercropped with cowpea. Also, Twala and Ossom (2004) did not find any significant differences in LAI between maize monocrop and maize intercropped with groundnuts. However, LAI obtained in this finding was in contrast with previous reports. Balde *et al*. (2011) found that maize intercropped with *Cajanus cajan* had higher LAI than sole maize crop; Thobatsi (2009) also found that maize intercropped with cowpea (*Vgna unguiculata*) had higher leaf area index compared to sole maize crop.

Plant spacing has a special significance it is ultimately related with plant population, root development, plant growth and fruiting (Davi *et al*., 1995). Generally the most appropriate plant spacing is one, which enables the plants to make the best use of conditions at their disposal (Maqbool *et al*., 2006). The plant height and LAI were higher at 25×60cm. This might be attributed to high plant density in closer spacing. Abuzar *et al*. (2011); Valadabali and Farahani (2010) reported that leaf area is influence by genotype, plant population, climate and soil fertility. They further stated that the highest physiological growth indices are achieved under high plant density, because photosynthesis increased by development of leaf area. Too wide spacing may result in abundant weed population due to more feeding area available (Maqbool *et al*., 2006).

Fresh and Dry Matter Yields of double-red maize, *T. bracteolata* and Maize/ *T. bracteolata* Mixtures

Sole crops of double-red maize (*Zea mays* L.) and *T. bracteolata* recorded highest forage yields while the least was obtained in intercrop treatments. The low yields in the intercrop might be due to inter specific competition and low plant density. The seeding rate in each intercrop was adjusted below its full rate to optimize plant density, because if full rate of each crop were planted, neither would yield well because of overcrowding. This agrees with the work of Gabatshele *et al*. (2012) who reported that sole crop produced significantly more dry weight than maize intercropped with cowpea and attributed it to high plant density and lack of competition for resources such as light, nutrients and water. Gbaraneh *et al*. (2004); Willey and Osiru (1972) also observed reduction in cowpea and maize yields in maize-cowpea intercrops due to lower plant densities. However, the combined total yields for maize/*T. bracteolata* intercrops were significantly higher. Intercropping has been reported to increase light interception, reduce water evaporation and improve conservation of soil moisture (Ghanbari *et al*., 2010).

Among the intercrops, 1:1maize/*T. bracteolata* mixture had the highest fresh and dry matter biomass yield for both species. This suggested a better contribution of *T. bracteolata* in 1:1maize/ *T. bracteolata* mixture, probably through the rhizobium nodulation mainly nitrogen as compared to the other treatments. The dry matter yield for *T. bracteolata* obtained in this study was higher than 970kgDM/ha reported by Ojo *et al*. (2012). In contrast, the average fresh weight (16.34t/ha) observed was lower than (35.67t/ha) recorded by Ishiaku *et al*. (2015). This might be as a result of plant method used by Ishiaku *et al*., 2015; drilling at 30cm space between the rows which led to

higher plant density as compared to dibbling at 25×60cm and 50×60cm used in this work. The mean forage yield for maize obtained in this study was higher than 1.4t/ha reported by Gbaraneh *et al*. (2004).

Maize Grain Yield and Total Land Equivalent Ratio (TLER)

Sole maize plots had better grain yield (3.04t/ha) compared to intercropped plots. The low grain yield in the intercrops could be attributed to interspecific competition during grain production stage and low plant density. This was in agreement with findings of Dwomon and Quainoo (2012) who also observed lower maize and groundnut grain yields in intercrop plots and attributed it to shading and interspecific competitions. Mkamilo (2004) stated that intercropping maize with forage legumes decrease maize grain yields.

Among the intercropped, 1:1 maize/ *T. bracteolata* treatment had highest (2.35t/ha) grain yields compared to other planting patterns. This suggests that the planting pattern of one *T. bracteolata* to one maize intra-row mixtures was less competitive in the intercrop. This agree with the findings of Hirpa (2014); Mutungamiri *et al*. (2001) who reported lower grain yield records from plots where maize was intercropped with two and three rows of bean compared to 1:1 row arrangement. The maize grain yield recorded in this study (Table 5) was below the potential maize grain yield of 7 metric tons per hectare reported by IITA (2011). The reason for the low grain yield might be connected with the prevalence of stem borer observed in the stem during reproductive growth stage. Souza *et al.* (2012) stated that maize is damage more by stemborer than other cereal crops because of higher amino acid and sugar than other gramineous host (sorghum and millet). Furthermore, maize emits volatile compounds, capaene, (Z)-3-hexenol, etc which attract these stemborers. Iowa State University (ISU) (2012) reported that yield losses as high as 40% could result from stem borer damage.

The current maize yield reported from smallholder farmers in Nigeria was 1.4-1.5t/ha (IITA, 2012). Since intercropping maize and *T. bracteolata* in 1:1 ratio yielded upto (2.35t/ha), it implies that smallholder farmers in Nigeria could practice this food-forage technology without adverse effect on maize grain yield. Another advantage to be derived from such grass-legume mixture is increased nutrients availability in the soil (Birteeb *et al*., 2011; Hassan *et al*., 2014) which could be utilized by the succeeding cereal crop in subsequent cropping seasons and improved efficiency in term of LER (Rashid, 2010). The result of this study for maize grain yield (1.43-2.35t/ha) in the intercrops was statistically higher than 1.27-1.94t/ha reported by Hassan *et al*. (2014) under irrigation condition. The range (1.70-2.88t/ha) recorded by Gbaraneh *et al*. (2004) in lablab-maize intercropped was slightly higher than the one recorded in this finding.

The total land equivalent ratios (LERs) for the mixture indicated a yield advantage of 15-50% over that from pure stands of the different species (Maize and *T. bracteolata).* This implies that sole crops would require 15-50% more land to achieve the yield obtained by the intercrops. This may indicate nitrogen contribution to grass through nitrogen fixation by the legumes and it transfer from the legume component to the grass (Amole *et al*., 2015). Among the planting pattern, 1:1 and 2:1 maize/*T. bracteolata* mixtures had the highest LER. This might be attributed to better utilization of growth resources in 1:1 and 2:1 maize/*T. bracteolata* mixtures. The result of this finding agreed with the report of Amole *et a*l. (2015) who obtained a yield advantage of 21-79% over that from an average of pure stands from different species. It's also corroborated with previous reports (Ishiaku, 2016: Lelmel, 2013).

CONCLUSION

It was concluded that intercropping maize and *T. bracteolata* at 1:1 mixture recorded the

highest forage yields, crude protein (8.13%) content and land equivalent ratio (LER) of 1.50. Plant spacing of 25×60cm produced the highest plant height (132.29cm), leaf area index (2.60cm), crude fibre (26.79%), ash (4.15%) and nitrogen free extract (62.34%) contents.

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