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INFLUENCE OF TILLAGE AND OVER-SOWING METHODS ON GROWTH, POPULATION DYNAMICS AND BIOMASS YIELD OF TWO STYLOSANTHES SPECIES IN NATURAL PASTURE

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ABSTRACT

Growth, population dynamics and biomass yield of two forage legumes oversown into natural pasture were evaluated. Two legumes (*Stylosanthes guianensis* cv. Cook and *Stylosanthes hamata* cv. Verano), two tillage methods (zero-tillage and minimal tillage) and two sowing methods (broadcast and drill) were combined into eight (8) treatments and replicated 4 times as a 2 × 2 × 2 factorial arrangements in a randomized complete block design. Planting was done in late rainy season (September, 2013) and the natural pasture were evaluated for height and canopy/soil cover between 2-8 months after sowing (MAS) which covered the dry and rainy seasons. Evaluation of dry matter yield (DMY) of the sown legumes, dominant grass and other herbaceous species occurred at the onset of rains (May and July, 2014). There were significant differences ($p<0.05$) in the soil covered by sown legumes, dominant forage grass (*P. maximum*) and other herbaceous species in the dry season. In May, *S. guianensis* produced higher DMY (9.00 t/ha) with minimal tillage prior to broadcast compared to similar least yields of 4.00 t/ha and 4.25 t/ha recorded for the same legume when oversown with minimal tillage-drill and zero tillage-broadcast respectively. Proportions of other herbaceous species were very low in ShZtD (11.79 %) and ShMtD (17.51 %) at 8 and 10 MAS respectively. Irrespective of the tillage or sowing methods employed, the two oversown legumes survived competition from existing species and drought of dry season; but with minimal tillage, drilled *S. hamata* thrived more and contributed higher DM yield amidst other companion species.

Keywords: botanical composition; dry matter yield; drought tolerance; *P. maximum*; *S. guianensis*; *S. hamata*

INTRODUCTION

Livestock plays a very important role in Nigerian agriculture, contributing about 26.31% of the Agricultural Gross Domestic Product (GDP) (CBN, 2012). However, insufficiency of quality fodder has been a perennial problem facing ruminant production, especially in the dry season in Nigeria. The natural pasture which is the cheapest source of forage in the moist savanna zone of Nigeria does not supply adequate year-round quality and quantity forage and needs to be improved. Oversowing of natural pasture with improved and proven forage legumes has long been proven as a feasible and productive option to increase the dry matter yield of natural pasture (Tarawali *et al*., 1999) and animals grazing such pastures are, therefore, exposed to forage with enhanced crude protein

status than a sole grass pasture (Crowder and Chheda, 1982). Germination of oversown seeds and growth of the seedlings rely on adequate follow-up rains, adaptation of the introduced grasses and/or legumes, suitability of the soil condition for radicle penetration and minimal or no competition from the existing species (Akinola, 2015). de Leeuw *et al*. (1992) stated that understanding of the population dynamics of *Stylosanthes* species in mixed grass-legume pastures is a necessary prerequisite for designing effective methods of establishment and developing biologically sound management strategies aimed at sustainable long-term yields with high legume content. So, investigating the trends of growth, population dynamics and contributory dry matter yield of *Stylosanthes* species or other legumes as oversown into natural pasture is important as well. Therefore, this study was designed to seek sustainable, low technical know-how and stress-free practices for effective over-sowing and improvement of natural pasture for enhanced ruminant production.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at Oja-Odan, Yewa North Local Government Area of Ogun state, Nigeria. The site lies in the Derived Savanna agro-ecological zone of Southwest, Nigeria. Oja-Odan is about 20.18 km and 78.82 km from Ilaro and Abeokuta, the Ogun State capital, respectively and lies on latitude 7º 1' 2.6" N and longitude 2º 50' 41" E, at altitude 35 m. Abeokuta lies on latitude 7º 9' 39" N, longitude 3.5º 20' 54" E, at altitude 67 m. Abeokuta records a mean annual rainfall of 1230mm in bimodal pattern with peaks in July and September and experiences high (83-100 %) and low (55-84 %) relative humidity during the rainy and dry seasons, respectively. Mean monthly temperature ranges between 23.25 ºC in April and 31.00 ºC in December (OORBDA, 2014). The soil at the experimental site was similar to the pre-classified Iwo series of alfisols (Nwachokor and Uzu, 2008); it was slightly acidic (pH 6.52) and sandy-loamy (Nwachokor *et al*., 2009).

Pre-planting activities and experimental design

An experimental land measuring 31 m × 15 m was mapped out in area with moderate concentration of naturally existing grasses. The land was minimally cleared to 20 cm average stubble height for easy access. Thereafter, the plots for minimal tillage were further cut to 5 cm stubble height, such that the top soil was minimally agitated (between 0-5 cm soil depth) with no serious overturning, while there was no soil agitation on the zero-tilled plots. The treatments were arranged as 2 × 2 × 2 factorial in a randomized complete block design with 4 replicates and 8 plots per replicate. Each plot measured 3 m^2, with 1 m inter-plots spaces and 1 m between the replicates. Two legumes (*Stylosanthes guianensis* cv. Cook and *Stylosanthes hamata* cv. Verano), two tillage methods (Zero-tillage and minimal tillage) and two sowing methods (broadcast and drill) constituted eight (8) treatment combinations. The treatments were randomly allotted to the plots per replicate. Herbaceous species, other than the sown legumes found on each plot were also identified (Appendix 1).

Planting materials, oversowing and post-sowing activities

The legume seeds were procured from National Animal Production Research Institute Shika, Ahmadu Bello University, Zaria. A day prior to planting, the legume seeds were scarified, using water at boiling point. The seeds were placed in a cotton cloth bag, immersed in boiling water for 3 minutes, and thereafter dried under a shade (Olanite, 1997). In late rainy season (September, 2013), sowing was carried out according to the treatments of each plot by broadcast or drill at 7 kg/ha seeding rate. Drilling was achieved with seeds been placed along each row, at 50 cm inter-row spacing. Seeds were evenly spread on each plot for the broadcast method. Single

superphosphate (SSP) fertilizer was broadcast on the plots at the rate of 60 kg/ha at the onset of rains (in April 2014).

Estimation of drought tolerance and plant growth

The drought tolerance and survival of the legumes amidst the existing dominant grass and other herbaceous species were visually estimated during dry (November, 2013 - January, 2014) and rainy (May and July, 2014) seasons, as percentage of green plant stands of the sown legumes, existing dominant grass and other herbaceous species covering each plot using two 0.5 m^2 quadrats. All plant materials within the quadrats were visually rated in percentage (Olanite, 1997). Height of the existing dominant grass, sown legumes and other herbaceous species were measured during the dry (November, 2013 - January, 2014) and rainy (May and July, 2014) seasons, within 0.5 m^2 quadrat using meter rule.

Sampling for yield estimation, botanical composition and species' identification

Samples of sown legumes, existing dominant grass and other herbaceous species were harvested for the determination of dry matter yield (DMY) at the onset of rains (May and July) in the second year (2014), in order to estimate establishment success and how the botanical composition thrived over the study period. All plant materials within 1 m^2 quadrat per plot were harvested at 20 cm stubble height. Harvested plant materials from each quadrat were differently and immediately weighed (total fresh weight, TFW) and sorted into sown legumes (legume fresh weight, LFW), existing grasses (grass fresh weight, GFW) and other herbaceous species (other plant species fresh weight, OFW). Thereafter, they were oven-dried at 65 ^oC until constant weight (dry sample weight, DSW). Dry matter percentage (%DM) and DMY of each component were calculated as follows: % DM = (Weight of dry sample / Weight of fresh sample) × 100;

DMY = Dry matter percentage × Fresh sample weight

Total DMY of every component were obtained by totaling the component DMYs i.e. Total DMY = existing grass DMY + sown legumes DMY + other herbaceous species DMY. Proportion of each component was as estimated for the grass DMY below:

Proportion of existing grass DMY = (grass DM yield / Total DMY) × 100

Statistical Analysis

All collected field data were subjected to analysis of variance and the treatment means were separated using Duncan's Multiple Range Test (SAS, 1999).

RESULTS AND DISCUSSION

Table 1 presents the effects of tillage practices and sowing methods on growth and population dynamics of two oversown *Stylosanthes* species, existing dominant grass (*Panicum maximum*) and other herbaceous species in oversown natural pasture during dry season. There were no marked differences ($p>0.05$) in the heights of the sown legumes, other herbaceous species, sown legume cover and *P. maximum* cover in the dry season. There were significant differences ($p<0.05$) in the soil covered by sown legumes, dominant forage grass (*P. maximum*) and other herbaceous species in the dry season.

TABLE 1: Effect of tillage and sowing methods on growth (cm) and population dynamics (%) of two oversown *Stylosanthes* species, *Panicum* and other plant species in dry season

Species	Tillage	Sowing	Plant Height (cm)			Soil Cover (%)		
			L	G	W	L	G	W
S. guianensis	Minimal	Broadcast	19.25	13.75	29.25	57.50^{ab}	5.00^{c}	37.50^{ab}
	Zero	Broadcast	18.75	12.75	28.75	65.00^{a}	5.00^{c}	30.00^{b}
	Minimal	Drill	20.25	16.00	33.75	55.50^{ab}	8.50^{b}	36.00^{ab}
	Zero	Drill	17.50	14.75	31.25	35.00^{c}	4.50^{c}	60.50^{a}
S. hamata	Minimal	Broadcast	17.25	15.50	34.50	47.00^{b}	5.00^{c}	48.00^{a}
	Zero	Broadcast	21.25	14.75	27.50	41.50^{b}	7.50^{b}	51.00^{a}
	Minimal	Drill	21.50	12.25	27.50	32.00^{c}	5.00^{c}	45.00^{a}
	Zero	Drill	22.25	12.75	31.50	56.00^{ab}	13.50^{a}	30.50^{b}
SEM			0.96	0.46	2.43	1.69	1.52	3.60

^{a,b}: Means on the same column with the same superscripts are similar (p>0.05); SEM: Standard error of means
L: Sown legume: G: Existing dominant grass; W: Other herbaceous species

Table 2 shows the effects of tillage practices and sowing methods on growth and population dynamics of the two oversown *Stylosanthes* species, *Panicum* and other plant species in oversown natural pasture during rainy season. There were no significant differences (p>0.05) in the heights of the legumes, other herbaceous species and existing dominant grass (*P. maximum*). Similarly, the soil cover was similar for all the plants' categories in the rainy season. Significantly different (p<0.05) percentage soil covered by the two legumes (32.00-65.00 %) in the dry season depicts considerable competition of the legumes with other existing herbaceous species (30.00-60.50 %) and similar (p>0.05) soil cover of the legumes (45.00-53.50 %) in the rainy season subsequently suppressed other herbaceous species (20.50-31.50 %). All treatments except zero tillage and drilling favoured higher dry season soil cover of *S. guianensis* compared to 40 % reported for sole Verano stylo within the first 30-40 days of establishment in early-rainy season (de Leeuw *et al.*, 1992).

However, higher other herbaceous species cover (60.50 %) recorded in the dry season for *S. guianensis* when it was drilled without soil agitation did not limit the growth and dominance of the legume later on in the rainy season. The major information usually used in the selection of forage accessions for evaluation in different agro-climatic zones includes rainfall, temperature (altitude) and soil pH (Hanson and Heering, 1992). Soil pH (6.52) of this experimental field which is close to the acidity range (*S. guianensis* (4.5-5.8); *S. hamata* (5.4-8.5)) for the two *Stylosanthes spp* (Hanson and Heering, 1992) might have been an added advantage for their survival and establishment. It is noteworthy that the similar (p>0.05) range of soil covered by the existing dominant grass (*P. maximum*) increased from dry (4.50-13.50 %) to rainy (23.00-30.50 %) seasons. The improvement recorded on the existing grass

might be due to the contributory nutrients from the over-sown legumes and rainfall influence.

TABLE 2: Effect of tillage and sowing methods on growth (cm) and population dynamics (cm) of two oversown *Stylosanthes* species, *Panicum* and other plant species in rainy season

Species	Tillage	Sowing	Plant Height (cm)			Soil Cover (%)		
			L	G	W	L	G	W
S. guianensis	Minimal	Broadcast	42.50	73.75	48.75	49.00	30.50	20.50
	Zero	Broadcast	47.50	67.50	35.00	50.50	25.50	24.00
	Minimal	Drill	46.25	76.25	35.50	49.50	29.50	21.00
	Zero	Drill	38.75	67.50	52.50	48.00	24.50	27.50
S. hamata	Minimal	Broadcast	35.00	62.50	37.75	45.00	23.50	31.50
	Zero	Broadcast	37.50	78.75	51.25	45.50	26.50	28.00
	Minimal	Drill	43.75	78.75	46.25	53.50	23.00	23.50
	Zero	Drill	34.25	65.00	48.00	50.50	28.50	21.00
SEM			1.95	1.60	2.51	2.64	2.83	1.56

[a,b]: Means on the same column without superscripts are similar (p>0.05); SEM: Standard error of means; L: sown legume; G: existing dominant grass; W: other herbaceous species; ns: not significant (p>0.05).

TABLE 3: Effect of tillage and sowing methods on dry matter yield (t/ha) of two oversown Stylosanthes species, existing dominant grass and other plant species in a natural pasture

Species	Tillage	Sowing	Legume	Grass	Herbs	Legume	Grass	Herbs
				May 2014			July 2014	
S. guianensis	Minimal	Broadcast	9.00[a]	10.75	6.96[a]	7.98	6.58	8.16[a]
	Zero	Broadcast	4.25[b]	7.25	5.45[ab]	7.99	7.95	5.65[ab]
	Minimal	Drill	4.00[b]	8.70	6.96[a]	9.00	8.07	6.45[ab]
	Zero	Drill	6.50[ab]	8.25	3.81[a]	8.97	9.98	7.66[a]
S. hamata	Minimal	Broadcast	5.25[ab]	7.75	4.62[a]	10.05	6.88	5.77[ab]
	Zero	Broadcast	5.75[ab]	8.75	5.57[a]	7.61	7.91	6.61[ab]
	Minimal	Drill	7.00[ab]	7.25	5.23[a]	11.66	5.63	3.67[b]
	Zero	Drill	5.25[ab]	8.00	1.77[a]	10.27	8.12	5.45[ab]
SEM			0.48	0.71	0.48	0.51	0.54	0.41

[a, b]: Means on the same column with different superscripts were significantly different (P<0.05); SEM: Standard Error of Means; Grass: Dry matter yield of *Panicum maximum;* Legume: Dry matter yield of sown legumes; Herbs: Dry matter yield of other herbaceous species.

Table 3 presents the effects of tillage practices, sowing methods and oversown legumes on dry matter yield of sown legumes, existing dominant grass (*P. maximum*) and other herbaceous species in the rainy season. The dry matter yield (DMY) of the legumes only differed ($p<0.05$) in May, but were similar in July ($p>0.05$). In May, *S. guianensis* produced higher DMY (9.00 t/ha) with minimal tillage prior to broadcast compared to the similar least yields of 4.00 t/ha and 4.25 t/ha recorded for the same legume when oversown with minimal tillage-drill and zero tillage-broadcast respectively. There were variations in the DMY of other herbaceous species across the treatments and at both sampling periods. Increased dry matter yields with extended cutting intervals are consequences of additional tiller, leaf formation, leaf elongation and stem development (Akinola *et al*., 1971; Robertson *et al*., 1976). The DMYs (4.00-9.00 t/ha) of this study surpassed the yield (0.19-3.71 t/ha) reported by Mani *et al.* (1992) for both Stylosanthes in fodder banks. The DMYs were within the range (5-10 t/ha) recorded by Mohammed-Saleem and Suleiman (1986) for fodder banks. Dry matter yield of the two legumes were also higher than those recorded (0.8-3.0 t/ha) for *S. guianensis* cv. Cook sown in different ratios with Rhodes grass and cut at 20 cm above-ground 120 days after sowing in Northern, Nigeria (Onifade and Akinola, 1986; Onifade and Akinola, 1990). The differences in the dry matter yields of the present study compared to earlier studies can be attributed to the zero-grazing of the plots and the uninterrupted longer time of growth before cutting. Similarities observed in the existing dominant grass could mean the legumes had similar influence on the yields of this particular grass species.

The relative proportions of the sown legumes, existing dominant grass and other herbaceous species by weight in the total dry matter yield of each treatment were evaluated (Figure 1). Both legumes generally contributed not less than 20.34 % and 33.71 % to the total DMY at both sampling periods respectively. Minimal tillage with drilling of *S. hamata* (ShMtD) contributed higher DMY of 35.93 % and 55.63 % of this study, at eight (8) months after sowing (MAS) (May 2014) and 10 MAS (July, 2014) respectively. The proportions of other herbaceous species in the natural pasture were very low in ShZtD (11.79 %) and ShMtD (17.51 %) at 8 and 10 MAS respectively. Drilled *S. hamata* thrived more and out-competed other companion species when compared to *S. guianensis*. Proportions of these sown legumes surpassed the 40 % reported after four grazing periods for *Centrosema pubescens* (ILRI 152) when sown with *Cynodon nlemfuensis* (Ib8) (Olanite, 1997). Zero-tilling or minimal tilling of the soil prior to drilling of *S. hamata* suppressed the weed most by recording the least other herbaceous species; 11.79 % and 17.56 % respectively. This is also similar to the weed suppressing ability of *Centrosema* species reported by Olanite (1997).

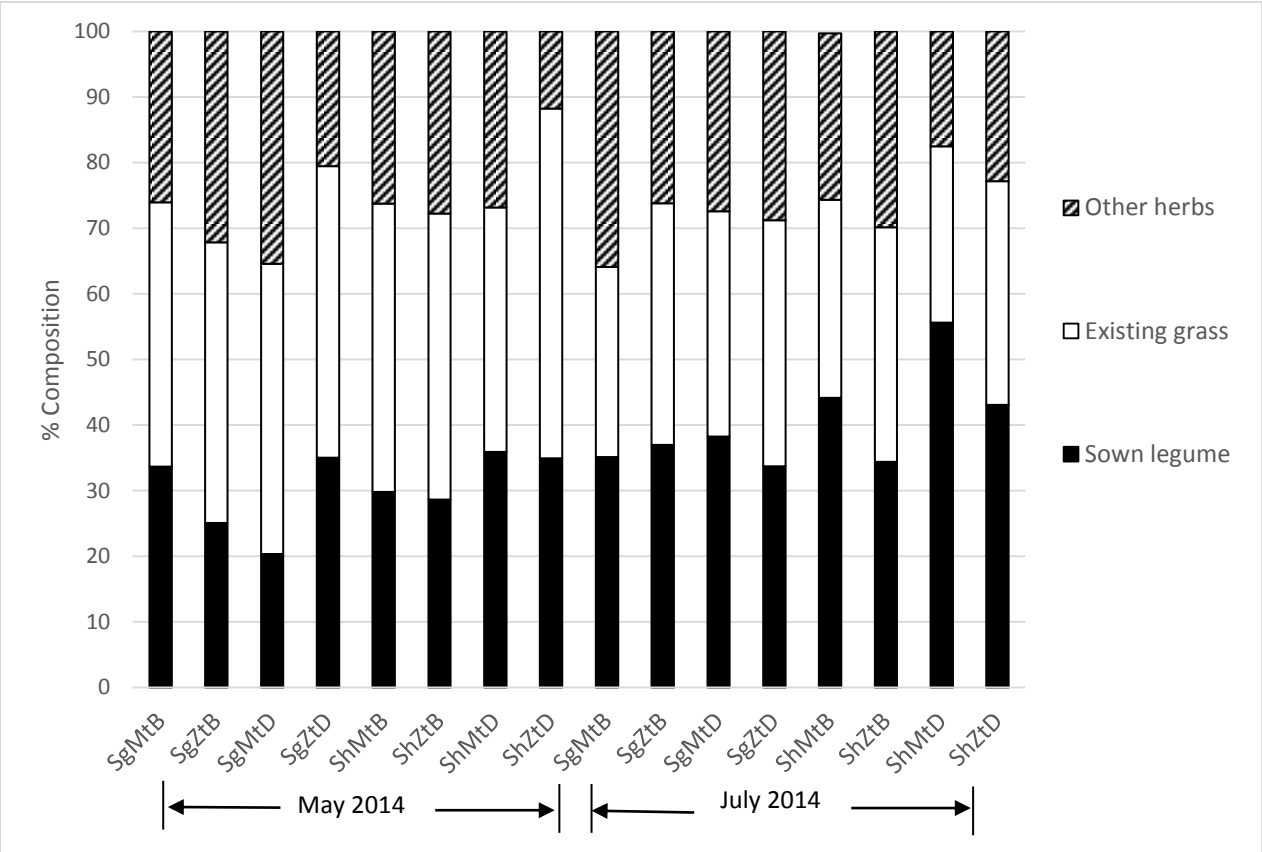


FIGURE 1: Proportionate contribution (%) of sown legumes, dominant existing grass and other herbaceous species to total dry matter yields of pastures in May and July 2014.

SgMtB= *S. guianensis* cv. Cook + Minimal tillage + Broadcast

ShMtB= *S. hamata* cv. Verano + Minimal tillage +Broadcast

SgZtB= *S. guianensis* cv. Cook + Zero tillage + Broadcast

ShZtB= *S. hamata* cv. Verano + Zero tillage + Broadcast

SgMtD= *S. guianensis* cv. Cook + Minimal tillage + Drill

ShMtD= *S. hamata* cv. Verano + Minimal tillage + Drill

SgZtD= *S. guianensis* cv. Cook+ Zero tillage + Drill

APPENDIX 1: The botanical inventory of other herbaceous species on the oversown natural pasture.

S/N	BOTANICAL NAME	COMMON NAME	FAMILY NAME	STATUS
1.	*Talinum triangulare*	Water leaf	Portulaceae	*Few*
2.	*Chromolaena odorata*	Siam weed	Asteraceae	*Few*
3.	*Cyperus esculentus*	Yellow nutsedge	Cyperaceae	*Common*
4.	*Tridax procumbens*	Tridax/Coat buttons	Asteraceae	*Common*
5.	*Mariscus alternifolius*	Umbrella sedge	Cyperaceae	*Common*
6.	*Trianthema potulacastrum*	Horse purslane	Aizoceae	*Few*
7.	*Aspilia Africana*	Haemorrhage plant	Asteraceae	*Rare*
8.	*Cassia mimosoides*	Japanese/Senna tea	Caesalpinaceae	*Rare*
9.	*Sida acuta*	Broom weed	Malyaceae	*Rare*
10.	*Cyperus rotundus*	Purple nutsedge	Cyperaceae	*Common*
11.	*Axonopus compressus*	Carpet grass	Poaceae	*Few*
12.	*Panicum maximum*	Guinea grass/Green panic	Poaceae	*Dominant*
13.	*Eleusine indica*	Goose grass/Bull grass	Poaceae	*Few*

Key: Dominant: 30 – 50 plants/m^2; *Common: 15 - 30 plants/m^2; *Few: 5- 15 plants/m^2; *Rare: 1-5 plants/m^2.

CONCLUSION

The two *Stylosanthes* species survived the drought of dry season. Irrespective of the tillage or sowing methods employed, the two oversown legumes survived high competition from companion or existing species over the growing periods. However, *S. hamata* that was sown by drilling method with minimal tillage, thrived more, out-competed and contributed more DM yield than other companion species compared to *S. guianensis*. The two legumes showed similar height pattern in both seasons and similar population dynamics in wet season. Hence, the two legumes have potentials for native pasture improvement.

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