FORAGE AND FODDER PRODUCTION IN NIGERIA:
Its Sensitivity in Sustainable Ranching

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SUMMARY OF PRESENTER'S BIODATA

Ibrahim R. Muhammad from Zuru in Kebbi State, was born on the 20th of June, 1964 at Bosso-Minna in the present Niger State. He began his education at LEA Primary School, Bosso, Minna from 1970 to 1976. He later attended Federal Government College, Maiduguri from 1977 to 1982. In 1982/83 academic year, I.R. Muhammad was offered admission at the University of Sokoto, presently, Usmanu Danfodiyo University, Sokoto for a two-year pre-degree programme which prepared him for the Bachelor of Science degree in Agriculture of the same university. In 1988, he graduated with a honours degree in Agriculture. For his national service in 1989, I.R. Muhammad taught at the Federal College of Agriculture, Obafemi Awolowo University, Akure. Soon after his NYSC, he was offered a job as an Assistant Research Fellow at the National Animal Production Research Institute (NAPRI), Ahmadu Bello University (ABU), Shika-Zaria in December, 1990. From 1991 to 1994, he obtained his M.Sc degree in Animal Science and PhD in 2004. While pursuing his PhD programme, I.R. Muhammad also attended some training courses *viz*: (i) Preparation and Writing of Research Proposal; (ii) Computer and Statistical Techniques in Experimental Designs, Agricultural Data Analysis and Information Management and, (iii) Participatory Technology Development.

While at NAPRI, I.R. Muhammad rose through the ranks from Assistant Research Fellow to Senior Research Fellow. He also, taught and supervised Bachelor of Agriculture undergraduate students of Ahmadu Bello University, Zaria. He was also a member of Livestock Systems Research Programme, Research Committee and Project Leader, On-Farm Adaptive Research (NAPRI). He was a member, Technical Review Meeting (TRM), Katsina and Zamfara States Agricultural Development Projects. He severally acted as Programme Leader, Livestock Systems Research Programme. He was a collaborating research scientist with International Livestock Research Institute (ILRI), International Institute for Tropical Agriculture (IITA) and International Cereal Research Institute for Semi Arid Tropics (ICRISAT).

I. R. Muhammad transferred his services to Bayero University, Kano (BUK) in 2004 where he rose through the ranks to become Professor in 2009. At Bayero University, Kano, Muhammad continued his research, teaching and supervision of both undergraduate and postgraduate students. He has severed as external examiner to over 300 sub-degree and 150 undergraduate students. He has graduated several undergraduate students from ABU, BUK and KUST; over 20 MSc and 10 PhD students, out of which two are now Professors. He has also served as External Assessor for 7 Readers and 3 Professors from Nigerian universities. He has served as

External Examiner, Department of Animal Science, Usmanu Danfodiyo University, Sokoto, University of Maiduguri, Modibbo Adama University of Technology, Yola, University of Ibadan, Abubakar Tafawa Balewa University, Bauchi, Kebbi State University of Science and Technology, Aleiro, Department of Animal Health and Production, Audu Bako College of Agriculture, Dambatta and Department of Animal Production and Health, Hassan Usman Kastina Polytechnic, Katsina.

I.R Muhammad has been a member of several committees within and outside the University, He is an active member of professional bodies: former Assistant Secretary, and later National Secretary, Nigerian Society for Animal Production (NSAP), a Registered Animal Science (RAS), Former Council Member (Pasture and Range Science) of Nigerian Institute of Animal Science; Fellow, College of Animal Scientist, Nigeria (FCASN); a one-time Zonal Co-coordinator, Society for Grassland Research and Development in Nigeria; Member, Animal Science Association of Nigeria and Australian Grassland Society.

I.R. Muhammad's research focus has been in the area of pasture agronomy and range management, nutrition of grazing animals and integration of forages into farming systems. He has a total of 217 publications to date out of which he is a major author to over 40%. His publications spread across peer-reviewed journals in national, international, edited conference proceedings, guides/manuals and monographs/annual reports. Over 70% of the publications by I.R. Muhammad are on forage agronomy and forage utilisation by livestock with about 30% on *Sorghum almum*. He is still in active teaching and research.

I.R. Muhammad is very hard working and has earned some commendations. He was the pioneer substantive Head, Department of Animal Science, (BUK); a one-time Dean, Faculty of Agriculture who saw to the take-off of the three young Departments (Food Science and Technology, Fisheries and Aquaculture and Forestry and Wild Life) that are yet to graduate their pioneer students. He is interested in playing badminton, chess and travelling. He is married and blessed with children.

Forage and Fodder Production in Nigeria: Its Sensitivity in Sustainable Ranching

Preamble

I am gratefully honoured by this opportunity to deliver this inaugural lecture. Today's lecture is the fourth from the Faculty of Agriculture and the first from the Department of Animal Science. I am indeed grateful to the University for inviting me to give an account of my academic stewardship after attaining my professorial chair in the Department of Animal Science, Bayero University, Kano. The thrust of my pasture and range management research efforts centres around supporting the provision of adequate meat and milk to overcome hunger and ensure food security in the sub humid and semi-arid sub regions. I am executing this thrust through studies in forage grasses and legumes with ruminant animals (cattle and sheep). To date, I have a total of 217 publications out of which 70% of publications are on forage agronomy and its utilisation by livestock with 30 percent of *Sorghum almum* alone. Today, I am sharing with you my contributions in the area of forage crop production and utilisation. The lecture is therefore titled **"Forage and Fodder Production in Nigeria: Its Sensitivity in Sustainable Ranching"**

Nothing gives me greater pleasure than to speak about forage-fed animal production, my life passion and dream. In my 29 years of teaching and research in the university system, I have been searching for answers to problems of animal protein shortage and malnutrition of grazing ruminants through the provision of adequate fodder that can be converted to high meat and milk. My approach to this had been in the continuous attempt to improve feed production and utilisation for livestock ranchers as well as to empower the small holder livestock farmers by developing fodder production strategies that can be integrated with the native crop-livestock production system.

Introduction

Globally, agriculture as a science consist of soil (Chemistry, Physics), agronomy of rain-fed and irrigated plants and their protection (arable, horticulture, floriculture, forages etc), animal husbandry (livestock, poultry and game production), fishery and aquaculture; forestry and forest resources, economy and extension. This vast industry provides livelihood for more people than any other industry. To raise rural income, support the increasing numbers dependent on the industry and to meet the food and raw material needs of the fast growing urban populations, there is the need for growth in agricultural production and productivity. Enhancing agricultural productivity contributes to industrial growth by providing capital investment, foreign exchange and markets of assorted produce for consumers. Agriculture has a frame for reducing poverty since most of the world's poor live in rural areas and are largely dependent on agriculture.

The career of Animal Science deals leads to the award of B.Sc. or B. Agriculture degree (Animal Science Option) or its equivalent obtained from Faculty of Agriculture. Animal science is taught in all universities that offer Agriculture in Nigeria through a five-year programme. After graduation, the profession has several areas of specialisation that include: Animal Bio-technology, Livestock Economy and Marketing, Livestock Extension and Information Technology, Range and Pasture Science, Animal Genetics and Breeding, Dairy Science, Poultry Science, Beef Production Science, Swine Production Science, Small Ruminant Production Science, Animal Reproductive Physiology and Bio-climatology, Micro Livestock, Game Animal Management, Feed Milling Industry and, Livestock Processing and Preservation Technology.

The above areas of specialisation are integral parts of livestock production expertise. The livestock industry, which is a total production package, has potential of generating income and employment to old and young, male and female, serving or retired individuals. This sector therefore, has multiplier effects on rural as well as urban dwellers and their corresponding economy. Amongst the different disciplines, dairy science, beef science, small ruminant science, micro livestock, forestry and wildlife have direct association with pasture and range science.

The Prominence of Product of Forage-Fed Animal in the Meal of Nigerians

Protein source tends to be the most expensive fraction in the diets of most people. Protein of animal origin is in most cases, the priority in the diets of many Nigerians that can afford it except vegetarians. However, if you are to sample opinions of Nigerians from the different parts of the country what they would have for lunch or dinner, the answer for those from the North, will probably be rice, *tuwo* (prepared from cereals i.e. rice, maize, sorghum or wheat), those from the middle belt, southern or western Nigeria may go for pounded yam, *eba*, *amala* or *fufu.* This shows that Nigerians are much more worried about satisfying hunger. This is in contrast to what obtains in developed economies. If you were to ask an American what he would have for lunch or dinner, the answer would most likely be steak, chicken or fish. This shows that while the consumption of animal product is a regular part of a meal of an American, it is not any news taking meals without any piece of meat in a regular diet for a large proportion of Nigerians. This perhaps explains the available statistics that, present Nigerians are malnourished, particularly, because of animal protein deficiency.

Scientific evidence abound that adequate animal protein intake is required for optimum physical and mental development. The Joint FAO/WHO/UNU (2007) Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition of 2002, Geneva, Switzerland recommended the minimum protein requirement of an adult as 0.656g protein/kg per day which means 66g of protein intake per 100kg person per day to be consistent with good living, 50% (33g) of this should come from animal protein source (Speedy, 2003) such as milk, meat, eggs or fish. The data on meat, milk, eggs and fish consumption for 180 countries was reported by (Speedy, 2003) and consumption of meat in the U.S. is 124kg/capita/y, while the global average is 38kg. One-third of the world's population consumes,10kg meat/y. The data on kg/capita/year for Nigeria are 8.1 meat, 5.8 milk, 3.5 eggs and 6.7 fish consumption which sum up to 24.1 kg/capita/y. This cumulative value for protein intake of Nigerian is below recommended average. Amongst these protein sources, meat appears to be the most commonly available. Yet, Nigerians consume less than 10kg/person/y. This may also explain why the report of the National Demographic Health Survey Unit of the National Population Commission (NPC and ICF Macro, 2009) places 41% of the Nigerian children under 5 years as stunted (reflecting malnutrition), 14% wasted (reflecting acute malnutrition) and 23% underweight (which reflects chronic malnutrition). Stunted children are likely to be more in the Northwest (53%) and lowest in the South-east (22%).

Livestock Production in Nigeria

Meat and milk sources of protein are mainly from ruminant animals. The production system of these ruminants in Nigeria are basically three. The extensive, semi intensive and intensive systems. Extensive system is mainly pastoralism. The pastoral production system is responsible for production of over 75% of these animals while 20% of the animals are with the agro-pastoral and only 5% in the intensive production system. The pastoral production system, thus, is the main source of milk of animal origin and also serves as the national reservoir of genetic trait of indigenous animals, source of draft power in addition to those slaughtered for meat. The pastoral system of livestock husbandry is characterised by transhumance and grazing of range for free. This production system, however, has conflicting opinions in support and against it. For example, according to Suleiman (1988), this system is regarded as an effective adaptation to counter the harsh, and challenging production conditions in the savannah environment and marginal returns to scarce resources are high. It accounts for 75% of the total activity time and provides over 50% of the total income. Contrary report stated that the World Bank and United States Agency for International Development (Gefu, 1988), and presently some state governments and individuals in Nigeria consider the production system a counter-productive strategy of raising food animals.

For a country ranked 15th in the world in cattle with the national estimated population of 20,529,190 million, 5th in sheep (42,091,042 million) and 3rd in goat (73,879,561 million) and 17th in camel (279,802), (FAO 2016), extensive system of production may not be a viable option since land area for grazing and feed availability are severely limiting factors in the high livestock producing zones of Nigeria. There is however, the need to increase fodder production to accommodate the feed requirements of Nigeria's Livestock. Increments in fodder production can be achieved by increasing yield per unit area of land not by expansion of grazing areas (Muhammad and Abubakar 2004) because of the present trend in competitive land use and demographic changes.

Forage Resource in Ruminant Animal Production

The science of the production, improvement and management of food animals is pivoted by a very strong forage resource base and feeding strategy, for which is dominantly acquired from the rangeland and sown pastures. The major objective of range management is production of livestock with efficient allocation of forage and other resources to sustainability of both forages and animal over an indefinite period (Kallah, 2004). Productivity and efficiency of production depend upon the ability of the range environment to supply forage in meeting the nutritional demands for maintenance, growth and reproduction.

Forage Production in Nigeria

Livestock interventions in Nigeria have all along been with feed and fodder production but as a relegated component. These efforts date back to pre-colonial period to the present day livestock colony concept by the Federal Government of Nigeria. Kallah (2004) stated that over the years, there had been several attempts on the development of forage resources based on planned programmes, rational technology of utilisation, conservation and management of the resources.

Pasture species evaluation (of both exotic and native) in Nigeria started since 1935 in Shika Grassland Research Station, the present National Animal Production Research Institute, Shika. Some of its achievements include identification of forage species, their mode of propagation, and seed rates suitable for the various ecological zones of Nigeria (Tables 1 and 2).

Table 1: *Recommended ecological zones, mode of propagation and seed rates of some forage grasses in Nigeria*

Botanical Name	Common Name	Ecological Zone adopted	Mode of Propagation	Seed Rate (kg/ha)
Andropogon gayanus	Gamba/Gambagrass	*1, 2, 3, 4	**S, V	50-60
Anthephora nigritana	-	1, 2, 3	S, V	10-15
Brachiaria brizantha	Signal grass	1, 2, 3, 4, 5	S, V	10-15
Brachiaria decumbens	Signal grass	1, 2, 3, 4, 5	S, V	10-15
Cenchrus biflorus	Karangiya/bargrass	1, 2, 3, 4	S	10-15
Cenchrus ciliaris	Buffel grass	1, 2, 4	S	10-15
Cenchrus prieurii	Spinless karangiya	1, 2	S	15-20
Chloris gayana	Rhode grass	1, 2, 3, 4	S	10-15
Digitaria smutsii	Wooly finger grass	2, 3, 4	V	-
Eragrostis tremula	Burburwa/lovegrass	1, 2, 4	S	5-10
Panicum maximum	Guinea grass	2, 3, 4, 5	S, V	5-10
Pennisetum pedicellatum	Kyasuwa	1, 2, 4	S	15-20
Pennisetum typhoides	Maiwa	1, 2	S	2-5
Pennisetum purpureun	Elephant grass	1, 2, 3, 4, 5	V	-
Sorghum almum	Columbus grass	1, 2, 3	S, V	15-20
Veteveria nigritana	Vetiver grass	1, 2, 3, 4	V	-
Cynodon plectostachyus	Giant star grass	2, 3	V	-

* 1=Sahel/Sudan; 2= Northern guinea savannah; 3= Southern guinea/derived savannah; 4= Montane and 5= South of derived savannah.

** S= seeding, V= vegetative transplanting

Source: *Muhammad and Abubakar (2004)*

Table 2: *Recommended ecological zones and seed rates of some common herbaceous forage legumes in Nigeria*

Botanical Name	Common Name	Ecological Zone adopted	Seed Rate (kg/ha)
Alysicarpus spp	Gadagi	*1, 2, 3	5-10
Arachis hypogaea	Groundnut	1, 2, 4	20-30
Calopogonium mucunoides	Calopo	1, 3, 5	3-10
Crotalaria macrocalyx	*Gujjiyar awaki*	1, 2, 3,	5-10
Desmodium spp	*Desmodium*	1, 3, 4	2-5
Centrosema pubescens	Centro	2, 3, 4, 5	-
Glycine max	Soybean	1, 2, 3, 4	30-50
Indigofera bracteolata	Indigo	1, 2, 3, 4	2-5
I. pulchra	Indigo	1, 2, 3, 5	5-10
Mucuna pruriens	Mucuna	1, 2, 3, 4	20-30
Canajus cajan	Pigeon pea	2, 3, 4, 5	20-30
Lablab purpureus	Lablab	1, 2, 3	10-25
Stylosanthes fructicosa	Shrubby stylo	1, 2, 3,	5-8
S. guianensis cv. Cook	Cook stylo	1, 3, 4	3-6
S. hamata cv. Verano	Verano stylo	1, 2, 3	3-8
S. humilis	Townsville stylo	1, 2, 3, 4, 5	3-8
Microptilium atropurpureum	Siratro	2, 3	-
Tephrosia bracteolate	Tephrosia	1, 2, 3, 5	-
Trifolium spp	Clover	4	4-7
Vigna spp	Cowpea, beans	1, 2, 3	25-30
Zornia glochidiata	Zonia	1, 2, 3, 5	-

Source: *Muhammad and Abubakar (2004)*

* 1=Sahel/Sudan; 2= Northern guinea savannah; 3= Southern guinea/derived savannah;

4= Montane and 5= South of derived savannah

Additionally, available records show there are 414 state grazing reserves in the country with 36% gazetted and only 2.7% had some form of developmental work (Kallah, 2004). All grazing reserves and traditional grazing areas of the country are in deplorable state of disrepair. Example is the Zange Grazing Reserve (Table 3). There are permanent users but the condition of the reserve is not satisfactory. The grazing laws are deliberately ignored thereby encouraging encroachment of gazetted grazing reserves. More so, resources allocated for improvement are underutilised if at all used for the purpose. In most places, areas proposed for grazing reserves are facing the challenges of blockage of stock route all over the country. The policy and legal vacuum only serves to exacerbate the conflict between pastoralists and crop producers, a situation that continues to escalate over much of the northern, middle belt states of the country and to the extent in recent times, some parts of southern states of the country. For example, within five months (Jan-May) there were recorded 16 cases of conflicts resulting to loss of over 300 persons. Also, some of the gazing reserves are being taken over by the cattle rustlers. All these have significant effect on food security and social stability of the nation (Muhammad, 2016).

Indications so far are that achievements made were far less than expectation with declining productivity and increasing land degradation in grazing areas. Sustainable development of forage resources in grazing reserve for higher biomass production, water availability and improved healthcare delivery services, security and entrepreneurial skill development are necessary imperative if the livestock industry is to respond positively to the future demands of our society.

Table 3: *Status of utilization of Zange grazing reserve by herders*

Nature of utilisation	Frequency	%
Permanent	200	50.0
Seasonal	110	27.5
Transient	90.0	22.5
Grazing duration (hour)		
4-5	10.0	2.5
6-7	70.0	17.5
8-9	320	80
Use of other grazing reserves		
Use others	200	50
Don’t use others	200	50
No. of other grazing reserves used		
Two	150	71.42
Three	50.0	23.3
Four	10.0	4.76
Condition of Grazing reserve		
Satisfactory	00.0	0.0
Not satisfactory	400	100

Source: *Mohammad, Muhammad and Baba (2015)*

Adaptation and Distribution of Pasture Species

Assertion on pasture adaptation and distribution requires the evaluation of its productivity; which involves measurements and analysis of two biological systems. The herbage produced and the plant animal system, which is recognised as feed production, utilisation, and conversion of pasture output as translated into animal products (growth or weight gains, milk yield, reproduction etc). The two aspects are dynamic, inter-related and require periodic monitoring and evaluation in animal production enterprise because climatic factor exerts a major influence on plant growth and animal production. Climate is the principal factor influencing the adaptation of forage plants, modifying the soil, vegetation and ultimately affecting all forms of life (Crowder and Chheda, 1982). Total annual rainfall and its distribution, length of growing period have direct implication on pasture productivity, livestock feed availability and livestock themselves together with other climatic variables regulate the establishment and adaptation of pasture species. Production practices therefore, are often modified to suit the climate under which the production system operates (Kallah, 2004)

Data show higher livestock population are associated with low rainfall areas (RIMS, 1992). The zones have irregular rainfall pattern which the inhabitants of the regions have however, classified into four, each with their defined climatic characteristics. These seasons concur with months of the year. For example in Hausa, from the month of March to May is *Bazara* (late dry season), June to August is *Damina* (early wet season), September to November is referred to *Kaka* (late wet season), and December to February as *Rani* (early dry season). Each of the seasons has implication on the availability of forage species and livestock production. As of necessity, livestock development will have to adjust and accept careful planning, commitment and targeting of production that will achieve higher yields of forage and animal products over smaller unit area of land.

Choice of Pasture Species

Forage species/varieties must prove their superiority in terms of their bulk productivity, palatability, chemical composition, nutrient availability, persistent under defoliation regimes, and or inclement climatic conditions, competition and or compatibility with other forages in the pasture sward. The result of pasture species evaluation of both exotic and native in Nigeria reveals that sown pastures, when properly managed have the potential to persist for 25 to 30 years with increase forage yield and quality several folds over the native grassland, and lead to marked increase in animal production (Muhammad and Abubakar, 2004). One of the input required for rehabilitation of the existing grazing reserves and the establishment of several ranches in both public and private sectors of the economy are thus in abundance.

Period for Pasture Establishment

The adaptation and the intricacy of sustainable management involves integrating soil, climate, herbivores and production goals. The quality of land for feed production is characterised by its climatic condition in particular, the length of growing period, which has direct implication on pasture productivity, livestock feed availability and livestock themselves. Planting period is a critical factor in pasture establishment particularly in climates with unimodal low rainfall regime.

Fodder from grasses form the bulk of feed for ruminant animal production. Forage Sorghum (Plate 1), Columbus grass (*Sorghum almum* Poradi*)* an introduction to Nigeria from Argentina was grown for seed multiplication at the National Animal Production Research Institute, Shika- Zaria. In my desire to augment for the feed shortage to ruminant animals, the nucleus of my research started with it. I realised there was need to establish the sowing period, fertilizer requirements, stages of maturity for optimum fodder production to enable its integration in the national feed resource data base. Initial trial investigated sowing in early, mid and late June and early July (4^{th}, 14^{th}, 24^{th} June and 4^{th} July) on growth components and dry matter yield of forage sorghum (*Sorghum almum*) at Gangara (11^0 to11^0 12"N and 6^0 55" to 7^0 33"E) during the 1990 and 1991 rainy seasons in sub-humid ecological zone.

(A) **(B)**

Plate 1: Columbus grass *Sorghum almum* (Parodi). Plant; B: Established pasture

Muhammad (2004), Muhammad *et al.* (2004) revealed sowing of forage grass in mid-June (14^{th} June) to early July (4^{th} July) resulted in superior stand establishment and dry matter yield than other dates. In mid-June and early July planting, day-14 post planting, plant density was 7.0 and 9.0 culms/m^2 while plant height was 20.4 and 11.3cm for the respective years. It had higher tiller production capacity which by day-56, plant density was greater than 100 culm/m^2. Plant height at that stage were generally greater than 200cm. Dry matter yield varied from 8 to 14.7tDM/ha. Seed yield for the respective years were 894.7 and 836.3 kg/ha (Table 4).

Table 4: *Effect of planning date on dry matter (DM) and seed yields of S. almum pasture at Gangara during the 1990 and 1991trials (Kg DM/ha)*

Treatments	1990	1991	Mean
Planting date	DM Yield		
4th Jun	8,033.7[b]	9,627.0[b]	8830.4[b]
14th Jun	11,140.9[a]	11,551.0[b]	11345.0[a]
24th Jun	8,111.1[b]	14,541.2[a]	11326.2[a]
4th Jul	8,166.1[b]	14,792.0[a]	11479.1[a]
S.E.D	301.50	393.30	347.40
	Seed Yield		
4th Jun	749.6[c]	729.0[c]	739.3[b]
14th Jun	894.7[a]	800.0[b]	847.5[a]
24th Jun	836.6[b]	810.2[b]	823.4[a]
4th Jul	863.3[b]	836.3[a]	849.8[a]
S.E.D	30.01	25.21	27.6

Source: *Muhammad et al. (2002)*

Means within the same column with different superscripts are significantly different (P<0.05) S.E.D. = standard error of difference

Influence of Nitrogen Fertiliser on Yield and Nutritive Value

Pasture species respond positively to nitrogen application depending on soil fertility. However, nitrogen (N), phosphorus (P), potassium (K) or compound (NPK) fertilisers are necessary for cereals; starter NPK and P is to be applied to legumes in the savannah zones of Nigeria. The application of fertiliser ensures successful pasture establishment. Soil nutrient deficiency should be identified and corrected with a balance fertiliser calendar. This is essential to ensure successful establishment of pasture species on the soils with low fertility, or depletion of nutrient due to intensive cropping. Muhammad *et al.* (2002) assayed the influence of level of fertilizer (0, 50, 150, 200kgN/ha) application on growth components of Columbus grass (*Sorghum almum)* in the northern guinea savannah ecological zone of Nigeria during the 1990 and 1991 rainy seasons. Results from these trials revealed fertiliser applied improved plant vigour, tiller number/plant and dry matter yield up to the highest N applied. Plant density at 35 days post planting ranged from 12 to

29culm/m^2. The corresponding values at day 56 (i.e 42 days following fertilizer application) were 32.0 to 101 culm/m^2. Dry matter yield rose steadily from 6.8tDM/ha to 13.6 tDM/ha as fertiliser was increased from 0 to 200kgN/ha. Seed yield during the same period for the respective years varied from 416 to 753.0kg/ha. The study established that forage grasses require the application of 200kgN/ha in the sub humid zone of Nigeria. Nitrogen increased the yield of forage grasses by 70-80% (Table 5). In another trial, high yield of forage dry matter was obtained with application of 100 to 150KgN/ha and 20 to 30KgP for grasses and 18 to 30 kg P/ha for legumes. Nitrogen fertiliser higher than 200kg N/ha is not economical (Muhammad and Abukakar, 2004).

Table 5: *Effect of Nitrogen fertiliser on dry matter (DM) and seed yields of S. almum pasture at Gangara during the 1990 and 1991trials (Kg DM/ha)*

Treatments	**1990**	**1991**	**Mean**
Fertiliser Rate			
KgN/ha	DM Yield		
0	6,770.4^{d}	8.867.0^{c}	7672.2^{e}
50	7,674.8^{e}	8,882.0^{e}	8278.4^{d}
100	8,951.8^{c}	9,174.0^{c}	9062.9^{c}
150	9,037.4^{b}	11,074.0^{c}	10055.7^{b}
200	12,508.4^{a}	13,600.0^{a}	13054.2^{a}
S.E.D	337.1	491.6	414.4
	Seed Yield		
0	416^{e}	528^{d}	472.0^{d}
50	482^{d}	599^{c}	540.5^{cd}
100	531^{c}	609^{c}	570.0^{c}
150	697^{b}	696^{b}	696.0^{b}
200	753^{b}	739^{a}	746.0^{a}
S.E.D	39.11	34.98	37.1

Means within the same column with different superscripts are significantly different ($P<0.05$)
S.E.D. = standard error of difference

Source: *Muhammad et al. (2002)*

During the 1990 and 1991 trial, main crop dry matter accumulation (Y) expressed as KgDM/Ha had significant ($P<0.05$) positive linear relationship with 50kg N/ha(x) applied (Figure 1). The equations $Y=0.07x+6.01$: $r^2=0.84$ and $Y=0.03x+6.94$: $r^2=0.89$ described the relationships, respectively. Similarly, the regrowth and the cumulative dry matter accumulation in 1991 had positive linear relationship. The equation $Y=0.01x+1.19$: $r^2=0.87$ and $Y=0.04x+8.13$: $r^2=0.92$ described the relationships, respectively.

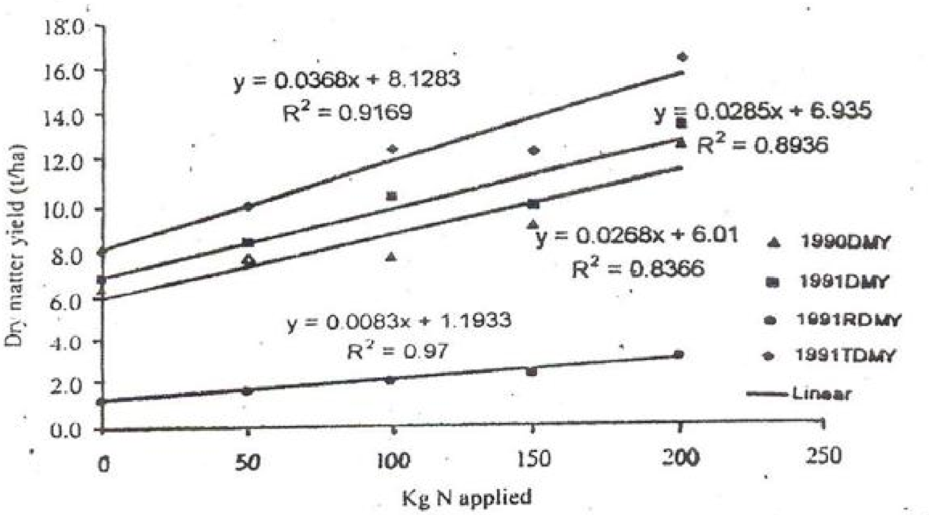


Figure 1. Relationships between kg N applied and dry matter production in *Sorghum almum*

Source: *Muhammad et al. (2002)*

Influence of Nitrogen Fertiliser on Yield and Nutritive Value of Irrigated Pasture

In the semi-arid regions of the world, irrigated production of cereals, fibre, sugarcane and horticultural crops is a common practice along with livestock husbandry which have sandwiched with the culture of the inhabitants both dwelling in urban and peri-urban areas. It is noted, the need to integrate fodder production into the irrigation production schemes to cater for the livestock of the farmers (Lufadeju and Muhammad, 1997). Trials were conducted with fertiliser during the dry season from February to April, in 2004, at Ahmadu Bello University Farm, Shika in the Northern Guinea Savannah of Nigeria. Forage grasses used were: *Chloris gayana* (Rhodes grass), *Sorghum almum* (Columbus grass) and *Andropogon* *gayanus* (Gamba) evaluated at 5 levels of nitrogen fertilizer (0, 50, 100, 150 and 200kgN/ha/year) by Muhammad *et al.* (2004). Within the week of planting at days 0 and 3, plots were irrigated using flood-surface irrigation method. Subsequently, plots were irrigated at weekly intervals. Dry matter yield obtained was higher ($p<0.05$) in Columbus grass (11.14t/ha) compared to Rhodes grass (5.72t/ha) and Gamba (2.17t/ha). The application of graded levels of nitrogen resulted in increases in forage yield. However, the application of nitrogen above 150N/ha did not increase main crop dry matter yield. However, forage yield of the re-growth were comparable for the three grasses evaluated at the rate of 100 to 200 kgN/ha applied.

In another trial by Muhammad *et al.* (2003) where forage legumes: Gadagi's *(Alysicapus vaginalis),* Lablab bean *(Lablab pupureus)* and Pascourum *(Centrocema pascourum)* response to four levels or applied phosphorus at 0, 30, 60 and 90 P_20_5 kg/ha under irrigation were examined. The results demonstrated the necessity for further studies since no clear cut trend was observed. Mean dry matter yield were 3. 10tDM/ha for Alysicapus, 4.87tDM/ha for Lablab and 2.5tDM/ha for Pascourum with application of 90 P_20_5 kg/ha (Table 6).

Table 6: *Effect of fertilizer phosphorus on yield (tDM/ha) of three irrigated legumes grown in northern guinea of Nigeria*

Legume species	**Fertilizer levels P_20_5kg/ha**				**Mean**
	0	30	60	90	
Alysicapus	2.60	3.00	2.88	3.98	3.10b
Lablab	3.03	4.89	4.67	6.90	4.87a
Pascourum	2.37	2.70	2.80	3.57	2.86b
Mean	267b	3.53b	3.43b	4.82a	-
SEM (fertilizer)	0.472				SEM (species)=0.695

Means within row or column with same letter superscript differ significantly ($P<0.05$)
Source: *Muhammad et al.(2003)*

In a study by Muhammad, *et al.* (2005), which determined the dry matter yield (tDM/ha), concentration of crude protein (CP), calcium and phosphorus (P) in *Sorghum almum* at 3 irrigation interval (5, 7 and 10days) showed dry matter yield for *Sorghum almum* varied ($P<0.05$) from 11.07 to 19.6tDM/ha Concentration of CP and Ca rose and declined thereafter with a mean concentration of 9.86% for CP and 0.08% for Ca while P declined consistently (Table 7). Interval of irrigation days had a relationship (P<0.05) with dry matter, Ca and P in lablab. The increasing trend in forage yield with increased in irrigation interval showed optimum irrigation interval was not attained. It is therefore recommended that longer irrigation intervals be tried to determine the optimum irrigation interval for which forage will be depressed due to moisture stress. From the present result however, *Sorghum almum* can be grown with 10days irrigation interval.

Table 7: *Effect of irrigation interval on yield and nutrient composition of Sorghum almum fodder harvested at full boom stage of maturity (80 days post-planning) at Talata Mafara in the Sudan Savannah zone of Nigeria.*

Irrigation intervals (Days)	Yield (tDM/ha)	CP(%)	Ca(%)	p(%)
5	11.07^{c}	8.90^{c}	0.07^{c}	0.23^{a}
7	16.80^{b}	10.90^{a}	0.09^{a}	0.20^{b}
10	19.60^{a}	9.79^{b}	0.08^{b}	0.19^{c}
Mean	15.82	9.86	0.08	0.21
S.EM	1.165	0.785	0.001	0.066

Mean within column with different letter superscript differ significant (P<0.05)

Source: *Muhammad et al. (2005)*

Response of Stages of Maturity on Yield to and Nutritive Value

Sorghum almum grass is robust, fast growing and perennial. It recovers rapidly after cutting or grazing and can give 2-3 harvest per growing season. Fodder production increases in *Sorghum almum* with delayed harvesting. Muhammad (1994); Muhammad, *et al.* (1999) assayed the influence of simulated grazing by harvesting *Sorghum almum* fodder at late vegetative/boot, early, mid and full bloom/dough stages of maturity in the Northern Guinea Savannah in 1990 to 1991. The finding was delayed harvesting resulted in higher yields. Mean forage yields ranged from 4.5 to 14.4 tDM/ha by delaying harvest from late vegetative/boot to full bloom/dough stage of maturity. The overall increases during the period of growth from full vegetative to 95% soft dough stage was 66%, with 18% increases when delayed from boot to 95% soft dough stages and only 8% from 95% flowering to 95% soft dough stages.

Furthermore, in trial during the dry season in Shika, Northern Guinea Savannah of Nigeria, *Andropogon gayanus* (Gamba), *Chloris gayana* (Rhodes grass) and *Sorghum almum* (Columbus grass) were evaluated in a simulated grazing trial at 5 and 10 weeks between cuts. The result revealed (Table 8). Columbus grass and Rhodes grass were faster growing than Gamba grass. Columbus grass and Rhodes grass were at full bloom stage of maturity while Gamba was only full vegetative stage by 90 days post planting. Delaying cut till 90 days post planting resulted in high fodder under irrigation (Muhammad *et al.,* 2004).

Also, experiment with legumes (Table 9) demonstrated similar trend like the grasses (Muhammad *et al*., 2003) where forage legumes: Gadagi (*Alysicapus vaginalis),* Lablab bean (*Lablab pupureus)* and Pascourum (*Centrocema pascourum)* response to two harvest dates under irrigation were examined. Mean dry matter yield were 3.10tDM/ha for *Alysicapus*, 4.87tDM/ha for *Lablab* and 2.9tDM/ha for *Pascourum.*

Table 8: *Effect of date of cut on yield (tDM/ha) of three irrigated grasses grown in Northern Guinea of Nigeria*

Harvest Days post planting	**Gamba**	**Rhodes grass**	**Columbus grass**	**Mean**
60	1.14	2.41	5.57	3.10^{b}
90	3.2	9.02	16.71	9.64^{a}
Mean	2.17^{c}	5.73^{b}	11.14^{a}	
		SEM=1.064		

Means within row or column with same letter superscript differ significantly (P<0.05)

Source: *Muhammad et al. (2004)*

Table 9: *Effect of date of cut on yield (tDM/ha) of three irrigated legumes grown in northern guinea of Nigeria*

Legume species	**Days of cut post planting**			**Mean**
	60	90	30 days regrowth	
Alysicapus	1.09	5.12	3.22	3.10^b
Lablab	2.62	7.13	1.13	4.87^a
Pascourum	1.47	4.35	2.58	2.86^b
Mean	1.69^b	5.53^a	1.08^b	-
SEM	1.101	1.101	1.101	

Means within row or column with same letter superscript differ significantly (P<0.05)

Source: *Muhammad et al.(2003)*

Available literature indicates that as plant matures, the mineral content accumulates and later decline due to natural dilution process and translocation of nutrients to the root system (McDowell, 1995). Reports of studies emanating from the semi-arid zone and sub-humid Nigeria (Kallah *et al*., 1999; Muhammad *et al.,* 2002) have consistently indicated low levels of most of the mineral in forages. However, legumes tend to remain green more nutritious long into the dry season when grasses are dried. Muhammad *et al.* (2002) evaluated the effect of date of cutting on fodder yield and *in vitro* dry matter digestibility of lablab (*Lablab purpureus).* The effect of date of cut at week 5, 10, 15 and 20 post planting on fodder yield, *in vitro* dry matter digestibility, crude protein and mineral contents were evaluated. Result obtained showed harvest made at week 15 post planting gave the highest (P<0.05). Forage dry matter yield increased from 5.9t/ha at week 5 to 7.1t/ha at week 15 and declined thereafter at week 20 post planting. The *in vitro* dry matter digestibility declined (P<0.05) from 81.4% at week 5 to 74.2% at week 20 post planting. Crude protein content increased significantly (P<0.05) from 17.3% at week 5 to 20.5 at week 15 and declined thereafter to 19.5% at week 20 post planting (Table 10). Phosphorus, K, Mg, Zn and Mn contents increased significantly (P<0.05) from week 5 to week 20 post planting. All the nutritive value indices evaluated showed positive relationship with the exception of *in vitro* dry matter digestibility. It was recommended that lablab be harvested for conservation as hay at 15 weeks post planting (*Muhammad et al. (2002)*).

Similarly, Muhammad *et al.* (2004) evaluated the effect of three cultivars of lablab in terms of fodder yield, crude protein, *in vitro* dry matter digestibility and mineral contents of lablab. Result obtained showed dry matter accumulation was highest in Rongahi brown (7.16t/ha and least in Highworth cultivar (6.47tDM/ha). Crude protein content varied significantly ($P<0.05$) from 17.69 to 19.43%. Digestibility coefficients obtained were 76.38 for Highworth and 78.00% for Ronghai brown and 78.00% Ronghai white (Table 11). Highworth had higher concentration of Zn, Ronghai brown had higher concentration of Ca and Mg while Ronghain brown had higher content of P, K and Fe. Based on dry matter yield, CP, invitro dry matter digestibility and mineral contents, Ronghai brown was superior and therefore recommended for large scale production.

Table 10: *Effect of date of cut (weeks after planting) on dry matter yield, crude protein, in vitro dry matter digestibility and mineral composition of Labab (Labab purpure) in the northern Guinea Savannah of Nigeria.*

Variables	Harvest date (Weeks post planting)				SE (±)
	5	10	15	20	
DMY(t/ha)	5.90	6.50	7.10	6.90	0.33
IVDMD (%)	81.40^{a}	78.70^{ab}	75.00^{b}	74.20^{b}	1.14
CP(%)	17.30^{b}	18.00^{b}	20.50^{a}	19.20^{ab}	0.67
Ca (%)	0.78	0.82	0.85	0.88	0.51
P (%)	0.22^{b}	0.25^{ab}	0.27^{a}	0.27^{a}	0.12
K (%)	0.73^{b}	0.74^{b}	0.80^{a}	0.82^{a}	0.10
Na (%)	0.04	0.06	0.07	0.07	0.10
Mg (%)	0.50^{b}	0.60^{a}	0.60^{a}	0.60^{a}	0.03
Fe (ppm)	198.20	197.80	206.60	208.70	6.24
Zn (ppm)	22.20^{b}	28.80^{ab}	29.60^{a}	30.50^{a}	1.62
Mn (ppm)	65.70^{b}	71.20^{ab}	76.80^{a}	76.30^{a}	3.52

Means within rows with different superscript differ significantly ($P<0.05$)

Table11: D*ry matter yield, in vitro dry matter digestibility, crude protein and mineral composition of three cultivars of Labab (Labab purpureus) at SHika, northern Guinea Savannah zone*

Parameters Evaluated	Lablab cultivars			S.E.D
	Highworth	Rongai-Brown	Rongai-White	
DM (t/ha)	6.47^{b}	7.16^{a}	6.72^{b}	0.35
IVDMD (%)	76.38^{b}	78.23^{a}	78.00^{a}	1.00
CP (%)	17.69^{b}	19.43^{a}	19.07^{b}	0.92
Ca (g/kg)	7.35^{b}	8.90^{a}	8.76^{a}	0.85
P (g/kg)	2.37^{b}	2.50^{b}	2.74^{a}	0.19
K (g/kg)	7.68^{b}	7.67^{b}	7.96^{a}	0.16
Na (g/kg)	0.68^{a}	0.61^{b}	0.68^{a}	0.04
Mg (g/kg)	0.51^{b}	0.60^{a}	0.57^{b}	0.05
Fe (mg/kg)	199.75^{b}	188.98^{b}	216.93^{a}	14.10
Zn (mg/kg)	30.94^{a}	24.75^{b}	28.12^{a}	3.10
Mn (mg/kg)	74.97^{a}	73.86^{a}	67.87^{b}	3.82

Means within rows with different superscript differ significantly (P<0.05)

Source: *Muhammad et al. (2004)*

Following successful establishment of *Sorghum almum* in Gangara, follow up studies were conducted to institute its establishment limits in the ecological zones of the country. Multi locational studies were conducted by Muhammad *et al.* (1994-1995); Muhammad *et al.* (2006) for its agro-ecological adaptability under rain-fed conditions in Nigeria. The studies were conducted at sites between latitude 07^{0} 10" to 13^{0} 22"N and longitude 03^{0}33" to 13^{0}42"E (Table 12). Mean annual rainfall amount for the sites varied from 510.5 to 1377.9mm. The data obtained showed that stand count/m^2, culm height and dry matter yield increased significantly (P<0.05) from the Sahel zone to Southern Guinea Savannah zone. Pasture establishment at all locations were observed to be good. Germination was complete within 10 days with pasture height varying from 13 to 17cm at all sites. By 40 to 60 days following planting, forage had made sufficient growth providing adequate fodder for *in situ* or zero grazing. At this stage, the pasture has 40% green leaf. For example, in Shika, a sub-humid area, higher plant height, density and forage yield were obtained by planting in mid-June to early July, and planting at mid-June produces a second ratton for use later in the year (Muhammad *et al.,* 2004). This suggests that for most of the perennial grasses desirable for ranch pasturage in the sub-humid zone, the establishment period is between mid-June to early July for the arid and semi-arid zones planting is to be within early July. It is proven that *S. almum* is adapted (Table 13) to the Sahel, Sudan, Northern and Southern Guinea Savannah zones (Muhammad *et al.* 2006). Yields increased linearly with rainfall as site varied from more Sahel (Daura) to mesic sites with higher rainfall Figure 2. Forage yields (kg) from the agro ecological zones suggests a relationship between rainfall amount (x) and forage yields described by the equation Y=0.012x- 1.7947; $R^2 = 0.852$.

Table 12: *Ecological zones and trial sites of Sorghum almum in the Savannahs of Nigeria.*

Ecological Zone	Trial Site	Latitude N	Longitude E
Southern guinea savannah	Abuja	07^0 10'	07^0 10'
	Ganye	07^0 14'	12^0 03'
	Ibadan	07^0 30'	03^0 03'
	Makurdi	07^0 44'	12^0 02'
	Mayo-Belwa	09^0 08'	08^0 32'
Northern guinea savannah	Nabardo	10^0 17'	09^0 49'
	Dadinkowa	10^0 18'	11^0 29'
	Birnin Gwari	10^0 36'	07^0 11'
	Kaduna	10^0 36'	07^0 27'
	Maigana	11^0 02'	07^0 38'
	Gangara	11^0 11'	07^0 39'
	Kaya	11^0 11'	07^0 35'
	Shika	11^0 11'	07^0 38'
Sudan savannah	Misau	11^0 18'	10^0 28'
	Fane	11^0 19'	14^0 11'
	Bama	11^0 32'	13^0 42'
	Potiskum	11^0 42'	11^0 02'
	Funtua	11^0 43'	07^0 38'
	Layin-Minista	11^0 43'	07^0 38'
	Damaturu	11^0 47'	11^0 57'
	Gusau	12^0 10'	06^0 24'
	Danbatta	12^0 27'	08^0 31'
	Talata-Mafara	12^0 33'	06^0 05'
Sahel savannah	Gumel	12^0 36'	10^0 03'
	Dogona	12^0 52'	11^0 02'
	Gashua	12^0 52'	11^0 03'
	Gombi	13^0 01'	13^0 00'
	Daura	13^0 02'	08^0 13'
	Nguru	13^0 09'	10^0 28'
	Isa	13^0 12'	06^0 24'
	Gwadabawa	13^0 22'	05^0 14'

Source: *Kowal and Knabe (1972)*

Table 13: *Forage production indices of Sorghum almum grown in the savannah of Nigeria*

Ecological zones	*Early vegetative		**Full bloom stage		
	stand count/m2	Height (cm)	stand count/m2	Height (cm)	dry matter
Sahel [1]	8.9[b1]	9.1[b]	17.0[c]	196.2[c]	5.4[c]
Sudan [2]	7.2[b]	9.3[b]	28.1[b]	198.6[c]	8.2[b]
Northern Guinea [3]	10.5[b]	11.0[b]	33.7[ab]	214.9[b]	13.2[a]
Southern Guinea[4]	18.1[a]	9.7[ab]	38.2[a]	246.1[a]	13.6[a]
SEM	3.62	1.63	5.91	16.82	0.93

*14 days post planting, ** 80 after planting

Means within the same column with different superscripts are significantly different (P<0.05)

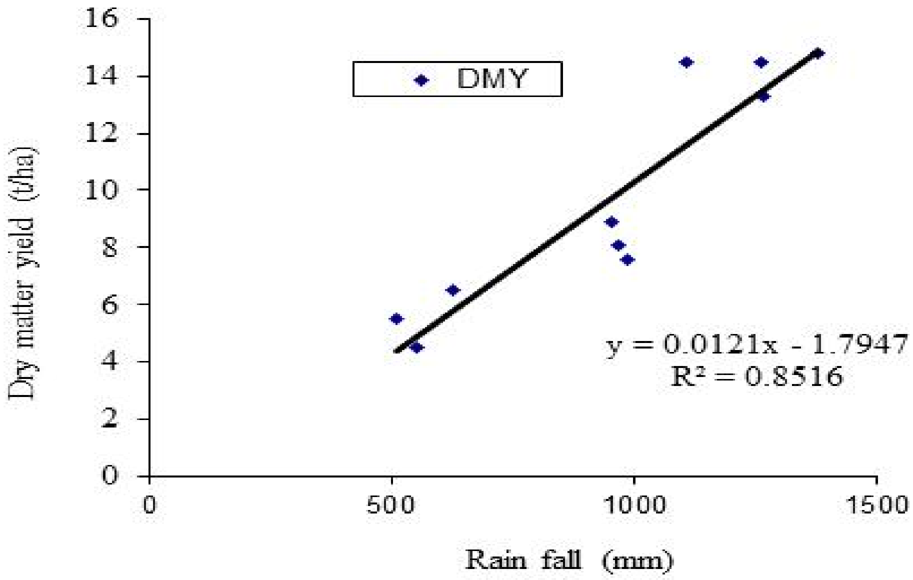
[1] Gumel, daura, Muna, Nguru, Isa, and Gwadabawa

[2]Misau, Fune, Bama, Potiskum, DamaturuGusau and Danbatta

[3]Nabordo, Dadin kowa, Birningwari, Kaya, Layin Minista, Shika;

[4]Abuja, Ganye, Makrdi, Mayo- Belwa

Source: Muhammad *et al.* (2006)



Source: Muhammad (2004)

Fig. 2: *Relationship between amount of rainfall and Sorghum almum fodder yield*

The quality of hay obtained were satisfactory. Crude protein (CP) varied significantly (P<0.05) with pasture established in the Northern Guinea Savannah containing higher CP followed by Sudan and least in the Sahel (Table 14). The concentrations of P, K and Na were similar for pastures established in the Sahel and Sudan, and higher compared to values obtained in the Northern Guinea Savannah with the exception of Na. Animals managed on *S. almum* fodder would respond positively to micro-minerals supplementation (Muhammad *et al.,* 2006).

Table 14: *Organic and inorganic constituents (%) S. almum at full bloom stage of maturity in the savannah ecological zones of Nigeria*

Agro-ecological zones	Organic			Mineral				
	CP	NDF	ADF	Ca	P	K	Mg	Na
Sahel [1]	10.87^{c}	66.01	41.81	0.09^{b}	0.20^{a}	0.70^{ab}	0.19^{b}	0.03^{b}
Sudan [2]	12.81^{b}	66.81	41.42	0.13^{a}	0.18^{ab}	0.80^{a}	0.24^{a}	0.03^{b}
Northern Guinea [3]	13.94^{a}	67.92	41.31	0.13^{a}	0.16^{b}	0.65^{b}	0.17^{a}	0.04^{a}
SEM	0.112	2.782	1.119	0.001	0.001	0.121	0.001	0.001

Means within the same column with different superscripts are significantly different (P<0.05)

[1] Gumel, daura, Muna, Nguru, Isa, and Gwadabawa

[2]Misau, Fune, Bama, Potiskum, Damaturu, Gusau and Danbatta

[3]Nabordo, Dadin kowa, Birningwari, Kaya, Layin Minista, Shika;

[4]Abuja, Ganye, Makrdi, Mayo- Belwa

Source: Muhammad *et al.* (2006)

It is established hitherto the adaptability of *S. almum* in the various ecological zones of the country. Seed distribution to farmers and agencies relevant to forage-fed livestock production commenced in earnest. Figures. 3 and 4 show the pattern of supply of *S. almum* seed to farmers, Agricultural Development Projects (ADPs), and some organisations (ILRI, NEAZDP, IFAD) as adapted in some of the agro-ecological zones from 1993 to1995. There are request for seeds in all the years but the supply of seeds to farmers in 1993 was low due to unavailability of seed. Following seeds availability in 1994 cropping season, the comparatively higher request for seed was almost met. Supply of seeds to farmers increased from less than 10 farmers in 1993 to about 60 farmers by 1995. Similarly, request for seed by the ADPs increased gradually. The request and supply of seeds to organisation like ILRI, IFAD, universities was not consistent. This could perhaps be that these organizations have started multiplication and collection of seeds since the technology is self-sustaining and will not demand sourcing for seed annually.

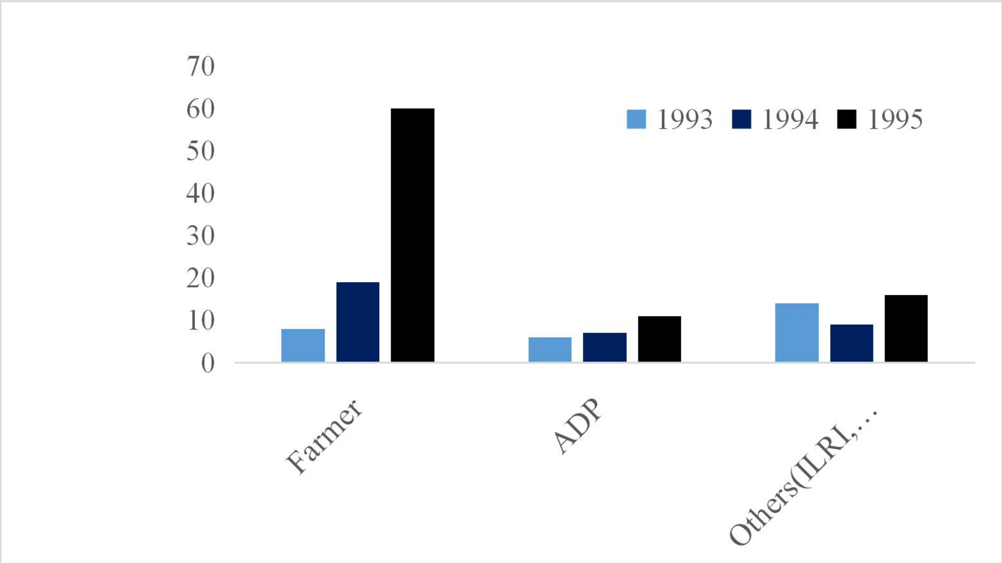


Fig. 3: *Pattern of S. almum seed distribution in Nigeria*

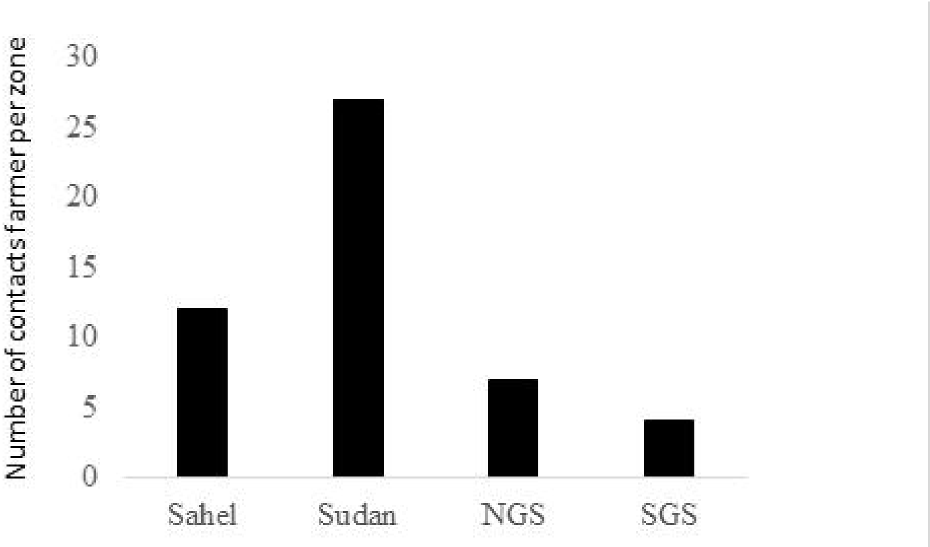


Fig. 4: *Agro-ecological zones*

Source: *Muhammad et al., (1994-1995)*

Methods of establishment of pasture vary depending on the planting material. Some forage species are prolific and viable seed producers while others are not. Those that produce low viable seeds are better propagated via stem or root cuttings. Pasture establishment by root or stem cuttings is very expensive and labour intensive since it involves digging out from the area of availability, loading and transporting to the required area, offloading, and transplanting. In order to cut down cost, few stem cutting could serve as propagule so as to minimise the quantity required when purchasing the foundation stock. Ibrahim *et al.* (2011) conducted an experiment to ascertain the effect of spacing and number of shoots per stand at planting on the establishment and yield of Gamba grass *(Andropogon gayanus)* in the semi-arid region of Nigeria. Uprooted tussock of 15cm shoots height of Gamba grass was transplanted at 5, 10, 15 and 20 shoots per stand using six different spacing (37.5cm x 37.5cm, 50cm x 50cm, 62.5cm x 62.5cm 75cm x 75cm, 87.5cm x 87.5cm and 100cm x 100cm. The result showed that spacing at 37.5cm and 15 shoots per stand had the highest plant height, number of tillers and biomass yield, thus, recommended spacing and number of shoot for establishment of vegetative propagated forage grasses in the semi-arid region of Nigeria.

Fodder Production in Crop Livestock in Crop-livestock Integrated Production System

In the past good relationship existed between pastoral and arable farming because of the role crop residues play in the dry season feeding of livestock. Animals play complimentary role in provision of traction, manure, income and production of vital human food (i.e meat and milk) from the crop residues and forages from lands that are of no alternative value then. Increasing population pressure is still causing changes in farming system. Over 80% of the livestock holder do not have title over land. Population growth, urbanisation and income growth are fuelling massive increase in the demand for food, particularly of animal origin. Population growth also means increased demand of larger parcels of land for crop production and human habitations. The net result of these incremental trends is diminishing area available for free range grazing, higher stocking density, overgrazing, land degradation and diminished livestock access routes. Research in forage crops is scanty when compared to other sub sets of livestock production; also, research in livestock production is not comparable to other sectors of agriculture. This has come about probably because the animal and crop production are separately administered.

As of 1988, it was reported that 30% of the pastoralists are sedentarised, 50% semi-nomadic (practice transhumance and only 20% are nomadic (Suleiman, 1988). The implication is that in the semi-arid region, the chance of integration of livestock into the cropping system increases with the degree of agro-pastoralism. Under agro pastoral production system, use of sown pasture and or conventional feed supplement to alleviate dry season feed shortage is easier said than done and perhaps costly, introduction of dual purpose legumes into the agro-pastoral cropping emerges to offer an acceptable option. Groundnuts and lablab are strategically established modifying the period of planting to achieve fodder of high quality and quantity. Application of agronomic techniques has been used to achieve higher fodder yield by managing the legumes for dual purpose.

The most important group of crop residues for livestock feed are cereal (Figure 5) based (sorghum, millet and maize). Using the crop residue extraction ratio by Alhassan (1988) enable prediction of the quantities of crop residues produced (Table 15) available for livestock as feed. Also, (Powell. 1986) estimated that 22% of sorghum is the leaf portion and feed.. Also, Alhassan (1988) reported on the length of stay in the field account for additional field losses due to termites or fire. Applying the grazing concept of take half, then 11% of sorghum leaf is available. Literature reports from Mali and Nigeria (Alhassan 1988) cattle spent 20 to 50% of their total grazing time on crop residues. Peak grazing time was in January (95%). Adding value of crop residues by chopping or milling and treatment with non-protein nitrogen (CRU process) enhances the utilisation and increases AU triple fold. Using an estimated weight of 275kg liveweight for a bull to be equivalent to 1 animal unit (AU), a daily intake of 7kg/head is applicable. Thus, the 2.97m tones sorghum leaf will support conservatively 2.4m head of cattle (46.7% of estimated Nigerian national herd) for the 6-month dry season.

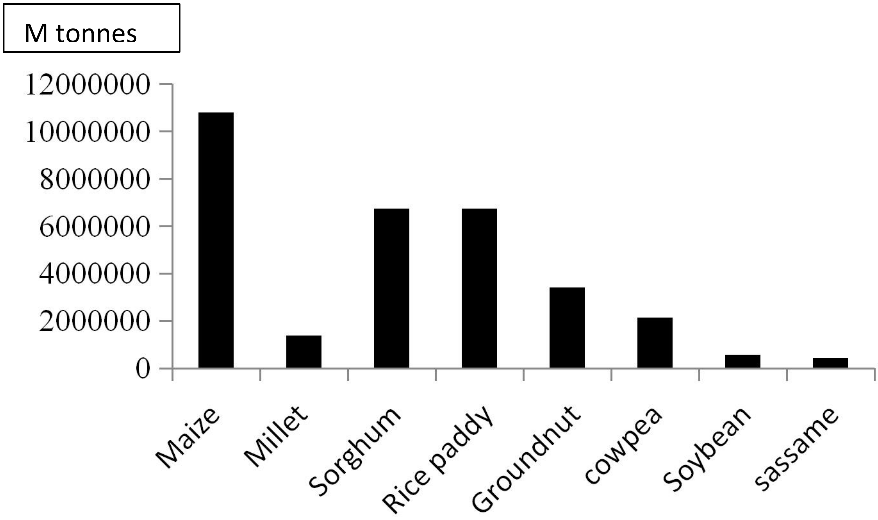


Fig. 5: *FAO 2016 estimated grain yield of the common crops grown in the semi arid and sub humid zones of Nigeria*

Table 15: *Estimated annual yield (million tons) of crop residues and animal unit for six months*

Crop	*Grain yield (Mt)	Crop residues (Mt)	AU for the 6 months dry season
Maize	10790600	43162400	3836657.8
Millet	1384900	11079200	984817.8
Sorghum	6741100	26964400	2396835.6
Groundnut	3413100	10239300	910160.0
Cowpea	2137900	10689500	950177.8
Total	24467600	102134800	9078648.9

*FAO 2016 yield data

The agro-ecological zones of Nigeria have a wide range of biodiversity dictated by rainfall amount and crop growing days. These wide climatic variations are associated with particular crops grown in the ecozones. This implies that the integration of forages into the cropping systems would have to vary in accordance with crop type and their respective growing days. For example, the integration of cereal legume cropping systems is common in the Sahel, Sudan and Savannah zones of Nigeria. This production system takes a variety of production patterns that includes relay, sequential, mixed cropping, while the use of browse plant is more common in the humid zones. Similarly, dual purpose groundnuts and dual purpose cowpeas (Muhammad *et al.* 1992) have been successfully integrated into crop livestock production system with farmers adopting the technology of delayed planting to produce high quality fodder from groundnut.

Initial study was screening of performance of seven elite varieties of cowpeas [*Vigna unguiculata* (L) WAlp.] consisting six improved lines (IT 80D-699, IT81-994, IT84S-22466-4, IT84-E-1-108, TVX 3236) and local variety (Dangidan Yunfa) as a check were evaluated under rain-fed conditions at the Usmanu Danfodiyo University Sokoto dry land farm in the 1987/88 wet season by Magaji *et al.* (1996). The seeds yield of the lines varied from 209 to 1711kg/ha (average 929 kg/ha) against 1343kg/ha for the check variety. Amongst the improved lines only IT 80D-699 out yielded the local land race. In another trial by Muhammad *et al.* (2001) with ten varieties of cowpea bred at IITA were evaluated for use as dual-purpose legumes to provide fodder for livestock and pulses for human consumption. The results obtained show mean seed yield was 666.0 kg/ha and mean shelling percentage was 71.9%. Mean fresh herbage and dry matter yield of the haulms was 6541.9 and 4470.5 kg/ha, respectively. Mean husk yield was 260.9 g/ha. Cumulative fodder was 4731.4. Variety IT93K-2057-14 was the best in seed production with 925.6 kg/ha. Variety IT96D-733 had the highest fodder production. Based on the fodder and seed yields, varieties IT96D-733 and IT93K-398-2 are considered good dual-purpose materials.

In another study, Larbi, *et al.* (1999) noted that forage and seed yields of groundnut (*Arachis hypogaea*) are considered to be joint products by crop-livestock farmers. Variations in forage and seed yields of 38 late-maturing groundnut cultivars were determined in 1995 and 1996 at Samaru, Zaria, northern Nigeria. Crude protein (CP), neutral detergent fibre (NDF), in sacco degradation of dry matter (DM), and nitrogen (N) were also estimated. Average yield of forage (4547 ±1087.9 kg ha^{-1}) and seed (1247 ± 266.6 kg ha^{-1}), Average (g kg^{-1} DM) leaf CP (158 vs. 111), soluble (262 vs. 181) and degradable (512 vs. 407) DM fractions, potential degradability (PD) (774 vs. 588) and effective degradability (ED) (542 vs. 429) were higher than those of the stem. Based on yield (forage and seed) and effective degradability of leaf and stem fractions, cultivars were identified (Table 16) for high (e.g. 42-48, M354-81, UGA-2, RMP-12,), medium (e.g. UGA-5, 59-85^{A}, M170-80^{1}) and low (e.g. 176-85^{A}, UGA-11, ICGV.86347) potential for seed and forage production.

Growing dual purpose legumes (lablab and cowpea (var. *Kannado*) early in the season gives fodder enough for pruning that can be ensiled yet producing ratoon that produce seeds but 40% less the potential production. The quality of the fodder however, compromises for the yield lost. Similarly, farmers utilised residual moisture from flooded valleys and lowlands to grow fodder from lablab (Muhammad, 2016).

In a study by Agyo (2011) on the effect of fortification of maize stover (MS) and sorghum stover (SS) with cowpea grain at 0, 10, 20, 30 and 40% on rumen degradation were incubated for 0, 12, 24, 36, 48 and 72hrs. It was concluded, that greater degradation of maize and sorghum stover can be achieved by inclusion of 40% cowpea grain in the supplementation of Yankasa sheep. It is thus recommended that higher levels of cowpea grain inclusion be evaluated to attain maximum potential and the economic implications (Agyo, 2011). In a research on rumen degradability studies of fourteen (14) soybean genotypes was carried out for 6, 12, 24, 48 and 72 hours (Audu 2015). The results showed dry matter degradability at 48hours incubation for all the inoculants-treated soybean genotypes had minimum of 50% degradation with higher rate of 66.30% in Genotype TGx 1951-3F. Furthermore, thirty-five (35) Uda rams with live-weight of 20-23kg were supplemented with diets containing 0, 10, 20, 30, 40, 50 and 60% soybean residues. Finding showed nutrient intake, nutrient digestibility, feed to gain ratio and cost of feed/kg gain showed significant ($P<0.05$) differences in all the treatments. Inclusion of soybean residues at 30% resulted in higher ($P<0.05$) intake and higher average daily gain It is thus beneficial to inoculate soybean to enhance its utilisation within 48 hours of feeding. Similarly, Inoculation increases grain yield and degradability of soybean residues by 15.24 - 22.19%. Musa (2016) evaluated crop residues from three late-maturing sorghum (Kaura, CRS 01 and ICSV 400) genotypes for fodder yield, nutritive value and DM degradability. Results revealed CSR 01 had more fodder yield but ICSV 400 had %DM of 96% and %CP of 4.95%. Groundnut Samnut 23 had the highest PD (83.27%) and ED (62.80%).

Table 16: *Grouping of 38 late-maturing groundnut cultivars into high, medium and low potential groups for forage and seeds (kg/ha) and effective dry matter degradability (ED, g/kg) of leaf and stem*

	Group				
	High	Medium	low		
	42-85	UGA-5	M569-80	176-85A	M558-79
	2346-79	59-85A	16-85	UGA-12	ICGV.86220
	M354-81	219-85	M364-80I	ICGV.86868	ICGV.86230
	M571-80I	M170-80I	UGA-11	ICGV.86191	ICGV.86347
	UGA-A	49-85	1691-79	530.80I	M516.79I
	RMP-12	249-85	ICGV.86231	M554-79I	RG-1
		ICGV.86222	UGA-1	ICGV.86869	ICGV.8229
	UGA-7	82-85			
	M554-76				
FOYLD	5760 ± 314.1	4728 ± 351.7		3758 ± 974.6	
SEYLD	1470 ± 259.8	1426 ± 139.7		1045 ± 202.3	
ED					
Leaf	549 ± 15.7	549 ± 13.3		537 ± 18.3	
Stem	431 ± 21.6	441 ± 21.2		438 ± 20.7	

Source: *Larbi et al. (1999)*

Forage Conservation

For ruminant animal production, forage is the major and cheapest source of feed and forms the bulk of the feed requirement. For any economical and sustainable livestock production enterprise, it must incorporate forage conservation. There are a number of pasture species (forage grasses and legumes) that are adapted to Northern Guinea and Sudan savannah agro-ecological zones which suitable for sustainable and profitable livestock production. The varieties of forage material (Plate 3) can be utilized for *in situ* grazing or fed as soilage/green chop. Furthermore, surplus fodder during the rainy season can be harvested and conserved as hay or silage for dry season feeding.

Hay (loose, stacked or baled) is the most valuable harvested forage (Plant 4) because it does not deteriorate appreciably in storage thereby making good quality fodder available for the animals. Forage species recommended most suitable for hay are *Brachiaria decumbens, Digitaria smutsii, Sorghum almum, Andopogon gayanus, Chloris gayana, Stylosanthes humilis* and *Centrosema pascourum.* Forage grasses mainly *(Brachiaria decumbens, Digitaria smutsii, Sorghum almum*, *Andopogon gayanus* and *Chloris gayana)* are permanent pasture materials each and when properly managed would last for the next 10 to 20 years with each producing on the average 8 to 15tDM/ha. *Sorghum almum* is fast growing forage material. The chemical analysis of the conserved fodder indicated hay of moderate nutritional value. Based on nutritional standards, it was concluded that the fodder at best provides maintenance diet where some level of production is required, supplementation of N, energy, P and Mg should be given due consideration. Further research on the species is advocated in view of the premium stockmen place on its fodder for feeding fresh or conservation for later utilisation.

Andropogon gayanus

Chloris gayana

Penniseium purpureum

Brachiaria decumbens

Plate 3: *Some forage grasses suitable for ranch pasturage, hay & silage*

Hay from legume is the predominant cattle feed. It can be given as the only feed for breeding stock, growing calves, lactating and pregnant stock where limited grains are desired. A good cured legume has tremendous protein and could make up the major portion of the ration. It is not necessary to feed a protein supplement if it is harvested before the stem becomes coarse and with minimum leaf shedding prior to harvesting, there is fairly good supply of energy. Calcium is present in quantities which exceed the required level. However, it supplies less than half the required level of phosphorus for most classis of beef cattle. Examples are lablab, stylo, *mucuna*, *vigna spp*. groundnut, Alysicapus etc. *Stylo* and Alysicapus have high nutritive value that would contribute to reduction in supplementary feed requirement or be useful for prime animals such as the young, sick, pregnant and lactating ones. These legumes shall be utilized based on a grazing schedule.


A -Baled hay


B - Loose hay

Plate 4: *Baled and loose hay*

Silage

Ensiling during the growing season can be strategically employed to conserve surplus fodder of high quantity and quality which can be stored for over 5 to 10 years without spoilage. Also, much of the silage can be used for emergency feeding in the drought years when feed production and grazing are limited. Ensiling is a process by which fresh or wilted forage material is preserved by fermentation through bacterial production of acetic and lactic acid. The process continues under aerobic conditions until the oxygen is removed and then subsequently under anaerobic phases until a pH of 3.5 to 4.5 is reached. It is however difficult to attain these high acidity levels with indigenous grasses due to their low content of carbohydrate. pH levels of 4.06 to 6.10 are common (Kallah *et al.,* 1999). At this stage, the bacterial action is essentially complete, and the forage is preserved and can be stored indefinitely in air-tight (oxygen-free) facilities. The end product is a succulent form of forage known as silage with a moisture content ranging from 55 to 65%.

Experiments conducted by Muhammad *et al.* (2008), Muhammad *et al.* (2009) to determine the species of legume that are compatible with Columbus grass for ensilage and to establish the optimum proportion of legume inclusion for better silage preparation. Field grown Columbus grass *(Sorghum almum* Parodi*)* was sampled at soft dough stage and fortified with legumes forage from Centurion (*Centrocena pascourum L.)*; Lablab bean (*Lablab purperium (L.)* and Groundnut (*Arachis hypogea L)*. The treatments were 100% Columbus grass; 80% Columbus grass plus 20% groundnut; 60% Columbus grass plus 40% Centurion. The results obtained showed the compounded silages were good and moderately acidic with pH varying from 5.33-5.77. Higher acidic value was obtained from silage prepared of 60% Columbus grass plus 40% groundnut. Dry matter as fed varied significantly ($p<0.05$) from 308.0-508.0g kg^{-1} succulent silage. Significantly higher ($p<0.05$) dry matter as fed was observed from treatments that had 60% Columbus grass plus 40% Lablab. Significantly, higher CP was obtained from the inclusion of 40% of lablab. Organic matter content (OM) of the silage vary significantly ($p<0.5$) from 45.7-69.1%. Ether Extract (EE) varied ($p<0.05$) from 6.6-19.4% with the higher values obtained from Columbus grass plus 40% lablab. The content of ash obtained showed significant variations ($p<0.05$) in the composed silages. Higher OM and CF content were obtained from treatments that had 100% Columbus grass (Muhammad *et al.* 2008).

In another experiment conducted to determine the species of legume that are compatible with Gamba grass for ensilage and to establish the optimum proportion of legume inclusion for better silage preparation. Field grown Gamba grass (*Andropogon gayanus)* was sampled at soft dough stage and fortified with legumes forage from Centurion *(Centrocema pascourum L.);* Lablab bean (*Lablab purpureum L)* and groundnut (*Arachis hypogea L)*. The results obtained showed the compounded silages were good and moderately acidic. Significantly higher CP was obtained from the inclusion of 40% of lablab (Muhammad *et al.* 2009).

Forage Utilisation by Ruminants

Researchers are perpetually manoeuvring plant and animal factors to maximise advancements derived from pastures for improving livestock production. The capacity of pasture has been increased as much as 50% by good grazing management (Muhammad 2004). Description of grazing systems should be based on common characteristics, since variation in grazing system is almost infinite. Livestock production in Nigeria are practised both by urban rural dwellers (Muhammad 2008). Livestock kept in the urban centres have access to dumps and some end up ingesting non-biodegradable material leading to rumen impaction (Mohammed and Muhammad, 2007; Muhammad, 2008).

Feed lot operation and fattening employs zero grazing system. *In vivo* trials were conducted to evaluate the benefit associated with the zero grazing system. In a study carried out to determine dry matter intake and the proportion of nutrients in *Sorghum almum* that is assumed to be absorbed by the Yankasa rams, crude protein content obtained from the fodder was moderate (8.1%) with calculated organic matter of 86.6%. The data obtained indicate that the fodder at full bloom stage of maturity is highly digestible. The apparent digestibility coefficients obtained were 70.6% for CP; 50.7% for organic matter and 68.3% for ADF. Feed intake was 513.0+0.16g/day and daily liveweight gain of 138.9±0.01g. Crude protein intake was 138g/kgLW$^{0.75}$. The crude protein and fibre constituents obtained from this indicated that *S. almum* at full bloom stage of maturity would adequately support maintenance of stall-fed animals with minimal or no protein supplementation (Table 17) as observed by Muhammad (2007).

Table 17: *Mean nutrient intake of experimental Yankasa rams fed Sorghum almum herbage at full bloom stage of maturity*

Nutrients	g/kgLW/ha	g/kgLW$^{0.75}$	%BWt	g/100kgLW/ha	/100kgLW$^{0.75}$
CP	151.1±0.01	138.±0.01	15±0.01	1516.1±0.30	3837.1±0.22
DM	53.8±0.04	40.4±0.03	5.4±0.01	5381.8±3.51	4036.3±2.63
Ash	3.0±.0.54	2.3±0.41	0.3±0.05	304.1±54.22	228.1±40.66
OM	50.8±0.51	38.1±0.38	5.1±0.05	5077.4±50.56	3808.1±37.92
NDF	40.8±0.02	30.6±0.01	4.1±0.01	4078.8±1.96	3059.1±1.47
ADF	20.6±0.02	15.5±0.01	2.1±0.01	2062.5±1.92	1546.9±1.44

Source: *Muhammad (2007)*

Also, in multi-locational trial (Table 18) performance of Yankasa rams, stall-fed *Sorghum almum* fodder harvested at full bloom stage of maturity resulted in positive daily liveweight gain and varied from 280-480g/h/d. Furthermore, the effect of grazing and performance of Bunaji bull calves husbanded on *Sorghum almum* pasture at full bloom stage of maturity during the dry season at Shika in Northern Guinea Savannah of Nigeria revealed positive daily liveweight gain 260g/h/d with herbage disappearances of 8.63t/tDM/ha (Table 19).

Table 18: *Performance of Yankasa rams stall fed Sorghum almum fodder harvested at full bloom stage of maturity in three trial locations in Northern Guinea Savannah of Nigeria*

Parameters evaluated	Trial locations		
	Layin Minista	***Birnin Gwari***	***Shika***
No. of animals	5	5	9
Feeding duration (days)	28	28	28
Initial liveweight (kg)	19.08	33.6	13.44
Final liveweight (kg)	20.36	38.4	17.33
Production/animal (kg)	0.28	4.8	3.03
Daily liveweight (kg)	0.05	0.16	0.13

Table 19: *Effect of grazing and performance of Bunaji bull calves husbanded on Sorghum almum pasture at full bloom stage of maturity during the dry season at Shika in Northern Guinea Savannah of Nigeria*

Parameters evaluated	Before grazing	After grazing	Disappearance
Pasture attributes			
Sorghum almum (tdm/ha)	11.77 ± 2.62	3.14 ± 1.55	8.63 ± 1.07
Invader grasses and forbs (tdm/ha)	0.99 ± 0.47	2.40 ± 0.07	(-1.41 ± 0.06)
Total herbage (t/DM/ha)	12.76 ± 2.60	5.13 ± 2.04	7.63 ± 0.56
Animal attributes			
Numbers of Animals	5	5	-
Liveweight (kg)	62.5 ± 2.36	78.75 ± 2.18	
Parameters evaluated	**Before grazing**	**After grazing**	**Disappearance**
Production/animals (kg)	-	16.25 ± 1.63	-
Grazing duration (days)	-	60	-
Daily liveweight gain (kg)	-	0.26 ± 1.16	-

Source: *Muhammad (2006)*

An *in situ* grazing of pasture is a form of forage utilisation. Several models have been derived to show the relationship between stocking rate and production per animal and product per unit area of land. Stocking rate is a critical factor affecting livestock production. Under-stocking results in wastage and lower animal gains per unit area while over-stocking results in excessive utilisation of forage, deterioration of range condition and low gains per animal (Muhammad, 2004). Findings based on multi-locational standing fodder yield, the estimated carrying capacity for the ecological zones during a year production cycle varied from 0.7LU/ha or 1.3ha/LU in the Sahel to 2.4 LU/ha or 0.4ha/LU in the Guinea Savanna zone (Table 20).

Table 20: *Average dry matter yields (tDM/ha) and estimated stocking rates (Ha/LU or LU/ha per year of Columbus grass (Sorghum almum) in the Savannah agro-ecological zones of Nigeria*

Ecological Zone	Rainfall (mm)	DM (t/ha)	Ha/LUyear	LU/ha/year
Sahel	<600	4.8^{c}	1.3	0.7
Sudan	<1000	8.2^{bc}	0.7	1.3
Northern guinea savanna	1000 – 1250	14.1^{ab}	0.4	2.4
Northern guinea savanna	1250-1377.9	14.6^{a}	0.4	2.4
SEM	-	6.20	-	-

Source: *Muhammad et al. (2002)*

The evaluation of *Sorghum almum* was carried out in trial to determine the influence of stocking rate on productivity of *Sorghum almum* pasture by measuring herbage availability and quality of herbage on offer. The established pasture was evaluated using three stocking rates (1.5, 3.5 and 5.5 animal units/ha designated as low (LS), medium (MS) and high (HS) stocking rates) by two seasons (dry and wet). Animal unit here is defined as a matured bull weighing 270kg liveweight. Prior to the commencement of grazing, the botanical composition of the pasture was categorized as decreaser (forage grasses), increasers (broad leaf annuals and litter materials) while rare broad leaf annuals as invaders. (Table 21) Apparently, decreaser species obtained were three forage grasses namely *Cynodon dactylon, Sataria anceps* and *Digitaria gayana* and two broad leaf annuals (*Acanthospermum hispidum* and *Amaranthus spinosus*). *Sateria anceps* was better decreaser specie relative to other forage grasses encountered. *Cynodon dactylon* and *D. gayana* prevailed to the end of the trial but *C. dactylon* manifested higher frequency of occurrence. The broad leaf annuals encountered, both manifested a relatively similar declining trend with advancement in grazing days. Increasers materials noted were rare broad leaf annuals that advanced with diminished decreaser species along with progression in grazing days. Accumulation of litter material and preponderance of bare ground increased consistently to the close of the trial (Muhammad, 2004).

Grazing at 1AU/ha on herbage dry matter yield showed forage on offer declined significantly ($P<0.05$) from 4.7t/ha to 0.4t/ha by day 86 (Table 22). Within the period, forage disappearance was at the daily rate of 0.05t/ha. The value obtained for herbage disappearance was however for both materials consumed at 1AU/ha and that which accumulated as litter material. This trial showed that broad leaf annuals (*A. hispidum* and *A. spinosus*) that are used as indices of overgrazing upon its manifestation were consumed thereby contributing to the feed on offer to animals. There was however accumulation of litter material which when considered along with the assumed urine and dung from the animals, could perhaps, upon decomposition, contribute to the build-up of soil nutrients that enhance subsequent pasture growth and yield and perhaps, proportion of the bare ground encountered could resuscitate to vegetation (See Plate 5). The regrowth of *S. almum* post grazing is shown in plate 5.

Plate 5: *Regrowth of S.almum after grazing*

Table 21: *Mean botanical composition of S. almum pasture as frequency of occurrence before the commencement of grazing in Northern Guinea of Nigeria*

Pasture composition	**Family**	**% occurrence**		
		1997	1998	Mean ± S.E
Grasses				
Sorghum almum	*Gramineae*	24.4	24.7	24.6 ± 2.85
Cynodon dactylon		12.4	18.1	15.3 ± 2.85
Setaria anceps		9.5	11.5	10.5 ± 1.00
Digitaria gayana		7.2	7.5	7.3 ±0.02
Cyperus sp	*Cyperaceace*	2.9	3.2	3.2 ± 0.15
Broad leaf annuals				
Acanthospermum hispidum	*Astetacede*	6.9	9.8	8.4 ± 1.45
Amaranthus spinosus	*Amaranthaceae*	6.9	4.6	5.8 ± 1.15
Cida acuta	*Malvaceae*	2.9	4.9	3.9 ± 1.00
Rare Broad leaf annuals	-	17.5	12.1	7.3 ± 0.02
Litter	-	3.2	1.7	2.5 ± 0.02
Bare ground	-	6.3	2	4.2 ± 2.15

Source: *Muhammad et al. (2004)*

With the exception of LS treatment where there was an increase in dry matter on offer followed by a decrease. Stocking rate resulted in reduction ($P<0.05$) in CP from LS to HS. Pasture grazed at HS treatment exhibited higher ($P<0.05$) fibre content compared to LS and MS. From the trial conducted in the dry and wet seasons, advancement in grazing period resulted in ($P<0.05$) decline in CP but, ADF and NDF (Table 23) increased ($P<0.05$). Stocking rates demonstrated significant ($P<0.05$) increases in the concentration of Ca, P and Mg in the forage on offer in the wet season (Table 24). During the dry season, while Ca content improved ($P<0.05$), K and Mg decreased as stocking rates increased.

From the study based on dry matter on offer, stocking at 1.5AU/ha provided more herbage to grazing cattle with corresponding adequate crude protein that will encourage intake for higher weight gain. Nevertheless, *S. almum* is insufficient in meeting the Ca, P, K and Na requirements of growing bulls to warrant the expression of their potential for optimum performance. The minimum biomass on offer to grazing animals used as index for withdrawal of animals from a pasture did not statistically reveal the effect of stocking rate (SR) on the liveweight of the animals. Perhaps, severe herbage removal might manifest clear differences between stocking rates treatments on pasture persistence and animal production. It is obvious that *Sorghum almum* in Northern Guinea Savannah when utilised in short time grazing provides for high animal production that could be expected from most high quality forage grasses. Furthermore, the growth rate and dry matter yield potential of *S. almum* makes it a sustainable feed material. More so, it provides feed for high carrying capacity and maximum livestock production per hectare.

Table 22: *Sorghum almum pasture on offer (tDM/ha) grazed at three stocking rates in sub-humid zone of Nigeria*

	LS	MS	HS	S.E.M
Dry season trial				
December 30th	10.84	13.16	13.38	4.53
January 29th	15.45	11.32	6.47	3.65
February 28th	11.74^{a}	5.93^{b}	2.85^{c}	3.75
March 26th	4.63	4.17	-	2.01
Grazing days attained	86	72	40	-
Wet season trial				
June 27th	11.76	10.24	13.03	3.96
July 27th	15.70^{a}	8.18^{b}	5.16^{c}	2.89
August 26th	9.29^{a}	4.68^{b}	1.64^{c}	1.79
September 26th	2.46	2.79	-	2.21
Grazing days attained	88	72	52	-

Source: *Muhammad et al. (2004)*

Table 23: *Crude protein and fibre composition (%) of S. almum pasture grazed at three stocking rates* in the dry and wet season trails in subhumid zone of Nigeria*

Treatments	CP	ADF	NDF	Grazing days
Dry season trial				
LS	7.89	48.55^{b}	82.45^{b}	86
MS	7.70	49.64^{b}	83.16^{b}	72
HS	8.11	54.03^{a}	85.01^{a}	40
SEM	0.474	4.034	1.674	-
Wet season trial				
LS	10.61^{a}	50.80	77.52	88
MS	9.12^{b}	50.77	79.57	72
HS	8.90^{b}	51.45	79.97	52
SEM	1.081	3.514	3.306	-

Source: *Muhammad (2004)*

* Stocking rates are low=1.5AU/ha, Medium =3.5AU/ha and High = 5.5AU/ha.
Along columns, means within season amongst stocking rate treatments with different letter superscripts differ significantly ($P<0.05$)

Table 24: Macro-mineral content of *Sorghum almum* on offer grazed at three stocking rates in sub-humid zone of Nigeria

Treatments	**Macro mineral (%)**					**Grazing days**
	Ca	***P***	***K***	***Na***	***Mg***	
Dry season trial						
LS	0.12^{b}	0.25	0.75^{a}	0.03	0.31^{a}	86
MS	0.13^{b}	0.25	0.63^{b}	0.03	0.30^{ab}	72
HS	0.14^{a}	0.27	0.59^{c}	0.03	0.29^{b}	40
SEM	0.03	0.042	0.036	0.00	0.01	-
Wet season trial						
LS	0.17^{b}	0.25^{b}	0.89	0.04	0.29^{a}	88
MS	0.18^{a}	0.26^{b}	0.68	0.04	0.25^{b}	72
HS	0.19^{a}	0.33^{a}	0.61	0.04	0.25^{b}	52
SEM	0.02	0.089	0.477	0.001	0.054	-

Source: *Muhammad (2004)*

* Stocking rates are low=1.5AU/ha, Medium =3.5AU/ha and High = 5.5AU/ha.

Along columns, means within season amongst stocking rate treatments with different letter superscripts differ significantly (P<0.05)

Furthermore, in the trial, we determined the influence of stocking rate of Columbus grass pasture *(Sorghum almum* Parodi) using changes in liveweight of young Zebu bulls as indices. Twelve (12) bulls (158.5±23.40kg) were continuously grazed in an 8- hourly wet season and 9- hourly dry seasons grazing routine. The treatments were stocking at 1.5, 3.5 and 5.5 animal unit (AU)/ha designated as low (LS), medium (MS) and high (HS) stocking rates. Cumulative liveweight of young bulls grazed at three stocking rates during the dry season demonstrated an initial increase within week 2 of commencement of the grazing trial and thereafter, presented a consistent decline (Plate 6).

The corresponding wet season cumulative liveweight at the three stocking rates treatments gradually increased from week 0 to 4 for HS treatment, 0 to 8 for MS and from 0 to 12 for LS treatments and thereafter declined (Figure 6). Data obtained showed ADG and LW/hd decreased with increased in stocking rate treatments. The decreases from LS to HS were 0.19 to 0.02kg/hd/day and 7.63 to 1.38kg/hd for ADG and LW/hd, respectively. Output per hectare increased with corresponding increase in stocking rates (Plate 4). The increases from LS to HS were 5.54 to 58.65kg/ha. The implication of the present finding is that *Sorghum almum* in sub-humid zone when utilised at 1.5AU/ha supports high animal production (Table 25).

Plate 6: *Experimental animal before and after grazing S. almum pasture at 1.5AU/ha*

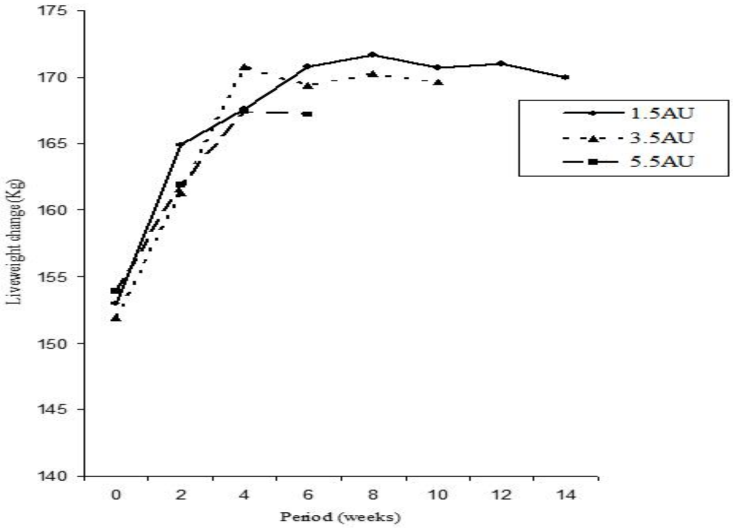


Figure 5. Effect of stocking rate on liveweight (kg) of growing bulls grazed on *Sorghum almum* pasture at Shika, sub humid zone.

Source: *Muhammad (2004)*

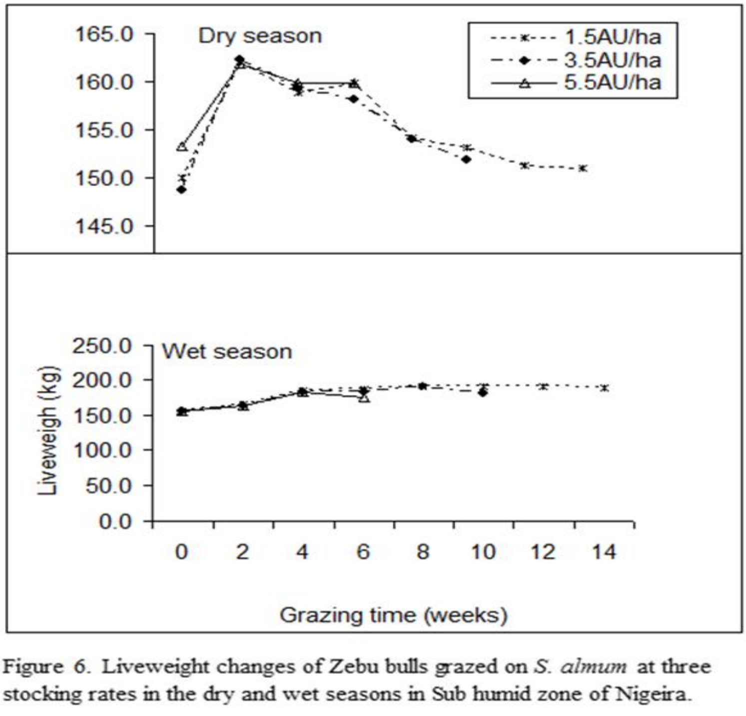


Figure 6. Liveweight changes of Zebu bulls grazed on *S. almum* at three stocking rates in the dry and wet seasons in Sub humid zone of Nigeira.

Source: *Muhammad (2004)*

Table 25: *Performance of young bulls grazed at three stocking rates (AU/ha) on S. almum during the dry and wet seasons in the sub-humid zone*

Performance variables	Stocking rate (Au/ha)			SED
	LS	MS	HS	
Dry season				
ADG (kg/hd/da)	0.19	0.04	0.02	0.373
LW/hd (kg/hd)	7.63	3.00	1.38	0.934
LW/ha (kg/ha)	3.53	11.54	58.65	2.985
Wet season				
ADG (kg/hd/da)	0.6	0.43	0.33	0.345
LW/hd (kg/hd)	37.75	34.13	22.25	4.041
LW/ha (kg/ha)	96.8	165.87	171.15	10.145

Source: *Muhammad (2004)*

Fodder as a Business Opportunity

Crop residues from cereal and legumes that used to be considered as waste to be grazed free by livestock has now become a major household source of income, and their by-products nevertheless, are feeds offering economic activities in some urban cities of the semi-arid zones of Africa (for example, Nigeria, Niger, Tchad, Mali, Sudan). Married adult males within the age group of 43 to 52years, majority (51%) managing household size of 1 to 6 members, sale hay from either cereal, legumes or both and their by-products for their livelihood in most urban centres of the semi-arid regions. Study by Muhammad *et al.* (2009) reveal production was equally profitable. We reported net benefit (₦ ha^{-1}) of 1442.91 for forage grasses, ₦617.87 for legumes and 50% each grass legume mixtures were ₦2021.13 (Table 26).

Table 26: *Cost benefit analysis of yield (kg/ha) of sole S. almum C. pascourum alone or in mixture sward in the semi-arid zone*

Pasture sward	DM yield	Unit price of output (₦ /kg)	Output (₦ /ha)	Total variable cost (₦ /ha)	Net benefit (₦/ha)
100% *S. almum* (S)	9700	0.17	1683.67	241.66	1442.91
100% *C. pascorum* (C)	3400	0.24	82620	208.33	617.87
25% S + 75% C	7700	0.18	1475.43	216.66	1258.75
50% S + 50% C	12100	0.21	2246.13	225.10	202113
75% S + 25% C	9200	0.18	1638.60	233.33	1405.28

Source: *Muhammad et al. (2009)*

Most forage hay is fed to animals on the farm producing it. However, with urbanisation and other competitive land use, for example the development of specialised, intensive livestock enterprises such as dairy, beef feeding, and horse production on high-priced lands near these population centres may give rise to a ready market for large quantities of harvested forages.

An opportunistic sale of fodder freely harvested from the range by urban and peri-urban inhabitants of different age group has for long provided seasonal employment with several segments which include labour for harvesting, transporting, and retailing of soilage material. The major forage species harvested for sale as green chop in urban Kano are native species with inherent low dry matter yield that rarely exceed 2tDM/ha (Table 27). The sale of fodder as soilage reveals an opportunity for commercialisation of higher improved pasture that is characterised by higher dry matter yield and quality relative to the native species for sale.

Table 27: *Major forage species harvested for sale as green chop in urban Kano*

Variables	**Frequency**	**%**
Digitaria horizontalis	70	35
Cynodon doctylon	50	25
Pannisetum pedicellatum	40	20
Commolina bengalensis	30	15
Dactyloctenium aegyptium	10	5
Total	200	100

Source: *Muhammad (2016)*

Pasture seed yield for Nigeria has been reported (Tanko *et al.*, 1997). The sale of pasture seeds is not very popular amongst forage vendors. The sale is limited to few elites' farms and the only animal production based research institute. The monopoly market is therefore exploited making pasture seeds more expensive than any food commodity. For example; a kilogramme of stylo seed (legume) goes for ₦3,000, a kilogramme of Gamba grass seed sells for ₦1,000 while brachiaria grass seed goes for ₦3,000/kg. These prices may be considered high for pastoral livestock farmers since investment for livestock feed is not a common practice.

Ranching in Nigeria

A ranch is a farm, usually large, devoted to the breeding and raising of cattle, sheep, or horses on rangeland. Under natural conditions, rangeland environments have built-in homeostatic mechanism (forces and counter-forces), which tend to maintain them in a more or less stable production condition. However, where livestock production and other human activities are involved, this buffer limits can be destabilised. Over grazing reduces desirable grasses, forbs, and browses which are replaced by less desirable plants or bare ground, thereby affecting animal productivity and human welfare. However, man can also wisely manipulate forces within the environment, which may lead to practical increases, maintenance at steady state or decreases in the productivity of forage and animal resources. From the stockman or farmers' perspective, economic consideration is applied to all aspects of inputs to and outputs from range and pasture lands. Rangeland ecosystem as well as sown pasture are to the stocker a renewable resource, and if properly managed, the system may be productive over an indefinite period of time.

Ranch farming or ranching, originated in the imposition of European livestock-farming techniques onto the vast open grasslands of the New World. Spanish settlers introduced cattle and horses into the Argentine and Uruguayan pampas and the ranges of Mexico early in the colonial period, and the herding of these animals spread readily into what is now the South Western United states. By the early 19th century the ranch had become an economic mainstay of the North American ranges. The cowboy emerged during this period as essentially a rancher on horseback, who moved from camp to camp, grazing cattle on unfenced public ranges. Biannual roundups were held for branding calves and separating steers to be driven north and east for fattening and slaughter.

The Homestead Act of 1862 in the United States generated the establishment of many grassland farms that expanded into the huge western ranches. Open-range ranching has remained an important economic activity in Australia and New Zealand and in parts of Africa, where it was introduced in the late 19th century.

The major national livestock production system is pastoralism. It is worth noting that pastoral livestock production is not only peculiar to Nigeria. Livestock production has been a traditional occupation to ethnic groups such as the Massai of East Africa (841,622 in Kenya and 377,089 in Tanzania) the Fulas of Sierra-Leone, the Toureg of Niger (790,000), Mali (450,000) Burkina Fasso (30,000), Algeria (25,000), Libya (20,000), Morocco (4,500) and Tunisia (2,000) the Fulani (4,000,000), Shuwa and other minority tribes in Nigeria. These pastoralists wherever you find them have love for animals and depend on them for economic earnings. They equally have the right to live and practice what they best known. However, as a result of multiple interests on land use by several stakeholders, challenges by desertification, global warming and climatic change have, either independently or collectively, affected the forage and animal resource negatively. Further, transient grazing reserved users makes sustainability of the feed resource on offer difficult. For any meaningful ranching to be successful, it has to be supported with an active land use act where the land for grazing will be invested upon to be considered as an economic business for the state. Furthermore, areas not used for grazing could be put to intensive pasture production to provide hay, thus strengthening the business of fodder vendors that can serve wider livestock owners at lower cost.

Conclusion and Recommendation

Forage-fed livestock produce organic meat and milk highly desired by all. There are a number of high yielding forage grasses and legumes both native and exotic that are adapted to the ecological zones of this nation and their modes of propagation is proven. The forage species can be established both under rain-fed or integrated along with irrigation schemes. Crop livestock or livestock farmers are encouraged to avail themselves with varieties of their choice to create the culture feed production for their livestock to curtail the seasonal weight loss of the animals as well as safeguarding the environment.

Pasture establishment in the arid and semi-arid zones should be from late June to early July while in the sub-humid zone, establishment is from mid-June to early July. The application of nitrogen fertilizers at the rate of 100-150kg/N/ha is recommended for forage grasses while 18 to 30 KgP_2O_5 for the legumes. It is more economical to produce mix pasture consisting of 50% grasses and 50% legumes for commercial pasturage. For high yielding pastures used for *in situ* grazing, 1.5-animal unit is to be stocked per hectare.

Ranching, in its real concept, is a forage-based economic business to be benefited by the federal, state and local governments, and the ranchers. The three tiers of government should invest in pasture production to be supported with active legislative acts on land use and range management.

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