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Improvement of annual forage and seed production in the sub-humid zone of Nigeria through supplement irrigation

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Abstract. A two-year study was conducted at Shika in the Northern Guinea Savanna of Nigeria to evaluate several perennial and annual forage species for seasonal and total annual herbage and/or seed production. Over the entire experimental period, total dry matter (DM) yields for grasses, perennial and hay-suited annual legumes varied from 27.5 to 79.1, 18.8 to 40.3 and 40.5 to 50.5 t/ha, to which irrigation contributed 48 to 66, 50 to 57 and 56 % respectively. Irrigated grass crude protein (CP) contents averaged 5.3 and 9.9 %; and legume CP contents 16.1 and 18.8 % for the May and December harvests while rainfed grass CP contents ranged from 7.7 % (August) to 10.9 % (October), the corresponding legume values being 18.7 and 20.9 %.

Irrigated cropping accounted for 55 to 56 % of the 9 207 to 12 461 kg/ha seed yield recorded in dual purpose legumes. It was inferred that on the basis of total herbage yield, distribution of yield and responsiveness to irrigation *Pennisetum purpureum, Brachiaria decumbens, Cajanus cajan* Acc UQ 50 or 3D 8104 and *S. guianensis* cv Cook proved to be promising; reasonable seed yield levels were obtained from *C. cajan* 3D 8104, *Glycine max* Acc. 49-14 and M 216 and *Vigna unguiculata* Acc Ivu 1283, whether irrigated or rainfed. The potential of irrigation is discussed in relation to feed, food and livestock production.

Index words: irrigation, tropical legumes and grasses

Introduction

For the past 27 years, and more especially since the late 1970's, it has proved increasingly difficult for Nigeria to provide even a quarter of the minimum animal protein requirements of her teeming population despite the substantial agricultural potential in terms of land, climate and human resources. While there has been a marked shortfall in the national gross protein supply, animal based protein percentage of the human diet has also continually diminished. Computed animal protein supply declined from 8.6 grams daily per caput in 1968 to 6.5 grams in 1980 and below 6.0 grams in 1985. These figures represent about 25 to 17 per cent of the minimum daily animal protein intake recommended by the British Medical Association.

Accurate human and livestock population figures for Nigeria are presently unavailable. However, human population tends to increase more rapidly (presumably because of the phenomenally high birth rates particularly in the rural areas and comparatively low average death rates due to considerably improved primary health care delivery). Based on a projected 2.5—3.2 per cent annual growth rate, this may rise from an estimated 84.9 million in 1984 (Oloruntoba, 1984) to about 134.0 million by the end of the century. On the other hand, the supply of livestock products by the country's estimated 9.3 million head of cattle (some authorities quote 11 to 15 million), 8.8 million sheep, 20.8 million goats, 0.86 million pigs and 133.5 million poultry grows only at a rate of about 0.75 per cent annually. Hinged on the above, it is expected that the livestock population level ought to satisfy the country's animal protein needs but, would be found deficient when translated into performance and livestock units, because of serious inefficiencies in the current livestock production systems. Since the overall annual requirement of animal products grows at a rate of 5 per cent, a rather wide gap thus exists between the domestic supply and demand, a discrepancy which cannot be taken care of even by 1992, unless the supply of animal products grows at an unprecedented annual rate higher than 11 per cent.

A major constraint on livestock production is the perennial feed shortage, especially during the drier part of the year. The Fulani pastoralists, who account for over 90 per cent of Nigeria's cattle population, depend almost exclusively on the natural grasslands and an extensive system of management. Notable characteristics of this include: the use of unimproved and low yielding native grasses; striking seasonal fluctuations in the quantity and quality of available forage to the extent that overgrazing, severe liveweight losses and in fact high mortality occur during the dry season; livestock owners' greater interest in the numerical strength than in the care of their livestock; lack of provision for supporting grazing during droughts and long dry seasons with supplements such as crop residues, agro-industrial by-products and/or high quality feed reserves; shortage of water and mineral licks. Other bottlenecks comprise tse-tse fly infestation particularly in the humid zone; manipulation of predominantly unproductive livestock breeds and generally inadequate veterinary care and services.

The hectarage on hand for livestock grazing in Nigeria is decreasing rapidly, possibly as a result of a combination of factors such as mounting population pressure, urbanization, industralization, land use for crop production and other agricultural programmes and, desert encroachment. New strategies therefore have to be devised and developed for improving land meant for agro-pastoralism to match the much needed high output of animal products per animal and per hectare. This is in addition to breeding and utilizing highly productive animals, sizably raising the level of livestock husbandry and applying optimal feeding regimes.

One feasible logistic is the integration of irrigated forage production into the overall land use package for improving the plane of animal nutrition and hence increasing not only meat and milk output but also the degree of animal resistance to attack by pests and diseases.

The Federal Government of Nigeria, upon realising the need to make more land cultivable, increase crop yields per hectare through a more efficient production system and guarantee sufficient agricultural raw materials for the country's rapidly developing industries, decided to set-up large irrigation schemes under several River Basin and Rural Development Authorities (RBRDAs). These Authorities were mandated to exploit, harness and manage the country's water resources with the objective of extenuating drought effects and raising all-inclusive agricultural productivity, among other things. More unambiquously, land would be cultivated for the production of crops and livestock both within and outside the irrigation schemes. Although this implicates the production of forage crops, at best irrigation efforts have been concentrated on cereal crops and the residue made available for livestock feeding.

Investigations in the subhumid zone of Nigeria (de Leeuw, 1972; Akinola, 1975) demonstrated the potential for forage production under dry season irrigation conditions. These studies suggested the need for long-term research on the yield responses of forage species to irrigation and different agronomic practises with a view to removing the constraints of chronic dry season scarcity of supplementary feeds.

This paper presents the results of experiments conducted over a two-year period to examine a number of forage crops for seasonal and total annual herbage and seed yields when grown under rainfed and dry season irrigated situations. The speculation was that the findings might help in the development of irrigation assisted forage production programmes, which would alleviate the problem of dry season feed shortages particularly in the subhumid and drier zones of Nigeria.

Materials and methods

Location

The experimental location was a low-lying area of the National Animal Production Research Institute (NAPRI), Shika (latitude 11°12′N, longitude 7°33′E), 22 km north-east of Zaria in the Northern Guinea Savanna of Nigeria. The dry season lasts approximately from October to April while July to September accounts for two-thirds of the 1034 mm long-term (1929—1976) mean annual rainfall. The study years contrasted in rainfall intensity and distribution as demonstrated by the occurrence of 857 mm from April to September in 1975 and 1284 mm between April and October in 1976. Mean maximum and minimum temperatures vary between 35.2/21.3°C (April) and 27.1/12.0°C (January). Mean relative humidity ranges from 15.2 % in January-February to 75.4 % in July-August while sunshine hours decline from 9.4 in November to 5.6 in August.

Analysis showed that the 0—15 cm horizon of the sandy clay loan soil, hitherto followed, was characterised a pH (H_2O) of 6.2; 1.24 % organic matter; 0.085 % total nitrogen; 0.40 kg/ha water extractable phosphorus; and 1.33, 3.56, 0.38 mequiv. exchangeable magnesium, calcium and potassium 100 g, respectively.

Land preparation

On 30 December 1974, the land which had been cleared and two days earlier flood irrigated, was disc-ploughed and harrowed twice. Following compound fertilizer (20N : $10P_2O_5$: $10k_2O$) application by hand broadcast at the rate of 377 kg/ha, 60 cm ridges were made and the furrows filled with irrigation water (Doorn van, 1972). At the start of the second cropping year (December 1975) this level of fertilizer was again applied.

Experimental design

Three experiments were laid down, each in a randomized complete — block design with three replicates, for species herbage and/or seed yield comparisons under rainfed and irrigated conditions. A plot measured 6 m × 4.2 m and was separated lengthwise from the next by a metre-wide gap, and, breadthwise by an unplanted ridge while blocks were demarcated by bunds.

Planting and management

Details of the plant species studied are presented in Table 1. Local *Cajanus cajan* accession is tall, late maturing and acropetal in the flower development pattern whereas

Table 1. Species, immediate origin and sowing rates.

Species	Immediate origin	Sowing rate (kg/ha)
Experiment 1 — Perennial grasses and legumes for herbage production		
Grasses (Perennials)		
Andropogon gayanus (Gamba)	S	50*
Brachiaria decumbens (Signal)	S	V
Cenchrus ciliaris cv Biloela (Buffel)	Q	7.5
Chloris gayana cv Callide (Rhodes)	S	7.5
Digitaria smutsii (Woolly finger)	S	V
Panicum maximum var Trichoglume (Green panic)	Q	7.5
Pennisetum purpureum (Elephant cv Ngala)	S	V
Pennisetum purpureum (Elephant cv Shika)	S	V
Legumes (Short-lived perennials)		
Cajanus cajan (Pigeonpea) Acc Local	M	25
Cajanus cajan (Pigeonpea) Acc. 3D 8104	I	25
Cajanus cajan (Pigeonpea) Acc. UQ 50	Q	25
Legumes (Perennials)		
Centrosema pubescens (Centro)	S	10
Desmodium scorpiurus (Samoan clover)	S	7.5
Desmodium uncinatum cv Silverleaf (Silverleaf desmodium)	Q	7.5
Neonotonia wightii cv Cooper (Cooper glycine)	Q	10
Macroptilium atropurpureum cv Siratro (Siratro)	Q	10
Stylosanthes guianensis cv Cook (Cook stylo)	Q	7.5
Experiment 2 — Hay-suited annual legumes for herbage production		
Glycine max (Soybean) var Congo Yellow	M	45
Glycine max (Soybean) var Malayan	M	45
Glycine max (Soybean) var Potchefstroom 55	.M	45
Vigna unguiculata (Cowpea) Acc. Ivu 1283	I	25
Experiment 3 — Short-lived perennial and annual legumes for seed production		
Cajanus cajan (Pigeonpea) Acc. 3D 8104	I	20
Glycine max (Soybean) var Improved Pelican	M	40
Glycine max (Soybean) Acc 49-14	Q	40
Glycine max (Soybean) Acc M 216	M	40
Vigna unguiculata (Cowpea) Acc Ivu 1283	I	20

* Seed with involucre sown.

V = Vegetatively established.
I = International Institute of Tropical Agriculture, Ibadan, Nigeria.
Q = University of Queensland, Queensland, Australia.
M&S = Mokwa and Shika Stations of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria.

the *C. cajan* accessions 3D 8104 and UQ 50 are intermediate and basipetal (Akinola and Whiteman, 1972). Except the *C. cajan* accessions used, *Glycine max* and *Vigna unguiculata* which had no problem of *hardseededness,* all legumes were scarified with concentrated sulphuric acid before inoculation with the appropriate *Rhizobium* strain. Seeds were drilled in shallow (1—3 cm) grooves on ridge tops at rates depending on size, germinability and intended use or sprigs planted 30 cm apart within the ridge on 2 January, 1975. Irrigation was supplied once weekly from November to May unless over 25 mm rain fell shortly before the scheduled irrigation date.

Experiment 1

No subsequent weeding was necessary after that carried out on 20 February, 1975. Herbage dry matter (DM) yield estimates were based on the inner 4.8 m × 3 m of each plot, the rest being cut and discarded on the dates shown in Table 2. Thus irrigated dry season periods of growths and regrowths totalled 209 and 207 days while rainfed wet season

Table 2. Dry matter yields (t/ha) of irrigated and rainfed perennial grasses and legumes.

		1975					1976				
	Harvest	Ir[+]	Ra	Ra	Ir		Ir	Ra	Ra	Ir	
	Harvest date	16/5	18/8	15/10	19/12	Species	10/5	9/8	8/10	21/12	Species
Species	Age[++]	134	94	58	75	total	133	91	60	74	total
A. gayanus		6.28	4.22	3.04	1.81	15.35	4.48	3.11	2.55	2.03	12.17
B. decumbens		12.30	5.84	3.53	2.30	23.97	10.98	7.54	4.42	2.25	25.19
C. ciliaris		6.82	6.33	2.90	2.18	18.23	5.63	4.85	3.08	2.33	15.89
C. gayana		7.57	6.56	3.20	1.98	19.31	6.23	5.81	3.17	1.40	16.61
D. smutsii		8.71	4.79	2.18	1.59	17.27	7.12	5.13	2.81	1.70	16.76
P. maximum var trichoglume		10.65	5.75	2.29	1.76	20.45	6.08	3.67	2.63	1.85	14.23
P. Purpureum cv Ngala		25.36	7.17	5.35	4.43	42.31	17.97	8.84	4.54	2.58	33.93
P. purpureum cv Shika		23.89	7.14	5.97	3.83	40.83	21.04	10.52	3.95	2.80	38.31
C. cajan, Local		7.55	6.16	3.15	2.78	19.64	8.83	4.38	1.86	0.69	15.76
C. cajan, 3D 8104		6.56	5.93	4.60	3.69	20.78	9.23	4.92	2.03	0.95	17.13
C. cajan, UQ 50		9.14	6.82	4.70	2.87	23.53	10.17	4.09	1.75	0.79	16.80
C. pubescens		4.81	3.77	2.59	2.20	13.37	5.29	4.25	1.13	0.53	11.20
D. scorpiurus		3.52	3.10	2.18	1.58	10.38	3.83	3.35	0.75	0.51	8.44
D. uncinatum		4.88	3.69	2.05	1.98	12.60	3.72	3.16	0.93	0.38	8.19
M. atropurpureum		4.30	3.15	2.71	2.01	12.17	4.11	3.13	1.31	0.54	9.09
N. wightii		5.98	3.39	3.17	1.89	14.43	4.76	4.28	1.06	0.45	10.55
S. guianensis		7.19	4.88	2.41	2.05	16.53	6.97	5.18	1.52	0.44	14.11
Harvest mean		9.15	5.22	3.30	2.41	20.08	8.03	5.07	2.32	1.31	16.73
LSD (P = 0.05)		3.29**	1.21**	1.21**	0.72**	4.31**	3.16**	1.82**	0.59**	0.45**	4.91**

	LSD (P = 0.05) mean over two years		
	Irrigated harvests	Rainfed harvests	Total harvests
Year (Y)	0.384**	0.241**	0.225**
Harvest (H)	0.384**	0.241**	0.318**
Y × H	0.592NS	0.341**	0.450**
Species (S)	1.118**	0.702**	0.656**
Y × S	1.582NS	0.993**	0.927NS
H × S	1.582**	0.993**	1.311**
Y × H × S	2.237**	1.404**	1.854**

[+] Ir, Ra = Irrigated and rainfed harvests.
[++] Days from planting (16/5/75 only) or cut back.
NS = Non-significant at P = 0.05; ** Significant at P = 0.01.

periods amounted to 151 and 152 days in 1975 and 1976, respectively. Harvesting was with the hand sickle and cutting heights above the ridge top were 30 cm for *C. cajan,* 20 cm for *Andropogon gayanus* and *Pennisetum purpureum,* and 15 cm for the remaining species. The harvested material was weighed, subsampled, oven-dried at 80°C for 48 hours, milled and analysed for crude protein (CP = N% × 6.25) content (AOAC, 1970) on plot basis.

Experiment 2

Ridges were weeded, cleared of trash and remoulded prior to each of the second, third and fourth sowings on 17 July 1975, 18 December 1975 and 22 July 1976. Each production cycle required one hand weeding. Harvesting and sampling for DM yield and CP content determination were as described in Experiment 1 except that plants were cut at the cotyledonary node. Days to hay stage, defined as time of first filled pod changing from green to yellow in 50 % of plants, varied from 85 (*G. max* var Congo Yellow and *V. unguiculata* Acc. Ivu 1283) to 115 for July sowings and from 120 to 140 for December sowings.

Experiment 3

Land preparation procedures and sowing dates in respect of *G. max* and *V. unguiculata* were similar to those outlined for Experiment 2 crops above. The *G. max* examined comprised relatively early (day 100) Improved Pelican and intermediate (day 116) maturing accessions 49-14 and M216. These days to maturity relied on Shika data during normal growing season. Harvesting for seed yield occurred when 90 to 95 % of filled pods had desiccated and were recorded as April/May and end of October for the irrigated and rainfed crops, respectively. *C. cajan* 3D 8104 stands remained in the plots from the trial establishment to termination but were cut back to 30 cm after each pod harvest in June (irrigated) and December (rainfed).

At harvest, reproductive branches were cut with hand sickles, sundried for three to four days and threshed. Sub-samples from the seeds recovered were dried to constant weight in hermetically sealed glass desiccator jars for seed yield determination and analysed for CP content (See Experiment 1) — *G. max* CP content being derived from the formula CP = N% × 5.71 (WATT and MERRILL, 1963).

Statistical analysis

Statistical analysis of the data was carried out as described by STEEL and TORRIE (1960).

Results

Experiment 1

Dry matter yield

The DM yields for four irrigated and four rainfed harvests during the two experimental years are presented in Table 2. Total DM yields were significantly higher (P/0.01) in 1975 (except for *Brachiaria decumbens*) despite the higher 1976 rainfall, 1976 grass and legume yields being lower by 12.5 and 22.5 % respectively. DM yields maximised in May and declined significantly with subsequent harvests to a December lowest so that the pooled irrigated harvests far out-yielded the rainfed harvests. Significant species DM yield differences occurred between years and among harvests within a year. Over both years, the *Pennisetum purpureum* cultivars gave the highest grass DM yields (cv Ngala 76.24 and cv Shika 79.14 t/ha), followed by *B. decumbens* (49.16 t/ha) with the lowest (27.52 t/ha) resulting from *A. gayanus.* For the legumes, *Stylosanthes guianensis* DM yield (30.64 t/ha) ranked next to the *Cajanus cajan* Acc. yields (35.40 to 40.33 t/ha), the lowest (18.82 t/ha) for *Desmodium scorpiurus* being, however, non-significantly different *D. uncinatum* and *Macroptilium atropurpureum* yields.

Irrigated grass harvests contributed 48 %, through 59 % to approximately 66 % of the two-year total DM yields for *Chloris gayana* (lowest), *Panicum maximum* var *Trichoglume* and *P. purpureum* respectively. The corresponding legume figures were 50 % for *D. scorpiurus,* 54 % for *S. guianensis* and 54 to 57 % for the *C. cajan* accessions. Unlike other swards, *B. decumbens* total annual DM yield was higher in 1976 in 1976 because of better May-October growth compared with the related 1975 period. In only *Cenchrus ciliaris* and *C. gayana* were irrigated harvest yields equal to or less than rainfed harvest yields.

Crude protein content

Average annual and harvest by harvest CP contents for all species are summarised in Table 3. CP contents were similar for both years but were significantly affected by harvest. Harvests taken in May had the lowest average CP contents, followed by those taken in August, December and October, irrespective of year. Legumes CP contents doubled those of the grasses, which resulted in the highly significant species differences encountered. Irrigated grass CP contents averaged 5.3 % and

Table 3. Crude protein contents (% dry matter) of irrigated and rainfed perennial grasses and legumes.

		1975					1976				
	Harvest	Ir[+]	Ra	Ra	Ir		Ir	Ra	Ra	Ir	
	Harvest date	16/5	18/8	15/10	29/12		10/5	9/8	8/10	21/12	
Species	Age[++]	134	94	58	75	Mean	133	91	60	74	Mean
A. gayanus		5.1	8.6	12.3	12.0	9.5	5.8	8.5	11.7	10.7	9.2
B. decumbens		5.4	7.4	10.8	9.8	8.4	5.3	7.9	11.0	10.3	8.6
C. ciliaris		5.2	7.6	10.3	8.8	8.0	6.0	7.9	10.0	9.4	8.3
C. gayana		5.3	6.3	9.8	9.8	7.8	5.5	8.1	10.4	9.9	8.5
D. smutsii		5.6	8.0	12.2	10.5	9.1	5.0	7.8	11.6	11.0	8.9
P. maximum var trichoglume		5.1	7.5	10.7	9.5	8.2	5.2	8.2	10.2	9.2	8.2
P. purpureum cv Ngala		4.9	7.5	11.7	9.3	8.3	5.1	6.3	10.2	9.4	7.8
P. purpureum cv Shika		4.8	7.9	11.6	9.9	8.6	5.0	6.5	9.9	9.3	7.7
C. cajan, Local		15.5	16.9	21.3	19.0	18.2	14.8	17.2	19.7	18.7	17.6
C. cajan, 3D 8104		16.8	17.8	19.8	19.3	18.4	16.1	18.6	20.5	20.0	18.8
C. cajan, UQ 50		16.3	18.3	19.8	18.8	18.3	15.5	17.9	19.3	19.5	18.1
C. pubescens		15.9	17.3	21.5	19.0	18.4	15.4	18.1	21.7	19.5	18.7
D. scorpiurus		16.9	20.6	22.6	21.6	20.5	17.3	21.8	23.8	22.5	21.4
D. uncinatum		14.7	17.0	18.6	17.9	17.1	13.9	16.3	18.1	17.6	16.5
M. atropurpureum		16.3	19.4	23.5	21.9	20.3	15.8	20.0	21.4	20.1	19.3
N. wightii		18.2	21.3	22.0	21.1	20.7	18.8	20.8	22.5	22.2	21.1
S. guianensis		15.6	18.1	20.3	19.3	18.3	16.3	17.7	20.9	20.3	18.8
Harvest mean		11.0	13.4	16.4	15.1	14.0	11.0	13.5	16.0	15.1	13.9
LSD (P=0.05)		2.18**	2.77**	3.07**	2.26**	1.67**	2.33**	2.81**	2.70**	3.77**	2.34**

	LSD (P=0.05) mean over two years		
	Irrigated harvests	Rainfed harvests	Total harvests
Year (Y)	0.521NS	0.472NS	0.328NS
Harvest (H)	0.521**	0.472**	0.464**
Y×H	0.737NS	0.668NS	0.656NS
Species (S)	1.520**	1.377**	0.957**
Y×S	2.149NS	1.948NS	1.353NS
H×S	2.149**	1.948NS	1.914NS
Y×H×S	3.039NS	2.755NS	2.706NS

[+] Ir, Ra = Irrigated and rainfed harvests.
[++] Days from planting (16/5/75 only) or cut back.
NS = Non-significant at P=0.05; ** Significant at P=0.01.

9.9 %, and legumes, 16.1 % and 18.8 %, for the May and December harvests respectively. Average rainfed grass CP contents varied from 7.7 % (August) to 10.9 % (October), the corresponding values for the legumes being 18.7 % and 20.9 %. The two *P. purpureum* cvs and *P. maximum* var *tichoglume* maintained the lowest CP contents under irrigated, and *A. gayanus* and *D. smutsii* the highest, whether irrigated or rainfed. Legume CP contents increased from low for *D. uncinatum,* through *S. guianensis* and *C. cajan,* to high for *D. scorpiurus* and *Neonotonia wightii.*

Crude protein yield

The overall effect of year on calculate total CP yield (t DM/ha × % CP × 1000) was similar to that observed for total DM yield. Average annual irrigated legume CP yield was 1.0 % more, and grass CP yield 2.9 % less, than the respective rainfed CP yields. The total irrigated grass CP yields in eight harvests ranged from 1021 kg/ha for *A. gayanus* to 2792 and 2794 kg/ha for *P. purpureum* cvs Shika and Ngala, amounting to 44 %, 55 % and 56 % of the total two-year CP yields. Comparatively, the legume values ranged from 1634 kg/ha for *D. uncinatum,* through 2701 kg/ha for *S. guianensis,* to 3683 kg/ha for *C. cajan* Acc UQ 50 and amounted to 49 %, 51 % and 54 % of the total two-year CP yields.

Experiment 2

Dry matter yield

DM yields from one irrigated and one rainfed cropping per year of annual legumes, over 1975 and 1976, totalled slightly more than 40 t/ha (lowest) for *V. unguiculata* or *G. max* var Congo Yellow and approximately 54.5 t/ha (highest) for *G. max* var Potchefstroom 55 (Table 4). The overall year effect was non-significant but, regardless of year, average DM yield was significantly greater for irrigated cropping. The contribution of as much as 56 % by irrigated cropping to total annual DM yield must have influenced the significant year × cropping interaction. Obvious DM yield differences between but not within croppings were demonstrated by the species.

Table 4. Dry matter yields (t/ha) of irrigated and rainfed hay-suited annual legumes.

Cropping / Species	1975			1976		
	Ir+	Ra	Species total	Ir	Ra	Species total
G. max var Congo Yellow	10.4	9.8	20.2	12.1	8.3	20.4
G. max var Malayan	13.0	11.6	24.6	14.0	10.0	24.0
G. max var Potchefstroom 55	14.2	11.0	25.2	16.9	12.4	29.3
V. unguiculata Acc. IVu 1283	10.4	8.6	19.0	12.2	9.3	21.5
Cropping mean	12.0	10.3	22.3	13.8	10.0	23.8
LSD (P=0.05)	3.43NS	3.34NS	4.05*	4.36NS	3.33NS	4.59**

LSD (P=0.05) mean over two years	
Year (Y)	1.00NS
Cropping (C)	1.00*
Y×G	1.42*
Species (S)	1.42*
Y×S	2.00NS
C×S	2.00NS
Y×C×S	2.83NS

+ Ir, Ra = Irrigated and rainfed croppings.
NS = Non-significant at P = 0.05; *, ** = Significant at P=0.05, P=0.01.

Crude protein content

The legumes averaged more CP contents in 1975 (Table 5), a reverse of the DM yield situation, although in neither case were the differences significant. Irrigated and rainfed CP contents compared favourably and the slightly higher value under irrigation were consistent among species in 1975 only.

Crude protein yield

Altogether, *G. max* vars Congo Yellow, Malayan and Potchefstroom 55 and *V. unguiculata* produced estimated CP yields of 5582, 6429, 7449 and 5830 kg/ha to which irrigation contributed 56 %, 57 % and 56 %, respectively. Irrigated cropping was significantly superior to rainfed cropping and all the CP yield responses to irrigation tended to be better in 1976.

Experiment 3

Seed yield

G. max var Improved Pelican produced significantly the lowest total seed yield (9207

Table 5. Crude protein contents (% dry matter) of irrigated and rainfed hay-suited annual legumes.

Species / Cropping	1975 Ir[+]	1975 Ra	1975 Species total	1976 Ir	1976 Ra	1976 Species total
G. max var Congo Yellow	14.4	13.8	14.1	13.6	13.6	13.7
G. max var Malayan	13.4	13.2	13.3	14.0	12.7	13.4
G. max var Potchefstroom 55	14.1	13.7	13.9	13.4	14.0	13.7
V. unguiculata Acc. IVu 1283	15.2	14.9	15.1	13.8	14.1	14.0
Cropping mean	14.3	13.9	14.1	13.8	13.6	13.7
LSD (P = 0.05)	3.74NS	3.81NS	2.22NS	3.36NS	3.36NS	1.93NS

[+] Ir, Ra = Irrigated and rainfed croppings.
NS = Non-significant at P = 0.05.

Table 6. Seed yields (kg/ha) of irrigated and rainfed perennial and annual legumes.

Species / Cropping	1975 Ir[+]	1975 Ra	1975 Species total	1976 Ir	1976 Ra	1976 Species total
C. cajan Acc 3D 8104	3562	2743	6305	3329	2827	6156
G. max var Improved Pelican	2623	2260	4882	2375	1949	4324
G. max Acc 49-14	3118	2733	5851	3505	2786	6291
G. max Acc M 216	3482	2958	6440	3290	2391	5681
V. unguiculata Acc IVu 1283	2951	2504	5455	3246	2347	5593
Cropping mean	3147	2640	5787	3149	2460	5609
LSD (P = 0.05)	517.6*	510.7NS	644.6*	479.7**	627.8NS	705.4**

LSD (P = 0.05) mean over two years	
Year (Y)	145.0NS
Cropping (C)	145.0**
Y × G	205.0NS
Species (S)	229.2**
Y × S	324.2NS
C × S	324.2NS
Y × C × S	458.4NS

[+] Ir, Ra = Irrigated and rainfed croppings.
NS = Non-significant at P = 0.05; *, ** = Significant at P = 0.05, P = 0.01.

kg/ha) over the two years compared with the highest (12 461 kg/ha) recorded for *C. cajan* Acc. 3D 8104 although the latter only differed marginally from other species yields. The meagre greater average 1975 seed yield was strongly influenced by *C. cajan* Acc. 3D 8104 and *G. max* Improved Pelican and M216 (Table 6). For both years irrigated cropping gave precisely similar total seed yields which significantly exceeded yields by the corresponding rainfed cropping. Species seed yield differences within season were significant for irrigated croppings and could be accounted for by the low *G. max* var Improved Pelican yield. On the average, irrigated *C. cajan, G. max* and *V. unguiculata* contributed 55 %, 55 % and 56 % of the overall annual seed yields.

Seed crude protein content

Seed CP contents tended to have increased generally in 1976 (Table 7). Irrigated croppings produced seeds with significantly higher CP contents, an observation that was consistent for all legumes except *G. max* Acc. 49-14 in 1975. The major species differences within cropping evolved from the inherently higher values for *G. max* which considerably outstripped those of *C. cajan* and *V. unguiculata.*

Seed crude protein yield

Since total seed yields were nearly uniform across the legumes (Table 6), the marked differences in calculated seed CP yields must have been sponsored by the seed CP contents, While *V. unguiculata* and *C. cajan* produced yields of 2536 and 2617 kg/ha, *G. max* yields varied from 3520 kg/ha for va. Improved Pelican to 4746 and 4793 kg/ha for Accs 49-14 and M 216 over the entire two-year period. The higher *G. max* Acc. 49-14 and *V. unguiculata* yields recorded in 1976 were a departure from the average species response trend. Irrigated cropping gave greater CP yields than rainfed croppings and accounted for 55 to 58 % of average annual CP yields.

Discussion

This study suggested that, if irrigation assisted, the total annual herbage DM, CP and

Table 7. Seed crude protein contents (% air-dry matter) of irrigated and rainfed perennial and annual legumes.

Species / Cropping	1975 Ir+	1975 Ra	1975 Species mean	1976 Ir	1976 Ra	1976 Species mean
C. cajan Acc 3D 8104	21.6	20.7	21.2	21.5	19.9	20.7
G. max var Improved Pelican	38.2	37.5	37.9	39.4	37.7	38.6
G. max Acc 49-14	38.8	39.0	38.9	40.1	38.1	39.1
G. max Acc M 216	40.2	38.1	39.2	40.5	38.9	39.7
V. unguiculata Acc IVu 1283	23.4	21.5	22.5	23.9	22.6	23.3
Cropping mean	32.4	31.4	31.9	33.1	31.4	32.3
LSD (P = 0.05)	3.42**	1.96**	1.75**	2.23**	1.74**	1.29**

LSD (P = 0.05) mean over two years	
Year (Y)	1.43NS
Cropping (C)	1.43**
Y×G	2.03NS
Species (S)	2.26**
Y×S	3.20NS
C×S	3.20NS
Y×C×S	4.53NS

+ Ir, Ra = Irrigated and rainfed croppings.
NS = Non-significant at P = 0.05; ** = Significant at P = 0.01.

seed yield of a number of promising perennial and annual forages/field crops could be at least doubled. Application of irrigation extended the growing season of the environment which represents the Nigerian subhumids with the approximately seven dry months a year and occasional drought incidents. In relation to earlier investigations conducted in Shika upland areas on herbage production from *P. purpureum* (AKINOLA, 1976), *V. unguiculata* (AKINOLA and DAVIES, 1978) and *B. decumbens* (AKINOLA, 1977), and seed production from the tested cultivars of *V. unguiculata* (AKINOLA and DAVIES, 1978) and *G. max* (AKINOLA, 1980) the present results have clearly identified water shortage as a principal constraint to the realisation of the potential yield and quality of adapted forages.

The need to use irrigation water judiciously was obvious. Although in the trials, *P. purpureum* and *B. decumbens,* among the grasses, responded best to irrigation water, the 20—23 t DM/ha obtained by de LEEUW (1972) from 100-day old *P. purpureum* established in mid-February at the same site indicated a higher growth rate explicable in terms of appropriate timing of irrigation and planting. Establishment in early January or commencement of irrigating forage regrowth as early as in December appeared, therefore, undesirable. This could be explained mainly as limitation on growth imposed by the low December—January temperatures.

CP contents of grasses harvested in May were low and therefore associated with the long growth interval. Grass herbage thus obtained would have to be supplemented before feeding to livestock for at least body weight maintenance. The legumes on the other hand contained high CP levels throughout the year. However, since selection for irrigation must be based on material to support profitable meat and milk production ventures which rely not only on high CP content but also adequate herbage energy levels, the legumes to immediately recommend would be *C. cajan* and *S. guianensis*. Anthracnose disease was not encountered by *S. guianensis* under irrigation and wet season stand counts indicated less than five per cent mortality.

The large CP yields estimated are notable. While grass CP yields relied heavily on high DM yields, legume CP yields would be observed to have been strongly influenced by high CP contents. Most importantly, the year-round DM and CP yield stabilization experienced (MOLINE, REHM and NICHOLS, 1974) certainly points out the significant role irrigation could play in overall agricultural output.

Although some responsive pure swards have been recognized, more work still needs to be done on grass-legume compatibility under irrigation for fuller exploitation of the climatic and adaphic environment and to support integration into other cropping systems. Since, currently, wheat and tomatoes are grown under irrigation, the investment cost of irrigating additional hectarages for combating feed shortage, improving livestock nutrition and survival and increasing leguminous grain production for human consumption (ADDO, AKINOLA and YUSUF, 1987) and industrial purposes, should be minimal. However, this notwithstanding it is necessary to investigate the presumptive cost/benefit ratio of investing in irrigation facilities.

Animal population *per se* is of little importance and the major worry should concern the number of animal units (AU) per hectare. Since overgrazing stems from the sociological inclination of the Fulani herdsmen towards possessing large AU's than administering proper husbandry and feeding, these shortcomings would be substantially reduced by increased herbage availability. Shika research has produced encouraging results from a few of the forages examined for beef production from set stocking (OKEAGU and AKINOLA, 1982) cattle milk production when ensiled (UMOH, 1975), sheep dressing percentage in feedlot operations (ADU and BRINCKMAN, 1981) and goat feed cost/unit liveweight gain when pen fed (IKHATUA and ADU, 1984). Moreover, work there also suggested the possibility of animal genetic influences (EHOCHE, ADU and OLORUNJU, 1983) on the various animal performances obtained could not be overlooked. Consequently the need would arise for breeding and maintaining animals with genetic potential for production to efficiently complement any increased and stabilized plane of nutrition.

There is a dearth of information from Nigeria's irrigation schemes on soil water table and the amount of surface irrigation water required to avoid over-irrigation when optimum forage yield and quality are envisaged. Other areas that need further work include soil conservation, soil permeability assessment, potential of lining canals and ditches and of devices for drainage to prevent water-logging.

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