EFFECT OF CULTURAL WEED CONTROL PRACTICES ON MAIZE GRAIN YIELD, FODDER PRODUCTIVITY AND BOTANICAL COMPOSITION OF CROPPED STYLOSANTHES PASTURES

BY

TISEER, FIDELIS AWEVER
(B.Sc.HONS BOTANY)

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (M.Sc) IN BOTANY

DEPARTMENT OF BIOLOGICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA
SEPTEMBER, 1993

DEDICATION

This work is dedicated to truth, to Lauretta, to the memories of my mother, Mrs Avaaswem Tiseer and Mr & Mrs J.I. Ahom.

CERTIFICATION

The thesis titled: Effect of Cultural weed control practices on maize grain yield, fodder productivity and botanical composition of cropped *Stylosanthes* pastures by Tiseer, F. A. meets the regulations governing the award of the degree of Master of Science (Botany) of Ahmadu Bello university and is approved for its contribution to knowledge and literary presentation.

..... 19/12/96
Dr. S. Mu'azu
Member, Supervisory Committee
Biological Sciences department
Ahmadu Bello University, Zaria.

..... 29/12/95
Dr. E. C. Agishi
Member, Supervisory Committee
Forage and Crop Residue Research,
National Animal Production Research
Institute, Shika, Ahmadu Bello
University, Zaria.

..... 13/01/97
Dr. C. A. Ajakaiye
Biological Sciences Department,
Ahmadu Bello University, Zaria.

..... 27/1/97
Professor Dalhat Mohammed
Dean, Post Graduate School
Ahmadu Bello University, Zaria.

ACKNOWLEDGEMENTS

My sincere appreciation goes first to Dr. Gbassey Tarawali without whom this work would not have been possible. My gratitutde and thanks go to Professor C. G. Vajime who initiated this collaboration and continously encouraged me throughout the duration of this research. I acknowleldge with gratitude the conceptual guidance and criticisms of my Supervisor Professor E. C. Agishi that have given this work the quality it has.

My gratitude goes to all the field staff of the International Livestock Centre for Africa Subhumid Zone, especially Mr. S. O. Magaji who, like a father, not only assisted but also enriched my knowledge of the flora of the subhumid zone. My appreciations also go to Lauretta who understood and endured all the while. To Agnes who never seized to encourage me despite the distance. This list will not be complete without the mention of a great friend, whose concern transcends just that of friendship but esteems from his very nature. He is my paradigm, the man D.I. Saror. Lastly I acknowledge Doo Yoosu for his great assistance.

ABSTRACT

Investigations were carried out on the effect of cultural weed control paractices on grain yield, fodder productivity and botanical compositon of cropped *Stylosanthes* pastures in four sites within the subhumid zone of Nigeria. These sites were, Abet, Lat. 9° 40'N and Long. 8° 10'E; Kurmin Biri, Lat. 10° 10'N and Long. 7° 55'E; Mazuga, 21km east of Kurmin Biri and Ganawuri, Lat. 8° 35' and Long. 9° 6'E. These legume pastures were established between 1987 and 1988. The first two are researcher-owned and managed while the latter two are farmer-owned researcher managed.

Exploiting the advantage of cropping old annual legume pastures had generated questions of sustainability related to the legumes' resilience. This was therefore investigated in this study which involved cropping maize in *Stylosanthes* pastures and instituting routine weed management practices of these localities in a modified fashion to give nine treatments. Weeding in this region is done at least twice consecutively from germination to harvest of any crop either with the big or small hoe 'galma' or fartanya' respectively in hausa. Apart from this convention, the crop was either not weeded or weeding was done in the first thirty days or second thirty days of planting with either of these hoes. Selective weeding was also done with the small hoe (hand hoe), the sown legume spared as mulch in either two consecutive times or only at the second of the two times. Also investigated was the cereal/legume (weed) interaction, the quality of the potential fodder after the maize harvest in light of its composition as

percentage forbs, grass and sown legume. Herbaceous flora was also evaluated before cropping, after each weeding, immediately after maize harrvest and one year subsequently.

Prior to cropping, grasses observedly took dominance from the sown legume which constituted less than 30% by density and biomass in the pastures. *Brachiaria Stigmatissata* was ubiquitous. Varying the frequency and time of weeding during the growth of the cereal revealed that herbaceous flora succession disfavoured grasses with increased weedind frequency while forbs appeared boosted. Consequently, forbs dominated other species in the pastures immediately after maize harvest, *Oldenlandia herbaceae* being ubiquitous. Weeding cleanly throughout the growth of the maize crop was shown to be unnecessary. Grains resulting from these were similar to those from weeding once at a critical time. Sparing the legume at weeding resulted in increased legume production, subsequent regeneration and increased maize yield. Precropping herbaceous flora neither related to the post harvest flora nor to that two years after. *Stylosanthes* however re-established dominance after crop harvest. Not weeding at all gave the highest total forage yield while maize grain yield was lowest. Since both high fodder and grain yields are desired by the agropastoralist, weeding once as well as sparing the legume at weeding treatments appeared to best suit the objective.

TABLE OF CONTENTS

PAGE

Title page i

Dedication ii

Certification iii

Acknowledgements iv

Abstract v

Table of Contents vii

List of Tables xi

List of Figures xiii

List of Appendices xiv

CHAPTER ONE: INTRODUCTION 1

CHAPTER TWO: LITERATURE REVIEW

2.1 The Dynamics of Encouraging Plant Diversification with Regards to Crop-Weed Interactions in an Agricultural Community. 8

2.2 Weed Management; State of the Art 10

2.3 An Overview of Weed Management in Maize 11

2.4 Cropping Systems in the Sub-humid Agroecological Zone of Nigeria .. 14

2.5 Weed Management in the Sub-humid Agro-Ecological Zone of Nigeria. 16

2.6 The Need for Cultural Weed Management in Attempts at Integrating Crop/Livestock Husbandry with Sustainable Considerations in the Sub-humid Zone 18

CHAPTER THREE: MATERIALS AND METHODS

3.1 Location of Sites 19
3.1.1 Abet 19
3.1.2 Kurmin Biri 19
3.1.3 Mazuga 19
3.1.4 Ganawuri 19
3.2 Experimental Design 20
3.2.1 Treatments 20
3.2.2 Land Preparation 21
3.2.3 Seed Obtained 22
3.2.4 Agronomic Practices 22
3.2.5 Crop Harvest and Dry Matter Determination 23
3.2.6 Floristic Survey and Herbaceous Biomass in the Second Year after Sowing of Maize 24
3.2.7 Statistical Analysis 24

CHAPTER FOUR: RESULTS

4.1 Precropping Floristic Survey 26
4.2 Precropping Herbaceous Biomass (July, 1991) 31
4.2.1 Abet Site 31

4.2.2	Kurmin Biri	31
4.2.3	Mazuga	31
4.2.4	Ganawuri	34
4.3	Pre-harvest Floristic Survey	34
4.3.1	Abet Site	34
4.3.2	Kurmin Biri Site	38
4.3.3	Mazuga Site	40
4.3.4	Ganawuri Site	43
4.4	Grain yield	45
4.4.1	Abet Site	45
4.4.2	Kurmin Biri Site	48
4.4.3	Mazuga Site	48
4.4.4	Ganawuri Site	49
4.5	Post-harvest Floristic Survey	49
4.5.1	Abet Site	49
4.5.2	Kurmin Biri Site	49
4.5.3	Mazuga Site	52
4.5.4	Ganawuri Site	52
4.6	Post-harvest Herbage Dry Matter Yield	52
4.6.1	Abet Site	52
4.6.2	Kurmin Biri Site	55
4.6.3	Mazuga Site	55
4.6.4	Ganawuri Site	59
4.7	Floristic Survey in the Second Year Sowing Maize	59

4.8 Herbaceous Dry Matter Yield at the end of the Second Year after Sowing Maize .. 66

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

5.1 Effect of Weeding Regimes on Flora Succession 72

5.2 Effect of Weeding Regimes on the Herbage Biomass 73

5.3 Effect of Weeding Regimes on Maize Grain Yield 75

5.4 Maize Grain Yield and Potential Forage, a Sustainable Assessment 78

5.5 Conclusions and Suggestions for Further Research 79

REFERENCES 81

APPENDICES 99

LIST OF TABLES

TABLES

1. Pre-cropping Survey of Dominant and other Herbaceous Species in the Treatment Plots (1991) .. ..
   a. Abet 27
   b. Kurmin Biri 28
   c. Mazuga 29
   d. Ganawuri 30
2. Pre-cropping Herbage Yield in the Treatment plots (1991) .. ..
   a. Abet 32
   b. Kurmi Biri 33
   c. Mazuga 35
   d. Ganawuri 36
3. Summary of Mean Herbaceous Flora Counts (1991) .. ..
   a. Abet 37
   b. Kurmin Biri 39
   c. Mazuga 42
   d. Ganawuri 44
4. Maize Grain Yield at the Four Experimental Sites (1991) 46

5. Post-harvest Survey of Dominant and other Herbaceous Species in the Treatment Plots (1991) .. ..

a Abet 50

b Kurmin Biri 51

c Mazuga 53

d Ganawuri 54

6. Post-harvest Herbage Yield in the Treatment Plots (1991) .. ..

a Abet 56

b Kurmin Biri 57

c Mazuga 58

d Ganawuri 60

7. Grain and Herbage Yield at the Four Experimental Sites (1991) 62

8. Summary of Total Herbage Dry Matter Yield and Percentage Legume Component in all Sites Before and after Cropping (1991) 63

9. Survey of Dominant and other Herbaceous Species in Treatment Plots, Two Years after Sowing Maize (1992) .. ..

a Abet 64

b Kurmin Biri 65

10. Total Herbage Yield in the Treatment Plots, Two Years after Sowing Maize (1992) .. ..

a Abet 67

b Kurmin Biri 69

LIST OF FIGURES

FIGURES		
1	Map of Nigeria Showing Different Ecological Zones and Experimental Sites	2
2	Yield of Maize Cropped in the Legume Pastures at the Various Sites (1991)	47
3	Herbage Biomass Immediately after Grain Harvest	61
4	Total Herbage Biomass Two Years after Sowing at Abet and Kurmin Biri (1992)	70
5	*Stylosanthes* Dry Matter Yield Two Years after Cropping (1992)	71

LIST OF APPENDICES

APPENDIX			
1	Herbaceous Flora Population Prior to Cropping (1991)		99
1.1	ANOVA for *Stylosanthes* Species Population Prior to Propping		99
	ai	Abet	99
	bi	Kurmin Biri	101
	ci	Mazuga	102
	di	Ganawuri	103
1.2	ANOVA for Grass Population Prior to Cropping (1991)		
	aii	Abet	104
	bii	Kurmin Biri	106
	cii	Mazuga	108
	dii	Ganawuri	110
1.3	ANOVA for Forbs Population Prior to Cropping (1991)		
	aiii	Abet	112
	biii	Kurmin Biri	114
	ciii	Mazuga	116
	diii	Ganawuri	118
2.	ANOVA for Flora Succession during the Cropping Interim (1991)		
2.1.1	ANOVA for Immediate Post First Weeding *Stylosanthes* Population		
	ai	Abet	120

bi Kurmin Biri 122

ci Mazuga 124

di Ganawuri 126

2.1.2 ANOVA for Immediate Post First Weeding Grass Population (1991)

aii Abet 128

bii Kurmin Biri 130

cii Mazuga 132

dii Ganawuri 133

2.1.3 ANOVA for Immediate Post First Weeding Forbs Population (1991) .. ..

aiii Abet 135

biii Kurmin Biri 136

ciii Mazuga 138

diii Ganawuri 140

2.2.1 ANOVA for Immediate Post Second Weeding *Stylosanthes* Population ..

ai Abet 142

bi Kurmin Biri 144

ci Mazuga 146

di Ganawuri 148

2.2.2 ANOVA for Immediate Post Second Weeding Grass Population (1991)

aii Abet 150

bii Kurmin Biri 152

cii Mazuga 153

dii Ganawuri 155

2.2.3 ANOVA for Immediate Post Second Weeding Forbs Population (1991)

aiii Abet 157

biii Kurmin Biri 159

ciii Mazuga 160

diii Ganawuri 162

3. Analysis of Variance for Maize Grain Yield (1991)

a Abet 163

b Kurmin Biri 164

c Mazuga 165

d Ganawuri 166

4. Analysiss of Variance for Herbage Dry Matter Yield after Grain Harvest (1991) .. .. ..

a Abet 167

b Kurmin Biri 168

c Mazuga 169

d Ganawuri 170

5.1 Analysis of Variance for Total Herbage Dry Matter Yield, Two Years after Cropping (1992) .. .. ..

ai Abet 171

bi Kurmin Biri 172

5.2 Analysis of Variance for *Stylosanthes* Dry Matter Yield Two Years after Cropping (1992)

aii Abet 173

bii Kurmin Biri 174

6. Z test for *Stylosanthes* Dry Matter

6.1 *Stylosanthes* Dry Matter before and after Crop Harvest in 1991 175

6.2 *Stylosanthes* Dry Matter Prior to Cropping and at the end of the Second Year after Sowing Maize 177

CHAPTER ONE

I N T R O D U C T I O N

Nigeria lies between latitudes 4°13′ and 14°00′ north and longitudes 2°40′ and 14°13′ east (Kay, 1959). It has an area of 94 million hectares, 75% of which is savanna (fig.1). Most of the estimated 12.5m cattle, 12.8m sheep and 26m goats in Nigeria are managed under extensive system (Onifade and Agishi, 1988).

Range lands provide most of the feed resources of the livestock, particularly in the savanna where a greater proportion of the ruminant livestock are concentrated (Olufade, 1988). Most of the Savanna areas are within the semi-arid and sub-humid zones with average annual rainfall of 400-900mm and 900-1500mm, respectively.

In these major livestock producing areas, range feed resources are highly seasonal. There is adequate forage of good quality for ruminants during the wet season, but this becomes limiting in both quality and quantity during the dry season (Onifade and Agishi 1988). The seasonal variation has even widened further as the range has become highly degraded due to decades of annual burning, over-exploitation of the forest, intermittent droughts and over-grazing by livestock (de Vries and Djiteye, 1982, Breman and Traore,1986a,b; and Breman and Cisse, 1977). The seasonal variation in forage availability has almost permanently entrenched nomadic/transhumant pastoralism in the livestock industry, a system which is no longer sustainable (Balogun, 1982). The semi-arid zone of the savanna (Sudan and

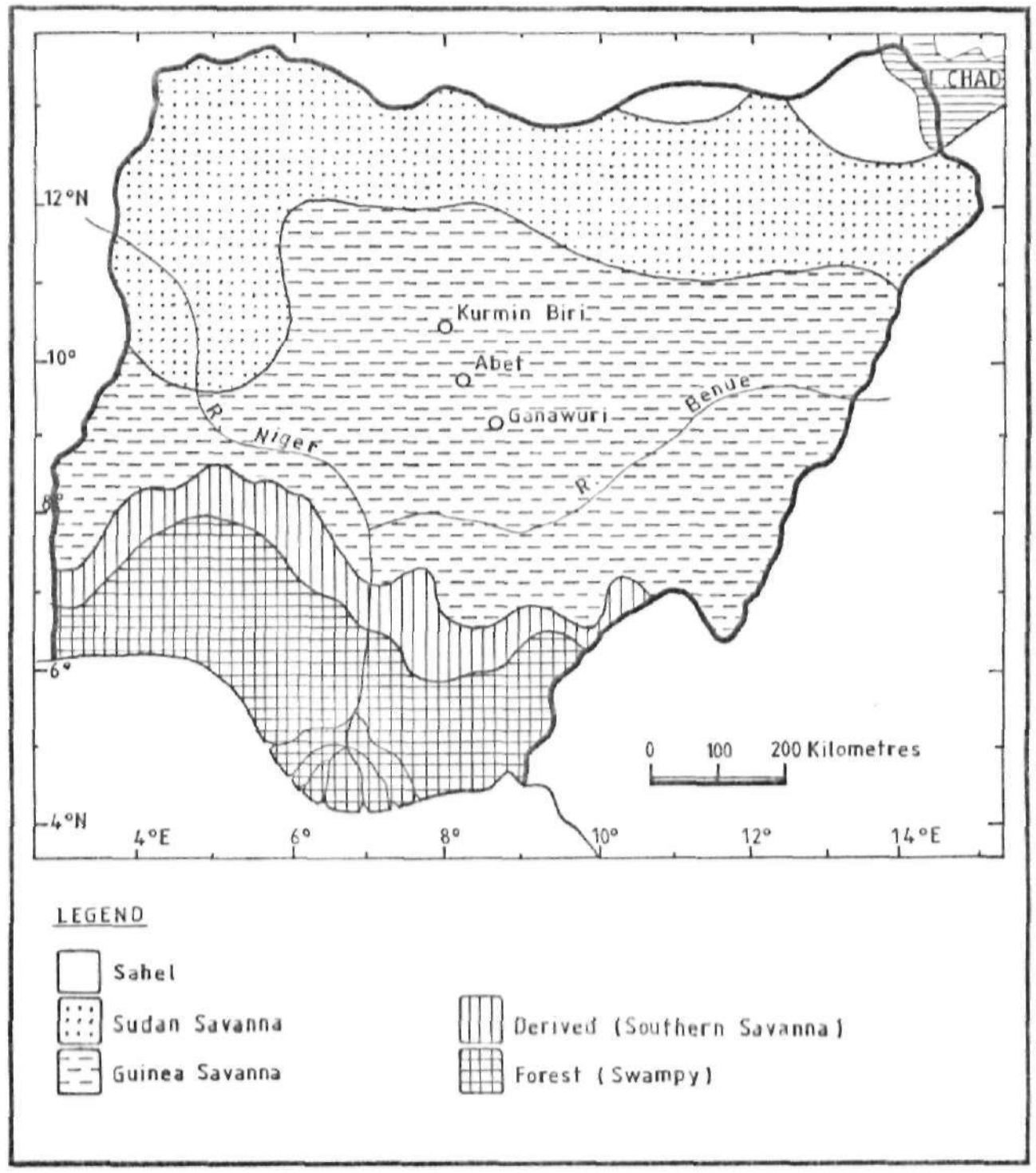


Fig. 1. Map of Nigeria showing different ecological zones and the experimental sites.

Sahel) with the 3-4 month rainfall periods and wide seasonal variations in forage feed availability accounts for majority of the cattle produced in Nigeria (Lamorde, 1985; Bourn et. al., 1984).

The pastoralists in this zone therefore move to the sub-humid zone to exploit dry season pastures (Bournet.al., 1984). The sub-humid zone, it is also recognised, presents the greatest potential for crop and livestock development due to its lower human population density and higher rainfall (Von Kaufmann, 1986; Olufade, 1988).

In realisation of this fact, government intervention was to first of all set aside land exclusively for livestock use prominently in this region (Ingawa et. al., 1988). This intervention was later to be developed into grazing reserves. These grazing reserves were established not only to protect grazing lands from crop farming and provide easier access to them by pastoralist but also to encourage the sedentralisation of nomadic (transhumant) pastoralists, provide them with legally secure titles to grazing and water, and hence promote livestock development in general in the country.

The subhumid zone is characterised by rainfall of 900-1500mm and a growing season of 180-270 days (Jahnke, 1982). The soils of the region are in general alfisols, low in organic matter, nitrogen and phosphorus. They are also prone to compaction and accelerated erosion (Ingawa, et. al. 1988; Adeoye 1989).

The vegetation is typically that of the Southern and Northern Guinea savannas. The herbaceous cover in the range areas consists

mainly of *Laudelia spp, Hyparrhenia spp. Brachiaria spp. Panicum maximum, Andropogon spp. Imperata cylindrica, Digitaria spp, and Pennisetum purpureum* (Olubajo, 1982; Agishi, 1985).

Thus,this region, though presentingthe greatest potential for crop and livestock development much of it was unlikely to be realised especially for livestock as the grazing reserves with their unimproved forage did not eliminate the seasonal fluctuations in feed quality and quantity. In fact, the grazing reserve system was more likely to strain the relationship between the pastorialist and the indigenous population who interpreted the set reserves as an attempt to usurp their lands (Ingawa et. al., 1988). As a result, even the utilisation of farmers' crop residues during the dry season when most settled pastoralist move out of the grazing reserves had to be by special arrangements.

The indigenous population amongst whom the pastoralist live are traditionally subsistence farmers. However,they also keep small ruminants as a secondary enterprise. Their farming systems depend on intermit tent fallow periods to rejuvenate the soil (Mohamed-Saleem and Otsyina, 1986). These fallow areas present sites upon which their very few small ruminants are tethered during rainy seasons to prevent damage to crops (Ikwuegbu and Tarawali, 1991). This husbandry practice lowers the over-all productive performance of the ruminants (Wilson, 1989; Ikwuegbu and Tarawali, 1991).

The seasonality of feed resources even on the grazing reserves coupled with the hostilities from the indigenous

population do not encourage the pastoralist to settle on the reserves. Innovations had therefore to be developed to significantly improve available feed on the reserves during the dry season and/or encourage the integration of crop/livestock farming through the use of appropriate forage production technigues that would be appreciated by both the arable farming communities (as they also keep small ruminant) and the pastoralists. Pastures of desirable yield and quality would require a good supply of nitrogen among other nutrients in the soil. But as the soils of this region are defficient in nitrogen, this has to be provided through fertilizers or legumes or both. However, the present high prices of fertilizers relative to livestock returns, does not justify their large scale use on pastures but justifies the use of good quality legumes (Agishi, 1984). These have the following advantages:

(i) they are not so restricted in growth as grasses by the low status of soil nitrogen because most of their nitrogen comes from the atmosphere.

(ii) their symbiotic Nitrogen so acquired is also released to the soil for the use ofaccompanying grasses (Vallis and Gardner, 1984).

(iii) these legumes also continue growth well into the dry season more than grasses and maintain a crude protein content of greater than 8% for much of the dry season (Agishi, 1984; Tarawali, 1991). Legumes therefore seem to have potentials of bringing about the much sought for co-operation between pastoralist and arable farmers.

Thus, in Nigeria, initial evaluation studies carried

out at the National Animal Production Research Institute (NAPRI, Shika, Zaria) led to the recommendation of *Stylosanthes* species as being among the legumes for pasture improvement (Foster, 1961; Foster and Mundy 1961; Agishi and Asare, 1980).

When the National Livestock projects division in conjunction with some international voluntary organisations began to explore ways of alleviating the dry season nutritional stress problem, the introduction of these *Stylosanthes* species (*S. guianensis* (Aubl.) Sw. cv. Cook and cv. Schofield and *S. hamata* (L) Taub. cv. verano were a major focus (Mohammed-Salem and Otsyina, 1984) and resulted in the development of a low input intervention, "Fodder banks". These have come to mean concentrated established units of *Stylosanthes* (Legume) pastures for supplementation of ruminants during stress periods.

Though the fodder bank concept was primarily a livestock intervention, increased arable crop yields were attained on fodder banks when cropped as compared to lands which were left to natural fallow (Mohammed-Saleem and Otsyina, 1986; Tarawali, 1991). This is because the *Stylosanthes spp* grown on fodder banks fix atmospheric nitrogen and transfer it to the soil (Vallis and Gardener, 1984) and improve soil physical properties.

After having a leguminous stand in a fodder bank for some time the resultant accumulation of nitrogen brings about the invasion of these areas by low quality nitrophilous grasses (Ingawa et. al., 1988) and even termites; both these reduce the quality of these pastures (Tarawali et. al. 1987). Cropping is

therefore considered to be essential management strategy for the fodder bank.

This means therefore that farmers could also exploit this technology for faster fertility rejuvenation of their fallow lands and realise optimal crop yields with minimal input. Also these fallow areas so sown to the legume could present sources of improved pastures for their small ruminants and possibly pastoralist herd both of which will also serve to recycle nutrients (Skerman 1977).

Farmers adopted this technology spontaneously and it has spread rapidly across the sub-humid zone. However, including a cropping phase in this innovation has implications for crop management especially as it pertains to weed control and the dynamics of weeds interrelationship with arable crops. Thus, while the rate of nitrogen economy is well established there is no information regarding a labour-demanding operation such as weeding.

This study therefore seeks to investigate opportunities presented by inherent weed tolerant phases in crop life cycles with a view to ascertaining both traditional methods and suppression times for cropped legume pastures in the sub-humid zone of Nigeria. Any recommendations that may arise from this, it is hoped would lead to a sustainable crop/livestock husbandry in this region as well as having ecological implications of both soil fertility and flora conservation.

CHAPTER TWO

LITERATURE REVIEW

2.1 The dynamics of encouraging plant diversification with regards to crop-weed interactions in an agricultural plant community

A community may be defined as a system of organisms living together and linked together by their effects on one another and their responses to a commonly shared environment (Whittaker, 1970). This definition also applies to the relationship between arable crops and the other plant species which co-exist in the field and interact in a number of ways and to varying degrees. This functional system known as the agricultural ecosystem is of paramount importance to sustainable total productivity. This is so because species diversity, distribution and productivity within a unit area are defined by the complementary relation ships that develop among weeds, crops and the environment they both share.

If weeds are allowed unchecked co-habitation with arable crops, yield losses of economic level could result (Rao et. al. 1989). Zimdahl (1980), in the United States of America identified nearly 600 publications which document crop yield losses due to weed interferences. The common feature of most of these documented studies is their emphasis on economic losses at various weed densities. The limiting factors accounting for these losses were not accorded proper treatment. Since the nature of the interference

between crops and weeds is poorly understood, weed management typically has involved the treatment of symptoms, that is, the actual weed presence rather than a careful consideration of the dynamics of weed/crop communities and a systematic prediction of control based on potential crop impacts.

In trying to consider carefully the dynamics of the relationship of weeds and crops, it is pertinent to know, when and at what density a particular weed adversely affects the yield of a particular crop, how long the effect lasts and if possible whether or not the crop draws from the same niche as the weeds, indicated probably from their germination and growth (Radosevich and Holt 1984). Once these are known, appropriate weed management measures regarding tools and suppression time and level can be suggested and the economic impact predicted with greater certainty.

In attempting to manage weeds, the agro-ecosystem is affected principally in two ways. There is reduced total plant density, also there is reduced and possibly altered plant species composition of the community (Coffman and Frank, 1992). The objective is to ultimately better the relative position of the crop plants among the other plants that make up the agricultural community. In absolute terms of control of weeds this may amount to the degradation of the ecosystem through whole flora removal which has long term consequences, that may include desertification as well as predisposition to hazards such as locust (Ewusie, 1980; Anon. 1992).

2.2 Weed Management: State of the Art

Various methods of weed management are in use to varying levels of efficiencies. Some of these methods could be selective in their weed removal while others are largely non-selective. In whichever way, weed management may not necessarily entail total weed removal from a crop and is not even desirable (Utulu, 1987; Rao et.al., 1989). What the practice should seek to achieve is a shift in weed dominance to one of crop dominance thereby creating different niches for the various components in the ecosystem. The dominating crop will now impose biological limitations on space (resources) and/or conditions (Aken'Ova and Atta-Krah, 1986). This aspect ofweed/crop interaction has been exploited to some extent.

Dawson (1970), working in Canada and Rao et al. (1989) in India, noted that critical phases exist in crop life-cycles when competition with weeds had the greatest effects on yields. Dawson (1970) in his particular case also noted that early weed emergence, especially if their growth rate was rapid, has severe limiting effects on crop performance because it is at this stage that the crop plant is most vulnerable to interferences. If therefore the vulnerability of crops to weed is time specific, it all means that, should weeds be suppressed at these critical periods, one operation is enough to obtain optimal crop yields (Zimdahl, 1980; Singh and Yadav, 1989).

The phenomenon of critical period of crop-weed interference has been proven to be universal and established for various crops. Data available globally show the time period to vary with the

nature of the weed as well as the crop and also the ecological location (Foncho, 1986), and the severity of the interaction with season (Lee and Moody, 1987). For example these workers observed that *Eclipta prostrata* L. had negative influence on rice even to as low as 20 plants per meter square in the dry season, while in the wet season it could be tolerated at even up to 60 plants/m^2. The critical period for the control of *E. prostrata* L. in rice in the dry and wet seasons were 10-45 and 20-45 days after sowing the crop respectively. The critical periods after planting for weed management in some crops have been reported in Nigeria. These are: 8-12 weeks in seed yam production from minisetts (Unamma and Melifon wa, 1988), 8 and 20 weeks after planting in sugar-cane *Saccharum afficinarum* L.) (Fadayomi and Abayomi, 1988), and 4-8 weeks in cassava (Orkwor et al, 1987).

2.3 An Overview of Weed Management in Maize (*Zea mays* L.)

Zea mays, L as an important food and feed crop in many parts of the world, has been considerably researched. Reports abound from various agro-ecological environment on the period of critical weed interference in *Zea mays* L. Kasasain (1971), reported the first month after planting in South Africa as the most weed sensitive period in maize life cycle. Similarly, Gleason (1956) in Cameroun, Knake and Slige (1965) and Li (1960) in the U.S.A., Nieto et al. (1968) in Germany and Okigbo (1966) in Nigeria all agree that weed growth before ten days or after 30-40 days after planting, appeared to have little effects on maize yields. Again in Germany, Majumdar (1968), reported that weed interference with maize growth and

development is most severe between 22 and 27 days after planting. In South Africa, it was reported that the critical stage of weed/maize interference is later than 37 days after planting (Anon., 1960), Staniforth (1957) in North America and Anderson and Jones (1958), in Canada reported 7 - 10 days before tasselling to be crucial for weed interference with maize.

All these accounts from the different agroecological environments around the globe indicate that maize has some measure of weed tolerance. Weed management in maize should therefore not only aim at achieving high grain yields but also at sustainable productivity through the conservation of soil and ground weed cover. This approach is important in the subhumid zone where the soils are prone to accelerated sheet erosion due to bare vegetation cover (Ingawa et. al.,1988; Adeoye and Mohammed-Saleem, 1990). The above defects of the soils are compounded by hard pan at shallow depths, and as such rooting is usually confined to the less dense Ap horizon. These soils are also coarse-textured which makes crops grown on them to experience moisture stress in face of even a short break during rainy periods. At such periods, soil temperatures, may rise to as high as 60°C (Lombin 1987; Adeoye 1990). These factors are known to exert adverse effects on plants by reducing the absorptive capacity of the roots as well as rendering them susceptible to diseases (Tromp, 1978; Kumarasinghe and Nutman, 1979). To alleviate these problems posed by water and temperature stresses, Ghuman and Lal (1983), suggested crop mixtures, especially those that occupy different canopy levels without undue

adverse interactions. Adeoye (1990), working in the Northern Guinea Savanna of Nigeria reported that straw mulching of the soil had the potential of ameliorating extremes of temperatures, combating soil moisture stress, erosion and also soil degradation. Minimum weeding as opposed to clean weeding has been suggested by Burnside and Wicks (1982), for low rainfall tropical conditions, where excessive weeding could lead to soil erosion and inter mittent moisture losses resulting in crop yield losses. Skerman (1977), in Australia, however, suggested the use of legumes as cover crops. These he stressed would not only guard against soil degration but also have the potential to smother other undesirable weeds and actually improve soil fertility and hence improve crop yields.

The importance of forage legumes in soil structural improvement and fertility replenishment is well recognised (Tarawali et. al., 1987), but appropriate management strategies have to be sought before a beneficial incorporation of forage legumes into cropping systems can be done (Mohammed-Saleem et. al., 1986). Such strategies include measures aimed at improving the dominance of the crop plant to the forage legume; the consequences of a suppressed weed (legume) density is that the fewer weed plants may step up their compensatory seed production in order to ensure continuous regeneration in subsequent years (Palmblad,1968; Harper, 1977).

Thus, this concept of critical period will not only enhance an economical weed management but will also enable the conservation of the forage legume, as preliminary work by Tarawali (Unpublished)

has indicated a lowered legume seedling numbers as a consequence of too frequent weeding, upholding observations made in Queensland, Australia which seem to discourage too frequent weeding in cropped annual self-regenerating legume stands for fear of eliminating the legumes (Puckridge and French, 1983). In effect, this concept, also tends to advocate for plant diversification through reduced weeding. This may result to a greater total productivity per unit area.

2.4 Cropping Systems in the Subhumid Agro-ecological Zone of Nigeria

To better appreciate the weed problem and hence management strategies employed in this region, it is necessary to review the present cropping systems within the region along side the socio-economic bracket to which the indigenes belong.

The subhumid zone is made up of the Southern and Northern Guinea Savanna. Rainfall range is 900 - 1500mm/year with 180 - 270 plant growing days. This zone was identified as having the greatest crop and livestock production potentials primarily because of its climatic conditions, large expense of land and low human population (Von Kaufmann 1986; Olufade 1988). Recently the zone has attracted several pastoralists and arable farmers to settle.

The main aim of both the farmers and agropastoralists groups in cropping within this region is to produce enough food to meet household consumption needs. For the agropastoralist, this serves to reduce the need to sell-off some of his animals for purchasing grain. The most important grain crops are sorghum, maize and millet

(Powell 1984). Their cash crops are mainly ginger, groundnuts and soybeans. Intercropping is prominent and it is common to see cereals, pulses and tubers grown together.

With the population rising rapidly and supplies of agricultural inputs limiting, the most common response is to cultivate more land. As the area under cultivation increases, prime grazing areas will diminish forcing ruminant livestock to depend on fodder obtained from cropped lands. This will therefore depend on innovations that seek to encourage the co-existence of cereal crops along side weeds in the field. There is one such fodder conservation innovation (fodder bank) based on the use of forage legumes which is used extensively in this region. This innovation has proven to be particularly useful in ruminant nutrition and is also proven to have soil improvement characteristics (Tarawali et. al., 1987).

Though Powell and Waters-Bayer (1984), working in the subhumid zone of Nigeria, observed that there tended to be an ethnic separation of livestock husbandry and cropping, Von Kaufmann (1986) stated that the two could complement each other. The target of research is therefore to explore methods of integrating crop and livestock husbandry in this region. At present, homesteads cultivate only small areas that range from 1.5 to 3.5 hectares. The fallow plots are seeded to *Stylosanthes* and used as improved fodder for ruminants. In cropping these hitherto legume fallow areas, minimum weeding of the regenerating *Stylosanthes* is desirable in order to achieve a sustainable production of both

livestock and crops.

2.5 Weed Management in the Subhumid Agro-ecological Zone of Nigeria

In the light of our knowledge of farming situations in the subhumid zone, it is not difficult to envision the kind of weed management options that would be adopted in the subsistence system that prevails in this region. In Nigeria generally, weed management has primarily centred on treatment of symptoms (actual weed presence) and little attention has been given to weed/crop community dynamics. This is implied in the statement of Kodilinye (1974), in his inaugural speech at the 4th Nigerian Weed Science Group Meeting, that the use of cultural methods of weed management as opposed to chemical control is inadequate to achieve effective control of weeds and thus blamed this for poor agricultural output. Thus attention is on cultural and chemical weed control and experiments on weed control in Nigeria involve mostly chemicals. The effect of the contention nevertheless has seen attempts made at weed control in Nigeria dominated by experimental trials that involve the use of chemicals. While Ogungbile and Lagoke (1986) in Samaru Zaria may have clearly demonstrated that labour requirement for weed management is reduced drastically by use of chemicals, Adejonwo (1988), in a review, warned that their use may be restricted due to lack of weather predictivity, inadequate literacy level and apparatuses. Other risk were associated with harm to man, livestock and the environment. The latter contention has also been recognised by Emeka (1991), and

Adamu (1992). In a system therefore that seeks to bring together livestock and crop husbandry, the use of chemicals as weed control agents may be inappropriate.

Nevertheless, studies carried out in the subhumid Nigeria that illustrate the importance of time specific/cultural weed control abound. For example Obilana (1982), stated that *Striga* presented a special weed problem in this zone and on a small scale suggested cultural weed management as appropriate to its control. Some of the trials of chemical weed management tend to even accentuate the concept nursed by a cultural approach which seeks to encourage biodiversity of species. Thus, Lagoke et. al., (1988), in Northern Guinea Savanna zone while experimenting with chemical weed control on transplanted pepper (*Capsicum frutesens* L.), noted that weed infestation in the crop at three weeks after transplanting had deleterious consequences. Otherwise the crop was fairly tolerant to weed. Otukelu et. al., (1991) working on groundnuts (*Arachis hypogaea* L.) in Northern Guinea Savanna also concluded that 21 to 42 days after planting were critical for weed control. On grain, example pearl millet, Lagoke et. al. (1991), in Samaru-Zaria, concluded three and six weeks after sowing were the required weed periods. In another study on cultural weed management in the subhumid zone, Ifenkwe et. al., (1992) in Jos showed that 4 weeks after planting was most critical for weed management in *Solanum tuberosum* (L.). All these instances clearly indicate that crops generally exhibit weed tolerant and weed sensitive phases. Consequently, adequate knowledge of such factors is required for a

scientific approach to successful weed management.

2.6 The need for Cultural Weed Management in attempts at integrating Crop/Livestock husbandry with Sustainability Considerations in the Subhumid Zone

In view of the literacy level of the predominant farming community of the subhumid zone, their socio-economic background and the size of unit farms per homestead, it becomes hardly justifiable to recommend herbicide usage even when one disregards their effects on the environment. If labour cost is the only deficiency of cultural weed control, this may be reduced by restricting weeding to only the critical phase of a crops life cycle. More importantly also is the desire to integrate crop and livestock husbandry in such a way as to encourage sustainable production.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of Sites

The experiments were conducted on three or four year-old *Stylosanthes* pastures located in Abet, Kurmin Biri and Mazuga in Kaduna State and Ganawuri in Plateau State.

3.1.1 Abet

The area under Abet is located between latitude 9°14'N. and longitude 8° 10'E. The site is 14 kilometres South of Zonkwa. Small ruminant husbandry is practised by the indigenes who are primarily arable farmers. Pastoralists are also settled among the native community. Both these groups have adopted the legume fodder bank technology and modified it to suit their particular needs and income.

The experiment here was laid out on a researcher-owned and researcher managed pasture (Farm II). The legume was pasture established in 1987 and seeded to *Stylosanthes guianensis* cv. Cook.

3.1.2 Kurmin Biri

The Kachia grazing reserve in which the experiment was laid out is located between latitude 10°10'N and longitude 7°55'E. The legume pastures of *Stylosanthes hamata* (L) Taub. were established in 1988 mainly for dry season supplementation of cattle and were resercher-owned and managed.

3.1.3 Mazuga

Mazuga is about 21 kilometres east of Kurmin Biri and is settled by pastoralists. The legume pasture was a farmer-owned,

resercher-managed pasture. The pasture was established in 1988 and seeded to *Stylosanthes hamata* cv. verano. By 1991, some stands of *S. guianensis* cv. Cook were observed in the field.

3.1.4 Ganawuri

The settlement is located between latitude 8°35'N and longitude 9°6'E. Small ruminant husbandry is practised by the indigenes. Unlike Abet, there are hardly any settled pastoralists here. The fodder banks which were established in 1988 were therefore primarily for wet season goat supplementation. Here also the experiment was conducted on a farmer-owned, researcher-managed *Stylosanthes guianensis* cv. Cook pasture.

3.2 Experimental Design

3.2.1 Treatments

The design was a randomised complete block with nine treatments and four replications. Each treatment consisted of four ridges of one meter wide by five meters long with a distance of 30 centimetres between ridges. The distance between adjacent treatments was 50 centimetres wide. The treatment plots in a block were arranged in three rows and three columns. The gross block size was therefore 267.2 square meters with a net of 180 square meters. The gross treatment plot size was 24.5 square meters with a net size of 20 square meters.

The nine treatments are:-

1. No weeding (control)
2. Weeding once in the first 30 days after planting maize with a hand hoe (1 x H/H < 30 DAP).

3. Weeding once in the second 30 days after planting with a hand hoe (1 x H/H > 30 DAP)
4. Weeding twice at three weekly intervals with a hand hoe (2 x H/H/).
5. Weeding twice selectively with a hand hoe, once in the first 30 days and again in the second 30 days after maize planting with *Stylosanthes sp.* Seedlings left as live mulch at both operations (2 x H/H L. S).
6. Weeding twice with a hand hoe, once in the first 30 days after planting non-selectively and again in the second thirty days selectively, leaving out *Stylosanthes sp.* at this time (2 x H/H L. S. at 2nd).
7. Weeding once with a ridging hoe (big hoe, Galma in hausa) in the first 30 days after planting (1 x B/H < 30 DAP).
8. Weeding once with a ridging hoe in the second 30 days after planting (1 x B/H > 30 DAP).
9. Weeding twice, once within the first 30 days and again in the second thirty days after planting, with the big hoe (2 x B/H).

3.2.2 Land Preparation

The experiments were laid out on 3 or 4 year old legume pastures in each of the four locations described in (3.1.1) above. Plots were earmarked in each of the pastures also as stated in (3.2) above. In July a floristic survey was taken with a $0.25m^2$ quadrat, four sites per plot prior to ridging. This survey was necessary as successional pattern in floral composition

as well as change in predominant flora within the pastures (as a consequence of the cropping) was envisaged. Harvesting was also done for dry matter determination.

3.2.3 Seed Obtained

Zea mays L. Seeds (TZSR) were obtained from the co-operative unit of the Kaduna State Agricultural supply company at Kachia. The seeds were pretreated with mercuric chloride to deter birds from harvesting the seedlings at germination.

3.2.4 Agronomic Practices

Ridging was manually done with hired labour. Urea, single superphosphate and muriate of potash were applied at the rate equivalent to 60kg/ha N,60kg/ha P, and 60kg/ha K at planting. This was followed by an application of Urea at a rate equivalent to 60kg N/ha six weeks later.

Three maize seeds were planted in 2.5cm deep holes spaced 25cm along the ridge. The seeds were lightly covered. The emerged seedlings were thinned to one per stand. The hand hoe which is referred to as 'fartanya' in Hausa, used in this experiment for weeding was operated in a manner similar to the traditional practice. That is scraping on the soil surface just deep enough to sometimes cut the stem of the weeds. Because of its small size, it proved useful in weeding between plants.

The big hoe (or Galma in Hausa) was also used in like manner as is traditionally done. The first weeding with this was achieved by breaking the sides of the moulded ridges thereby burying the weeds in the furrows. If the same plot were to be

reweeded as is the case in weeding in the first and second thirty days, the ridges are remoulded in the second weeding operation. This second weeding in all cases was done during the second split nitrogen application.

30 days after each weeding operation, a floristic survey of all treatment plots was carried out as described earlier. At each survey, the species enumerated were classified into either the sown legume, grasses or forbs.

3.2.5 Crop harvest and dry matter determination

The maize crop was harvested in November 1991. In the process, the following measurements were taken.

(i) The number of stands per individual ridge were counted before cutting

(ii) The number of cobs per individual ridge were also counted before cutting.

(iii) The weight of dehusked cobs per individual ridge was determined after cutting

(iv) Weight of stalk per individual ridge was determined after cutting.

(v) Grain weight per individual ridge was also determined after threshing of cobs.

Whole plots were cut and potential grain yield for a hectare was estimated by multiplying (i) by (ii) by (v) by a correction factor in the computer package (M. Stat) used for the analysis.

Immediately after the crop harvest a floristic survey was again made of the herbaceous weed components which were afterwards

harvested for dry matter determination.

3.2.6 Floristic Survey and herbaceous biomass in the Second year after Sowing of Maize

After the grain harvest floristic survey and herbaceous bomass determination of November 1991, the plots in the researcher owned fodder banks at Abet with *Stylosanthes guianensis* cv. Cook and Kurmin Biri with *S. hamata* cv. Verano were left undisturbed during the growing season of 1992. The aim was to observe for succession among the herbaceous community. Twelve months after grain harvest, a dominant community of herbaceous plants was assumed to have ensued and therefore a floristic survey of the treatment plots was done as described earlier. Dry matter yields of the sown legume (*Stylosanthes*), grasses and forbs were also determined during the November, 1992 sampling.

3.2.7 Statistical Analysis

Difference amongst treatment means for maize grain yield, fodder productivity and population of herbs in the three groups viz - forbs, grass and sown legumes were tested statistically by the analysis of variance. Computing the analysis for grain yield and fodder productivity was done using ANOVA-2 package. The threshold among the means were tested using the least significant difference (*LSD*).

The t-test was also used to determine whether the differences in mean yield of *Stylosanthes* dry matter within the cropping year and between the two years were statistically significant.

CHAPTER FOUR

RESULTS

4.1 Precropping Floristic Survey (Plants/m^2)

Prior to cropping at Abet, the herbaceous flora in the *Stylosanthes* pastures was dominated by *Brachiaria stigmatisata* with a mean of 25 plants/m^2, *Chrysanthellum americanum* 23, *Digitaria ciliaris* 12 and *Stylosanthes guianensis* cv. Cook 8 plants/m^2 (Table 1a). At Kurmin Biri, *B. stigmatisata* had a mean of 88 plants, *S. hamata* cv. verano 32, *Spigelia anthelmia* 30 and *Borreria verticellata* 15 plants/m^2 (Table 1b). At Mazuga, *Ageratum conyzoides* was most dominant with a count of about 95 plants/m^2 followed by *B. stigmatisata* 61, *Sida rhombifolia* 31 and *Stylosanthes hamata* cv. Verano 26 plants/m^2 (Table 1c). At Ganawuri, sedges were most dominant with a mean count of 27 plants/m^2 followed by *Eleusine indica* 19, *B. stigmatisata* 14 and *S guiaensis* cv. Cook 13 plants/m^2 (Table 1d).

Table 1 also records other species present that did not merit individual recognition. These are grouped into two artificial classes namely, other grasses, including sedges and 'other forbs'. Analysis of variance for the population of the various herbaceous groups given in appendix 1 shows that there is no significant difference between means of *Stylosanthes spp.* count among different treatment plots and blocks before cropping in all sites. (Appendix 1.1ai, 1.1bi, 1.1ci and 1.1di). However, the difference between means of grass population (Appendices 1.2.aii, 1.2.bii,

Table 1a Result of precropping survey of dominant plant species in different treatment plots at **Abet** in July, 1991 (Plant / m²)

	TREATMENTS										
Species	1	2	3	4	5	6	7	8	9	x	%total
Sylosanthes guianensis cv. cook	17.0	7.3	16.3	6.8	6.8	6.3	7.8	5.8	4.5	8.3	4.5
Brachiaria nigropedata	13.0	14.5	13.3	37.3	25.0	27.7	33.5	26.3	37.7	24.6	13.7
Stenotaphrum secundatum	3.0	-	29.0	5.5	3.0	16.5	70.0	53.0	24.3	22.9	12.7
Digitaria milanjiana	12.3	12.0	6.0	7.5	5.3	5.5	10.0	9.3	14.5	11.5	6.4
Other grasses	54.8 (5)	30.0 (7)	21.5 (6)	46.5 (6)	31.0 (6)	22.7 (9)	23.5 (7)	40.0 (8)	22.7 (9)	31.5	17.5
Other forbs	55.8 (12)	57.8 (15)	73.3 (11)	90.8 (14)	103.3 (15)	53.3 (12)	79.8 (8)	59.8 (11)	44.5 (12)	81.3	45.2
TOTAL	181.3	138.4	159.6	194.4	164.9	131.4	224.6	194.2	193.4	174.7	

* Actual number of species contributing the plant density immediately above

Table 1b Precropping survey of dominant and other herbaceous species in the treatment plots at **Kurmin Biri** in July, 1991 (Plant / m²)

Species	TREATMENTS										
	1	2	3	4	5	6	7	8	9	x	%total
Stylosanthes humata cv verano	33.5	34.5	26.0	17.8	49.3	55.0	16.8	20.5	11.0	31.6	14.1
Brachiaria stigmatisata	38.5	129.5	105.5	40.3	68.5	106.0	145.5	85.5	76.5	88.4	39.4
Spigelia anthelmia	10.5	46.5	26.3	14.0	34.5	27.0	54.8	33.5	22.0	29.9	13.3
Borreria verticillata	6.0	22.2	17.3	11.8	14.8	18.5	14.7	8.7	18.0	14.7	6.6
Other grasses	11.5 *(4)	35.5 (8)	16.8 (4)	11.8 (3)	19.8 (4)	20.8 (6)	28.3 (7)	21.3 (5)	19.5 (4)	20.6	9.2
Other forbs	11.5 *(7)	43.8 (6)	23.8 (6)	38.3 (8)	32.5 (7)	36.0 (8)	37.0 (7)	106.3 (10)	23.5 (6)	39.2	17.5
TOTAL	131.5	312.0	215.7	134.4	219.4	263.3	297.1	275.8	170.5	224.3	

* Actual number of species contributing the plant density immediately above

Table 1c Precropping survey of dominant and other, herbaceous species in the treatment plots at **Mazuga** in July, 1991 (Plant / m²)

Species	TREATMENTS										
	1	2	3	4	5	6	7	8	9	x	%total
Stylosanthes humilis cv Verano	11.5	17.0	24.8	19.5	31.6	45.5	22.3	29.8	31.5	25.9	6.3
Brachiaria stigmatisata	88.0	40.5	69.0	99.5	49.5	58.8	26.5	40.8	71.5	60.5	14.8
Ageratum conyzoides	18.0	231.0	35.3	73.5	78.0	60.8	261.6	91.0	24.8	94.9	23.2
Sida rhombifolia	15.2	33.5	34.0	19.3	12.5	39.5	36.7	69.0	16.5	30.6	7.5
Other grasses	72.8 *[9]	71.8 (9)	116.5 (9)	98.0 (8)	77.8 (8)	98.8 (8)	89.8 (7)	109.5 (8)	67.0 (7)	89.0	21.8
Other forbs	136.8 *[13]	74.8 (18)	133.5 (17)	116.0 (12)	130.8 (17)	91.3 (13)	85.3 (13)	93.8 (13)	107.2 (12)	107.9	26.4
TOTAL	342.3	448.6	413.1	425.8	580.2	394.7	521.4	435.9	318.5	408.9	

* Actual number of species contributing the plant density immediately above

Table 1d Precropping survey of dominant and other herbaceous species in the treatment plots at **Ganawuri** in July, 1991 (Plant / m²)

Species	TREATMENTS 1	2	3	4	5	6	7	8	9	x	%total
Siplosanthes guianensis CV 1008	15.5	17.5	12.0	15.0	18.6	10.0	12.5	16.8	8.5	13.4	7.7
Sedges	23.8	38.0	28.8	29.5	31.8	22.8	26.3	23.0	19.0	27.0	15.4
Eleusine indica	15.8	38.0	20.5	13.3	14.5	13.8	20.5	20.3	14.5	19.0	10.9
Brachiaria stigmatisata	14.3	16.0	14.3	12.8	11.5	14.8	13.5	15.5	11.5	13.8	7.9
Other grasses	49.5 *(5)	45.5 (5)	23.5 (7)	43.5 (4)	47.5 (6)	29.0 (4)	29.3 (5)	41.3 (5)	45.3 (6)	39.2	22.4
Other forbs	52.0 *(13)	67.0 (17)	54.5 (12)	49.5 (17)	50.8 (12)	70.3 (12)	81.0 (15)	56.0 (17)	82.5 (15)	62.6	35.8
TOTAL	170.9	216.0	153.6	163.6	174.9	160.9	183.1	172.9	179.3	175.0	

* Actual number of species contributing the plant density immediately above

1.2cii and 1.2.dii), and between means of forbs (Appendices 1.3.aiii, 1.3.biii, 1.3.ciii and 1.3.diii) were statistically significant at $P<0.05$ at all the sites except Mazuga.

4.2 Pre-cropping herbaceous biomass July 1991

4.2.1 Abet Site

Prior to cropping, the herbage dry matter yield in the experimental site at Abet had a mean of 1324.2kg/ha. Among the treatment plots, dry matter yield ranged from 1022.0kg/ha for the 'no weeding' to 1771.0kg/ha for the once weeding with the big hoe within the first 30 days after planting (Treatment 7). When the herbage dry matter yield is partitioned into stylo, grass and forbs, their corresponding percentage contributions are 20.2, 40.5 and 39.4 (Table 2a).

4.2.2 Kurmi Biri Site

At Kurmi Biri, the herbage dry matter had a mean of 2088.0kg/ha. Among the treatment plots, that designated for two times selective weeding, sparing *Stylosanthes sp.* each time had the lowest herbage yield of about 1619.7kg/ha. The highest herbage dry matter yield of 2368.3kg/ha was attained on the plot to be given two times clean weeding with the hand hoe. When the overall herbage dry matter yield is proportioned into its components, the legume accounted for 14.3% of the mean total, grass 58.0% and forbs 28.0% (Table 2b).

4.2.3 Mazuga Site

At Mazuga, total herbage dry matter yield prior to cropping had a mean of 990.7kg/ha. Among treatment plots, the least yield of

Table 2a: Precropping herbage yield in the treatment plots at Abet (D.M kg/ha) 1991

Treatment	cook stylo	Grass	Forbs	Total	% cook stylo	% grass	% Forbs
1	228.0	424.0	370.0	1022.0	22.3	41.5	36.2
2	365.1	641.6	481.5	1488.2	24.5	43.1	32.4
3	214.4	394.9	769.0	1373.0	15.6	28.8	56.0
4	347.7	673.8	384.1	1405.6	24.7	47.9	27.3
5	477.0	312.0	574.5	1363.5	35.0	22.9	42.1
6	203.1	396.5	413.0	1012.6	20.1	39.2	40.8
7	149.9	791.0	830.1	1771.0	8.5	44.7	46.9
8	270.8	703.1	406.8	1380.7	19.6	50.9	29.5
9	124.6	496.4	480.0	1101.0	11.3	45.1	43.6
Mean	264.5	537.0	523.2	1324.2	20.2	40.5	39.4

TREATMENTS

1. No weeding
2. 1 x H/H < 30 DAP
3. 1 x H/H > 30 DAP
4. 2 x H/H
5. 2 x H/H LS
6. 2 x H/H LS at 2nd
7. 1 x B/H < 30 DAP
8. 1 x B/H > 30 DAP
9. 2 x B/H

Table 2b: Precropping herbage yield in the treatment plots at Kurmin Biri (D.M. kg/ha) 1991

Treatment	verano stylo	Grass	Forbs	Total	% verano stylo	% grass	% Forb
1	316.4	1193.1	249.1	1758.6	18.0	67.8	14.2
2	310.8	1223.9	591.3	2126.3	15.0	57.6	27.8
3	255.1	1296.0	640.2	2191.3	11.6	59.1	29.2
4	252.8	1506.0	609.5	2368.3	10.7	63.6	25.7
5	258.4	972.5	388.8	1619.7	16.0	60.0	24.0
6	466.3	979.4	552.6	1998.3	23.3	49.0	27.7
7	394.4	1097.3	683.0	2174.7	18.1	50.5	31.4
8	253.9	1257.9	850.1	2351.9	11.0	53.5	36.6
9	97.8	1333.2	771.9	2202.9	4.4	60.5	35.0
Mean	289.5	1201.6	594.1	2088.0	14.2	58.0	28.0

764.4kg/ha was attained on the 'no weeding' treatment. The plot designated for 'twice weeding with the big hoe' had the highest dry matter yield of about 1400.5kg/ha. The percentage composition of the components of the total dry matter was about 4.1 for stylo, 60.9 for grass and 35.0 for forbs (Table 2c).

4.2.4 Ganawuri Site

At Ganawuri, the herbage dry matter yield prior to cropping had a mean of 855.4kg/ha. Among treatments, the lowest yield of 671.3kg/ha was recorded on plots designated for 'twice clean weeding with the big hoe', while that designated for 'hand hoeing once cleanly within the first 30 days of planting and then again in the second 30 days selectively sparing *Stylosanthes sp.* seedlings', had the highest yield of 1253.4kg/ha. The percentage components of the total dry matter yield were 13.5 for stylo, 40.7 for grass and 44.1 for forbs (Table 2d).

4.3 Pre-harvest Floristic Survey August and September 1991

4.3.1 Abet Site

The results of pre-harvest floristic survey for Abet are presented in table 3a. These show that after the first weeding, treatments with low Cook stylo density of five plants/m^2 were those weeded only once in the second 30 days after planting with the big hoe, and twice cleanly, once in the first 30 days after planting and again in the second 30 days after planting. Statistically however, the variations among the mean counts of legume between treatments were not significant at $P<0.05$ (Appendix 2.1.1ai).

Table 2c: Precropping herbage yield in the treatment plots at Mazuga (D.M. kg/ha) 1991

Treatment	verano stylo	Grass	Forbs	Total	% verano stylo	% grass	% Forbs
1	59.3	508.6	196.8	764.7	7.8	66.6	25.7
2	81.5	405.2	523.7	1010.4	8.1	40.1	51.8
3	28.8	611.4	254.6	894.8	3.2	68.3	28.5
4	1.5	571.8	272.1	845.4	0.2	67.6	32.2
5	22.5	611.8	294.1	928.4	2.4	65.9	31.7
6	52.5	586.5	712.8	1351.8	3.8	43.4	52.7
7	18.5	453.4	321.0	792.0	2.3	57.3	40.5
8	43.1	598.1	287.2	928.4	4.6	64.4	30.9
9	60.0	1044.4	296.3	1400.5	4.3	74.6	21.2
Mean	40.9	599.0	351.0	990.7	4.1	60.9	35.0

TREATMENTS

1. No weeding
2. 1 x H/H < 30 DAP
3. 1 x H/H > 30 DAP
4. 2 x H/H
5. 2 x H/H LS
6. 2 x H/H LS at 2nd
7. 1 x B/H < 30 DAP
8. 1 x B/H > 30 DAP
9. 2 x B/H

Table 2d: Precropping herbage yield in the treatment plots at Ganawuri (D.M kg/ha) 1991

Treatment	cook stylo	Grass	Forbs	Total	% cook stylo	% grass	% Forbs
1	82.9	330.8	344.6	758.3	10.9	43.6	45.4
2	85.7	280.7	401.7	768.1	11.2	36.5	36.6
3	65.0	342.0	344.7	751.7	8.7	45.5	45.9
4	104.5	308.2	385.4	798.1	13.1	38.6	48.3
5	291.1	306.9	447.8	1045.8	28.0	29.4	42.8
6	222.9	502.9	527.4	1253.2	17.8	40.1	42.1
7	137.4	369.6	293.3	800.3	17.2	46.2	36.7
8	12.5	392.2	447.1	851.8	1.5	46.0	52.5
9	89.3	269.1	312.9	671.3	13.3	40.1	46.6
Mean	121.3	344.7	389.4	855.4	13.5	40.7	44.1

Table 3a: Summary of mean herbaceous flora counts at Abet (plant/m) 1991

	Stylosanthes guianensis		Grass		Forbs	
Treatment	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding	30 days after first weeding	30days after second weeding
1	6.0	3.5	58.8	94.3 a	34.8	22.8a
2	5.8	10.8	71.8	52.3 b	48.0	29.5bc
3	8.5	4.8	91.3	44.5bc	60.0	27.5bc
4	5.0	3.8	93.5	35.0bc	36.3	44.5ab
5	5.8	16.3	124.5	30.5 c	48.0	54.3a
6	29.0	9.3	64.0	29.5 c	45.3	39.5b
7	8.5	24.3	83.8	22.8 c	35.0	30.3bc
8	4.5	7.5	72.5	22.0 c	30.5	50.5ab
9	8.8	11.0	89.3	20.5 c	29.8	53.3a
Mean	9.1	20.9	82.3	39.0	40.9	39.1
L.S.D (0.05)				17.48		12.49

After the second weeding, the 'no weeding' treatment and two times cleanly hand hoed treatment had the lowest Cook count of four plants/m^2 (Appendix 2.2.1ai and table 3a). Generally, the mean legume count improved from 9 to 21 plants/m^2 after the second weeding. Grass population of 125 plants/m^2 after the first weeding was highest in the two times selective weeding and least, (59 plants/m^2) in the 'no weeding' treatment. (Appendix 2.1.2aii and table 3a). However, after the second weeding, grass count was lowest in the plots weeded at two separate occasions with the big hoe (21 plants/m^2) and highest with the 'no-weeding' treatment (94 plants/m^2). This difference was significant at $P<0.05$ (Appendix 2.2.2aii).

After the first weeding, the least population of forbs was obtained on the plots designated for 'two separate weedings with the big hoe' (30 plants/m^2), while the highest count was from the plots 'for once weeding with the hand hoe within the second 30 days of planting' (60 plants/m^2) (Appendix 2.1.3aiii). However, after the second weeding the density was least on the unweeded plot and highest on the plots hand hoed on two separate occasions sparing Cook each time at 23 plants/m^2 and 54 plants/m^2 respectively (Appendix 2.2.3aiii and table 3a).

4.3.2 Kurmin Biri Site

At Kurmin Biri, results of pre-harvest floristic survey as presented in table 3b show that, after the first weeding the highest legume count of 17 plants/m^2 was recorded on plots to be left unweeded (Appendix 2.1.1bi). After the second weeding, the

Table 3b: Summary of mean herbaceous flora counts at Kurmin Biri 1991

	Stylosanthes guianensis cv verano		Grass		Forbs	
Treatment	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding
1	17.0	30.3	61.5	80.8	95.0	149.5
2	9.5	11.3	56.0	86.5	112.0	174.0
3	4.0	10.0	29.8	35.0	134.0	243.0
4	7.3	6.0	28.5	46.5	99.3	154.8
5	13.3	19.8	16.0	44.0	126.3	258.0
6	6.8	8.5	28.0	49.8	128.0	122.8
7	7.0	8.5	42.0	65.8	122.0	334.5
8	8.3	13.0	25.8	63.3	164.0	442.5
9	5.3	8.5	36.3	60.0	90.8	193.0
Mean	8.7	2.9	36.0	59.1	119.0	230.2
L.S.D. (0.05						

verano count increased to 30 plants/m^2. Legume populations were depressed in all weeded treatments (Appendix 2.2.1bi and table 3b). Either, after the first or second weeding grass populations followed a similar trend as that of the legumes being highest in the 'no-weeding' treatment plots. Also all weeding treatments had significantly reduced grass populations (Appendix 2.1.1bii and 2.2.2bii and table 3b).

The density of forbs after the first weeding was least on the plots to be weeded with the big hoe on two successive occasions (91 plants/m^2) and highest on the plots to be weeded only once with the big hoe in the second 30 days after planting (164 plants/m^2) (Appendix 2.1.3biii). After the second weeding, forbs population was least on the plots weeded twice with the hand hoe, once non-selectively in the first 30 days and then selectively in the second 30 days sparing the sown legume in this instance (123 plants/m^2). The highest forbs count was attained on plots weeded with the big hoe only once in the first 30 days after planting, 335 plants/m^2 (Appendix 2.2.3biii). On the whole, forbs population increased from 119 plants/m^2 after the first weeding to 230 plants/m^2 after the second weeding (Table 3b).

4.3.3 Mazuga Site

At Mazuga, after the first weeding, the lowest Verano count was recorded on the plots to be weeded twice with the hand hoe, once non-selectively within the first 30 days of planting and again within the second thirty days this time sparing Verano (3 plants/m^2). The highest legume count of 11 plants/m^2 was attained on

the plots to be weeded on two successive instance with the big hoe (Appendix 2.1.1ci and table 3c). After the second weeding the least legume counts were obtained on the plots weeded with the hand hoe only once within the second 30 days after planting and those weeded with the big hoe once also but in the first 30 days after planting (2 plants/m^2 each). The highest legume count of 7 plants/m^2 was attained on the unweeded treatment (Appendix 2.2.1ci). Verano population in this instance declined with the second weeding at 4 plants/m^2 compared with 6 plants/m^2.

Grass population in the treatment weeded with the hand hoe on two successive instances sparing Verano each time was 125 plants/m^2 compared with 265 plants/m^2 in the unweeded treatment after the first weeding (Appendix 2.1.1ciii). After the second weeding, the treatment weeded at two successive instance with the big hoe had the least grass density of 56 plants/m^2 while the highest density of 200 plants/m^2 was attained on the unweeded treatment (Appendix 2.2.2ciii). On the whole, the population of grass reduced after the second weeding at 113 plants/m^2 compared with 168 plants/m^2.

After the first weeding, the treatment weeded with the big hoe on two successive instances had the least population of forbs numbering 113 plants/m^2. The highest forbs density was recorded on the treatment weeded with the big hoe once in the second 30 days after planting numbering 196 plants/m^2 (Appendix 2.1.3ciii). Forbs count after the second weeding showed the density to be low on the plots weeded with the big hoe only once in the second thirty days after planting (131 plants/m^2). The highest density of 186 plants/m^2

Table 3c: Summary of mean herbaceous flora counts at Mazuga (plants/$m^2$2) 1991

	Stylosanthes guianensis cv verano		Grass		Forbs	
Treatment	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding
1	4.8	6.8ab	265.3	200.0 a	125.8	145.8
2	4.8	2.5 b	163.5	163.5 a	151.0	145.8
3	4.8	2.0 b	208.8	92.5bc	182.8	152.0
4	7.5	3.5 b	129.5	77.5bc	149.0	157.8
5	9.0	7.8 a	124.5	60.0 c	148.0	185.5
6	2.5	2.8 b	153.3	106.8 b	126.5	182.3
7	3.3	2.0 b	129.3	178.3 a	118.5	167.0
8	4.8	3.5 b	182.5	78.8bc	196.0	131.0
9	10.5	4.3ab	151.5	56.3 c	112.5	161.8
Mean	5.8	3.9	167.6	112.6	145.6	158.8
L.S.D (0.05)		4.27		40.74		

was obtained on the treatment hand hoed twice successively, sparing verano each time (Appendix 2.3.3ciii). Forbs population increased after the first weeding from 146 plants/m^2 to 159 plants/m^2 at second weeding (Table 3c).

4.3.4 Ganawuri Site

At Ganawuri, pre-harvest floristic survey data presented in table 3d show that after the first weeding Cook had the least density (2 plant/m^2) on the treatment hand hoed only once within the second 30 days of planting and the highest count of 6 plants/m^2 in the treatment given two successive selective hand hoeing, sparing the legume at each time (Appendix 2.1.1di and table 3d). After the second 30 days' weeding, Cook density was least on the treatment weeded once with the big hoe in the second 30 days after planting (1 plant/m^2). The legumes density also declined after the second weeding to 3 plants/m^2 compared with 4 plants/m^2 (Appendix 2.2.1di).

Grass population after the first weeding was lowest on the treatment weeded with the big hoe on two successive times (107 plants/m^2). The highest density of 205 plants/m^2 was attained on the treatment to be left unweeded (Appendix 2.1.2dii). Twice successive weeding with the big hoe and weeding with the hand hoe, once non-selectively in the first 30 days and again in the second thirty days after sowing produced 71 plants/m^2 which was the lowest density after the second weeding. The unweeded treatment recorded the highest grass density of 226 plants/m^2 (Appendix 2.2.2dii). On the whole grass density declined after the second weeding at 104

Table 3d: Summary of mean herbaceous flora counts at Ganawuri (plants/$m^2$2) 1991

	Stylosanthes guianensis cv cook		Grass		Forbs	
Treatment	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding	30 days after first weeding	30 days after second weeding
1	3.8	3.0ab	205.0 a	226.0 a	85.0	65.8 c
2	4.3	3.8ab	122.5 b	130.5 b	78.5	81.3ba
3	2.3	4.0ab	151.3ab	85.0 b	98.0	111.3ab
4	5.8	4.3ab	107.8 b	78.5 b	120.5	129.3 a
5	5.5	5.5 a	116.0 b	78.0 b	106.8	119.3ab
6	5.3	3.8ab	114.0 b	71.0 b	95.8	99.3ab
7	3.8	2.0 b	150.8ab	98.0 b	76.3	83.0ba
8	5.0	1.3 b	132.3 b	96.0 b	70.8	87.0bc
9	3.8	1.5 b	106.8 b	71.0 b	91.8	97.5
Mean	4.4	3.24	134.1	103.8	91.5	97.1
L.S.D (0.05)		3.38	61.0	69.43		30.94

plants/m^2 compared with 134 plants/m^2 before the second weeding.

The population of forbs after the first weeding was least in the treatment to be weeded with the big hoe only once in the second thirty days of planting (71 plants/m^2). The highest count of about 121 plants/m^2 was attained in the treatment to be weeded cleanly with the hand hoe at two successive times (Appendix 2.1.3diii). After the second weeding, the least forbs count was recorded in the unweeded treatment (66 plants/m^2). The highest count of 129 plants/m^2 was attained on the treatment hand-hoed cleanly on two successive times. Forbs population increased after the first weeding at 92 plants/m^2 to 97 plants/m^2 at the second weeding (Appendix 2.2.3diii).

4.4 Grain Yield

Maize grain yield for all four experimental sites is given in Table 4 and figure 2. The analysis of variance for this is presented in appendix 3.

4.4.1 The Abet Site

At Abet, the no weeding treatment yield 44% lower yield than the twice consecutive weeding treatment (1556.2 kg/ha vs 2771.4kg/ha). Weeding at two successive times selectively with the hand hoe and sparing *Stylosanthes* each time produced the highest maize grain yield at 2961kg/ha. This out-yielded the conventional twice successive cleanly hand hoed treatment by about 7% (2961 kg/ha vs 2771.4kg/ha). Even the treatment that spared the legume in the second 30 days out yielded the clean-weeded treatment by about

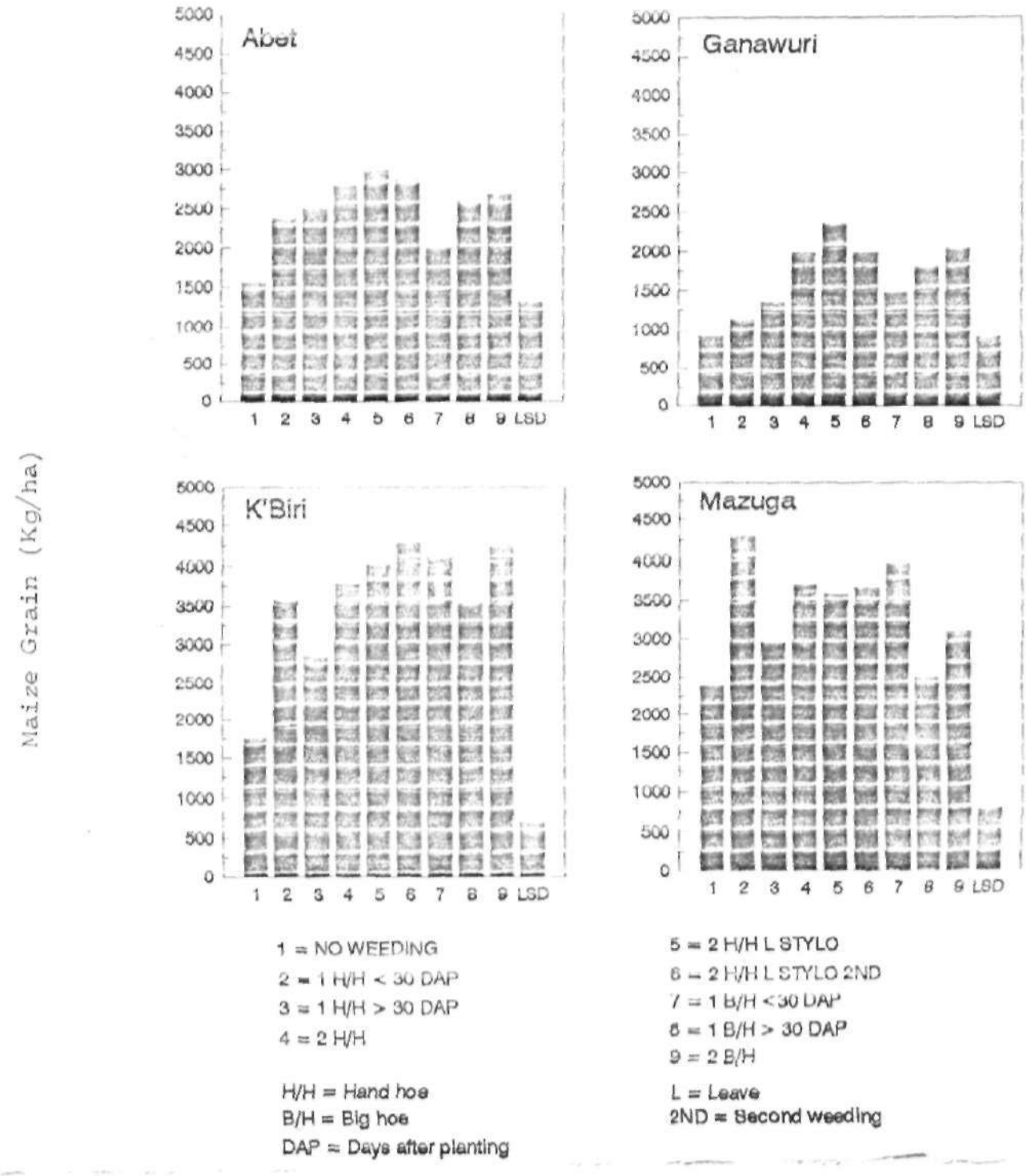


Fig 2 Yield of Maize Cropped in the Legume Pastures at the Various Sites (1991)

Table 4: Maize grain yield at the four experimental sites (kg/ha) 1991

Treatment	Abet	Kurmin Biri	Mazuga	Ganawuri	Mean
1	1556.15b	1746.95 e	2391.55 c	919.98c	1653.66
2	2377.90ab	3566.90bc	4278.95 a	1133.00bc	2839.19
3	2483.40ab	2845.08 d	2949.70ba	1348.00bc	2466.55
4	2771.40ab	3771.98abc	3694.35ab	1970.83bc	3052.14
5	2961.28a	4023.38abc	3573.98ab	2345.23ab	3225.97
6	2863.05a	4277.15 a	3660.55ab	1981.28ab	3195.51
7	1976.80ab	4086.10abc	3966.55a	1465.85abc	2873.83
8	2589.28ab	3517.70cd	2497.63c	1812.13abc	2604.19
9	2654.43ab	4232.60ab	3092.98bc	2037.20ab	3004.30
L.S.D. (0.05)	1293.24	675.26	776.53	908.48	

TREATMENTS

1. No weeding
2. 1 x H/H < 30 DAP
3. 1 x H/H > 30 DAP
4. 2 x H/H
5. 2 x H/H LS
6. 2 x H/H LS at 2nd
7. 1 x B/H < 30 DAP
8. 1 x B/H > 30 DAP
9. 2 x B/H

4% (2863.11kg/ha vs 2771.4kg/ha). Weeding only once with the hand hoe within the second 30 days after planting produced comparable grain yield to weeding twice cleanly at $P<0.05$. This also out yielded weeding only once within the first 30 days of planting in actual terms (Table 4 and Appendix 3a).

4.4.2 The Kurmin Biri Site

At Kurmin Biri, not weeding at all depressed the yield of the maize grain by about 54% (1747kg/ha vs 3772kg/ha). Here also two successive selective weedings with the hand hoe, sparing *Stylosanthes* at all instances out yielded twice cleanly hand hoed plots. At Kurmin Biri however, weeding within the first 30 days after planting with the hand hoe produced maize grain yield which were statistically similar to twice clean weeding at $P<0.05$ and out yield those weeded once only in the second thirty days after planting. Treatments instituted with the big hoe in this site out yielded their hand hoed equivalents (Table 4, Appendix 3b and Fig.2).

4.4.3 The Mazuga Site

The unweeded treatment at Mazuga depressed the yield of maize grain by about 35.3% (2391.55kg/ha vs 3694.43kg/ha). The highest yields of grain in this location were attained by weeding once only within the first 30 days (4279.0kg/ha) with the hand hoe and (3966.6kg/ha) with the big hoe. Weeding at two successive times and sparing *Stylosanthes* in the second instance produced 3660.6kg/ha grains which was statistically similar to two successive selective weeding, sparing the legume each time

3674.0kg/ha. Both these treatments' yields were similar statistically with two successive clean weeding at $P<0.05$ (Table 4 Appendix 3c and Fig.2).

4.4.4 The Ganawari Site

At Ganawuri, the unweeded treatment yielded the lowest maize grain of 920.0kg/ha. The highest grain yield was attained with twice successive and selectively hand hoed treatment sparing the legume each time (2345.2kg/ha). Here, like at Abet, weeding only once within the second 30 days after planting produced grain comparable to two successive clean weeding at $P<0.05$ (Table 4 Appendix 3d and Fig.2).

4.5 Post Harvest Floristic Survey

4.5.1 The Abet Site

After removal of the maize in November of 1991; a floristic survey conducted on the treatment plots revealed that *Oldenlandia herbaceae* was most dominant at 47 plants/m^2, *Borreria verticellata* 14 plants/m^2 and *Stylosanthes guianensis* cv. Cook, 7 plants/m^2. Individually less important species grouped into 'other grasses' had 50 plants/m^2 while 'other forbs' had 69 plants/m^2 (Table 5a).

4.5.2 The Kurmin Biri Site

At Kurmin Biri, the dominant species were *Ageratum conyzoides* 44 plants/6m^2 *Oldenlandia herbaceae* 20 plants/m^2 *Borreria Verticellata* 18 plants/m^2 and *Stylosanthes hamata* cv verano 10 plants/m^2. Here again 'other forbs' recorded a count of 70 plants/m^2 while 'other grasses' had about 12 plants/m^2 (Table 5b).

Table 5a Post harvest of dominant and other herbaceous species in the treatment plots at **Abet** in November, 1991 (Plant / m²)

	TREATMENTS										
Species	1	2	3	4	5	6	7	8	9	x	%total
Siphosanthes guianensis ex cook	9.8	4.5	4.0	4.0	11.0	7.0	6.0	5.0	7.5	6.5	3.2
Oldenlandia herbacea	13.5	37.5	22.5	46.3	41.5	78.5	70.0	52.5	39.8	46.9	22.9
Ageratum conyzoides	11.3	26.0	30.0	23.5	12.3	11.0	30.5	12.0	11.3	18.6	9.1
Borreria verticillata	25.5	18.0	9.0	14.8	5.8	23.8	8.0	18.0	4.5	14.2	6.9
Other grasses	87.3 +(8)	60.0 (4)	35.3 (5)	16.0 (3)	45.5 (5)	40.0 (7)	72.5 (5)	45.0 (6)	46.5 (4)	49.8	24.3
Other herbs	42.0 +(8)	53.4 (10)	32.8 (8)	98.0 (7)	108.2 (15)	139.3 (14)	37.5 (12)	53.3 (12)	54.8 (10)	68.8	33.6
Total plant count	189.4	199.4	133.6	202.6	224.3	399.8	224.3	185.8	184.2	204.8	

+ Actual number of species contributing the plant density immediately above

4.5.3 The Mazuga Site

The herbaceous flora was dominated by the following *A. conyzoides*, 37 plants/m^2, *Hyptis suaveolens*, 11 plants/m^2 *Leucas martinensis*, 7 plants/m^2 and *S. hamata* cv. verano, 6 plants/m^2. Other forbs recorded 39 plants/m^2 and other grasses had 18 plants/m^2 (Table 5c).

4.5.4 The Ganawuri Site

At Ganawuri the dominant herbaceous flora was made of *Oldenlandia herbaceae* 32 plants/m^2, *Mitracarpus scaba*, 26 plants/m^2, *B. verticellata*, 22 plants/m^2 and *S. guianensis* cv. Cook, 8 plants/m^2. The densities of 'other forbs' and 'other grasses' were 40 and 31 plants/m^2 respectively (Table 5d). In all four sites grasses failed to make individual recognition at immediate post harvest.

4.6 Post Maize Harvest Herbage Dry Matter Yield (November 1991)

4.6.1 The Abet Site

At immediate post maize grain harvest in November, 1991, the dry matter yield of the weed flora at Abet had a mean of 2355.7kg/ha. Among treatments, the one that was weeded cleanly two successive times with the big hoe had the lowest herbage of about 1230.7kg/ha while the unweeded treatment produced the highest herbage dry matter yield of 4077.0kg/ha. When the herbage dry matter yield is partitioned into stylo, grass and forbs, their percentage contributions are 15.3, 37.0 and 48.0 respectively. Among individual treatments, the legume contribution to the total

Table 5c Post harvest of dominant and other herbaceous species in the treatment plots at Mazuga in November, 1991 (Plant / m^2)

Species	TREATMENTS										
	1	2	3	4	5	6	7	8	9	x	%total
Styosanthes hamata cv verano	6.3	8.0	5.5	4.8	9.3	6.0	4.3	5.0	5.8	6.1	5.2
Ageratum conyzoides	32.3	36.8	38.0	50.8	31.3	34.3	32.0	33.0	43.0	36.8	31.6
Hyptis specigera	21.3	9.5	7.0	13.8	4.5	14.0	5.3	9.0	10.5	10.5	9.0
Leucas martinensis	7.0	4.0	6.0	5.5	3.0	6.0	5.5	10.3	10.8	6.5	5.6
Other grasses	30.0 +(4)	10.8 (4)	15.8 (5)	10.5 (4)	15.5 (4)	11.0 (4)	21.5 (5)	10.8 (4)	25.0 (6)	17.8	15.3
Other forbs	40.5 +(13)	37.8 (19)	52.8 (19)	47.0 (16)	40.0 (15)	34.8 (13)	27.3 (11)	36.8 (13)	29.0 (10)	38.8	33.3
Total	133.6	146.4	134.1	151.0	201.8	196.4	179.2	244.6	178.9	174.1	

+ Actual number of species contributing the plant density immediately above

Table 5d Post harvest of dominant and other herbaceous species in the treatment plots at **Ganawuri** in November, 1991 (Plant / m^2)

Species	TREATMENTS										
	1	2	3	4	5	6	7	8	9	x	%total
Stylosanthes guianensis cv cook	11.0	6.3	6.6	6.0	11.0	8.3	8.8	7.3	7.0	8.1	5.1
Oldenlandia herbacea	11.0	41.8	16.3	31.0	47.8	48.3	24.5	24.0	42.8	31.9	20.1
Mitracarpus scaba	15.0	34.8	13.5	24.3	31.0	28.8	31.8	32.8	18.5	25.6	16.1
Borreria verticillata	12.3	16.0	25.8	31.0	23.8	23.8	23.0	22.8	21.5	22.2	14.0
Other grasses	59.5 *(9)	42.5 (5)	36.3 (3)	27.0 (4)	17.5 (5)	27.0 (4)	31.5 (6)	26.3 (5)	13.3 (6)	31.6	19.7
Other forbs	48.3 *(16)	42.5 (14)	40.3 (11)	35.3 (11)	32.8 (12)	31.8 (11)	49.3 (11)	49.0 (13)	26.3 (9)	39.5	25.5
Total	157.1	183.9	139.0	154.6	163.9	168.0	168.9	162.2	129.4	158.6	

* Actual number of species contributing the plant density immediately above

dry matter in the treatment which was weeded twice successively with the hand hoe and *Stylosanthes sp.*spared at all the instances was 41% (Table 6a and Appendix 4a).

4.6.2 The Kurmin Biri Site

At Kurmin Biri, the mean herbaceous dry matter yield was 3259.5kg/ha. The unweeded plot again accounted for the highest dry matter among treatments at 6752.0kg/ha. The least dry matter of 1949.0kg/ha was attained at the two times successive clean weeding with the big hoe. Verano proportion of the dry matter of individual treatments was highest at the treatment that spared the legume at all two weeding instances, accounting for about 61.3% of the total herbage yield of that treatment. When however the mean total herbage yield of this location is partitioned into stylo, grass and forbs, their respective percentage contributions are 16.3, 11.4 and 72.6 (Table 6b and Appendix 4b).

4.6.3 The Mazuga Site

The mean herbaceous dry matter yield at Mazuga was 5211.0kg/ha, with the unweeded treatment producing the highest yield of 8693.0kg Dm/ha. The two times cleanly hand-hoed treatment gave the lowest dry matter at 331.0kg/ha. The mean total herbaceous dry matter yield of this location was made of 12.6% *Stylosanthes*, 7.7% grass and 81.0% forbs. At individual treatment levels the highest legume dry matter was attained at the twice successive selectively hand hoed treatment where it contributed 51.7% of the total herbage dry matter (Table 6c and Appendix 4c).

Table 6a: Post harvest herbage yield in the treatment plots at Abet (D.M kg/ha) November 1991

Treatment	cook stylo	Grass	Forbs	Total	% cook stylo	% grass	% Forbs
1	375.0	2514.0	1188.0	4077.0	9.2	61.7	29.1
2	268.0	1234.0	1789.0	3291.0	8.1	37.5	54.6
3	191.1	1199.0	1300.9	2691.0	7.1	44.6	48.3
4	92.61	943.3	1020.1	2058.0	4.5	45.8	49.7
5	1186.4	325.0	1379.0	2890.4	41.1	11.2	47.7
6	330.0	287.0	783.0	1400.0	23.6	20.5	55.9
7	245.0	357.0	900.4	1502.4	16.3	23.8	59.9
8	258.0	467.0	1336.0	2061.0	12.5	22.7	64.8
9	152.4	807.0	271.3	1230.7	12.4	65.6	22.0
Mean	344.3	903.7	1107.5	2355.7	15.3	37.0	48.0

TREATMENTS

1. No weeding
2. 1 x H/H < 30 DAP
3. 1 x H/H > 30 DAP
4. 2 x H/H
5. 2 x H/H LS
6. 2 x H/H LS at 2nd
7. 1 x B/H < 30 DAP
8. 1 x B/H > 30 DAP
9. 2 x B/H

Table 6b: Post harvest herbage yield in the treatment plots at Kurmin Biri

Treatment	verano stylo	Grass	Forbs	Total	% verano stylo	% grass	% Forbs
1	1013.0	3229.0	2510.0	6752.0	15.0	47.8	37.2
2	250.0	281.0	1904.0	2435.0	10.3	11.5	78.2
3	156.0	276.0	2770.0	3202.0	5.0	8.6	86.5
4	174.0	167.0	1795.0	2136.0	8.0	7.8	84.0
5	2204.0	60.0	1329.0	3593.0	61.3	1.7	37.0
6	339.0	183.0	1836.0	2338.0	14.5	7.8	78.5
7	282.1	370.0	3261.0	3913.1	7.4	9.5	83.3
8	233.0	236.0	2548.0	3017.0	9.1	7.8	84.5
9	303.0	-	1646.0	1949.0	15.6	-	84.5
Mean	550.5	533.5	2177.7	3259.5	16.3	11.4	72.6

Table 6c: Post harvest herbage yield in the treatment plots at Mazuga (D.M. kg/ha) 1991

Treatment	verano stylo	Grass	Forbs	Total	% verano stylo	% grass	% Forbs
1	517.0	2326.0	5850.0	8693.0	6.0	39.8	67.3
2	446.0	544.0	3295.0	4285.0	10.4	12.7	76.9
3	164.0	143.0	4085.1	4392.1	3.7	3.3	93.0
4	27.0	30.0	3274.0	3331.0	0.8	0.9	98.3
5	3514.0	131.0	3153.0	6798.0	51.7	1.9	46.4
6	1147.0	155.0	3670.0	4972.0	23.1	3.1	73.8
7	329.0	314.0	5072.0	5715.0	5.8	5.5	88.8
8	296.0	96.6	4198.0	4590.0	6.5	2.1	91.5
9	284.0	-	3839.0	4123.0	6.9	0	93.1
Mean	747.1	415.4	4048.4	5211.0	12.7	7.7	81.0

4.6.4 The Ganawuri Site

The mean herbaceous dry matter yield was 4389.2kg/ha. Out of this, 11.8% was stylo, 22.4% grass and 65.8% forbs. At individual treatment levels, the unweeded treatment gave the highest dry matter yield of 8627.0kg/ha while two successive clean weeding with the big hoe produced the lowest yield at 2584.0kg/ha. The legume proportion of individual treatments was again highest in the twice selectively weeded treatment accounting for 27.4% of the total herbage dry matter (Table 6d and Appendix 4d). A graphical representation of the immediate after grain harvest herbage dry matter is given for all sites in figure 3.

4.7 Floristic Survey in the Second Year after Sowing

At the end of the growing season, November, 1992, two years after maize was sown at these four experimental sites, a floristic survey of the treatments plots were recorded for the Abet and Kurmin Biri sites only. At Abet the herbaceous flora was dominated by *Setaria anceps* with a count of 14 plants/m^2, while *Stylosanthes guianensis* cv, Cook, *Borreria verticellata* and *Chaemocrista rotundifolia* had 12.7 six and four plants/m^2 respectively. The 'other grasses' and 'other forbs' recorded 12 and 22 plants/m^2 respectively (Table 9a).

At Kurmin Biri, the herbaceous flora was dominated by *Stylosanthes hamata* cv. verano with 25 plants/m^2, *Borreria verticellata* 15 plants/m^2, *Ageratum conyzoides*, 9 plants/m^2 and *Paspalum orbiculare*a, 7 plants/m^2. 'Other grass' had a mean of 19 plants/m^2 while 'other forbs' recorded 39 plants/m^2 (Table 9b).

Table 6d: Post harvest herbage yield in the treatment plots at Ganawuri (D.M kg/ha) 1991

Treatment	cook stylo	Grass	Forbs	Total	% cook stylo	% grass	% Forbs
1	709.0	6010.0	1908.0	8627.0	8.2	69.7	22.1
2	432.0	1566.0	3366.0	5364.0	8.1	29.2	62.8
3	256.0	772.3	3006.0	4034.3	6.4	19.1	75.1
4	252.1	384.0	2783.2	3419.3	7.4	11.2	81.4
5	1072.0	289.4	2551.4	3912.8	27.4	7.4	65.2
6	874.0	396.0	2658.0	3928.0	22.3	10.1	67.7
7	300.0	1167.0	2695.0	4163.0	7.2	28.0	64.7
8	304.3	482.0	2666.0	3452.3	8.8	14.0	77.2
9	273.6	332.2	1978.2	2584.0	10.6	12.9	76.6
Mean	497.0	1266.5	2623.5	4389.2	11.8	22.4	65.8

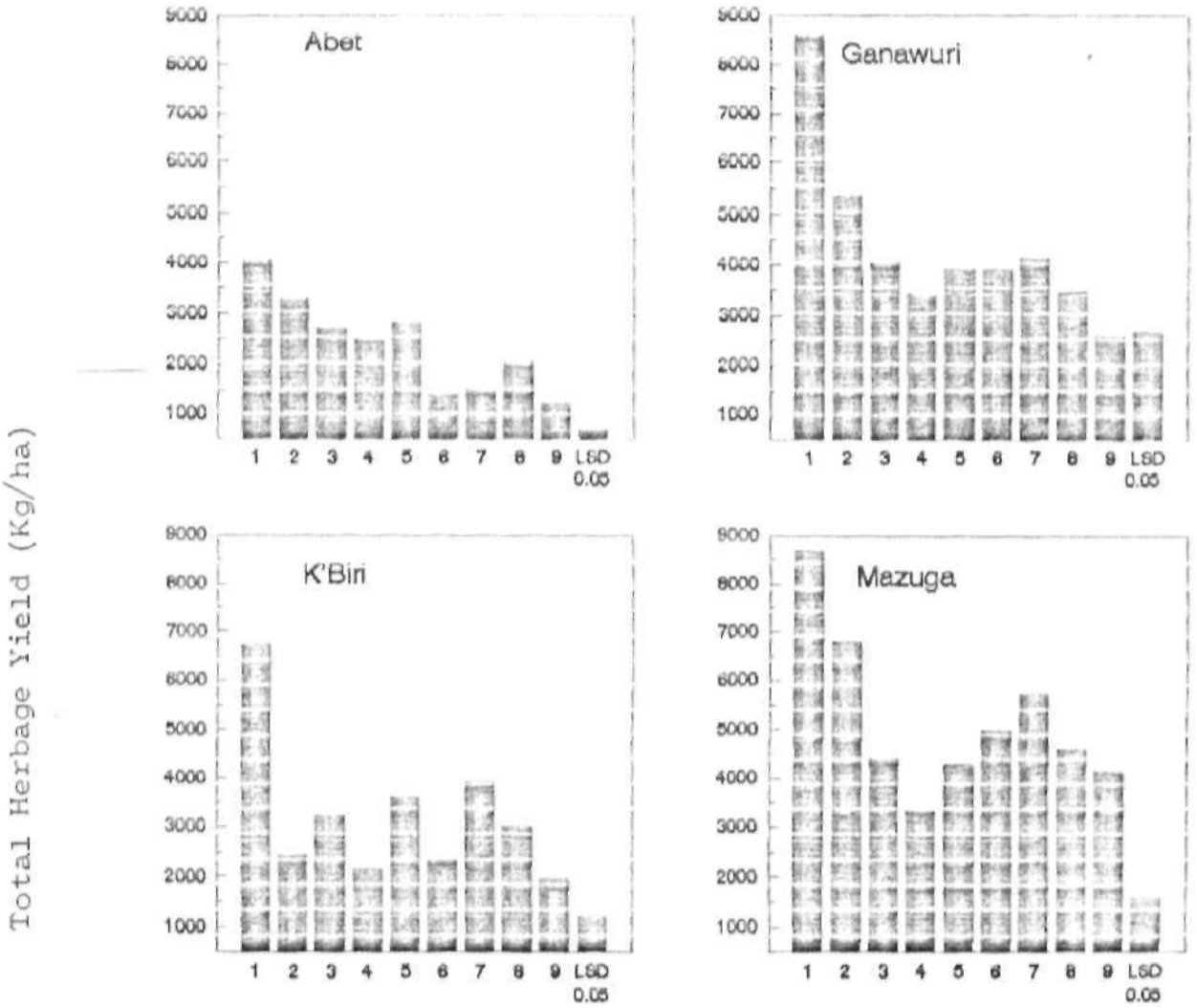


Fig 3 Herbage Biomass Immediately after Grain Harvest (Nov. 1991)

Table 7 Grain and Herbage yields at the four experimental sites (kg/Ha)

TREATMENT	LOCATION							
	ABET		KURMIN BIRI		MAZUGA		GANAWURI	
	Grain*	Herbage♠	Grain	Herbage	Grain	Herbage	Grain	Herbage
1	1556.2*b*	4077.0*a*	1747.0*e*	6752.0*a*	2391.6*c*	8673.0*a*	920.0*c*	8627.0*a*
2	2377.4*ab*	3291.0*b*	3567.0*bc*	2435.0*cde*	4279.0*a*	4285.0*cde*	1133.0*bc*	5363.7*b*
3	2483.4*ab*	2691.0*bcd*	2845.1*d*	3202.0*bcd*	2949.7*bc*	4392.1*cde*	1348.0*bc*	4060.0*bc*
4	2771.4*ab*	2475.6*cd*	3772.0*abc*	2136.0*de*	3694.4*ab*	3301.0*c*	1970.8*bc*	3417.0*bc*
5	2961.3*a*	2815.6*bc*	4023.4*abc*	3593.0*bc*	3574.0*ab*	6798.0*b*	2345.2*ab*	3913.8*bc*
6	2863.1*a*	1400.0*ef*	4277.2*a*	2338.0*de*	3660.6*ab*	4972.0*cd*	198.3*ab*	3928.0*bc*
7	1976.8*ab*	1502.4*ef*	4086.1*abc*	3913.0*bc*	3966.6*a*	5715.0*bc*	1465.9*abc*	4163.0*bc*
8	2589.3*ab*	2061.1*de*	3517.7*cd*	3017.0*bcde*	2497.6*c*	4590.0*cde*	1812.1*abc*	3452.3*bc*
9	2654.4*ab*	1230.8*f*	4232.6*ab*	1949.1*e*	3093.0*bc*	4122.7*de*	2037.2*ab*	2583.9*c*
LSD(005)	1293.2	677.5	675.3	1208.4	776.5	1575.6	908.5	2673.6

* Grain in Kg/ha
♠ Herbage in Kg/ha DM
Means within same columns with same subscripts are not significantly different ($P < 0.05$)

Table 8 Summary of total herbage dry matter yield and percentage legume component in all sites pre- and postcropping, 1991

TREATMENT	LOCATION															
	ABET				KURMIN BIRI				MAZUGA				GANAWURI			
	Pre-cropping		Post-harvest		Pre-cropping		Post-harvest		Pre-cropping		Post-harvest		Pre-cropping		Post-harvest	
	①	②	①	②	①	②	①	②	①	②	①	②	①	②	①	②
1	1343.3	22.3	4077.0	9.8	1758.6	18.0	6752.0	15.0	764.7	7.8	8693.0	6.0	758.3	11.0	8627.0	8.2
2	1468.2	24.5	3291.0	8.1	2126.5	15.0	2435.0	10.3	1010.4	8.1	4285.0	10.4	768.1	11.2	5364.0	8.7
3	1373.0	15.5	2691.0	7.1	2191.3	11.6	3202.0	5.0	894.8	3.2	4392.0	3.7	751.7	8.7	4034.0	6.4
4	1405.6	24.7	2058.0	4.5	2368.3	10.7	2136.0	8.0	845.4	0.2	3331.0	0.8	796.1	13.1	3419.3	7.4
5	1363.5	35.0	2890.0	41.1	1619.7	16.0	3593.0	61.3	928.4	2.4	6798.0	51.7	1045.8	28.0	3912.8	2.7
6	1012.6	20.1	1400.0	23.6	1998.3	23.3	2338.0	14.5	1351.8	3.8	4972.0	23.1	1253.2	17.6	3928.0	22.3
7	1771.0	8.5	1502.0	16.3	2174.7	18.1	3913.0	7.4	792.0	2.3	5715.0	5.8	800.3	17.2	4163.0	7.2
8	1380.7	19.6	2061.0	12.5	2351.9	11.0	3017.0	9.1	928.4	4.6	4590.0	6.5	851.8	1.5	3452.3	8.8
9	1101.0	11.3	1230.0	12.4	2202.9	4.4	1949.0	15.6	1400.5	4.3	4123.0	6.9	671.3	13.3	2584.0	10.0

① Total Dry Matter (Kg/ha DM)
② percentage Legume component of the total Dry Matter

Table 9a Survey of dominant and other herbaceous species in the treatment plots two years after sowing at Abet in November, 1992 (Plant / m²)

	TREATMENTS										
Species	1	2	3	4	5	6	7	8	9	x	%total
Hyparrhenia glabrescens	28.3	20.0	6.3	13.7	12.3	13.9	5.8	12.3	6.7	12.3	17.4
Setaria sp.	14.3	5.3	12.3	11.3	8.3	13.3	8.3	7.3	5.7	10.7	13.4
Bothriochloa insculpta	6.0	4.0	4.0	8.3	5.0	11.0	9.0	5.3	4.3	6.9	9.8
Themeda triandra	3.3	3.3	1.3	5.7	12.0	3.0	7.0	1.3	1.0	4.2	5.9
Other grasses	9.3 (4)	14.3 (3)	6.0 (4)	13.3 (3)	13.3 (3)	16.0 (4)	10.3 (4)	4.3 (4)	12.3 (3)	11.6	16.4
Other forbs	18.3 (5)	24.4 (7)	41.8 (7)	20.3 (11)	31.3 (9)	18.3 (6)	16.7 (5)	11.0 (6)	13.4 (6)	22.0	31.0
Total	125.0	74.3	72.4	71.7	81.6	72.9	57.2	43.7	43.3	70.7	

* Actual number of species comprising the plant density immediately above

Table 9b Survey of dominant and other herbaceous species in the treatment plots two years after sowing at **Kurmin Biri** in November, 1992 (Plant / m²)

	TREATMENTS										
Species	1	2	3	4	5	6	7	8	9	x	%total
Stylosanthes hamata cv verano	30.8	22.3	22.3	20.5	38.0	23.9	21.0	26.3	13.0	24.5	21.6
Borreria verticellata	9.9	12.0	13.6	13.6	16.3	17.9	17.2	17.3	13.0	14.5	12.8
Ageratum conyzoides	6.3	3.5	8.0	8.0	14.3	5.5	10.7	8.7	17.3	9.1	8.0
Paspium orbiculare	8.0	14.8	4.8	3.0	10.5	7.0	9.0	7.0	3.0	7.4	6.5
Other grasses	13.4 *(4)	12.0 (6)	14.5 (3)	18.8 (3)	22.5 (4)	24.3 (4)	25.7 (5)	17.8 (5)	24.3 (3)	19.3	17.0
Other forbs	34.3 *(14)	46.8 (9)	37.8 (8)	42.3 (10)	29.4 (10)	50.6 (10)	31.6 (6)	31.9 (9)	44.3 (10)	38.8	34.2
Total	102.7	111.4	100.2	106.2	131.0	131.2	115.2	109.0	114.9	113.6	

* Actual number of species comprising the plant density immediately above

4.8 Herbaceous Dry Matter Yield at the end of the Second Year After Sowing, November 1992

At the end of the second year after sowing, the herbage dry matter at the experimental site at Abet had a mean of 4183.0kg/ha. Among the treatment plots, weeding only once within the first 30 days after planting produced the highest dry matter 6446.0kg/ha. The least herbage yield was attained at the treatment hand hoed at two successive times, once in the first 30 days of planting cleanly and selectively in the second 30 days after planting sparing the legume at this instance. This yielded 2242.6kg/ha dry matter. When the mean total herbage yield is partitioned into stylo, grass and forbs, their corresponding percentages are 40.0, 49.0 and 11.0 respectively (Table 10a and Appendix 5ai). A graphical representation of the dry matter yield in 1992 is given in fig.4.

At individual treatment level, the Cook proportion of the twice successively and selectively hand hoed treatment sparing the legume at all instances had higher percentage *Stylosanthes* dry matter proportion at 62.0% of the total herbage dry matter yield. This was followed by the treatment that was hand hoed only once in the first 30 days of planting. This even produced the highest cook stylo dry matter in actual terms (Appendix 5aii) see figure 5.

At Kurmin Biri, the herbage dry matter had a mean of 3132.4kg/ha. Among treatment plots the unweeded treatment produced the highest dry matter at 4073.5kg/ha, while the twice cleanly weeded treatments with the big hoe produced the least at 2584.0kg/ha. Statistical analysis however showed the dry matter

Table 10a Total herbage yield in the treatment plots, two years after sowing at **Abet** in November, 1992 (DM Kg/ha)

TREATMENT	HERBAGE DRY MATTER YIELDS						
	Cook stylo	Grass	Forbs	Total DM	%cook stylo	%grass	%forbs
1	1260.0^{cd}	2189.3^{ab}	379.8^{ab}	3929.0^{abc}	32.9	57.2	9.9
2	3612.5^{a}	2467.8^{ab}	365.8^{ab}	6446.0^{a}	56.0	38.3	5.7
3	1323.0^{cd}	3746.3^{a}	399.8^{ab}	5469.0^{ab}	24.2	68.5	7.3
4	2213.8^{abc}	1609.3^{b}	875.5^{a}	4698.5^{abc}	47.1	34.3	18.6
5	2740.8^{ab}	1246.0^{b}	418.3^{ab}	4405.0^{ab}	62.2	28.3	10.0
6	461.0^{d}	1324.5^{b}	457.3^{ab}	2242.8^{c}	20.6	59.1	20.4
7	2250.0^{bcd}	1070.5^{b}	543.3^{ab}	3863.8^{abc}	58.2	27.7	14.1
8	1375.0^{bcd}	1849.3^{b}	298.3^{b}	3522.5^{bc}	39.0	52.5	8.5
9	583.0^{d}	2511.3^{ab}	76.3^{b}	3170.5^{bc}	18.4	79.1	2.4
Mean	1757.7	2001.6	423.8	4188.0	39.9	49.4	10.8
LSD (0.05)	1405.1	1799.8	543.1	2892.9			

Means within same columns with different superscripts are significantly different ($P < 0.05$)

yield from all treatment in this location to be even at $P<0.05$. The mean total herbage dry matter is shown to be 32.3% *Stylosanthes hamata* cv. verano, 46.0% grass and 22.0% forbs (Table 10b and Appendix 5bi). A graphical representation of the total dry matter yield at Kurmin Biri is given in figure 4. The twice selectively hand hoed treatment that spared the legume consecutively yielded the highest *Stylosanthes hamata* dry matter, contributing 52.2% total herbage dry matter yield (Appendix 5bii). See figure 5.

Table 10b Total herbage yield in the treatment plots, two years after sowing at **Kurmin biri** (DM Kg/ha) in November, 1992

TREATMENT	HERBAGE DRY MATTER YIELDS						
	Verano stylo	Grass	Forbs	Total DM	%verano stylo	%grass	%forbs
1	801.8^{b}	2634.0^{a}	637.8^{ab}	4073.5^{a}	19.7	64.7	15.7
2	1056.8^{b}	530.0^{a}	907.8^{a}	2494.5^{a}	42.4	21.3	36.4
3	1021.8^{b}	1171.3^{a}	662.5^{ab}	2855.5^{a}	35.8	40.0	23.2
4	1018.3^{b}	835.0^{a}	810.0^{ab}	2663.3^{a}	38.2	32.0	30.4
5	1925.0^{a}	1309.0^{a}	452.5^{ab}	3686.5^{a}	52.2	35.5	12.3
6	953.0^{b}	1245.8^{a}	555.0^{ab}	2753.8^{a}	35.6	45.2	20.2
7	515.0^{b}	2331.5^{a}	650.0^{ab}	3496.5^{a}	14.7	66.7	18.6
8	966.3^{b}	2237.5^{a}	380.0^{b}	3583.8^{a}	27.0	62.4	10.6
9	640.3^{b}	1193.8^{a}	750.0^{ab}	2584.0^{a}	24.8	46.2	29.0
Mean	988.7	1498.6	645.0	3132.4	32.3	46.0	21.8
LSD (0.05)	607.6	2153.2	498.5				

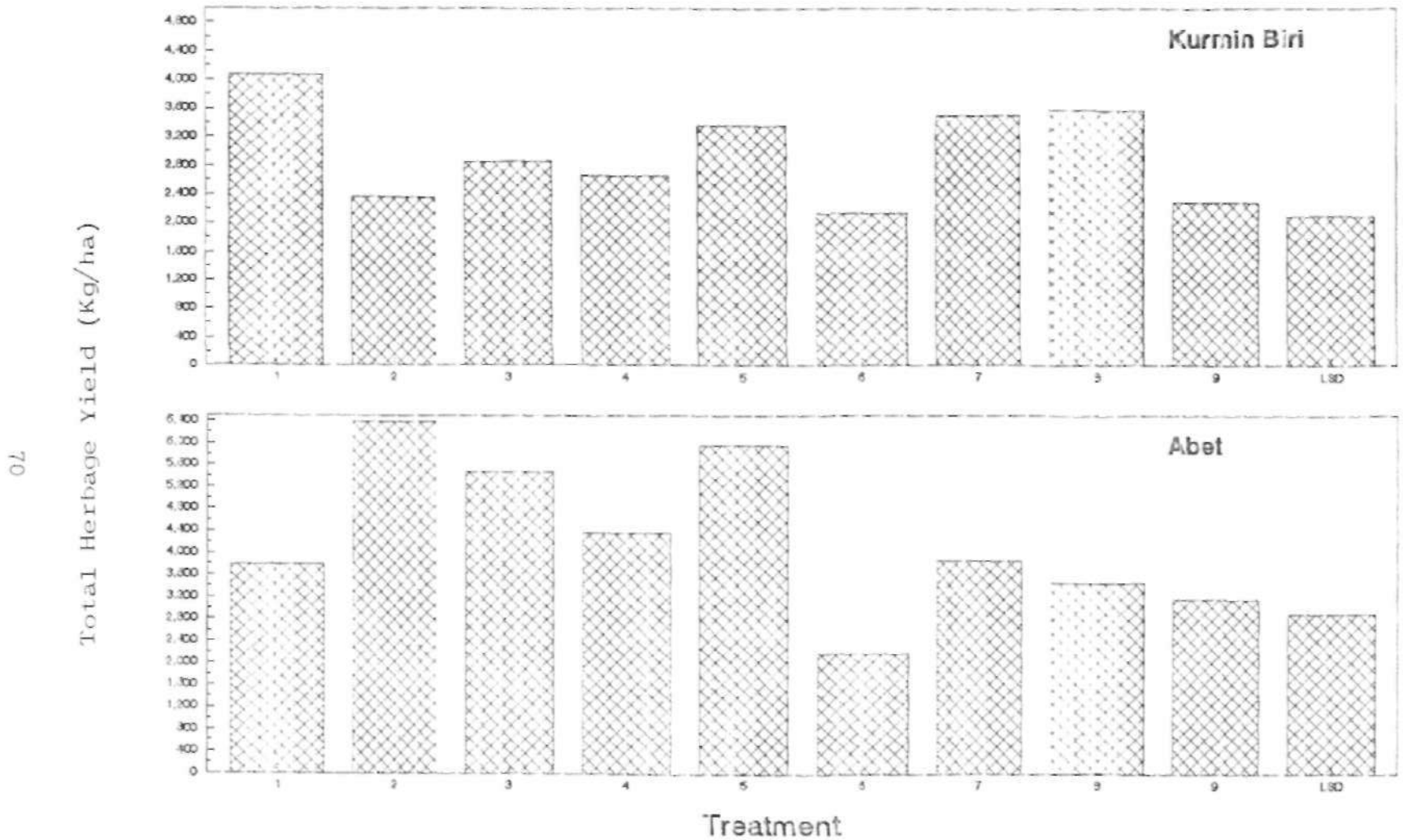


Fig 4 Total Herbage Biomass Two Years after sowing at Abet and Kurmin Biri (1992)

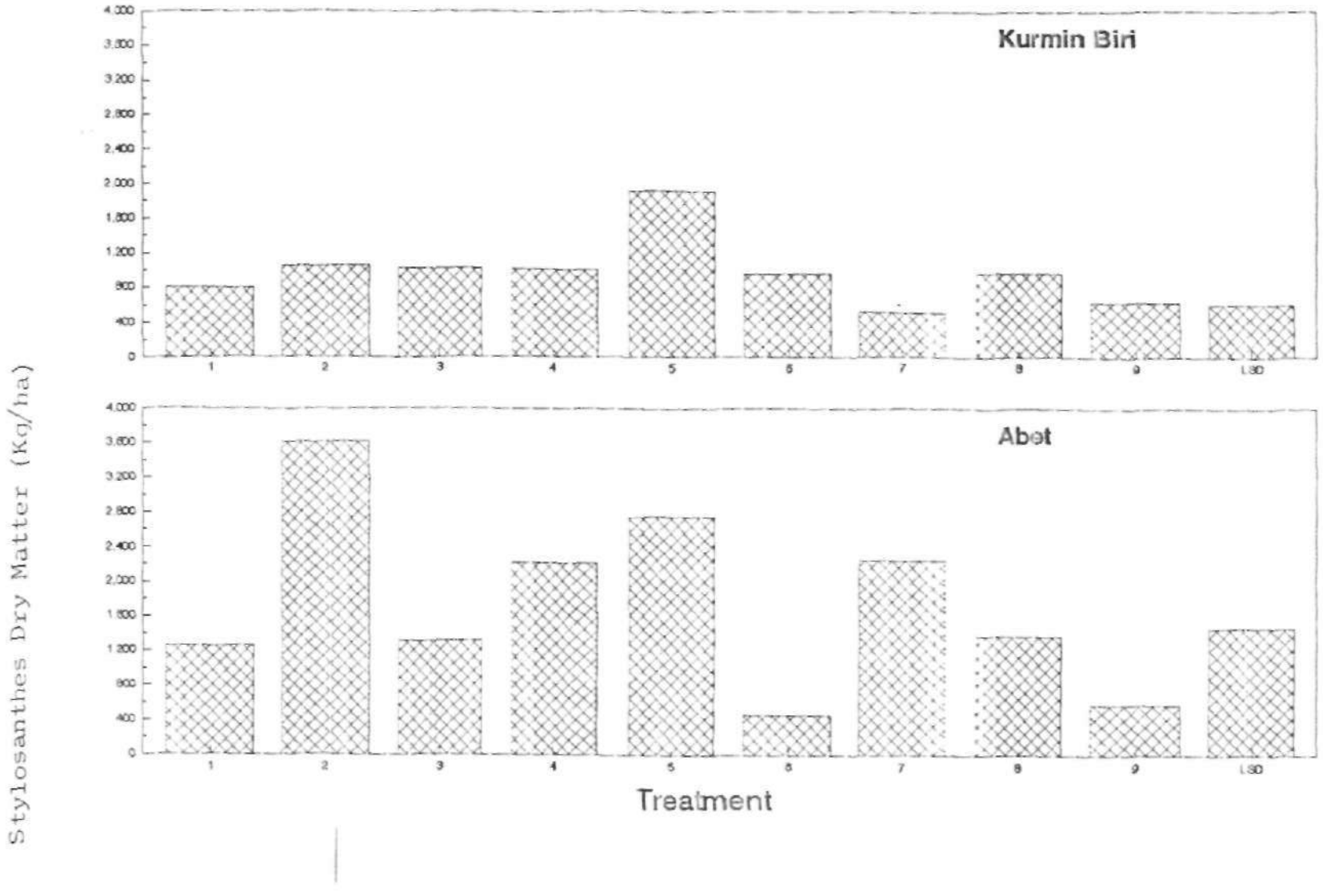


Fig 5 Stylosanthes Dry Matter Yield Two Years after Cropping (1992)

DISCUSSION AND CONCLUSIONS

5.1 Effect of weeding regimes on flora Succession

There appeared to be no relationship between the dominant herbaceous species prior to cropping and, those under the instituted treatment regimes. The population changes within the two species of *Stylosanthes* have however been most interesting.

The Cook Stylo density at Abet increased after the first and second weeding operations, the decline in the density of Cook stylo at Ganawuri with weeding follows a similar trend shown by Verano stylo at Kurmin Biri and Mazuga. When stylo stands are deliberately spared during weeding, their populations tended to increase markedly at all sites.

Weeding reduced grass population but increased that of other forbs. This situation agrees with an earlier position of Dawelbeit and Azhari (1992), who found that grass density tends to be far more reduced than forbs which even appear stimulated with weeding. This may be explained by the differences in periodicity of grass weeds and broad leafed weeds. Grass weeds have been reported to have closer spaced flushes of germination than the broad leaf weeds (Deat et. al. 1980). The grasses are therefore more likely to be present at the time of weeding and therefore more likely to be removed by either of the weeding practices than the forbs. The dominant position of forbs after cropping may therefore be expected. *Stylosanthes* species density on the average was low after crop harvest, consistent with the density situation during the crop phase. As may be expected, treatments weeded with a view to

preserving *Stylosanthes* generally had higher legume density than the others, but the increase in population was not significant statistically. Cropping and weeding tended to alter the floristic composition in the legume pasture as well as reduce the herbaceous plant density in line with an earlier finding by Coffmann and Frank (1992).

Generally, the mean total plant density decreased after cropping compared with that before cropping. However, some individual grass and other herbaceous species became more prominent in the second year, after cropping. These were *Setaria anceps, Borreria verticellata*, and *Chaemocrista rotundifolia* at Abet and *Paspalum orbiculare, Ageratum conyzoides* and *B. verticellata* at Kurmin Biri. This observation would tend to suggest that these species were more adapted to the soil conditions that followed the cropping.

5.2 Effect of treatment regimes on the herbage biomass

Herbage yield seemed to relate directly to the successional pattern of the species in the legume pastures at all sites. The precropping dry matter sampling was taken at a time (July) when the herbs were still in their seedling and early growth stages. Consequently, the greater density of the various plant species did not reflect in their biomass production prior to cropping which was lower than that at immediate post harvest sampling.

There was a clear dominance in the grass proportion of the mean total herbage biomass prior to cropping. This is to be expected from a three year-old legume pasture, as at this stage the

legume would have accumulated much nitrogen in the soil from atmospheric N-fixation becoming detrimental to it's growth as reported by Ingawa et. al. 1988. These findings have earlier been reported for Stylo pastures at Kurmin Biri and Abet by Tarawali et. al (1987).

Immediately after crop harvest in November, 1991, however, *S. guianensis* cv, Cook dropped in overall percentage component of the dry matter yield from 20% and 14% at Abet and Ganawuri before cropping to about 15% and 12% immediately after crop harvest for the respective areas. *S. hamata* cv. Verano, on the other hand improved at Kurmin Biri from 14% before cropping to 16% immediately after crop removal and at Muzuga from 4% before cropping to 14% immediately after. Generally, the proportion of legume across all treatments in the total dry matter yield in the pastures increase with cropping in all sites. This may therefore have confirmed the fact that cropping is a good strategy for restoring high legume content in a deteriorating *Stylosanthes* pasture.

The proportion of grass in the total herbage biomass dropped after crop harvest in 1991 but that of forbs increased. This trend reflects the pattern of succession consequent upon cropping and weeding as witnessed.

In the second year after cropping, both Cook stylo and Verano stylo increased markedly in their densities and biomass. The twice consecutively and selectively hand-hoed plots produced herbage dry matter whose legume component compared to the desired level of over 40% recognised by Otsyina et. al. (1987). *Stylosanthes* reached 62%

of mean total dry matter in the preservative treatment at Abet and 52% at Kurmin Biri.

Since the grass proportion of the unweeded plots remained highest in November, 1991, and in the second year after sowing, and the more frequently weeded plots still had a high proportion of forbs in the second year after sowing, it is obvious that a deliberate attempt to maintain stylo in the pasture at weeding to keep it at an acceptable proportion is necessary.

Weeding once only was observed to also produce a favourable ratio between grass and legume in the second year after sowing. This treatment has an added advantage of using less labour than other treatments.

5.3 Effect of weeding regimes on Maize Grain Yield

The grain yield response of the maize could be grouped into two general patterns in the four experimental sites. At Abet and Ganawuri, where there was an observed slow regrowth of weeds after ridging, the maize crop was evidently not disturbed at the early stages of its growth but weeding became necessary in the second thirty days when weed density was observedly high and interference eminent. This is confirmed by the 14% and 10% drops in yields from weeding within the first or second thirty days respectively at Abet. This yield response agrees with findings by Staniforth (1957), and Anderson and Jones (1958), who asserted that 7 to 10 days before tasselling were most crucial for weed control in maize.

The other pattern of maize yield response was peculiar to Kurmin Biri and Mazuga. Weed regrowth in these sites was fast, so

it was more pertinent to suppress the weeds in the first 30 days after planting. Maize grains resulting from this treatment were indeed, similar to two times consecutive weeding ($P < 0.05$). In fact weeding once only in the second thirty days at Mazuga produced grains that were not significantly higher than that from the unweeded treatment ($P<0.05$).

A clear phenomenon in all these sites is that a single weeding at the right time could produce optimal yield, which complements earlier conclusions by Singh and Yadav (1989), and Rao et. al. (1989), of the specificity of weed check and hence the needlessness of clear weeding.

At Kurmin Biri, weeding with a big hoe was observed to produce higher grain yields. This was probably due to the weeding actions of the big hoe, which amounts to sub-soiling. Improved absorptive root and nutrient contact could have been enhanced resulting in better nutrient utilisations hence the yield advantage. Infact, this reason was advanced by Adeoye and Mohammed-Saleem (1990), who found that due to the clay nature of the soils at Kurmin Biri, better nutrient absorption is enhanced with sub soiling.

The differences in the resilience of the weeds after ridging in the sites within the same broad ecological zone and the critical periods within which weeds had to be suppressed to avoid lethal damages to maize tended to suggest that the weed-crop interaction in this study was dependent on weed density. This was the contention of Dawson (1965), who opined that in a density dependent weed crop interaction, the severity of the effect could also be

judged by the rigour of growth of the weeds. In addition, micro-ecological differences within this zone may have also been responsible for this varied responses as suggested by Foncho (1986).

A common feature in all sites is that, where weeding was done and *Stylosanthes* spared, higher grain yields resulted which even surpassed cleanly weeded plots. The reason may have been that the legume transferred nitrogen directly to the maize plants or acted as a live mulch, controlling the probability of erosion-induced productivity losses (Siebert and Scott 1990). The fact that the spared legume stands did not depress grain yield suggests that even at the critical periods in crop life cycles, they could withstand some amount of weed infestation, as *Stylosanthes* may be regarded technically as weed in this situation. Similar findings have been reported by Lee and Moody (1987), on rice/*Eclipta prostrata* interactions. This may also have informed the suggestion by Aken'Ova and Atta-krah (1986) that clean weeding is not necessary once a crop has attained biological dominance over a weed. Clean weeding may actually have been deleterious in some of the sites due possibly to erosion induced productivity losses or even excesses of temperature, explaining why weeding two times successively yielded less grain than weeding only once within the first thirty days at Mazuga. Lombin (1989), and Adeoye (1990) have attributed similar decrease in yield to moisture and temperature stresses which occur at intermittent dry spells during rainy seasons.

5.4 Grain yield and potential forage a sustainable assessment

Under an agropastoralist production system, both grain and forage are important. It is clear that since cropping improved *Stylosanthes* spp. position, in the pastures, the legume-based cropping scheme is important as a management strategy for the pastures. Aside from the management aspect, this practice aims at integrating crop and livestock husbandry, as such, trade off and balances have to be determined in other to ensure sustainability on the venture.

Results available from this study clearly show that some amount of forage is produced from every treatment despite the amount of weeding regime it entails. When this is considered, bearing in mind the maize grain yield possible from the same treatment, certain observations can be made. Not weeding at all may have the greatest forage potential, in terms of dry matter yield, this treatment however does not compromise well with maize grain yield. At Abet and Ganawuri, weeding only once in the first 30 days after planting also held great promise for high potential forage but again the poor yield of maize grain did not appear to justify the benefits of high forage yield. However only economic analysis which was not undertaken in this study can ascertain the validity of this statement. A better compromise could apparently therefore be sought from weeding only once in the second 30 days after planting. At Kurmin Biri and Mazuga, a good compromise is presented by weeding only once in the first 30 days after sowing. Grain yield from these treatments are comparable to cleanly weeded plots and

were even higher at the Mazuga site. Where one has to weed twice, it will be better to weed selectively and spare *Stylosanthes* stands. This is beneficial in terms of both grain and the forage yields, and ensures sustainability in production. In the longer term, the cleanly weeded treatments that produce very low herbage yield may cause some degradation (Price 1990; Turner et al. 1990, and Anon. 1992).

5.5 Conclusions and Suggestions for further research

The study has shown that cropping a deteriorating 3 to 4 year old legume *Stylosanthes* spp. pasture rejuvenates the pasture as dominance of the legume was reestablished two years after cropping. Frequent weeding had reduced grass density and total herbage yield. Frequent weeding may therefore not be necessary as the forbs that would dominate as a result of this practice may not complement the legume in ruminant diet.

On the strength of this study, it can be said that density dependent weed/maize interactions has a critical phase during which deleterious consequences could result. This was shown to depend on the rigour of the weed regrowth after ridging as had been stated by Ross (1969). Weeding once therefore at this critical time is as effective as weeding twice consecutively and is even better considering the implications for vegetation (herbage) and soil conservation (Schaffer 1980). From the present study also there are indications that selective weeding has the potential of enhancing sustainability on the forage legume cropping scheme, as the climax community that resulted two years after cropping certainly shows.

There is need to investigate the observed grain yield advantage of the big hoe over the small hoe in some sites. While this could be explained by subsoiling hence increasing infiltration of the soil by water, enhancing mineral absorption in more silty clay environments, the long-term effect of this tillage practice needs to be examined with regards to soil degradation. It is also desirable to look into the possibility of once selective weeding with a view to improving the successional pattern of the herbage within the fodder bank. This may hopefully create a better balance between the legume and grass. And as weeding frequencies related soil degradation and yield reduction factors are indicted in this study, this practice may prove to be better apart from being cost effective due to the reduced labor involved.

R E F E R E N C E

1. Adamu, Y. M. (1992). Global warming and us. New Nigerian on Sunday 26th July, 1992.

2. Adejonwo, K. O. (1988). Weeds and their Control - a review. Samaru Journal of Agricultural Education 2 (2): 45-54.

3. Adeoye, K. B. (1989). Nutrient Status of Nigerian Soils in relation to forage production. A paper presented at the Pasture Production Training Course at NAPRI, Shika, Zaria 31st October - 3rd November, 1989.

4. Adeoye, K. B. (1990). Effects of amount of mulch and timing of mulch application on maize in Samaru, Northern Nigeria. Samaru Journal of Agricultural Research 7: 57-65.

5. Adeoye, K. B. and Mohamed-Saleem, M. A. (1990). Comparison of effects of some tillage methods on Soil physical properties and yield of maize and Stylo in a degraded ferrugenous tropical soil. Soil and Tillage Research 18: 63-72.

6. Agishi, E. C. (1983). Forage legumes and pasture development in Nigeria. In: Nigeria - Australia Collaborative

Research. Nuru, S. and Ryan, J. G.(Eds.) ACIAR Proceedings Series No. 4. pp 79-87.

7. Agishi, E. C. (1984). Use of legumes for livestock production in Nigeria (unpublished).

8. Agishi, E. C. (1985). Forage resources of Nigerian range lands. A paper presented at the National Conference on Small Ruminant Production at Zaria, Nigeria." 6th - 11th October, 1985.

9. Agishi, E. C. and Asare, E. O. (1980). Pasture establishment and seed production in Savanans of Nigeria. Proceedings of the Livestock and Veterinary Conference, Ahmadu Bello University, Zaria, Nigeria 15-17th April, 1980, pp282-301.

10. Aken'Ova, M. E. and Atta-Krah, A. N. (1986). Control of Spear grass (*Imperata cylindrica* L. Beauv.) in an alley cropping fallow. Nitrogen Fixing Tree Research Reports 4: 27-28.

11. Anderson, G. W. and Jones, G. E. (1958). Weed Competition in Corn. In: Proceedings of the 12th Meeting of the Eastern Section of the National Weed Community, Canada. pp 29-35.

12. Anon. (1960). Farming in South Africa:- Competition between

maize and weeds. Extrait de weed control in the tropics. Edited by Kasasain, L. (1971). Chemical Rubber Co. Press.

13. Anon. (1992). Plant trees, local government boss pleads. Nigerian Tribune, 18th August, 1992. p.4.

14. Balogun, S. T. (1982). Livestock extension and beef production in Nigeria. In: Osinowo, O. A.; Ikhatua, U. J. and Ehoche, W. O. (Eds.) Beef Production in Nigeria. Proceedings of the National Conference on Beef Production, July, 1982. Kaduna.

15. Bourn, D.; Milligan, K. and Wint, W. (1984). Tsetse, Trypanosomiasis and Cattle in a changing environment. In proceedings of the Second ILCA/NAPRI Symposium held in Kaduna Nigeria. 29th October - 2nd NOvember, 1984. Edited by Vonkaufmann R.; Chater, S. and Blench, R. Published by ILCA Addis Ababa. Ethiopia pp 85-109.

16. Breman, H. and Cisse, A. M. (1977). Dynamics of Sahehan pastures in relation to drought and grazing. Oecologia (Berlin) 28: 301-315.

17. Breman, H. and Traore; N. (Eds.) (1986a). Analyse des conditions de l'evange et propositons de politiques et de programmes Niger OECD, Paris, SAHELD 86 284 p. 194.

18. Breman, N, and Traore, N. (Eds.) (1986b). Analayse des conditions de l'evange et propositions des politiques et de programmes. Burkina Faso. QECD, Paris, SAHELD 86 (300): 202.

19. Burnside, C. O. and Wicks, A. G. (1982). Weed control in corn planted into untilled winter wheat Stuble. Agronomy Journal 74: 521-526.

20. Coffman, B. C. and Frank, R. J. (1992). Corn-weed inter-actions with long term conservation tillage management. Agronomy Journal 84 (1): 17-21.

21. Dawelbeit, I. M. and Azhari, A. H. (1992). Effects of variation of tillage on weeds and groundnuts establishment and yield in Rahab Project Sudan. Soil and Tillage Research 22 (2-3) 363-370.

22. Dawson, J. H. (1965) Competition between irrigated sugar beets and annual weeds. Weeds 13, 245- 249.

23. Dawson, J. H. (1970). Time and duration of weed infestation in relation to weed-crop competition. Southern Weed Science Society 23: 13-25.

24. Deat. M.; Sement, G. and Fontenay, P. (1980). Role of the

proceeding crops on weed infestation on cotton in a crop rotation system. In: I.O Akubundu (ed.). Weeds and their Control in Humid and Subhumid Tropics. pp. 305 - 311. International Institute of Tropical Agriculture, proceedings series No.3.

Emeka, O. (1991). Integrated pest management. The Nigerian Situation. The Nigerian Farmer 1 (009): 37.

Ewusie, Y. J. (1980). Elements of tropical ecology 1st Ed. Heinemann. pp 21-22.

Fadayomi, O. and Abayomi, Y. A. (1988). Effects of varying periods of weed interferance on Sugar cane *(Saccharium officinarum)* growth and yield. Nigerian Journal of Weed Sciences 1(2): 65-70.

Foncho, P.A. F. (1986). The critical growth stage of maize *(Zea mays* L.) in relation to spear grass (*Imperata cylindriea)* and nutsedge (*Cyperus rotundus*) weeds. Science and Technology Review; Agronomy and Animal Science 1 (2). 57-67 Published by Ministry of Higher Education and Scientific Research Rep. of Cameroun.

29. Foster, W. H. (1961). Notes of establishment of a legume in rangelands in Northern Nigeria. Empire Journal of Experimental Agriculture 29 (116): 319-322.

30. Foster, W. H. and Mundy, E. J. (1961). Forage Species in Northern Nigeria Tropical Agriculure (Trinidad) 38: 311-318.

31. Ghuman, B. S. and Lal, R. (1983). Effects of Crops cover on temperature regime of an alfisol in the tropics. Agronomy Journal 75(6): 931-935.

32. Gleason, L. S. (1956). Weed control in corn in the wet tropics In: Proceedings of the 13th North Central Weed Control Conference, Cameroun. p 54.

33. Harper, J. L. (1977). Population biology of plants. Academic Press, London. p 86.

34. Ifenkwe, O. P.; Nwokocha, H. N. and Orkor, G. C. (1992). Effects of time of weed removal on the development and yield of potato *(Solanum tuberosum* (L.) in Jos Plateau of Nigeria. A paper presented at the 6th Annual Conference of the Botanical Society of Nigeria. University of Jos 29th March - 1st April, 1992.

35. Ikwuegbu, O. A. and Tarawali, G. (1991). The productivity of West Afrcian dwarf goats in the subhumid zone of Nigeria. A paper presented at the 1991 National Livestock and Veterinary Conference, ABU, Zaria Nigeria, 6 - 8th August, 1991.

36. Inah, E. I. (1992). Plant Species compostion in four Local Government Areas and Yankari National Park, Bauchi State Nigeria. A paper presented at the 6th Annual Conference of the Botanical Society of Nigeria. UniversiDty of Jos, Jos Nigeria. 29th March - 1st April 1991.

37. Ingawa, S. A.; Tarawali, G. and von Kaufmann, R. (1988). Grazing Reserves in Subhumid Nigeria, problems, prospects and policy implications-revised version of a paper presented at the National Workshop on Guidelines for Development of settlements in Grazing Reserves in Nigeria. Zaranda Hotel, Bauchi State. 29th Aug. - 1st Sept., 1988.

38. Jahnke, H. E. (1982). Livestock production systems and livestock development in tropical Africa. Kieler Wissenchafftserlag Vaulk Federal Republic of Germany p.253.

39. Kasasain, L. (1971). Weeds control in the tropics. Chemical Rubber Co. Press pp. 75- 90, 144-145.

40. Keay, R. W. J. (1959). An outline of Nigerian Vegetation. Crown Agents London p. 55.

41. Knake, E. L. and Slige, F. W. (1965). Gaint foxtail seeded at various times in corn and soybean. Weeds 13: 331 - 334.

41. Kodilinye, H. C. (1974). Opening Speech. In: Proceedings of the 4th Nigerian Weed Science Group Meeting, held at University of Nigeria, Nsukka, Nigeria. 15 - 18th July, 1974.

42. Kumarasinghe, R. M. K. and Nutman, P. S. (1979). The influene of temperature on root hair infection of *Trifolium parviflorum* and *T.glomeratum* by root module bacteria. International Journal of Experimental Botany 30: 503 - 515.

43. Lagoke, S. T. O.; Adejonwo, K. O.; Nongu, T. T., Umunnah, C. E. and Lawal, K. O. (1988). Studies on weed interference and chemical weed control in chili pepper (*Capsicum frutescens* l.). Nigerian Journal of Weed Science 1(3): 3-10.

44. Lagoke, S. T. O.; Shebayan, T. Y. and Kuchinda, N. C. (1991). Herbicide evaluation for weed control in millet. A paper presented at the 19th Annual Conference of the Weed Sceince Society of Nigeria 1 - 5th December, 1991. IAR., ABU, Zaria.

45. Lamorde, A. G. (1985). Collaborative research projects in livestock diseases. In: Nuru, S. and Ryan, J. G. (Eds). Proceedings of the Nigerian-Australia Seminar on Collabo rative Agricultural Research, Shika, Nigeria 14-15 November, 1983. ACIAR Proceedings Series No.4 pp 61-66.

46. Lee, H. K. and Moody, K. (1987). Growth and yield of upland rice under different densities and competitive periods of *Eclipta prostrata* (L.). Research Reports of Rural Develop ment Administration. Crop Protection (1990). 32(2): 32-38.

47. Li, Mung-yu (1960). An evaluation of the critical period and effects of weeds competition on corn and oats. Ph.D. Thesis. University of Rutgers. p. 166.

48. Lombin, G. (1987). Soil and climate constraints to crop production in the Nigeiria Savanna region. A paper presented at the 5th Annual Conference of the Soil Science Society of Nigeria, Kaduna. 21-24th September, 1987.

49. Majumdar, J. C. (1968). Extrait de: 'Weed Control in the tropics' Ed. Kasasain, L. (1971). p.144.

50. McIlory, R. J. (1976). Introduction to tropical grassland husbandry. Oxford University Press, London. p. 51.

51. Mohamed-Saleem, M. A. and Otsyina, R. M. (1984). Evaluation of some Stylosanthes accessions for subhumid conditions of Nigieria. ILCA Bulletin 20: 14-17.

52. Mohamed-Saleem, M. A. and Otsyina, R. M. (1986). Grain yield of maize and the nitrogen contribution following *Stylosanthes* pasture in the Nigerian subhumid zone Experimental Agriculture,22: 207-214.

53. Mohamed-Saleem, M. A.; Suleiman, H. and von Kaufmann, R. (1986). Tillage methods for the cropping of Sorghum in legume fodder banks in the subhumid zone of Nigeria. Field Crops Research 16:85-94.

54. Nieto, J. N.; Brando, M. A.; Gonzalez, J. J. (1968). Critical growth periods of the crop growth cycle for competition with weeds. PANS (c) 14: 159-166.

55. Nwosu, N. A. (1960). A propagation of *Stylosanthes* and establishment from stem cuttings, Nigerian Scientist 1: 24-32.

56. Obillana, T. A. (1982). Special problems in crop production in Nigerian Savannas. A paper presented at the 11th Annual Conferences of the Weed Science Society of Nigeria held at IAR Zaria. 1 - 6th March, 1982. p8.

57. Ogungbile, A. O. and Lagoke, S. T. O. (1986)., On-farm evaluation of the economics of chemical weed control in Nigerian Savanna. Tropical Pest Management 32(4): 269-273.

58. Okigbo, B. N. (1966). Effects if mulching and frequency of weeding on the performance and yield of maize. Nigerian Agricultural Sciences Journal 2(1): 7-9.

59. Olubajo, F. O. (1982). Utilization of roughages for beef production in Nigeria. In: Proceedings of the National Conference on Beef Production, Kaduna Nigieria. 27 - 30th July, 1982. Osinowo, O. A.; Ikhatua, U. J. and Ehoche, W. O. (Eds.) Published by NAPRI, ABU Zaria, Nigeria.

60. Olufade, A. (1988). Small ruminant production in Nigeria. In: Proceedings of the Workshop on the Improvoement of Small Ruminants in West and Central Africa. Ibadan, Nigeria. Adeniji, K. O. (Ed). Published by OAU Press pp 283-293.

61. Onifade, O.S. and Agishi, E.C. (1988). A review of forage production and utilization in Nigerian Savannas. A paper presented at the Workshop on utilization of Research Results on Forages and Agricultural By-productions in Africa. Malawi, 5-9th Dec. 1988.

62. Orkwor, G.C.; Ene, L.S.C.; Okoli, O.O. and Unamma, R.P.A. (1987). Weed control/management in root and tuber crops in Nigeria. A paper presented at the Seminar/Exhibition on "Break throughs in Agricultral Research in Nigeria" Centre for Development Studies University of Jos. Jos, Nigeria 24-27th March, 1987.

63. Otsyina, R.M.; Vonkaufmann, R.R.; Mohammed-Saleem, M.A. and Suleiman, H. (1987). Manual on Fodder Bank Establishment and Management. Published by S.H.Z. Programme, ILCA Addis Ababa Ethiopia, P.18.

64. Otukelu, A.A.; Adebitan, S.A. and Pal, U.R. (1991). Groundnut-weed competition as affected by weeding regime and phosphorus in Guinea Savanna of Nigeria. A paper

presented at the 19th Annual Conference of the Weed Science Society of Nigeria, 1-5th December, 1991. IAR, A.B.U., Zaria.

5. Palmblad, I.G. (1968). Competition in experimental populations of weeds with emphasis on the regulation of population size. Ecology 49: 26-34.

3. Penning de vries, F.W.T. and Djiteye, A.M. (Eds.) (1982). La productivite des poturages Sahaliens. Une etude des, sols des vegetations et de'exploitation de cette resources maturelle. Agricultural Research Report. 918 pudoc. Wageningen P. 525.

'. Powell, J.M. (1984). Cropping systems in the subhumid zone of Nigeria. In: Proceedings of the Second ILCA/NAPRI. Symposium held at Kaduna, Nigeria, 29th Oct-2nd Nov., 1984. P.243-267. Published by ILCA Addis Ababa, Ethiopia.

68. Powell, J.M. and Waters-Bayer, A. (1984). Interactions between livestock husbandry and cropping system in West African Savanna. In: Proceedings of the International Savanna Symposium, 1984. (Eds.) Tothill, J.C. and Mott, J.C. published by Australian Academy of Sciences, Canberra.

69. Price, M.F. (1990). Humankind in the biosphere. The evolution of international interdisphinary research. Global Environmental Change (Human and Policy Dimensions) 1 (1): 3-13.

70. Puckridge, D.W. and French, R.J. (1983). The annual legume pasture in cereal-ley farming systems of Southern Australia: a review. Agricultural Ecosystems and Environment 9 (3): 229-267.

71. Radosevich, R.S. and Holt, S.J. (1984). Weed Ecology. Implications for vegetation management. John Weley and Sons New York, Pp. 93-105, 195-202, 227-241.

72. Rao, M.R.: Shethy, S.V.R.; Reddy,S.L.N. and Sharma, M.M. (1989). Weed management in improved rainfed cropping system in Semi arid India. ICRISAT Conference paper No. C P. 489.

73. Ross, M.A. (1969). The establishment of Seedlings and the development of patterns in grassland. Ph.D thesis University of Wales.

74. Sarma, J.S. and Yeung, P. (1985). Livestock products in the third world: Past trends and projections to 1990 and 2000. Research Reports, 49. International Food Policy Research Institute Washington D.C. P.23.

75. Schaffer, G. (1980). Ensuring mans food supplies by developing new land and preserving cultivated land. Applied Geography and Development 16: 7-27.

76. Siebert, F.S. and Scott, W.T. (1990). Influence of top soil removal and fertilizer application on peanut at yields from an Indonesian ultisol. Agricultural Ecosystems and Environments 32: 213-221.

77. Singh, R. and Yadav, S.K. (1989). Time and Methods of weed control in pearl millet. Experimental Agriculture 26: 319-324.

78. Skerman, P.J. (1977). Tropical forage legumes. FAO Plant Production and Protection Series No. 2 FAO Rome.

79. Snedecor G.W. and Cochran, W.G. (1967). Statistical Methods, 6th Ed. Iowa State Unveristy Press Ames.Iowa. P. 507.

80. Staniforth, D.W. (1957). Effects of annual grass weeds on the yield of corn Agronomy Journal, 49 (10): 551-555.

81. Tarawali, G. (1991). The residual effects of *Stylosanthes* fodder banks on maize yield at several locations in Nigeria Tropical Grasslands 25: 26-31.

82. Tarawali, G.; Mohamed-Saleem, M.A. and Von Kaufmann R. (1987). Legume-based cropping, a possible remedy to the land tenure constraints to ruminant production in the subhumid zone of central Nigeria. A paper presented at the PANESA Worshop held at Arusha (Tanzania) 27th-30th April, 1987.

83. Tromp, J. (1978). The effect of root temperature on the absorption and distribution of K, Ca, & mg in three root stock clones, of apple with coxs orange pippin. Garten back Wissen Schaft 43: 49-54.

85. Turner II, B. L.; Kasperson, R. E.; Mayer, B. W.; Dow, M. K. Golding, D.; Kasperson, X. J.; Mitchell, C. R. and Ratick, S. J. (1980). Two types of global environmental changes. Definitional and Spatial scale issues in their

human dimensions. Global Environmental Change (Human and Policy Dimension) 1 (1): 14-28.

85. Unamma, P.A.R. and Melifonwa, A. A. (1988). Critical period for weed removal in seed yam production from minisetts Nigerian Journal of Weed Science; 1: 11-16.

86. Utulu, S. N. (1987). Critical period of weed interference in oil palm (*Elaesis guinensis* Jaca.) Seedlings in the nursery. Nigerian Journal of Agronomy 2 (3) pp, 77-81.

87. Vallis, I and Gardener, C. J. (1984). Nitrogen imputs into agricultural systems by *Stylosanthes*. In: Stace, H. M. and Edje, L. A. (Eds.) The Biology and Agronomy of *Stylosanthes* Academic Press Australia pp. 359-379.

88. Von Kaufmann R. (1986). An introduction to the Subhumid zone of West Africa and the ILCA Subhumid zone Programme. Von Kaufmann R.; Chater, S. and Blench, R. (Eds). Proceedings of the Second ILCA/NAPRI Symposium, held at Kaduna, Nigeria. 29th October - 2nd November, 1984. Published by ILCA Addis Ababa Ethiopia pp. 11-36.

89. Whittaker, R. H. (1970). Communities and ecosystems: MacMillan London.

90. Wilson, R. T. (1989). Reproductive performance of African indigenous Small Ruminants under various Management systems: A Review Animal Production Science, 20: 265-286.

91. Zimdahl, R. L. (1980). Weed-Crop Competition. A review. International Plant Protection Centre, Corvallis Oregon U.S.A.

LIST OF APPENDICES

1 Herbaceous flora population prior to cropping.

Appendix 1.1ai: *Stylosanthes* Species population prior to cropping at Abet (plants/m^2) (1991)

Treatments	Blocks				Mean
	1	2	3	4	X
1	10	8	14	8	10.0
2	6	10	6	7	7.3
3	4	9	48	6	16.8
4	13	4	6	4	6.8
5	14	5	4	4	5.8
6	6	7	4	8	6.3
7	4	12	8	7	7.8
8	4	8	4	7	7.8
9	4	6	0	8	4.5
X	7.2	7.7	10.4	6.6	

A N O V A

Source	DF	SS	MS	F
Block	3	78.77	26.22	0.45 NS
Treatment	8	526.72	65.84	1.15 NS
Residual	24	1377.25	57.39	-
Total	35	1982.97		

CF $\frac{(GT)^2}{----} = \frac{(287)^2}{----} = 2288.03$

$$n \qquad 36$$

$$\text{Total SS} = V_1^2 + V_2^2 \ldots . V_{36}^2 - CF.$$

$$= 10^2 + 6^2 \ldots \ldots . 8^2 = 4271.00 - 2288.03$$

$$= 1982.97$$

$$\text{Blocks} = \frac{(\Sigma Blk1)^2 + (\Sigma Blk2)^2 \ldots . (\Sigma Blk4)^2}{\text{No. of treatment}} - CF$$

$$= \frac{65^2 + 69^2 + 94^2 + 59^2}{9} - CF$$

$$= 2367.00 - 2288.03$$

$$= 78.97$$

$$\text{Treatment ss} = \frac{(\Sigma \text{ Trt1})^2 + (\Sigma \text{ Trt2})^2 \ldots . (\Sigma Trt9)^2}{\text{No.4 blocks}} - CF$$

$$= \frac{(40)^2 + (29)^2 \ldots . (18)^2}{4} - 2288.03$$

$$= 526.75$$

Residual ss = Total ss - (Blocks + treatment ss)

= 1982.97 - 605.75

= 1377.25

Treatments

1 = No weeding (control)

2 = 1 x H/H <30DAP

3 = 1 X H/H >30DAP

4 = 2 X H/H

5 = 2 X H/H L.S.

6 = 2 X H/H L.S. at 2nd

7 = 1 x B/H <30DAP

8 = 1 X B/H >30DAP

9 = 2 X B/H DAP = Days afer planting

Appendix 1.1bi: *Stylosanthes* Species population prior to cropping at Kurmin Biri (plants/m^2) (1991)

Treatments	Blocks				Mean
	1	2	3	4	X
1	162	9	32	11	53.5
2	86	17	18	17	34.5
3	26	37	21	20	26.0
4	30	12	8	21	17.8
5	32	52	44	69	49.3
6	38	21	120	41	55.0
7	41	8	4	14	16.8
8	24	11	24	23	20.5
9	8	12	9	15	11.0
X	49.67	19.89	31.11	25.0	

A N O V A

Source	DF	SS	MS	F
Block	3	6360.97	2120.32	2.39 NS
Treatment	8	11223.50	1402.94	1.59 NS
Residual	24	21240.28	-	-
Total	35	38824.75		

F ratio not significant for both blocks and treatments at P(0.05).

457

NOV

Appendix 1.1ci: *Stylosanthes* Species population prior to cropping at Mazuga (plants/m^2) (1991)

Treatments	Blocks				Mean
	1	2	3	4	X
1	10	9	12	15	11.5
2	0	22	25	21	17.0
3	33	38	13	15	24.8
4	13	35	18	12	19.5
5	38	43	22	6	27.3
6	36	33	80	33	45.5
7	6	23	24	28	20.3
8	12	17	67	23	29.8
9	20	28	40	38	31.5
X	18.8	27.6	33.4	21.2	

A N O V A

Source	DF	SS	MS	F
Block	3	1188.22	396.10	1.93 NS
Treatment	8	3155.22	394.4	1.92 NS
Residual	24	4934.78	205.62	
Total	35	9278.22		

Appendix 1.1di: *Stylosanthes* Species population prior to cropping at Ganawuri (plants/m^2) (1991)

Treatments	Blocks				Mean
	1	2	3	4	X
1	10	44	8	0	15.5
2	6	5	5	30	11.5
3	14	12	6	16	12.0
4	20	12	19	9	15.0
5	32	8	19	16	18.8
6	13	8	9	9	9.8
7	16	4	19	10	12.3
8	20	9	26	12	16.8
9	15	8	7	4	8.5
X	16.2	12.2	13.1	11.8	

A N O V A

Source	DF	SS	MS	F
Block	3	1188.22	396.10	1.93 NS
Treatment	8	3155.22	394.4	1.92 NS
Residual	24	4934.78	205.62	
Total	35	9278.22		

Appendix 1.2aii: Grass population prior to cropping at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	68	99	147	88	99.0
2	78	51	56	55	60.0
3	62	42	30	28	40.5
4	11	127	76	71	91.3
5	36	60	49	62	51.8
6	44	70	69	37	55.0
7	80	68	72	48	67.0
8	109	60	70	63	75.6
9	73	80	47	67	66.8
X	71.2	73.0	68.4	57.0	

A N O V A

Source	DF	SS	MS	F
Block	3	1396.97	465.66	1.20 NS
Treatment	8	11242.50	1405.31	3.64*
Residual	24	9259.28	385.80	
Total	35	21898.75		

LSD (0.05) = 36.91

Treatment	X	Rank
1	99.0	a
2	60.0	bcd
3	40.5	d
4	91.3	ab
5	51.8	cd
6	55.0	bcd
7	67.0	abcd
8	75.6	abcd
9	66.8	abcd

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 1.2bii: Grass population prior to cropping at Kurmi Biri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	52	48	51	47	49.5
2	73	230	208	147	164.5
3	131	94	108	157	122.5
4	49	60	48	51	52.0
5	39	128	146	40	88.3
6	143	118	197	49	126.8
7	103	237	208	147	173.8
8	138	74	105	110	106.8
9	116	93	95	80	96.0
Mean X	93.8	120.2	129.6	92.0	

A N O V A

Source	DF	SS	MS	F
Block	3	9622.97	3207.41	1.8 NS
Treatment	8	60655.56	7581.15	4.8*
Residual	24	42243.77	1760.16	
Total	35	112521.56		

LSD (0.05) = 77.51

Treatment	X	Rank
1	49.5	d
2	164.5	ab
3	122.5	abcd
4	52.0	cd
5	88.3	bcd
6	126.8	abc
7	172.8	a
8	106.8	abcd
9	96.0	abcd

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 1.2cii: Grass population prior to cropping at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	159	168	160	156	160.8
2	112	83	148	106	112.5
3	235	214	160	133	185.5
4	225	223	170	172	197.5
5	104	146	129	130	127.3
6	162	160	162	147	157.6
7	112	103	145	105	116.3
8	152	149	148	152	150.3
9	118	150	136	147	150.3
Mean X	158.8	155.1	150.9	138.7	

A N O V A

Source	DF	SS	MS	F
Block	3	20642.98	688.33	1.33 NS
Treatment	8	27069.06	3383.63	6.54*
Residual	24	12416.27	517.35	
Total	35	41550.31		

LSD (0.05) = 42.13

Treatment	X	Rank
1	160.8	a
2	112.3	b
3	185.5	a
4	197.0	a
5	127.3	b
6	157.6	ab
7	116.3	b
8	150.3	b
9	150.3	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 1.2dii: Grass population prior to cropping at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	70	69	133	141	103.4
2	128	140	156	126	137.5
3	90	77	94	87	87.0
4	97	92	110	97	99.0
5	77	69	135	140	105.3
6	90	77	94	60	80.4
7	109	70	77	102	89.5
8	97	96	110	97	100.0
9	91	91	83	88	88.3
Mean X	94.3	86.8	110.2	104.2	

A N O V A

Source	DF	SS	MS	F
Block	3	2918.89	972.96	2.67*
Treatment	8	8966.56	1120.82	3.08*
Residual	24	8736.11	364.00	
Total	35	20621.56		

LSD for Blocks at P(0.05) = 23.55

Block	X	Rank
1	94.3	b
2	86.8	b
3	110.2	a
4	104.2	b

L. S. D. for treatments at P(0.05) = 35.34

Treatment	X	Rank
1	103.4	ab
2	137.5	a
3	87.0	b
4	99.0	b
5	105.3	a
6	80.4	b
7	89.5	b
8	100.0	b
9	88.3	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H DAP = Day after planting

Appendix 1.3aiii: Grass population prior to cropping at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	**109**	82	88	80	89.8
2	78	88	80	105	87.8
3	130	134	93	52	102.3
4	110	92	100	83	96.3
5	91	130	68	136	106.3
6	80	72	56	71	69.8
7	200	140	136	123	149.8
8	70	120	121	140	112.3
9	172	93	134	91	122.5
Mean (X)	115.6	105.7	97.3	97.9	

A N O V A

Source	DF	SS	MS	F
Block	3	1962.45	654.15	0.8 N.S
Treatment	8	16880.56	2110.07	2.83*
Residual	24	17910.55	746.27	
Total	35	36753.56		

LSD (0.05) Treatment = 50.6

Treatment	X	Rank
1	89.8	ab
2	87.8	ab
3	102.3	ab
4	96.3	ab
5	106.3	ab
6	69.3	b
7	149.8	a
8	112.0	ab
9	122.5	a

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 1.3biii: Grass population prior to cropping at Kurmin Biri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	28	30	30	24	28.0
2	134	105	103	108	112.5
3	36	67	86	81	67.5
4	72	54	33	97	64.0
5	94	78	88	67	81.8
6	77	84	83	82	81.5
7	106	100	104	116	106.5
8	145	91	170	188	148.5
9	81	46	50	77	63.5
Mean (X)	85.9	72.8	83.0	93.3	

A N O V A

Source	DF	SS	MS	F
Block	3	1956.31	652.10	1.68 N.S
Treatment	8	38872.00	4854.00	12.49*
Residual	24	9339.44	388.94	
Total	35	50162.75		

L.S.D for treatment = 23.55
(0.05)

Treatment	X	Rank
1	28.0	d
2	112.5	ab
3	67.5	c
4	64.0	cd
5	81.8	bc
6	81.5	bc
7	106.5	b
8	148.5	a
9	63.3	cd

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 1.3ciii: Grass population prior to cropping at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	192	165	163	160	170.0
2	117	147	151	862	319.2
3	168	230	251	162	202.8
4	284	171	233	127	208.8
5	213	293	180	199	221.3
6	180	171	173	204	182.0
7	401	745	272	113	382.8
8	223	286	210	304	255.8
9	152	138	225	79	148.5
Mean (X)					

A N O V A

Source	DF	SS	MS	F
Block	3	16719.56	5573.19	0.21 N.S.
Treatment	8	182916.50	22864.56	0.86 N. S.
Residual	24	640971.94	26707.16	
Total	35	840608.00		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 1.3diii: Grass population prior to cropping at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	43	42	79	44	52.0
2	58	70	50	90	67.0
3	60	51	52	55	54.5
4	63	43	51	41	49.5
5	43	56	59	50	50.8
6	64	68	90	60	70.5
7	97	100	53	74	81.0
8	48	51	55	70	56.0
9	77	144	69	70	82.5
Mean (X)	61.4	66.1	61.4	61.5	

A N O V A

Source	DF	SS	MS	F
Block	3	144.75	48.25	0.20 N.S.
Treatment	8	5399.56	674.95	2.78*
Residual	24	5820.11	242.5	
Total	35	11364.31		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.1ai: Posot first weeding *Stylosanthes* species population at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	3	11	6	4	6
2	10	6	4	3	5.8
3	3	11	2	18	8.5
4	2	13	5	0	5.0
5	5	14	4	0	5.8
6	6	5	98	7	2.9
7	7	9	7	11	8.5
8	4	5	5	4	4.5
9	6	8	2	19	8.8
X	5.1	9.1	14.8	7.3	

A N O V A

Source	DF	SS	MS	F
Block	3	461.42	153.81	0.59 N.S.
Treatment	8	1867.5	233.44	0.46
Residual	24	6497.83	270.74	
Total	35	8826.75		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

2

DAP = Day after planting

Appendix 2.1.1bi: Post first weeding *Stylosanthes* Species population at Kurmin Biri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	45	9	8	6	1.7
2	24	4	5	5	9.5
3	9	5	1	1	4
4	10	3	9	7	7.3
5	9	12	19	13	13.3
6	6	7	6	8	6.8
7	18	4	2	4	7
8	11	10	4	8	8.3
9	9	2	3	7	5.3
X	15.17	6.22	6.33	6.56	

A N O V A

Source	DF	SS	MS	F
Block	3	583.86	194.62	4.24*
Treatment	8	532.89	66.61	1.46 N.S
Residual	24	1100.11	45.87	
Total	35	2217.69		

L.S.D. for Blocks = $t_{0.05}$ x SEED 1 3

2.62 x 3.19 = 8.36

Block	X	Rank
1	15.17	a
4	6.56	b
3	6.33	b
2	6.22	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.1ci: Post weeding *Stylosanthes* Species Population at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	3	3	5	8	4.8
2	1	2	9	7	4.8
3	1	7	6	5	4.8
4	14	5	1	10	7.5
5	6	11	11	8	9
6	0	2	4	4	2.5
7	2	2	2	7	3.3
8	3	8	5	7	4.8
9	4	8	6	24	10.5
X	3.4	5.3	5.2	8.7	

A N O V A

Source	DF	SS	MS	F
Block	3	115.64	38.55	2.44 N.S.
Treatment	8	228	28.5	1.8 N.S
Residual	24	379.11	15.80	
Total	35	722.75		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.1di: Post first weeding *Stylosanthes* Species Population at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	9	2	2	2	3.8
2	2	3	7	5	4.3
3	4	2	2	1	2.3
4	3	5	10	5	5.8
5	3	4	12	3	5.5
6	3	6	8	4	5.3
7	3	4	6	2	3.8
8	8	3	3	6	5
9	3	7	3	2	3.8
Mean (X)	4.22	4	5.89	3.33	

A N O V A

Source	DF	SS	MS	F
Block	3	31.87	10.62	1.55 N.S
Treatment	8	40.06	5.01	0.73 N.S
Residual	24	164.38	6.85	
Total	35	236.31		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.2aii: Post first weeding grass Population at Abet (plants/m^2)1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	56	57	38	84	58.8
2	63	83	64	72	71.8
3	158	78	78	51	91.3
4	97	151	64	62	93.5
5	146	72	204	76	124.5
6	77	71	61	47	64.0
7	74	96	48	117	83.8
8	132	43	42	73	72.5
9	78	111	78	90	89.3
Mean (X)	98.4	79.1	75.2	74.7	

A N O V A

Source	DF	SS	MS	F
Block	3	3338.97	1112.99	0.87 N.S
Treatment	8	12520	1562.75	1.22 N.S
Residual	24	30651.78	1277.16	
Total	35	4640245		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.2bii: Post first weeding grass Population at Kurmin Biri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	117	15	46	68	61.5
2	104	49	47	24	56.0
3	21	52	20	26	29.8
4	56	9	19	30	28.5
5	15	7	26	16	16.0
6	74	9	18	11	28.0
7	39	25	37	67	42.0
8	24	29	27	23	25.8
9	27	19	12	87	36.3
Mean (X)	53	23.78	28	39.11	

A N O V A

Source	DF	SS	MS	F
Block	3	4608.5	1536.18	2.65*
Treatment	8	7002.72	875.34	1.52 N.S
Residual	24	1384.72	577.07	
Total	35			

L.S.D. for Blocks = 29.66
(P0.05)

Block	X	Rank
1	53.0	
4	39.1	
3	28.0	
2	23.8	

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.2cii: Post first weeding grass Population at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	321	413	137	190	266.3
2	214	204	107	729	163.5
3	301	142	185	207	2088
4	135	141	98	144	129.5
5	112	122	210	54	124.5
6	156	106	138	221	155.3
7	115	105	140	157	129.5
8	164	149	130	287	182.5
9	147	160	192	107	151.5
Mean (X)	18.5	17135	14856	16622	

A N O V A

Source	DF	SS	MS	F
Block	3	6130.44	2643.48	0.47 N.S
Treatment	8	66636.22	8329.53	
Residual	24	164409.56	4350.40	
Total	35	177176.22		

Appendix 2.1.2dii: Post first weeding grass Population at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	167	234	188	231	205
2	123	99	100	168	122.5
3	188	90	164	163	151.3
4	150	83	105	93	107.8
5	153	88	90	133	116
6	117	141	126	92	114
7	174	84	186	159	150.8
8	164	125	107	133	132.3
9	88	77	162	110	106.8
Mean (X)	14741	11344	13533	14033	

A N O V A

Source	DF	SS	MS	F
Block	3	5446.22	1165.4	1.67 N.S
Treatment	8	31372.14	3921.32	3.62 N.S
Residual	24	260224.53		
Total	35	52890.89		

L.S.D for Treatment = 61
P(0.05)

Treatment	X	Rank
1	205	a
3	151.3	ab
7	150.8	ab
8	132.3	b
2	122.5	b
5	116	b
6	114	b
4	107.8	b
9	106.8	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.3aiii: Post First weeding forbs Population at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	23	27	41	48	34.8
2	16	46	67	63	48.0
3	142	14	46	38	60.0
4	26	36	42	41	36.3
5	17	49	53	73	48.0
6	19	34	63	65	45.3
7	41	39	23	37	35.0
8	39	22	28	33	30.5
9	24	41	29	25	29.8
Mean (X)	38.6	34.2	43.6	47.0	

A N O V A

Source	DF	SS	MS	F
Block	3	849	283	0.47 N.S
Treatment	8	3245	405.63	0.67 N.S
Residual	24	14531	605.46	
Total	35	18625		

Appendix 2.1.3biii: Post First weeding forbs
Population at Kurmin Biri(plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	34	87	83	76	95.0
2	183	56	12	197	112.0
3	246	109	66	115	134.0
4	162	130	33	72	99.3
5	191	92	79	143	126.3
6	203	157	45	107	128.0
7	187	156	81	64	122.0
8	187	156	81	64	122.0
9	94	95	93	81	90.8
Mean (X)	174.1	120.0	65.6	116.4	

A N O V A

Source	DF	SS	MS	F
Block	3	53109.64	17703.2	6.60*
Treatment	8	16822.72	2102.84	0.78 N.S
Residual	24	64342.58	2680.94	
Total	35	134274.97		

L.S.D for Block = 63.95
(0.05)

Block	X	Rank
1	174.11	a
2	120	ab
3	116.44	ab
4	65.56	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.3cii: Post First weeding forbs
Population at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	93	57	213	140	125.8
2	184	131	126	163	151.0
3	79	134	160	258	182.8
4	172	199	86	139	149.0
5	56	90	211	235	148.0
6	35	233	137	101	126.5
7	149	142	76	107	118.5
8	333	117	112	222	196.3
9	37	204	130	79	112.5
Mean (X)	126.4	146.2	150.1	160.4	

A N O V A

Source	DF	SS	MS	F	
Block	3	4013.75	1337.92	0.23	N.S
Treatment	8	24766.14	3095.77	0.53	N,S
Residual	24	139232.44	5861.37		
Total	35	168012.64			

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.1.3diii: Post First weeding forbs
Population at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	126	45	125	44	85.0
2	95	41	83	88	78.5
3	99	82	91	120	98.0
4	124	145	66	147	120.5
5	142	61	136	87	106.5
6	69	44	93	157	95.8
7	89	48	54	114	76.3
8	94	49	65	75	70.8
9	104	75	85	103	91.8
Mean (X)	106.9	66.8	88.7	103.9	

A N O V A

Source	DF	SS	MS	F
Block	3	9467.92	3155.97	3.97*
Treatment	8	8185.75	1023.22	1.29 N.S
Residual	24	19094.03	795.59	
Total	35	36947.75		

L.S.D for Blocks = 30.94
P(0.05) 1 3

Block	X	Rank
1	106.89	a
4	103.89	a
3	88.67	ab
2	66.33	b

Appendix 2.2.1ai: Post Second weeding *Stylosanthes* Species Population at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	4	2	3	5	3.5
2	16	2	243	1	10.8
3	4	3	10	2	4.8
4	5	7	0	3	3.8
5	6	20	21	18	16.3
6	17	16	4	0	9.3
7	36	0	37	24	24.3
8	28	0	1	1	7.5
9	0	0	2	42	11.0
Mean (X)	12.9	5.7	11.3	10.7	

A N O V A

Source	DF	SS	MS	F
Block	3	272.45	90.82	< 1 N.S
Treatment	8	1437.06	179.63	1.32 N.S
Residual	24	3270.05	136.25	
Total	35	4979.56		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

Appendix 2.2.1bi: Post Second weeding *Stylosanthes* Species Population at Kurmin Biri(plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	80	8	18	6	30.3
2	18	2	10	15	11.3
3	21	6	6	7	10.0
4	10	3	5	6	6.0
5	14	15	19	31	19.8
6	8	5	4	13	8.5
7	16	4	10	4	8.5
8	14	17	11	10	13.0
9	12	4	8	10	8.5
Mean (X)	22.4	7.1	10.1	11.3	

A N O V A

Source	DF	SS	MS	F
Block	3	1212.75	404.25	2.31 N.S
Treatment	8	1897.5	237.19	1.35 N.S
Residual	24	4202.5	175.1	
Total	35	7312.75		

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

Appendix 2.2.1ci: Post Second weeding *Stylosanthes* Species Population at Mazuga(plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	5	6	10	6	6.8
2	1	5	2	2	2.5
3	0	5	1	2	2.0
4	7	2	0	5	3.5
5	4	9	11	7	7.8
6	2	3	4	2	2.8
7	0	4	1	3	2.0
8	1	7	5	1	3.5
9	3	4	2	8	4.3
Mean (X)	2.56	5	4	4	

A N O V A

Source	DF	SS	MS	F
Block	3	27.34	9.11	1.73 N.S
Treatment	8	135.56	16.95	3.21*
Residual	24	126.66	5.28	
Total	35	289.56		

L.S.D for Treatment = 4.27
(P0.05)

Treatment	X	Rank
5	7.8	a
1	6.8	ab
9	4.3	ab
8	3.5	b
4	3.5	b
6	2.8	b
2	2.5	b
7	2.0	b
3	2.0	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

Appendix 2.2.1di: Post Second weeding *Stylosanthes* Species Population at Ganawuri(plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	8	2	1	1	3.0
2	2	3	6	4	3.8
3	3	4	3	6	4.0
4	4	6	5	2	4.3
5	4	4	10	4	5.5
6	5	2	4	4	3.8
7	3	1	1	3	2.0
8	2	1	1	1	1.3
9	4	0	1	1	1.5
Mean (X)	3.89	2.56	3.56	2.89	

A N O V A

Source	DF	SS	MS	F
Block	3	22.78	7.59	2.27 N.S
Treatment	8	76	9.5	2.84^2
Residual	24	80.22	3.34	
Total	35	179		

L.S.D for Treatment = 3.38
P(0.05)

Treatment	X	Rank
5	5.5	a
4	4.3	ab
3	4.0	ab
6	3.8	ab
2	3.8	ab
1	3.0	ab
7	2.0	ab
9	1.5	b
8	1.3	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

Appendix 2.2.2aii: Post second weeding grass population at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	85	124	129	39	94.3
2	92	49	19	49	52.3
3	54	42	38	39	44.5
4	21	19	38	10	22.0
5	13	36	27	15	22.8
6	16	26	29	11	20.5
7	24	34	32	28	29.5
8	48	22	28	24	30.5
9	69	17	46	8	35.0
Mean (X)	46.9	41.0	42.9	24.8	

A N O V A

Source	DF	SS	MS	F
Block	3	2552.23	850.74	9.56*
Treatment	8	17279.56	2159.32	24.28* N.S
Residual	24	2135.59	88.98	
Total	35	29167.56		

L.S.D for Blocks = 11.66
(0.05)

L.S.D for treatment = 17.48

(0.05)

Blocks	X	Rank
1	46.9	a
2	42.9	a
3	41.0	a
4	24.8	b

Treatment	X	Rank
1	94.3	a
2	52.3	b
3	44.5	bc
4	22.0	b
5	22.8	c
6	20.8	c
7	29.5	c
8	30.5	c
9	35.0	c

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

Appendix 2.2.2bii: Post Second weeding grass Population at Kurmin Biri(plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	170	88	46	19	80.8
2	56	29	106	155	86.5
3	26	68	42	4	35
4	36	31	58	61	46.5
5	85	30	31	30	44.0
6	71	16	55	57	49.8
7	47	96	45	75	65.8
8	24	36	130	63	63.3
9	56	78	54	52	60.0
Mean (X)	63.4	52.4	63.0	57.3	

A N O V A

Source	DF	SS	MS	F
Block	3	733.45	244.48	0.15 N.S
Treatment	8	9346.89	1168.36	0.75 N.S
Residual	24	37361.55	1556.73	
Total	35	47441.89		

Appendix 2.2.2cii: Post Second weeding grass Population at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	240	156	221	183	200.0
2	134	169	142	171	163.5
3	134	67	91	78	92.5
4	96	81	49	84	77.5
5	67	74	48	51	60.0
6	131	83	79	134	106.8
7	229	233	113	139	178.3
8	118	81	51	64	78.8
9	56	53	56	60	56.3
Mean (X)	138.1	117.8	94.6	107.1	

A N O V A

Source	DF	SS	MS	F
Block	3	9088.75	3029.58	6.27*
Treatment	8	93322.06	11665.26	24.13*
Residual	24	11601.5	483.30	
Total	35	119012.31		

L.S.D for Blocks = 27.17
(0.05)

L.S.D for treatment = 40.74
(0.05)

Block	X	Rank
1	138.1	a
2	110.8	b
3	194.6	b
4	107.1	b

Treatment	X	Rank
1	200.0	a
2	163.5	b
3	92.5	bc
4	77.5	b
5	60.0	c
6	106.8	b
7	178.5	a
8	78.8	bc
9	56.3	c

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

1 3
8 = 1 x B/H >30 DAP

9 = 2 x B/H DAP = Day after planting

Appendix 2.2.2dii: Post Second weeding grass Population at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	188	290	164	263	266.3
2	183	77	152	110	130.5
3	126	45	125	44	85.0
4	95	48	83	88	78.5
5	98	50	52	112	78.0
6	78	92	64	50	71.0
7	99	82	91	120	98.0
8	89	93	45	157	96.0
9	94	75	65	50	71.0
Mean (X)	116.7	94.7	93.4	110.4	

A N O V A

Source	DF	SS	MS	F
Block	3	3603.12	1201.07	0.86 N.S
Treatment	8	78448.89	9806.11	6.98*
Residual	24	33713.55	1404.73	
Total	35	115765.64		

L.S.D for Treatment = 69.43
P(0.05)

Treatment	X	Rank
1	266.3	a
2	130.5	b
3	85.0	b
4	78.5	b
5	78.0	b
6	71.0	b
7	98.0	b
8	96.0	b
9	71.0	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.2.3aiii: Post Second weeding forbs Population at Abet (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	41	8	20	22	22.5
2	24	8	14	72	29.5
3	30	31	21	28	27.5
4	27	46	54	48	44.5
5	17	90	14	96	59.3
6	56	24	63	15	39.5
7	24	20	12	65	30.3
8	100	24	28	50	50.5
9	100	35	50	28	53.3
Mean (X)	46.6	31.8	30.7	47.1	

A N O V A

Source	DF	SS	MS	F
Block	3	2200.30	733.43	10.02*
Treatment	8	4615.22	576.90	7.88*
Residual	24	1757.46	73.23	
Total	35	24386.98		

L.S.D for Blocks = 10.56
(0.05)

L.S.D for treatment = 12.49
(0.05)

Block	X	Rank
1	46.6	a
2	31.8	b
3	30.7	b
4	47.1	a

Treatment	X	Rank
1	22.5	a
2	29.5	bc
3	27.5	bc
4	44.5	ab
5	54.3	a
6	39.5	b
7	30.3	bc
8	50.5	ab
9	53.3	a

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.2.3biii: Post Second weeding forbs Population at Kurmin Biri(plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	43	166	98	291	149.5
2	202	87	198	209	174.0
3	561	146	150	115	243.0
4	308	86	114	211	154.8
5	308	408	63	253	258.0
6	99	219	69	164	122.8
7	782	170	106	280	334.5
8	681	759	217	113	442.5
9	123	138	137	374	193
Mean (X)	334.1	242.1	128.0	216.7	

A N O V A

Source	DF	SS	MS	F
Block	3	194106.52	64702.17	2.17 N.S
Treatment	8	340717.80	42589.73	1.43 N.S
Residual	24	717203.98	298830.50	
Total	35	1252028.30		

Appendix 2.2.3ciii: Post Second weeding forbs Population at Mazuga (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	105	89	215	174	145.8
2	101	196	92	194	145.8
3	153	78	180	197	152.0
4	85	185	96	265	157.8
5	94	254	121	273	185.5
6	129	337	180	83	182.3
7	83	253	162	170	167.0
8	91	142	189	102	131.0
9	160	271	103	113	161.8
Mean (X)	11.2	200.6	148.7	174.6	

A N O V A

Source	DF	SS	MS	F
Block	3	39222.75	130725.58	2.84*
Treatment	8	9998.00	1249.75	0.27
Residual	24	110332.05	4697.17	
Total	35	159552.80		

L.S.D for Blocks = 83.74
(0.05)

Block	X	Rank
1	111.2	b
2	200.6	a
3	148.7	a
4	174.6	a

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 2.2.3diii: Post Second weeding forbs Population at Ganawuri (plants/m^2) 1991

Treatments	Blocks				Mean
	1	2	3	4	X
1	72	84	63	44	65.8
2	83	94	66	82	81.5
3	125	116	94	110	111.3
4	115	138	129	135	129.3
5	98	89	170	120	119.3
6	98	106	110	83	99.3
7	64	86	95	87	83.0
8	76	89	97	87	87.3
9	98	110	96	86	97.5
Mean (X)	92.1	101.3	102.2	92.7	

A N O V A

Source	DF	SS	MS	F
Block	3	798.31	266.10	0.95 N.S
Treatment	8	13036.50	1629.56	5.48*
Residual	24	6699.44	279.14	
Total	35	20526.75		

L.S.D for Treatments = 30.94
(0.05)

Treatment	X	Rank
1	65.8	a
2	81.5	bc
3	111.3	ab
4	129.3	a
5	119.3	ab
6	99.3	ab
7	83.0	bc
8	87.3	bc
9	97.5	b

Treatments

1 = No weeding (control)

2 = 1 x H/H <30 DAP

3 = 1 x H/H >30 DAP

4 = 2 x H/H

5 = 2 x H/H L.S.

6 = 2 x H/H L.S. at 2ND

7 = 1 x B/H <30 DAP

8 = 1 x B/H >30 DAP

9 = 2 x B/H

DAP = Day after planting

Appendix 3a: Analysis of Variance for Maize Grain Yield at Abet (1991).

Data file MAZ91MZG

Title: location 1=mzg, 2=ab, 3=gn, 4=kb

Function: ANOVA-2
Data case no. 37 to 72
Without selection

Two-way analysis of variance over variable 2
rep
with values from 1 to 4
and over variable 3
tmt
with values from 1 to 9

Variable 4
grain yld kg/ha

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	31869765.10			
Variable 2	3	6535513.79	2178504.597	2.77	.063
Variable 3	8	6487795.76	810974.470	1.03	.439
Error	24	18846455.55	785252.315		
Non-additivity	1	430590.12	430590.123	0.54	
Residual	23	18415865.43	800672.410		

Grand Mean= 2470.408 Grand Sum= 88934.700 Total Count= 36

Coefficient of Variation= 35.37%

Means for variable 4 for each value of 2

VAR 2	1	2	3	4
MEAN	2706.789	2551.156	1758.000	2865.689

Means for variable 4 for each value of 3

VAR 3	1	2	3	4	5
MEAN	1556.150	3377.700	2483.400	2771.400	3261.275

VAR	3	6	7	8	9
MEAN	2863.050	1976.800	2589.275	2654.425	

Appendix 3b: Analysis of Variance for Maize Grain Yield i-
Kurmin Biri (1991).
Data file MAZ91MZG

Title: location 1=mzg, 2=ab, 3=gn, 4=kb

Function: ANOVA-2
Data case no. 109 to 144
Without selection

Two-way analysis of variance over variable 2
rep
with values from 1 to 4
and over variable 3
tmt
with values from 1 to 9

Variable 4
grain yld kg/ha

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	29668601.21			
Variable 2	3	3317909.32	1105969.775	5.17	.006
Variable 3	8	21212580.43	2651572.554	12.39	.000
Error	24	5138111.46	214087.977		
Non-additivity	1	2069680.62	2069680.617	15.51	.000
Residual	23	3068430.84	133410.037		

Grand Mean= 3563.092 Grand Sum= 128271.300 Total Count= 36

Coefficient of Variation = 12.99%

Means for variable 4 for each value of 2

VAR	2	1	2	3	4
MEAN		3278.333	3529.133	3379.211	4065.689

Means for variable 4 for each value of 3

VAR 3	1	2	3	4	5
MEAN	1746.950	3566.900	2845.075	3771.975	4027.375

VAR 3	6	7	8	9
MEAN	4277.150	4086.100	3517.700	4232.600

Appendix 3C: Analysis of Variance for Maize Grain Yield at Mazuga (1991).
Data file MAZ91MZG

Title: location 1=mzg, 2=ab, 3=gn, 4=kb

Function: ANOVA-2
Data case no. 1 to 36
Without selection

Two-way analysis of variance over variable 2
rep
with values from 1 to 4
and over variable 3
tmt
with values from 1 to 9

Variable 4
grain yld kg/ha

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	24030837.36			
Variable 2	3	3717967.31	1239322.437	4.38	.013
Variable 3	8	13518094.03	1689761.753	5.97	.000
Error	24	6794776.02	283115.667		
Non-additivity	1	548614.22	548614.219	2.02	.168
Residual	23	6246161.80	271572.252		

Grand Mean = 3345.136 Grand Sum= 120424.900 Total Count = 36

Coefficient of Variation = 15.91%

Means for variable 4 for each value of 2

VAR 2	1	2	3	4
MEAN	3734.844	3130.178	2929.544	3485.978

Means for variable 4 for each value of 3

VAR	1	2	3	4	5
MEAN	2591.550	4278.950	2949.700	3674.350	3573.975

VAR	3	6	7	8	9
MEAN	3600.050	3900.550	2497.625	3092.975	

Appendix 3d: Analysis of Variance for Maize Grain Yield at Banawuri (1991).

Data file MA191MZG

Title: location 1=mzg, 2=ab, 3=gn, 4=kb

Function: ANOVA-2
Data case no. 73 to 108
Without selection

Two-way analysis of variance over variable 2
rep
with values from 1 to 4
and over variable 3
tmt
with values from 1 to 9

Variable 4
grain yld kg/ha

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	20353742.95			
Variable 2	3	3875928.86	1291976.286	3.33	.036
Variable 3	8	7177589.13	897198.641	2.32	.053
Error	24	9300224.96	387509.373		
Non-additivity	1	2755088.71	2755088.706	9.68	.004
Residual	23	6545136.25	284571.141		

Grand Mean= 1666.197 Grand Sum= 60055.100 Total Count= 36

Coefficient of Variation= 37.32%

Means for variable 4 for each value of 2

```
VAR   2          1          2          3          4
MEAN      1276.050   1071.000   1544.087   2160.144

Means for variable  4  for each value of  3

VAR   3          1          2          3          4          5
MEAN       919.975   1133.000   1348.300   1970.825   2345.225

VAR   3          6          7          8          9
MEAN      1981.275   1465.850   1812.125   2037.200

Appendix 4a: Analysis of variance for herbage dry matter yield
             after Grain Harvest at Abet (1991)
 Data file   WEED91

Title: Weed management trial (1991) loc 1=ab 2=kb 3=gn 4=mz

Function: ANOVA-2
Data case no.  1  to  36
Without selection

Two-way analysis of variance over variable  3
rep
with values from  1  to  4
                          and over variable  2
tmt
with values from  1  to  9

Variable  5
t_dry matter yield

A N A L Y S I S   O F   V A R I A N C E   T A B L E

                Degrees of      Sum of
                   Freedom     Squares   Mean Square   F-value   Prob
-------------------------------------------------------------------------
Total                   35 35001285.24
Variable  3              3  1202507.84     400835.945      1.86   .163
Variable  2              8 28626186.95    3578273.369     16.60   .000
Error                   24  5172590.46     215524.602
-------------------------------------------------------------------------
Non-additivity           1     2464.23       2464.229      0.01
Residual                23  5170126.23     224788.097
-------------------------------------------------------------------------

Grand Mean =   2393.828  Grand Sum =   86177.800  Total Count =  36

Coefficient of Variation=   19.39%
```

Means for variable 5 for each value of 3

VAR 3	1	2	3	4
MEAN	2518.133	2582.956	2108.133	2566.089

Means for variable 5 for each value of 2

VAR 2	1	2	3	4	5
MEAN	4077.000	3291.000	2691.000	2475.550	2815.600

VAR 2	6	7	8	9
MEAN	1400.000	1502.400	2061.100	1230.800

Appendix 4b: Analysis of Variance for Herbage Dry Matter Yield after Grain Harvest at Kurmin Biri (1991).

Data file WEED91

Title: Weed management trial (1991) loc 1=ab 2=kb 3=[illegible] 4=m2

Function: ANOVA-2
Data case no. 37 to 72
Without selection

Two-way analysis of variance over variable 5
rep
with values from 1 to 4
and over variable 2
tmt
with values from 1 to 9

Variable 5
f_dry matter yield

ANALYSIS OF VARIANCE TABLE

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	87031146.20			
Variable 3	3	1351615.84	450538.614	0.65	
Variable 2	8	69225787.68	8653223.460	12.[illegible]	.000
Error	24	16453742.68	685572.612		
Non-additivity	1	3636062.53	3636062.526	6.[illegible]	.017
Residual	23	12817680.15	557290.441		

Grand Mean = 3259.467 Grand Sum = 117340.799 Total Count = 36

Coefficient of Variation= 25.40%

Means for variable 5 for each value of 3

VAR 3	1	2	3	4
MEAN	3272.622	3570.889	3119.356	3084.000

Means for variable 5 for each value of 2

VAR 2	1	2	3	4	5
MEAN	6752.000	2435.000	3202.000	2136.000	3573.000

VAR 2	6	7	8	9
MEAN	2338.000	3913.100	3017.000	1949.100

Appendix 4C: Analysis of Variance for herbage dry matter yield after grain harvest at Mazuga (1991)

Data file WEED91

Title: Weed management trial (1991) loc 1=ab 2=kb 3=ng. 1=a.z

Function: ANOVA-2
Data case no. 109 to 144
Without selection

Two-way analysis of variance over variable 3
rep
with values from 1 to 4
and over variable 2
tmt
with values from 1 to 9

Variable 5
f_dry matter yield

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	%125136574.25			
Variable 3	3	10359691.89	3453230.630	2.96	.052
Variable 2	8	86801302.60	10850162.825	9.31	.000
Error	24	27975579.76	1165649.156		
Non-additivity	1	13931610.66	13931610.658	22.62	.000
Residual	23	14043969.10	610607.352		

Grand Mean = 5207.633 Grand Sum = 187474.800 Total Count = 36

Coefficient of Variation = 20.73%

Means for variable 5 for each value of 3

VAR	3	1	2	3	4
MEAN		6105.911	5131.911	4804.756	4787.956

Means for variable 5 for each value of 2

VAR	2	1	2	3	4	5
MEAN		8093.000	4264.900	4392.100	3301.000	6793.000

VAR	2	6	7	8	9
MEAN		4972.000	5715.000	4590.000	4122.700

Appendix 4d: Analysis of Variance for Herbage Dry Matter Yield after Grain Harvest at Ganamuri (1991).

Data file WEED91

Title: Weed management trial (1991) loc 1=ab 2=kb 3=gn 4=mz

Function: ANOVA-2
Data case no. 72 to 108
Without selection

Two-way analysis of variance over variable 3
rep
with values from 1 to 4
and over variable 2
tmt
with values from 1 to 9
DUPLICATE FOR VAR 3 = 4 AND VAR 2 = 9
VAR 5 = 1649.199951171875 AND 3124.800048828125

Variable 5
1_dry matter yield

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	%109867907.48			
Variable 3	3	303610.03	101203.345	0.29	
Variable 2	8	%101130923.86	12641365.483	35.98	.000
Error	24	8433373.59	351390.566		

Non-additivity	1	1145464.27	1145464.269	3.61	.069
Residual	23	7287909.32	316865.622		

Grand Mean = 4369.861 Grand Sum = 157315.000 Total Count = 36

Coefficient of Variation= 13.57%

Means for variable 5 for each value of 3

VAR 3	1	2	3	4
MEAN	4293.289	4337.156	4322.444	4526.556

Means for variable 5 for each value of 2

VAR 2	1	2	3	4	5
MEAN	8627.000	5363.900	4064.000	3417.300	3913.800

VAR 2	6	7	8	9
MEAN	3928.000	4163.000	3452.300	2399.450

Appendix 5.1ai: Analysis of Variance for Total Herbage Dry Matter Yield at Abet (1992)

Data file WFREQ92

Title: Location 1 = Abet, 2 = K'Biri

Function: ANOVA-2
Data case no. 1 to 36
Without selection

Two-way analysis of variance over variable 2
Rep
with values from 1 to 4
and over variable 1
Tmt
with values from 1 to 9

Variable 3
Total prod.

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F-value	Prob
Total	35	%183042802.00			
Variable 2	3	27379236.44	9126412.148	2.32	....

Variable 1	8	61359372.50	7669796.683	1.75	.093
Error	24	99305152.06	5929383.002		
Plot Quality	1	3091917.12	3091917.147	0.5	
Residual	23	96253774.91	5914638.474		

Grand Mean = 4292.000 Grand Sum = 154512.000 Total Count = 36

Coefficient of Variation= 46.1%

Means for Variable 3 for each value of 2

VAR	2	1	2	3	4
MEAN		5647.750	2937.556	4576.222	3938.444

Means for variable 3 for each value of 1

VAR	1	1	2	3	4	5
MEAN		5795.250	6378.750	5468.750	4735.000	5952.500

VAR	1	6	7	8	9
MEAN		2385.500	3053.750	3448.250	3170.250

Appendix 5.1bii Analysis for Total Herbage Yield at Kurmin Biri(1992)

Data file: MTCD92

Title: Location 1 = Abet, 2 = K Biri

Function: ANOVA-2
Data case no. 37 to 72
Without selection

Two way analysis of variance over variable 2
Rep
with values from 1 to 4
and over variable 1
Tmt
with values from 1 to 9

Variable 3
Total prod.

A N A L Y S I S O F V A R I A N C E T A B L E

	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob

Appendix 6.1: Analysis of the day matter yields of *Stylosanthes* spp prior to cropping and after crop harvedst in the first year of sowing at Abet

Treatment	Before Cropping	After crop harvest	Z	Z^2
1	228	375	147	21609
2	365.1	268	97.1	9428.41
3	214.4	191.1	23.3	542.89
4	347.7	92.6	255.1	65076.01
5	477	1186.4	709.4	503248.36
6	203.1	330	126.9	16103.61
7	149.9	245	95.1	9044.01
8	270.8	258	12.8	163.84
9	124.6	152.4	27.8	772.84
Mean (X)	264.5	344.5	1494.5	625988.97

$$Z = \frac{1494.5}{9} = 166.06$$

$$S = = \frac{625988.97 - \frac{(1494.5)^2}{9}}{8}$$

where n = 9

$$= \frac{625988.97 - \frac{2233530.25}{9}}{8}$$

$$= \frac{625988.97 - 248170.03}{}$$

$$= \frac{377818.94}{8}$$

$$= 47227.37$$

$$= 217.32$$

$$t = \frac{Z}{\frac{S}{\sqrt{n}}} = \frac{166.06}{\frac{217.32}{\sqrt{9.}}}$$

$$= \frac{166.06}{\frac{217.32}{3.}}$$

$$= \frac{166.06}{72.44}$$

$$= 2.29$$

Tabulated t at 5% lelvel of significance = 2.26

at 10% 1.83

Abet calculated t = 2.29 No.1 significant at 5%

significant at 10%

Kurmin Biri calculated t = 1.78 therefore not signifi cant at 5% or 10% levels of significant

Mazuga calculated t = 1.95 not signifciant at 5% significant at 10%.

Ganawuri = calculated t = 13.66 significant at both 5% & 10%.

6.2 *Stylosanthes* dry matter prior to cropping and at the end of the second year after cropping

I. Abet

$$t = \frac{Z}{\frac{S}{\sqrt{n.}}} = \frac{1496.41}{\frac{957.44}{\sqrt{9.}}}$$

$$= 4.69$$

Tabulated t = 2.26 at 5% and t = 1.83 at 10%

Hence the difference between the mean of legume biomass in the second year after sowing is significantly dif ferent from the mean prior to cropping.

II. Kurmin Biri

$$t = \frac{699.12}{\frac{417.94}{\sqrt{3}}}$$

$$= \frac{699.12}{139.3}$$

$$= 5.02$$

Difference is significant at both 5% and 10% levels of significance.