

EFFECT OF PHOSPHORUS LEVEL AND DEFOLIATION DATE ON  
SEED PRODUCTION OF STYLO (STYLOSANTHES  
GUIANENSIS CV. SCHOFIELD) IN  
THE SOUTHERN GUINEA SAVANNA  
ZONE OF NIGERIA

BY

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THESIS APPROVAL

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## ABSTRACT

During 1979-1981, three experiments were conducted to investigate the effect of phosphorus and defoliation on the growth, seed production and percentage seed germination of *S. guianensis* cv. Schofield, using a split plot design.

1. Experiment I considered the effect of five phosphorus levels (0, 30, 60, 90 and 120 kg P/ha) on seedling emergence, dry matter (DM) yield, herbage chemical composition and seed yield of *S. guianensis*. Counting and cutting dates constituted the sub-plots for seedling emergence and DM yield while seed harvesting date formed the sub-plot for chemical composition and seed yield.

2. In experiment II the effect of five defoliation treatments (no defoliation compared with defoliation on 25/7, 25/8, 25/9 and 25/10/79 = Main plot) on seed yield of *S. guianensis* regrowth was sought. The sub-plot treatment was different seed harvesting dates.

3. Experiment III examined the effect of five level of phosphorus on percent germination of *S. guianensis* seed harvested on different dates from 3/1/81 to 14/3/81.

The number of seedlings emerging increased progressively with increasing level of P. By the 14th day of sowing, approximately 75 percent of the total seedlings counted on day 21 had emerged. DM yield increased from 13.5t/ha without

P to 15t/ha with 120kg P/ha in the year of establishment. The corresponding DM yield values two years after (1981) in response to residual P were 14t and 19.2t/ha respectively.

Percentage crude protein in tops rose with additional P and declined with delay in harvesting as hay. Crude fibre, ether extract, ash and nitrogen free extract percentage were not consistent in respect of either P or date of cutting.

Seed yield in the first year (1979/80) maximised at 60 kg p/ha and tended to decline at higher P doses. In 1980/81 however, seed yield response to residual P reflected the level of P applied in the 1979 growing season. Late January/mid February appeared the most suitable for harvesting *S. guianensis* cv. Schofield for seed. On this basis, and using modest P (30 to 60 kg P/ha), standing seed yield varied from 325 to 434 kg/ha for the 1979/80 crop. The corresponding total seed yield values were 387 to 507 kg/ha and 346 to 445 kg/ha, respectively. Seed yield declined considerably after mid-February due to severe pod shedding (standing seed) and intensified seed gathering by harvester ants (fallen seed).

Defoliation between late July and late September resulted in the highest seed yield when seed harvesting occurred in mid-February. The data suggested that *S. guianensis* cv. Schofield regrowth could be for conservation up to late September without

necessarily causing any observable reduction in subsequent total seed yield.

P had no effect on seed germination. The number of fallen seed germinating significantly exceeded that of standing seed.

## CHAPTER 1

### INTRODUCTION

Legumes have a considerable potential for enhancing grazing resources. This occurs largely by directly adding to the total sward dry matter (DM) and nitrogen (N) yield (Schofield, 1945; Adegbola, 1964; Stobbs, 1966) and indirectly by providing the associated grasses with N (Cowling, 1961; Horrel and Newhouse, 1966). In south western Nigeria, Moore (1962) recorded a total fixation of 280 kg N/ha from a giant star grass (Cynodon nlemfuensis)/centro (Centrosema pubescens) mixture, in which the legume was found to have raised the N content of the grass from 1.8 to 2.4 percent. In the Northern Guinea Savanna Zone of Nigeria, a stylo (Stylosanthes guianensis)/Rhodes grass (Chloris gayana) mixed sward yielded the same dry matter (DM) and crude protein (CP) as a C. gayana sward receiving 84 kg N and 187 kg N/ha, respectively (Haggar, 1971).

Economic livestock production from the Guinea Savanna of Nigeria should rely on legume-based rather than nitrogen-fertilized tropical grass pastures because of the inadequate rainfall and poor soil conditions. However, considerable research on the forage and seed yield potential of the more

promising legume species and varieties is necessary to facilitate selection for specific requirements in terms of either sown pastures or range improvement.

Ample supply of clean, viable and true to type seed of the improved grasses and legumes (Humphreys, 1977) is key to successful pasture development. At present, Nigeria imports even its limited seed requirements for research and small scale production. In addition to high costs in terms of foreign exchange, imported seed could accommodate noxious weeds and seed-borne diseases. Consequently there is the urgent need to initiate local seed production programmes.

Although tropical legumes have capacity for high seed yield, seed recovery from them is mostly poor (Bogdan, 1977). Substantial improvement could be achieved through good management and would involve appropriate timing of seed harvest, efficient seed cleaning procedure and availability of good storage facilities.

The objective of this work was to investigate the seed yield responses of *S. guianensis* cv. Schofield to different levels of P and timing of seed harvest. The influence of stage of crop growth when defoliated on subsequent seed yield was also investigated. It was envisaged that the findings

from this study might assist in recommending a suitable level of P for the seed production of this cultivar. The defoliation study could point to the most appropriate time of cutting for hay or silage without drastically reducing seed yield.

## CHAPTER 2

## LITERATURE REVIEW

## 2.1 SELECTION OF ENVIRONMENT FOR SEED PRODUCTION

## 2.1.1 Site

Whilst pasture seed yield is influenced by site, varieties differ markedly in adaptation to a given environment. Some crops such as S. guianensis and C. pubescens are ubiquitous and will grow well on a wide range of soil types (Humphreys, 1979). S. guianensis tolerates a degree of waterlogging and a great measure of water stress (Gilchrist, 1967; Teitzel and Mortiss, 1971). On the other hand, poorly drained sites are unsuitable for leuceana (Leuceana leucocephala) and glycine (Glycine wightii) (Humphreys, 1979). Areas chosen for seed production should be in climatic zones where a pronounced dry season coincides with seed ripening. Heavy rainfall and high humidity at harvesting make production far more difficult, if not impossible (Jones and Roe, 1976).

## 2.1.2 Soil

A free draining soil of moderate fertility is recommended because highly fertile soils often cause excessive weed problems particularly with legumes (Jones and Roe, 1976).

In this connection, virgin grassland, and to some extent woodland sites, support less weed competition than land previously under cultivation. According to Humphreys (1979), the physical characteristics of the soil should be suited to intermittent cultivation and a level land is an advantage especially if ground seed recovery is to be employed, as is sometimes the case with Townsville stylo (S. humilis) and siratro (Macroptilium atropurpureum). Since oxygen is needed for absorption of N and other nutrients by plant roots, seed crop soils must have good soil aeration.

Ahlgren (1956) recorded that many forage crops require a pH of 6.0 to 7.0 for best growth and that few forage crops would grow satisfactorily at pH below 5.5 or above 8.5. Munns (1968) found that a pH of 4.5 stopped nodulation in lucerne (Medicago sativa) but did not prevent root growth. However, many tropical legumes such as lotononis (Lotononis bainesii), S. guianensis Cv. Schofield, M. atropurpureum and Kaimi clover (Desmodium canum) have been found to thrive at pH as low as 4 without the addition of lime provided other nutrients were supplied in adequate amounts (Skerman, 1977).

### 2.1.3 Climatic factors

#### 2.1.3.1 Radiation

Crops grown in areas with high radiation have a greater potential for seed production as seed yield is influenced by rapid early crop growth rates which determine flower number, and on continued photosynthesis during grain filling (Hesketh, 1963). In addition, flower opening and insect activity are greater in bright sunlight. Crops grown in the northern states of Nigeria have a higher potential for seed yield than their southern states counter parts because of the higher radiation levels (172.6 compared with 133.2 Kcal/cm<sup>2</sup>/yr) and greater rate of DM yield (Kassam and Kowal, 1973). Most tropical pasture legumes are shade intolerant and under such low levels of radiation, growth and seed production can be drastically reduced.

#### 2.1.3.2 Daylength

Flowering response is controlled mostly by daylength (the relative length of the light and dark periods) and this response determines where and when seed crops of particular cultivars can be away from their native environment (Loch, 1980). Variation in daylength increases with higher latitudes. Short-day plants, whose critical

photoperiods are more than 12 hours, flower progressively earlier, as the latitude decreases (Cameron, 1967). Most tropical pasture legumes belong to this group (Akinola, 1981 personal communication).

#### 2.1.3.3 Temperature

Temperature affects vegetative growth and all the reproductive phases of plant development such as floral induction, inflorescence differentiation, blooming, pollen germination, seed setting and seed maturation (t'Mannetje, 1965; Chailakhyan, 1968). Though tropical pasture legumes have a temperature optimum for growth of about 30°C, G. wightii does not set seed at temperature above 27°C (Wutoh et al., 1968). Temperature regimes of 28 - 25°C and 35 - 30°C prevented flowering in S. humilis (Cameron, 1967) and in S. guianensis and caribbean stylo (S. hamata cv. Verano) (t'Mannetje, 1965) respectively. Different selection of S. humilis have varying optimum temperature regimes for good seed production, but seeds in none of these, mature at night temperatures below 10°C (Skerman and Humphreys, 1973). Sites which are suitable for seed production can be made unsuitable if its condition of temperature and humidity are such that would support high incidence of diseases.

Botrytis cinerea, a parasitic fungus which adversely affect S. guianensis, flourishes under cool moist conditions (Loch et al., 1976a).

#### 2.1.3.4 Rainfall

A knowledge of the annual amount and distribution of rainfall of an environment is a useful guide in site selection for seed production. Skerman (1977) suggested that very high rainfall adversely affects the growth of some leguminous cold species and a dry season or very cold season could be useful in suppressing insect pest and diseases. He recommended that an area with a uniform medium rainfall of 1,250 to 1,750 mm generally gives the best performance. A dry season during seed harvesting period is required for reliable seed production.

##### 2.1.3.4.1 Humidity

Pollination and pollen germination of many tropical species are greatly handicapped by high humidity. High atmospheric humidity has indirect effects on pathogens and insect population. It is negatively related to the incidence of dehiscence (shattering) which may cause substantial seed losses in legume seed crop such as C. pubescens and M. atropurpureum before harvest.

## 2.2 CROP HUSBANDRY OF TROPICAL PASTURE LEGUME GROWN FOR SEED PRODUCTION

### 2.2.1 Establishing the pasture legume crop.

No amount of seed will ensure a successful establishment if the resident vegetation has not been destroyed before sowing.

Tropical pastures are sown at about  $10^6$  to  $7 \times 10^6$  seeds/ha (Humphreys, 1980) whereas natural seed load already in pasture soils may be  $50 \times 10^6$  to  $500 \times 10^6$  seeds/ha (Johnston et al. 1969); Jones and Evans, 1977).

Successful pasture establishment is obtained by providing the right conditions for seeds or cuttings to sprout and grow and by eliminating unwanted species (Humphreys, 1980).

Favourable conditions for establishment include good soil aeration and reduced competition for air, moisture and nutrients from existing vegetation.

#### 2.2.1.1 Land preparation

To a large extent, the degree of seed bed preparation necessary for a successful crop establishment depends on the nature of the vegetation present, the sort of seed being sown and the use to which a crop will be put. Large seeded legumes will often tolerate poorer seed bed conditions than small seeded grasses. Pasture meant for grazing alone

requires less thorough seed bed preparation compared with a seed crop. Full land preparation which produces an even seed bed will facilitate subsequent husbandry and harvest operations (Humphreys, 1979). For a seed crop, the initial ploughing is often made with a heavy disc implement, followed by harrowing and rolling to give a firm level seed bed. However, on sloping land, too fine a seed bed presents erosion risks. In this case, a rough seed bed with contour-worked ridges and furrows remaining will trap run-off and ensure good moisture conditions, for seedling establishment in the furrows (Humphreys, 1980).

#### 2.2.1.2 Sowing time

The best time to sow varies with the species and location. On new agricultural lands, seed could be grown when rainfall has become steady. On the other hand, use of old agricultural lands where weed competition is a problem, might involve a delay in sowing to allow weed seeds to grow and be ploughed under before sowing. Species such as greenleaf desmodium (Desmodium intortum) requiring a long growing period before flowering, should be grown soon after the true rains (Agishi, 1981 personal communication). At Nsukka, south-eastern Nigeria, early sowing of S. guianensis resulted in

heavy vegetative growth and poor seed yield (Okigbo, 1972).

#### 2.2.1.3 Sowing method

Pasture seed crop can be grown in rows or in swards, but row culture is often recommended because of less seed rate, easier off type and better weed control, apart from the added advantage of reduced competition for light, moisture and nutrients (Humphreys, 1979). The distance between rows depends on the mode of growth of the species. Species that tiller profusely or produce a lot of runners require wider row spacings than bunch type species. For most seed crops, the recommended row spacings range between 30 to 90 cm, though row spacings as high as 180cm for S. guianensis have been suggested (Adegbola, 1965).

#### 2.2.1.5.2 Seed rate

The best establishment occurs from seed with high scores in terms of vigour and germinability. Further more, such seeds must be free from weed seeds, pest and diseases. Seed treatment with chemicals (dieldrin) may be required to avoid ant theft (Roeleveld and de Leeuw, 1977). Skerman (1977) suggested high initial seeding rate of two to three times the normal recommendation for pasture purposes.

#### 2.2.1.4 Hardseededness

Seed dormancy, caused by hardseededness, is a natural protective phenomenon which prevents the seed of a population from germinating all at once, thereby insuring it against environmental hazards such as rainfall cessation early in the growing season. Hardseededness decreases naturally with age and upon either exposure to alternating or high temperatures or subjection to mechanical, chemical or hot water scarification (Gilbert and Shaw, 1979).

##### 2.2.1.4.1 Mechanical scarification

Skerman (1977) reported that while small seed lots can be scarified by rubbing the seed lightly between two pieces of emery or sand paper, large parcels of G. wightii seed have been successfully scarified in a cement mixer containing some gravel in Brazil. He added that commercial rice hullers were also effective.

##### 2.2.1.4.2 Chemical treatment

Although alcohol or acetone will dissolve some of the substance inhibiting germination in hard seed, treatment with concentrated sulphuric acid is more commonly used.

Grundy (1959) in Tanzania emersed hardseeds in concentrated sulphuric acid, using 4.5 litres of acid per 55kg of seeds treated. The length of time varied between 25 minutes for M. atropurpureum and 5 minutes for D. intortum. Seeds were washed and dried immediately after treatment. This acid treatment increased germination in hand harvested M. atropurpureum from 10-95 percent (Skerman, 1977). Wycherley (1960) succeeded in breaking dormancy in Puero (Pueraria phaseoloides) and C. pubescens by soaking them in warm glycerine at 50°C for one hour.

#### 2.2.1.4.3 Hot water treatment

Humphreys (1978) recommended hot water treatments ranging from 80°C for 2 minutes for L. leucocephala to 70°C for 6 minutes for M. atropurpureum to 55°C for 20 minutes for S. guianensis and S. humilis. Similarly Agishi (1971) found 60 to 70°C for 15 minutes to be ideal for S. guianensis cv. cook. The robust pod of S. hamata cv. Verano protected the seed from hot water treatment of 65 to 80°C for 5 minutes (Gilbert and Shaw, 1979).

A cold pretreatment followed by heat treatment produced better germination result in S. guianensis (Brolman, 1975).

Dry heat treatment on S. humilis previously cooled at 0°C contained fewer hard seed than that cooled at 5°C (Butler, 1978).

#### 2.2.1.4.4 Other methods

Wycherley (1960 reported that 8 hours exposure to infrared lamps (150 watts, Philips infraphil type 13373F/479) enhanced germination of calopo (Calopogonium mucunoides).

#### 2.2.1.5 Vegetative propagation

Pasture legumes may be vegetatively propagated as this hastens multiplication and also maintains the genetic purity of the species planted for seed (Humphreys, 1979). Nwosu (1961) observed that S. guianensis cuttings taken from the parent shoot or primary branches survived and foliated better than those taken from relatively immature plant parts, while cuttings from distal plant portions may not produce seed in the year of establishment (Adegbola, 1965). Paul (1948) in Sri Lanka and Vivian (1959) in Malaya recommended the planting of terminal portions of S. guianensis shoot in preference to the basal part. Planting stem cuttings into moist soils has

proved more successful than other vegetative propagation techniques (Humphreys, 1979). This method has been used for S. guianensis and S. humilis.

#### 2.2.1.6 Fertilizer requirement

Proper fertilizer application is an important prerequisite for maximum returns. Some elements play a specific role in seed production while others provide basic nutrients for normal crop growth. Andrew (1976) observed that extreme nutrient deficiency may result in seedling death. Evenness of fertilizer application is essential in reducing the variability of flowering time (Skerman, 1977; Humphreys, 1979).

#### Method of application

Fertilizer can be applied either by surface broadcasting or incorporating them into the soil through drilling, discing or harrowing. Humphreys (1980) indicated that more efficient responses could be obtained if fertilizer was incorporated into the soil rather than surface broadcast. The fertilizer should be drilled preferably in a bound, but separated from the seed.

## Macronutrient

## Phosphorus (P)

P influences legume growth and P deficiency more than the deficiency of any other element, limits the realization of their production potential. Although Blunt and Humphreys (1970) reported that P level (11.2 to 89.7 kgP/ha) had no effect on seed emergence, Harty (1967) observed that germination declined with P rate of 22 kg/ha and was completely inhibited by rates above 45 kgP/ha in Townsville stylo. At Ile-Ife, P. phaseoloides did not respond to P application in a loamy sand soil (Bray P = 12 ppm) (Falade, 1973).

There is evidence to show that P is necessary for rapid establishment of tropical legume (Jamieson, 1969; Teitzel and Bruce, 1971). Shelton and Humphreys (1971) and Rickert and Humphreys (1970) recorded a much larger P response in the seedling growth phase than at the later stage of development of S. humilis. However Wendt (1970) reported that C. pubescens, M. atropurpureum and S. guianensis did not respond to P application during establishment.

#### Nitrogen (N)

Small additions of N to the soil enhance nodulation and legume growth, whilst the reverse is true for high levels of N application. Gibson and Humphreys (1973) in an open box experiment reported that N application increased seed yields of D. uncinatus cv. silverleaf desmodium, by 21 to 31 per cent mainly through increasing inflorescence density and seed size.

#### Potassium (K)

Heathcoat and Stockinger (1970) associated K deficiency with cropping intensity and the rate and frequency of application of other fertilizers such as P and N which interact with K. The availability of this element would probably not decline to the extent of posing a serious problem under the non intensive farming conditions prevailing in Nigeria (Heathcoat, 1973; Yayoek et al., 1979).

#### Sulphur (S)

S is important for nitrogen metabolism and initiation of nodule formation but has little subsequent effects (Gates, 1970). Its impact on legume seed production may therefore be indirect.

### 2.2.1.6.3 Micronutrients

The micronutrients have been studied more in relation to the growth, nodulation and physiology, than the seed production, of pasture legumes.

#### Boron (Bo) and Copper (Cu)

Bo and Cu are essential particularly because the seed crops are more sensitive to their deficiencies than the grazing crops. Teitzel (1969) found greatly reduced number of pods per plant in plots of Cu deficient M. atropurpureum cv. siratro. Generally the initial effect of Cu deficiency is partial wilting of the younger growth with sometimes a loss of chlorophyll and necrosis of younger leaves and shoots (Andrew, 1963). Andrew and Thorne (1962) concluded that for the legumes studied (D. uncinatum, P. lathyroides, C. pubescens, Indigofera spicata (indigofera), Stylosanthes bojeri, T. ripens (white clover), T. fragiferum (strawberry clover), T. alexandrinum (berseem clover) Medicago sativa (Lucerne), M. tribloides (barrel medic), a concentration above 5ppm was satisfactory, 4-5ppm was marginal and less than 4ppm indicated deficiency. The application of ordinary borax at the rate of 8kg/ha usually corrects and deficiency.

## Molybdenum (Mo)

The most important function of Mo is in N fixation in nodules and protein metabolism of leguminous plants (Bruce, 1978). Addition of Mo improves legume seed yield but usually in circumstances where general N metabolism is involved (Humphreys, 1979). It is supplied as either sodium molybdate or molybdenised superphosphate which is a mixture of superphosphate and molybdenum trioxide. In Queensland, it is available in four concentrations: 0.02, 0.04, 0.08 percent Mo and with Cu and Zn at 0.03 percent Mo. Although Ostrowski (1969) and Cook (1978) recommended applications of 200 to 300 g Mo/ha, Johansen *et al.* (1977) observed that 100g Mo/ha remained effective for more than three years.

## Zinc (Zn)

Bruce (1978) suggested that less than 20ppm Zn concentration in legume tops is a reasonable indicator of deficiency in S. humilis, M. atropurpureum, S. guianensis cv. Cook, S. hamata cv. Verano and D. intortum. Teitzel and Bruce (1972) and Cook (1978) recommended fertilization at 8kg Zinc sulphate (23 percent Zn)/ha Stylosanthes species, M. lathyroides and P. phaseoloides responded better than D. intortum to Zn application (Andrew and Bryay, 1958; Russell, 1966).

#### 2.2.1.9 The Rhizobium inoculation of legumes

Legume seeds are inoculated in order to provide coating with a sufficiently high number of viable Rhizobia of the correct strain and hence ensure early and effective nodulation of the legume in the field. Vincent (1970) indicated that about 300 bacteria per seed would be the minimal requirement for satisfactory nodulation. Effective seed coating inoculation with Rhizobia could be achieved by mixing the seed with a paste of peat culture of the effective Rhizobium strain. The paste may be obtained by adding the peat culture to a sticker, usually any of 10% sucrose, 45 percent gum arabic and 4 percent methyl cellulose (methofas) (Norris, 1964).

#### 2.2.1.8. Weed control

##### 2.2.1.8.1 Pre-emergence weed control

Pre-emergence herbicidal spray like DCPA (2,2-dichloro-propionic acid) at 4.48 - 11.2kg/ha a.i., dalapon ( $\text{CH}_3 \text{H}_4 \text{Cl}_2 \text{O}_2$ ) at 11.2kg/ha a.i., simazine (2-chloro 4 - ethyl amino - 1, 3-5) at 2.24kg/ha a.i., and trifluralin (2, 6- dinitro - N - di propyl - 4 trifluoromethyl aniline) at 0.56, 0.84 and 1.12 kg/ha for sandy, loam and clay soil respectively have been widely used for controlling grass weeds in legume seed crops.

For *D. intortum* and other legumes which are susceptible to these herbicides (Nicholls *et al.*, 1973), activated charcoal placed immediately above the seed rows can give protection from adverse effects of broad spectrum pre-emergence herbicides used to control weeds between the rows (Cowan, 1970).

#### 2.2.2 Crop management

##### 2.2.2.1 Fertilizer application

Application of fertilizers at the beginning of the season's growth was usually more effective than later applications (Humphreys, 1978). On light soils where leaching is a problem, split application is more effective. Because N, K and S are mobile nutrients which can be readily leached from the soil profile, they require frequent applications (Humphreys, 1979). According to this author, removal of plant residue from the farm after seed harvest quickly induces K deficiency. Humphreys (1978) indicated that microelements such as Cu and Mn are usually applied to last six to seven years in the soil while Mo applications were needed every 3 to 4 years.

##### 2.2.2.2 Effect of defoliation on legume seed crops.

Defoliation, described as the removal of plant shoots by grazing or cutting, may be considered in terms of frequency, intensity and timing (Humphreys, 1978). Winch (1959) and

Akinola and Whiteman (1975) showed that preharvest clipping decreased seed yield in birdsfoot trefoil (Lotus corniculatus) and pigeon pea (Cajanus cajan) respectively. Mc Alister and Krober (1958) examined the effects of two levels of leaf removal (40 and 80 percent) on soybean (G. max) at flowering stage and found marked depression in seed yield, number of pods per plant and to a smaller extent, reduced weight per seed. Defoliation of S. humilis at floral initiation, flower appearance or advanced flowering stage sharply resulted in 55, 84, 86 percent reduction respectively relative to the undefoliated treatment (Loch and Humphreys, 1970).

In contrast to the above, Rossiter (1961) observed that cutting or grazing before or during early flowering stage stimulated inflorescence production and increased subterranean clover (Trifolium subterraneum L.) seed yield by 27 percent. Defoliation hastened pod ripening, reduced time to pod harvest, decreased 1000 seed weight but increased seed protein content and percentage seed germination in lupin (L. angustifolius) and broad bean (Vicia faba) (Karcznarczyk 1973). Loch et al. (1976b) defoliated S. guianensis cv. Schofield early enough to permit full recovery of the vegetative framework before flower initiation and observed no effect on seed production. However when the authors applied this treatment

at a later stage both the quantity of seed produced and the pattern of production were adversely affected.

An understanding of the ways in which defoliation affects seed formation in tropical pasture legumes is a necessary prelude to the development of management recommendation directed either to the dual use of crops for seed and fodder or to the long term persistence of grazed pastures. For example Akinola and Whiteman (1975) suggested the possibility of combining hay cuts or grazing with seed production of C. cajan in a single management system.

#### 2.2.2.3 Post-emergence weed control

Maintenance of weed free seed crop reduces seed contamination. In seed crops of D. intortum cv. greenleaf desmodium and M. atropurpureum cv. siratro, weed problem increased with age due to N accumulation in the soil (Vallis and Jones, 1973). Rolling to break tall succulent weeds can be effective in reducing weed competition and also in promoting uniform flowering above the leaf canopy (Jones and Roe, 1976).

##### 2.2.2.3.1 Application of herbicides

In weed control experiments, S. guianensis, D. intortum and D. uncinatum tolerated moderate concentrations of

2, 4-D anine (2, 4 - dichlorophenoxyacetic acid up to 1 kg a.i. (active ingredient)/ha when at least six weeks old but not during flowering (Gilchrist, 1967; Bailey, 1969). Bailey (1969) found that when C. pubescens was sprayed with 2, 4 - D during flowering, the resultant seed germination was lowered by about 15 percent.

#### 2.2.2.3.2 Roguing or hoeing

Roguing or hoeing has proved more effective and selective than chemical measures in countries where manual labour is cheap. A strategic slashing usually gives S. guianensis a competitive advantage over weeds (Loch et al. 1977).

#### 2.2.2.4 Control of insects and diseases

The dense environment of a seed crop lends itself more to the build up of pathogens and pests than that of a grazed pasture. Disease and pest attacks can be minimized by treating the planting material with fungicide and insecticides and by planting genetically resistant species and strains. C. pubescens, cv. Belatto is more resistant to cercospora leaf spot (Cercospora apii) than common C. pubescens (Humphreys 1979). S. lanata cv. verano is

more tolerant to anthracnose (Collectotrichum gloeosporoides) than S. humilis and S. guianensis cv. Cook exhibits a mild tolerance (Paladines et al., 1974).

Many other cases of pests and disease problems of seed crops have been reported in Australia, U.S.A. and Kenya. In northern Queensland, Australia, botrytis (Botrytis cinera) caused considerable reduction in seed yield of S. guianensis cv. Schofield (Loch et al., 1976a) whilst aphids (Aphis craccivora) and larvae of Bean pod borer (Maruca testulalis) and Blue butterfly (Lepidus boeticus) concentrated on floral parts (Saunders, 1968). The author suggested that insects could be controlled using DDT. (2, 2-bis (p-chlophenyl) 1,1,1-trichloroethane) at 0.1 percent concentration beginning two days after plant emergence and should be sprayed 4 times for Beanfly (Melanogronyza phaseoli). For the control of Aphids, Saunders, (1968) recommended Deneeton-S-methyl (Metasystox 55) at 0.025 percent. At present, no major diseases have been reported in pasture seed crops in Nigeria and this could remain so for some time to come if pasture seeds are not indiscriminately imported.

## 2.3 SEED HARVESTING AND SEED YIELD OF THE PASTURE LEGUME CROP

### 2.3.1. Judging the optimum time of harvest

The harvesting of tropical pasture legume seed crop presents many problems such as difficulty in judging the optimum harvesting time, early shattering, presence of bristle, hooks, awns and other seed parts which interfere with harvesting and cleaning and high content of vegetative material. The most important of these problems is uneven maturity of seed resulting in heavy seed losses. In *S. guianensis* for example, harvesting took between 6 to 8 weeks (Adeghola, 1965). However, where stickiness is a problem, the choice of harvesting time would be a compromise between diminishing stickiness of seed heads and declining yield (Loch et al., 1977).

Griffith *et al.* (1967) in their review on temperate pasture species, considered that seed size, moisture content, endosperm consistency, viability, biochemical changes and seed abscission were useful characteristics for assessing maturity. Humphreys (1979) suggested that changes in testa colour from green to yellow or brown are reasonable indicators of ripeness.

### 2.3.2 Methods of harvesting and seed yield potential

The method of seed harvest is an important determinant of seed yield/ha. Table 1 presents a survey of several

tropical pasture legumes, and shows seed yield to vary from as low as 33 kg/ha in Lotononis bainosii to a very high value of over 1,100 kg/ha in S. humilis. Seed could be harvested manually if labour is cheap and this gives higher yields of good quality seed (Humphreys, 1978). In the Phillipines, C. pubescens hand harvested by school children in coconut plantation yielded 488 kg seed/ha in three pickings compared to 436 kg seed/ha by the simulated machine method. The latter involved clipping once and for all the vines with a mower mounted on a garden tractor, drying and threshing with a stationary thresher. 550 kg seed/ha of M. atropurpureum was recovered by hand picking from a potential yield of 700 to 800 kg/ha compared to 134 kg/ha seed from simulated machine harvesting (Javier, et al., 1972). In northern Queensland seed recovery of M. atropurpureum by combine harvesting was estimated at 10 to 20 percent for a total yield of 1,600 kg/ha (Hopkinson and Loch, 1973). Hopkinson and Vicary (1974) using a suction harvester recovered 200 to 350 kg seed/ha of the estimated 900 kg seed/ha of fallen seed. Sillar (1969) allowed S. humilis to fall on the ground and thereafter harvested them with a vacuum harvester after which they were cleaned with screen and gravity seed cleaners.

Table 1: Seed yield of some tropical pasture legumes

Experimental environment	Test legume	Method of harvesting	Yield kg/ha	References
Northern Queensland Australia	Calopo ( <u>Calopogonium mucunodites</u> )	all crop harvester	200-300	Davis and Hutton (1970)
Kenya	Silverleaf desmodium ( <u>Desmodium uncinatum</u> )	hand harvesting machine	330	Suttie and Ogada (1967)
Queensland, Australia	Greenleaf desmodium ( <u>D. intortum</u> )	cutting and threshing	200-350	Strickland (1971)
Kenya	Greenleaf desmodium ( <u>D. intortum</u> )	cutting and threshing	80-100	Suttie and Ogada (1967)
Queensland, Australia	Glycine ( <u>Glycine wightii</u> )	machine	500-750	Allen (1960)
Kairi, northern Queensland	"	"	330	Kelly (1963)
"	"	"	110	Kelly (1963)
Brazil and Bolivia	Lablab bean ( <u>Lablab purpureus</u> )	hand picking machine	up to 1000	Skerman (1977)
Queensland, Australia	Siratro ( <u>Macroptilium atropurpureum</u> )	machine	500	Davis and Hutton (1970)
Los Banos Philipines	"	hand picking	200	Hutton (1962)
Los Banos Philipines	"	machine	550	Javier <i>et al.</i> , (1972)
Zaire	Stylo ( <u>Stylosanthes guianensis</u> )	hand harvesting machine	134	
Northern Queensland Australia	cv. Schofield	hand harvesting machine	100-200	Risopoulos (1966)
Philippines	"	hand harvesting	90-100	Gilchrist (1967)
Rockhampton, Queensland	Townsville stylo ( <u>Stylosanthes humilis</u> )	machine	214	Mendoza <i>et al.</i> (1976)
Southeast Queensland	Lotononis ( <u>Lotononis bainesii</u> )	machine	330-1100	Graham (1963)
Serere, Uganda	Centro ( <u>Centrosema pubescens</u> )	hand picking/cutting	33-55	Bryan (1961)
Philippines		hand harvesting	220-275	Wilson and Lansburg (1958)
		three hand pickings	488	Javier and Sasis (1969)
		machine (once)	436	"

Asare and Agishi (1979) recovered S. humilis seed by hand sweeping with broom and winnowing repeatedly with metal pans and calabashes.

S. guianensis cv. Schofield was directly headed with a combine harvester in Queensland, Australia, but seed recovery was low due to the great bulk of tangled material and sticky seed heads (Hopkinson and Loch, 1977). S. guianensis harvested by hand picking, cutting the terminals or cutting the whole plant resulted in seed yields of 253.8, 165.4 and 223.8 kg/ha, respectively but cutting the whole plant constituted the cheapest method (Mendoza et al., 1976). Although seed setting in cv. Schofield is prolific, seed yields as low as 77 to 220 kg/ha have been obtained over a number of years at the Research experimental station in the Burdekin district of Queensland, Australia, due to low recovery rate (Cowdy and Verhoeven, 1961). In Nigeria, Agishi (1979) reported on S. guianensis cv. Cook cut for hay at the seed ripe stage and baled. Up to 1000 kg/ha of clean seed was recovered when the fallen seed, collected by ants and deposited around their nests, were gathered periodically and winnowed.

## CHAPTER 3

## MATERIALS AND METHODS

## 3.1 The experimental site

The experiment was conducted at the Kachia Grazing Reserve in Kurumin - Biri village, situated along Kaduna - Kachia road in the Southern Guinea Savanna Zone of Nigeria. (Latitude 10.02'N and Longitude 8.0'E). The terrain is rocky and hilly. It receives an annual rainfall of 1140 - 1400mm (average 1,200 mm), with a six month wet season from April to October and a well defined dry season which starts from November.

Table 2 shows the 1979-81 climatic observations recorded from Kaduna, approximately 70 km north of the experimental site. Higher rainfall was recorded in 1979 than any other year. December to February were usually rainless and the major rains fell between May and September, with a peak in August. The lowest and the highest temperatures occurred in December - January and March - April, respectively. There tended to be an inverse relationship between sunshine hours per day and rainfall per month.

Table 2: METEOROLOGICAL OBSERVATIONS AT KADUNA\* IN 1979, 1980 AND 1981

Year	Month	Rainfall mm	Days of rainfall	Relative humidity (%)	Mean Temperature (°C)		Daily sunshine (Hrs)
					Min.	Max.	
1979	Jan.	0	0	28	13.5	32.2	9.0
	Feb.	0	0	28	16.6	34.4	9.3
	Mar.	TRACE	0	37	20.9	35.8	7.2
	April	68	6	54	21.5	34.7	8.3
	May	173	13	78	21.0	31.8	7.7
	June	141	14	82	20.0	29.7	7.1
	July	290	23	84	19.2	28.7	6.3
	Aug.	417	20	86	19.9	28.5	5.6
	Sept.	286	21	84	18.8	29.2	5.9
	Oct.	54	7	76	19.1	31.5	8.2
	Nov.	42	2	57	16.4	31.9	8.7
	Dec.	0	0	35	12.9	29.7	8.6
		Total	1481	106	-	-	-
	Mean	-	-	60.8	18.3	31.5	7.7
1980	Jan.	0	0	29	15.3	32.6	9.6
	Feb.	0	0	24	17.3	33.3	8.1
	Mar.	2	1	35	20.0	34.3	8.3
	April	4	2	47	23.7	36.0	7.8
	May	248	14	79	20.3	31.4	7.3
	June	171	10	83	20.3	29.7	7.5
	July	133	16	86	20.1	30.6	5.6
	Aug.	420	22	87	20.1	28.5	5.5
	Sept.	122	15	83	20.1	30.6	7.5
	Oct.	46	10	79	19.8	31.4	7.7
	Nov.	0	0	52	15.1	32.4	8.9
	Dec.	0	0	35	13.8	30.3	8.3
		Total	1146	90	-	-	-
	Mean	-	-	59.9	18.8	31.8	7.7
1981	Jan.	0	0	32	14.5	30.4	9.0
	Feb.	0	0	30	16.8	33.9	9.1
	Mar.	TRACE	0	39	20.0	35.5	8.0
	April	67	7	52	21.9	36.1	9.4
	May	124	10	76	21.3	31.6	7.9
	June	184	11	78	20.8	30.2	7.4
	July	261	17	85	19.8	27.8	5.4
	Aug.	355	21	85	19.6	28.9	6.0
	Sept.	220	20	82	19.6	29.8	7.2
	Oct.	16	2	69	19.0	32.4	8.5
	Nov.	0	0	34	15.6	31.0	7.4
	Dec.	0	0	25	13.6	32.5	9.7
		Total	1227	88	-	-	-
	Mean	-	-	57.3	18.5	31.7	7.9

\*Approximately 70km north of experimental site.

### 3.2 Features of the soil type

Kurumin - biri falls within the area classified by Klinkenberg and Higgins (1968) using D'Hoore's legend (D'Hoore, 1964) as Ferruginous tropical soils on crystalline acid rock. These soils were developed under climatic regimes with appreciable but seasonal rainfall. The clay fraction consists mainly of kaolinite and sometimes small quantities of illinite. The composition of the clay fraction of the loam is reflected in the moderately low cation exchange capacity, which is of the order of 20 to 40 meq per 100g clay. The soil may be shallow in some places and varies in colour from greyish brown to yellowish red.

### 3.3 Vegetation

The vegetation ranges from shrub savanna to forest. However, extensive burning and cultivations have changed the pattern in many areas into farmed parkland around the village. Among the dominant trees are Isobertinia tomentosa, Lophira alata, Monotes Kerstingii and Butros Butrosperma paradoxum (Clayton, 1966). The native grasses include Andropogon gayanus var squamulatus, A. teclorum, Bracharia alata, Chloris robusta, Hyparrhenia cyanescens Pennisetum purpureum. Notable herbs and shrubs

consist of Crotalaria calycina, Sphernostylis schweinfurthii, Dissolis indicum, Aeschynomene indica and Tephrosia vogelli (Hutchinson and Dalziel, 1954).

#### 3.4 Experiment I

The objective of Experiment 1 was to investigate the effect of different levels of phosphorus application and cutting dates on the dry matter yield and seed production of S. guianensis.

##### 3.4.1 Land preparation and soil analysis

In 1977, Lablab (Lablab purpureus) was grown on the trial site following the application of 50 kg P/ha. Thereafter the land was left uncropped until July 1979 when it was disc ploughed and harrowed twice to produce a good seed bed. The top soil (0-13 cm) was sampled immediately on 20/7/79 and analysed for physical (Bouyoucos, 1951) and chemical (AOAC, 1975) properties (Table 3).

Twenty plots measuring 8m x 5m each were pegged out, allowing 1m margin between them. A completely randomised block design consisting of five levels phosphorus (P) and four replications was used for the experiment. The source of P was single superphosphate (19% P<sub>2</sub>O<sub>5</sub>) hand-broadcast at 0, 30, 60, 90 and 120 kg P/ha.

#### 3.4.2 Seed sowing and seedling emergence counts

Seed of *S. guianensis* cv. Schofield imported from Queensland, Australia, was field grown at Kuramin-biri in pure stands in 1976. These produced the seeds used for the present investigation. The seeds were sown on 20/7/79 at a high rate of 10kg/ha to offset the adverse effects of harvester ants since insecticide was not available for control. Before broadcasting, the seeds were well mixed with dry soil to facilitate even distribution.

Emergence counts of seedlings were undertaken using a split plot design which consisted of P level as mainplot and sampling date as the subplot. On each of 27/7/79, 3/8/79 and 10/8/79 that is 7, 14 and 21 days respectively after sowing, seedling counts were made in four 1 x 1m<sup>2</sup> quadrat samples randomly sited per sub-plot, thus ending the emergence count experiment.

All plots were hand weeded two times during the growing season.

#### 3.4.3 Estimation of dry matter yield

During the flower initiation stage (24/11/79) in the year of establishment and 14/10/81 at the termination of the study), four 1 x 1m quadrat samples were randomly taken from each plot. The 1981 harvest was regrowth

after cutting back on 30/4/81. The sward was cut with sickles to leave stubbles 30 cm high above the ground level. After bulking, the total plot fresh yield was weighed. A subsample was taken and oven dried to constant weight at 90°C for calculation of dry matter yield.

#### 3.4.4 Evaluation of herbage chemical composition

Following a cut back of the legume sward on 30/4/80 the regrowths were sampled for evaluating the effect of age on crude protein, crude fibre, ether extract, nitrogen free extract and ash content.

Two 1m x 1m quadrat samples were taken per plot on 17/10/80 (flower initiation stage), and 8/1/81, 17/1/82, 31/1/81 and 14/2/81 (70% of pods turning brown stage). The samples were bulked, sub-sampled and oven-dried to constant weight at 90°C.

#### 3.4.5 Chemical analysis of dried herbage

Dried plant material meant for proximate analysis was ground using a hammer mill (Christy and Norris laboratory mill) fitted with a 1 mm mesh sieve - Standard procedures as outlined by AOAC (1975) were used for determining crude nitrogen free extracts. The analytical procedure consisted

essentially of the following:

	<u>Procedure</u>	<u>Chemical used</u>
(a) Crude protein	Digestion	Concentrated sulphuric acid with copper sulphate/potassium sulphate mixture (1:20 w/w) as catalyst.
	Distillation	40% w/w sodium hydroxide
	Collection of distillate	20% boric acid containing 2-3 drops of 0.1% methyl red/bromo cresol green solution as indicator.
	Titration of distillate	0.0244 normal hydrochloric acid.

After titration,  $N_2$  was obtained and  $CP_2$  was found from the relationship  $CP_2 = N_2 \times 6.25$ .

(b) Crude fibre on fat free DM using Fibretec system 1010 heat extractor

	Digestion under reflux	0.255 N. Sulphuric acid 0.313 N sodium hydroxide.
	Wash	hot water and acetone.

Residue from above was dried at  $105^{\circ}\text{C}$  to constant weight. Dried sample was weighed with crucible and ashed at  $55^{\circ}\text{C}$  for 6 hours.

Calculation

$CF\% = \frac{\text{Dried sample weight after digestion} - \text{weight of ash}}{\text{weight of sample before digestion}} \times 100$ .

(c) Ether extraction using soxhlet apparatus

Extraction was done on hot water bath for 4 hours

40 - 60°C petroleum ether.  
Dried at 105°C to constant weight

Calculation

EE% =  $\frac{\text{weight of flask and oil} - \text{weight of flask}}{\text{weight of sample}} \times 100$ .

(d) Ash.

Ash was determined by burning a known weight of sample in a furnace at 550°C for 6 hours

Calculation

Ash% =  $\frac{\text{weight of ash}}{\text{weight of sample}} \times 100$ .

(e) Nitrogen free extract

This was obtained by difference.

Calculation

NFE% =  $100 - (\text{CP} + \text{CF} + \text{EE} + \text{Ash})\%$

## 3.4.6 Estimation of seed yield.

Each of the 0 - 120 kg P/ha plots was further split into 5 sub-plots of different seed harvesting dates (31/1/80, 14/2/80, 1/3/80, 15/3/80 and 29/3/80) and the first sampling

coincided with time when 50% of pods had turned brown. Samples were cut 30cm above the ground level using sickles. The seed - bearing plant top was air dried for one week and threshed to separate the seed from the vegetative matter by lightly hitting with a rubber sandal.

Winnowing resulted in clean seed which were weighed for the estimation of "standing seed" yield/ha. The remains of the plant tops (main stem, branches and leaves) was bagged and oven dried, prior to preparation for chemical analysis.

The stubble was cut close to ground level and seed which had fallen was collected by sweeping with a broom. Winnowing helped to remove some dead organic matter while sieving to remove soil particles and hand picking the stones produced the completely clean seed. The seed so collected was weighed to obtain "fallen seed" yield/ha (Table 7).

Following a cut back on 30/4/80, the resultant regrowths were harvested for seed on 3/1/81, 17/1/81, 31/1/81, 14/2/81, 2/2/81 and 14/3/81 respectively. The method of harvesting, collection and cleaning of seed followed the pattern described above. Here, harvesting started earlier (30 - 40% of pods having turned brown).

On 30/4/80, the experimental soil was sampled as before to find out the changes, if any, that might have occurred as a result of different levels of P application (Table 3).

### 3.5 Experiment II

3.5.1 Experiment II was designed to find the effect of defoliation and seed harvesting dates on standing and total seed yield of *S. guianensis* regrowth. The regrowth of cv. Schofield sown in August 1978 and which received 50kg P/ha at establishment (and no subsequent fertilizer application) was used for this study. The stand was harvested for seed in February 1979, and cut back to a uniform height of 30cm above the ground level on 30-4-79.

Twenty plots, each measuring 8m x 5m were laid out on 25-7-79 (86 days after cutting back) allowing a one-meter path between the plots. The experiment involved a split plot design with five defoliation treatments as main-plots and five seed harvesting dates as sub-plots. There were four replications. The defoliation treatments included non-defoliated control (D<sub>0</sub>) and swards cut with sickles at 30cm above ground level on 25/7/79 (D<sub>1</sub>), 25/8/79 (D<sub>2</sub>), 25/9/79 (D<sub>3</sub>) and 25/10/79 (D<sub>4</sub>). These respective dates equalled 86, 117, 148 and 179 days after cut back. Each treatment was hand weeded twice.

Seed was harvested on 31/1/80, 14/2/80, 1/3/80, 15/3/80 and 29/3/80 or 160, 174, 190, 204 and 218 days respectively

Table 3: Physical and Chemical properties of the 0-15cm soil horizon (a) before planting (b) after seed harvest.

P level (kg/ha)	Particle content** (%)				pH H <sub>2</sub> O	Chemical Composition (%)			
	Clay	Silt	Sand			Ca	Mg	PP	
			Fine	Coarse					
	2mmu mmu	2-20 mmu	20-210 mmu	210-2000 mmu					
(a) before planting (20/7/79)									
0	33.7	8.2	37.6	20.5	5.9	4.7	.048	.014	.016
30	33.2	8.4	36.8	21.6	5.6	4.5	.047	.012	.017
60	34.2	8.9	36.4	20.5	5.8	4.6	.048	.015	.015
90	32.9	9.2	38.1	20.8	5.9	4.7	.046	.013	.016
120	33.0	8.5	37.6	20.9	5.6	4.5	.044	.013	.016
Mean	33.4	8.6	37.3	20.8	5.8	4.6	.046	.014	.016
(b) after seed harvest 30/4/80									
0	35.5	9.2	35.8	19.5	5.3	4.2	.049	.012	.028
30	36.6	9.2	35.5	18.7	4.9	3.9	.053	.011	.026
60	36.9	9.3	34.9	18.9	4.8	3.8	.056	.013	.029
90	37.6	10.2	35.2	17.0	4.5	3.6	.059	.011	.034
120	36.6	10.2	35.7	17.5	4.5	3.6	.064	.011	.041
Mean	36.6	9.6	35.4	18.3	4.8	3.8	.056	.012	.032

\*\* Hydrometer method (Bouyoucos, 1951).

after the July to October defoliation dates. Details of sampling, processes followed the description provided earlier (see 3.4.6 above

### 3.6 Experiment III

3.6.1 The objective of this study was to evaluate the effect of residual phosphorus and seed harvesting date on percentage seed germination of S. guianensis.

A split plot design involving phosphorus as main plot and seed harvesting date as sub plot. The main plot included five levels of P (0, 30, 60, 90 and 120 kg P/ha) applied on 25/7/79. The harvesting dates were 3/1/81, 17/1/81, 28/2/81 and 14/3/81.

On 1/7/81 (179, 165, 151 and 137 days after the first, second third and fourth seed harvesting dates), germination tests were conducted on the standing and fallen seeds. Each treatment involved placing 50 seeds in a petridish which had been padded with absorbent paper. The petridishes were re-randomised daily after germination counts to offset the effect of position.

Two groups of seeds were examined - one untreated and the other emersed in hot water (70°C) for 15 minutes.

Seeds were kept moist throughout the investigation, which occurred under laboratory conditions at 28°C.

Germination counts commenced on 2/7/81 and continued till 8/7/81. A seed was regarded as having germinated when its radicle had emerged.

### 3.7 Statistical analysis of data

The analysis of variance technique as outlined by Steel and Torrie (1960), was statistically applied to the data collected. The approach of Duncan's multiple range test was used to compare the means.

## CHAPTER 4

## RESULTS

## Changes in soil physical and chemical properties

An analysis of the soil on 30/4/80 after seed harvest (Experiment 1) observed that the addition of superphosphate apparently resulted in increased soil content of clay, silt, Ca, and P, while it caused a reduction in the content of sand, pH and Mg.

## 4.1 Experiment I

4.1.1 Effect of phosphorus level and time (days after sowing) on the number (counts/m<sup>2</sup>) of S. guianensis seedlings emerging.

Table 4 shows the number of S. guianensis seedlings which emerged per m<sup>2</sup> in relation to P level up to 21 days after sowing. The same number of seedlings emerged at 0 and 30 kg P/ha. However, beyond the 30 kg P/ha rate, additional P resulted in significant increases ( $P < 0.05$ ) in seedling counts. With a progressive delay in time to count, the number of seedlings which emerged increased significantly ( $P < 0.05$ ). The data indicated that by day 14, over 70 percent have emerged.

Table 4: Effect of phosphorus level and time (days after sowing) on seedling emergence counts (number/m<sup>2</sup>) of *S. guianensis*.

Days after sowing	Phosphorus level (kg P/ha)					Date mean	
	0	30	50	90	120		
7	106	100	113	106	113	108 <sub>c</sub>	27%
14	275	256	288	268	325	286 <sub>b</sub>	70%
21	325	344	356	490	406	366 <sub>a</sub>	90%
Phosphorus mean	235 <sub>d</sub> *	233 <sub>d</sub>	252 <sub>c</sub>	265 <sub>b</sub>	281 <sub>a</sub>		
	58%	57%	62%	65%	69%		

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

Table 5: Effect of phosphorus level on dry matter (DM) yield (t/ha) of *S. guianensis* in 1979 and 1981+

Date of cutting	Phosphorus level (kg/ha)					Year mean
	0	30	60	90	120	
24-11-79	13.5	14.0	14.0	14.6	15.0	14.2 <sub>b</sub>
14-10-81	14.0	14.4	15.2	16.0	19.2	15.8 <sub>a</sub>
Phosphorus mean	13.8 <sub>e</sub> *	14.2 <sub>d</sub>	14.6 <sub>c</sub>	15.3 <sub>b</sub>	17.1 <sub>a</sub>	

\*Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

†Regrowth after cutting back on 30-4-81; a response to residual P.

The interaction between phosphorus and counting date was significant ( $P < 0.05$ ). The tendency for seedling numbers to increase with additional P was least obvious on day 7 and most marked on day 21. Regardless of P level, the least and the highest seedling counts were made on days 7 and 21, respectively, within the limits of the experiment.

#### 4.1.2 Effect of phosphorus level on dry matter (DM) yield of *S. guianensis* in 1979 and 1981.

DM yield rose significantly ( $P < 0.05$ ) with increasing level of applied P (Table 5). The DM yield of the regrowth in 1981 significantly ( $P < 0.05$ ) exceeded the DM yield of the crop in the year of establishment. The phosphorus x year interaction was significant ( $P < 0.05$ ). In 1979 DM yield varied from 13.5t DM/ha without P to 15.0t DM/ha with 120 kg P/ha. In 1981, the corresponding DM yield values with residual P were 14.0t and 19.2t DM/ha.

#### 4.1.3 Effect of phosphorus level and cutting date on chemical composition (%DM) of *S. guianensis* in the 1980/81 season.

The effects of different levels of phosphorus applied in 1979 and dates of harvesting of crop regrowth

from 17/10/80 to 14/2/81 on chemical composition of the herbage are shown in Table 6.

#### Crude protein (CP) content

Averaged over all the harvesting dates, P affected herbage CP content significantly (Table 6a). However when applied at rates in excess of 60 kg/ha crop response became less noticeable. The age of the sward at harvest strongly influenced the CP content. Percent CP fell significantly ( $P < 0.05$ ) with later harvests. There was a non-significant ( $P > 0.05$ ) phosphorus x harvesting date interaction. On 17/10/80 and 3/1/81 the response to P was erratic but on other sampling dates, plant tops CP content increased with increasing P. The generally low CP content was due to the age of the plant (140-290 days) at cutting.

#### Crude fibre (CF) content

Occasionally, per cent CF tended to decline with increasing P level but in most instances CF and P showed no clear relationship with each other (Table 6b). For the levels 0-120 kg P/ha, CF content did not differ significantly ( $P > 0.05$ ). Although the age of the plant at harvest significantly ( $P < 0.05$ ) affected its CF content, the mean data indicated that the herbage was

Table 6a: Effect of phosphorus level<sup>+</sup> and cutting date<sup>++</sup> on crude protein content (% DM) of *S. guianensis* hay in the 1980/81 season.

Date	Cutting Days after cut back**	Phosphorus level (kg P/ha)					Date mean
		0	30	60	90	120	
17-10-80	140	9.9	9.8	10.6	11.9	10.9	10.6 <sub>a</sub>
3- 1-81	248	8.0	8.9	9.9	8.8	9.3	8.8 <sub>b</sub>
17- 1-81	262	7.5	7.8	8.1	8.4	8.4	8.0 <sub>c</sub>
31- 1-81	276	6.7	6.8	7.5	7.9	8.2	7.4 <sub>d</sub>
14- 2-81	290	6.4	6.4	7.0	7.1	7.4	6.9 <sub>d</sub>

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

+ Residual phosphorus

++ From floral initiation to about 70% of pods turning brown

\*\* The sward was cut back on 30/4/80

Table 6b: Effect of phosphorus level<sup>†</sup> and cutting date<sup>\*\*</sup> on crude fibre content (% DM) of *S. guianensis* hay in the 1980/81 season.

Date	Cutting Days after cut bact**	Phosphorus level (kg P/ha)					Date mean
		0	30	60	90	120	
17-10-80	140	45.4	46.1	42.5	43.4	42.2	43.9 <sub>a</sub>
3- 1-81	248	42.3	39.7	40.5	39.7	44.8	41.4 <sub>bc</sub>
17- 1-81	262	42.0	41.0	40.5	40.6	40.1	40.9 <sub>c</sub>
31- 1-81	276	43.1	43.5	42.1	43.9	42.3	43.0 <sub>a</sub>
14- 2-81	290	43.4	42.7	42.4	42.2	41.7	42.5 <sub>ab</sub>
Phosphorus mean		43.2 <sub>a</sub> *	42.6 <sub>a</sub>	41.6 <sub>a</sub>	42.0 <sub>a</sub>	42.2 <sub>a</sub>	

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

† Residual phosphorus

\*\* From floral initiation to about 70% of pods turn brown

\*\* The sward was cut back on 30/4/80.

Table 6c: Effect of phosphorus level<sup>†</sup> and cutting date<sup>\*\*</sup> on ether extract content (% DM) of *S. guianensis* hay in the 1980/81 season.

Date	Cutting Days after cut back**	Phosphorus level (kg P/ha)					Date mean
		0	30	60	90	120	
17-10-80	140	1.0	1.1	0.9	0.7	0.9	0.9 <sub>d</sub>
3- 1-81	248	3.4	4.2	3.6	3.9	2.6	3.6 <sub>c</sub>
17- 1-81	262	4.1	4.2	4.0	3.7	3.2	3.9 <sub>bc</sub>
31- 1-81	276	4.3	4.0	4.3	3.8	4.0	4.1 <sub>ab</sub>
14- 2-81	290	4.3	4.4	4.4	4.8	3.9	4.3 <sub>a</sub>

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

† Residual phosphorus

\*\* From floral initiation to about 70% of pods turn brown

†† The sward was cut back on 30/4/80.

Table 6d: Effect of phosphorus level<sup>†</sup> and cutting date<sup>\*\*</sup> on ash content (% DM) of *S. guianensis* hay in the 1980/81 season.

Date	Cutting Days after cut back**	Phosphorus level (kg P/ha)					Date mean
		0	30	60	90	120	
17-10-80	140	7.3	7.1	6.1	6.1	5.6	6.4 <sub>a</sub>
3- 1-81	248	5.4	5.3	5.1	5.9	5.2	5.4 <sub>b</sub>
17- 1-81	262	5.5	6.3	5.3	6.1	5.6	5.8 <sub>b</sub>
31- 1-81	276	5.4	4.4	5.5	5.8	5.5	5.3 <sub>b</sub>
14- 2-81	290	5.4	5.3	5.1	5.4	5.1	5.3 <sub>b</sub>

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

† Residual phosphorus

\*\* From floral initiation to about 70% of pods turning brown

\*\*\* The sward was cut back on 30/4/80

Table 6e: Effect of phosphorus level<sup>†</sup> and cutting date<sup>††</sup> on nitrogen free extract content (% DM) of *S. guianensis* hay in the 1980/81 season.

Date	Cutting Days after cut back**	Phosphorus level (kg P/ha)					Date mean
		0	30	60	90	120	
17-10-80	140	36.4	35.9	39.9	37.9	40.3	38.1 <sub>c</sub>
3- 1-81	248	40.9	41.9	41.1	41.7	37.9	40.7 <sub>ab</sub>
17- 1-81	262	40.8	41.2	42.0	41.2	42.6	41.6 <sub>a</sub>
31- 1-81	276	40.4	40.7	40.7	38.6	40.0	40.1 <sub>b</sub>
14- 2-81	290	40.2	40.7	41.2	40.5	41.9	40.9 <sub>ab</sub>

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

† Residual phosphorus † pods turning brown

†† From floral initiation to about 70% of pods turning brown

\*\* The sward was cut back on 30/4/80

least fibrous in mid January (41% CP) and most fibrous in mid-October and late January. The phosphorus x harvesting date interaction was non-significant ( $P > 0.05$ ) for CP. At no given P level was CP content consistently associated with the age of the herbage.

#### Lignin extract (EE) content

EE content did not change significantly ( $P > 0.05$ ) with increasing P level but rise with delay in time to harvest (Table 6c). The major effect of sampling date would be observed in the substantial mean increase from 0.9% on 17/10/80 to 3.6% on 3/1/81 and 4.3% on 14/2/82.

#### Ash content

Whilst P was relatively non effective, the age of plant at harvest apparently significantly ( $P < 0.05$ ) influenced forage ash content (Table 6d). On 17/10/80, per cent ash declined gradually with increasing P. However, on other dates ash % fluctuated. Apart from the sudden rise on 17/1/81, ash content tended to decrease with age.

Percentage nitrogen free extract (NFE)

P did not significantly ( $P > 0.05$ ) influence the NFE content of *S. guianensis* tops (Table 6e). On the other hand, the effect of harvesting date was significant ( $P < 0.05$ ). NFE increased from 38.1% on day 140 to 41.6% on day 262 and declined thereafter. Inconsistent NFE values characterised P level regardless of harvesting date as well as harvesting date for each P level. These probably accounted for the non-significant phosphorus x harvesting date interaction.

4.1.4 Effect of phosphorus and seed harvesting date on seed yield during 1979/80 and 1980/81.

4.1.4.1 The 1979/80 crop

The main effects of P and seed harvesting date were highly significant ( $P < 0.05$ ) for both standing seed yield and total seed yield (Table 7). P and seed harvesting date also interacted significantly, suggesting that these factors did not influence yield independently of each other.

Table 7: Effect of phosphorus level and seed harvesting date (commencing from 50% of pods turning brown)<sup>+</sup> on standing and total seed yield\*\* (kg/ha) of *S. guianensis* in 1979/80 season.

Harvesting Date	Days after sowing <sup>++</sup>	Phosphorus level (kg P/ha)					Seed harvesting date mean
		0	30	60	90	120	
(a) Standing seed yield							
31- 1-80	190	195	380	434	226	170	281 <sub>b</sub>
14- 2-80	204	298	393	325	404	306	345 <sub>a</sub>
1- 3-80	218	297	206	265	311	307	277 <sub>b</sub>
15- 3-80	232	89	127	129	117	203	133 <sub>c</sub>
29- 3-80	246	33	38	69	51	35	45 <sub>d</sub>
Phosphorus mean		182 <sub>d</sub>	229 <sub>b</sub>	244 <sub>a</sub>	222 <sub>b</sub>	204 <sub>c</sub>	
(b) Total seed yield							
31- 1-80	190	222	400	456	242	187	301 <sub>c</sub>
14- 2-80	204	427	507	387	469	340	426 <sub>a</sub>
1- 3-80	218	476	307	394	404	406	397 <sub>b</sub>
15- 3-80	232	269	273	271	290	386	298 <sub>c</sub>
29- 3-80	246	259	263	259	269	273	264 <sub>d</sub>
Phosphorus mean		330 <sub>b</sub> *	350 <sub>a</sub>	353 <sub>a</sub>	335 <sub>b</sub>	319 <sub>c</sub>	

\* Means in the same row or column with similar letters do not differ significantly at P = 0.05, according to Duncan's multiple range test.

+ 50% and 100% of pods turned brown on 31/1/80 and 29/3/80 respectively.

++ Sowing date = 20/7/79.

\*\* Total seed = standing + fallen seed yield.

#### Standing seed yield

The highest standing seed yield of 434 kg/ha was obtained on 31/1/80, 190 days after sowing with 60kg P/ha (Table 7a). The lowest seed yield of 33kg/ha without P was recorded on 29/3/80 (day 246).

On all the sampling dates, except 31/1/80 and 29/3/80, there appeared to be no trend in the standing seed yield response to P. However, averaged over all the dates, 60 kg P/ha resulted in the highest standing seed yield/ha which differed significantly ( $P < 0.05$ ) from seed yield at any other P level.

Regardless of P level, the amount of seed borne by the standing crop maximised on 14/2/80 (day 204) and declined significantly thereafter. Seed yields on 31/1/80 prior to obtaining completely ripe pods and on 1/3/80 when pod shedding had intensified were similar. By March ending, standing seed yield had dropped drastically.

#### Total seed yield

Like standing seed yield, total seed yield (Standing seed plus fallen seed) responses to P were erratic (Table 7b). Seed yield over 450 kg/ha was observed at different

P levels (except 120 kg P/ha) on the first three sampling occasions. The highest yield of 507 kg/ha was produced with 30kg P/ha on 14/2/80. When the data were pooled over all harvesting dates, 60kg P/ha gave the highest seed yield which however, only marginally superseded seed yield with 30kg P/ha.

Harvesting date more greatly influenced the seed yield of cv. Schofield than P application. The results suggested that significantly higher yields ( $P < 0.05$ ) were produced between mid February and early March (average 411 kg/ha) than earlier (300 kg/ha) or later (288 kg/ha) periods. It would appear that the generally reduced fallen seed (total minus standing) and total seed yield could be accounted for in terms of increasing disappearance of fallen seed due to the activities of seed-collecting ants.

#### 4.1.4.2 The 1980/81 crop

The 1980/81 crop (regrowth) experienced a much longer growing season and this might have accounted for its more massive development (visual observation) than the 1979/80 crop. Further, the 1980/81 crop matured slightly earlier than the 1979/80 crop. For the 1979/80 crop the first pods ripened (pod colour turning brown)

Table 8: Effect of phosphorus level<sup>+</sup> and seed harvesting date<sup>++</sup> on standing and total seed yield (kg/ha) of S. guianensis regrowth in the 1980/81 season.

Harvesting Date	Days after cut back**	Phosphorus level (kg P/ha)					Seed harvesting date mean
		0	30	60	90	120	
(a) Standing seed yield							
3-1 -81	248	208	193	221	212	217	210 <sub>d</sub>
17-1 -81	262	207	202	232	275	258	235 <sub>c</sub>
31-1 -81	276	207	321	283	323	427	312 <sub>a</sub>
14-2 -81	290	139	263	265	346	359	294 <sub>b</sub>
28-2 -81	304	120	133	163	211	141	154 <sub>e</sub>
14-3 -81	318	84	90	90	108	93	93 <sub>f</sub>
Phosphorus mean		161 <sub>d</sub>	201 <sub>c</sub>	226 <sub>b</sub>	246 <sub>a</sub>	249 <sub>a</sub>	
(b) Total seed yield							
3-1 -81	248	227	217	239	249	246	236 <sub>d</sub>
17-1 -81	262	226	231	334	309	309	277 <sub>b</sub>
31-1 -81	276	239	357	363	416	529	381 <sub>a</sub>
14-2 -81	290	189	346	445	436	469	377 <sub>a</sub>
28-2 -81	304	182	201	285	320	311	260 <sub>c</sub>
14-3 -81	318	144	158	157	216	174	170 <sub>e</sub>
Phosphorus mean		201 <sub>e</sub> *	252 <sub>d</sub>	296 <sub>e</sub>	329 <sub>b</sub>	340 <sub>a</sub>	

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

+ Residual phosphorus.

++ 30% and 100% of pods turned brown on 3/1/81 and 14/3/81 respectively.

\*\* Crops were cut back on 30/4/80.

during early January 1980 while in the case of the 1980/81 regrowth, first pod ripening occurred in mid-December, 1980.

Differences in seed yield due to varying P levels and seed harvesting dates were significant ( $P < 0.05$ ) (Table 8). The P x seed harvesting date interaction was also significant.

#### Standing seed yield

Standing seed yield response to residual P reflected the level of P applied in 1979 (Table 8a). In a descending order, the pattern of seed yield was P120 P90 P60 P30 P0. However not much difference existed in yield response to P90 and P120 ( $P > 0.05$ ). On the average, the standing crop bore significantly higher amounts of seed on 31/1/81 and 14/2/82 than on any other sampling date. The lowest yield occurred in mid-March, 1981.

The highest seed yield on plots basis of 427 kg/ha resulted from 120kg P/ha on 31/1/81 whilst the lowest, 84kg/ha was recorded from unfertilised 318-day old (14/3/81) regrowth. P did not appear to have effected any significant changes in the quantity of seed retained on 3/1/81 and 14/3/81.

### Total seed yield

Total seed yield increased with rise in P level and reached a peak between 31/1/81 and 14/2/81 (Table 8b). The overall mean total seed yield was similar for 90 kg P/ha and 120 kg P/ha. Across all levels of P, nearly equal amounts of seed were collected on 31/1/81 and 14/2/81. Yield without P varied from 144 kg/ha on 14/5/81 to 239 kg/ha on 31/1/81 whilst yield with P ranged from 156 kg/ha at 30 kg P/ha on 14/3/81 to 529 kg/ha at 120 kg P/ha on 31/1/81. The mean yield for each sampling date indicated that cv. Schofield had production potential of at least 380 kg/ha seed but harvesting beyond mid-February would result in heavy yield losses. A greater proportion of the seed losses so encountered was due to seed shedding and seed stealing by ants.

The 1979/80 and 1980/81 total yields were compared using the 't' test, but there was no significant difference between them ( $P > 0.05$ ) ( $t = 1.62$ ).

## 4.2 Experiment II

### 4.2.1 Effect of defoliation and seed harvesting dates on standing and total seed yield (kg/ha) of S guianensis regrowth in the 1979/80 season

Defoliation date, and to a greater extent seed harvesting date, exerted significant influences on the

Table 9: Effect of defoliation and seed harvesting dates on standing and total seed yield (kg/ha) of *S. guianensis* regrowth† in 1979/80 season.

Date	Harvesting						Seed harvesting date mean
	Days after** cut back	D <sub>0</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>	
(a) Standing seed yield							
31- 1-80	276	333	392	293	182	67	253 <sub>b</sub>
14- 2-80	290	262	280	306	353	189	278 <sub>a</sub>
1- 3-80	304	166	188	218	163	108	169 <sub>c</sub>
15- 3-80	318	63	74	113	76	49	75 <sub>d</sub>
29- 3-80	332	51	49	23	22	14	32 <sub>e</sub>
Defoliation date mean		175 <sub>b</sub>	197 <sub>a</sub>	191 <sub>a</sub>	159 <sub>c</sub>	86 <sub>d</sub>	
(b) Total seed yield							
31- 1-80	276	384	472	346	239	87	305 <sub>b</sub>
14- 1-80	290	335	396	442	410	250	367 <sub>a</sub>
1- 3-80	304	248	321	356	319	202	289 <sub>c</sub>
15- 3-80	318	181	260	265	231	194	226 <sub>d</sub>
29- 3-80	332	173	183	186	182	180	181 <sub>e</sub>
Defoliation date mean		264 <sub>d</sub> *	326 <sub>a</sub>	319 <sub>b</sub>	276 <sub>c</sub>	182 <sub>e</sub>	

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

† Plant were cut back on 30/4/79.

\*\* D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> = defoliated on 25/7, 25/8, 25/9 and 25/10/79 respectively.

seed yield of *S. guianensis* (Table 9). To a larger extent, timing of defoliation strongly affected the seed yield produced on a particular harvesting date.

#### Standing seed yield

Overall mean standing seed yield values of 175, 197, 191, 159 and 86 kg/ha were recorded for the non defoliated plot and for plots defoliated 86, 117, 148 and 178 days respectively, after cutting back on 30/1/79 (Table 9a). Thus defoliation between late July and late August produced higher seed yields than the control or defoliation imposed after August.

In this study, the amount of mature seed retained by the standing crop reached a peak in mid February and declined significantly afterwards. The yield of as much as 333 kg seed/ha by the control treatment on 31/1/80 could be due to the earlier onset of maturity than the defoliate treatments. No reason could be advanced for the rise in yield to 392 kg/ha on that date by defoliating on 25/7/79 but progressively lower yields accompanied later defoliations. When seed harvesting was delayed till 11/2/80, yield from the

undefoliated and earliest defoliated plots declined while the yield from other defoliation dates increased. For plots defoliated as late as 25/9/79 the high yield of 353 kg/ha on 14/2/80 was unexpected. Yield of 280 kg/ha and 306 kg/ha for defoliations on 25/7/79 and 25/8/79 respectively did not differ significantly ( $P > 0.05$ ) from each other but markedly superceded yield for other but seed harvesting dates.

#### Total seed yield

The trend of total seed yield as influenced by defoliation and seed harvesting dates (Table 9b) was similar to that described for standing seed yield (above). The highest yields resulted from plots defoliated on 25/7/79 or 25/8/79, with 14/2/80 apparently the most appropriate date for seed collection. The data suggested that after cutting S. guianensis for forage between 25/7/79 and 25/9/79, its regrowth had a total seed yield potential of 300kg/ha (standing) and 400 kg/ha (standing + fallen) if harvested on 14/2/80 (regrowth then aged 203 to 142 days respectively).

#### 4.3 Experiment III

Effect of residual phosphorus and seed harvesting date on germination of S. guianensis seed

Table 10 shows that the level of P applied in the 1979 growing season had significant effect ( $P < 0.05$ ) on percentage germination between 3/1/81 and 14/3/81. Germination declined with increase in the level of P applied in the scarified batch but in the unscarified group, P effect was inconsistent.

##### Unscarified seed

The effect of P on seed germination was significant both for standing, fallen, seed in the unscarified batch. More standing seeds germinated with increase in P upto P90. But for the fallen seed, the best germination was with P30.

The main effect of seed harvesting date on germination was highly significant ( $P < 0.01$ ) for both standing and fallen seed (Table 10a). Seed harvested on 28/2/81 germinated better than seed harvested earlier or later. A significantly higher number of fallen seeds germinated than standing seeds, ( $t = 6.29$  at 8df), except on 3/1/81.

## Scarified seed

Scarification of standing and fallen seeds with hot water increased germination by 360% and 156% respectively. Results in the scarified batch showed that germination percentage declined with increase in P for both standing and fallen seed. The effect of seed harvesting date on the germination of the scarified seed was significant ( $P < 0.05$ ). Standing seeds harvested on 3/1/81, 17/1/81 and 28/2/81 germinated better than those harvested on 14/3/81. For the fallen seed, those harvested 3/1/81 and 14/3/81 germinated better than those harvested 17/1/81 and 28/2/81. (Table 10b). Similarly the scarified standing seed and fallen seed germinated almost equally ( $t$  value = 0.38 at 5% and 8 df).

Table 10a: Effect of phosphorus<sup>†</sup> level and seed harvesting date on percentage germination of unscarified *S. guianensis* seed.

Date		Phosphorus level (kg/ha)					Seed harvesting date mean
		0	30	60	90	120	
3- 1-81	SS**	2.0	1.0	3.6	3.6	3.0	2.6c
	FS	2.0	5.6	5.0	3.6	8.6	5.0c
28- 2-81	SS	30.6	20.0	29.6	25.6	39.6	29.0a
	FS	46.0	48.6	44.0	42.0	47.6	45.6a
14- 3-81	SS	13.6	17.6	19.0	27.6	11.6	17.8b
	FS	46.6	46.6	37.0	32.0	33.6	30.2b
Phosphorus	SS	15.4 <sub>ab</sub>	12.8 <sub>b</sub>	17.4 <sub>ab</sub>	18.8 <sub>a</sub>	18.0 <sub>a</sub>	
	FS	31.6 <sub>ab</sub> *	33.6 <sub>a</sub>	28.6 <sub>ab</sub>	25.8 <sub>b</sub>	29.8 <sub>ab</sub>	

\* Means in the same row or column with similar letters do not differ significantly at  $P = 0.05$ , according to Duncan's multiple range test.

† Residual phosphorus (Phosphorus applied in 1979)

SS\*\* = Standing seed and FS = Fallen seed produced by 1980/81 regrowth.

Table 10b: Effect of phosphorus<sup>†</sup> level and seed harvesting date on percentage germination of *S. guianensis* seed scarified with hot water.

Date		Phosphorus level (kg/ha)					Seed harvesting date mean
		0	30	60	90	120	
3- 1-81	SS**	85.0	78.6	77.0	70.0	75.6	77.2 <sub>a</sub>
	FS	89.0	82.6	83.0	79.6	81.6	83.2 <sub>a</sub>
17- 1-81	SS	85.0	91.6	64.6	78.0	84.0	80.6 <sub>a</sub>
	FS	82.6	61.0	73.0	60.0	55.6	66.4 <sub>b</sub>
28- 1-81	SS	82.0	84.6	84.0	76.0	63.6	78.0 <sub>a</sub>
	FS	81.0	84.0	57.0	62.0	63.0	69.4 <sub>b</sub>
14- 3-81	SS	71.0	67.0	74.0	65.0	63.0	68.0 <sub>b</sub>
	FS	76.6	80.6	84.0	79.6	79.0	80.0 <sub>a</sub>
Phosphorus	SS	80.8 <sub>a</sub>	80.4 <sub>a</sub>	74.8 <sub>b</sub>	72.2 <sub>b</sub>	71.6 <sub>b</sub>	
	FS	82.2 <sub>a</sub>	77.0 <sub>b</sub>	74.2 <sub>bc</sub>	70.2 <sub>c</sub>	69.8 <sub>c</sub>	

\* Means in the same row or column with similar letters do not differ significantly at P = 0.05, according to Duncan's multiple range test.

† Residual phosphorus (Phosphorus applied in 1979).

SS\*\* = Standing seed and FS = fallen seed produced by 1980/81 regrowth.

SS x FS t value = 0.38

t<sub>1</sub> table value at 8 df = 2.262

## CHAPTER 5

## DISCUSSION

## 5.1 Experiment I

At Kurumin-biri, S. guianensis cv. Schofield fertilized at 0, 30, 60, 90 and 120 kg P/ha was evaluated for seedling emergence, DM yield, seed yield and herbage proximate composition during the 1979/80 and 1980/81 seasons. The effect of defoliation and seed harvesting dates on seed yield also investigated.

## 5.1.1 Seedling emergence

The data suggested that P strongly influenced the seedling emergence of S. guianensis at the experimental site. This conformed with the general acceptance of the necessity for P for rapid establishment of tropical pasture. Jones (1974) examined 30 Stylosanthes accessions and reported that growth increased generally with moderate application (24 to 48 kg P/ha). On the other hand, Harty (1967) reported a depressed germination in S. guianensis with increasing level of P. Elunt and Humphreys (1970), Wendt (1970) and Gilbert and Shaw (1979) found no visible response to P by legumes.

including *S. guianensis*, during establishment. It would appear that soil P content prior to the addition of P could account for these discrepancies.

The result indicated that up to 21 days after sowing should be allowed before a reliable trend of seedling emergence in response to P could be obtained.

#### 5.1.2 Dry matter yield

DM yield increased significantly with increasing P, in agreement with earlier reports (Norman 1959; Shaw *et al.* 1966). Pruce and Teitzel (1978) found that maximum DM yield occurred at 25 kg P/ha and, like Jones (1974), that yield declined at 100 kg P/ha and above. Blunt and Humphreys (1970) reported that yield of *S. guianensis* increased up to the 90 kg P/ha level. In the present study, 120 kg P/ha applied in 1979 resulted in the highest DM yield in both 1979 and 1981. Higher DM yield in 1981 than 1979 (11% more) was probably due to greater ground cover and stronger establishment (visual observation). Further more the duration of crop growth was considerably shorter in 1979 than 1981, although both crops were cut at approximately the same physiological age/onset of flowering).

### 5.1.3 Herbage chemical composition

There is a dearth of information on the effect of P on the chemical composition of S. guianensis. The data on CP, CF, EE, Ash and NFE therefore aimed at providing a preliminary information. However, the major weakness of the chemical analysis was its lack of accompanying DM yield figures.

#### Crude protein content

CP content of S. guianensis increased significantly with P up to 60 kg P/ha. Norman (1959) Shaw et al. (1966), Andrew and Robins (1969) Blunt and Humphreys (1970) showed that 22-90 kg P/ha applied to S. guianensis increased herbage CP content. Application of over 60 kg P/ha did not significantly increase CP in the present trial. The observed fall in herbage CP content with age is quite normal. In order to obtain a fairly good hay without much seed loss, S. guianensis may have to be cut in late January when CP content would be about 7.4%.

#### Crude fibre content

P had no clear cut effect on S. guianensis CF content. That percentage CF fluctuated during the period of cutting contrasted the general view that forage CF content increases with age.

#### Ether extract content

EE content did not change with increasing P, but rose with delay in the time of harvest. Stylo exudes a glutinous substance during seed production and could have resulted in the four fold increase in EE content then compared with the vegetative phase.

#### Ash.

Ash content of plant tops was not consistent with P. However, the value declined with age, suggesting that a part of constituents (P, Ca or K) might have been transported to the upwards to the seeds or downwards to the root system.

#### Nitrogen free extract

The tendency for NFE to decline after an initial rise could be attributed to changes in the pattern or direction of carbohydrate translocation with time (Akinola, personal communication). It could also be as a result of errors in the determination of CP, CF, EE and Ash.

#### 5.1.4 Seed yield

The literature review showed that very few studies have been conducted to show the effect of P on pasture

legume seed production and authors have rather concentrated more on harvesting techniques. However, Shelton and Humphreys (1971) reported that application of 50kg P/ha increased the seed yield of S. humilis by 20 percent.

Erratic standing seed yield responses to P in both years of study were probably due to sampling errors, increased plant lodging with additional P and/or unevenness of pod ripening. However, seed yield maximised at 60 kg P/ha and 90-120 kg P/ha in the 1979/80 and 1980/81 crops respectively. In regard to the time of harvest, the highest seed yields were recorded for the first year (1979/80) crop in mid February and the second year regrowths in late January/mid-February. This corresponded to the time of nearly 100 percent of pods ripening and preceded the onset of severe pod shedding. Ideally these observations would be important for recommending the time of mechanical seed harvesting.

The lack of a trend in the effect of P on total seed yield on different dates could have resulted from the variable seed losses due to seed harvester (stealing) ants. Not all the seed removed by these agents were

recoverable via the sweeping method of collection adopted. Nevertheless the data suggested that considerable (total) seed yield could be produced with 30-60 kg P/ha provided *S. guianensis* was harvested in mid February prior to the intensification of seed shedding and harvester ant activities.

Seed can be hand-harvested in which case the plant tops are cut and threshed to obtain the standing seed yield. The collection of the fallen seed involves sweeping and winnowing. Alternatively the plant tops may be mechanically harvested and the fallen seed efficiently collected with a suction (vacuum) pump.

The range of standing seed yield obtained by harvesting at the suggested late January/mid February periods, using the moderate fertilizer rate of 30 to 60 kg P/ha was 324 to 434 kg/ha for 1979/80 crop and 263 to 365 kg/ha for the 1980/81 crop. The corresponding total seed yield values were 387 to 507 kg/ha and 346 to 445 kg/ha respectively. These compare favourably with the 90 to 214 kg/ha earlier recorded for cv. Schofield in Zaire (Risopoulos, 1966), in northern Queensland (Gilchrist, 1967) and Phillipines (Mendoza *et al.*, 1976).

However, it falls short of short of the 330 to 1100 kg/ha reported for S. humilis at Rockhampton in tropical Queensland (Graham, 1963).

As a pre-requisite for obtaining information on optimum and economical seed yields, there is the urgent need to investigate S. guianensis cv. Schofield seed yield using different seed rates, seeding sowing method (broadcast versus row) and weed control technique (hand, mechanical or chemical).

## 5.2 Experiment II

### 5.2.1 Defoliation

Loch et al., (1976) reported that defoliation early enough to permit full recovery of the vegetative framework of S. guianensis prior to flower initiation had no effect on seed production, while defoliation imposed later adversely affected both the pattern and the quantity of seed produced. This observation is similar to the results of this investigation.

Regardless of defoliation date, mid February appeared the most suitable time for seed harvest at the experimental location. This further confirmed the results of time

of seed harvest earlier reported for the P versus seed harvesting date effect. Defoliation between late July and late August (vegetative phase) resulted in higher seed yields than either the non-defoliated control or later defoliations. Later defoliations presumably occurred between the floral initiation and floral appearance stages. Working on S. humilis, Loch and Humphreys (1970) found that defoliation as late as during these developmental stages sharply reduced seed production.

Total seed yield for plots defoliated on 25/9/79 still exceeded that of the control showing that it is possible to cut the crop for hay or silage up to late September without causing a substantial reduction in seed yield.

### 5.3 Experiment III

#### 5.3.1 Seed germination

Ideally, the effect of P on seed germination ought to have been sought using seed harvested between January and March 1980 since the P under investigation was soil applied in 1979. Consequently the trial results could

be concluded strictly only in terms of seed produced by crop regrowth in response to residual P. However, variation in P significantly affected the germination of standing, fallen, unscarified or scarified seed. While increased P increased germination in standing seed of unscarified batch, it lowered germination for fallen seed in the unscarified batch and for both standing and fallen seeds in the scarified batch.

The influence of seed harvesting date was highly significant.

In the unscarified lot, a higher germination percentage resulted from seed harvested on 28/2/81 than those harvested earlier or later. No reason could be advanced for this, although the seeds were paler than those harvested earlier and larger in size than those harvested later. It was also found that significantly more fallen seeds germinated than standing seeds ( $t = 6.29$  at 8 df). Testa pigment has been used as a criterion for determining germination and greater germination has been associated with the paler seeds (Cowdy and Verhoeven, 1961). The fallen seed was paler and hence apparently less "hard" than the standing seed. This probably accounted for the difference in germination percentage.

When scarified with hot water, all seeds irrespective of testa colour or date of harvest germinated equally. It might be emphasised that hardseededness could be advantageous under unreliable conditions of rainfall. Scarification of newly harvested seed would ensure maximum and uniform germination in steady rainfall situations.

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