RHODES GRASS (*Chloris gayana* Kunth.) SEED QUALITY IN RESPONSE TO FERTILIZER APPLICATION AND HARVESTING REGIMES

BY

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Declaration

Declaration by the student

The thesis is my original work and has not been presented for a degree in any other university. No part of this thesis may be produced without the prior permission of the author or university of Eldoret

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Dedication

All Pasture Seed Growers

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List of abbreviations

FAO: Food Agricultural Organization

ISTA: International Seed Testing Association

PGS: Pure germinating seed

GOK: Government of Kenya

KEPHIS: Kenya Plant Health Inspectorate Service

CRD: Completely randomized design

DM: Dry matter

CIG Certified seed generation

Abstract

Forage seeds play a vital role in livestock development as they are the foundation for increased feed production per unit area. Availability of good quality establishment of old stands is important in ensuring continuous and adequate supply of forage. Establishment of ley pasture is a problem to farmers mainly because of low quality seed. The quality of seed is affected during management of seed production plots harvesting processing and storage. This study accessed seed quality of different Rhodes grass varieties through optimal fertilization , harvesting regimes and degluming that were sourced from Lanet seed laboratory and isolation plots. A completely randomized design in the laboratory was used to access the quality of seeds from isolation plots in Endebes and those from Lanet seed laboratory. Then a split plot experiment was set at Kitale and at the University of Eldoret to determine the how dry matter herbage yield and seed degluming responded to optimal fertilization and harvesting regimes. Analysis of variance (ANOVA) was used to determine the significant difference in quality of seeds in Lanet laboratory and those from the isolation plots in Endebes and between the treatment means of fertilizer level and harvesting regime the treatment means were separated by $HSD._{0.05}$(Turkey method). The quality of seeds in Lanet laboratory and isolation plots was very low while there was a significant difference in fertilizer levels and harvesting regimes in terms of dry matter PGS, and degluming. Fertilizer application, date of harvesting and degluming enhances the quality of Rhodes grass seeds.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information

Developing countries have two thirds of the world livestock but produce only a quarter of the world's meat and one fifth of the world's milk (FAO, 2002). Kenya has a cattle population of 13.9 million of which 2.2 million are exotic dairy animals (FAO, 2005). About 50% of the animals in Kenya are found in the arid and Semi-Arid Lands (ASAL) where they are mainly grazed on unimproved pastures (Ego, 2001). The livestock productivity in the ASAL areas is low because of poor management, poor nutrition and poor animal health.

The nutrition of animals directly influences their health, production and fertility. Research has identified improper feeding as one of the major causative factors of low livestock productivity. In intensive production systems, feeding accounts for 60-80% of total production costs (Skea; 1987, Lusweti, 2000). Whereas the total area under pasture in Kenya is estimated at 60.7 million hectares (FAO, 2005), the acreage under improved pasture is estimated at only 242,095 hectares. The improved ley pastures are comprised of Rhodes grass (*Chioris gayanna* Kunth), Nandi and Nasina setaria (*Setaria spacelata*.Schumach) and *Panicum coloratum* (GoK, 200l). Improved pastures are usually grown by large scale farmers. These farmers manage the pastures better and achieve superior dry matter production and animal nutrition per unit area compared to what is obtained from natural pastures (G0K, 2001).

Forage seeds play a vital role in livestock development as they are the foundation for increased feed production per unit area. Good quality establishment of ley pastures is important in ensuring continuous and adequate supply of forage. During pasture establishment farmers have the options of utilizing farm prepared seed, obtained from farmers or purchase certified seed has guaranteed quality and therefore the best establishment. Rhodes grass like tropical grasses produces significant forage and performs well on in many Agro-ecological conditions Lonch 2004). The seed is characterized by low laboratory purity and germination percentages locally produced Rhodes grass seed requires a germination percentage of only 50% and a percentage of only 40% to be certified for sale in Kenya (GoK, 2004). This relatively low seed quality creates uncertainties which force farmers to use higher seed rates and therefore make pasture establishment and field reseeding an expensive operation.

The low quality of planted seed manifests in low germination, slow vigour and poor stand establishment. The slow vigour and poor stand lengthens the period required before first grazing thus causing low initial herbage quantity, increase weeding and overall pasture management costs.

1.2. Statement of the Problem

Forage seeds play a vital role in livestock development as they are the foundation for increased feed production per unit area. Availability of good quality establishment of old stands is important in ensuring continuous and adequate supply of forage. Gakonyo (2013) observed that Rhodes grass seed sometimes exhibits germination failure and field establishment is greatly affected when low vigour seed is sown in high weed competition environments. Whereas fields sown with Rhodes are expected to cover the ground and ready for grazing in four to six months (Gakonyo, 1978), the establishment of adequate ground cover' has been observed to take 12-18 months (Gakonyo, 1978).

Rhodes grass exhibit Low germination which varies among varieties. The variation could be caused by both purity and physiological quality. The variability in the stage of maturity of seed within an inflorescence has been identified as one of the causes of "unfilled seeds" in grasses (Strawbridge, 1992). Therefore there is need to access how crop handling can improve seed quality in order to improve milk and meat production.

1.3. Study Justification

The Kenya livestock sub-sector contributes 11 percent of Kenya's Gross Domestic Product (GDP) and employs about 50 percent of the agricultural labor force (Miaron, 2006). Over the years, there has been human and livestock population growth although livestock numbers per family have declined (Lesogorol, 2003).The changing land systems have seen communal grazing land subdivided, leading to restricted movement and access to pasture (Gitumu 2003). Inaccessibility to pastures' has further reduced production and productivity from livestock and has caused food insecurity especially to the communities that rely on livestock for their livelihood. Population pressure in high and medium potential lands is forcing agricultural production to shift to marginal areas hence further reducing land available for grazing land.

Presently, majority of livestock farmers rely on natural pasture grasses for supply of biomass necessary for the sustenance, growth and reproduction of livestock. With the space for natural grazing diminishing, and livestock population increasing, natural pastures are increasingly overwhelmed. The utilization of well-established pastures is probably the best alternative approach to meeting the pasture requirement for livestock. Increasing the acrearage of nutritious, well established good-stand pasture and increased livestock health management are key components of improving livestock productivity in a sustainable manner. However, good stands of pasture can only be obtained from good quality seed. Good quality seed is an important input currently in short supply. Studies into seed quality aspects of Rhodes grass, the most common species of established pasture grasses in Kenya are crucial to the livestock sub-sector. Through the use of good quality seed increased livestock productivity. The accessibility and availability of fertilizer is a hindrance attaining good quality herbage and seed.

1.4. Objectives

1.4.1. Overall objective

To assess seed quality of different Rhodes grass varieties obtained from lanet laboratory, existing isolation plots in Endebes and through optimal fertilization and harvesting regimes

1.4.2 Specific objectives

1. To evaluate seed quality of existing isolation plots in Endebes
2. To assess the Seed Quality Status of current breeder's Rhodes grass seed at Lanet seed laboratory over years.
3. To determine the best harvesting regime and fertilizer level application to obtain optimal seed quality.
4. To assess the effect of degluming on germination of Rhodes grass seed.

1.5. Hypothesis

H_{01}: Seed Quality Status of existing isolation plots of Rhodes grass varieties at Endebes does not differ significantly

H_{02}: Rhodes grass Seed quality at Lanet laboratory does not differ significantly over years of harvest.

H_{03}: different harvesting regimes and different fertilizer application rates do not influence Rhodes grass seed quality significantly.

H_{04}: Degluming does not improve significantly seed quality of Rhodes grass.

CHAPTER TWO

LITERATURE REVIEW

2.0. Overview

Kenya's livestock industry targets domestic self sufficiency in milk, meat and their products for sustenance in the face of increasing human population (KARl, 1995). This has not been realized due to low meat and milk yields per animal and relatively low off-take rates (Kimani and Lekasi, 2000). The major link between nutrition and fertility is that animals in severe negative energy balance during early lactation have lower conception rates. Energy and protein supplied by feeds are important for maintenance, growth and production. Acute shortages of forages of forages frequently reported in the arid and semi-arid areas of North Eastern province, parts of Eastern province, parts of eastern and Rift Valley Province are indications that optimum productivity and sustainability is yet to be achieved.

2.1. Rhodes Grass general Ecology

Rhodes grass belongs to family Poacea, sub family Chloridodeae and tribe Cynodonteae (Nyanjong. 1998). The grass was named after a South African, Cecil Rhodes who popularized its use in late 19th century. It is a stoleniferous sward forming grass. Commercial varieties have digitate panicles with 8- 12 racemes 6-9cm long.

It is a versatile and widely adaptable plant that grows in the latitude range of 18-33° North and South of the equator. It has its origins in tropical and sub-tropical Africa (Loch, 2004). Several temperature ranges have been recorded for its growth with the optimum temperature for growth being 35°C (Ponsens, 2010). It is however thrives at 40°C in the Arabian Dessert under irrigation (Boonman, 1993), and it has been recorded to be able to withstand frost (Kumar, 2005). It is found naturally all over Africa in woodland and on lakeside. Some varieties are day neutral while others respond to short days (Lonch, 2004). Rhodes grass readily forms stolons that allow rapid ground cover and has a relatively reliable seed production. It matures for grazing 4-6 months after planting but its highest production normally comes in the second year after establishment (Moore, 2006) .It is acceptable to many livestock, its resistance to leaf diseases and easy to cut for conservation or stall feeding (Loch, 2004). It is preferred in short time crop-pasture rotations due to its rapid soil nitrogen (N) recycling qualities and ease of eradication through ploughing (Kumar, 2005).

Rhodes grass is cross pollinating (Bogdan, 1961) with self compatibility estimated at 1-4% (Loch, 2004). Rhodes grass seed is made of fluffy spikelets which mature 23-25 days after flowering. Flowering of the grass in Kitale, Kenya was observed to take place in the afternoons (Bogdan, 1959). Harvested seed remains viable for four years (Nyanjong, 1998). There are 3-5 million seeds in a Kilogram and the average weight of 1000 seeds is 200-325mg (Boonman, 1993).

2.2. Rhodes Grass Varieties

Varieties of East African origin are tetraploids(4n=40). While those of South African origin are diploid (2n-20). Diplod varieties include Pioneer, Nzoia, and Katambora.. The diploids are more subtropical and they flourish at more than 20°C latitude and are more cold tolerant. They also have little post harvest seed dormancy (Loch and Harvey, 1999). The tetraploids include Callide (also known as Kongwa , Mpwapwa), Mbarara, Rongai, Samford, Pokot, Masaba and Kapedo. They flourish within 200m of the equator (Loch and Harrvey, 1999). Diploids have better set (Nyanjong, 1998) The main agro-ecological zone of natural distribution of Rhodes grass in East Africa is zone 111, which is from 1000- 2000 m above sea level (Boonman, 1993). Equatorial varieties perform very well in the rainy season and are drought tolerate, surviving with little as 500-600 mm annual rainfall and are salt and water-logging tolerance (Boonman, 1993).

2.2.1. Differences between Rhodes grass genotypes in forage yield

The studies show that differences Rhodes grass cultivars are insignificant. This may be attributed to the fact that all of the five Rhodes grass cultivars belonged to the diploid type with at least three of them being of the same genetic background. The cultivar Katambora Australia is an ecotype from Katambora Zimbabwe mother population, whereas Fine Cut has been derived from the Australian ecotype, (Loch et al 2004). On the other hand cultivar Top Cut which was bred in Australia from Pioneer group was believed to be had experienced some introgression with some of the Australian ecotypes, (Loch et al 2004).Due to the insignificant differences among Rhodes grass cultivars, contrast analysis grass as one group was performed vs. Abu Sabein and Garawya as one group. The contrast analysis has indicated that Rhodes grass group significantly out yields forage Sorghum in all cuts other than the first cut. According to the recent statistic of the Ministry of Agriculture and Animal Wealth of Khartoum State, the traditional cultivar Abu Sabein covered 75 % of the area cropped to fodders.

2.3. Establishment of Rhodes grass

2.3.1. Vegetative propagation

Rhodes grass can be established from seed or by vegetative propagation. Vegetative propagation using stolons and splits was carried out in Central Kenya but the method was later proved unreliable (Bogdan. 1959). The main challenges were in identifying the best physiological age of the planted material and frequent unfavorable weather conditions which led to the death of a lot planting material (Bogdan. 1965). Root splits were found to perform better than stolon sections. However, splits dug from second or third year swards are difficult to keep alive, and mowing before digging does not significantly help in survival (Boonman, 1993).

2.3.2. Establishment of Rhodes grass pasture from Seed

Poor Plant stand establishment is responsible for reduced yields in food crops and in pastures. Losses of approximately 30% of the potential yield of sorghum and sunflower were estimated in the central highlands of Queensland, Australia (Radford, 1989). The success of sown pasture depends on the success of sowing. A sward 50cm high can be achieved in 50 days from sowing using good quality seed at the recommended seed rate (Boonman, 1977). One kilogram of 100% Pure germinating Seed (PGS) or four kilograms of 25% PGS is required per hectare. This gives a potential of 360 plants per square metre with a potential yield of 2000 kg of dry matter (DM) per hectare (Hacker, 1999). However, seedling mortality is usually very high with less than 100 seedlings establishment per square metre (Boonman, 1993). This translates into a mere 7% of total florets sown (assuming a 25% PGS lot) and maximum of 27.7% assuming a 100% PGS seed lot. Because of this low survival rate, farmers often use higher seed rates, especially for home prepared seed of unknown germination capacity, high seed rates are wasteful, require greater investment and are therefore expensive. In addition, closely growing seedlings of Rhodes grass seldom from stolons produces poor pasture establishment (Bogdan, 1959; Boonman, 1993).Therefore, close sowing of Rhodes grass is not recommended, especially in wide rows because stolons cannot develop properly and field will have an appearance of a row crop rather than a sward for years(Boonman, 1993). Further reduction in the seed rate increases risk of establishment failure in the event of unfavorable conditions which predispose high seedling mortality. A rather poor root system is one of the causes of low seedling survival. This is because the seedlings are often only lightly anchored in the soil with no more than threadlike elongated node, making them vulnerable to uprooting and desiccation (Boonman, 1993).

The principle of sowing, is to give plants the greatest, competitive advantage over existing plants and others which may germinate from soil seed bank (Rebello, 2001). Unlike food crops from Poaceae, seed size has not been a major criterion for selection of herbage plants and thus majority of herbage species in use today have small seeds which weighs less than 2 mg per seed (Loch and Thomson, 1994). The herbage seeds compete with 5,000-50,000 other seeds already in the soil for germination micro sites (Marshal and Naylor, 1985). The sites must provide correct temperature, water, light, oxygen ideal soil particle size, and pH. In order for the seeds of sown pastures to complete favorably they must have high vigour.

2.4. Variation in Seed quality

Seed quality is normally determined by the viability and vigor of seed lots. Good seed quality ensures efficient transfer of standards, attributes, and heritable characters pertaining to crop performance. On the other hand, poor seed quality is cause of poor seedling establishment and therefore selection of high vigour seed may be a strategy for improving the field establishment of crops (Mershall and Naylor, 1985). The viability of a seed lot is determined by capacity of the seeds to germinate and produce normal seedlings (Dornbos, 1995), while vigour is the sum of those properties that determine the potential level of activity and performance of a seed lot of a seed lot during germination and seedling emergence (ISTA, 1995).

Viability is determined using the standard germination test. The test is done under ideal conditions and often over estimates field performance (Kim, 1994). High seed quality emphasizes that each seed sown produces a vigorous seedling which will ensure high yields (Basu, 1994). Use of high vigour seed at correct seed rates points to the need for gapping and increases uniformity in growth and synchrony in development (Basu, l994).

The quality of seeds widely varies even between individual seeds of seed lot. Hill and Loch (1983) observed that the variation was due to differences in earliness of individual spiketets and the seeds found even in well synchronized crops of tropical grasses. Such harvesting leads to a collection of seeds at different levels of maturity. It has been observed that by virtue of the positioning of individual seeds on the racemes, spikelets or pods onset of seed formation and seed filling begins and ends at different times, so much so that some seeds reach physiological maturity before seed filling in other seeds is completed (Chamnia, 1990; Tekrony and Egli, 1997; Muasya, 2006). All the seeds are usually harvested at the same time with the harvester ending up with seeds of different ages and at different levels of seed filling and maturity (Muasya, 2006). The viability and vigour of such seeds will not be uniform (Keigley and Mullen, 1986; Adam, 1989, Illipronti, 2000b). Seed lots of the same cultivar and with identical germination and seedling growth, tolerance to stress conditions, field emergence and in biological and agricultural yields (Han, 1995; Gustafsson and Ehrlen, 2003). If the variation exhibited is high, the bulk quality as stated by germination percentage and percent purity is compromised (Marcos-Filho, 1980; Chamma, 1990). This is because of differences that may exist within seed lot. The variation in seed vigour is associated with variation in the time of pollination, seed filling rate and duration of seed filling(Ferguson and Loch, 1999). Variation in reserves content potentially leads to variation in initial growth rates between plants in a stand. Seedlings with a high initial growth rate grow much faster, are more stress tolerant and may lead to an increase in difference in growth and development rates so that at the time of harvest the difference in seed development is quite high.

2.5. Caryopsis content in grass seeds

The percentage of grass seed that is actually harvested compared to what the crop produces is as low as only 15-20% of florets that are harvested as seed in a crop of rye grass and only a small percentage of seeds harvested carry caryopsis(Marshall, 2004).

The basic unit of grass inflorescence is the floret. It is made up of actual fruit known as caryopsis surrounded by lemma and palea. It is the caryopsis that carries the embryo and germinates. The grass seed are small, are not produced synchronously and are shed soon after maturation (Marshall, 2004).The genetics of pasture variety, agronomic practices. environmental conditions, seed harvesting and cleaning practices and storage conditions affect the number of florets in a seed lot that contain caryopses. Florets without caryopses are of no value to farmers. It is difficult to remove all empty glumes during cleaning and therefore large number of florets has been found without seeds even after cleaning. Low caryopsis count in grasses is attributed to the few-hour lifespan of grass pollen, lack of embryo formation, embryo abortion, poor seed filling due to environmental stresses where the caryopsis is immature, too small or malformed and shattering that causes caryopsis loss (Elias and nelson, 2009). The variation in the physiological seed age leads to variation in time and rate of emergence and therefore variation from the onset of autotrophic growth in seed lot (Baalbaki, Mackdonald, 2009). All these factors affect the quality of individual seeds and the overall bulk quality of a seed lot.

Seed of good viability may fail to germinate due to dormancy. Freshly harvested pasture seed can be dormant for several months. Such dormancy was observed in buffel grass (*Ceynchrus ciliaris*) (Kumar, 2005).

2.6.1 Effect of harvesting regime and fertilizer on germination percentage

The objective of germination test is to determine the maximum germination potential of a seed lot which can in turn be used to compare quality of different lots and also estimate the field planting value (ISTA, 2004). Since a seed lot is composed of single seeds each of which contributes to the quality of the lot, every seed tested is examined for its quality. The evaluation process in the laboratory begins with the emergence of the primary root and ends when the seedling has developed to the stage where it can be evaluated according to ISTA rules (ISTA, 2004).The rules require the observation of essential structures which serve as indicators to whether or not the seedling is able to grow further into a satisfactory plant under favorable conditions in the soil. The percentage germination of the lot is recorded and it indicates the proportion of seeds that have produced seedlings classified as normal. A normal seedling is one that shows potential for continued development into satisfactory plants when grown in good quality soil and under favorable conditions of moisture, temperature and light.

Different plant species are evaluated at different germination conditions. The Rhodes grass germination test is done 'top of paper' with 7-day pre-chilling period at 5°C in 0.2% Potassium Nitrate solution and temperature range of 20-30°C in the germination chamber with light illumination of 750-1250 Lax for at least 8 hours in a day. Seedling evaluation is carried out on the 7th and 14th days (ISTA 2004).

2.6.2. Effect of harvesting regime and fertilizer on Herbage and Seed quality

There is need to develop methods and techniques to obtain high yields of good quality seed in grasses. The excessive vegetative growth of grasses, under certain conditions, may discourage seed yield. Thus there is a need to strike a balance between the amount of vegetative growth and the reproductive phase. (Kumar et al, .2005). Allowing herbage mass to exceed the optimum point (e.g. delayed harvest), or harvesting to below the optimum point, will reduce the instertenous herbage accumulation rate. The herbage mass curves define a range of herbage mass within which pastures can be managed to achieve high herbage weight, and maintaining pastures within 90% of the maximum herbage quantity maybe a practical target for producers. David, 2010).

In *Setaria sphacelata*, Dwivedi and kasmbol, (l999), reported that defoliation/cutting suppressed the seed yield over uncut crops. Besides management of vegetative growth, seed yield also depends on the fertility status of the soil and on the amount of fertilizer, especially N fertilizer, applied. Adequate nitrogen nutrition increases tiller density and the number of inflorescences and subsequently seed yield in tropical grasses (Boonman, 1972, Babnisch & Humphreys, 1977; Loch, 1980; Loch et al., 1999; Dwivedi, 1999; Gohius. 2001; Kumar, 2005). In view of the above considerations, the effect of cutting, management and level of N: P: K fertilizer on seed yield attributes and seed yield of Rhodes grass(*Chloris gayana* Kunth.) shall be evaluated. (Gwathmey, 2009) discovered that higher K fertility shifts the partitioning of dry matter and K to vegetative organs relative to fruit, of earlier maturing cotton (*Gossypium hirsutum* L.).

The low seed yield in one-cut or clipped crop in comparison to uncut crop may be due to slower regrowth, poor synchronization of tiller development and also delayed inflorescence emergence (Dwivedi et al., 1999). In cowpea (*Vigna unguiculata*), Mwanarusi et al (2010) determined that leaf harvesting at seven days interval reduced grain yield while harvesting at fourteen days interval led to high grain yield. Hiroshi et al,. (2010) reported that starch was translocated from the stem to the panicle in the second crop when the first crop was cut at a height of 15 cm, insufficient starch was translocated to the panicle when the first crop was cut at 5 and 0 cm because of the low temperatures after heading in double-harvested forage rice (*Oryza sativa* (L.)

Selection of crops and management practices that optimize yield, and maintain a high level of resource partioning to roots at low to intermediate N input rates will promote the development of productive and efficient bio-energy systems in perennial grass

(Heggenstaller,2009). Interrante et al,. (2009) reported varietal difference on persistence after defoliation of Bahia grass (*Paspalum notatum* Flugge).

CHAPTER THREE

MATERIALS AND METHODS

Three studies were carried out to achieve the set objectives

3.1. Research one: Determination of Seed quality of different grass existing Rhodes grass in isolation Fields at Elgon downs farm-Endebess

This involved determination of seed quality of existing Rhodes breeders seed quality planted in isolation at Elgon downs farm-Endebess . the grass involved were Pokot Rhodesat chorlim field, Katambora rhodes at bull field block, and Elmba rhodes at kamunje field. The isolation plots were established more than 2 years ago. Elmba Rhodes at kamunje farm Endebess was planted on 13/11/2006 and Katambora rhodes at bull block was planted on 15/4/2006 and was 4 years old, Pokot Rhodes was planted on 26/5/2008 and it was 2 years old. Elmba Rhodes was inspected on 20/7/2007, Katambora on 23/07/2007 and Pokot Rhodes on 16/9/2008 and certified by KEPHIS for seed production. The 3 plots were harvested and seasoned for 3 weeks, then the seed was threshed and 500gms sampled for laboratory seed quality determination. The data collected was Seed purity (%), Seed germination (%) and 1000 seed weight (gm).

3.1.2 Data analysis

The a experiment was arranged as completely randomized design (CRD) in the laboratory and data collected was subjected to ANOVA with means separated using LSD using the statistical model below

$$Y_{jk} = \mu + T_i + £_{jk}$$

Where:

Y_{jk}=Response variable

μ= General mean

T_i= Treatment means

$£_{jk}$= Experimental error

3.2 Research two: Evaluation quality trends of different seed lots stored at Lanet in Nakuru in the past ten years

Information on Purity(%) , germination(%) and PGS given by the tecnitian in the laboratory was collected.The data was analyzed using excel to shows trends of different seed clusters of Rhodes grass. Breeders, Pre basic, basic and of certified seed different levels classes of seed were collected over 10 years. The laboratory was accredited by ISTA for seed testing in Kenya. The laboratory is situated in Nakuru County and grains and pastures are collected and tested.

3.2.1 Data analysis

The data collected was presented as an average.

3.3. Research three: (Field experiment): Influence of fertilizer rates and harvest regimes on Rhodes grass seed quality

The third study involved setting up an experiment at Elgon downs farm (Kenya seed Company) and university of Eldoret to assess how to improve seed quality by use of fertilizer and cutting regime.

3.3.1 Eco-zones for testing treatments

3.3.1.1Kitale

Is under UM4 with a cool altitude area, at 1850-2400 m a.s.l and rainfall of 1000-2500mm rainfall. The soils in Kitale being humic ferrasols.

3.3.1.2 University of Eldoret

Eldoret is under LH3 with cool and wet altitudes with annual rainfall 1190mm per annum

3.3.2 Experimental procedure and design

The experiment was laid out in a split plot design. The treatments consisted of three levels of Agroblen fertilizer (N: P: K 20:10:10) 100kg/ha,75kg/ha and 50kg/ha, three varieties of Rhodes grass (Elmba, Pokot and Katambora Rhodes grasses) and three harvesting regimes (zero cut, 1 cutting and 2 cuttings).Harvesting regime formed the main plot while fertilizer and variety formed the subplots with three replications. Each plot measured 12.5m^2 and consisted of 11 rows, 5m long planted at 30cm between rows. CAN was applied at the rate of 50kg/ha after every harvesting equally to all the treatments. Weeding was done after every three weeks. Harvesting of each plot was done when the plants were at the stage of 50% maturity. One m^2 of a randomly thrown quadrant was harvested and fresh weight taken, and then a sample of 200 g from each of the clipped plots was put in poly bags and taken to the laboratory for dry matter determination. The seed was harvested and seasoned within the plot then after three weeks the seed was separated from vegetative parts; 500 g of seed was sampled and taken to the laboratory for seed quality determination.

3.3.2.1. Treatment Combinations

Varieties used were those being marketed by Kenya Seed Company limited: V1-Elmba, V2-Pokot Rhodes, and V3-Katambora Rhodes. Fertilizer rates were rated as F1:50kg/ha (37.5g per plot), F2-75kg/ha (56.5g) and F3-100kg/ha (75g per plot). Varieties were combined into 3 levels variety and three levels of fertilizer to make 9 treatments randomized in each harvest regime. Layout (appendix19) was similar for both sites (Endebes and University of Eldoret).

3.3.3. Field management and Data collected

Weeding was done every after 3 weeks and stand count taken at that stage using quadrant ($1m^2$). Harvesting of each plot was done when the plants were at the stage of 50% maturity. One m^2 of a randomly thrown quadrant was harvested and fresh weight taken, and then a sample of 200 g from each of the clipped plots was put in poly bags and taken to the laboratory for dry matter determination. The seed was harvested and seasoned within the plot then after 3 weeks the seed was separated from vegetative parts; 500 g of seed was sampled and taken to the laboratory for seed quality determination. The following variables were measured.

3.3.3.1. Days to 50% flowering: counted from the planting date. It was done by counting days from planting date when 50% of the plants per plot had flowered.

3.3.3.2. Fresh herbage (t/ha): Harvesting was done thrice after every heading. It was determined by weighing total herbage obtained by cutting grass from a randomly thrown quadrant ($1m^2$). When the field was established, zero cut fields were not clipped at all. Cutting 2 of herbage was done just after the 1st seed harvest and subsequent harvest no clipping was done. Cutting 3 of herbage was done was done every after seed harvest of seed.

3.3.3.3.Dry matter weight (t/ha):Was determined by randomly sampling 200g in each plot at 50% flowering, and placed in an oven 100^{o}C for 24 hours, before weighing.

3.3.3.4. Purity analysis (%)

The seed sampled from the plots were sun dried until moisture content of 13% was reached. The seed was drawn from representative sample, using a mechanical divider the seed was split to Obtain 4 working samples estimated at 2,500 seed units(ISTA rules chap.2 Table 2A.T he " working sample" to be used for purity and germination

The purity test was done at Kenya Seed Company quality assurance laboratory since it has been accredited by ISTA. The purity was used to determine the mechanical quality of the sample and percentage by weight of each component namely; pure seed, other crop seed and inert matter. The purpose of the test is to determine the percentage of the pure seed fraction. It is the fraction that was used in germination tests. Rhodes grass seed is small, light and chaffy. Rhodes grass seed purity was determined using uniform blowing method with the help of a blower. The blower consists of a tube through which a uniform flow of air introduced with a valve regulating the amount of pressure.

The working sample was obtained by first mixing the seed lot at least eight times using a soil divider (ISTA, 2004). The mixing was done to obtain homogeneity in the test sample. A spoon was used to scoop seed which was weighed using electronic balance (Model KERN 770/GS/GJ).One (1) gram was transferred to a blower cup. The blower is Hoffman 67 blower calibrated for *Chloris gayanna* to the pressure of thirteen units. Each sample was blown for three minutes according to ISTA (2004). The lightest material was blown away and residue consisting of heavy florets, most of them containing caryopsis, fraction .made up of pure seed fraction. The purity percentage was determined from fraction of pure seed fraction divided by the weight of initial seed sample.

3.3.3.5. Percentage seed Germination Test

The seed sampled from the plots were sun dried until moisture content of 13% was reached. The seed was drawn from representative sample, using a mechanical divider the seed was split to Obtain 4 working samples estimated at 2,500 seed units (ISTA, 2004). The “working sample” to be used for germination. This test was carried out at Kenya Seed Company quality assurance laboratory in Kitale, Kenya since it is ISTA accredidated. The pure seed fraction obtained from during purity analysis was used in germination tests. Four replications of every seed lot were placed on top of three(3) 9 mm ‘Whatman 4’ filter paper that had been moistened with 5 milliliters of distilled water in petri-dishes.are placed in a germination chamber. Four replications were done for each seed lot a sample was labeled according to its seed lot and replication .The samples were arranged in randomized block design. Relative humidity of 70% and a temperature of 20°c were maintained. Daily counts of seedling emergence by observation of radical emergency were done; initial and final count was done at 7^{nt} and 14^{nt} day respectively (ISTA, 2004).

3.3.3.6. PGS (viability test)

The PGS is an indication of viability of pure seed fraction of the seed lot. It is a product of the germination and purity percentages.

$$PGS\% = \frac{\text{Germination percentage x Percent purity}}{100}$$

3.3.3.7. Caryopsis seed and chaff weight: Caryopsis sample where purity and germination (%) for both glumed and deglumed seeds were determined in laboratory.The seed was deglumed to obtain caryopsis and both deglumed (caryopsis) and seed (glumed seed was used). Viability test was done for *Chloris gayanna* at the National Genebank of Kenya. Hundred seeds were used in two replicates of 50 seeds each. The 1% water agar was used as a media and Potassium Nitrate (KNO_3) was added to the media to assist in breaking dormancy. The seed were placed in an incubator set, alternating temperatures of 20^{o}C and 30^{o}C.After 7 days the 1st count was done and after 14 days respectively. The average was recorded.

3.4. Data analysis

The ANOVA was used to determine significance of main factor (harvest regime) and sub-factor (Treatment combination of fertilizer rates and variety) using SAS statistical package version 9.1. Mean separation was done by HSD at 0.05 level of significance (Tukey's method) to determine the significant difference between treatment means.

Mathematical model shown was used for analysis:-

- $X_{jklm} = \mu + \alpha_j + \beta_k + £_{jk} + (\Lambda_j + \ddot{Y}_{jl})£_{jklm}$

Where;

- X_{jklm} = Plot observation.
- μ = Mean of plot observation.
- $\alpha_{j =}$ Main treatment effect.
- β_k = Replication or block effect.
- $£_{jk}$ = Experimental error (1).
- Λ_j = Sub- treatment effect.
- $\ddot{Y}_{jl}$ = Interaction, Main treatment x sub treatment.
- $£_{jklm}$ = Experimental error (2)

CHAPTER FOUR

RESULTS

4.1. Research one: pasture seed quality status of breeder's seed from Endebes isolation plots

Isolation plots are normally established to raise breeder's seed under close supervision by breeder, maintainer, and seed regulator (KEPHIS). The varieties below showed very low viability. Pokot Rhodes being young at two years gave comparable high germination of 12% compared to Elmba Rhodes(3%) and Katambora Rhodes (4%) which were four years old (table…) in terms of 1000 seed weight Pokot Rhodes weighed 0.457 while Elmba Rhodes and katambora weighed significantly less at 0.42g and 0.43g respectively. Similarly Pokot Rhodes that significantly ($p \leq 0.05$) more pure seed (31.8%) compared to Elmba and Katambora the seed weight was inclusive of glumes.

Table 1: Rhodes Grass Seed Quality Status from Field of Endebess

Variety	Field location	Age	Purity (%)	Germination (%)	PGS	1000 seed weight(g)
Elmba Rhodes	Kamunje	4 years	31.1	3	0.9	0.42
Katambora	Bull block	4 years	31.0	4	1.2	0.43
Pokot Rhodes	Chorlim	2 years	36.8	12	4.4	0.457

4.2. Research two: Seed quality of Rhodes grass of pre-basic and basic seed class from records at Lanet KEPHIS laboratory over the last 10 years.

Basic seed is also called foundation seed either generated from breeder's seed or Pre basic seed. The data in figure 4 shows that over years most seed met the National threshold of PGS of 20.

Pre-Basic is also named foundation seed which is generated from breeder's seed, With an Isolation at 400 meters from other Rhodes varieties. Over the last 10 years PGS has been above 20.

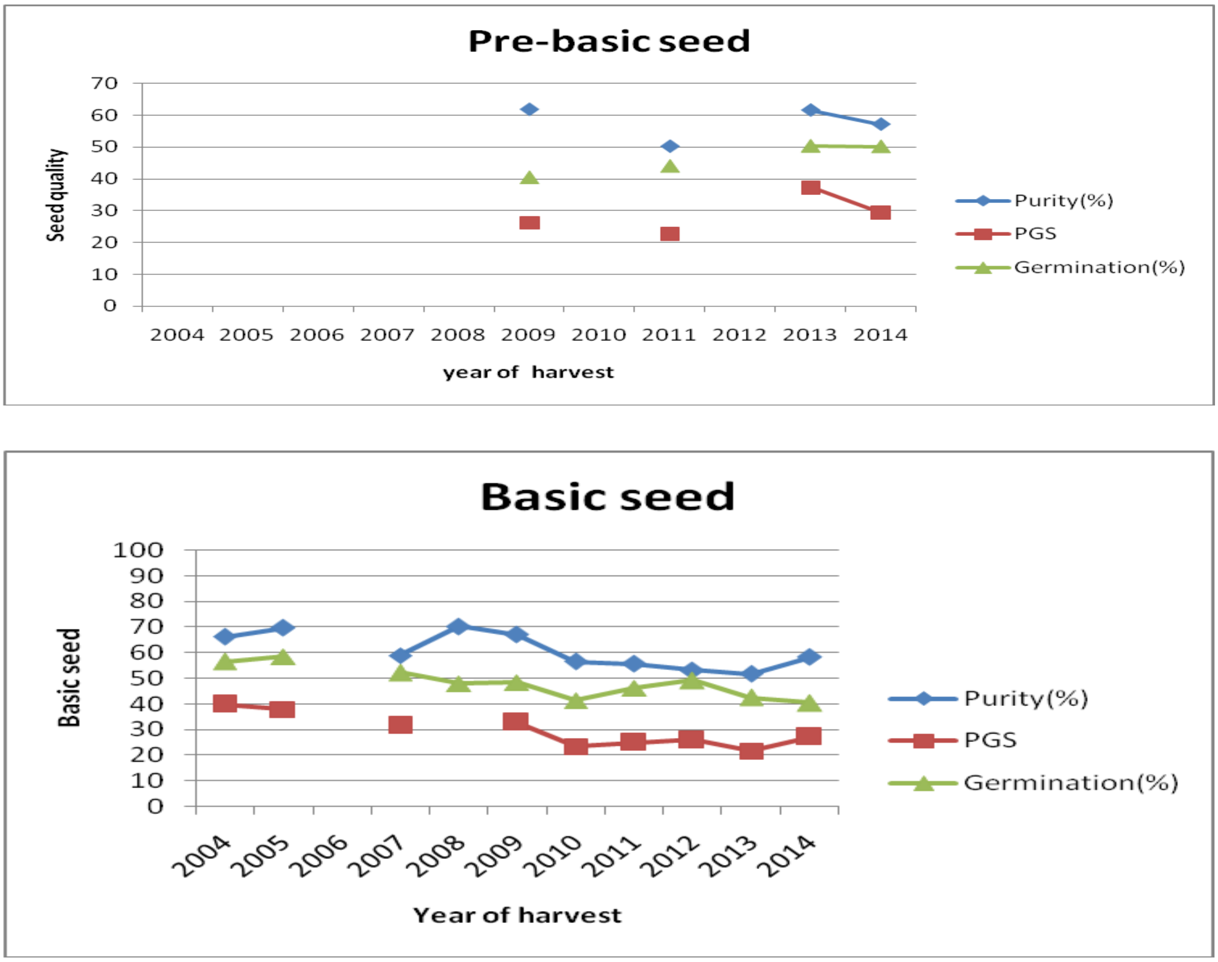
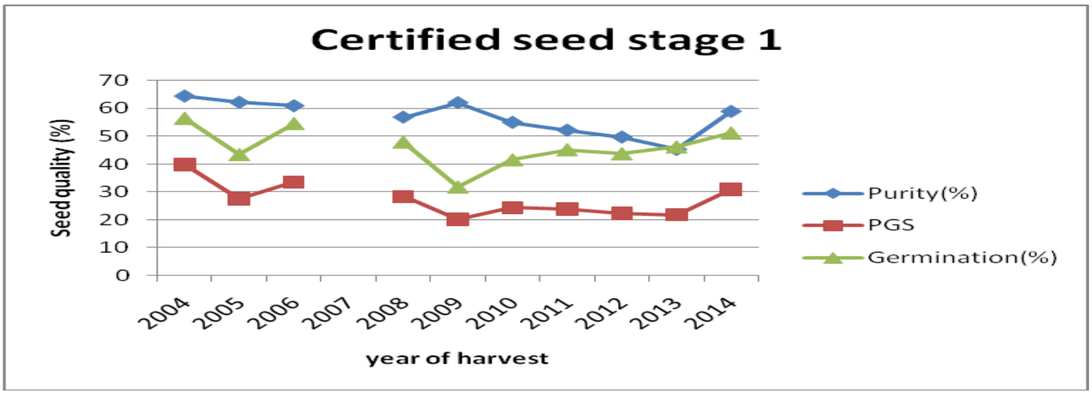
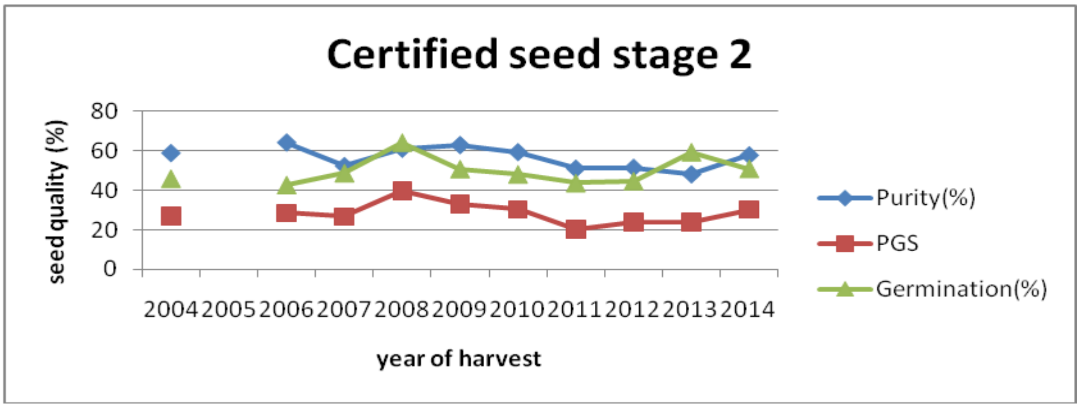


Figure 4: Seed quality (pre- basic and basic for the last 10 years

Certified Seed Class 1, is seed generated from Basic Seed, the PGS levels was above 20.Germination was below 60%. Certified Seed Class 2 is generated from Certified Seed class1.The chart shows that PGS was greater than the recommended National seed recommendation of 20. But germination percentage was less than 60% and greater than 40%. Certified Seed Class 3 is generated from Certified Seed Class 2. The figure shows that despite PGS being in the threshold of above 20, the germination percentage was below 50%.





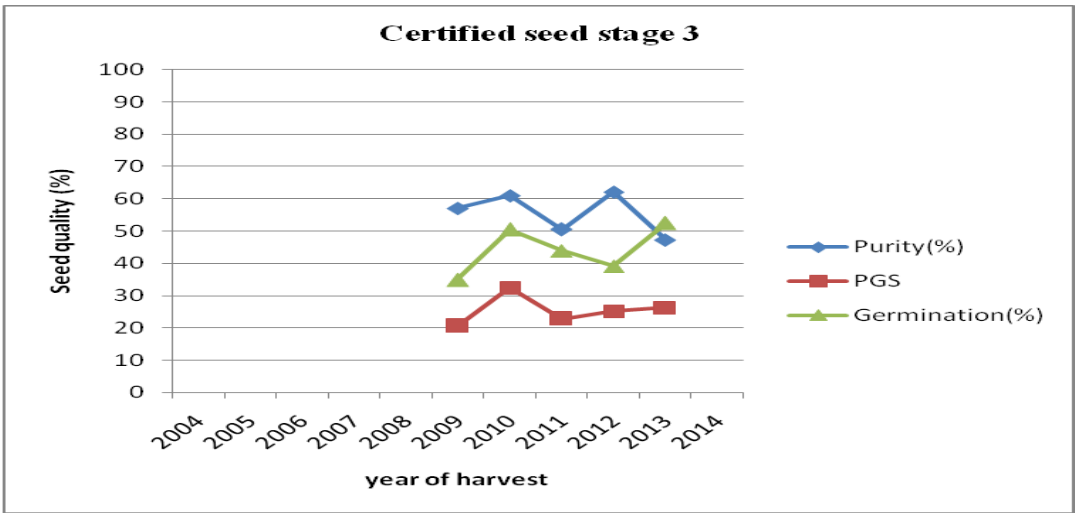


Figure 5: Quality trends of different classes of certified seed stored at Lanet KEPHIS over the last 10 years.

In some cases there is another class of seed that does not undergo the mandatory certification process, single plants are planted out and seed generated is bulked in large quantities for sale. This is referred to as standard seed class despite meeting the recommended standard of 20 PGS; germination was below 50% over the years.

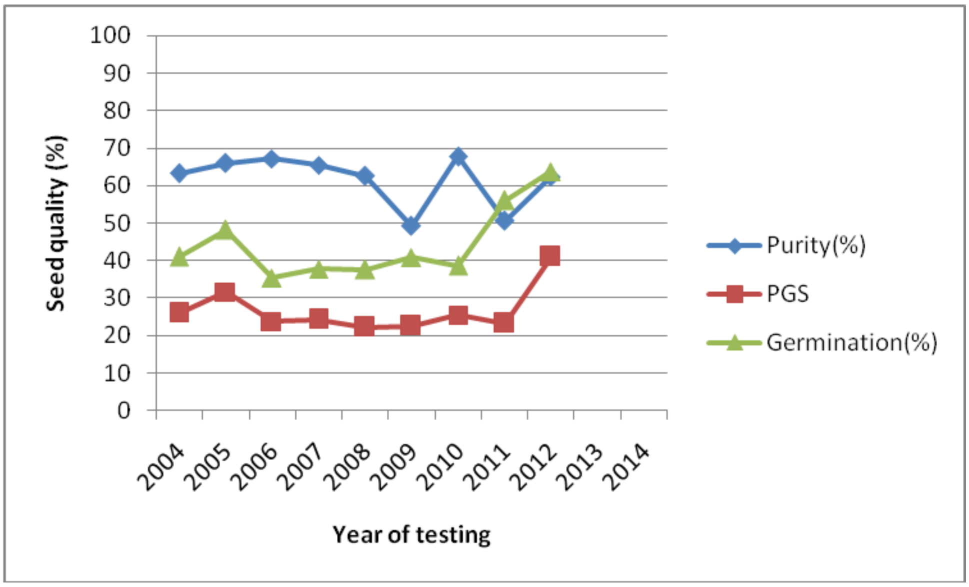


Figure 6: Seed Quality trend of standard Rhodes grass seed at Lanet Kephis for the last 10 years.

4.3. Research three (Field experiment): Influence of fertilizer rate and harvest regime on seed quality of Rhodes grass

4.3.1. Effect of harvest regime, fertilizer rate and variety on Days to 50% flowering of Rhodes grass varieties at University of Eldoret and Endebes.

Generally at Endebess all the varieties headed late, than at the university of eldoret. There was no significant difference between treatments at 0.05 significant level of both sites **(Table 2).**

Table 2: Effect of harvest regime, fertilizer rate and variety on Days to 50% flowering of Rhodes grass

Treatments	**Germination percentage**		
	Chepkoilel	**Endebess**	**Mean**
Harvest Regime			
Once	85.6	120.3	145.8
Twice	82.4	121.2	143
Thrice	85.0	121.5	145.8
$HSD_{0.05}$	**3.9**	**4.9**	
Fertilizer rate(kg/ha)			
50	86.1	120.4	146.3
75	80.4	121.0	140.9
100	86.5	121.5	147.3
$HSD_{0.05}$	**4.1**	**3.2**	
Variety			
Elmba	85.9	120.4	146.1
Katambora	85.1	121.0	145.6
Pokot	82.1	121.7	143
$HSD_{0.05}$	**3.8**	**3.6**	
Mean	**84.3**	**121**	**102.65**

4.3.2 Effect of harvest regime, fertilizer rate and variety on Fresh Herbage (t/ha) of Rhodes grass

Katambora Rhodes grass had relatively high herbage at 4.7 t/ha, and Pokot Rhodes lowest at 3.89 t/ha. However there was no significance ($P \leq 0.05$) difference between the three varieties at university of Eldoret. Endebess site had the highest fresh herbage (over 66%) compared to university of Eldoret. Elmba Rhodes had the highest yield of 36.5 t/ha compared to Katambora and Pokot Rhodes, but the three varieties did not differ significantly. Increasing fertilizer rates and varying the harvesting regime did not increase fresh herbage yield significantly **(Table 3)**

Table3. Effect of harvest regime, fertilizer rate and variety on Fresh Herbage (t/ha) of Rhodes grass

Treatments	**Germination percentage**		
	Chepkoilel	**Endebess**	**Mean**
Harvest Regime			
Once	4.5	34.7	21.9
Twice	4.5	33.6	21.3
Thrice	3.3	35.3	21.0
$HSD_{0.05}$	**2.53**	**9.28**	
Fertilizer rate(kg/ha)			
50	3.8	36.1	21.9
75	4.0	33.3	20.7
100	3.7	34.2	20.8
$HSD_{0.05}$	**1.054**	**5.3**	
Variety			
Elmba	4.2	34.8	21.6
Katambora	4.0	33.6	20.8
Pokot	5.1	32.9	21.6
$HSD_{0.05}$	**1.27**	**5.52**	
Mean	**4.1**	**35.2**	**19.65**

4.3.4. Effect of harvest regime, fertilizer rate and variety on Dry Matter Herbage (t/ha) of Rhodes grass

Dry matter yield at university of Eldoret was lower than endebes. Elmba Rhodes, Pokot Rhodes and katambora were not significantly different at both sites. Katambora Rhodes and Elmba Rhodes had high dry matter herbage at 11 t/ha and 10.7t/ha respectively at Endebess site.

In the University of Eldoret harvesting regime, fertilizer rate and variety did not affect DM yield significantly. In Endebes fertilizer rate and variety significantly affected DM yield but not harvesting regime. Katambora and Elmba produced significantly higher DM yield at 11t/ha and 10.7 t/ha respectively than Pokot Rhodes. Fertilizer rate application of50kg/ha produced significantly higher DM followed by 70kg/ha and 100/ha. **(Table 4)**

Table 4: Effect of harvest regime, fertilizer rate and variety on Dry Matter Herbage (t/ha) of Rhodes grass

Treatments	**Germination percentage**		
	Chepkoilel	**Endebess**	**Mean**
Harvest Regime			
Once	1.3	10.3	6.5
Twice	1.3	10.3	6.5
Thrice	1.4	10.3	6.6
$HSD_{0.05}$	**0.03**	**0.0496**	
Fertilizer rate(kg/ha)			
50	1.4	13.0	7.9
75	1.2	9.6	6.0
100	1.4	8.4	5.6
$HSD_{0.05}$	**0.1**	**0.2513**	
Variety			
Elmba	1.7	10.7	7.1
Katambora	0.9	11.0	6.4
Pokot	1.1	9.6	5.9
$HSD_{0.05}$	**1.1**	**0.231**	
Mean	**1.3**	**10.4**	**5.85**

4.3.5. Effect of harvest regime, fertilizer rate and variety on Purity Percentage (%) of Rhodes grass

Seed purity (%) was not significantly affected by grass variety, Fertilizer application rates significantly ($p \leq 0.05$) affected seed purity at both sites while harvesting regime significantly affected seed purity at Endebes and not university of Eldoret **(Table 5)**.

In Endebess although there was no significant difference of all the treatments at 0.05 level of significance, there was numerical difference. Pokot Rhodes had high purity percentage of 53.2% while Elmba Rhodes Rhodes had 52% and 51.7%. Harvesting twice gave high purity percentage of 53.8%, harvesting once and thrice gave low purity of 51.9% and 51.3 %. Fertilizer application at 100kg/ha had the highest purity at 54.6%, application of fertilizer at 50g/ha and 75kg/ha gave low purity of 49 % and 48% respectively.

Table 5: Effect of harvest regime, fertilizer rate and variety on Purity Percentage (%) of Rhodes grass

Treatments	**Germination percentage**		**Mean**
Harvest Regime	**Chepkoilel**	**Endebess**	
Once	45.5	46.6	68.8
Twice	46.2	53.8	73.1
Thrice	46.7	51.8	72.6
$HSD_{0.05}$	**25.45**	**4.09**	
Fertilizer rate(kg/ha)			
50	47	49.6	71.8
75	32.6	48.0	56.6
100	43.8	54.7	71.6
$HSD_{0.05}$	**9.27**	**6.34**	
Variety			
Elmba	46.1	52.0	72.1
Katambora	44.9	53.0	71.4
Pokot	44.6	51.7	70.5
$HSD_{0.05}$	**8.66**	**4.97**	
Mean	**44.2**	**51.2**	**47.7**

4.3.6. Effect of harvest regime, fertilizer rate and variety on Germination Percentage (%) of Rhodes grass

Seed germination (%) was not significantly affected by grass variety, Fertilizer application rates did not significantly ($p \leq 0.05$) affected seed germination at both sites. Katambora Rhodes had the highest germination percentage at 25%. Pokot Rhodes had the lowest at 19%. Elmba Rhodes at 22%. Pokot Rhodes is not adapted to hot areas and hence the low germination percentage (%). Endebess 54% germination was exceptionally better more than Chepkoilel. However there was no significant difference at ($P \leq 0.05$) in harvest regime and fertilizer rates in all sites **(Table 6).**

Table 6: Effect of harvest regime, fertilizer rate and variety on Germination Percentage (%) of Rhodes grass

Treatments	Germination percentage		
Harvest Regime	**Chepkoilel**	**Endebess**	**Mean**
Once	23.2	50.7	48.6
Twice	22.1	52.6	48.4
Thrice	22.8	52.5	49.1
$HSD_{0.05}$	**16.35**	**11.93**	
Fertilizer rate(kg/ha)			
50	67.0	52.2	93.5
75	24.7	46.6	48.0
100	21.4	53.7	48.3
$HSD_{0.05}$	**7.54**	**9.46**	
Variety			
Elmba	21.4	49.9	46.4
Katambora	27.2	52.3	53.4
Pokot	19.5	53.3	46.2
$HSD_{0.05}$	**9.04**	**9.27**	
Mean	**32.7**	**51.5**	**42.1**

4.3.7 Effect of harvest regime, fertilizer rate and variety on Weight per gram of Caryopsis and chaff of Rhodes grass

Weight of caryopsis and chaff was not significantly affected by harvesting regime, fertilizer rates and varieties ($p \leq 0.05$).Although at 0.05 significance level there was no significant difference on germination percentage of weight of caryopsis of seed lots, numerically Katambora was heavier than the rest varieties. Elmba Rhodes had heavier caryopsis at 100kg/ha fertilizer rate during the 1st cutting. Generally, caryopsis forms less than 5% of all the seed lots **(Table7).**

Table7: Effect of harvest regime, fertilizer rate and variety on Weight per gram of Caryopsis and chaff of Rhodes grass

Treatments	**Germination percentage**	
Harvest Regime	**Weight of Caryopsis (g)**	**Weight of Chaff (g)**
Once	0.38	0.91
Twice	0.04	0.91
Thrice	0.04	0.90
$HSD_{0.05}$	**0.01**	**0.02**
Fertilizer rate(kg/ha)		
50	0.16	0.91
75	0.4	0.90
100	0.26	0.90
$HSD_{0.05}$	**0.02**	**0.03**
Variety		
Elmba	0.04	0.91
Katambora	0.04	0.91
Pokot	0.05	0.91
$HSD_{0.05}$	**0.04**	**0.2**
Mean	**0.16**	**0.91**

4.3.8. Effect of harvest regime, fertilizer rate and variety on Germination Percentage of Glumed and de-glumed seeds of of Rhodes grass

The study shows that the removal of glumes to improve the germination of seeds to about 70% compared those with glumes at between 28%-48% **(Table8).** Variation of harvesting regimes, fertilizer rates and variety did not affect the germination (%) of seed with glumes and without glumes. **R**esults of germination tests showed large variations in germination within and among species. Both these varieties had low germination when fresh seeds (with glumes) were tested. On the other hand, there was significant improvement in germination for seeds of when tested with glumes (above 70%).

Table8: Effect of harvest regime, fertilizer rate and variety on Germination Percentage of Glumed and de-glumed seeds of Rhodes grass

Treatments	**Germination percentage**	
	With Glumes	**Without glumes**
Harvest Regime		
Once	42.8	79.5
Twice	28.4	70.7
Thrice	32.7	69.7
$HSD_{0.05}$	**2.1**	**2.2**
Fertilizer rate(kg/ha)		
50	34.4	73.6
75	42.6	70.7
100	38.1	69.7
$HSD_{0.05}$	**2.3**	**3.1**
Variety		
Elmba	38.6	71.55
Katambora	48.2	76.6
Pokot	33.9	74.0
$HSD_{0.05}$	**3.2**	**2.5**
Mean	**37.7**	**72.9**

CHAPTER FIVE

DISCUSSION

5.1 Initial pasture seed quality status at Endebes isolation plots

Isolation plots are normally established to raise breeder's seed under close supervision by breeder, maintainer, and seed regulator (KEPHIS). All the varieties in the isolation plots had very low viability **(Table 1).** This could be due to poor management practices i.e. direct gracing, lack of use of fertilizers and other practices.

5.2. Seed Quality of Rhodes grass Pre-Basic and Basic seed Class from Lanet KHEPHIS laboratory records

The study shows that over years most seed classes met the National threshold of PGS of 20. In majority cases PGS was greater than the recommended National seed recommendation of 20. Germination percentage was less than 60% and greater than 40%. This could be due to the maintenance practices. Basic and pre-basic seeds are under the strict care of the breeder while standard seed undergoes certification hence differences in seed quality.

5.3 Influence of fertilizer rate and harvest regime on seed quality of Rhodes grass.

In terms of Days to 50% flowering of grass it was not significantly influenced by harvest regime, fertilizer rate and variety generally the varieties headed late, Elmba Rhodes, headed earlier than Pokot Rhodes and katambora Rhodes by one day. There was no significant difference between treatments at 0.05 significant levels. Increasing fertilizer rates delays heading in Rhodes grass a mean of 85 days at 50kg/ha, and 86 days at 100kg/ha respectively. This could be due to fertilizers promote vigorous plant growth and a larger leaf area that contribute to the dry matter yield of the Pastures. Similarly, the increasing trend of green forage yield in response to increasing level of

N fertilization was also observed by many other workers (Sultana *et al.,* 2005; Khan *et al.,* 1996).

Fresh Herbage (t/ha) of Rhodes grass there was no significance at (P≤ 0.05) of University of Eldoret. Generally Endebess site had the highest Fresh herbage over 66% than Chepkoilel site mean fresh herbage **(Table 3).** Fertilization increased pasture yield in all treatments. N-fertilizer effect on forage yield has been discussed by many authors. Curll et al.(1985) determined a 20%increase of herbage accumulation due to N supply. Molina (1978) determined a greater than 60% forage yield increase with N- fertilization in many sown grasses in Santa Cruz. Dumont and Lanuza (1993) also determined an increase in forage production with N- supply.

On Dry Matter Herbage (t/ha) of Rhodes grass, Treatment effects on DM yields were significant at Endebes but not at university of Eldoret .Generally mean dry matter was high at Endebess site compared to University of Eldoret site by 90%. However there was no significance at (P≤ 0.05), dry matter in all sites **(Table 4).**In general, applying fertilizer N To Seed Crops(Assuming that there is no greater limiting factor such as soil moisture (Ralston et d ,1994)increases tilling and dry matters production (which has implications on inflorescence density and yield component hence increases seed yield and quality (Hebblethwaite and Ivins,1977., Roiston et al., 1994) . In the pure grass plots, the application of 40 kg/ha N plus the release of nitrogen following cultivation would have contributed to the high DM produced. In pure grass pastures, in the absence of added fertiliser N, DM production declines with age of the stand as N is accumulated in the below-ground material (Robbins et al 1986). Cultivation is necessary to release this N and boost DM production. The findings of this study with respect to Rhodes grass was also comparable to the findings reported for Tanzania and Zimbabwe (FAO 1981) in which Rhodes grass harvested under different growth stages and in mixtures with forage legumes increased DM yield ranged to 20% (Fresh, first cutting, early bloom, in Tanzania) and to 28.20% (fresh pasture, in Zimbabwe).

Purity Percentage (%) of Rhodes grass Elmba Rhodes had the highest seed purity at 46%, while Pokot Rhodes and Katambora Rhodes had the lowest purity at 44%. Harvesting twice and thrice had relatively highest purity at 46% while harvesting once had lowest seed purity at 45%. Fertilizer application at 75kg/ha had the highest seed purity at 47% .While 50kg/ha and 100kg/ha had low at 46% and 43% respectively **(Table 5).**Most tropical perennial grass seed is harvested and sold 'in the floret'. However, tropical grass Seed heads tend to ripen unevenly and at harvest some of the florets may be empty and not contain any seed. A high proportion of empty florets can be indicated by a high value on the seed test certificate for 'inert material'. Similarly, a high proportion of seeds other than the cultivar that you are buying (including weed seeds) will be indicated by a high value for 'other seeds'. This also applies to coated seed since the tested seed sample may include all of the harvested material (florets with seed, empty florets, straw and other seeds, can all be part of coated seed).

Germination Percentage (%) of Rhodes grass harvesting once had the highest germination percentage at 23 %. Harvesting twice and thrice had the same germination percentage at 22%. Fertilizer application at 75kg/ha had the highest germination percentage at 24% however at 100kg/ha we had the lowest germination percentage at 21% **(Table 6). This** shows effect of nitrogen and phosphorus application. Nitrogen plays a great role in synthesis of protein. Also, phosphorus plays an important role in starch. Similar results regarding the increased crude protein due to the fertilizers application (Brima, 2007).

Results showed that mean crude protein in 1st cut was better than 3rd cut. This is due to the fact that the 1st was early stage of forage but the 3rd was late stage of forage. This is in agreement with Keftasa (1990) who reported that nitrogen fertilization increased the crude protein of Rhodes grass by 15% at the early stage of growth, but the percentage reduced at advanced growth stage. This could have contributed to the high quality seeds with high PGS and germination the present study.

Cutting thrice had positive effect on PGS. Application of fertilizer at 75kg/ha had positive effect on PGS though low compared to recommended rate**.**

On Pure Germinating Seed of Rhodes grass Variety Application of fertilizer at 75kg/ha had positive effect on PGS though low compared to recommended rate **(Table 7).** The germination of seeds supplied with fertilizer was higher than that of seeds not supplied with fertilizer because seeds treated with fertilizer contained larger food reserves, which enable them to nourish the embryo longer during germination (Deo and Khosia ,1983). These seeds nourished with fertilizer have got big embryos that germinate vigorously as compared to those that have not been supplied with fertilizer and therefore stressed. Furthermore, seeds supplied with fertilizer have got sufficient nitrogen that is essential for the production of enzymes, which play an important role in metabolic processes of germination and growth (Saleen etal., 2003). Seeds produced under conditions of nutrient stress have their chemical compounds such as carbohydrates and proteins stored and not utilized in the provision of energy and biochemical building blocks of the seed to enhance germination (Thagana and Ndegwa, 1996).

Weight per gram of Caryopsis and chaff of Rhodes grass .weight of caryopsis was Not significantly affected by fertilizer application. Seed yield (with husk) levels of Chloris *gayana* and *Cenchrus ciliaris* found in the present study are comparable with the seed yield levels reported elsewhere. Skerman and Rivoros (1989) reported clean (naked) seed yield of 100-650 and 10-60 kg/ha in respect of *Chloris gayana* and *Cenchrus ciliaris*, respectively, and Chatterjee and Das (1989) reported seed yield (naked) of 500 to 600 and 100-200 kg/ha in respect of *Chloris gayana* and *Cenchrus ciliaris* , respectively.

Germination Percentage of Glumed and de-glumed seeds of Rhodes grass was not significantly affected by varieties both with glumes and without glumes (**Table 8)** Lower germination percentage in bulk seed could be attributed to inclusion of immature seed of late formed panicles, possible loss of viable good quality seed due to shattering and possible loss of viability of a fraction of seed due to delay in harvesting the seed (Nadaf et al.,2004). This is not unexpected, as harvesting good quality seed is a major problem faced by grass seed growers. Grass seed growers often face substantial loss of good quality (viable) seeds while harvesting due to lack of knowledge about the appropriate harvesting time. It has been observed that some tropical grass species may produce good yields of seeds to the extent of 1000 kg/ha and above, but only a small proportion (perhaps 5-7% in Setaria anceps) is commercially recoverable (Chatterjee and Das, 1989). Deglumed seed resulted in higher germination than seeds with glumes. Freshly harvested and viable seeds sometimes fail to germinate because of dormancy. Glumes may prevent or delay the germination of viable seeds in several ways. This problem seriously interferes with germination test results, besides reducing germination during germplasm (Sastry et,al 2006).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- The existing old established Rhodes grass pasture seed quality is too low.
- The quality of pre-basic and basic of Rhodes grass seeds was higher than certified seed stage 1 and standard seeds.
- Although the effect of fertilizer application and harvest regime were not significantly different seed quality increased with increase of fertilizer level and harvest regime
- Degluming improves germination of Rhodes grass seed from old and new established fields by reducing dormant portion of seed lot.

6.2 Recommendation

- Rhodes grass seed growers should be paid per weight of caryopsisand not total seed delivered to the company
- Seed testing institutions should consider including percentage of caryopsis content of Rhodes seed lots and paying Rhodes grass seed growers per the same
- Seed companies to grow Rhodes grass in right eco zones, especially Endebess and similar eco zones
- Evaluation to done on appropriate management practices for Rhodes grass seed crops

6.3 Further research The effect Cutting regime needs more cuttings even up to 10th cutting for us to reach to right conclusion.

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Appendices

Appendix I: Anova tables for Stand Count of Rhodes grass Endebess Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F calculated	F tabulated	Sign.
Replication	2	6619.0	3309.0	0.47		
Harvest Regime	2	349.0	174.0	0.02	0.976	NS
Variety	2	3793.0	1897.0	1.45	0.248	NS
Fertilizer Rate	2	3326.0	1663.0	0.80	0.471	NS
Error 1	4	28188.0	7047.0	3.4		
Harvest Regime x Variety	4	17826.0	4456.0	3.14	0.018	NS
Harvest Regime x Fertilizer	4	5234.0	1308.0	0.63	0.650	NS
Variety x Fertilizer	4	4007.0	1002.0	0.77	0.554	NS
Error 2	12	24904.0	2075.0	1.59		
Harvest Regime x Variety xFertilizer	8	17947.0	2243.0	1.72	0.128	NS
Error 3	32	47027.0	1306.0			
Total	76	159220.0				

Appendix II: Anova tables for Plant Height of Rhodes grass Endebess Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign
Replication	2	2143.0	1071.5	8.24		
Harvest Regime	2	108.1	54.1	0.42	0.685	NS
Variety	2	1559.8	779.9	3.72	0.034	S
Fertilizer Rate	2	18.7	9.3	0.05	0.947	NS
Error 1	4	520.3	130.1	0.76		
Harvest Regime x Variety	4	1715.6	428.9	2.05	0.108	NS
Harvest Regime x Fertilizer	4	1115.6	278.9	1.64	0.229	NS
Variety x Fertilizer	4	827.3	206.8	0.99	0.427	NS
Error 2	12	2046.8	170.6	0.81		
Harvest Regime x Variety xFertilizer	8	1241.1	155.1	0.74	0.655	NS
Error 3	32	7539.2	209.4			
Total	76	18835.6				

Appendix III: Anova tables for Days to 50% Flowering Endebess Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	171.28	85.64	2.03		
Harvest Regime	2	17.95	8.98	0.21	0.817	NS
Variety	2	16.69	8.35	0.2	0.818	NS
Fertilizer Rate	2	12.91	6.46	0.23	0.799	NS
Error 1	4	168.79	42.2	1.49		
Harvest Regime x Variety	4	324.94	81.23	1.96	0.121	NS
Harvest Regime x Fertilizer	4	176.49	44.12	1.56	0.247	
Variety x Fertilizer	4	51.53	12.88	0.31	0.868	
Error 2	12	339.26	28.27	0.68		
Harvest Regime x Variety xFertilizer	8	252.17	31.52	0.76	0.638	
Error 3	32	1488	41.35			
Total	76	3020.69				

Appendix IV. Anova tables for Fresh Herbage of Rhodes grass Endebess site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**Sign.**
Replication	2	1234.55	617.27	4.1		
Harvest Regime	2	7.28	3.64	0.02	0.976	NS
Variety	2	49.93	24.97	0.25	0.78	NS
Fertilizer Rate	2	248.8	124.4	1.56	0.251	NS
Error 1	4	602.87	150.72	1.89		
Harvest Regime x Variety	4	420.3	105.07	1.05	0.78	NS
Harvest Regime x Fertilizer	4	230.26	57.56	0.72	0.594	NS
Variety x Fertilizer	4	488.02	122.01	1.22	0.319	NS
Error 2	12	959.01	79.92	0.8		
Harvest Regime x Variety xFertilizer	8	317.6	39.7	0.4	0.915	NS
Error 3	32	3599.83	100.00			
Total	76	80158.46				

Appendix V: Anova tables for Dry Matter Herbage of Rhodes grass Endebess Site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**Sign**
Replication	2	0.9817	0.4908	113.85		
Harvest Regime	2	0.0086	0.0043	1.00	0.444	NS
Variety	2	50.15	25.08	143.15	‹0.001	S
Fertilizer Rate	2	304.314	152.157	847.39	‹0.001	S
Error 1	4	0.0172	0.0043	0.02		
Harvest Regime x Variety	4	0.0138	0.0035	0.02	0.999	NS
Harvest Regime x Fertilizer	4	0.0138	0.0035	0.02	0.999	NS
Variety x Fertilizer	4	535.4	133.85	763.99	‹0.001	S
Error 2	12	2.155	0.1796	1.02		
Harvest Regime x Variety xFertilizer	8	0.0262	0.0033	0.02	1.00	NS
Error 3	32	6.3071	0.175			
Total	76	899.40				

Appendix VI: Anova tables for Purity Percentage (%) of Rhodes grass Endebess Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	sign
Replication	2	1016.62	508.31	17.38		
Harvest Regime	2	94.43	47.22	1.61	0.306	NS
Variety	2	30.75	15.37	0.19	0.827	NS
Fertilizer Rate	2	307.1	153.55	1.34	0.298	NS
Error 1	4	117.00	29.25	0.26		
Harvest Regime x Variety	4	101.08	25.27	0.31	0.866	NS
Harvest Regime x Fertilizer	4	150.74	37.68	0.33	0.853	NS
Variety x Fertilizer	4	482.06	120.52	1.5	0.225	NS
Error 2	12	1374.2	114.52	1.42		
Harvest Regime x Variety xFertilizer	8	208.27	26.03	0.32	0.951	NS
Error 3	32	2655.16	80.46			
Total	76	6030.13				

Appendix VII. Anova tables for Germination (%) glumed seed of Rhodes grass Endebess Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	172.7	86.4	0.35		
Harvest Regime	2	63.4	31.7	0.13	0.884	NS
Variety	2	198.9	99.5	0.35	0.704	NS
Fertilizer Rate	2	64.8	32.4	0.13	0.882	NS
Error 1	4	997.0	249.3	0.98		
Harvest Regime x Variety	4	1971.5	492.9	1.76	0.161	NS
Harvest Regime x Fertilizer	4	639.7	159.9	0.63	0.652	NS
Variety x Fertilizer	4	142.9	35.7	0.13	0.971	NS
Error 2	12	3055.9	254.7	0.91		
Harvest Regime x Variety x Fertilizer	8	436.0	54.5	0.19	0.990	NS
Error 3	32	9251.2	280.3			
Total	76	16762.9				

Appendix VIII: Anova tables for Germination Percentage (%) of deglumed seed of Rhodes grass Endebess Site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**sign**
Replication	2	1850.1	925.0	1.77		
Harvest Regime	2	2251.2	1125.6	2.15	0.232	NS
Variety	2	121.2	60.6	0.33	0.724	NS
Fertilizer Rate	2	47.6	23.8	0.11	0.899	NS
Error 1	4	2095.2	523.8	2.87		
Harvest Regime x Variety	4	920.7	230.2	1.26	0.338	NS
Harvest Regime x Fertilizer	4	843.6	210.9	0.95	0.448	NS
Variety x Fertilizer	4	765.6	191.4	0.86	0.497	NS
Error 2	12	2190.3	182.5	0.82		
Harvest Regime x Variety xFertilizer	8	1561.3	195.2	0.88	0.545	NS
Error 3	32	8013.1	222.6			
Total	76	20660.0				

Appendix IX: Anova tables for Duration of withering of Rhodes grass in the field Endebess Site

Source of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	3099.31	1549.66	653.28		
Harvest Regime	2	213.54	106.77	45.01	0.002	S
Variety	2	29.52	14.76	0.61	0.762	NS
Fertilizer Rate	2	383.54	191.77	0.96	0.411	NS
Error 1	4	9.49	2.37	0.01		
Harvest Regime x Variety	4	889.19	222.30	0.91	0.469	NS
Harvest Regime x Fertilizer	4	3694.93	923.73	4.62	0.017	S
Variety x Fertilizer	4	1133.43	283.36	1.16	0.345	NS
Error 2	12	2397.99	199.83	0.82		
Harvest Regime x Variety xFertilizer	8	1196.35	149.54	0.61	0.762	NS
Error 3	32	8802.59	244.52	5.20		
Withering duration	2	240.35	120.18	2.56	0.942	NS
Harvest regime x withering	4	80.03	20.01	0.43	0.790	NS
Fertilizer x withering	4	93.63	23.41	0.50	0.737	NS
Variety x withering	4	118.67	29.67	0.63	0.641	NS
Harvest regime x fertilizer x withering	8	694.25	86.78	1.85	0.077	NS
Harvest regime x variety x withering	8	272.911	34.11	0.73	0.668	NS
Fertilizer x variety x withering	8	465.48	58.18	1.24	0.285	NS
Harvest regime x fertilizer x variety x withering	16	539.6	33.72	0.72	0.771	NS
Error 4	101	4748.00	47.01			
Total	236	27536.20				

Appendix X: Anova tables for Weight of Chaff per gram of Rhodes grass Chepkoilel Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	0.048	0.024	2.46		
Harvest Regime	2	0.016	0.008	0.8	0.511	NS
Variety	2	0.017	0.009	1.02	0.39	NS
Fertilizer Rate	2	0.023	0.012	1.46	0.246	NSS
Error 1	4	0.04	0.01	1.18		
Harvest Regime x Variety	4	0.029	0.007	0.88	0.505	NS
Harvest Regime x Fertilizer	4	0.04	0.01	1.27	0.298	NS
Variety x Fertilizer	4	0.028	0.007	0.87	0.493	NS
Error 2	12	0.1	0.008	1.05		
Harvest Regime x Variety xFertilizer	8	0.079	0.009	1.09	0.395	NS
Error 3	32	0.286	0.09			
Total	76	0.697				

Appendix XI: Anova tables for Weight of Caryopsis of Rhodes grass gram at Endebess site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**Sign.**
Replication	2	0.0005	0.0003	0.14		
Harvest Regime	2	0.002	0.0011	0.60	0.591	NS
Variety	2	0.003	0.0016	2.12	0.163	NS
Fertilizer Rate	2	0.001	0.0006	0.65	0.526	NS
Error 1	4	0.0005	0.0003	0.14		
Harvest Regime x Variety	4	0.003	0.0007	1.01	0.439	NS
Harvest Regime x Fertilizer	4	0.005	0.001	1.38	0.262	NS
Variety x Fertilizer	4	0.004	0.0009	1.05	0.394	NS
Error 2	12	0.009	0.007	0.8		
Harvest Regime x Variety xFertilizer	8	0.006	0.0008	0.83	0.58	NS
Error 3	32	0.033	0.0009			
Total	76	0.0748				

Appendix XII: Anova tables for Germination Percentage (%) of deglumed seeds of Rhodes grass Edebess site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	2882.0	1441.0	2.65		
Harvest Regime	2	1138.3	569.2	1.05	0.431	NS
Variety	2	3127.5	1563.7	4.97	0.027	S
Fertilizer Rate	2	1811.0	905.5	2.28	0.117	NS
Error 1	4	2176.2	544.0	1.73		
Harvest Regime x Variety	4	681.4	170.3	0.54	0.709	NS
Harvest Regime x Fertilizer	4	2202.8	550.7	1.39	0.258	NS
Variety x Fertilizer	4	1556.3	389.1	0.98	0.431	NS
Error 2	12	3776.4	314.7	0.79		
Harvest Regime x Variety xFertilizer	8	1093.0	136.6	0.34	0.942	
Glume	32	1429.4	397.0	1.52	‹0.01	S
Error 3	1	42599.6	42599.6	163.02		
Harvest regime x glume	2	142.7	71.3	0.27	0.762	NS
Variety x glume	2	394.8	197.4	0.76	0.475	NS
Fertilizer x glume	2	1150.4	575.2	2.2	0.12	NS
Harvest Regime x Variety x glume	4	993.0	248.2	0.95	0.442	NS
Harvest Regime x Fertilizer xglume	4	2023.5	505.9	1.94	0.118	NS
Variety x Fertilizer x glume	4	1585.8	396.5	1.52	0.21	NS
Variety x harvest regime x fertilizer x glume	8	815.0	101.9	0.39	0.921	NS
Error 4	54	1440.7	261.3			

Appendix XII: Anova tables for Plant Height of Rhodes grass Chepkoilel Site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**Sign.**
Replication	2	224.0	112.0	1.28		
Harvest Regime	2	159.3	79.7	0.91	0.473	NS
Variety	2	642	321.2	1.03	0.385	NS
Fertilizer Rate	2	218.4	109.2	0.58	0.567	NS
Error 1	4	351.1	87.8	0.28		
Harvest Regime x Variety	4	763.3	190.8	0.61	0.66	NS
Harvest Regime x Fertilizer	4	595.4	148.9	0.79	0.542	NS
Variety x Fertilizer	4	337.0	84.3	0.45	0.775	NS
Error 2	12	3725.7	310.5	1.64		
Harvest Regime x Variety xFertilizer	8	1387.9	173.5	0.92	0.515	NS
Error 3	32	6247.9	189.3			
Total	76	14087.7				

Appendix XIV: Anova tables for Dry Matter Herbage of Rhodes grass Chepkoilel Site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**Sign.**
Replication	2	331.14	165.57			
Harvest Regime	2	330.42	165.21	1.0	0.445	NS
Variety	2	329.41	164.71	0.99	0.398	NS
Fertilizer Rate	2	139.79	69.89	0.98	0.38	NS
Error 1	4	663.13	165.78	1.00		
Harvest Regime x Variety	4	220.75	55.19	0.78	0.549	NS
Harvest Regime x Fertilizer	4	662.29	165.57	1.00	0.445	NS
Variety x Fertilizer	4	663.13	165.78	1.00		
Error 2	12	1986.48	165.54	2.33		
Harvest Regime x Variety xFertilizer	8	442.71	73.78	1.04	0.421	NS
Error 3	32	1987.65	70.99			
Total	76	5821.35				

Appendix XV: Anova tables for Fresh Herbage of Rhodes grass Chepkoilel Site

Source Of Variance	**df**	**Sums of Squares**	**Mean Sums of Squares**	**F.calculated**	**F.tabulated**	**Sign.**
Replication	2	4.8	2.44	0.23		
Harvest Regime	2	25.73	12.86	1.23	0.38	NS
Variety	2	4.61	12.03	0.51	0.62	NS
Fertilizer Rate	2	4.35	2.17	0.6	0.55	NS
Error 1	4	41.89	10.47	2.3		
Harvest Regime x Variety	4	7.69	1.92	0.42	0.79	NS
Harvest Regime x Fertilizer	4	20.11	5.03	1.39	0.26	NS
Variety x Fertilizer	4	15.02	3.76	1.04	0.40	NS
Error 2	12	54.67	4.56	1.26		
Harvest Regime x Variety xFertilizer	8	26.79	3.35	0.93	0.51	NS
Error 3	32	115.76	3.62			
Total	76	320.05				

Appendix XVI: Anova tables for Germination Percentage(%) of Rhodes grass Chepkoilel Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	87.3	43.7	0.1		
Harvest Regime	2	15.6	7.8	0.02	0.98	NS
Variety	2	196.1	98.1	0.45	0.648	NS
Fertilizer Rate	2	703.9	351.9	2.57	0.15	NS
Error 1	4	4536.8	1134.2	5.73		
Harvest Regime x Variety	4	909.1	227.3	1.15	0.39	NS
Harvest Regime x Fertilizer	4	1260.3	315.1	1.52	0.30	NS
Variety x Fertilizer	4	1072.5	268.1	1.29	0.36	NS
Error 2	12	1780.3	197.8	0.95		
Harvest Regime x Variety xFertilizer	8	2334.9	338.6	1.61	0.27	NS
Error 3	32	1451.5	207.4			
Total	76	8135.5				

Appendix XVII: Anova tables for Purity Percentage (%) of Rhodes grass Chepkoilel Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	3514.6	1757	1.56		
Harvest Regime	2	246.5	123.3	0.11	0.9	NS
Variety	2	135.7	67.8	0.34	0.72	NS
Fertilizer Rate	2	1260.3	315.1	1.52	0.30	NS
Error 1	4	4536.8	1134.2	5.73		
Harvest Regime x Variety	4	909.1	227.3	1.15	0.394	NS
Harvest Regime x Fertilizer	4	1260.3	315.1	1.52	0.295	NS
Variety x Fertilizer	4	1072.5	268.1	1.29	0.359	NS
Error 2	12	1780.3	197.3	0.95		
Harvest Regime x Variety xFertilizer	8	2334.9	338.6	1.61	0.273	NS
Error 3	32	1451.5	207.4			
Total	76	8135.5				

Appendix XVIII: Anova tables for Pure Germinating Seed of Rhodes grass Chepkoilel Site

Source Of Variance	df	Sums of Squares	Mean Sums of Squares	F.calculated	F.tabulated	Sign.
Replication	2	286.65	143.32	1.06		
Harvest Regime	2	9.72	4.86	0.04	0.965	NS
Variety	2	12.86	6.43	0.10	0.908	NS
Fertilizer Rate	2	229.38	114.69	3.86	0.074	NS
Error 1	4	543.04	135.76	2.05		
Harvest Regime x Variety	4	134.39	33.6	0.51	0.73	NS
Harvest Regime x Fertilizer	4	63.98	15.99	0.54	0.713	NS
Variety x Fertilizer	4	77.76	19.44	0.66	0.642	NS
Error 2	12	596.02	66.22	2.23		
Harvest Regime x Variety xFertilizer	8	424.12	60.59	2.04	0.184	NS
Error 3	32	207.75	29.68			
Total	76	1042.14				

Appendix XIX: Plot layout for university of Eldoret and Endebes

Plot Layout-Endebess