SEED YIELD AND QUALITY OF *CENCHRUS CILIARIS* Cv. BILOELA UNDER VARIOUS AGRONOMIC PRACTICES IN SUB-HUMID EASTERN ZONE OF TANZANIA

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EXTENDED ABSTRACT

Livestock production especially ruminants, is one of the major agricultural activities in Tanzania. Both traditional and improved livestock production depend on natural and improved forages which are inadequate due to land use pressures from other users which sometimes result in resource use conflicts. Land ownership to intensify livestock farming is shown to be one of the steps for increased livestock productivity, improved degraded grazing land and for resolving conflicts associated with land use pressures. Pasture establishment is an alternative solution to improve owned land and hence increased livestock productivity, despite inadequate availability of good quality planting material especially grass pasture seeds. *Cenchrus Ciliaris* cv.Biloela (buffel grass) is among those adapted promising grass species promoted for establishment for its desirable drought tolerant characteristics, Inadequacy and poor viability of the buffel grass seeds seem to be the hindrance. Available information showed that, low fertility of soils and high risks of diseases are among the major factors affecting viability of buffel grass seeds in wet season. There is also limited information on production of seeds and forage biomass of this grass in dry season under irrigation, its response to different fertilizer application rates, rows spacing, cutting heights and the overall biomass productivity under field conditions. Therefore, there was a need to conduct a study to gain a practical experience on how to compromise facts on seed quality and forage biomass production under field conditions in sub humid agro-ecological zone of Tanzania. The main objective of the study was to evaluate the effects of various agronomic practices on seed yield and quality of *Cenchrus ciliaris* cv. Biloela in the sub-humid eastern zone of Tanzania.

In order to achieve the main objective of the study, a field survey of three pasture seed farms was done, followed by field trials at Magadu dairy farm of Sokoine university of Agriculture to evaluate different agronomic practices including fertilizer levels and row spacing under two cutting heights on how they affect seed yield, quality and forage biomass production in wet and dry season. The three seed farms were Mazimbu in Morogoro, Vikuge pasture seed production farm in Kibaha and TALIRI, Tanga. A laboratory experiment was conducted to assess viability status of sampled *Cenchrus ciliaris* seeds from the visited farms and those produced from the field trial. Soil samples were also taken from visited farms so as to assess current fertility status of these seed farms. The results showed that spikelet germination percentage was 8.33% for Mazimbu, 0.25% for Vikuge and 1.83% for Tanga farms. Total soil Nitrogen was observed to be at very low to low levels i.e. 0.08%, 0.13% and 0.12% for Vikuge, Tanga and Mazimbu farms, respectively. From this study it could be concluded that old age sward produced low quality seeds in terms of viability, and this could be further exacerbated by low soil fertility. In order to improve an understanding of grass seed production, additional studies on fertilizer rates, irrigation during dry season, rows spacing, cutting height on how they affect seed yield and quality were conducted in the similar agro-ecological zone. For specific objective 2 and 3, study two was conducted at Sokoine University of Agriculture farm to assess the effects of different levels of Nitrogen and Phosphorus 0 KgN/ha 0KgP/ha, 40KgN/ha 20KgP/ha, 60KgN/ha 30KgN/ha P abbreviated as (0N 0P, 40N 20P, 60N 30P) , row spacing (25, 75 and 100 cm) under two cutting heights (15 cm and ground cut) under rain fed and irrigation in wet and dry seasons on seed yield and vegetation characteristics of *Cenchrus ciliaris* cv.Biloela. The study was done in two consecutive years 2012 and 2013 (March – June and June-September) for long rains and dry seasons, respectively. It was observed that, seed yields were higher at higher rates of nitrogen and phosphorus at ground cutting (77.5 kg/ha) than at 15 cm cutting height (56.7 kg/ha) with a trend of decreased seed yields in the second year (77.5 to 38.4 kg/ha) and (56.7 to 35.5 kg/ha) at the same levels of nitrogen and phosphorus. Row spacing of 100cm showed slightly higher seed yield (70 kg/ha) as compared to other two row spacing (25 cm and 75cm) that gave 67.2 and 69.3 kg/ha, respectively. Higher seed yields were observed in dry than wet season for two consecutive years under all cutting heights (66.7 and 37.8 kg/ha 15 cm cutting for dry and wet season, respectively). Higher levels of nitrogen and phosphorus yielded significantly ($p<0.05$) higher forage biomass (13.2 and 11.1 t DM/ha) from 15cm and ground cutting respectively as compared to 10.0 and 8.6 t DM/ha for low level of nitrogen and phosphorus rates. High plant density at 25 cm row spacing yielded higher biomass (12.2 t DM/ha) than low plant density at 100 cm row spacing (11.4 t DM/ha). It was concluded that, ground cutting could be beneficial management practice for rhizomatous grass so as to obtain higher seed yields since it allows healthier ground tillers from rhizomes than profuse aerial tillers produced at higher cutting heights. Irrigation during dry season was the best option for *Cenchrus ciliaris* cv. Biloela seed production when row spacings of 75 cm and 100 cm are used at ground cutting height with proper rates of nitrogen and phosphorus. However, strategies for bird scaring during dry period (offseason) were highly emphasized from blooming stage to seed maturity to maximize seed yield.

Study two (specific objective three) was done to investigate the effect of fertilizer levels and row spacing under two cutting heights on seed quality of *Cenchrus* *ciliaris* cv. Biloela in wet and dry season using irrigation. In this study, four parameters of seed quality namely; caryopsis index, spikelet germination, seed colour and physical grain qualities (good and damaged) were assessed for first and second harvest. The findings showed significantly high ($p \leq 0.05$) caryopsis index for seeds produced in dry and wet season (37.9 and 24.3%) respectively. The interaction of fertilizer levels within seasons marked a clear variation on caryopsis index and germination potential in dry season seeds for seeds of first harvest than second harvest. The colour of seeds produced during the wet season indicated a vivid sign of fungal infection. The age of vegetation also significantly ($p<0.05$) affected the germination of seeds in both year one and year two from 20.4 to 30.0% and 12.9 to 22.8%, respectively. It was also observed that, old age vegetation produced low viable seeds than younger vegetation. Viability improved with time of storage, however only six months were tested**.** These results suggest that dry season and higher rates of nitrogen and phosphorus fertilizer be taken into consideration to improve production of quality grass pasture seeds, however proper fertilizer rates depends on soil fertility status of the site. Harvest time had a significant ($p < 0.05$) effect on quality of batches of seeds produced. The first harvested seeds were significantly ($p < 0.05$) higher in viability than second harvest thus were good for commercial purposes. For specific objective 4, the third study was conducted to evaluate profitability of both seed and forage biomass production of buffel grass (*Cenchrus ciliaris* cv.Biloela) based on irrigation in dry season and wet season under different levels of Nitrogen and phosphorus using Urea and Triple Super Phosphate (TSP) fertilizers. The study was carried out at Magadu Dairy farm of Sokoine University of Agriculture, Morogoro, Tanzania. Two seasons (wet and dry) were involved with three treatments:- without fertilizer (0KgN/ha 0KgP/ha), combined fertilizers (40KgN/ha 20 KgP/ha) and (60KgN/ha 30KgP/ha). All the fixed and variable costs were recorded and computed for cost benefit analysis during the trial and supplemented with secondary information from other input suppliers and farms. The results of this study showed that higher level of fertilizer significantly ($p<0.05$) led into more seed yield and biomass than when lower levels were applied. Economically, break even level was reached in wet season for revenues from both seeds and forage in year 1 and 2. However, only one level of fertilizer (60KgN/ha 30KgP/ha) was profitable by (TZS 81,011.75) during the year 1 in dry season due to costs incurred for irrigation and planting materials. The profit in dry season was realized in second year. Trend of seed and forage production was profitable in year two for both seasons as no costs were incurred for establishment for perennial species where planting materials costs are only incurred in first year. It was learnt that it was profitable to produce forage biomass in wet season than dry season however, seed production showed vice versa trend and hence relatively profitable to produce seeds in dry season. It is therefore recommended that the use of irrigation and proper fertilizer rates for grass pasture seed production can be a potential option for improved quality and quantity of grass seed production to meet demands of livestock producers.

DECLARATION

I, JONAS BARAHEMANA KIZIMA, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work done within the period of registration and has neither been submitted nor being concurrently submitted in any other institution.

Jonas Barahemana Kizima **(PhD candidate)**	**Date**

The above declaration is confirmed by:

Prof. E.J. Mtengeti **(Supervisor)**	**Date**

Prof. S. Nchimbi-Msolla **(Supervisor)**	**Date**

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DEDICATION

This thesis is dedicated to my parents, Jovine Barahemana and my mother late Franscisca Jovine who sacrificed their meager resources for my education.

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LIST OF PAPERS AND MANUSCRIPTS

This thesis is based on the following studies (papers and manuscripts), which will be referred to in the text by their roman numerals:

Paper I:
Kizima J.B., Mtengeti, E.J. and Nchimbi-Msolla,S.(2013). Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. *Livestock Research for Rural Development. Volume 25, Article #85.* Retrieved July 10, 2013, from http://www.lrrd.org/lrrd25/5/kizi25085.htm.

Paper II:
Kizima J B, Mtengeti E J and Nchimbi-Msolla S. (2014). Seed yield and vegetation characteristics of *Cenchrus ciliaris* as influenced by fertilizer levels, row spacing, cutting height and season. *Livestock Research for Rural Development. Volume 26, Article #148.* Retrieved August 5, 2014, from http://www.lrrd.org/lrrd26/8/kizi26148.htm.

Paper III:
Kizima J B, Mtengeti E J and Nchimbi-Msolla S (2014). Seed quality of *Cenchrus ciliaris* as affected by fertilizer levels, row spacing, cutting height and season in Eastern Sub-humid zone of Tanzania. (Manuscript III submitted to Huria Journal of Open University of Tanzania)

Paper IV:

Kizima J B, Mtengeti E J ,Nchimbi-Msolla S. and Mishili F.J.(2014). Profitability of irrigating grass pasture for seed and forage production in Tanzania: A case of *Cenchrus ciliaris*. (Manuscript to be submitted in any reputable journal).

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ABBREVIATIONS AND SYMBOLS

ADF	Acid Detergent Fiber
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASDP	Agricultural Sector Development Programme
CP	Crude Protein
CSIRO	Commonwealth Scientific and Industrial Research Organization
cm.	Centimeters
cv.	Cultivar
DM	Dry Matter
et al.	And others
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization statistics
GLM	General Linear Model
GDP	Gross Domestic product
GPS	Geographical Position System
ha	Hactres
m.a.s.l	Metres above sea level
ME	Metabolizable Energy
MLDF	Ministry of Livestock and Fisheries Development
MLD	Ministry of Livestock Development
MWLD	Ministry of Water and Livestock Development
NDF	Neutral Detergent Fiber
NLRI	National Livestock Research Institute

TALIRI	Tanzania Livestock Research Institute
TALIRO	Tanzania Livestock Research Organization
t	Tones
tDM/ha	Tones dry matter per hectare
TOSCI	Tanzania Official Seed Certification Institute
TSP	Triple Super Phosphate
TZS	Tanzanian Shillings
SAS	Statistical Analysis Systems
SUA	Sokoine University of Agriculture
SEM	Standard Error Mean
UAC	Uyole Agricultural Centre

CHAPTER ONE

1.0 INTRODUCTION

Livestock sector is important for the economy of Tanzania as is for many other developing countries. In Tanzania, the sector contributes about 5.9 % of the Gross Domestic Product (GDP) and employs about 40% of the 3.9 million agricultural households who are involved in crops and livestock production (MLD, 2006). Ruminant livestock populations in Tanzania are estimated at 18 million head of cattle, 12.6 million goats and 3.6 million sheep (FAOSTAT, 2010). This animal population has been increasing steadily over years as compared to animal population of 1920 of 3.0, 2.0 and 1.4 million cattle, goats and sheep respectively (MWLD, 2005).

Growing human and livestock populations increase the demand on land resources, causing decline of grasslands and thus create forage shortage for both traditional and improved ruminants keeping systems. Ruminant livestock production is an important enterprise in eastern zone sub humid regions including Tanga, Morogoro, Coast and Dar Es Salaam due to an increasing demand of livestock products along the fast growing coastal cities (Kizima *et al.,* 2013). Milk and meat demand together with favorable climatic conditions in these sub humid regions have led to people soliciting land for intensive ruminant livestock farming. Forage shortage during the dry season, however is still a constraint for high productivity all year round. Sustainable solution to forage shortage is possible when technical efforts are invested to improve production and utilization of natural and planted forages. Improved ruminant production requires high-quality improved forages, especially for dairy and finishing beef cattle (Kumwenda *et al.,* 2003).

1.1 Pasture Seed Production in Tanzania

Apart from natural pastures, establishment of pastures is an approach to improve availability and accessibility of quality forage towards intensive livestock production. Improvement to supply high quantity and quality forage demands for good quality pasture seeds/ planting materials for grasses, legumes and fodder trees. Challenges facing pasture development in the country include; lack of supply of good quality pasture seeds; lack of knowledge on pasture conservation and promotion of investment in pasture seed production. Change of policy on privatization encouraged more investors in ruminant livestock farming. This creates an increased demand of pasture seeds especially grass pasture seeds. Quality seeds are the basic foundations of any agricultural system setting the main concern for increased agricultural productivity and economic gains among farming communities (ASARECA, 2007). In order to develop a good working seed production system responding to market oriented demands more expertise is required to support policy institutions which will help to enforce mechanisms of pasture seed production in the country. Therefore, development of technologies to improve grass pasture seed yield and quality in seed production industry will be a step forward towards quality forage production in Tanzania to improve ruminant livestock productivity.

Efforts to improve management and use of established forages in Tanzania started since 1930s (MWLD, 2005) and thereafter the emphasis was pasture establishment, management and utilization. Research trials were conducted on station for introduction and evaluation to screen newly introduced pasture species for adaptability in different agro ecological zones. Research on forage conservation techniques, use of browse species and crops residues have also been done. However, few or no research has been done on farm for evaluation of pasture seed production in the country (Kusekwa *et al.,* 1987). Pasture establishment in large scales mostly remained practiced in institutional and parastatal farms, probably with very few or none in smallholder farms due to availability of natural forages. However at present there is decline of open accessed grazing lands. Introduction of dairy cattle in mid 1970s under smallholder farmers in some parts of Tanzania like Northern, and Southern Highlands, Western and Eastern regions, set a condition of establishing a forage plot as a prerequisite in joining dairy farming project. This approach was done purposely for indoor dairy cattle farming and was a good starting point to create awareness on pasture establishment to smallholder farmers in the country.

According to Andrade, (2001), efficient and low cost production systems, which rely on the use of cultivated pastures, was the basis of efficient beef and milk production in Brazil. The success of the pasture establishment based systems would not be possible without the support of an aggressive and dynamic pasture seed production system. Seed production systems in Brazil vary from highly specialized to opportunistic according to the grass species. Prior to the seventies, most of the cultivated Brazilian pastures were established with the use of cuttings, until when the country put more emphasis on initiatives of producing pasture seeds to minimize transportation costs of cuttings and pasture seed importation. This is a scenario of seed shortage facing the pasture establishment initiatives in many developing countries.

Different efforts have been invested in pasture research in Tanzania. Such efforts as outlined by Kidunda *et al.* (1987) were undertaken by the Tanzania Livestock

Research Organisation (TALIRO) which was formed in 1981. The organisation had various research stations representing different ecological zones within the country. Such stations included Mpwapwa Livestock Production Research Institute, Kongwa Pasture Research Centre, West Kilimanjaro Research Centre, Malya Research Centre and Tanga Livestock Research Centre. Sokoine University of Agriculture (SUA) and Uyole Agricultural Centre (UAC) were also two other institutions which were actively engaged in forage and other feed resources research.

Introduction and evaluation trials as initial pasture species screening on station aimed to evaluate species performance, survival, forage dry matter and chemical composition. Study by Kusekwa *et al.* (1987) showed that, from the ten evaluated pasture grass species from Australia and Ethiopia; *Cenchrus ciliaris (*cultivars Biloela ,Kongwa, Gayndah*), Chloris gayana* (cultivar Mpwapwa), *Panicum coloratum* and *Cynodon plectostachyus* had the best performance in on-station trials. However research continuation for up or out scaling was not done, this created a gap of information on performance under farmers conditions. Kusekwa *et al.* (1987) reported that among the forage productivity study where various species were tested at NLRI Mpwapwa, *Cenchrus ciliaris* cultivar Biloela showed to be the highest in productivity of 13.9 t/ha (Table 1), the factor which has probably made it to spread faster than the other cultivars in Tanzania. *Cenchrus ciliaris* cv. Biloela is productive, perennial and resistant to drought conditions due to its tuft-rhizomatous growth habit (Kumar *et al.,* 2001). The demand for *Cenchrus ciliaris* cv. Biloela seeds in Tanzania is currently high due to its ability to survive even when soil moisture is low (Mr. N.Ngota 2010, personal communication).

Table 1: Annual Dry Matter yield recorded at NLRI Mpwapwa

Grass species/ cultivars	**Annual forage Dry Matter yield (t/ha)**
Cenchrus ciliaris cv. Biloela	13.9
Panicum coloratum cv. Bambatsi	13.5
Panicum maximum cv. Gatton	9.5
Chloris gayana cv. Samford	9.0
Chloris gayana cv. Pioneer	7.0
Chloris gayana cv. Petric	6.5
Cenchrus Ciliaris cv. Gayndah	6.5
Bothriochloa insculpta cv. Hatch	2.0
Cenchrus ciliaris cv. West Australia	1.5
Cenchrus setigerus	1.5

Source: Kusekwa *et al. (1987)*

However, due to lack of knowledge on grass seed production, expansion of farms under *Cenchrus ciliaris* is still a problem. Sale of vegetative splits for establishment instead of seeds due to poor seed quality is now common (Mr N. Ngota and Dr. R.B Msangi, 2010 personal communication), farm managers of Vikuge and Kongwa pasture seed farms, respectively).

Recent high demand of grass pasture seeds in the country, livestock keepers/ farmers awareness on pasture seeds creates an alertness and attention to find means of improving grass seed quantity and quality. There is a need to look on the basic important issues on the ground with regard to grass seed production, issues related to viability and health status of available seeds, agronomic practices, market channels and way of improvement. According to FAO (1986) production of quality pasture grass seeds requires careful attention. There is a need for good seedbed preparation, sowing procedure, and good quality seeds so as to ensure high germination and good grass pasture establishment.

1.1.1 Effect of row spacing or plant density on grass pasture seed production

Seed production is maximized at an optimum plant density (row spacing), both very low and very high densities reduce seed yield in grasses depending on the fertility status of soils. According to Kumar *et al.*(2005), experiment on three row spacing (40, 60 and 75 cm) showed that wider row spacing (75 cm) enhanced seed production of *Cenchrus ciliaris.* In their experiment, closer spacing did not favour seed production of *Cenchrus ciliaris.* In fact, the highest seed yield (97 Kg/ha) was recorded from the 75 cm row spacing in second year. This was significantly higher than yields for 60 cm (83.7 Kg/ha) and 40 cm wide (75.9 Kg/ha).

Most of the pasture farms in Tanzania were basically planted with *Cenchrus ciliairis* cultivar Biloela and C*hloris gayana* cv. Boma for hay production. Seed broadcasting method to establish swards was a common practice. The growing of pasture grass seed crop in rows, rather than random broadcasting is advocated for good pasture grass seed production (FAO, 1986, Kumar *et al*., 2005). Grass stands that are seeded in rows usually produce more seeds and are easier to fertilize and weed. Row seedlings also have more efficient access to sunlight, nutrients, and available water than broadcast-seeded stands (sward). In addition, row plantings require a lower seeding rate and volunteer plants from shattered seed are easier to control. The row spacing becomes an important factor in certified or registered seed production systems and has been practiced in Australia, Brazil and India. Row spacing to improve production of quality grass seed is not a common practice in the climatic conditions of sub humid eastern zone of Tanzania and need to be investigated to improve seed quality for internal and external demands. The influence of local soil, climate and management conditions may override differences in species and plant cultivar responses to variation in row spacing.

1.1.2 Fertilizer use on pasture seed production

Fertilizer use is an essential input for seed producers to produce seed quality that maximize returns in seed production business. The producers should understand all the nutrient deficiencies in their local soils and determine the fertilizer requirements of the species or cultivars. Ayerza (1980) in Argentina reported that seed yields of *Cenchrus ciliaris* improved with application of Phosphorus. Nitrogen and Phosphorus are also very important in seed production. Cameroun and Humphrey, (1976) reported that Nitrogen application increased tiller density, tiller fertility, and raceme number on individual inflorescence of *Paspalum plicatulum*. Nitrogen availability is a dominant factor controlling the rate of the various processes which result in seed formation and development. Fertilizer application for pasture production in Tanzania is very uncommon even in deteriorating grazing lands. The need to use fertilizer for forage production improvement and quality grass seed production is inevitable.

1.1.3 Irrigation practice for seed production

In areas where irrigation is possible due to water availability, agronomic principles of seed production can be applied to benefit the seed industry (FAO 1986). Irrigation can be used during the dry season for seed production to minimize biotic and abiotic stresses and hence improve seed quality. Selection of good sites for seed production in any country is important in order to produce good quality seeds with available potentials in the area.

1.1.4 Effects of season on grass seed yield and quality

Forage production has been a primary goal to all pasture farms in Tanzania. This has been done in wet season for utilizing rainfall water. Grass seed production is very sensitive during the wet season due to high levels of humidity which is a predisposing factor to poor grass seed quality. Report by FAO (1986) using irrigation during the dry season noted that seed producers can produce good quality seeds with less challenges of diseases and insect attack, and less weather damage during the seed harvest.

1.1.5 Relationship between cutting height and seed yield components

The excessive vegetative growth of grasses, under certain conditions, may discourage their seed yield. Hence, there is a need to develop methods and techniques to obtain high yields of good quality seed in grasses. Cutting management may be one of the techniques to strike a balance between the amount of vegetative growth and the reproductive phase for good quality grass seeds (Kumar *et al.,* 2008). By cutting management practices, the growth and sprouting of the grasses could be weeded, fertilized and suitably managed to synchronize the reproductive phase with most favourable photoperiod and temperature regimes.

1.2 Problem Statement and Justification

Shortage of forages is a limiting factor to improved ruminant livestock production systems in Tanzania. Inadequacy in terms of quantity and quality of forages leads to poor health conditions which lead to low productivity and hence unstable livestock farming system. In Tanzania, pasture research in the past emphasized on the introductions, evaluations and selection of the grasses and legumes for on station evaluation trials undertaken by research institutions in different agro ecological zones. The main evaluation criteria used in these investigations included persistence, dry matter production, resistance to grazing, drought tolerance, and quality mainly the chemical composition, in vivo and in vitro digestibility (Lwoga *et al.,* 1984). Further trials were also done to assess the response of selected promising grass and legumes cultivars/ species to mineral fertilizers. Rather limited information is available from on farm performance and seed production of recommended promising pasture species/cultivars under different agro ecological zones as well as its production under irrigation. Production of quality grass seeds needs a special attention as compared to legume as from establishment, field crop management, seed harvest and processing.

C*enchrus ciliaris* cv. Biloela is a drought resistant grass pasture species adapted to wide range of soil types in different agro ecological zones from semi arid to sub-humid climatic zones (Hacker *et al.,* 2001). The grass is easily established by farmers in different areas as forage for their livestock during the wet seasons. Its establishment in Tanzania has been by use of seeds, however of recent due to poor seed germination complaints from customers (Dr R.B Msangi and N.Ngota, 2010, personal communication) seed source farms have opted to supply vegetative splits for the purpose of establishment. This is due to low seed yield and quality produced from the sources. According to Rains *et al., (*1993), seed quality is variable from poor, standard to extreme high, and improves with growing technical know how by suppliers and customer discrimination. Use of vegetative splits has disadvantages compared to seeds. The disadvantages include high costs and bulkiness in transportation, tedious and labour intensive in uprooting, sorting and planting and easy transmission of plant diseases, pest and weeds. Limited information is available on the buffel grass seed production with regard to its production in dry season under irrigation management, its response to different fertilizer application rates, row spacing, cutting heights and the overall biomass productivity under field conditions.

Therefore, there was a need to evaluate these agronomic practices on how they affect seed yield and quality of *Cenchrus ciliaris* cv. Biloela (buffel grass) in the sub humid climate of eastern zone of Tanzania and hence establish seed production field criteria based on study components for improvement. The main objective of the study was to evaluate the effects of various agronomic practices on seed yield and quality of *Cenchrus ciliaris* cv. Biloela in the sub-humid eastern zone of Tanzania. The main objective of this study has been addressed through the following specific objectives:

1) Evaluation of current viability status of *Cenchrus ciliaris* from three prominent seed farms in eastern sub-humid zone of Tanzania (Paper I);
2) Assessment of effects of season, cutting height, row spacing, nitrogen and phosphorus rates on *Cenchrus ciliaris* cv. Biloela seed yield and vegetation characteristics in the eastern sub humid zone (Paper II)
3) Investigation on the effects of season, cutting height, row spacing, nitrogen and phosphorus rates on *Cenchrus ciliaris* cv. Biloela seed quality in the eastern sub humid zone (Paper III)
4) Economic analysis of seed and forage biomass production in wet and dry season using irrigation (Paper IV).

Study questions

i) Do *Cenchrus ciliaris* cv. Biloela seeds produced from different farms differ in viability?

ii) What agronomic practices should be followed so as to improve pasture grass seed yield and quality?

1.3 References

Andrade, R. P. (2001). Pasture Seed Production Technology in Brazil. Embrapa Cerrados – Planaltina, DF, Brazil. www.internationalgrasslands.org/files/igc/publications/2001/tema3-2.pdf

ASARECA (2007). Rationalisation and Harmonisation of Seed Policies and Regulations in Eastern and Central Africa. ASARECA Technology Uptake and Up-scaling Support Initiative(TUUSI). Sharing knowledge and Experience. ***http://www.asareca.org/tuusi/index.php?option=com_tuusiviewbestpractice&act=view&Itemid=42&project=42***

Ayerza, R. (1980). Effect of phosphate fertilizer on the seed production of buffel grass (*Cenchrus ciliaris* L. Revista de ciencias Agrarias, 1:99 buffel grass (*Cenchrus ciliaris* L.) in Australia using a climate-soil model. *Plant Protection Quarterly* 19: 155-163.

Bremmner, J.M. and Mulvaney, C.S. (1982). Total Nitrogen. *In: Methods of soil analysis. Part 2* (Edited by Black et al). Agronomy Monograph 9, American Society of Agronomy, Madison, Wisconsin, USA pp. 1149 – 1170.

Cameroun, A.G. and Humphrey, L.R. (1976). Nitrogen supply, and harvest time effect on *Paspalum plicatulum* seed production. Tropical Grassland, 10:205.

Crowder, L.V. and Chehda, H.R. (1982). Tropical Grassland Husbandry. Tropical Agricultural Series. Longman. London and New York. 562pp

FAO (1986).Tropical Pasture Seed Production. Plant Production and Protection Paper. Edited by Humphrey L.R and F.Riveros. FAO, Rome. 203pp

FAO (1990). Tropical grasses. FAO Plant Production and Protection Series. By Skerman P.J. and F. Riveros. FAO, Rome. 832pp

FAOSTAT (2010). Food and Agriculture Organization of the United Nations. Statistics Division. http://faostat.fao.org/site/573/DesktopDefault.aspx?PageID=573#ancor

Hacker, J. B. (1989). The Potential for Buffel Grass Renewal from Seed in 16-Year-Old Buffel Grass-Siratro Pastures in South-East Queensland. *Journal of Applied Ecology*, Vol. 26, No. 1 (Apr., 1989), British Ecological Society pp. 213-222.

Hacker, J.B. and Radcliff, D. (1989). Seed dormancy and factors controlling dormancy breakdown in buffel grass accessions from contrasting provenances. *Journal of Applied Ecology* 26: 201-212.

Hacker, J.B and Waite, R.B. (2001). Selecting buffel grass (*Cenchrus ciliaris*) with improved spring yield in subtropical Australia. *Tropical Grasslands* 35: 205 – 210.

International Seed Testing Association ISTA (2009). International Rules for Seed Testing 2009 Edition. Secretariat, Zürichstrasse 50, CH-8303 Bassersdorf, Switzerland.

Kidunda, R.S. and Lwoga, A.B. (1987). The constrains of Research to the Development of Pasture and forage in the traditional livestock sector. Proceedings of Tanzania Society of Animal Production, Arusha, Tanzania. pp 175- 198

Kizima, J.B., Mtengeti, E.J. and Nchimbi-Msolla, S. (2013). Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. *Livestock Research for Rural Development. Volume 25, Article #85.* http://www.lrrd.org/lrrd25/5/kizi25085.htm

Kizima, J. B., Mtengeti E.J. and Nchimbi-Msolla, S. (2014). Seed yield and vegetation characteristics of *Cenchrus ciliaris* as influenced by fertilizer levels, row spacing, cutting height and season. *Livestock Research for Rural Development. Volume 26, Article #148.* http://www.lrrd.org/lrrd26/8/kizi26148.htm

Kumar, D., Dwivedi G.K. and Singh S. (2005). Seed yield and quality of buffel grass (*Cenchrus ciliaris*) as influenced by row spacing and fertilizer level. *Tropical Grasslands* 39. 107-111.

Kumar, D., Seth, R., Natarajan, S., Dwivedi G.K. and Shivay, Y.S. (2008). Seed yield response of marvel grass (*Dichanthium annulatum*) to cutting management and nitrogen fertilisation in central India. Division of Agronomy, Indian Agricultural Research Institute, Pusa, New Delhi-110 012, India. *Journal of Agronomy Research* 6 (2): 499–509.

Kumwenda, M. and Ngwira, A. (2003). Forage demand and constraints to adoption of forage technologies by livestock keepers in Malawi. *Tropical Grasslands.* Volume 37, 274 –278

Kusekwa, M. L., Kaganda, S. R. and Msangi, R. B. (1987). Introduction and evaluation of pasture species for central Tanzania. In: *Proceedings of Tanzania Society of Animal Production*, August, 1987, Arusha, Tanzania 271- 298 pp.

Larson, R.S., and Kellogg, E. A. (2009). Genetic Dissection of Seed Production Traits and Identification of a Major-Effect Seed Retention QTL in Hybrid *Leymus* (Triticeae) Wildryes. *Journal of Crop Science Society of America* 49:29–40.

Lwoga, A.B., Lugenja, M.M.S and Kajuni, A.R. (1984).Pasture Research in Tanzania. Pasture Improvement Research in Eastern and Southern Africa (Ed. by Jackson A. Kategile). Proceedings of a workshop held in Harare, Zimbabwe, 17-21 September 1984.

MLD (2006). Ministry of Livestock Development. National Livestock Policy. United Republic of Tanzania. Dar Es salaam.45 pp.

Mtengeti, E.J.(1990). Effect of cutting interval and nitrogen fertilizer rate on the yield and nutritive value of *Brachiaria brizantha* and *Chloris gayana*. Unpublished dissertation award of MSc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. pp 45-58.

MWLD (2005). Ministry of Water and Livestock Development. Proceeding of Hundred Years of Livestock Services in Tanzania 1905 -2005, Held at

Livestock Production Research Institute on June 06-11, 2005. Mpwapwa ,Tanzania.

Olsen, S.R. and Sommers L.E. (1982) Phosphorus *In:Methods of soil analysis part 2* (Edited by Page A.L) Chemical and microbiological properties. Pp 403 – 429.

Pamo, E.T and Pieper, R. (2000). Introduction to Range management in Free and Open Access Environments of Sub- Saharan Africa. Technical Centre for Agricultural and Rural Cooperation, CTA, Wagenngen.

Rains, J.P., Hopkinson, J.M. and Tregea, S.P. (1993). Tropical Pasture Establishment. Ten Satisfying industry's pasture seed requirements. *Tropical Grasslands (1993).* Volume 27, 359 –366

Rethman, N.F.G and Boshoff, W.H. (1980). Seed Production and Quality of buffel grass *(Cenchrus ciliaris)* selections. Department of Plant Production and Soil Science, University of Pretoria, Pretoria 0002, South Africa.

Reynolds, S.G. (1988). Pastures and Cattle Under Coconuts. FAO Plant Production and Protection. Paper 91, FAO. Rome, 321pp.

SAS (2000). Stastical Analysis System. SAS/STAT users guide. Statistical Analysis Institute, Inc; Cary, Nc. USA.

Statistical Package for Social Sciences (SPSS) (2000). Ref.CSx HA32.FI54.2000. London Sage Publishers.

UNDP/FAO (1967). East African Livestock survey, FAO. Rome. Volume II pp 18 -28

CHAPTER TWO

2.0 PAPER I

Kizima J.B., Mtengeti, E.J. and Nchimbi-Msolla, S.(2013). Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. *Livestock Research for Rural Development. Volume 25, Article #85.* http://www.lrrd.org/lrrd25/5/kizi25085.htm (Published)

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Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania

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Abstract

Low level of some soil nutrients in soils and older age of swards seem to be factors among other factors that contribute to low pasture seed viability in Tanzanian sub-humid farms. A laboratory study was conducted to assess viability status of *Cenchrus ciliaris* seeds, agronomic practices and soil nutrient status from three farms namely Mazimbu in Morogoro, Vikuge in Kibaha and Tanga. Seeds and soil samples were collected from respective farms for seed viability tests including purity, caryopsis index and germination, where as soils samples were analysed for nutrient status at Sokoine university laboratory. *Cenchrus ciliaris* pasture species was considered as the most demanded grass species by livestock keepers in Tanzania due to its tolerance to drought conditions. Spikelet germination rate was 8.33% for Mazimbu, 0.25% for Vikuge and 1.83% for Tanga farms. Total soil Nitrogen was observed to be very low levels i.e 0.08%, 0.13% and 0.12% for Vikuge, Tanga and Mazimbu farms respectively. From this study it is concluded that old age of sward produced low quality seeds in terms of viability, and this could be further exacerbated by low soil fertility. Further studies on fertilizer rates, irrigation during dry season, rows spacing and seed health challenges are required to bring more understanding on grass seed production in the similar agro-ecological zone.

Keywords: *age of the sward, grass seeds quality, soil nutrient status*

Introduction

Livestock sector is important for the economy of Tanzania as is for many other developing countries. In Tanzania, the sector contributes about 5.9 % of the Gross Domestic Product (GDP) and employs about 40% of the 3.9 million agricultural households who are involved in crops and livestock production (MLD 2006). The growing human and livestock populations increase demand on land resources, and is causing a decline of grasslands for other uses and create forage shortage for both traditional and improved ruminants keeping systems.

According to Pamo et al 2000, sub humid zones have a range of 1000 to 1500 mm of annual rainfall and the growing period of 180 to 270 days. Climatic conditions in these eastern sub humid regions of Tanga, Coast (Pwani), Morogoro and Dar es Salaam in Tanzania are favourable for agriculture and livestock production. Favourable climate condition and availability of markets for the livestock products have motivated people in this agricultural zone to solicit land for intensive ruminant livestock farming to produce milk and meat. However forages shortage during the dry season is still a constraint for high productivity all the year round. Sustainable solution to forage shortage is possible when technical efforts are invested to improve production and utilization of natural and planted forages. It is well understood that improved ruminant production system requires high quality forages, especially for dairy and beef cattle (Kumwenda et al 2003).

Pasture establishment aims to improve productivity of livestock production system through increased forage yield. However pasture establishment requires good quality seeds. According to ASARECA (2007), quality seeds are the basic foundations of any improved ruminant production system and economic gains among farming communities. Pasture seed production in Tanzania need a close technical attention as they do not reach formal markets due to lack of required standards. More studies are needed for pasture seed to reveal the current situation of agronomic practices in seed farms and viability status of available seeds. In order to develop a good functional seed production system responding to market oriented demands more expertise is required to support policy institutions. Therefore, development of technologies to improve grass pasture seed yield and quality in seed production industry will be a step forward towards quality forage production in Tanzania in order to improve ruminant livestock productivity. This study therefore, aimed to assess viability status of *Cenchrus ciliaris* seeds from three prominent pasture seed producing farms Mazimbu, Vikuge and Tanga as an initiative to create awareness to stakeholders for pasture grass seed quality improvement to meet the growing demand.

Materials and Methods

Study areas

This study was conducted in three prominent pasture seed farms in eastern sub humid agro ecological zone. The farms studied were Mazimbu, Vikuge- Kibaha and Tanga as described below. Rainfall, humidity and temperature data were obtained from respective meteorological stations of Kibaha, Tanga Livestock Research Institute and Sokoine Universirty of Agriculture. Vikuge pasture seed farm is located in Kibaha at (6°47'16.68" S and 38°51'49.99" E GPS coordinates) in Coast region, with a bimodal rainfall pattern 1000- 1500 mm annual rainfall (Figure 1). The mean temperature ranges from 21 ^{o}C to 31 ^{o}C.

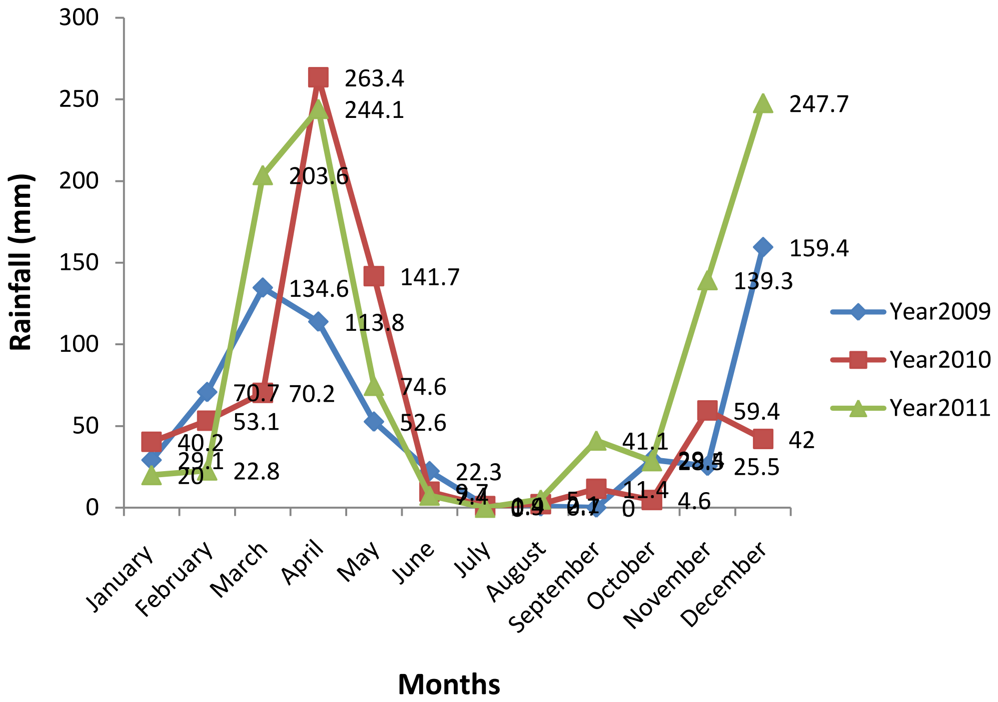

Figure 1: Rainfall distribution of Kibaha, Tanzania

Tanga farm at Livestock Research Institute is located at 5°05' 19.24" S and 39°03'51.15" E GPS coordinates in Tanga region with a bimodal rainfall pattern 1230 - 1400 mm annual rainfall (Figure 2) The mean temperature ranges from 26^{o}C to 33^{o}C.

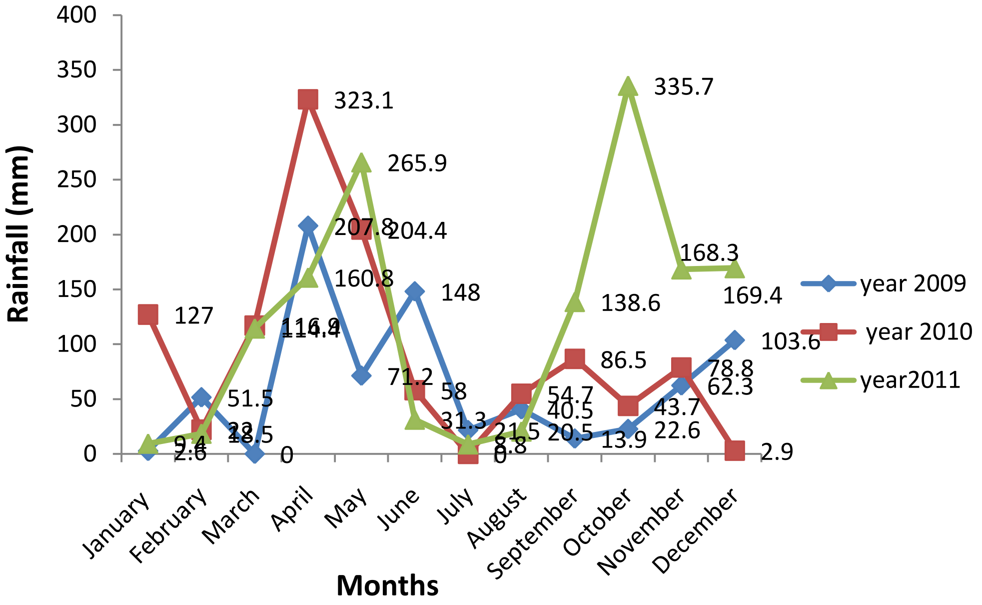

Figure 2: Rainfall distribution of Tanga, Tanzania

Mazimbu farm of Sokoine University of Agriculture is located at 6°46' 59.42" S 37°37'35.14" E GPS coordinates in Morogoro region with a bimodal rainfall pattern 1000- 1200 mm annual rainfall (Figure 3) With the mean temperature of 18 – 30 ^{0}C

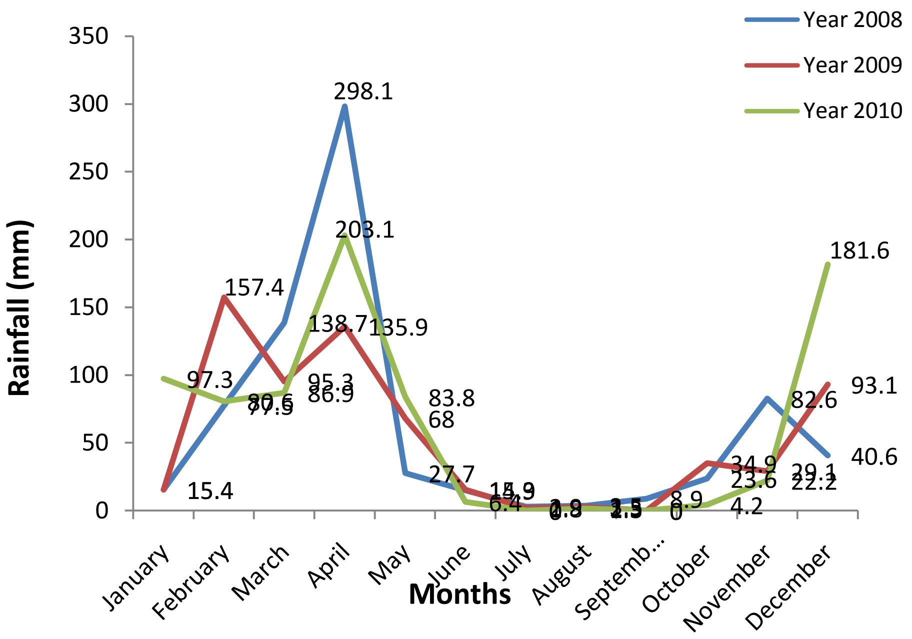

Figure 3: Rainfall distribution of Morogoro, Tanzania

Preliminary survey and farm visits
Three farms were visited in November 2010 to interview farm managers using an interview checklist on daily production activities, agronomic practices and challenges facing pasture seed production in their farms. The farms visit aimed at learning to get an experience from the ground on what is being practiced on pasture seed production in sub-humid eastern zone of Tanzania. Farm annual reports were used to obtain data on seed production, demand and annual sales. Fields for seed and hay productions were visited in all farms, all grass pasture species and cultivars in the fields were recorded. During the farm visit the samples of *Cenchrus ciliaris* seeds and soils were collected for laboratory analyses.

Soil sampling and analysis
Soil samples were collected randomly in the seed farm and mixed to constitute a representative sample from each farm. The soil samples were taken at a depth of 0 to 20 cm from the soil surface. Soil samples were then brought for laboratory analysis in the Soil Science Department of Sokoine University of Agriculture, Morogoro, Tanzania. The collected soil samples were air dried and ground to pass through 2mm sieve before laboratory analysis. Total Nitrogen (N) and soil extractable Phosphorus (P) were analyzed using Micro- Kjeldahl and Bray I methods, respectively (Bremner and Mulvaney 1982; Olsen and Sommer 1982).

Seed sampling
In each farm a seed lot of 3 kg of *Cenchrus ciliaris* was sampled from the seed stock available for sale and delivered to Sokoine Universirty of Agriculture laboratory for seed quality analysis. These seeds were already stocked for 3 months since harvest. Seed samples were collected from stored stock not from the seed fields to represent seeds which were ready for marketing.

Seed moisture content test
The levels of moisture content of the seeds sampled were determined at SUA using oven method (direct method). Two empty petri dishes were weighed before weighing 10 g of *Cenchrus ciliaris* seeds and then dried in the oven at 103°C for 17 hours and allowed to cool in desiccators for 15 minutes. The dried samples were then reweighed and thereafter, moisture content calculated.

Testing of seeds viability
Caryopsis percentage assessment of the seeds from each farm was calculated from each sample. Four hundred spikelets were dissected to assess presence of caryopsis (grain) using forceps under a hand lenses (at magnification of X 20)**.** The same exercise was repeated three times for each sample to find an average caryopsis percentage. Percentage Purity was assessed by weighing a sample seed lot followed by removing extraneous materials and then final weighing of the pure seeds to obtain

a proportion of pure seeds. Lots of Seeds from respective farms were put on white paper to compare their colours. Before starting an assessment of germination potential, potassium nitrate solution was used to saturate the germination substrate so as to break seed dormancy. All seeds and blotter papers were soaked in a solution of 0.2 % KNO_3 prepared by dissolving 2 grammes of KNO_3 in 1 litre of water. Germination test was then conducted (for spikelet and naked caryopsis) using petri dishes set in the germination cabinet at room temperature ranging from 25 to 30^0C. Hundred seeds were placed on moist blotter paper in each petri dish; during the following days of an experiment, seeds were moistened using distilled water to avoid contamination. Three replications of petri dishes were set and germinated spikelets and naked caryopsis were then counted and recorded daily from the day 3 to 28 days of germination, according to the recommendation of ISTA (2009). Obtained results from laboratory test on germination of *Cenchrus ciliaris* seeds from three farms were then subjected to general linear model using SAS (2000) statistical package programme to compare the means difference .

Results and Discussion

Demand of *C. ciliaris* seeds from the respective farms

Cenchrus ciliaris grass pasture species was the dominant specie covering larger part of established grass species in the surveyed farms. The dominant cultivar was C. *ciliaris* Cultivar *Biloela*, however some traces of *C. cilaris* cultivar *gayndah* were observed in Vikuge and Tanga grass seed production farms. Other improved grass species were *Chloris guyana, pennisetum purperium and Trypsacum laxum.* Looking of the data of purchased seeds at Vikuge (Table 1), demand of the seeds was observed to be high covering many regions of the Tanzania. Both seeds and vegetatives splits are sold to customers, and use of vegetative splits for establishment was observed to cost much compared to seeds in terms of acreages.

Cenchrus ciliaris grass seed cv. Biloela demand was observed to be high as compared to other grass species probably due to its drought tolerance characteristics and adaptability to sub-humid agro ecological zone and other regions of Tanzania. This finding is similar to the results that were reported by Kumar et al (2005) on *Cenchrus ciliaris* from India. In this study the species exhibited high productivity, perennially and persistent to drought conditions probably due to its tuft-rhizomatous growth habit. Vikuge pasture seed farm is the most prominent pasture seeds farm for many years as compared to others which have just started seed and hay production recently. Pasture seeds that are produced in the farms (Tanga and Mazimbu) are used for own farms expansion initiatives.

Table 1: Purchased seeds of Cenchrus ciliaris (seeds and vegetative splits) from 2007- 2010 from Vikuge Pasture Seed Production farm

Customer Area/ Region	Amount of seeds (kg)	Value in Tshs (10,000 /kg)	Amount vegetative splits (Kgs) @500 Tsh	Value in Tshs (1 US $ ≈ 1625 TShs)
Eastern zone	415	4,150,000	-	
Morogoro				
Dar es salaam	53	530,000	-	
Coast	31	310,000	2200	1,100,000
Tanga	50	500,000	16,500	8,250,000
Weastern zone				
Shinyanga	50	500,000		
Mwanza	15	150,000		
Tabora	25	250,000		
Southern zone	6	60,000		
Mbeya				
Ruvuma	60	60,0000		
Rukwa	20	20,0000		
Mtwara	20	20,0000		
Central and Nortehrn zone	50	500,000		
Arusha				
Dodoma	80	800,000		
	Grand total 872	**8,720,000**	**Total 18,700**	**9,350,000**
		Equivalent to 174.5 ha established (seed rate 5 kg/ha)		Equivalent to 80.2 ha established (one truck trips costing 700,000/= Tsh from Kibaha to Tanga can establish 6 ha

Source: *Financial report- Vikuge - Pasture Seed farm 2007- 2010*

Agronomical practices in Vikuge, Mazimbu and Tanga pasture seed farms

Normally the pasture seed field is left intact (uncultivated for perennial established grass species) during the long rain season of March to June, and the seeds are harvested in July and August during the dry season of the three respective farms (Figure 1,2 and 3). However, during short rains sometimes seeds set were also harvested when mature. Produced seeds were harvested and air dried in open room and stored cumulatively mixed with the remaining stock. No irrigation was reported for seed production in all three farms. Grass seed production was reported to be very sensitive during the wet season due to high levels of humidity which is a predisposing factor to diseases infection. The mature spongy cylindrical inflorescence of *Cenchrus ciliaris* tends to absorb moisture during the rainy season, and this creates favourable site for fungal infection and multiplication. According to FAO (1986), pasture seeds production using irrigation system was noted to produce good quality seeds with few challenges of diseases, and less rainy weather damages during the seed harvest. In all the three farms, the sward used for hay production was also used for seed production (Table 2). Vikuge pasture seed farm had older *C. cilaris* sward (8 years) for seed production as compared to other two farms (1 year for Mazimbu and 5 years for Tanga farm). Swards for seed production were basically observed to be saving two purposes, hay and seed production. During hay harvest, it was observed that the left cut tillers of swards were ranging from 15 – 25 cm of height on average, where drum and disc type of mowers were commonly used to harvest hay in all farms. During an interview with farm managers, Tanga and Vikuge farms were reported not to apply industrial fertilizer or manure for seed production for about five years. However, Mazimbu farm was observed to apply manure and Urea (but the rate was not known).

Table 2: Levels of grass pasture seed production in prominent pasture seed farms

Farm	Established *C. ciliaris* area (ha)	Age of the sward (years)	Seeds produced in 2010 (kg)
MAZIMBU			
Hay production	28	16	
seed production	2	1	20
VIKUGE			
Hay production	250	8	-
Seed production	50	8	20
TANGA			
Hay production	145	2	
Seed production	5	5	20

Challenges facing grass seed production in sub-humid farms

Results in Table 3, indicate the main challenges that face pasture seed production activities. Lack of funds was observed to be a big challenge to all three farms. These farms depended on funds from government disbursement of which their adequacy and timing were not guaranteed. However, the marketing of seeds was observed not to be a challenge/constraint for Vikuge farm. This was reported to be due to many years of experience in pasture seed production and more contact to customers; however they still need more funds for further promotion and production strategies. Tanga farm was reported not to face seed marketing challenge because the seeds produced from this farm were used for farm expansion in their annex Buhuri farm, about 10 km from the main farm. Mazimbu farm had no reliable seed market probably because they have recently started seed production and few customers were aware of their products.

Levels of pasture seed moisture content

Moisture content of seeds in Mazimbu farm was 5.6%**,** while those of Vikuge and Tanga farms were 5.2% and 5.0%, respectively. These findings are within the recommended moisture content (below 8%) for safe storage of grass seeds (International Seed Testing Authority, 2010). The lower the moisture content the safer the storage of the seeds.

Table 3: Challenges which face grass seed production farms

Seed production challenges	Priority ranking of challenges for respective farm (1,2,3,4,5 and 6)		
	Mazimbu	Vikuge	Tanga
1. Unreliable rainfall due to climate change	1	5	2
2. Timing of farm activities is big problem due to inadequate fund resulting into late weeding, fertilizer application, seed harvest and other activities.	2	1	1
3. Inadequate number of technical people on grass seed production	5	2	5
4. Lack of genetic purity	-	4	3
5. Lack of funds for advertisement of pasture seeds marketing	-	3	4
6. Doubt on Inadequate marketing of pasture seeds	3	-	-
7. Problems of water for irrigation	4	6	6

Ranking; 1= High priority and 6 = Low priority

Colour of seed lots

It was observed that colour of the seeds (Plate 1) from the three farms were a bit different although they were all harvested in July 2010. The colour of seeds from Mazimbu farm was kharkish while those from Vikuge and Tanga were a bit brownish. This may need more studies on fungal infection since this could have affected the colour of seeds.

Plate 1; Seed colour (kharkish and brownish) Farm 3-Mazimbu, Farm 2-Tanga and Farm 1 -Vikuge

Seed viability

The purity of seeds from Vikuge and Tanga farms was 90% (Table 4). However the purity for pasture seeds from Mazimbu farm was slightly below (86.7%) the recommended purity of 90% (FAO 1993). The germination test for spikelet and caryopsis showed significant ($p < 0.05$) difference between the farms. The spikelet germination percentages were 8.33, 1.83 and 0.25 for Mazimbu, Tanga and vikuge farms, respectively. The study conducted in a neighbour country of Kenya by Mganga et al (2010) reported a bit higher germination of 12% for *Cenchrus ciliaris* seeds. The results from the study and those reported from Kenya were below minimum germination (spikelets) of 20% for seed quality standards as for FAO quality declared seed set for *Cenchrus ciliaris* species (FAO 1993). The differences of results between the farms and country may be due to low level of soil fertility (Table 5). This is supported by Bekunda et al (2004) that average crop yields in East Africa are alarmingly below potential yields (values obtained at national research stations). This may be due to complex interactions between several factors including soil fertility pests, diseases, climate and management. Low fertility levels (Table 4) in farms may have affected caryopsis (grain fill) resulting in more empty spikelets harvested which lower germination percentages. Germination of caryopsis started earlier from the third day of experiment while the germination for spikelets started later in the sixth day, this was due to the fact that caryopsis were naked and easily absorbed or imbibed in water than spikelets. Basing on caryopsis germination, seeds from Tanga showed higher result (56.17 %) followed by Mazimbu and Vikuge (Table 4).

Table 4: Variables of *Cenchrus ciliaris* seed viability testing from three prominent pasture seed farms in eastern sub humid zone of Tanzania

Seed sources (Farms)					
Parameters	**Mazimbu**	**Vikuge**	**Tanga**	***SEM***	***p* - value**
No. of observations (n)	12	12	12	-	-
Purity (%)	86.7	90	90	-	-
Spikelet germination (%)	8.33^a	0.25^b	1.83^b	1.06	0.0001
Caryopsis index (%)	34.33^a	12.08^c	21.83^b	1.78	0.0001
Caryopsis germination (%)	32.50^b	31.83^b	56.17^a	4.41	0.0004
1000 seed weight (g)	1.12^a	0.99^b	0.98^b	0.02	0.0025

Means within row with the same superscript letters are not significantly different (P < 0.05). . SEM = Standard Error of Means

Soil fertility

The soil fertility status of the samples collected from the farms showed some deficiencies in some nutrients (Table 5). Looking at levels of soil macronutrients N,P,K that are required by plants in larger amounts, nitrogen was deficient in all studied farms. Total Nitrogen for Vikuge farm was at very low level of 0.08%, while the soils from Tanga and Mazimbu showed low N levels of 0.12 and 0.13, respectively (Moberg 2000). It was therefore observed that soil nutrient levels in terms of total nitrogen in all three farms were deficient, and this might be the cause of poor seed setting which affected seed quality in terms of viability. According to Eckert (2012), a nitrogen-deficient plant is generally small and develops slowly because it lacks the nitrogen necessary to manufacture chlorophyhyll for efficient photosynthesis.

The results for Phosphorus nutrient from the soils that were analysed showed that, P level was very high for the Mazimbu farm (46.19 mg/kg), whereas they were very low at Vikuge and Tanga farms (with 2.10 and 1.48 mg/kg, respectively). These results might be due to the fact that Mazimbu received manure and urea, while other farms did not. The results agree with Bekunda *et al* (2004) who stated that Phosphorus is a less mobile nutrient in soils, causing it to accumulate more in soils where mineral fertilizers are applied. Adequate Phosphorus in soils of Mazimbu farms is reflected in spikelet germination percentage where Mazimbu seeds showed slightly better results than the other farms. According to Griffith (2012), Phosphorus nutrient is essential for the general health and vigor of all plants. Some specific growth factors that have been associated with the presence of the Phosphorus nutrient are to stimulate root development, increase inflorescence stalk size and stem strength, improved flower formation and seed production.

According to Moberg (2000), soil fertility ratings of Potassium were observed to be at medium levels of 0.61 and 0.39 $cmol_{(+)}/kg$ at Mazimbu and Tanga farms, indicating optimum levels of available Potassium for plants. However, low level was observed at Vikuge farm soils (0.22 $cmol_{(+)}/kg$). Soils of Vikuge farm were observed to be more deficient in all macronutrients due to continuous cultivation without application of fertilizers showed by age of the sward for seed production which was older compared to other farms (Table 2).

Conclusions and Recommendations

The results show that, the quality of *Cenchrus ciliaris* seeds from three farms was low according to minimum recommended seed quality standards (FAO 1993). Among other factors soil nutrient levels important for plants growth as per soil analysis was at low levels in all farms. Thus, these farms need soil nutrient adjustment through fertilizer application basing on soil fertility recommendations. Age of the sward seem probably to be also a factor affecting viability of seeds. Seed production in the farm with sward above four years resulted in poor quality seeds. It is recommended that farms conduct seed testing (for viability and health) from newly established to old vegetation to monitor quality of seeds each year and batches produced. However further studies on fertilizer rates, dry season irrigation, row spacing and seed heath challenges are required to bring more understanding on seed production in this sub humid agro-ecological zone of Tanzania.

Acknowledgements

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Table 5: Soil nutrient status from three prominent pasture seed farms

Variables	MAZIMBU	Remarks	VIKUGE	Remarks	TANGA	Remarks
PH (1:2.5)(in H_2O)	6.68	**neutral**	4.81	**strong acidity**	6.04	**medium acid**
EC (ds/m)	0.08		0.01		0.06	
%clay	10		12		12	
%silt	4		4		4	
%Sand	84		84		84	
Soil Texture	Loamy sand		Loamy sand		Loamysand	
OC BlkW (%)	0.56	**Very low**	0.44	**Very low**	0.59	**Very low**
Total N-kjeld(%)	0.12	**Low**	0.08	**Very low**	0.13	**Low**
Ext. P (mg/kg)	46.19	**Very high**	2.10	**Very low**	1.48	**Very low**
CEC (cmol$_{(+)}$/kg)	6.8	**Low**	4.8	**Very low**	6.4	**Low**
Exchangeable bases (cmol$_{(+)}$/kg)						
Ca^{2+}	5.06		2.07		4.74	
Mg^{2+}	1.16		0.61		0.97	
K^{+}	0.61	**Medium**	0.22	**Low**	0.39	**Medium**
Na^{+}	0.19		0.14		0.17	
Cu	0.04		0.04		0.14	
Zn	2.21		0.26		1.40	
Mn	15.13		29.21		124.42	
Fe	12.72		23.88		32.80	

PH= Hydrogen ion concentration, EC= Exchange Cation, OC= Organic content, N= Nitrogen, P= phosphorus, CEC= Cation Exchange capacity , Ca^{2+} =calcium Mg^{2+} =magnesium K^{+}= Na^{+} =sodium Cu= copper Mn=Manganese Fe =iron

References

Andrade R P 2001. Pasture Seed Production Technology in Brazil. Embrapa Cerrados – Planaltina, DF, Brazil. http://www.internationalgrasslands.org/files/igc/publications/2001/tema3-2.pdf

ASARECA 2007. Rationalisation and Harmonisation of Seed Policies and Regulations in Eastern and Central Africa**.** ASARECA Technology Uptake and Up-scaling Support Initiative (TUUSI). Sharing knowledge and Experience.
http://www.asareca.org/tuusi/index.php?option=com_tuusiviewbestpractice&act=view&Itemid=42&project=42

Ayerza R 1980. Effect of phosphate fertilizer on the seed production of buffel grass(*Cenchrus ciliaris* L. Revista de ciencias Agrarias, 1:99 buffel grass (*Cenchrus ciliaris* L.) in Australia using a climate-soil model. *Plant Protection Quarterly* 19: 155-163.

Bekunda M A, Ebanyat P, Nkonya E, Mugendi D & Msaky J J 2004. Soil fertility Status, Management, and research in East Africa. *Eastern African Journal of Rural Development* Vol.20(1) 2004: 94-112

Bremmner J M and Mulvaney C S 1982. Total Nitrogen. *In: Methods of soil analysis. Part 2* (Edited by Black *et al*). Agronomy Monograph 9, American Society of Agronomy, Madison, Wisconsin, USA pp.1149 – 1170.

Eckert D J 2012. Nitrogen Efficient fertilizer use manual. (Available at http://www.rainbowplantfood.com/agronomics/efu/environment.pdf.)

FAO 1993. Quality declared seed. FAO plant production and protection paper. Rome, Italy.186pp

FAO 1986. Tropical Pasture Seed Production. Plant Production and Protection Paper. Edited by Humphrey L.R and F.Riveros. FAO, Rome.203pp

Griffith B 2012. Essential Role of Phosphorus (in plants). Efficient fertilizer use manual. (Visited site http://www.rainbowplantfood.com/agronomics/efu/environment.pdf)

Hacker J B and Waite R B 2001. Selecting buffel grass (*Cenchrus ciliaris*) with improved spring yield in subtropical Australia. *Tropical Grasslands* 35: 205 – 210.

International Seed Testing Association, ISTA 2009. International Rules for Seed Testing 2009 Edition. Secretariat, Zürichstrasse 50, CH-8303 Bassersdorf, Switzerland.

Kumar, D , Dwivedi GK and Singh S N 2005. Seed yield and quality of buffel grass (*Cenchrus ciliaris*) as influenced by row spacing and fertilizer level. Tropical Grasslands 39. 107 -111.

Kumar D, Seth R, Natarajan S, Dwivedi G K. and Shivay YS 2008. Seed yield response of marvel grass (*Dichanthium annulatum*) to cutting management and nitrogen fertilisation in central India. Division of Agronomy, Indian Agricultural Research Institute, Pusa, New Delhi-110 012, India. *Journal of Agronomy Research* **6**(2), 499–509, 2008

Kumwenda M. and Ngwira, A 2003. Forage demand and constraints to adoption of forage technologies by livestock keepers in Malawi. *Tropical Grasslands.* Volume 37, 274 –278

Moberg J P. 2000. Tropical Soil analysis Manual. Sokoine University of Agriculture, Morogoro, Tanzania.

Mganga **K Z, Musimba N K R, Nyariki D M, Nyangito M M, Mwang'ombe A W, Ekaya W N, Clavel D, Francis J, Kaufmann R, Verhagen J and Muiru W M 2010**. Dry matter yields and hydrological properties of three perennial grasses of semi-arid environment in east Africa. African Journal of Plant Science Vol. 4(5), pp. 138-144. http://www.academicjournals.org/ajps

MLD 2006. Ministry of Livestock Development , Dar es salaam. Tanzania

Olsen S R and Sommers L E. 1982. Phosphorus *In:Methods of soil analysis part 2* (Edited by Page A.L) Chemical and microbiological properties. Pp 403 – 429.

Pamo, E T and Pieper R, 2000. Introduction to Range management in Free and Open Access Environments of Sub- Saharan Africa. Technical Centre for Agricultural and Rural Cooperation, CTA, Wagenngen.

SAS, 2000. Stastical Analysis System. SAS/STAT users guide. Statistical Analysis Institute, Inc; Cary, Nc. USA

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CHAPTER THREE

3.0 PAPER II

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Seed yield and vegetation characteristics of *Cenchrus Ciliaris* as influenced by fertilizer levels, row spacing, cutting height and season

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Abstract

Grass pasture seed production is commonly done in wet season in Tanzania with limited information on production in dry season under irrigation. Low fertility of soils and high risks of diseases are reported to affect pasture grass seed yield and viability in wet season while their demand is growing. There was a need to conduct a study to gain a practical experience on how to compromise facts on seed yield and forage biomass production under field conditions in sub humid agro-ecological zone of Tanzania. An field trial using split plot experimental design was conducted at Sokoine University of Agriculture farm to assess effects of different levels of Nitrogen and Phosphorus (0KgN/ha 0 KgP/ha , 40 KgN/ha 20KgP/ha, 60KgN/ha 30KgP/ha), row spacing (25, 75 and 100 cms) under two cutting heights (15cm, ground cut) in wet and dry seasons under irrigation on seed yield and vegetation characteristics of *Cenchrus ciliaris* cv.Biloela. The study was done in two consecutive years 2012 and 2013 (March – June and June- September) for long rains and dry season respectively. Seed yields were higher at higher rates of Nitrogen and Phosphorus at ground cutting (77.5 kg/ha) than at 15cm cutting height (56.7kg/ha) with a trend of decreased seed yields in the second year (77.5 to 38.4kg/ha) and (56.7 to 35.5 kg/ha) at the same levels of Nitrogen and Phosphorus. Row spacing of 100cm showed slightly higher seed yield (70 kg/ha) as compared to other two row spacing (25 cm and 75cm) that gave 67.2 and 69.3 kg/ha respectively. Higher seed yields were observed in dry than wet season for two consecutive years under all cutting heights (37.8 and 66.7 kg/ha in 15cm cutting height for wet and dry season respectively). Higher levels of Nitrogen and Phosphorus yielded significantly ($p<0.05$) higher forage biomass (13.2 tDM/ha) and (11.1 tDM/ha) from 15cm and ground cutting respectively as compared to 10.0 and 8.6 tonnes DM/ha for low level of Nitrogen and Phosphorus rates. High plant density at 25cm row spacing yielded higher biomass (12.2 tDM/ha) than low plant density at 100cm row spacing (11.4 tDM/ha). It was concluded that, ground cutting height could be beneficial management practice for rhizomatous grass so as to obtain higher seed yields since it allows healthier ground tillers from rhizomes than profuse aerial tillers produced at higher cutting heights. Irrigation during dry season can be the best option for *Cenchrus ciliaris* cv. Biloela seed production when row spacing of 75cm and 100 cm are used at ground cutting height with proper rates of Nitrogen and Phosphorus. However, strategies for bird scaring during dry period (offseason) is highly emphasized from blooming stage to seed maturity to maximize seed yield.

Keywords: *biomass, irrigation, nitrogen, phosphorus, Rhizomatous grass, seed production, tillering*

Introduction

Pasture seed production in Tanzania need a close technical attention of many stakeholders so as to produce more forage to support livestock sector. Rather limited information is available on pasture seed production of recommended promising pasture species under different agro ecological zones in the country. Efforts to improve management and use of established forages in Tanzania started since 1930s (MWLD 2005). On station and on-farm trials of introductions and evaluations to screen for adaptability of new introduced pasture species was done. However it is apparent that little efforts were done on pasture seed production. Challenges of changing climate and arising conflicts among land users which is now apparent between livestock keepers, crop farmers and other land users is mainly due to lack of improved pastureland to support livestock and hence minimize uncontrolled livestock movements all over the country. However shortage of pasture seeds has been a major limitation to sown pasture in Tanzania (Lwoga et al 1984). According to FAO (2006), several research stations and parastatal livestock farms have been producing (uncertified) pasture seeds, but lack of funds has stifled the development and expansion of this important activity.

Growing demand of grass pasture seeds in the country and neighboring countries for both grass and legume seeds necessitate researchers to respond to requirements to bring pasture seed industry to a functional level and meet the seed standards. Grass pasture seed production is commonly done in wet season in Tanzania with limited information on production in dry season under irrigation which necessitates conducting studies on grass pasture seed production in dry season using irrigation to fill the gap. Low fertility of soils and high challenges of diseases in wet season are reported to affect pasture grass seed yield and viability (Kizima et al 2013). Most soils are deficient in Nitrogen and Phosphorus which are essential nutrients for early root development, plant growth and seed maturation. Use of fertilizers in pasture establishment helps to replace and maintain soil nutrient levels for quality seed production.

Pasture establishment using seed broadcasting method is commonly practiced, however growing of pasture grass seed crop in rows, rather than broadcasting is advocated for good pasture grass seed production (FAO, 1986, Kumar et al., 2005). Grass stands that are seeded in rows with reduced plant density usually produce more seeds and are easier to fertilize and weeding. Row seeded stands have also more efficient access to sunlight, nutrients, and available water than broadcast-seeded stands. Management practices of pasture swards such as cutting height are said to affect vegetation characteristics and seed yield, therefore studies on effects of cutting height is important. According to Rains et al. (1993), seed quality is variable from poor, standard to extreme high, and improves with growing professionalism by suppliers and customer discrimination.

Materials and methods

Study area

The study was conducted at Magadu Dairy farm of Sokoine University of Agriculture in Morogoro municipal, Tanzania about 526 m.a.s.l (S 6° 50' 58.80" E

37°39'12.22" GPS coordinates). The farm received an annual rainfall of 694.4 mm in year 2012) and 570.6 mm in year 2013 (Figures 1 and 2). During experimentation periods there was a mixture of cool and warm temperature, ranging between 15.4 to 19.9 °C for min temperature in cold dry season and maximum temperature range of 28 to 36.2 °C in the warm wet season. High relative humidity (64.93%) was recorded in April during the wet season and lowest record was 39.3% in September during the dry season.

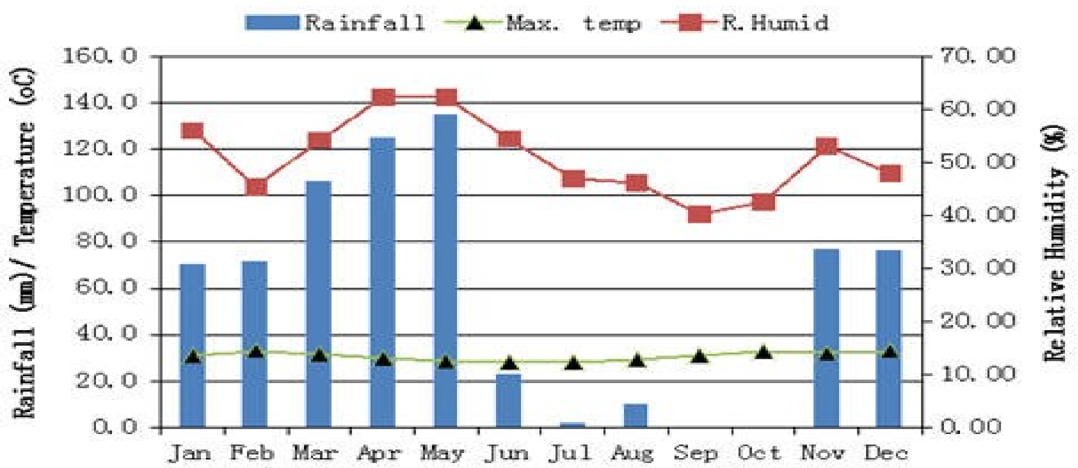

Figure 1: Rainfall, Relative humidity and Max. temperature at Morogoro (Year 2012)

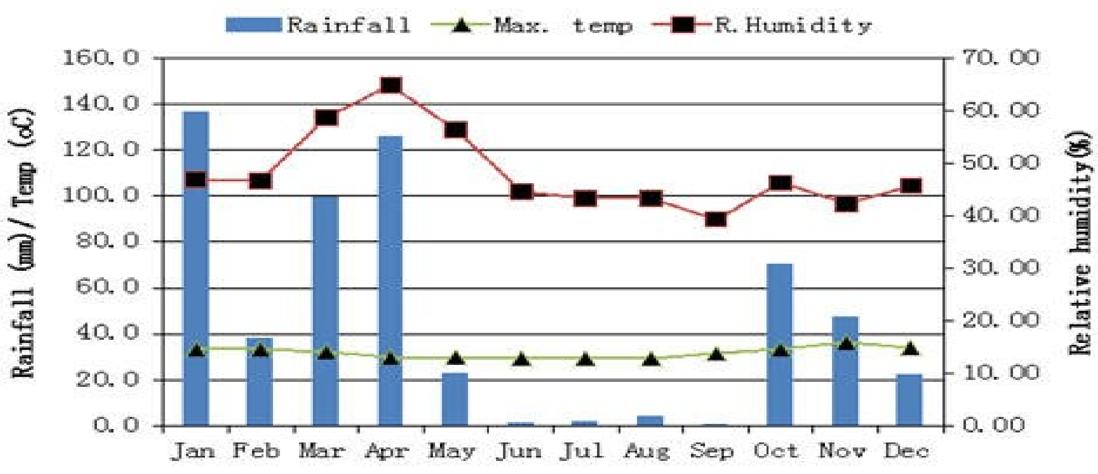

Figure 2: Rainfall, Relative humidity and Max. Temperature at Morogoro(Year 2013)

Experimental design

A study with split plot experimental design was conducted to evaluate effects of fertilizer levels and row spacing under two cutting heights in wet and dry seasons on how they affect grass seed yield and vegetative characteristics of *Cenchrus ciliaris* cv. Biloela. The experiment employed three treatments (Nitrogen and Phosphorus levels and row spacing under two cutting heights) assigned in two seasonal blocks (wet and dry season using irrigation). Three Nitrogen N and Phosphorus P levels of (i) 0KgN/ha: 0KgP/ha; ii) 40KgN/ha: 20KgP/ha iii) 60KgN/ha: 30KgP/ha abbreviated as(0N:0P, 40N:20P and 60N:30P) and three row spacing (25 cm row as control , 75 cm and 100 cm) replicated three times to make 27 plots of 4m x 4m, The plots were split into two subplots of 2m x 4m to accommodate two cutting heights (ground and 15cm cut) in each season.

Data collection

Soil testing was done before the experiment. Soil of experimental plots was slightly acidic pH 5.7 and had the following results: (%TN = 0.15, % OC= 1.87, Phosphorus = 8.73mg/kg, Clay texture with 49% clay,13% silt and 38% sand; copper =2.42mg/kg, zinc= 2.54mg/kg, manganese =85.18mg/kg, iron= 73.02mg/kg, CEC= 31.2cmol$_{(+)}$/kg, calcium = 3.77cmol$_{(+)}$/kg, potassium =0.55cmol$_{(+)}$/kg , sodium= 0.30cmol$_{(+)}$/kg). Vegetative splits of *Cenchrus ciliaris* were planted 84 days before the wet and dry season experiments to ensure good establishment before cutting height treatments were applied. No fertilizer was used during the establishment phase. Each season had separate experimental plots which were cut during the start of data collection.

In second year, the same plots for each season were used with the same treatments. Urea fertilizer (46%N) was applied after the cutting in mid March and early June followed by Triple super phosphate (TSP 46%) P_2O_5 application after 2 weeks. Wet season experiment depended entirely on rainfall while dry season experiment used irrigation. Irrigation was done using water pipe and watering can. Watering after flowering stage was done to the basal part of vegetation to avoid wetting the inflorescence. This was done purposely to make sure the inflorescence do not contaminate with moisture which is a predisposing factor of fungal growth. Irrigation was done daily in the early stages and later at an interval of one day. Soil Moisture content in plots was monitored using digital moisture meter (VG-meter-200) at 20 cm soil depth and maintained at 40-50% moisture content by irrigation. Data were also collected on the following grass seed yield components: - total tiller/tussock, fertile tiller/tussock, tiller height (cm), tiller diameter at the third internode (mm), average number of aerial tiller per plant, inflorescence length (mm), inflorescence diameter (mm).

Harvested seeds (first harvest (70 days) and second harvest(84 days)) from the same sward of each plot were air dried then yield recorded (kg /ha), visual assessment on days to 50% flowering, days to flowering, anthesis and seed maturity, measuring vegetation height to estimate forage bulk density(kgDM/m^3) and forage yield (tDM/ha). After second seed harvest, forage yield estimate was done and samples of forage were taken for laboratory chemical composition analysis and other samples for sorting of stem and leaf to calculate leaf to stem ration. After each season the experimental sward was cut down and left to regrow for next year trial.

Data analysis

Collected data were entered in coded excel sheets then transferred to SAS for General Linear Model procedure of Statistical Analysis System (SAS, 2000) for multiple analysis of variance of means. Means of factors were then separated using Multiple Duncan Range test.

Results and discussion

Growth performance

In this study it was observed that regrowth of *Cenchrus ciliaris* sward had already started by 3rd day for both ground and 15 cm cuttings. The regrowth vegetation took a range of 30-35 days to reach 50% flowering stage, followed by one week to reach anthesis stage of growth (Plate 1).

Plate 1: *Cenchrus ciliaris* inflorescence at flowering (Left) and anthesis stage (Right)

The sward took about 66-70 days from clean cutting to seed maturity for first harvest and an additional 14 days for second seed harvest (making a total of 84 days for the two seed harvests). Clarke et al (2004) reported that *Digitaria eriantha* grass take about 60 -90 days from cleaning cut to seed maturity. A study conducted by Kumar et al (2005) in India establishing *Cenchrus ciliaris* using seeds instead of vegetative splits observed that it took the plants 54-61 days to reach 50% flowering and 103 – 118 days to seed maturity. These results indicate that it takes relatively fewer days to produce seeds from existing stubble vegetation rather than newly established sward from seeds. By the knowing the number of days the grass species takes from cutting or sowing to seed maturity and weather records (e.g rainfall days); the information may assist to know when to do clean cutting and fertilizer application of existing vegetation planned for seed production so as to get better results (Figure 1 and 2)

Vegetation characteristics

Inflorescence

Mature inflorescence length varied from 8 to 13.5 cm (Table 1a and 1b)**.** Large Spike length (10-13 cm) appeared in the first seed harvest and a mixture of 8 to10cm and 5-8 cm were mostly harvested in second seed harvest (Plate 2 and Table 1a and 1b).

Plate 2: Showing *Cenchrus ciliaris* – inflorescence three categories of spike lespike length

Tillering

Higher cutting height (15cm) stimulated profuse aerial tillering (Plate 3b) as opposed to ground cutting that allowed fewer basal tillers (Plate 3a) mainly from the rhizomes that were relatively thicker in diameter (Table 1a and 1b) . Onyeonagu *et al* (2012) reported that 15 cm cutting height yielded greater number of tillers during the harvest period when *Panicum maximum* was subjected to cutting heights of 5,10 and 15cms. This means that high cutting height gives more profuse tillering of aerial thin tillers as opposed to lower cutting heights or ground cutting that gives fewer but thicker tillers.

Plate 3: Showing (a) few basal tillers and (b) profuse aerial thin tillers of *Cenchrus ciliaris* as affected by cutting height of sward (ground and 15 cm height)

Grass seed yield components

Season had no significant effect on seed yield components and other plant parameters. Fertilizer application significantly ($p \leq 0.05$) increased number of tillers per tussock from 75 to 101 for control (i.e. without Nitrogen and Phosphorus) and 60KgN/ha: 30KgP/ha, respectively (Table 1a). Increase of optimal Nitrogen level fertilization significantly increased tiller height, diameter and tiller population. These findings are supported by Mushtaque *et al* (2010) that Nitrogen triggers the activation of dormant buds and enhances the vegetation sward filling through the highest rate of tiller replacement, which supports a higher proportion of very active healthier young tillers for each plant.This results in higher tiller density and consequently increases seed and biomass production. Ground cutting favoured emergence of new few thicker healthier tillers from ground rhizomes (88) as compared to thinner aerial (108) total tillers per tussock for 15cm cutting height (Table1(a). Ground cutting yielded relatively longer and thicker tillers as compared to 15cm cutting that produced shorter and thinner tillers (Table 1a and b). Ground cutting produced significantly lower number of aerial tillers per plant (3-4) as compared to higher cutting height (6 and above).

Seed yield

There was a significant difference on seed yield between the seasons and cutting heights and a decline of seed yield in year two (Table 2 a,b and 3).Seed yields were significantly ($p<0.05$) high at higher rates of nitrogen and phosphorus at ground cutting (77.5 Kg/ha) than 15cm cutting height (56.7 Kg/ha) with a decreasing trend of seed yields in year two (77.5 to 38.4 Kg/ha and 56.7 to 35.5 Kg/ha at the same level of fertilizer and cutting heights, respectively). Row spacing of 100cm showed slightly higher seed yield of (70 kg/ha) as compared to other two row spacing (67.2 and 69.3 Kg/ha for 25 cm and 75cm respectively). These results comply with findings reported by Kumar et al (2005) in India that seed production for *Cenchrus ciliaris* is maximized at low plant densities when wider row spacing are used compared to narrow row spacing which result into higher plant density (Table 1 a and b). Ground cutting height could be beneficial management practice for rhizomatous grass so as to obtain higher seed yields since it allows healthier thicker basal tillers from rhizomes than profuse thin aerial tillers produced at higher cutting heights. Relatively higher seed yield were obtained in dry season than wet season (66.7 and 37.8 Kg/ha) under cutting heights of 15cm and ground cutting (Table 3) for two consecutive years. FAO (1990) reported seed yield of 10-60 Kg/ha pure clean seeds, and Kumar et al (2005) also reported a yield of 97 Kg/ha in India, these differences might be due to cultivar, climatic and soil fertility differences.

Table 1(a): Mean values of Seed yield components and other plant parameters as affected by fertilizer levels, row spacing and cutting height 2012

Variables	Fertilizer levels					Row spacing					Cutting height			
	F_0	F_1	F_2	SEM	p	S_0	S_2	S_3	SEM	p	GND	15cm	SEM	p
Total tiller/tussock	75^b	79^b	101^a	18.8	0.0404	120^a	119^a	93^b	15.5	0.0399	88^b	108^a	13.9	0.0405
Fertile tiller/tussock	38^b	48^c	60^a	11.8	0.0189	59	57	63	5.8	0.7386	52	54	1.5	0.8442
Av.# tiller/ plant	5	5	5	1.72	0.9665	7	5	6	3.1	0.9270	4^b	7^a	2.6	0.0001
Tiller diam(mm)	2.35^b	2.6^b	3.5^a	0.55	0.0022	2.3^b	2.6^b	3.7^a	0.7	0.0085	3.0	2.7	0.2	0.7103
Tiller height(cm)	88^b	93^b	128^a	19.8	0.0012	87.0^b	96.5^c	116^a	13.5	0.0074	104.5	99.6	3.4	0.6401
Inflores. length (cm)	12	11.5	13.3	0.88	0.0648	9.0^b	11.3^{ab}	13.3^a	2.1	0.0495	11.5	12.1	0.4	0.2699
Inflores. diam.(mm)	13.2^b	13.8^b	16.5^a	2.0	0.0248	11.5	13.0	16.3	2.3	0.0586	14.4	13.5	0.6	0.6203

Means in rows (within the same factor) with different superscripts are significantly different at $p<0.05$.; F_0= 0KgN/ha 0KgP/ha, *F_1=40KgN/ha 20KgP/ha, F_2=60KgN/ha 30KgP/ha, S_0= 25cm, S_2=75 cm, S_3=100 cm, GND= Ground cutting, SEM= standard Error Mean*

Table 1 (b): Mean values of Seed yield components and other plant parameters as affected by fertilizer levels, row spacing and cutting height 2013

Variables	Fertilizer levels					Row spacing					Cutting height			
	F_0	F_1	F_2	SEM	p	S_0	S_2	S_3	SEM	p	GND	15 cm	SEM	p
Total tiller/tussock	71^b	73^b	99^a	18.9	0.0298	117^a	117^a	84^b	17.8	0.0241	87^b	103^a	8.1	0.0104
Fertile tiller/tussock	30^b	42^a	49.5^a	10.6	0.0146	51	51	53	2.0	0.6834	42	49	3.4	0.1350
Av.# tiller/ plant	5	5	5	1.6	1.000	5	5	6	2.3	0.9429	3^a	6^a	1.5	0.0001
Tiller diam(mm)	2.2	2.5	3.25	0.5	0.0503	2.1^b	2.35^b	3.4^a	0.6	0.0060	2.7	2.6	0.1	0.5791
Tiller height(cm)	88^b	89^b	122^a	17.4	0.0013	88^b	93.5^b	115^a	12.9	0.0033	102.0	98.0	2.0	0.5661
Inflores. length (cm)	9.25	11	12.6	1.7	0.1023	9	10.5	12.5	1.8	0.0865	10.1	11.5	0.7	0.0869
Inflores. diam.(mm)	11^b	13.25^{ab}	14.25^a	2.0	0.0307	11^b	12^b	14^a	1.5	0.0341	13.3^a	11.9^b	0.7	0.0489

Means in rows (within the same factor) with different superscripts are different at $p<0.05$; F_0= 0KgN/ha 0KgP/ha, F_1=40KgN/ha 20KgP/ha, F_2=60KgN/ha 30KgP/ha, S_0= 25cm, S_2=75 cm, S_3=100 cm, GND= Ground cutting, SEM= standard Error Mean

Table 2 (a): Seed yield (Kg ha^{-1}) as affected by Nitrogen and Phosphorus levels, row spacing at two cutting heights (Year 2012)

	15cm cutting			Ground cutting		
	1st Harvest	2rd Harvest	Total yield	1st Harvest	2rd Harvest	Total yield
F_0(0 N 0P)	35.1	11.9	47.0^b	48.0	16.0^b	64.0^b
F_2(40N 20P)	39.0	14.0	53.0^a	49.0	16.1^b	65.1^b
F_3(60N 30P	40.0	16.7	56.7^a	54.0	23.4^a	77.5^a
SEM	4.7	3.0	7.1	4.7	3.0	7.1
P values	0.2923	0.0987	0.0255	0.5034	0.0387	0.0254
S_0 (25cm)	39.0	13.9	53.0	50.3	16.9	67.2
S_2 (75 cm)	37.5	13.6	51.2	49.8	19.5	69.3
S_3(100 cm)	37.7	15.0	53.0	50.9	19.1	70.0
SEM	4.7	3.0	7.1	4.7	3.0	7.1
P values	0.833	0.0538	0.5660	0.6744	0.0620	0.5540

Means in column within the same factor with different superscripts are different at P< 0.05, SEM = standard error of the means

Table 2 (b): Seed yield (Kg ha^{-1}) as affected by Nitrogen and Phosphorus levels, row spacing at two cutting heights(Year 2013)

	15cm cutting			Ground cutting		
	1st Harvest	2rd Harvest	Total yield	1st Harvest	2rd Harvest	Total yield
F_0(0 N 0P)	18.6	5.8	24.4^b	18.6	8.1	26.7^b
F_2(40N 20P)	23.2	9.4	32.6^a	19.1	10.6	29.7^b
F_3(60N 30P	23.3	12.0	35.5^a	23.7	14.7	38.4^a
SEM	3.1	1.8	4.5	3.1	1.8	4.5
P values	0.2923	0.0345	0.0410	0.2873	0.0422	0.0380
S_0(25cm)	24.2	8.8	33.0	21.4	10.2	31.6
S_2(75 cm)	22.2	9.2	31.4	21.2	11.6	32.8
S_3(100 cm)	18.7	9.4	28.1	18.9	11.7	30.5
SEM	3.1	1.8	4.5	3.1	1.8	4.5
P values	0.6485	0.8829	0.7990	0.2066	0.7918	0.4450

Means in column within the same factor with different superscripts are different at P< 0.05. SEM = standard error of the means.

Table 3: The effect of season on seed yield (kg ha^{-1}) in two different cutting heights

Season	Year 2012		Year 2013	
	15 cm cutting	Ground cutting	15 cm cutting	Ground cutting
Wet (Rain season)	37.8^b	69.0	13.8^b	24.0^b
Dry (Irrigation)	66.7^a	68.7	48.0^a	39.2^a
SEM	5.8	5.8	3.7	3.7
P values	0.0051	0.0649	0.0289	0.0388

Means in column within the same factor with different superscripts are different at P< 0.05.
SEM = standard error of the means

Forage biomass productivity

Rain season favoured higher forage biomass yields than dry season under irrigation (Table 4). Cutting height of 15 cm recorded higher biomass in wet season (12.6 and 12.3 t/ha) as compared to dry season harvest (10.7 and 9.5 tDM/ha) in year one and two respectively. There was significance difference in forage biomass produced with higher level of fertilizer (13.2 tDM/ha) as compared to low levels (8.0 tDM/ha)(Table 4). Similar records of biomass production (13.9 tDM/ha) for *Cenchrus ciliaris* cv.Biloela were also reported by Kusekwa et al (1987) at Mpwapwa Livestock Research Insitute, Tanzania. Significance difference in biomass yields ($p \leq 0.05$) were observed from both higher levels of fertilizer and narrower row spacing as compared to low biomass yields from low fertilizer levels and wider row spacing respectively. These results resemble findings by Sundriyal et al (1993) who reported a decline in biomass yield at 5cm cutting height of three grass species (*Heteropogon contortus, Chrysopogon mountanus* and *Eulalia trispicata*) as compared to increased forage biomass yield at 15 cm cutting height. Onyeonagu et al (2012) also reported that higher cutting height (15 cm) of *Panicum maximum* at different periods increased tiller production, which led to increased biomass as opposed to reduced cutting heights (5 and 10cm). Row spacing of 25cm showed significantly ($p \leq 0.05$) higher forage biomass (12.2 tDM/ha) as compare to 75cm and 100cm (11.3 and 11.4 tDM/ha) respectively. This means the higher the plant density the higher the biomass productivity. Jefferson et al *(*1997) observed similar findings that highest harvested forage yield estimates of *Psathyrostachys juncea* and *Agropyron cristatum* were observed in the narrowest row spacing of 30cm, when compared with other row spacing of 45, 60, 75 and 90cm

Table 4: Total forage biomass yield (tDMha^{-1}) as influenced by season, fertilizer levels and row spacing under two cutting heights

Factors	Year 2012		Year 2013	
	15cm cutting	Ground cutting	15cm cutting	Ground cutting
Wet Season	12.6	11.8^{a}	12.3^{a}	11.0^{a}
Dry Season	10.7	7.9^{b}	9.5^{b}	6.7^{b}
SEM	0.42	0.42	0.43	0.43
P values	0.0754	0.0224	0.0255	0.0344
F_0 (0N 0P)	10.0^{b}	8.6	9.6	8.0
F_2 (40N 20P)	11.8^{ab}	9.9	11.4	9.0
F_3 (60N 30P)	13.2^{a}	11.1	11.8	9.6
SEM	0.51	0.51	0.51	0.51
P values	0.0411	0.7660	0.0622	0.7880
S_0 (25cm)	12.2^{a}	10.0	11.4	8.8
S_2 (75 cm)	11.3^{b}	10.3	11.1	9.6
S_3 (100 cm)	11.4^{b}	9.3	10.4	8.1
SEM	0.51	0.51	0.53	0.53
P values	0.0100	0.5544	0.3322	0.5001

SEM = Standard Errom mean. 40N 20P= 40kgN/ha, 20kgP/ha, 60N 30P= 60kgN/ha, 30kgP/ha. Means in column within the same factor with different superscripts are different at P< 0.05

It was apparent that wet season favoured higher biomass productivity than dry season in two cutting heights for two consecutive years (Table 5). Cutting height of 15 cm showed higher biomass than ground cutting in all seasons, fertilizer levels and row spacing. This means when *Cenchrus ciliaris* vegetation is cut at higher heights it allow profuse aerial tillering (plate 3b) from internodes as opposed to the vegetation cut on ground which yielded few tillers. This phenomenon might be a contributing factor towards higher forage biomass observed in 15cm as compared to ground cutting.

Table 5: Total forage biomass yield (tDM ha^{-1}) as affected by Nitrogen and Phosphorus levels and row spacing in wet and dry seasons

	Year 2012		Year 2013	
	Wet season	Dry season (Irrigation)	Wet season	Dry season (Irrigation)
F_0 (0N 0P)	11.1^{b}	7.4^{b}	11.4	6.2^{b}
F_2 (40N 20P)	12.2^{ab}	9.5^{c}	12.1	8.3^{c}
F_3 (60N40P)	13.4^{a}	11.0^{a}	11.6	9.8^{a}
SEM	0.51	0.51	0.53	0.53
P values	0.0432	0.0255	0.6550	0.0310
S_0(25cm)	12.1	10.2^{a}	11.2	9.0^{a}
S_2(75 cm)	12.1	9.5^{ab}	12.4	8.3^{ab}
S_3(100 cm)	12.6	8.2^{b}	11.5	7.0^{b}
SEM	0.51	0.51	0.53	0.53
P values	0.0768	0.0441	0.1088	0.0331

SEM = Standard Errom mean.40N 20P= 40KgN/ha 20KgP/ha, 60N 30P= 60KgN/ha 30KgP/ha Means within column with the same factor with different superscripts are different at P< 0.05

Forage bulk density

It was observed that bulky density was significantly ($p \leq 0.05$) higher (11.14 $KgDMm^{-3}$) in higher rates of fertilizer than in control treatment (8.91 $kgDMm^{-3}$) and narrow spacing had significantly higher ($p \leq 0.05$) biomass per unit volume (10.87$kgDMm^{-3}$) than wider row spacing (9.49 $kgDMm^{-3}$)(Table 6) . This was probably due to higher tiller density which led to higher biomass accumulation in narrow row spacing and higher cutting height than in wider and ground cutting treatments. Butler (2007) reported a low bulk density of 6.89 kg/m^3 of above ground biomass of herbaceous plants in American Great Plains when used the same technique of sampling of clip and weigh using quadrat sampling unit area in relation to vegetation height. The study findings may be higher probably because of differences in species and soil fertility. Forage bulk density in the field can be used as a good indicator in estimating how much biomass is available for grazing or for harvest. Higher bulk density indicate larger amount of forage available in smaller area. This means good management practices may increase vegetation height and biomass yield per area hence higher forage bulkiness per unit volume in the field.

Table 6: Bulky density (kg DMm^{-3}) of *Cenchrus ciliaris* as affected by fertilizer levels, row spacing, cutting heights and seasons.

Factors	Year 2012		Year 2013	
	15cm	Ground	15cm	Ground
F_0 (0N 0P)	8.91^{b}	7.19	8.49	6.68
F_2 (40N 20P)	9.89^{ab}	8.12	9.56	7.37
F_3 (60N 40P)	11.14^{a}	9.03	9.94	7.78
SEM	0.49	0.49	0.51	0.51
P values	0.0140	0.0647	0.0976	0.1539
S_0 (25cm)	10.87^{a}	8.58	10.05^{a}	7.58
S_2 (75 cm)	9.58^{ab}	8.13	9.36^{ab}	7.61
S_3 (100 cm)	9.49^{b}	7.63	8.58^{b}	6.63
SEM	0.49	0.49	0.51	0.51
P values	0.0676	0.0508	0.0015	0.2011
Wet season	10.16	8.91	9.60	8.31
Dry (irrigation)	9.80	7.32	9.06	6.24
SEM	0.40	0.40	0.42	0.42
P values	0.5836	0.3185	0.8650	0.0654

SEM = Standard Errom mean.40N 20P= 40KgN/ha, 20KgN/ha, 60N 30P= 60KgN/ha, 30KgP/ha
Means in column within the same factor with different superscripts are different at P< 0.05

Leaf to Stem ratio

There was no significant ($p \geq 0.05$) difference between the treatments in terms of leaf to stem ratio. Wet season showed relatively high leaf to stem ratio as compared to dry season (Table 7). Slightly higher ratios of leaf to stem ratio were also observed in wider row spacing as compared to narrow row spacing. Ground cutting showed lower leaf to stem ratio than 15cm cutting height. This may be due to profuse tillering which allowed growth of leafy biomass as opposed to ground cutting (Table 1a and 1b) which yielded few healthier tillers with relatively large stem diameter and few aerial tillers. Nisa *et al* (2006) reported lower leaf to stem ratio (0.63) for *Cenchrus ciliaris* when vegetative splits were planted and clipped after two months. This difference might be due to cultivar differences.

Table 7: Leaf to stem ratio as affected by fertilizer levels, row spacing and season.

Factor	Year 2012	Year 2013
Fertilizer levels		
F_0 (0N 0P)	0.71	0.70
F_2 (40N 20P)	0.73	0.71
F_3 (60N 40P)	0.77	0.72
SEM	0.02	0.02
P values	0.1487	0.1344
Row spacing		
S_0 (25cm)	0.72	0.72
S_2 (75 cm)	0.75	0.72
S_3 (100 cm)	0.75	0.73
SEM	0.02	0.02
P values	0.6572	0.6320
Season		
Wet season	0.76	0.73
Dr season	0.72	0.72
SEM	0.02	0.02
P values	0.0678	0.0667
Cutting height		
Ground cutting	0.72	0.71
15 cm cutting	0.76	0.69
SEM	0.02	0.02
P value	0.0788	0.0782

F_0= 0KgN/ha 0KgP/ha, F_1=40KgN/ha 20KgP/ha, F_2=60KgN/ha, 30KgP/ha, S_0= 25cm, S_2=75 cm, S_3=100 cm; SEM= Standard error of means

Chemical composition analysis

Higher level of fertilizer increased % CP content (5.161 to 7.062 and 3.940 – 6.528) in dry and wet season samples respectively (Table 8). These CP figures were closer to minimum (7%) required to sustain rumen functionality in beef cattle (NRC 1996). García-Dessommes (2007) reported higher mean CP% (8.7) of *Cenchrus ciliaris* hybrid and five genotypes. Digestible crude protein (DCP %) also increased with fertilizer levels both in the dry and wet season. Dry season samples showed slightly higher DCP as compared to wet season samples, this might be due to the fact that continued irrigation allowed continuous sprouting of the vegetation which was a bit fresh even during harvest of forage biomass.

Table 8: Chemical composition analysis of *Cenchrus ciliaris* hay harvested after seed harvest

	Fertilizer level	Cutting height	%DM	%DDM	%CP	%DCP	ADF%	%NDF	%TDN	ME
	F_0 (0N 0P)	15 cm	90.7	47.5	5.2	3.5	53.1	82.4	42.0	0.69
DRY SEASON		Ground	89.6	48.2	5.5	3.9	52.3	80.6	42.9	0.705
	F_2 (40N 20P)	15 cm	90.8	47.7	4.8	3.3	52.9	79.1	42.2	0.693
		Ground	90.7	47.2	5.3	3.7	53.6	82.2	41.5	0.681
	F_3 (60N 40P)	15 cm	90.5	49.3	7.1	4.9	50.9	82.1	44.5	0.732
		Ground	90.5	48.0	6.6	4.5	52.5	83.7	42.7	0.701
WET SEASON	F_0 (0N 0P)	15 cm	90.6	43.0	4.8	3.0	58.9	89.8	35.4	0.581
		Ground	90.5	43.9	5.2	3.4	57.8	87.0	36.7	0.602
	F_2 (40N 20P)	15 cm	91.3	42.7	4.1	2.7	59.3	88.4	34.9	0.573
		Ground	90.5	43.0	3.9	2.6	58.9	88.5	35.4	0.581
	F_3 (60N 40P)	15 cm	91.0	45.4	6.5	4.3	55.9	87.2	38.8	0.638
		Ground	91.2	45.1	4.3	4.0	56.2	88.5	38.4	0.631

DM= Dry matter, DDM = Digestible Dry matter, CP= Crude Protein, DCP= Digestible Crude Protein, ADF= Acid Detergent Fiber, NDF= Neutral Detergent Fibre, TDN = Total Digestible Nutrients, ME =Metabolizable Energy

Use of irrigation for seed production during the dry season

The results from this study showed that it is practically possible to produce high yields of *Cenchrus ciliaris* seeds in Morogoro during the dry period (June – October, about 120 days) by use of irrigation as compared to wet season period (Table 2 a, b). This advantage of favourable dry season weather conditions for grass seed production may however be utilized with precautions of birds threat (Plate 4).

Plate 4: Scaring of *Lonchura cucullata* birds from seeds of *Cenchrus ciliaris* field at Magadu farm, Sokoine University of Agriculture, Morogoro, Tanzania

Since there are no other ripe crops in the field, dry season pasture grass seed production faces the threat of invasion of big groups of small birds (*Lonchura cucullata*) which feed on grass seeds from the milky stage to maturity. Without protection these birds can attack the irrigated field of grass seeds and wipe up small farms before harvest time. According to Andersen *et al* (2000), *Lonchura cucullata* - are described as prolific small birds (about 9 cm length) moving in groups. Small flocks of these birds are said to be found in a variety of habitats, where there are suitable seeds and often sit huddled together on grasses and bushes wheezing *chik, chik, chik*. Those birds are commonly found in the coast regions of Tanzania and commonly known as tonnes gobofu in Swahili and as *Utongwa* in Luguru language in Morogoro. Hiring manpower to scare these birds is inevitable during the dry season and thus increases cost of seed production.

Conclusion and recommendations

The study concludes that, it is practically possible to produce grass seeds during the dry season (June – October) in the eastern zone of Tanzania by supplementing soil moisture with irrigation when facilities are in place. Higher seed yields were observed in dry than in wet season as opposed to higher forage biomass in wet than dry season. Higher rates of Nitrogen and Phosphorus significantly increased seed yield, and total biomass. Wider row spacing increased seed yield than narrow row spacing. Ground cutting led to higher seed yield from high number of basal healthier tillers per tussock as compared to higher cutting height which resulted in profuse thin aerial tillers. It is therefore recommended that irrigation during dry season can be the best option for *Cenchrus ciliaris* cv. Biloela seed production when row spacing of 75cm and 100 cm are used at ground cutting height with proper rates of nitrogen and phosphorus. However, strategies for bird scaring during dry period are highly emphasized from flowering stage to seed maturity (35 days) to maximize seed yields.

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References

Ajmi A A and Salih A A 2010 Soil water uptake efficiency of some irrigated indigenous and exotic forage species under gcc desert climatic conditions. The A*sian Journal of Science and Technology vol. 1 (1) pp.001-004, march, 2010.* http://www.journalajst.com

Andersen G W and Reid F 2000 Birds of Dar Es salaam, Common birds of Coastal East Africa. Illustrated by Allan Bramley. Mogens Winther. Clausen offsetAps Denmark.

Beltrán LS, Pérez P J, Hernández G A, García M E, Kohashi S J and Herrera H J G 2001 Effect of cutting height on tiller population density and herbage biomass of buffel grass. International grassland journal. Institute. http://www.internationalgrasslands.org/files/igc/publications/2001/id0132.pdf

Butler B 2007 Calculating Accurate Aboveground Dry Weight Biomass of Herbaceous Vegetation in the Great Plains: A Comparison of Three Calculations to Determine the Least Resource Intensive and Most Accurate Method .In: Butler, Bret W.; Cook, Wayne, comps. 2007. The fire environment— innovations, management, and policy; conference proceedings. 26-30 March 2007; Destin, FL. Proceedings RMRS-P-46CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 662 p. CD-ROM.

Clarke B and Gardner P 2004 Digit grass seed production. Agnote DP-403, 2nd edition ISSN 1034-6848. NSW Agriculture.

De Medeiros H R, Dubeux Jr J C B, Sobral Neto E 2007 Effects of nitrogen fertilization on buffel grass productivity andd water efficience use. Journal of Tropical Grassland ,Department of Animal Science of FederalRural University of Pernambuco (UFRPE). downloaded February 25, 2014 http://tropicalgrasslands.info/public/journals/4/Elements/DOCUMENTS/2007-vol29-rev1/Vol_29_rev107pags_79-81.pdf .

FAO 2006 Country Pasture/Forage Resource Profiles, United Republic of Tanzania country by Sarwatt s and Mollel E. edited by J. M. Suttie and modified by S.G. Reynolds. Rome, Italy. http://www.fao.org/ag/agp/AGPC/doc/Counprof/tanzania/tanz.htm

FAO 1986 Tropical Pasture Seed Production. Plant Production and Protection Paper. Edited by Humphrey L.R and F.Riveros. FAO, Rome. 203

García-Dessommes J G, Ramírez-Lozano R G, Morales-Rodríguez R and García-Díaz G 2007 Ruminal digestion and chemical composition of new genotypes of buffelgrass (*cenchrus ciliaris* l.) under irrigation and fertilization.http://www.scielo.org.ve/pdf/inci/v32n5/art13.pdf

Hare M D, Tatsapong P and Saipraset K 2007 Seed production of two brachiaria hybrid cultivars in north-east Thailand. Method and time of planting. Tropical Grasslands volume 41,26-34. http://www.tropicalgrasslands.asn.au/Tropical%20Grasslands%20Journal%20archive/PDFs/Vol_27_1993/Vol_27_01_93_pp37_42.pdf

Jefferson P G and Kielly G A 1997 Reevaluation of row spacing/plant density of seeded pasture grasses for the semiarid prairie. Canadian journal of plant science

Kizima J B, Mtengeti E J and Nchimbi-Msolla S 2013 Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. *Livestock Research for Rural Development. Volume 25, Article #85.* http://www.lrrd.org/lrrd25/5/kizi25085.htm

Kumar D, Seth R, Natarajan S, Dwivedi G K and Shivay Y S 2008 Seed yield response of marvel grass (*Dichanthium annulatum*) to cutting management and nitrogen fertilisation in central India. Division of Agronomy, Indian Agricultural Research Institute, Pusa, New Delhi-110 012, India. Journal of Agronomy Research **6**(2), 499–509, 2008.Kumar, D., Dwivedi G.K and Singh (2005). Seed yield and quality of buffel grass (*Cenchrus ciliaris*) as influenced by row spacing and fertilizer level. Tropical Grasslands 39. 107 -111.

Lwoga A B, Lugenja M M S and Kajuni A R 1984 Pasture research in Tanzania. Proceeding of Pasture Improvements Research In Eastern and Southern Africa, held in Harare, Zimbabwe, 17-21 Sept. 1984. IDRC, pp 210-221.

Ministry of Water and Livestock Development MWLD 2005 Proceeding of Hundred Years of Livestock Services in Tanzania 1905 -2005, Held at Livestock Production Research Institute on June 06-11, 2005. Mpwapwa ,Tanzania.

Mushtaque M, Ishaque M, Haji M A A and Bakhsh A 2010 Influence of maturity on morphological characters and biomass of buffel grass. Pakistan Journal of Science (Vol. 62 No. 2 June, 2010)

Mushtaque M, Ishaque M, Haji M A A, Bukhsh A 2010 Growth and herbage yield of *setaria sphacelata* grass in response to varying clipping stages. The Journal of Animal & Plant Sciences, 20(4): 2010, Page: 261-265 ISSN: 1018-7081. http://www.thejaps.org.pk/docs/20-04-2010/10-033-Revised%20final.pdf

NRC 1996 Nutrient Requirements of Beef Cattle. 7th ed. National Academy Press. Washingtonnes , DC, USA. 76 pp.

Nisa M, Khan M A, Sarwar M, Mushtaque M, Murtaza G, Lee W S and Kim H S 2006 Influence of Re-growth Interval on Chemical Composition, Herbage Yield, Digestibility and Digestion Kinetics of *Setaria sphacelata* and *Cenchrus ciliaris* in Buffaloes. Asian-Australia Journal of Animal Science vol 19(3). 381-385. http://www.ajas.info/Editor/manuscript/upload/19-62%20correct%20(080509).pdf

Onyeonagu C C and Ugwuanyi B N 2012 Influence of cutting height and nitrogen fertilization on plant height and tiller production of guinea grass (*Panicum maximum* Jacq) pasture. African Journal of Agricultural Research Vol. 7(48), pp. 6401-6407, http://www.academicjournals.org/AJAR

Rains J P, Hopkinson J M and Tregea S P 1993 Tropical Pasture Establishment. Ten Satisfying industry's pasture seed requirements. Tropical Grasslands (1993). Volume 27, 359 –366

Rao A S, Singh K C, and wight J R 1996 Productivity of *Cenchrus ciliaris* in relation to rainfall and fertilization. Journal of Range management 49(2), march 1996

SAS 2000 Stastical Analysis System. SAS/STAT users guide. Statistical Analysis Institute, Inc; Cary, Nc. USA.

Sundriyal R C, Sharma E and Negi S S 1993 Effect of cutting height and frequency on the above-ground biomass in a central Himalayan grassland in India. Tropical Grasslands (1993) volume 27, 37-42

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CHAPTER FOUR

4.0 PAPER III

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Seed quality of *Cenchrus ciliaris* as affected by fertilizer levels, row spacing, cutting height and season in eastern Sub-humid zone of Tanzania

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Abstract

The present study investigated the effect of fertilizer levels, row spacing, cutting height and time of harvest on seed quality of *Cenchrus ciliaris* cv. Biloela during the wet and dry seasons. Irrigation was used to supply soil moisture in the dry season. Four parameters of seed quality namely; Caryopsis index, spikelet germination, seed colour and physical grain qualities (good and damaged) were assessed. Caryopsis index was significantly ($p \leq 0.05$) higher (37.9 %) in dry season than in wet season (24.3%).This trend of results were vivid in both years of study. Higher levels of fertilizer (60N 30P) had significant ($p \leq 0.05$) higher caryopsis index than the control (0N 0P) in first harvest (i.e.35.8 vs 27.8 %, respectively). No significant results on caryopsis index were observed for second harvest within row spacing and cutting height in all levels of fertilizer. Viability in terms of germination percentage was higher in year one (20.4- 30.0%) than year two (12.9- 22.8%) when assessed at different storage period. Germination improved with seed storage period. Interaction of harvest time within fertilizer levels marked a clear variation on caryopsis index and germination potential in dry season than in wet season. The colour of seeds produced during the wet season indicated a vivid sign of fungal infection. These results suggest that dry season and higher rates of nitrogen and phosphorus fertilizer be taken into consideration to improve production of quality grass pasture seeds, however proper rates depends on soil fertility status of the site. It is recommended that batches of seeds from first harvest and second harvest should not be mixed for commercial purpose as the second harvest will tend to lower overall viability and thus affect commercial seed quality value. Use of irrigation for dry season grass seed production is proposed to farms which can manage to install irrigation facilities to substitute wet season seed production.

Keywords: *Caryopsis index, Germination percentage, seed viability, soil fertility, seed physical qualities*

Introduction

Preliminary studies on introduction and evaluation of existing and introduced pasture species in Tanzania has been undertaken on research station in early 1980s by several scientists, various species and cultivars of pasture grasses and legumes were introduced and released from the tropics particularly tropical Australia, however other studies can be traced back in 1960s (Kusekwa et al.,1987, Brzostowisk et al.,1966 and Wigg,1973). *Cenchrus ciliaris* Cv. Biloela is one of the most promising established grass pasture cultivar which is showing high demand in Tanzania (Kizima *et al.,* 2013). It is drought tolerant, produces high biomass, has deep root system, relative palatable and tolerate grazing. According to FAO (1990), cultivar Biloela was introduced to Australia from Dodoma Tanzania in 1937 by CSIRO where it was tested at Rockhampton Queensland and further developed at Biloela Research Station, Australia where its name originated. It can be established by seeds or vegetative splits.

The use of vegetative splits has been opted for assured easier establishment when the source of these planting materials is near. When the source of these splits is far away from the farm to be established, seeds remain to be the best planting material due to transport and labour costs. According to NLP (2006), forages and pasture seed production in Tanzania is mainly constrained by insufficient supply of pasture seeds, unreliable rainfall and water sources, low viability of seeds, and limited knowledge of grass pasture seed production among the farmers. FAO (2005) states that quality seed is critical to agricultural production and poor seed limits the potential yield and reduces the productivity of the farmer's labour. There are four basic parameters of seed quality attribute: Physical qualities of the seed in the specific seed lot; Physiological qualities which refer to aspects of performance of the seed; Genetic quality which relates to specific genetic characteristics of seed variety and health which refers to the presence of diseases and pests within a seed lot.

There are several factors affecting production of quality seeds in the field and during storage. Soil fertility, management practices such as row spacing, cutting height may affect the quality of produced seeds. Weather conditions during wet and dry season may also significantly affect seed quality. However, harvest time and storage period may also influence seed viability.

In areas where irrigation is possible it can be used during the dry season for seed production to minimize wet season disease challenges and hence improve seed quality. Grass seed production is very sensitive during the wet season due to high levels of humidity which is a predisposing factor for pathogen infections on plants leading to poor grass seed quality. Cutting management may be one of the techniques to strike a balance between the amount of vegetative growth and the reproductive phase for good quality grass seeds (Kumar *et al.,* 2008). Seed production is maximized at an optimum plant density (row spacing), both very low and very high densities reduce seed yield in grasses depending on the fertility status of soils (FAO, 1986). Cameroun and Humphrey, (1976) reported that Nitrogen application increased tiller density, tiller fertility, and raceme number on individual inflorescence of *Paspalum plicatulum*. Nitrogen availability is a dominant factor controlling the rate of the various processes which result in seed formation and ultimately good quality.

When seed has good physical, physiological, health and genetic qualities, farmers have greater prospects of producing a good pasture crop. Therefore, provision of good quality seeds of *Cenchrus ciliaris* cv. Biloela to farmers responding to prevailing demand prompted to conduct the study on how viability is affected by fertilizer levels, row spacing, cutting height, harvest and storage time in wet and dry season using irrigation. The need for good quality pasture seeds locally and readily available for farmers is a requirement of stable forage production to support livestock sector.

Materials and methods

Study area

The study was conducted at Sokoine University of Agriculture in Morogoro, Tanzania for both field trials and laboratory tests. Annual rainfall was 694.4 mm and 570.6 mm for year 2012 and 2013respectively. Highest relative humidity of (64.93%) was recorded in April during the wet season and lowest record was 39.3% in September during the dry season experiment. It was a mixture of cool and warm temperature, ranging between 15.4 - 19.9 °C and 28 to 36.2 °C for minimum and maximum temperature, respectively.

Research design

A field experiment was conducted to obtain seeds of *Cenchrus ciliaris* cv. Biloela for viability tests in laboratory. A factorial experimental design using split plot arrangement was used to evaluate effects of cutting height, row spacing and fertilizer levels in wet and dry seasons. The experiment employed three treatments (Nitrogen and Phosphorus levels, row spacing and cutting heights) assigned in two blocks (wet and dry season using irrigation). Three Nitrogen N and Phosphorus P levels (in Kg/ha) of (i) 0KgN/ha 0KgP/ha (0N 0P) ii) 40KgN/ha 20KgN/ha (40N 20P) and iii) 60KgN/ha 30KgP/ha (60N 30P) were applied using Triple Supper phosphate (TSP-46% $P_2 O_5$) and Urea 46% N according to treatments. TSP was applied during the start of experiment, while Urea was applied two weeks later. Three row spacing (25 cm row as control , 75 cm and 100 cm) replicated three times to make 27 plots of 4m x 4m, The plots were split into two subplots of 2m x 4m to accommodate two cutting heights (ground and 15cm cut) in each season. After maturity seeds were harvested in two different harvest times. Harvest one was immediate after seed maturity while second harvest was done two weeks later. Two batches of seeds were separated for viability tests. Parameters assessed were; caryopsis index, germination percentage, seed colour and physical quality of grains. Assessment of grain physical quality aimed to observe whether morphologically the caryopsis were in good or damaged quality.

Data collection

Four hundred spikelets from each treatment were dissected using forceps under a hand lenses (at magnification of X 20) to assess presence of caryopsis or grain**.** The number of caryopsis or grain obtained from four hundred spikelets divided by 400 multiplied by 100 gave the caryopsis index value. The same exercise was repeated three times for each treatment sample so as to determine the mean caryopsis percentage per treatment. During the dissection, morphological quality/physical deformities of the caryopsis or grains were observed and recoded as good or damaged grain. Counted Number of damaged or good seeds over the total dissected spikelets gave the percentages of damaged or good caryopsis. Potassium nitrate solution was used to saturate the germination substrate before starting germination test so as to break seed dormancy. All seeds and blotter papers were soaked in a solution of 0.2 % KNO_3 prepared by dissolving 2 g of KNO_3 in 1 litre of water. Germination test was then conducted for spikelets using petri dishes placed in the germination cabinet at room temperature ranging from 25 to 30^0C (ISTA 2009). Hundred seeds were placed on moist blotter paper in each petri dish in germination cabinets; During the germination test, seeds were moistened using distilled water to avoid any contamination. Three petri dishes were used per treatment and germinated spikelet recorded daily from the day 3 to 28 days of germination test, according to the recommendation of ISTA (2009).

Data analysis

Data on germination test, caryopsis index, damaged and good seeds of *Cenchrus ciliaris* seeds were subjected to SAS (2000) statistical package programme to compare the means difference.

Results and discussion

Physical characteristics of the spikelets

The results showed that the wet and dry seasons yielded seeds with two apparent distinct colours (Plate 1).This was observed immediately after harvest in each season before storage. Seeds harvested from wet season plots portrayed blackish tan colour while dry season seeds were just Kharkish .

Plate 1: Difference in colour of seeds (spikelet) produced in dry and wet season

This colour difference of mature spikelets was even observed in mature inflorescences in the field. This might have been caused by fungal infection exacerbated by high atmospheric humidity during the rainy season (Kizima *et al.,*2014). This is in agreement with Mlay (2013) who screened for C*enchrus ciliaris* seeds from different farms in Tanzania for seed-borne microorganisms. His study observed 10 fungal microorganisms namely; *Phoma spp, Curvularia lunata*, *Artenaria alternate,Bipolaris spp, Fusarium pallidoroseum, Exserohilum rostratum, Pyricularia grisea, Fusarium spp, Fusarium moniliforme*, and *Nigrospora oryzae*. Brzostowski (1966) also reported ergot (*Claviceps sp.)* to be the fungus disease affecting *C. ciliaris* seed production for both indigenous and introduced varieties in rain season in Kongwa, Tanzania.

Caryopsis index (%)

There was a slight difference between fertilizer levels in harvest one, however there was no significant difference in harvest two (Table 1).Shelled grains (Caryopsis index) of C*enchrus ciliaris* from spikelet (Plate 2) showed high significance difference (p≤ 0.05) between seasons in harvest one (Table 2). One caryopsis per spikelet was observed, however other studies have indicated up to two caryopsis within a spikelet.

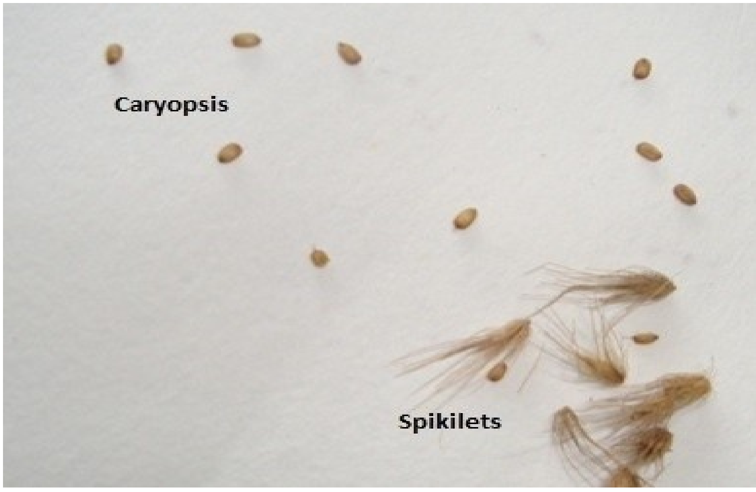

Plate 2: Caryopsis peeled from spikelet

There was slight difference in caryopsis index between fertilizer levels within harvest period (Table 1). It is evident that first harvest yielded more caryopsis than second harvest. Harvest period in *Cenchrus ciliaris* has an implication on what type of tiller develops inflorescence earlier. As shown by Kizima *et al* (2014) on vegetation characteristics studies, healthier primary basal tillers produces inflorescence which mature earlier while those thinner aerial secondary tillers branching from basal tillers mature later and normally contribute to the second harvest. Spikelets from second harvest contain relatively lower caryopsis index (Table 1 and 2). Kizima *et al* (2013), and Mlay (2013), reported a varied range of caryopsis index from seed spikelet tested from different farms in Tanzania. Reported caryopsis index ranged from 6.7 to 50%. This variation may be caused by many factors such as agronomic and post harvest practices including fertilizer use and row spacing as well as mixing batches of harvested seeds, and diseases risks during the production time.

Table 1: The effects of harvest time and fertilizer levels on mean Caryopsis index of *Cenchrus ciliaris* seeds

Harvest time	Fertilizer level	Caryopsis Index Year 2012	Year 2013
1	F_0(0N 0P)	27.8 ± 6.4[b]	17.8 ± 4.4[b]
	F_2(40N 20P)	29.6 ± 9.1[b]	20.9 ± 6.2[b]
	F_3(60N 30P	35.8 ± 14.6[a]	30.5 ± 11.4[a]
2	F_0(0 N 0P)	25.8 ± 4.6	15.3 ± 2.4
	F_2(40N 20P)	25.0 ± 4.8	15.0 ± 2.8
	F_3(60N 30P)	24.9 ± 5.6	15.9 ± 2.9

Means in column for harvest time 1 with different superscripts are different at p<0.05
0N 0P= 0KgN/ha 0KgP/ha, 40N 20P= 40KgN/ha 20KgP/ha, 60N 30P= 60KgN/ha 30KgP/ha

Seed production during dry season using irrigation significantly favoured higher caryopsis index than wet season in two consecutive years (Table 2). Seed pathology investigation was not conducted in this study, but fungal and other disease stresses during wet rainy season might have contributed much in reduced caryopsis as indicated in Table 3 where large number of caryopsis had morphological deformities. This finding is supported by FAO (1986), that grass seed production in rain season is constrained by high disease risks.

Table 2: Effects of Season and harvest time on Mean Caryopsis index (%)

Harvest time	Season	Year 2012 Caryopsis index	Year 2013 Caryopsis index
1	Wet	24.3 ± 6.1[b]	14.1 ± 4.2[b]
	Dry(Irrigation)	37.9 ± 10.8[a]	27.9 ± 8.1[a]
2	Wet	24.7 ± 4.6	14.7 ± 2.6
	Dry(Irrigation)	25.7 ± 5.3	15.7 ± 2.5

Means in column for harvest time 1 with different superscripts are different at p<0.05

Physical quality of caryopsis

Two categories (damaged and good grains) of physical qualities were observed in this study (Table 3). When assessed under magnifying (x 20) lens a greater number of naked grains (caryopsis) produced during the wet season showed physical deformities (damaged) than those produced during dry season. This might be due to disease stresses as supported by Parihar and Pathak (2006) that poor seed setting in spikelet is related to weather condition prevailing at the time of anthesis and grain formation. The diseased caryopsis or empty spikelet of *Cenchrus ciliaris* might have resulted from the effect of weather conditions during seed setting and microorganism infection. Grass seeds produced during rainy season succumb to challenges of diseases including fungus which ultimately affect viability of the seeds. Good seeds in terms of grains physical qualities were observed during the dry season harvest, which has an implication on improved viability.

Table 3: The effect of season on physical qualities of caryopsis (Good and damaged %)

Season	Harvest time	Year 2012 Good	Year 2012 Damaged	Year 2013 Good	Year 2013 Damaged
Wet season	1	15.3	8.98	11.1	2.4
	2	17.8	6.85	9.3	2.0
Dry season	1	36.7	1.1	21.0	3
	2	25.3	0.33	19.0	1
Wet Season Overall Mean		16.6^{b}	7.92^{a}	10.2^{b}	4.2^{a}
Dry Season Overall Mean		31.0^{a}	0.72^{b}	20.0^{a}	2.0^{b}

Overall means in column for each parameter with different superscripts are different for seasons ($p<0.05$)

Germination and seed storage time

In this study it was observed that the highest germination percentages were reached after six months of storage. These were 30.9, 24.6 and 22.8 % for high, moderate and control levels of fertilizer application, respectively (Figure 1). Debouba *et al*,(2011) reported germination of 40% from *Cenchrus ciliaris* seeds (without saline treatment) in Tunisia when he was testing how the seeds can tolerate saline stress. Nadaf *et al* (2009) also observed germination ranging from 48.09- 54.67% in Oman. Spikelet germination from first harvest showed superior germination as compared to harvest two (Figure 1 and 2). Use of fertilizer improved seed viability significantly ($P < 0.05$) as shown in Figure 1. FAO (1990, 1993) recommended a minimum germination of 20% for *Cenchrus ciliaris* quality declared seeds required for commercial sale. Rethman (2001) observed a range of germination when testing different accessions of *Cenchrus ciliaris* in South Africa. In year one, Rethman's study observed germination of 39% for fresh seeds against stored seeds germination of 67%. Reduced germination potential was observed in the seeds harvested in year two for both fresh seeds (4%) against stored seeds (31%). In this study storage of seeds improved germination and this fact is supported by Hacker and Radcliff (1989). FAO (1990) and Jones (1973) reported that seeds of *Cenchrus ciliaris* can remain viable for two to three years when stored under favorable conditions.

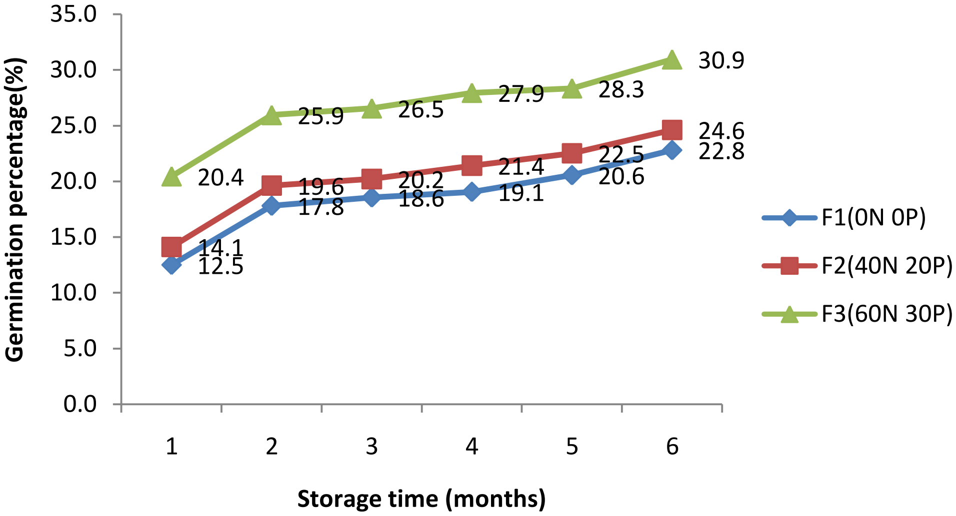

Figure 1: The effect of storage time on seed germination (%) for first harvest - Year 2012

There was significant difference in germination percentage of seeds stored for one month after harvest and those stored for sixth months (Figure 1). However no significance difference was observed in germination of seeds between month 2, 3, 4 and 5.

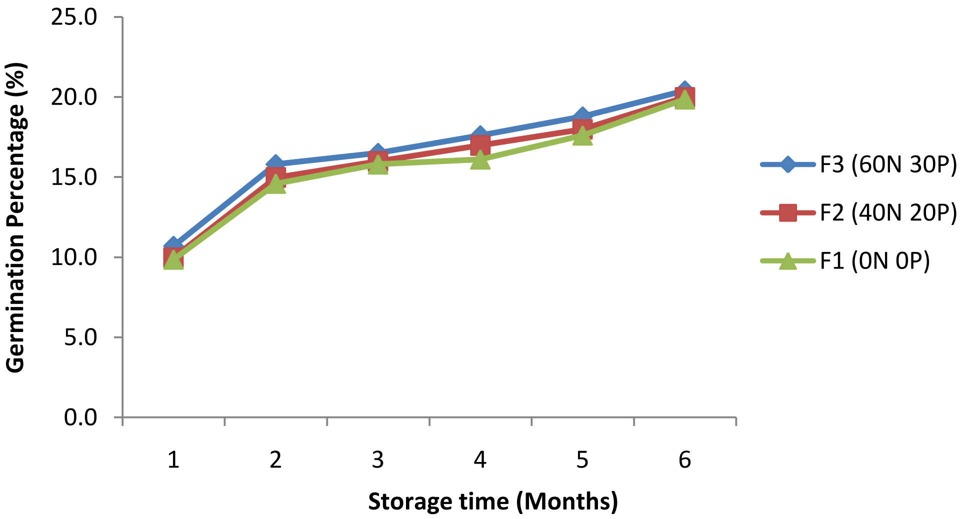

Figure 2: The effect of storage time on seed germination (%) for second harvest - Year 2012

Seeds produced from year one vegetation showed overall higher mean of spikelet germination as compared to those harvested in year two (Figure 3) indicating that age of the sward may affect seed germination. Age of vegetation of *Cenchrus ciliaris* has been mentioned to affect viability as the residual vegetation becomes older. FAO (1986) recommended a maximum of two years seed production on the same vegetation. Kizima *et al* (2013) observed a declined viability of seeds from the vegetation fields of older ages from pasture seeds farms in the eastern zone of Tanzania.

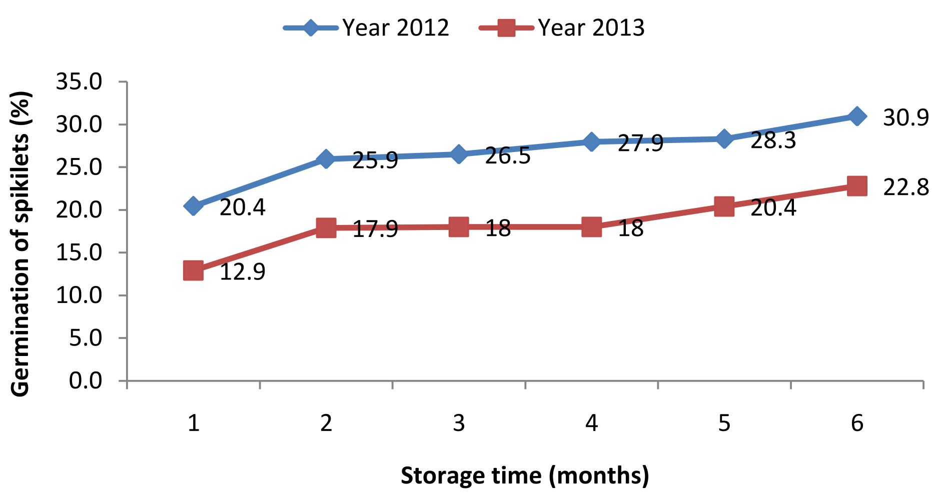

Figure 3: Trend of spikilets germination (%) in year 2012 and 2013

A small pot trial was conducted in the field to test the germination of spikelet (Plate 3) .The study was conducted to prove spikelet germination in soils without controlled laboratory conditions and potassium nitrate treatments. On average germination of 24.7% (from high rate of nitrogen and phosphorous) was recorded from harvest one seeds of dry season yield stored for three months. This gives an indication that seeds stored for 3 months can germinate well without any treatment so long as soil moisture is adequate.

Plate 3: Showing growing plants in pot experiment planted using seeds (spikelets) stored for three months.

Conclusions

i. Season has a significant effect on caryopsis index and physical qualities of grains within the spikelets which has implications on viability. Seed production in dry season using irrigation yielded good viable seeds as compared to wet season.
ii. germination. Improvement of soil fertility using Nitrogen and Phosphorus increased seed viability
iii. Seeds from first harvest and second harvest time differ in viability and need to be separated
iv. Storage time improves viability

Recommendations

i. The study recommends more trials on pasture grass seed production in the country to come up with clear picture on seed qualities so as to meet required standards.
ii. Authorities for seed viability tests are advised to incorporate caryopsis index tests as one of prior criteria in judgment of the quality of grass seeds before spikelet germination, as it helps to know how much grain feel the seeds have before conducting germination test
iii. It is recommended that good quality seeds be produced in dry season, however synchronizing season can be useful to reduce costs of irrigation so that flowering is reached when rains are over to reduce inflorescence be contaminated by rainfall moisture
iv. It is also advised to separate first harvest seeds with second harvest from the same season for commercial purpose as second harvest lowers caryopsis index and ultimately germination which may affect quality for marketing purposes.

Acknowledgements

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References

Brzowstowski, H.W. and Owen, M.A. (1966). Production and germination capacity of buffel grass (*Cenchrus ciliaris*) seeds. *Tropical Agriculture (Trinidad)* 43(1).

Debouba, M., Kbaier, N., Talbi, S., Gouia, H. and Ferchichi, A. (2011). Seeds germination and shoot growth responses of a threatened poaceae (*Cenchrus ciliaris* L.) to increasing salt stress. Rev.col._(Terre_Vie) vol.(66)19-27. http://www.researchgate.net/publication/221675133.

FAO (1986). Tropical Pasture Seed Production. Plant Production and Protection Paper. Edited by Humphrey L.R and F.Riveros. FAO, Rome. 203pp

FAO (1993). Quality declared seed. Plant production and protection paper. Rome, Italy.186pp

FAO (1990). Tropical Grasses. Edited by P.J Skerman and Riveros F. Rome, Italy. 832pp

FAO (2005). Seed and Seed Quality. Technical Information for Emergency Staff. Seed and Plant Genetic Resources Service Rome, Italy

Hacker, J.B. and Radcliff, D. (1989). Seed dormancy and factors controlling dormancy breakdown in buffel grass accessions from contrasting provenances. *Journal of Applield Ecology 26:* 201-212.

International Seed Testing Association ISTA (2009). International Rules for Seed Testing 2009 Edition. Secretariat, Zürichstrasse 50, CH-8303 Bassersdorf, Switzerland.

Kizima, J.B., Mtengeti, E. J. and Nchimbi-Msolla, S. (2014). Seed yield and vegetation characteristics of *Cenchrus ciliaris* as influenced by fertilizer levels, row spacing, cutting height and season. *Livestock Research for Rural Development. Volume 26, Article #148.* Retrieved August 5, 2014, from http://www.lrrd.org/lrrd26/8/kizi26148.htm

Kizima, J.B., Mtengeti, E.J. and Nchimbi-Msolla, S. (2013). Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. *Livestock Research for Rural Development. Volume 25, Article #85.* http://www.lrrd.org/lrrd25/5/kizi25085.htm

Kumar, D., Dwivedi, G.K. and Singh, S. (2005). Seed yield and quality of buffel grass (*Cenchrus ciliaris*) as influenced by row spacing and fertilizer level. *Tropical Grasslands* 39. 107 -111.

Kusekwa, M.L., Kaganda, S.R. and Msangi, R.B. (1987). Introduction and evaluation of pasture species for central Tanzania. Tanzania Society of Animal Production proceedings, Arusha. pp 271- 298.

Mlay, J,A. (2013). Screening buffel grass (*Cenchrus ciliaris*) from selected pasture seed farms in Tanzania for seedborne microorganisms; Pathogenecity and effect on germination. Unpublished MSc. Dissertation of Sokoine University of Agriculture, Morogoro, Tanzania.

Nadaf, S.K., AL-Farsi, S.M., AL-hinai, S.A., Al-adawy, M.H., Al-hinai, R.S. and Al-bakri, A.N. (2009). Effect of harvesting time on seed weight *per se* and seed quality in indigenous rangeland and forage grass species. *Karnataka Journal Agricultural Scientific 22 (5) (955-964):*

NLP (2006). National Livestock Policy. Ministry of Livestock and Fisheries Development , Dar es salaam. Tanzania.

Parihar, S.S. and Pathak, P.S. (2006). Flowering phenology and biology of selected tropical perennial grasses. Tropical Ecology 47(1):pp 81-87

Rethman, N.F.G and Boshoff, W.H. (2001). Seed production and quality of buffelgrass *(cenchrus ciliaris)* selections. International Grassland Congress proceedings XIX IGC 2001, ID # 03-04, Sao Paulo, Brazil http://www.internationalgrasslands.org/files/igc/publications/2001/id0304.pdf

SAS (2000). Stastical Analysis System. SAS/STAT users guide. Statistical Analysis Institute, Inc; Cary, Nc. USA.

Wigg, P.M. (1973). The role of some pastures in semiarid central Tanzania. *East African Agricultural and Forestry Journal*, 38, 375-382.

Yadav, M.S., Rajora, M.P. and Sharma, S.K. (2001). Effect of storage and seed treatments on germination in buffel grass. *Range Management and Agroforestry*, 22, 1–5.

CHAPTER FIVE

5.0 PAPER IV

Kizima J.B, Mtengeti E J, Nchimbi-Msolla S. and Mishili F. (2014). Profitability of irrigating grass pasture for seed and forage production in Tanzania: A case of *Cenchrus ciliaris* (Manuscript to be submitted in any reputable journal)

Profitability of irrigating grass pasture for seed and forage production in Tanzania: A case of *Cenchrus ciliaris*

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Abstract

Irregularity in weather patterns and climate change is a major challenge in agriculture and livestock production. A study was conducted to evaluate profitability of both seed and forage biomass production of buffel grass (*Cenchrus ciliaris* cv. Biloela) under rain fed scenarios and irrigation in the dry season. Different levels of Nitrogen and phosphorus were applied using Urea and Triple Super Phosphate (TSP) fertilizers as base sources. The experiment was set at Magadu Dairy farm at Sokoine University of Agriculture, Morogoro, Tanzania. The treatments included: Without fertilizer (0KgN/ha 0KgP/ha), combined fertilizers (40KgN/ha 20KgP/ha) and (60KgN/ha 30KgP/ha) in two seasons (wet and dry). Fixed and variable costs were recorded and Cost-Benefit analysis was employed to determine profitability of the treatments for the two scenarios. It was observed that, higher level of fertilizer application significantly increase seeds and biomass compared to lower levels. Economically, breakeven level was achieved in wet season with revenues from both seeds and forage in year 1and 2. Nonetheless, only one level of fertilizer application (60KgN/ha 30KgP/ha) was profitable (by 81,011.75Tshs) in year 1 during the dry season due to irrigation and planting materials costs, but profit in dry season was realized in year 2. Trend of seeds and forage production in both seasons was profitable in year two since no new investment in terms of planting material costs were incurred for perennial species establishment. Further, it was observed that, it is profitable to produce forage biomass in wet season and seeds in dry season. From these findings, it is recommended that, the use of irrigation and other appropriate cultivation practices could be potential option for improved grass pasture and quality seed production to meet demands of grass seeds for pasture establishment.

Keywords: *economics of grass pasture seed production, Irrigation, Variable costs, wet and dry season production*

Introduction

Production of grass and other forages seeds entirely depend on availability of soil moisture and thus easily produced during the rain or wet season. Grass seeds produced during wet season are however of poor quality. Wet season supports forage production, however produced biomass are inadequate to feed animals all year round especially during dry season. Despite feed shortage to sustain all year round forage and seed availability still wet season is entirely the main production time due to the lack of irrigation infrastructure to make use of dry spell for pasture seeds and forage production. Low fertility of soils and high risks of diseases leading to poor viability of seeds are reported during the wet season that affects grass pasture seed production in Tanzania. Therefore, the most active season for forage production is wet season (rainfed) while information on production to support livestock in dry season under irrigation is lacking. It was reported by Volesky *et al.* (2003) that, use of irrigated pasture has a potential in livestock production in dry seasons. Likewise, Kizima *et.al.* (2014) reported that grass pasture seeds production is commonly done in wet season in Tanzania with limited information on dry season production under irrigation.

The growing livestock sector creates a situation whereby, intensive livestock production is inevitable for increased productivity and profit margin. Intensification though, requires improved pasture establishment, use of inputs such as fertilizers, good quality seeds, machinery and irrigation in order to realize profit. Such inputs requirements for intensive livestock production systems need further studies and analysis to evaluate the viability and profitability of the options. Available option could range from irrigation possibilities; water availability; equipment availability and affordability to suit different farms; labour availability; and best combination of seed and forage production. Such concerns prompted this study to outline cost benefit analysis of seeds and hay production in wet and dry season.

Materials and methods

Study area

The study was conducted in Magadu dairy farm at Sokoine University of Agriculture farm in Morogoro municipal, Tanzania. The farm experienced an annual rainfall of 694.4 mm and 570.6 mm for year 2012 and 2013 respectively. It was a mixture of cool and warm temperature, ranging between 15.4 - 19.9 °C and 28 to 36.2 °C for minimum and maximum temperatures respectively. High relative humidity (64.93%) was recorded in April during the wet season experiment and lowest record was 39.3% in September during the dry season. The study site was located at about 526 m.a.s.l (S 6° 50' 58.80" E 37°39'12.22" GPS coordinates)

Experimental design

A split plot experimental design was used to evaluate effects of, fertilizer levels in wet and dry seasons on how they affect grass seed yield and forage biomass (hay) of *Cenchrus ciliaris* cv. Biloela. The experiment employed three levels of Nitrogen and phosphorus assigned in two seasonal blocks (wet and dry season using irrigation). Three Nitrogen N and Phosphorus P levels were used (0N 0P = 0KgN/ha 0KgP/ha control - without fertilizer), (40N 20P = 40KgN/ha 20KgP/ha) and (60N 30P = 60KgN/ha ,30KgP/ha)

Data collection

Both primary and secondary data on input costs, labour charges, and market prices of seeds and forage (hay) were collected during the study. Charges of water used for irrigation were obtained from Morogoro urban water authority, where prices charged for sales of grass seeds, vegetative splits and forage were obtained from three farms namely Tanga, Mazimbu and Vikuge.

Land preparation and pasture establishment

Soil testing was done before the experiment for fertility adjustment. Vegetative Splits of *Cenchrus ciliaris* were planted 84 days before start of wet and dry season to ensure good establishment before zero cutting during the start of each season trial. Fertilizers used were Urea (46%N) and Triple Super phosphate (TSP 46% P_2O_5). TSP was applied after the zero cutting in mid March and early June followed by urea application after 2 weeks. Wet season experiment depended entirely on rainfall water while dry season experiment used irrigation water which was measured by water meter installed in the field so as to record the amount of water used per unit of production area. Economic analysis started from costs involved in land preparation by plowing and harrowing, no costs of bush clearing was involved in this study as the land used from experimental field was a fallow clean land, where plowing and harrowing were done directly using machinery.

Management of the fields

The field was managed throughout the period of study. Weeding was done twice in each season. Irrigation was done using water pipe and watering can, watering after blooming stage was done to the basal part of vegetation to avoid wetting the inflorescence. This was done purposely to make sure the inflorescence/spike do not contaminate with moisture which is a predisposing factor of fungal growth. Irrigation was done daily in the early stages and later at an interval of one day. Seed harvest was done in two batches, first harvest was done after 66 – 70 days from the zero cutting, while second harvest was done after two weeks of the first harvest. Forage biomass harvest was done immediately after the second harvest of seeds.

Data analysis

Total variable costs were calculated based on establishing one hectare unit of perennial grass species *Cenchrus ciliaris* for seed and forage biomass production. The variable costs included land preparation costs, vegetative splits as planting materials where no seeds were used, labour charges for planting, irrigating, weeding and fertilizing. The vegetation established yielded two products (seeds and forages biomass). The harvested seeds and forages biomass were weighed and recorded and multiplied by prices to obtain revenue values. Gross profit was then calculated for each season in year 1 and 2 to compare profitability.

Results and Discussion

Land preparation

The costs of inputs to developing one hectare of pasture field are shown in Table 1. As the land had no bushes, no costs of bush clearing were recorded. The costs involved plowing and harrowing using tractor. These costs are for one hectare.

Management of vegetation in the field

Cenchrus ciliaris is a perennial grass pasture species, when established can stay permanent for more than ten years. In the second year of establishment in this study, only management of the field vegetation was done for each season of production. The study used vegetative splits to establish a field of *Cenchrus ciliaris* crop. However in Table 1, price of seeds are indicated but not used in calculating variable costs. Established vegetation was cut during the start of each season, weeded and top dressed using fertilizers TSP during the start of experiment and Urea applied after two weeks. Costs of the variable inputs for each season are indicated in Table 1.

Harvest of seeds and forage biomass

The study was conducted for two seasons in a year. The season between March – June, representing wet season and mid June – September for dry season. Seeds and forage were harvested in June for wet season and September for dry season. Seed harvest preceded forage biomass harvest. The seeds and biomass were air dried to obtain dried weights. It was learned that higher levels of fertilizers yielded higher forage yields in wet season (13.2 t/ha) as compared to 11.0 t/ha in dry season , while 78.6 kg/ha of seeds were harvested in dry season as compared to 55.7 kg/ha in year 2012 (Table 2). Yields of seeds and forage and calculated revenues are shown in Table 2. The trend of costs incurred for inputs were higher in first year 2012 and decreased in second year (2013). This was due to costs incurred to establish vegetation of perennial grass in year one, while no costs were incurred in the second year after for establishment of pasture, instead only management costs are reported in second year of production.

Table 1: Seasonal Input costs (TShs) and options for Cenchrus ciliaris Pasture establishment in Eastern zone Tanzania

Item/activity	Unit	Quantity	Unit price	Total cost/item (TShs)	Year 1 Option	Year 2 Option
A. Operational costs						
Land preparation (Hiring machinery)						
Ploughing	ha	1	150000	150000	150000	0
Harrowing	ha	1	75000	75000	75000	0
Planting and fertilization				0	0	0
Vegetative splits	tones/ha	2	130000	260000	260000	0
Seeds	kg	5	20000	100000	0	0
Fertilizer application (Combination options)				0	0	0
Nitrogen 60kgN/ha (UREA 46%N)	kg	130.4	1200	156480	0	
Phosphorus 30kgP/ha (TSP 46%P_2O_5)	kg	65.2	1200	78240	234720	234720
Nitrogen 40 KgN/ha (Urea 46%N)	kg	86.95	1200	104340	0	0
Phosphorus 20P kg/ha (TSP 46%P)	kg	43.5	1200	52200	156540	156540
Casual labourers	Mandays/ha	15	5000	75000	75000	0
Water charges (Dry Season -Irrigation)	Cubic meter/ ha/season	1759.3	902.5	1,587,768.25	1,587,768.25	1,587,768.25
Weed control (manpower)				0	0	0
First weeding	Mandays/ha	32	5000	160000	160000	160000
Second weeding	Mandays/ha	24	5000	120000	120000	120000
Harvest (seed and forage hay)				0	0	0
Seed Harvest (Hand harvest)	Mandays	23	5000	115000	115500	115500
Forage harvest (machinery harvest, mowing, raking and bailing)				0	0	0
Tractor fuel	litres/ha	40	2150	86000	86000	86000
Casual labourers 3	Mandays/ha	24	5000	120000	120000	120000
				Total variable costs for dry season		
				Fertilizer level (60N 30P) and other variable costs as shown in this table	2,863,988.25	2,303,988.25
				Fertilizer level (40N 20P) and other variable costs as shown in this table	2,785,808.25	2,225,808.50
				Without application of Fertilizer and other variable costs as shown in this table	2,629,268.25	2,069,268.25
				Totals variable costs for wet season		
				Fertilizer level (60N 30P) and other variable costs as shown in this table	1,276,220.00	716,220.00
				Fertilizer level (40N 20P) and other variable costs as shown in this table	1,198,040.00	638,040.25
				Without application of Fertilizer and other variable costs as shown in this table	1,041,500.00	481,500.00

Note: ***1 US $ ≈ 1630 TShs (September 2014)***

Table 2: Revenues from forage and seed production in year 2012 and 2013

Production/ factors	***Wet season production (Kg/ha)***					Revenues (Tshs)	
Forage Production	Yield Y1	Yield Y2	Number of 20kg hay Bales		Price /kg (Tshs)	Year 1	Year 2
Fertilizer levels			Year 1	Year 2			
Nitrogen and Phosphorus (0N 0P)	9958.7	11400	497.935	570	2500	1244837.5	1425000
Nitrogen and Phosphorus (40 N 20P)	11782.7	12100	589.135	605	2500	1472837.5	1512500
Nitrogen and Phosphorus (60 N 30P)	13199.4	11600	659.97	580	2500	1649925	1450000
	Dry Season production (kg/ha)						
Nitrogen and Phosphorus (0N 0P)	7400	6200	370	310	2500	925000	775000
Nitrogen and Phosphorus (40 N 20P)	9500	8300	475	415	2500	1187500	1037500
Nitrogen and Phosphorus (60 N 30P)	11000	9800	550	490	2500	1375000	1225000
Seed production	***Wet season production (kg/ha)***						
Nitrogen and Phosphorus (0N 0P)	51.9	15	Nil	Nil	20000	1038000	300000
Nitrogen and Phosphorus (40N 20P)	52.4	20	Nil	Nil	20000	1048000	400000
Nitrogen and Phosphorus (60N 30P)	55.7	21.7	Nil	Nil	20000	1114000	434000
	Dry Season production (kg/ha)						
Nitrogen and Phosphorus (0N 0P)	58.9	36.2	Nil	Nil	20000	1178000	724000
Nitrogen and Phosphorus (40N 20P)	65.7	42.3	Nil	Nil	20000	1314000	846000
Nitrogen and Phosphorus (60N 30 P)	78.5	52.2	Nil	Nil	20000	1570000	1044000
Total Revenues (forage and seeds) from Dry season harvests							
Fertilizer level (60N 30P)						2,945,000.00	2,269,000.00
Fertilizer level (40N 20P)						2,501,500.00	1,883,500.00
Without application of Fertilizer						2,103,000.00	1,499,000.00
Total Revenues (forage and seeds) from Wet season harvests							
Fertilizer level (60N 30P)						2,763,925.00	1,884,000.00
Fertilizer level (40N 20P)						2,520,837.5	1,912,500.00
Without application of Fertilizer						2,282,837.5	1,725,000.00

0N 0P = 0KgN/ha 0KgP/ha, 40N 20P= 40KgN/ha 20KgP/ha, 60N 30P= 60KgN/ha 30KgP/ha

Total revenues from seeds and forages biomass

Total annual revenues were calculated separate for wet and dry season. Total revenues for seeds and forages from each level of fertilizer level for both years is presented in Table 2. Higher levels of fertilizer led to higher revenues from produced seeds and forages biomass. Dry season revenues were relatively higher (Table 3) due to higher market prices of seeds (Table 1). Total annual revenues for both dry and wet seasons were comparatively low in year 2 as compared to year 1(Table 3). This shows that the trend of yield decline as the age of vegetation advances.

Irrigation costs

Irrigation costs ranged from 55 - 77% of the total variable costs in year 1 and 2 for all fertilizer levels. Irrigation raised highly the production costs because the water charges used were based on water meter for domestic uses. According to FAO (1997) costs of irrigation per hectare in Tanzania varied from system to system, and varied with crops. In the case of the traditional gravity system the annual (fixed) cost per hectare was reported to be US$ 16 compared to US$ 43/ha in the case of the improved gravity system, and total costs of irrigation per hectare with 100 percent crop intensity was ranging from US$ 126 – 306 for maize. From this study it was observed that intensive irrigation of this grass crop cost 1,587,768.25 TShs = US$ 974.1(Table 1). These findings might be high when compared to reported charges seven years ago. Probably these charges can be reduced when irrigation infrastructures are in place specifically for the purpose of irrigation and costs may decrease with time.

Gross profit

The profitability analysis was done by calculating gross profit (total revenue – total costs) to evaluate the breakeven value of seed and forage for dry and wet season. It was observed that, only one option of fertilizer level 60KgN/ha and 30KgP/ha of seed and forage production in dry season exceeded breakeven value by 81,011.75/= TShs profit. Use of other production levels of fertilizer using irrigation in dry season did not reach breakeven value and hence not profitable due to high costs of irrigation in dry season using domestic water system.

Wet season production of seeds and forages showed higher revenues and gross profit from different levels of fertilizers in year 1 and 2. However quality of seeds produced in wet is relatively poor as compared to quality of seeds produced in dry season (Kizima *et. al,* 2013 and 2014). This means, seeds produced in dry season considering their good quality could fetch higher prices and hence break-even.

Table 3: Summary table for Gross profits from Total revenues (Tshs) from seeds and forages in dry and wet season

Season and (N, P levels)	Revenues(Tshs)		Inputs (Tshs)		Gross profit		Irrigation costs	
Dry season Production	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Fertilizer level (60N 30P)	2,945,000.00	2,269,000.00	2,863,988.25	2,303,988.25	81,011.75	-34,988.25	55%	69%
Fertilizer level (40N 20P)	2,501,500.00	1,883,500.00	2,785,808.25	2,225,808.50	-284,308.25	-342,308.50	57%	71%
Without application of Fertilizer	2,103,000.00	1,499,000.00	2,629,268.25	2,069,268.25	-526,268.25	-570,268.25	60%	77%
Wet season Production								
Fertilizer level (60N 30P)	2,763,925.00	1,884,000.00	1,276,220.00	716,220.00	1,487,705.00	1,167,780.00		
Fertilizer level (40N 20P)	2,520,837.50	1,912,500.00	1,198,040.00	638,040.25	1,322,797.50	1,274,459.75		
Without application of Fertilizer	2,282,837.50	1,725,000.00	1,041,500.00	481,500.00	1,241,337.50	1,243,500.00		

0N 0P = 0KgN/ha 0KgP/ha, 40N 20P= 40KgN/ha 20KgP/ha, 60N 30P= 60KgN/ha 30KgP/ha

However, costs of using fertilizers rise production costs using manure therefore may be an option to reduce costs of pasture establishment in order to breakeven as recommended by Mdoe *et. al.*(1992). Smallholder farmers obtain manure from their own farms or from neighbours, mainly free of charge or at reasonably cheaper price. The costs involved in using manure for pasture production would be the costs of collecting manure from cattle sheds, carrying it to pasture plots and spreading it in the plots. Fertilizer however, can as well be used to supplement for other nutrients required by the pastures.

Conclusions and recommendations

Basing on economic analysis, it is concluded that irrigation costs increases costs of production by more than 55% of total variable costs, as a result, only higher levels of fertilizer led to breakeven level in first year. However in second year, production costs goes down for profit production of seeds and forages. Production of grass seeds in dry season improves seed quality regardless of being costly due to irrigation and fertilizers costs. It is recommended that use of manure as partial substitute of fertilizer be an option to minimize costs of production.

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References

FAO (1997). Economics of irrigation. Irrigation Technology Transfer in Support of Food Security. Water Reports. Rome, Italy. http://www.fao.org/docrep/W7314E/w7314e0h.htm

Kizima, J. B., Mtengeti E. J. and Nchimbi-Msolla, S. (2013). Viability status of *Cenchrus ciliaris* seeds in the three farms of the sub-humid eastern agro-ecological zone of Tanzania. *Livestock Research for Rural Development. Volume 25, Article #85.* http://www.lrrd.org/lrrd25/5/kizi25085.htm

Kizima, J. B., Mtengeti E. J. and Nchimbi-Msolla, S. (2014). Seed yield and vegetation characteristics of *Cenchrus ciliaris* as influenced by fertilizer levels, row spacing, cutting height and season. *Livestock Research for Rural Development. Volume 26, Article #148.* Retrieved August 5, 2014, from http://www.lrrd.org/lrrd26/8/kizi26148.htm

Mdoe, S. Y., Mlay G. I. and Urio, N. A. (1992). Comparing costs associated with the utilisation of Crop residues and planted pastures in smallholder production systems in the highlands of Hai, District, Tanzania. The Complementarity of Feed Resources for Animal Production in Africa, FAO Corporate Document Repository, Rome, Italy. http://www.fao.org/wairdocs/ilri/x5519b/x5519b1h.htm

Volesky, J. D. and Clark, R.T. (2003). Use of Irrigated Pastures and Economics of Establishment and Grazing. Proceedings, The Range Beef Cow Symposium XVIII, December 9, 10 and 11, 2003, Mitchell, Nebraska. University of Nebraska-Lincoln. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1059&context=rangebeefcowsymp

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 General Conclusions and Implications of the Study Findings

The overall objective of this thesis was to investigate seed yield and quality of *Cenchrus ciliaris* cv. Biloela in subhumid eastern zone of Tanzania. The study aimed to assess viability status of seeds produced in three prominent pasture seed farms (paper 1), and thereafter evaluated on how seed yield, quality and vegetation characteristics are influenced by fertilizer levels, row spacing, cutting height, time of harvest in wet and dry season using irrigation (paper 2 and 3). The fourth study (Manuscript 4) aimed on economic analysis, to evaluate whether it is profitable to venture in *Cenchrus ciliaris* establishment for seed and forage production in sub-humid eastern zone of Tanzania using irrigation. The main findings of the study may therefore be summarized and concluded as follows:

i. Seed quality in terms viability of *Cenchrus ciliaris* from three farms was low below 20% according to seed quality Standards for declared grass seed quality (FAO 1993).

ii. Among other factors soil fertility as important factor for plants well being as per soil analysis was at low levels in soil samples from three farms. Thus, these farms needed soil fertility adjustment through fertilizer application basing on soil fertility recommendations. Age of the vegetation sward was also a factor affecting viability of seeds, seed production in the farm with sward above four years resulted in poor quality seeds.

iii. Grass seed production is practically possible during the dry season (June – September) in the eastern zone of Tanzania by supplementing soil moisture with irrigation when facilities are in place. Higher rates of Nitrogen and Phosphorus significantly increased seed yield and quality in dry season using irrigation than in wet season, however forage biomass production were highly favored in wet season. Wider row spacing increased seed yield than narrow row spacing in ground cutting height. Ground cutting led to fewer healthier basal tillers and lengthy inflorescence in tussock which resulted to higher seed yields as compared to higher cutting height which resulted in profuse thin aerial tillers.

iv. Dry season had significant better effect against wet season on seed quality tests including Caryopsis index, Good Vs damaged grains, which resulted in viable seeds with better germinations.

v. Seeds from first harvest and second harvest time differ in viability and need to be separated.

vi. Storage time improves seed viability

vii. Basing on economic analysis, It is concluded that irrigation costs increased production costs by more than 55% of total variable costs, as a result, only higher levels of fertilizer led to breakeven level in year 1. Production of grass seeds in dry season improves seed yield and quality in year one regardless of higher production costs due to irrigation and fertilizers costs.

6.2 Recommendations

Based on the findings obtained from this study, it is recommended that:

i. Farms conduct seed testing (for viability and health) each year from newly established to old vegetation to monitor quality of seeds batches produced.

ii. Further studies on seed heath challenges are required to bring more understanding on grass seed production in this sub humid agro-ecological zone of Tanzania.

iii. Irrigation during dry season is the best option for *Cenchrus ciliaris* cv. Biloela seed production when row spacing of 75cm and 100 cm are used at ground cutting height

iv. Soil fertility adjustment should use proper rates of nitrogen and phosphorus. However studies on use of manure as partial substitute to reduce costs of fertilizer could be a strategy to minimize costs of production.

v. Strategies for bird scaring during dry period are highly emphasized from flowering stage to seed maturity (35 days) to maximize seed yields

vi. More trials on pasture grass seed production in the country are needed to come up with clear picture on seed qualities so as to meet required seed certification standards. Long study is recommended on how to manage and sustain basal tillering for sustainable high yields and quality seeds.

vii. Testing authorities of seed viability are advised to incorporate caryopsis index tests as one of prior criteria in judging the quality of grass seeds before spikelet germination.

viii. Seasons synchronization (wet and dry) could be useful to reduce costs of irrigation so that flowering is reached when rains are over.

ix. It is also recommended to separate harvest one seeds from second harvest for commercial purpose as second harvest had lower caryopsis index and ultimately poor germination.