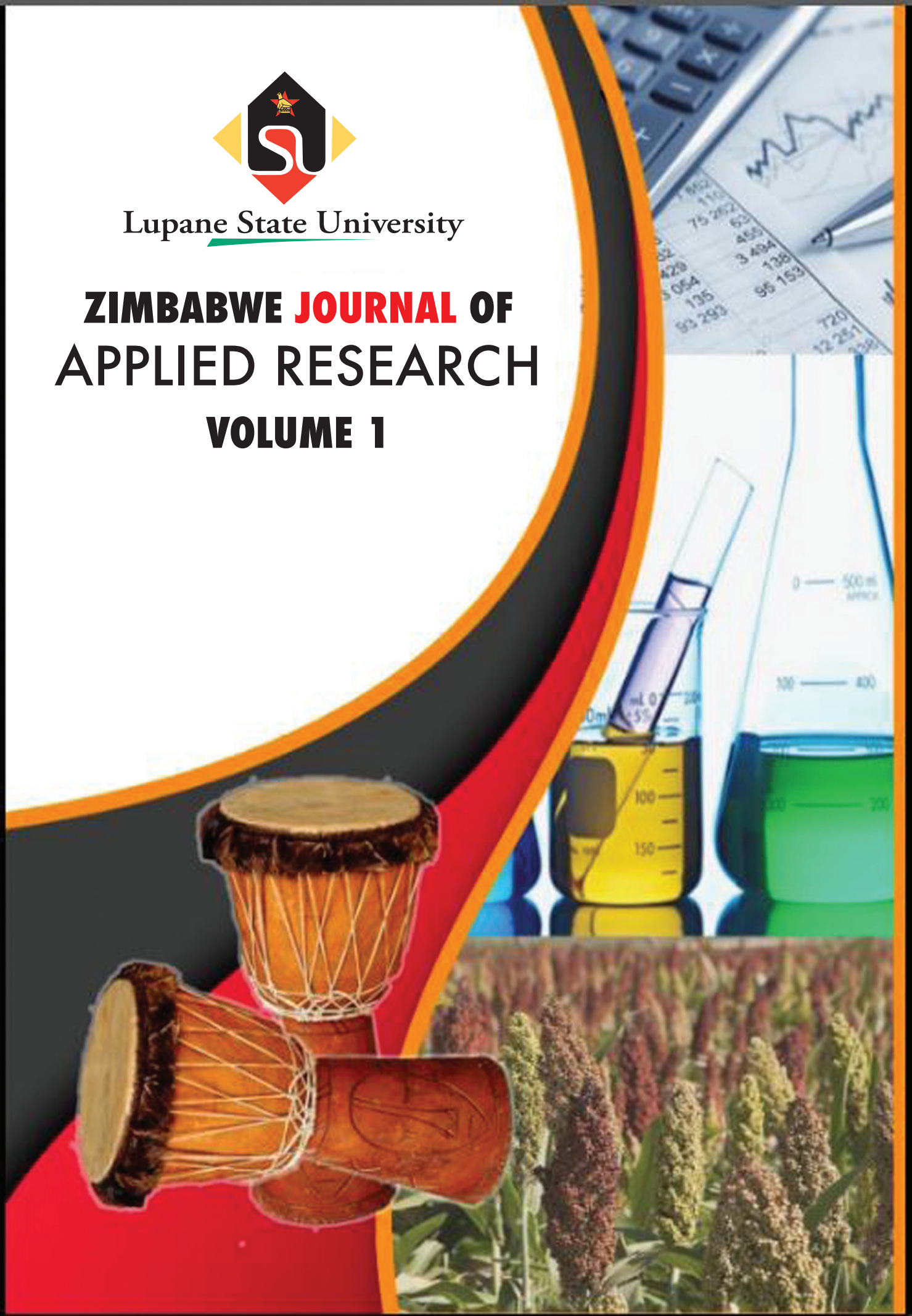Lupane State University

ZIMBABWE JOURNAL OF
APPLIED RESEARCH
VOLUME 1

JOURNAL OBJECTIVES

The Zimbabwe Journal of Applied Research aims to publish peer reviewed articles that employ Scientific Research Methodologies to generate applied knowledge in the fields of Agriculture, Commerce, Social Sciences and Humanities. The journal seeks to give its wide readership evidence based knowledge that bridges the gap between theory and practice. It also offers academia and practitioners across disciplines a platform to assess the merit of their research and subsequently make their work known to the journal readership.

NOTE FROM THE EDITOR

I am delighted that Lupane State University is publishing its own journal. Welcome to the inaugural issue of the Zimbabwe Journal of Applied Research (ZJAR). The journal is multi-disciplinary covering Agricultural Sciences, Commerce, Social Sciences and Humanities. It gives researchers from various disciplines an opportunity to share their up to date high quality original research based knowledge and innovations with other scholars. This knowledge can also be harnessed to solve some of the pressing problems and challenges that communities encounter.

The ZJAR seeks to give its readers knowledge that bridges the gap between theory and practice. Much as we accept that research for its own sake can end up giving valuable insights and knowledge, for Africa much more is expected. As the continent struggles with numerous challenges of

drought, hunger, wars, low productivity, lack of clean drinking water, and many others, it is frantically looking for researches that provide findings that will lead to the alleviation of some of these problems, research that can lead to tangible changes in peoples' lives.

ZJAR aims to provide a platform for researchers who want to make a difference in the lives of individuals who live in the developing world by giving them knowledge that empowers them, by pointing to them possible directions that they should take if thing are to improve for them. All papers submitted to the Journal are subjected to a double blind review process.

In this maiden edition there are five original research papers, two of which look at crop production, one on animal feed, the other is on environment and the last one has investigated issues of gender and employment opportunities. ZJAR is encouraging scholars to submit their research papers on similar and many other areas and is looking forward to receiving them. The journal aims to make two publications a year and with the researchers and readerships' support we are sure this can be done.

Getrude Nyakutse
Chief Editor
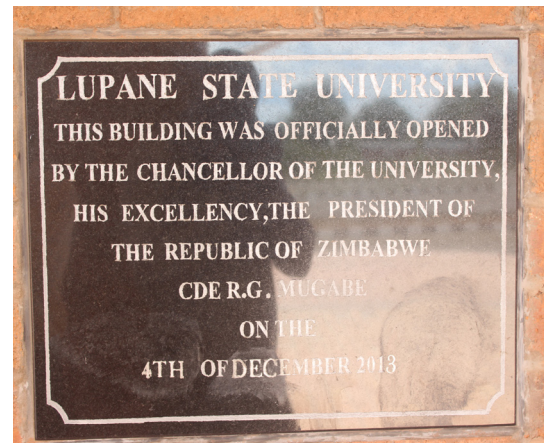
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AN INVESTIGATION INTO THE EXTENT OF GENDER FORMAL EMPLOYMENT GAP IN ZIMBABWE

(Pages1-10)

A CASE STUDY OF BULAWAYO METROPOLITAN

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ABSTRACT

The paper investigated the extent of the gender formal employment gap in Zimbabwe almost ten years after the ratification of the International labour Organization (ILO) convention number 111 (1958) and Southern African Development Community (SADC) Protocol on Gender (2008). These advocate for equal opportunities for both men and women in all spheres of life. Applying probit regressionon survey data conducted in Bulawayo in 2017, the findings revealed the existence of gender formal employment gap in Zimbabwe. The gender formal employment gap was found to be rampant in the private and parastatal sectors with formal employment gender gaps of 0.25 and 0.35 respectively. The analysis of variance (ANOVA) revealed a significant difference in gender employment gaps across sectors. The public sector revealed the lowest gender employment gap of 0.09. Service sector has the lowest gender formal employment gap of -0.12.The chance of being formally employed varies with educational attainment. Thus, the higher the level of education, the higher the probability of one being employed. Also the place of residence was found to have a significant effect on female formal employment at 5% level of significance. The research recommends policies that promote and encourage women to be active economic agents across the economic domain. Recommended also is the establishment of a monitoring agent to ensure 50/50 recruitment of males and females employees by employers across all sectors and industries. This would encourage women to further their studies and increase their participation in the economic sphere, thus harnessing their productive labour resource for inclusive growth.

Key words:
gender, employment gap, Affirmative Action, STEM (Science, Technology, Engineering, Mathematics).

INTRODUCTION

Women constitute the majority of the population in the world and yet their representation in the labour market is skewed in favour of their male counterparts (United Nations Year Book, 2015). The unbalanced representation of women in employment is a cause for concern in many countries, both developed and developing. Gender employment equity is one of the key elements of Sustainable Development Goals (SDGs).This is because the notion of a male bread winner has resulted in most societies, both developed and developing world, focusing on men and ignoring the role played by women in family poverty eradication through female employment (United Nations Yearbook, 2015).

Traditionally, women are considered to "belong to the kitchen" and this has resulted in women not being economically active because they are viewed simply associal assets. This has seen most women being engaged in activities that are not economically recognized such as subsistence farming and unpaid family labour. In Southern Africa, Zimbabwe included, women are mainly engaged in family activities and the informal sector, which frequently go unrecorded (United Yearbook, 2015). Instead of being empowered through employment they are entrusted with the responsibility of bearing and nurturing children as well as general family upkeep. This has kept women away from the formal labour

market thereby resulting in widening the gap between men and women in employment and occupation. This implies that women are facing cultural, legal, institutional and economic barriers to employment. The involvement of women in formal employment over and above their family activities is one of the gateways through which families can escape poverty.

Labour employment is a crucial tool in economic growth and poverty eradication. This is because labour is the main source of income for most people. Labour generates income for families and individuals that were previously marginalised, thus improving their welfare. Given the potential benefits of employment, it is therefore imperative that the extent of the gap in gender employment Zimbabwe be investigated so as to come up with policies that would improve the employment of females in the formal sector. Employment equity would promote balanced and future oriented economic growth. The inability of an economy to promote equity in the labour market might result in jobless, rootless, voiceless and futureless growth. As more women participate in formal employment, they create more employment as the demand for other services such as child minding and home care increases. Increasing the number of women in formal employment maybe undertaken only if the extent of employment gap between males and females is understood. Thus, the paper focuses on finding out the extent of gender formal employment gap in Zimbabwe.

It is worth noting that female employment has been associated with high productivity and high returns in some areas and in other areas it is associated with low mortality levels and higher education for the generations that follow, thus ensuring economic growth and poverty reduction (ILO, 2012). It is through employment that women can be involved in their countries' economic developments and enjoy the benefits. Once there is an improved representation of women in the labour market, it is most likely that family poverty will reduce. This is because of the role played by women in child nurturing which is strengthened by economically empowering women through formal employment. The existence of gender employment gap is generally appreciated but the extent of such a gap in Zimbabwe is not clear.

PROBLEM STATEMENT
At independence, the government of Zimbabwe embarked on extensive investment in education which focused on education for all. In 1992, a policy on affirmative action was put in place to promote gender equity in education. The implementation of the affirmative action policy resulted in lowering the entry requirements for secondary and tertiary education for girls across all disciplines of study. The 2013 Constitution of Zimbabwe section 17 advocates for full gender balance in Zimbabwean society and empowers the state to take positive measures that rectify gender imbalances that are a result of past practices and policies (Government of Zimbabwe, 2013).

Other than massive investment in education, Zimbabwe is a signatory to various treaties, protocols and conventions that are meant to address gender imbalances in the labour market, thus fostering equal employment participation. Among the treaties signed by Zimbabwe are International Labour Organization Convention Number 111 (1958), the Beijing Declaration (1995) and the SADC Protocol on Gender and Development (2008). These treaties advocate for equal participation of women and men in the labour market with specific reference to employment. Yet women are not very visible in the labour market especially in the primary sectors (such as mining, manufacturing and electrical) and decision making positions (Mudiwa-Guramatunhu, 2010; Zimbabwe Statistics Agent, 2014 & Ntuli, 2009). This is a cause for concern and hence the need to draw the attention of policy makers to the extent of labour market gender formal employment gap.

These past policies and practices would have been expected to yield gender in employment equity. However twenty years have passed and the labour market still exhibit gender employment gap. It is against this background that the study seeks to investigate the extent of gender employment gap in Zimbabwe with

specific reference to Bulawayo Metropolitan Province and highlight the factors that promotes such differences.

LITERATURE REVIEW

This section highlights theories that explain gender employment gap between men and women and it also tracks the work that has been done by other scholars such as (Luebker 2008). There are various reasons for differences in gender employment. The human capital theories cited in Becker (1984) attribute the differences in employment to differing skills levels as well as education and an individual's experiences. These theories link labour productivity to labour demand. Highly productive labour is in high demand and this means that if female labour is assumed to be less productive, it will also command lower demand thereby resulting in lower female employment as compared to their male counterparts who might be perceived to be productive. Thus, capital endowment is positively related to employment as well as experience. The theory would, therefore, explain the difference in employment as due to characteristics such as time spent in school, the nature of qualification and skills endowment which is reflected in labour productivity. Like the human capital theories, the neoclassical view attributes gender employment gap to differing skills levels and labour productivity. The varying skills demand from different sectors may explain the differences in the extent of gender employment gap across sectors.

Hedonic theories of employment highlight risk and earnings preference as the driver of gender employment gap across sectors. One's risk-earning preferences dictates the choice of employment and the sector (McConnell, Brue and Macpherson, 2016). If an individual is risk averse, he or should would seek employment in sectors that have minimum risk of injury or death. High risk jobs though may attract higher earnings and women tend to avoid industries and jobs that are risky, thus widening the gender employment gap in such industries. The trade-off between risk and employment helps to explain the employment gap that exists between men and women as women might

prefer to work in pleasant conditions that might absorb a sizeable number of employees thereby resulting in the gap in employment between men and women.

Ehrenberg and Smith (2003), highlighted job matching as one of the possible explanation for gender employment gap in the world. He highlighted that workers and employers that best suit each other match in a trial and error process. As workers attempt to maximise utility subject to their objective function, they consider both monetary and non-monetary aspects of the job. This means that job earnings are not all that matter, but occupational tasks and how workers' preferences match with job tasks are also critical elements in the matching process. From the matching theory it can be noted that women who might have certain preferences such as short and flexible working hours might not match themselves with occupations that meet their preferences. This promotes gender employment gap in such occupations.

Statistic discrimination theory postulates that employers exercise discrimination basing on the average characteristics of a population. This has, in many instances worked against women in the labour market. The employers might be possessing limited information on female labour force productive capacity thereby preventing females from entering certain sectors of the economy and therefore resulting in low employment participation by women as compared to their male counterparts (Watson, 2013). This is common in primary sectors such as mining and manufacturing.

The behaviour and attitudes of customers and other employees might push female employees out of the labour market, thus excluding women from employment because of subjective behaviours (Watson, 2013). This is because some customers might not be comfortable to be served by female employees. In fear of losing business, the employers would then not hire female labour. Taste discrimination can also be practiced by other employees especially men who might not be willing to offer their much required labour because they are not willing to work with women. To avoid loss of productive

labour, employers may respond by not employing female workers. Taste discrimination sometimes devalue women's worth in the labour market to an extent that women shy away from the labour market as their labour is not paid its market value. Thus they find other sources of employment which might not be economically beneficial to them (Ntuli, 2009).

The segmentation theories highlight the division of the employment market into primary and secondary sectors with primary markets having higher wages while risky working environment has resulted in women being crowded in the secondary sector which offer very low wages (Ehrenburg and Smith, 2003). This has exposed women to higher opportunity cost of employment, making some women opt to redirect their energies towards daily upkeep of the family.

The differences in social responsibilities and roles played by men and women in bringing up children have had a great impact on the employment participation of women (Weeden, 2002). The idea that women find societal recognition through child bearing and nurturing has resulted in gender employment gap with more women tending to be content with child bearing and family upkeep. Women are entrusted with child nurturing which has a direct influence on the choice of employment and the sector to supply their labour to. Because of social responsibilities, women, in some instances would prefer to work in environments with flexible hours as compared to their male counterparts who might be indifferent to working odd hours..

The Keynesian school of thought highlights fiscal policy as a possible predictor variable to employment gap. The theory posits that government's social expenditure might lead to employment gap. If a government adopts a generous social services grant such as child support grant, it might mean an increase in household income which would reduce the probability of women participating in the labour market (Pressman, 2002). Using the Namibian data, Mufume (2013) found that women with non labour income such as child grant are less likely to be employed. This might imply that a generous fiscal policy might work to further worsening the gender employment gap. The unavailability of credible government support to families might serve to explain the increase of women's participation in the informal sector in Zimbabwe and the increased number of females enrolling to further their education.

Pressman (2002) revealed unequal participation of men and women in the United States labour market which makes employment inequality not to be the case peculiar to Zimbabwe but a global problem. Their findings attribute the differences to education levels, marital status and occupation. United Nations Development Programme (UNDP), (2015) highlighted that where women are employed most of them are in the services sector or in part-time employment which allows them to leave employment to attend to family issues such as child bearing and nurturing.

Using the Nambian labour market data, Mufume (2013) found that though women are increasingly participating in the labour market, they are still lagging behind in many aspects such as numbers employed. Leubker, (2008) found that the Zimbabwe labour market is dominated by informal sector employment and that there are more women participating in the informal sector as compared to their male counterparts. Mupunga, (2013) concentrated on the determinants of female labour force participation in Zimbabwe using time series data. Their research findings revealed economic development as the major determinant of female employment. The studies highlighted above focused on factors affecting female labour participation and the general analysis of gender employment gap without highlighting the extent of such a gap. This paper investigates the extent of the gender employment gap problem in Zimbabwe so as to inform policy.

METHODOLOGY

The study focused on validating genderformal employment gap in Bulawayo Metropolitan Province as reflected in the Zimbabwe Labour Force Survey (ZLFS) of 2014.Stratified sampling technique was used to collect data from Bulawayo

Metropolitan province. The population was first clustered by income group which were low, medium and high income groups. The subjects were selected from each income group using probability proportionate sampling that ensured equal representation of all the income groups. To establish the extent of gender formal employment gap in Zimbabwe, data from ZLFS was analysed using ANOVA and the t test to check for the significance difference between male and female formal employment. Using the probit regression analysis, gender employment gap in Bulawayo Metropolitan Province was established.

Primary data was collected from randomly selected one hundred Bulawayo households after stratifying the suburbs into low, medium and high density suburbs. Income and employment

Table 1 Sample Selection

Number of Households	100
Questionnaires distributed	200
Returned questionnaires	170
Unreturned Questionnaires	30
Response rate	85%

questionnaire was used targeting individuals in the labour force. Labour force are individuals between the age of sixteen and sixty five years excluding those in institutions as defined by International Labour Organisation standards. The questionnaires were administered to both males and females who met the criteria. The number of questionnaires per household was determined by the number of individuals in a household who were in the labour force and were economically active at the time of research. The distribution was proportionate to population density with one hundred, sixty and forty questionnaires distributed to high, medium and low density suburbs respectively. One hundred and seventy questionnaires were returned and thus indicating a response rate of eighty five percent as shown on the table below.

After the questionnaires were collected, the data was captured and analysed using STATA 14, probit regression to investigate the extent of gender formal employment gap.

Normality test was carried out and the data was normalized using the box cox transformation, $X^i=(X+C)$. Where X^i is the transformed value of X and C is a constant which is added to each observation. After the transformation, the *t test* was carried out.

Probit modelling was used is as follows;

$$Pi = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta_1+\beta_{Xi}} e^{-t^2} dt$$

$$P(Y = 1) = 1 - (\sum \beta i X i)$$

$$P(Y = 1) = 1 - F(-\beta_0 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 + \cdots \beta_n X_k)$$

Where t is a standardized normal variable; $t{\sim}N(0,1)$, P is the probability of employment for either female or male labour participant and X^i are vectors of factors that influence the probability of employment (age, education, marital, status, suburb) and B^i are vector coefficients.

Estimating the model will help us identify the equality of employment chances between males and females. After the significance test, the sources of gender employment gap were identified and analysed.

ResultAnalysis

The distribution of gender formal employment by sector is highlighted in table 2 below;

Table 2. Percentage employment distribution by gender and sector

Sector	Gender		
	Female	**Male**	**Gender gap (male –female)**
Government (GOV)	45.1	54.9	9.8
Parastatal (PAR)	35.6	64.4	28.8
Private Sector (PVT)	38.5	62.15	23.65
Domestic (DOM)	55.9	44.1	-11.8
Agriculture (AGR)	54.6	46.3	-8.3
Mining (MIN)	10.8	89.2	78.4
Manufacturing (MANUF)	22.5	77.5	55
Electrical (ELEC)	4.8	95.2	90.4
Retail (RETAIL)	62.1	37.9	-24.2
Health (HEA)	64.2	35.8	-28.4
Education (EDUC)	57	43	-14
Service (SERV)	56	44	-12
Management positions (MGRS)	27.4	72.6	45.2
Total (EMP)	89.4	92.3	2.9

Source: Own Calculations from ZLFS 2014data.

There are more males in employment as compared to their female counterparts. From table 2 above, about 92.3% of males are employed as compared to about 89.4% of females. This presents an employment of gap of 2.9%. Sectors that were found to have the largest employment gap were parastatal and private sectors with employment gaps of 28.8% and 23.65% respectively. Public sector excluding health and education had the lowest gender employment gap of 9.8%. This might be explained by the government's commitment to implement policies on equal opportunities. The services, retail, health and education have negative gender employment gaps with gaps of -12%, -24.2%, -28.4% and -14% respectively. It is worth noting that, though the gender employment gap in Zimbabwe is generally low, the distribution of males and females across sectors and positions revealed very low percentage of women in management positions and primary sectors such as mining, electricity and manufacturing sectors as compared to their male counterparts.

The sector with the lowest percentage of females employed are the electrical and mining sectors with gender gaps of 90.4% and 78.4% respectively. This could be because these sectors might be considered to be risky, and at the same time do not have flexible working hours that would enable women to balance work and general family responsibilities. These sectors also require physical labour which women might not be able to provide. The sectors such as

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health and retail have more female employees than male. This could be because these sectors do not require physical strength and also have flexible working hours.

The employment difference between male and females across sectors was subjected to the analysis of variance and the results are shown in table 3 below;

Table 3. Analysis of variance

Source of Variation	SS	df	MS	F	P-value	F critical
Between Sectors	1841.942	14	1841.942	3.134253	0.036826	4.170877
Within Sectors	17630.44	14	587.6813			
Total	19472.38	28				

The ANOVA results show a significant difference between women and men in formal employment across sectors. This is because the probability for the F-statistics is less than 0.05 which means that there is a significant difference at 5% level of significance. The difference in employment gender gap is due to differences across sectors and gender.

Other than the ANOVA, the t test also revealed a significance difference at 5% level of significance. Both one tail and two tail P-values are less than 0.05 which means that there is a significant gender employment gap in Zimbabwe.

Table 4. t-Test: Paired two sample for means

	Female	Male
Mean	41.11138	59.00385
Variance	389.4297	387.7777
Observations	13	13
Pooled variance	388.6037	
Hypothesized Mean Difference	0	
Df	24	
t Stat	-2.31354	
P(T<=t) one-tail	0.014788	
t Critical one-tail	1.710882	
P(T<=t) two-tail	0.029575	
t Critical two-tail	2.063899	

The paired *t* test results show that there is significant employment difference between females and males.

Chi square test was carried out to ascertain the presence of the significant difference in employment between males and females.

Table 5 Employment gap

Employment	coefficient
Male	0.471581
	$(0.6594)^*$
Female	-0.121236
	$(0.45064)^*$
Constant	0.5784

*R2 = 0.4512, chi2 = 0.000; * Significant at 0.05*

From table 5, the results confirmed the presence of a significant difference between female and male employment at 5% level of significance. After the chi square test revealed the presence of gender employment gap, the paper further investigated the level of the gap between males and females in Zimbabwe. This was analysed using probit regression and the results are as shown on table 6.

Table 6. Gender employment gap analysis according to age, level of education, marital status and place of residence

Employment	female	male
Age	0.03367	0.4345
	(0.0026)*	(0.0021)*
High density	0.0176	0.3401
	(0.0062)*	(0.0031)*
Low density	0.16785	0.0165
	(0.0042)*	(0.0670)**
Medium density	0. 1574	0. 2345
	(0.067)**	(0.002)*
No-school	-0.2348	0.4240
	(0.0507)**	(0.0561)**
Primary	-0.1098	0.6078
	(0.0897)**	(0.0033)*
Secondary	0.0231	0.2210
	(0.0050)*	(0.6512)**
Tertiary	0.4516	0.5821
	(0.0138)*	(0.0251)*
Married	-0.0237	0.6941
	(0.0413)*	(0.00126)*
Constant	0.02454	0.4214

*R2 = 0.3512, chi2 = 0.001; * Significant at 0.05; **significance at 0.1*

From the results, the study found that age had an effect on formal employment probability. Females were found to have about 0.033 chance of being employed while their male counterparts had about 0.43 chance of being formally employed. The gender age formal employment gap was found to be 0.40. This means that males of the same age as females were likely to be formally employed than females.

The study revealed that the place residence had a bearing on the formal employment probability. Low density areas had the lowest chance of formal employment for both males and females. This could be attribute to higher non-wage family income and wealth levels. Though the low density had the lowest chance of formal employment, females in the low density had

a higher chance of formal employment than males in the same suburbs with probabilities of about 0.167 and 0.0165 respectively. High density areas had the highest gender formal employed gap of 0.032 while the low density had the lowest of -0.15. The difference in gender formal employment gap by residence could be because of network effect where low density individuals are better networked than the high density individuals.

Lack of education was found to reduce the chance of being formally employed. The probability of formal employment was found to increase with education level. The gender formal employment gap was found to be widest with primary level of education with a formal gender employment gap of 0.71 while tertiary had the lowest gender

formal employment gap of about 0.13.

Marriage was found to reduce the probability of formal employment for females while increasing the probability of employment for males.

The probit regression results showed that males have a higher chance of being employed as compared to their female counterparts. Residence (low, medium and high density), marital status, education level and age have an influence on formal employment gender gap and were found to be significant at 5 and 10 percent. Being married reduces an individual's probability of being employed for females and increases for male. This could be because, married women, maximize their utility, taking into consideration their spouses' income. The probability of employment is lowest among women who reside in high density suburbs. This could be attributed to pre labour market discrimination whereby individuals in the high density, might have been excluded from school because of low income. The level of education was found to be important in explaining the extent of gender employment gap. The probability of employment increases as the level of education increases, thus narrowing the gender employment gap. The findings are consistent with the results that were found by Fafchamps (2009) using the Zambian data. Their research found skills differentials between men and women to be one of the major drivers of gender employment gap in Zambia. Fitzenberger (2004), using Western German data revealed existence of gender employment gap. This implies that world leaders need to take a holistic approach in addressing gender employment gap.

CONCLUSION

From the research findings, it can be concluded that despite the policies on gender employment equity at both national, regional and international levels, gender employment inequality is still prevalent in Zimbabwe, and is more pronounced in mining, electrical and manufacturing sectors. The findings also indicated that the gender employment gap tends to narrow down as individuals attain higher levels of education. Government has made significant strides towards reduction of gender employment gap

as highlighted by a small gender employment gap in the government sector. The private and parastatal sectors are still lagging behind in embracing gender employment equity.
Recommendations

Given the findings from the research, there is need to put in place polices that address gender employment disparities as these differences can pose socio-economic problems such as increased crime rate and social ills which are a common sight in most parts of the country especially in urban areas. To promote the participation of women in the science and technology sectors such as electrical, mining and manufacturing, there is need to invest in low risk production methods, come up with regulations and programmes that advance women's interest as they fight to balance formal employment and other social responsibilities. The promotion of women in STEM might improve the employment of women in sectors that are predominantly male and thus reduce the gender employment gap. In addition to crafting gender equity laws and policies the government might consider setting up a monitoring board on equal employment opportunities. There is need to have more women in decision making positions as this might promote the employment of women in the formal sector. Further research might be carried out to find out whether the gender employment gap narrows or expands as the years go by.

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BUTTERNUT SQUASH SEEDLING EMERGENCE PATTERNS ON NORTH AND SOUTH FACING FURROW SIDES IN LATE WINTER FIELD CROPS

(Pages 11-17)

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ABSTRACT

In Bulawayo, market demand for butternut squash is usually at peak during the Christmas festive season and most growers target this market. As a result of low late winter temperatures, erratic seedling emergence and inadequate crop stand are often a serious challenge in establishing an early four month crop to target this market. A field 22factorial experiment was conducted in Glengarry suburb of Bulawayo to test the severity of poor emergence and hence suggest alternative sowing method. Seeds of Waltham variety were sown on north and south sides of furrows on two dates in late winter 11 days apart. Results on patterns of seedling emergence for the two furrow sides and two sowing dates were analyzed on SPSS 16.0 using t-test for comparison of means for independent samples. There was no significant difference in seedling emergence between north and south facing furrow sides for the two sowing times (p> 0.05). There was no significant difference for seedling emergence for north facing sides in both sowing times (p> 0.05). There was also no significant difference in seedling emergence pattern for south facing sides of both sowing times (p> 0.05). Hence from this study butternut seedling emergence is not affected by seed sowing side using the sowing methods studied.

Key Words: Crop stand, Glengarry, Waltham variety

INTRODUCTION

Butternut squash/winter squash (Cucurbita moschata Duchesne.), a summer crop usually targeted for the Christmas festive season in Zimbabwe, matures over four months thereby necessitating its late winter sowing when the danger of frost is past at the end of the month of August to early September for accurately targeting this market. One major problem in butternut production, therefore, is erratic emergence, mainly arising from too low soil temperatures for seed germination and emergence during this sowing time.

For butternut, soil temperature is a major determinant of seed germination speed and seedling emergence (Singh et al., 2001) and most studies have confirmed this crucial role of temperature. Germination temperature for butternut ranges above 15ºC while the optimum ranges between from 29ºC to 32ºC and the crop grows best at 23ºC to 29ºC (day) and 15ºC to 21ºC night (Anonymous, 2011). Kurtar (2010) found temperature as the single most important limiting factor in speed and success of germination with optimum values ranging from 27ºC to 30ºC and maximum of 45ºC. Napier (2009) and Maynard (2007) determined the base temperature for cucurbit seed germination to be 12.22ºC. At 16ºC, it takes 14 days for cucurbit seed to germinate, accelerating to 7 days at 20ºC and 4 days at 25ºC (Napier, 2009). Most of the foregoing conclusions were, however, entirely

based on laboratory conditions; hence may not sufficiently reflect response under field conditions.

Continuous light exposure for 24 hours for maize and Gomphrena perennis seeds were both found to significantly increase germination speed when compared to 12 hour exposure (Idikut, 2013; Acosta et al., 2012). In Hippophaes alicifolia exposure of seed to red and yellow light was found to be most effective in speeding germination (Rattan and Tomar, 2013). However, contrasting results were obtained for bean seed (unspecified species) with dark conditions significantly increasing germination success (Washa, 2015). Red light was reported to enhance germination speed in small seeds but less so in larger seeds of wild tropical tree species (Aud and Ferraz, 2012; Jala, 2011; Kettenring, 2006).Fifty-four arable weeds with large seeds studied by Milberg et al.(2000) were found to be more germination responsive to temperature rather than light. Elsewhere, far red light for some seeds was found to inhibit germination (Piskurwicz et al., 2009). But seed size alone is not the final determinant in light influence on germination, as has been found with some grass seed, where salinity was also concluded to be a major factor (Wu etal., 2015). Documented information for light influence on germination of cucurbit seeds, in particular, is scanty, particularly focusing on climatic conditions of the subtropical.

It is common practice for planting winter squash on ridges or mounds where soil texture is loam to clay loam for better soil drainage (Russ and Keinath, 2015; Boyhan et al., 2014; Newenhouse, 2011) regardless of the irrigation method used. This is because squash is sensitive to waterlogging related hypoxic conditions (Chiang et al., 2014; Barrett-Lennard, 2003) as this predisposes roots to soil diseases. Where furrow irrigation is used, the crop is established through seed drilling on top of the ridge or on the edges of ridges. Butternut squash growth and flowering performance on ridges or raised beds is superior to flat-bed planting (Baloch et al., 2013). It can, thus, be concluded that soil drainage is critical in successful squash production. The aim of this study was to find out whether seedling emergence of butternut squash sown on north and south facing sides of furrows gives different seedling emergence patterns and its relationship with both the soil temperature on day of sowing and prevailing daily mean temperatures during the two experimental periods of late winter.
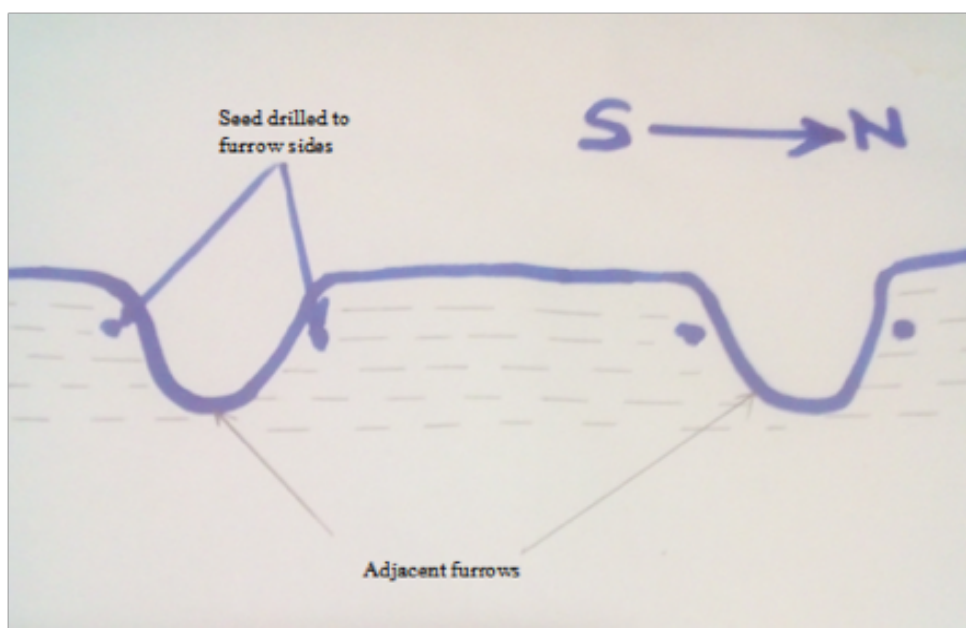

Figure 1: Cross section of two adjacent furrows with seed drilled into their sides

MATERIALS AND METHODS
Experimental site, land preparation and seed sowing

The site of the experiment was 7 Glengarry Crescent, Mahatshula (Grid ref. -20.124113: 28.630986), a peri-urban plot with clay loam semi-active black riverine soils, typical of Acacia sp. vegetation. Soils had traditionally been used for summer maize cropping for three years with stover retention and primary tillage and two weedings. The land used was leveled and 15 centimetre deep furrows made in east-west direction spaced one metre apart. Furrows were 35 centimetres wide and 7.5 metres long for the first sowing and 8.5 metres for second sowing to account for any seed deterioration due to delayed sowing of seed from the same packet. Furrows were one metre apart. Watering was done to field capacity 24 hours before seed drilling. Seed sowings of Waltham butternut variety (95 % germination rate) were done in late August and in early September (11 days difference in sowing dates). Sowing depth was five centimetres with in-row space of 25 centimetres on either side of furrows (Figure 1).Watering frequency was once in six days.

EXPERIMENTAL DESIGN

The experiment was set up in a 22 factorial with sowing times of 25 August and 5 September, and two sowing aspects on north and south-facing fur-row sides. Three replications were assigned to each sowing furrow side. For the first sowing, each furrow side had 28 planting stations while this was increase to 32 for the second sowing. Soil temperatures were recorded at three centimetre depths from four randomly selected spots on each of all six furrow sides a day after sowing. This was done hourly from dawn (0630 hours to 2100 hours). Mean daily ground surface temperatures were also recorded from sowing date up to 18 days after sowing (DAS).

DATA COLLECTION AND ANALYSIS

Data were recorded on counts of emerged seedlings starting nine DAS and ending at 18 DAS. Charts on cumulative seedling emergence and soil temperature variations were drawn to show trends for each treatment. The total emerged seedling counts at 18 DAS were analyzed using t-tests for comparison of means on SPSS Version 16.0 (2007 SPSS Inc.) after reducing the data counts to percent emergence. Ungerminated seed was retrieved and tested for germination in Petri dishes at room temperature (25ºC).

RESULTS
Seedling emergence rates
Seedling emergence percentages at 18 DAS gave higher values for the north facing furrow sides than south-facing sides except for T21 (replicates 1 for second sowing). However, furrow sides gave close values for the second sowing (Figure 2).
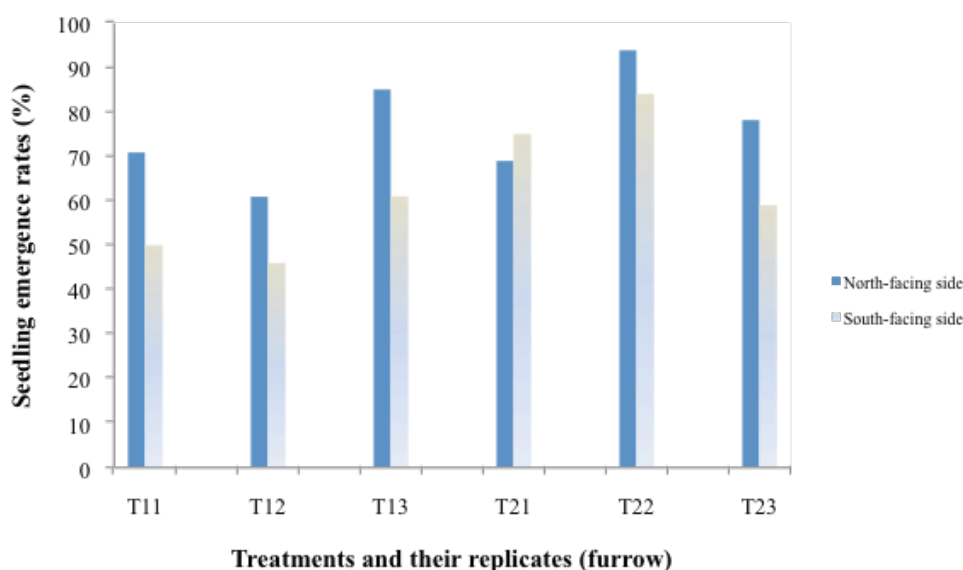

Figure 2: Comparative seedling emergence rates of seedlings at 18 DAS. Notes: T11-first sowing, replicate 1, T12- first sowing, replicate 2, T13- first sowing replicate 3, T21- second sowing replicate 1, T22- second sowing replicate 2, T23- second sowing replicate 3

T-TESTS RESULTS

The t-test for independent samples on seedling emergence percentage showed that:

For the first sowing, there was no significant difference in seedling emergence percentage on the north facing furrow side (M=72.6, SD=12.62) and south facing furrow side (M = 72.93, SD = 12.62) conditions; t(4) = 2.403, p = 0.074. For the second sowing, there was no significant difference in seedling emergence percentage on the north facing furrow side (M=80.17, SD=12.54) and south facing furrow side (M = 52.37, SD = 7.44) conditions; t(4) = 0.702, p = 0.522.

For two sowing times there was no significant difference in seedling emergence percentage for the north facing furrow side for early sowing (M=72.6, SD=12.54) and north facing furrow side for the late sowing (M = 80.17, SD = 12.62) conditions; t(4) = -0.958, p = 0.502. For two sowing times there was no significant difference in seedling emergence percentage for the south facing furrow side for early sowing (M=52.37, SD=7.44) and south facing furrow side for the late sowing (M = 72.93, SD = 12.63) conditions; t(4) = 0.428, p = 0.072.

SEEDLING EMERGENCE PATTERN

Earlier butternut sowing for both furrow sides (north and south facing) showed lower emergence rates than later sowing. In both planting times seedling emergence was slower on south facing sides than north facing sides. Later sowing gave near-geometric emergence rates (Figure 3)
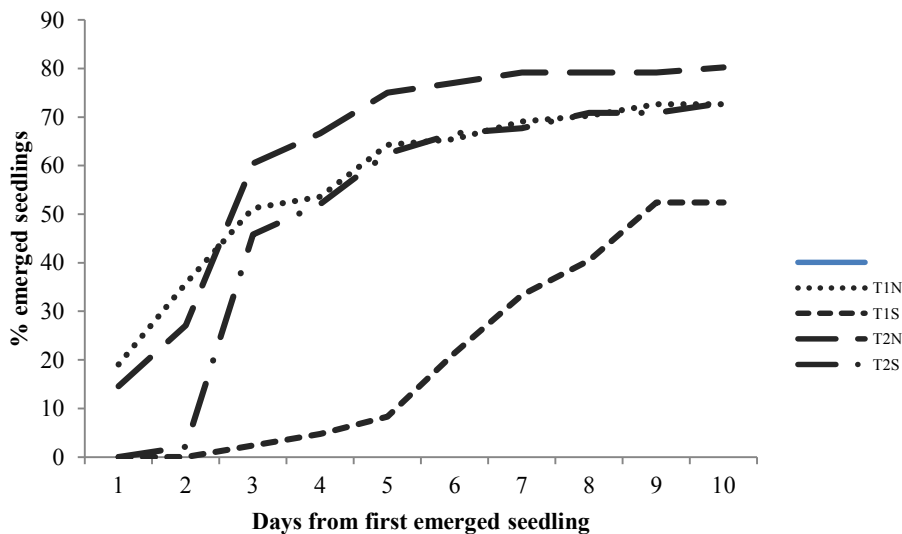

Figure 3: Patterns of seedling emergence for the two furrow sides and two sowing times.
Notes: T1N-first sowing north furrow side, T1S- first sowing south furrow side, T2N- second sowing north furrow side, T2S-second sowing south side

MEAN DAILY TEMPERATURES

For both sowing times, mean daily ground surface temperatures fluctuated widely for the duration of the experiment. The temperature means during the second seedling emergence period were generally higher than for the first sown seeds and emergence periods overlapped slightly (Figure 4).
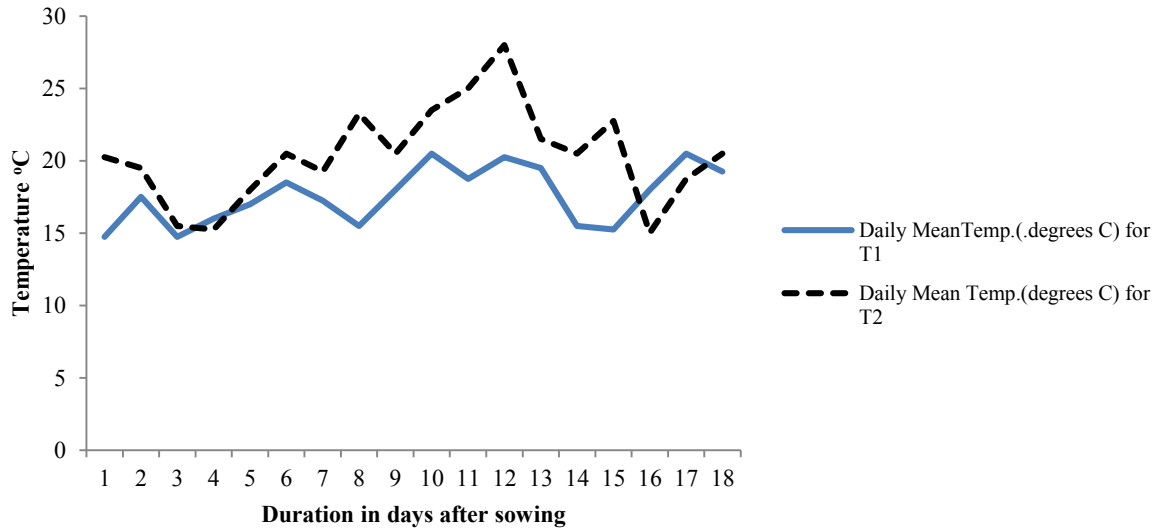
Figure 4:Variation for in-field ground level mean daily temperatures for both sowing periods T1-first sowing and T2-second sowing

SOIL TEMPERATURES

Soil temperatures one DAS were more depressed during the day for the first sowing than the second sowing. For both sowings, north facing furrow sides maintained higher temperatures three centimetres below ground than south facing sides (Figure 5).

Figure 5: Soil temperature variation at 3 cm soil depth from dawn to dusk one day after sowing.
Notes: T1N-first sowing north furrow side, T1S- first sowing south furrow side, T2N- second sowing north furrow side, T2S-second sowing south side

DISCUSSION

Soil temperature is the single most important factor in germination and, hence seedling emergence patterns observed in this study. Sowing method for late winter has to ensure that the soil receives enough irradiance to raise soil temperature well above the minimum 15ºC (Kurtar, 2010). Emergence percentages for each furrow wer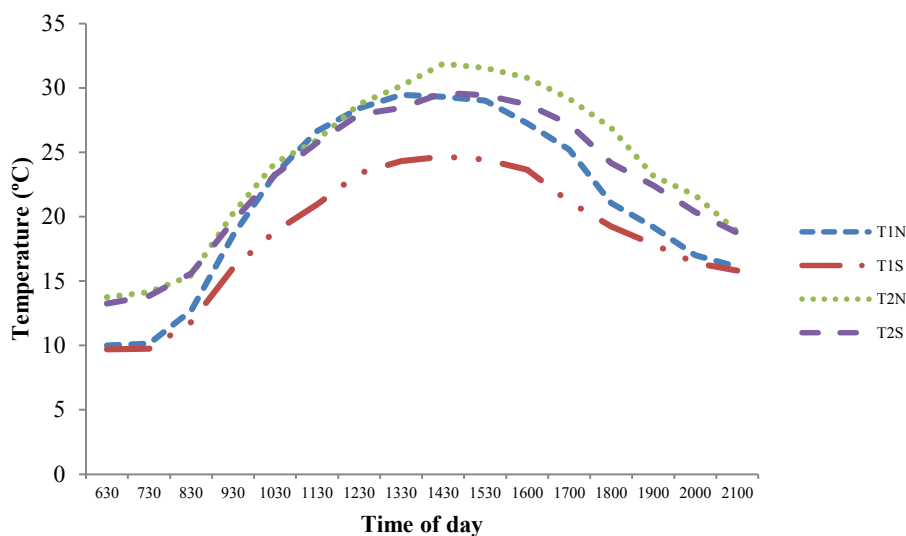e lower for the south facing furrow (Figure 2) although the two sides received the same amount of water at irrigation. Furthermore, both sides of each furrow were taken to be homogeneous in all soil characteristics as they were created from the same soil. The main factor to explain the differences in emergence rates was irradiance. Soil temperatures recorded at the experimental site were far too low to meet this requirement (Figure 5), particularly for the earlier sowing, and worse for seed drilled on south facing furrow sides. For the first sowing, soil temperature for night hours as implied by temperatures recorded at dawn (0630 hours) was well below the base temperature of 12.22ºC (Figure 5) determined by Napier (2009) and Maynard (2007). The slight rise in soil temperature between the first and second sowing times (Figures 4 and 5) gave higher emergence rates observed in Figure 3, and these findings corroborate those by Napier (2009). The germination patterns for the first sowing for the north facing side in Figure 3, which appeared similar to the pattern shown by the second sowing also supports findings by Napier (2009).Mean daily temperatures recorded at the ground level also confirm and explain the low soil temperatures recorded.

Those seeds that were exposed to more irradiance on north facing furrow sides also received more red light than on south facing sides which were largely shielded from direct sunlight during that part of the year. The emergence pattern observed confirms findings on other seed types in light requirements for seed germination (Rattan and Tomar, 2013; Idikut, 2013; Acosta etal., 2012). Findings of the emergence patterns may have other indirect influencing factors than soil temperature and irradiance as soil chemistry changes caused by prevailing temperature and irradiance differences were not investigated in this study. Besides individual seed differences of food content, placement orientation, maturity status, contact area with soil and other unforeseen factors could partially account for why other seeds germinated faster in the field than others for the same planting times.

CONCLUSION AND RECOMMENDATION

The two sowing positions and furrow sides gave no statistically different results. Hence, there is no statistically compelling reason to use either of the seed sowing sides from this study. Further research must be done to conclude otherwise.

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THE EFFECT OF COMBINED UREA AND MOLASSES TREATMENT OF MAIZE STOVER ON NUTRIENT COMPOSITION AND

PALATABILITY OF TREATED STOVER

(Pages 18-25)

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ABSTRACT

An on-farm study was carried out to determine the effect of treating maize stover with mixtures of urea and molasses on the nutrient composition and palatability of resultant feed. Maize stover was mixed with 5% urea and graded levels of molasses of 0, 10, 20 and 30 percent and incubated for 28 days before nutrient composition and palatability were determined. A palatability test was done using Afrikaner x Brahman steers fed in cafeteria style the differently treated maize stover. The nutrient composition of urea and urea-molasses treated stover was better than that of untreated maize stover with regards to crude protein, neutral detergent fibre, acid detergent fibre and hemicelluloses content (P<0.05). Neutral detergent fibre and acid detergent fibre content declined as the molasses component increased. Hemicellulose content was also significantly lower P<0.05) in treated stover than in untreated maize stover. The palatability of urea-molasses treated stover was significantly higher (p<0.05) than the urea only treated maize stover. Palatability ranking was higher for stover treated with 20% than that treated with 30% and 10% molasses levels, respectively. Molasses inclusion of up to 20% in the urea treatment of maize stover improves nutrient composition and palatability of treated maize stover.

Key words: cafeteria, urea- molasses, mixtures, steers

INTRODUCTION

Cattle in the smallholder sector in Zimbabwe are reared for productive purposes such as provision of manure, draught power and milk as well as for sales yet they experience large weight losses and high mortalities during the dry season (Nkomboni et al., 2014, Tavirimir-wa et.al. 2013). Poor performance of livestock is mainly due to shortage of quality dry season forage. Several ways of bridging the limited for-age supply such as ensiling, (Titterton & Maars-dorp, 1997, Mudzengi et.al., 2014) hay making as well as urea treatment of stover (Ngongoni et al., 2007) are possible. The first two options have not been adopted by many smallholder farmers due to high prioritization of cropping for human consumption than for livestock production (Nkomboni et al., 2014).

Although crop residues are widely acknowl-

edged to be a useful feeds, they are not utilized efficiently as they are usually grazed in situ (Nkomboni et al., 2014) and hence are subjected to trampling, soiling, termite damage and fires which result in low utilization of available crop residues (Hassen, Ebro, Kurtu & Terydte, 2010). While farmers practise collection and /or utilization of crop residues, very few farmers fortify the crop residues with proven methods such as urea treatment and at most they sprinkle stover with salt solution to improve palatability (Nkomboni et al., 2014).

Urea treatment improves the nutrient value particularly crude protein content but intake of such treated stover may be limited by palatability. Palatability could be improved by simultaneous urea and molasses treatment of crop residues. This technology has been used on wheat and rice straw with improved productivity in cattle (Biswas, Hoque, Kibria,Rashid & Akther, 2010), buffalo (Sarwar et al., 2012) and goats (Batool, Qama, Mirza & Khan, 2013). In Swaziland ensiling maize stover with urea and molasses improved crude protein content and reduced the neutral detergent fibre content of the resultant product (Mashwama, Ogwang & Makhabela, 1996). In other countries such as Pakistan urea-molasses treated straws can replace up to 30% of concentrate in fattening diets (Hassan, Nisa, Shahzad,. & Sarwa, 2011)

In Zimbabwe molasses has commonly been used as an additive to maize stover at feeding (Manyuchi, Mikayiri & Smith, 1994), but feeding this way tends to be cumbersome as molasses is added at feeding time. Communities have to find both cheap and effective locally available alternatives for making whole diet stock feeds that provide most of the animal's nutritional requirements.

OBJECTIVE
The objective of the study was to establish the effects of combined molasses and urea treatment of maize stover on the nutrient composition and palatability of the treated maize stover.

MATERIALS AND METHODS
Description of the study site
The research was carried out at Thursfield A1 farm in Bromley area in Goromonzi District, in Mashonaland East Province of Zimbabwe between October 2012 and January 2013. Bromley is known for beef production and the Department of Livestock Production and Development had records of a cattle herd of between 16 000 to 17 000 in 2012.

PREPARATION OF MAIZE STOVER
Maize stover was collected after harvesting the 2011/2012 grain crop and stored in a shed for four months for subsequent treatment. Before treatment, the stover was run in a hammer mill and crushed into small pieces of about 2 cm lengths. Four samples of untreated maize stover were collected and kept for further analysis. Two hundred and fifty kilogrammes of air dry maize stover was weighed and spread evenly on a clean sheet of plastic sheet. Ten kilogrammes of urea was dissolved in 40 litres of water and evenly sprinkled over the maize stover to have approximately 5% urea treatment. The Urea maize stover mixture was further divided into four equal portions for further treatment with molasses. One portion did not receive any molasses treatment and was divided into four equal portions which were packed in four plastic bags. The three remaining portions were treated with 5, 10 and 15 kilograms of molasses which were diluted with equal quantities of water to have 10, 20, 30% molasses inclusion in the urea treated maize stover. Each of the three urea-molasses treated stover treatments was thoroughly mixed before being divided into four equal portions and put into plastic bags. The materials were compressed in the plastics bags so as to expel air out, labeled and then tied up before placing them in a polythene sheet lined pit (3 m long by 1 m wide by 1.5 m deep. The bags were placed in four layers with each layer having a bag from each treatment. The pit was covered by a polythene sheet and soil and materials left to incubate for 28 days. Shade was constructed to protect the pit from rains. After 28 days the pit was opened and bags were opened to let out excess ammonia and stored in a shed until commencement of the palatability trial.

TREATMENT AND EXPERIMENTAL DESIGN

The experiment was run in a randomized complete block design with five treatments and four replications. Each layer of bags in the pit constituted a block.

The five treatments of maize stover were;
1. Untreated maize stover
2. Urea treated maize stover (UTMS)
3. Urea + 10% molasses treated maize stover (UTMS+10%M)
4. Urea +20% molasses treated maize stover (UTMS +20%M)
5. Urea +30%molasses treated maize stover (UTMS +30%M

CHEMICAL ANALYSIS

The samples of maize stover collected before mixing with urea and molasses and stored at room temperature and the sub-samples of the treated maize stover collected from each bag after incubation were sent to the laboratory for analysis. The samples were analyzed for dry matter (DM) content, crude protein (CP) content, neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose and ash content.

Dry matter was determined by drying the sample in at 100oC oven temperature for 24 hours. Crude Protein was determined by the macro-Kjeldahl method, using a factor of 6.25. Neutral detergent fibre and ADF determinations were based on the method of Goering & van Soest (1970) for herbage samples. Hemicellulose content was determined as difference between NDF and ADF content. Ash was determined by burning the sample in a muffle furnace at 5000C overnight.

PALATABILITY TRIAL

The palatability trial was run using urea treated maize stover and urea-molasses treated maize stover. The treated stover was fed to Afrikander x Brahman steers which were approximately two years old. Eight selected steers were dosed with Systemax worm remedy to control internal parasites and sprayed with Tick Buster to control ticks before commencement of palatability trials. The steers were introduced to urea treated maize stover diet two weeks prior to commencement of the palatability trial.

Four feeding pens were established; each pen had a water trough and four feeding troughs, placed at a spacing distance of 5 meters apart to ensure enough feeding space at all times. Two steers were randomly selected and allocated to each pen. The steers were offered 10 kg of treated stovers comprising 2.5 kg of each treatment placed in four separate troughs in each pen. The feed was offered for two hours from 9 am to 11am for four consecutive days. The order of placement of feeds in the troughs was randomised every day to avoid habit reflex. After two hours feed refusals were weighed and recorded and feed eaten was calculated as difference between feed offered and refusals. A palatability index was calculated for each treatment using the following equation;

$$Palatability\ index = \frac{Weight\ of\ feed\ treatment\ x\ consumed}{Weight\ of\ most\ preferred\ feed\ consumed} x100\%$$

DATA ANALYSIS

The data on nutritional composition and palatability trial was analysed using the following linear model;

$$Y_{ij}=\mu+\lambda_{i+}\beta_j+\varepsilon_{ijk}$$

Where;

Y_{ij}=Response variable. μ= Overall mean, λ_i= Treatment effect (treated stover).

β_j= Block effect ,ε_{ij}=Error term.

Treatment means were separated using standard error of means.

RESULTS

Nutrient composition of untreated and treated maize stover

As shown in Table 1, the dry matter content of the stover significantly ($P<0.05$) declined as molasses inclusion increased. The crude protein content of untreated maize stover was significantly ($P<0.05$) lower than that of urea and urea-molasses treated maize stover. There was no significant difference in crude protein content ($p<0.05$) between urea treated maize stover and urea molasses treated maize stover though there was a declining trend as molasses inclusion increased (Table 1). Neutral detergent fibre decreased with increase in molasses proportions. There was a significant difference ($p<0.05$) between untreated maize stover and Urea treated stover treatments. Among the urea treated treatments urea treated maize stover had significantly higher NDF content ($P<0/05$) than urea-molasses treated stovers. Among the urea-molasses treated stovers, urea+30% molasses had significantly lower NDF content than 10% and 20% molasses inclusion levels.

Although the values for the ADF were showing a general decrease from that of untreated maize stover, there was no significant difference between ADF content of untreated maize stover and urea treated maize stover or urea-molasses treated stover of 10 and 20 percent molasses inclusion. Significant decline in ADF content occurred at 30 % molasses inclusion level.

Hemicelluloses content also declined with inclusion of urea and molasses in treatment of the maize stover. There was a significant decline of hemicelluloses content between untreated maize stover and the other four treatments

Table 1: Dry matter (g/kg) and nutrient composition of untreated, urea treated and urea molasses treated   maize stover (g/kg DM)

Treatment	DM	CP	NDF	ADF	HC	Ash
MS	913[a]	38[a]	713[a]	460[a]	248[a]	55
UTMS	865[a]	128[b]	650[b]	463[a]	180[b]	45
UTMS+10Molasses	875[a]	118[b]	608[c]	428[a]	170[b]	45
UTMS+20Molasses	808[b]	115[b]	588[c]	450[a]	128[b]	48
UTMS+30Molasses	800[b]	110[b]	473[d]	303[b]	168[b]	55
SEM	15.8	24.9	5.5	7.18	10.3	7.9

DM=dry matter, CP=crude protein, NDF=Neutral detergent fibre, ADF=Acid detergent fibre,

HC= hemicellulose, MS= Maize stover, UTMS=urea treated maize stover

Ash content was not affected by stover treatment as there was no significant difference between ash content of untreated maize stover and that of urea only or urea-molasses treated maize stover.

PALATABILITY OF UREA TREATED AND UREA-MOLASSES TREATED MAIZE STOVER

There was a significant difference (p<0.05) in the palatability of urea treated maize stover and urea molasses treated maize stover. There was significant increase in palatability (p<0.05) with increase in molasses levels (Table 2). There was however no significant difference between 20% and 30% molasses inclusion levels. Urea treated maize stover was the least palatable (p<0.05). Among the urea-molasses treated stover 10% molasses inclusion was less palatable than urea treated maize stover with 20% and 30% molasses inclusion levels (p<0.05).

Table 2. Palatability Ranking-of urea and urea molasses fermented stover

Diet	% eaten	Palatability rank
UTMS	72.6[a]	4
UTMS+10Molasses	84.2[b]	3
UTMS+20Molasses	99.5[c]	1
UTMS+30Molasses	98.5[c]	2

UTMS= urea treated maize stover, UTMS +10Molasses= urea treated maize stover plus 10% molasses, UTMS +20Molasses= urea treated maize stover plus 20% molasses, UTMS +30Molasses= urea treated maize stover plus 30% molasses,

DISCUSSION

The dry matter content of urea-molasses maize stover treatments were lower than the DM content of untreated stover due to additional moisture that was used to make urea and molasses solutions. This is similar to findings by (Elkholy et al., 2009) where maize stover treated with molasses had dry matter content of 760g/kg.

Urea and urea-molasses treatment of maize stover improved the crude protein content due to ureolysis which generates ammonia which penetrates into the matrix of the stover thus elevating the nitrogen and hence crude protein content of the stover (Karimi et al., 2014). The decline in all fibre components measured is comparable to findings by Hirut, Solomon,& Mengistu (2011) who got similar results of 305g/kg DM ADF, 544g/kg DM NDF and 150g/kg DM hemicelluloses after treating with 3% urea and 5% molasses in rice straw. The reduction in fibre content could be due to higher moisture content of urea-molasses treated stover which increases the ammonia ions that permeate the matrix of the stover (Munozi et al, 1991) thus reducing the fibre content of the stover. The urea and molasses may also influence rumen micro-flora as such treated residues tend to have high NDF and ADF degradability (MacDonald, Edward & Greenhalgh, 2005). Luc et al. (2009) indicate that urea-molasses preparations activate fungal and bacterial digestion in rumen, with consequent increase in feed intake. The decline in fibre components could be due to the contribution of both urea and molasses to hydrolysis of cellulosic fibre (Karimi et al., 2014).

It appears that inclusion of molasses enhances fibre hydrolysis as the results of this study show lower NDF content than results of Mesfin et al. (2011) who used urea only to treat maize stover. The reduction of fibre components could be due to the solubilizing effects of urea and molasses

on the fibre fraction and subsequent degradation of cell wall contents as evidenced by low NDF, ADF and hemicelluloses content treated stover.

PALATABILITY OF UREA AND UREA-MOLASSES TREATED MAIZE STOVER

Molasses is used in compounded feeds to improve palatability. In this study palatability index increased as level of molasses increased, thus justifying its use in the stock feed industry. The increase in palatability up to 20 % molasses inclusion level may suggest that inclusion beyond this level may not be of advantage as far as enhancement of dry matter and crude protein intake is concerned.

Improved palatability may be due to sensory stimulation of the animals by the molasses scent and sweetness. Animals select one feed over another based on smell, feel, and taste (Baumont, 1996). In the case of the treated maize stover the differences could be attributed to smell and taste rather than texture as the stover base was chopped to similar sizes. Improved palatability of the stover could also be explained by the low concentration of weakened fibre components in urea-molasses treated maize stover (Sheikh et al ,2017. Palatability of feeds can be used to screen a number of different feeds before embarking on more costly digestibility, degradability and growth or production trials.

CONCLUSION

The inclusion of molasses in urea treatment of maize stover improved nutrient composition and palatability of the treated stover. Addition of molasses to urea treatment of stover did not significantly reduce the crude protein content of such treated stover for the range of molasses treatments used. Urea-molasses treatment of maize stover reduces the cell wall contents as evidenced by reduced NDF, ADF and hemicelluloses contents with increasing molasses levels. The study shows that molasses can be included up to 20% as higher levels do not seem to improve nutrient content or palatability of treated stover.

The study focussed on nutrient composition and palatability only. Further research can be done to focus on intake, digestibility and animal performance using various rations and different livestock species and classes.

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MULTIVARIATE ANALYSIS IN GROUNDNUT YIELD STABILITY AND ADAPTABILITY RECOMMENDATIONS FOR ZIMBABWE

(Pages 26-34)

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ABSTRACT

Groundnut is an important legume in Zimbabwe with a potential of improving peoples' livelihoods. Breeding programmes have not released new groundnut varieties to meet the ever changing needs of farmers and other stakeholders. Resources for most plant breeding programmes are very limited. Thus there is need to carefully select appropriate environments to test genotypes. The aim of this study was to determine the potential use of Additive Main Effects and Multiplicative Interaction (AMMI) and Genotype and Genotype-by-Environment (GGE) in assessing adaptation of new advanced groundnut lines to identify high yielding stable lines, the most ideal testing environment and to determine the presence of groundnut mega environments in the country. Yield stability and adaptation of 20 groundnut genotypes was evaluated in four environments Matopos, Lucydale, Gwebi and Kadoma during the 2014/15 season. The results of AMMI analysis indicated the presence of a scale genotype by environment interaction (p>0.05). From the AMMI biplot, genotype G8 was found to be the highest yielding genotype with dynamic stability and can be recommended for release as a commercial variety. Genotype G17 was relatively stable and can be released to meet communal farmer's needs because of its static stability. The Genotype and Genotype-by-Environment (GGE) biplot analyses using the environmental focusing plot grouped Matopos and Lucydale into one mega environment. Furthermore, using the environment vector biplot the study found the most discriminating environment for groundnut yield in thee four sites tested was Kadoma. Overall, AMMI and GGE combined gave a complete picture of the performance of the groundnut lines and the suitability of the test environments used in Zimbabwe.
Key words: AMMI, Arachis hypogea,
G × E, GGE

INTRODUCTION

The bulk of Zimbabwe's groundnut is produced by smallholder farmers mainly as a source of protein. However the high demand by the oil producing industry and confectioners makes it an important source of revenue that can contribute significantly to the economy. The groundnuts are mainly grown under dry land conditions and rank second to maize in terms of importance and area under cultivation (Tui et al., 2016).

Breeding to increase yield potential is an important objective in Zimbabwe's groundnut breeding and crop improvement programmes. Breeder's materials, including advanced

breeding lines and released genotypes are tested at many sites in Zimbabwe representing a wide range of environmental conditions. During evaluation of advanced breeding lines or released genotypes, there is a differential performance of given genotypes across environments due to genotype by environment (G × E) interactions (Crossa et al., 1999). This means that a high performing genotype in one environment does not necessarily perform as well in other environments. Such variation in responses slows down progress in progeny selections during breeding. Moreover, groundnut farmers in Zimbabwe have limited access to improved varieties. The most dominant source of seed for groundnut farmers is in the informal seed sector (Tui et al., 2016). Given the high costs and time

for testing genotypes in many sites representing the diversity of environmental conditions it is important to identify sites that discriminate groundnut yield difference in trials. For example soybean, rice and wheat breeding programmes in various parts of the world have investigated the importance the discriminating power of their environments (Atnaf et al., 2013; Tukamuhabwa et al., 2012; Letta, 2007; Samonte et al., 2005). The expansion of groundnut production using newer genotypes in new agro-ecologies necessitates a rigorous and continuous study of genotype by environment interaction across several representative environments.

Accordingly, determining groundnut yield stability and environmental adaptability is critical to understand cultivar performance. Breeders and farmers can be able to choose a cultivar which performs consistently across the representative production zones. G×E interaction is important in crop improvement because it affects the genetic gain, recommendation and selection of genotypes with wider adaptability. New approaches such as AMMI and GGE have the potential to estimate G × E so that informed decisions about genotypes and environments are made. Such studies inform National Agricultural Research Systems (NARS) and allow efficient use of resources. Therefore, this study sought to assess yield stability and adaptability of groundnut genotypes which are necessary before the release of varieties. The specific objectives of the study we therefore to i) assess the nature and magnitude of G × E interaction in groundnut production ii) identify genotypes with stability and adaptability for grain yield across selected agro-ecological regions of Zimbabwe and iii) determine which environments are ideal for evaluating groundnut yield.

MATERIALS AND METHODS
Study Sites and genotypes

The sites selected to investigate the yield stability and adaptability were Matopos, Gwebi, Lucydale and Kadoma to investigate yield stability and adaptability. Nineteen advanced breeding lines and a standard check variety (JL24) were used in the study and these were planted during the rainy season of 2014/15. These locations represent different agro-climatic conditions were groundnut is produced with Gwebi (Agroecological region IIa) representing the high-potential area with good rains and soils, Kadoma (Agroecological region IIb) representing the intermediate potential area with average rainfall, Lucydale and Matopos (Agroecological region IV) representing the low potential area with erratic, low rainfall and poor soils (Table 1). These areas are also characterized by different soil types, which range from the Red-clay soil at Gwebi, Red loam soils at Kadoma and Red clay at Matopos and Sandy soils at Lucydale.

Table 1. Description of the four selected experimental sites used to evaluate grain yield during the 2014/2015 season in Zimbabwe

Site	Location	Altitude	Max temp	Min temp	Coordinates	Soils	Rainfall (mm)
E1	Matopos	1138	25	12	20^0S/$28^0$31E	Red clay	591
E2	Lucydale	1250	25	13	$20^0$24S/$28^0$25E	Sandy	570
E3	Kadoma	1149	28	14	$29^0$53E/$17^0$41S	Red loam	735
E4	Gwebi	1148	22	13	$30^0$53E/$18^0$19S	Clay	750

EXPERIMENTAL DESIGN AND LAYOUT

The trials were in a Randomized Complete Block Design (RCBD) replicated twice with each genotype sown in 4 m x 3 m plots spaced at 45 cm inter-row and 10 cm intra-row. Basal Compound D was applied at planting at a rate of 200 kg/ha. The trials were rainfed across all the sites. Topdressing with Ammonium Nitrate (34.5% N) was applied at a rate of 150 kg/ha after six weeks from germination. Weeding was done using hoes at all trial locations. The data considered for test was from the selected plants from net plot, thus the two centre rows.

DATA COLLECTION AND ANALYSES

Data of each genotype were standardized to 10 % moisture content and converted into kilogrammes per hectare. The combined yield data across all locations were subjected to analysis of variance. AMMI and GGE biplots were constructed using Genstat 17th edition (Payne et al., 2010). AMMI was based on a model Gauch (2006) and GGE was based on the model for two Principal components according to Yan and Tinker (2006) equation 1 and 2 respectively.

Where Y_{ij} is the measured mean of ith genotype in j^{th} environment, μ is the grand mean, G_i is the main effect of ith genotype, E_j is the main effect of jth environment, λ_n is the singular value (SV) for the first principal component (PC1), ξ_{in} is the eigenvector of genotype I for PC1 , ηjn eigenvector of environment j for PC1, respectively ε_{ij} is interaction between i^{th} genotype and j^{th} environment

$$Y_{ij} - \mu - \beta j = \lambda_1 \xi_{i1} \eta_{j1} + \lambda_2 \xi_{i2} \eta_{j2} + \varepsilon_{ij} \dots\dots\dots (2)$$

Where Yij is measured mean of genotype $i(=1,2,....,n)$ in environment j $(=1,2...,m)$, μ is the grand mean, βj is the main effect of environment j, $\mu + \beta j$ being the mean yield across all genotypes in environment j, $\lambda 1$ and $\lambda 2$ are the singular values (SV) for the first and second principal component (PC1 and PC2), respectively, $\xi i1$ and $\xi i2$ are eigenvectors of genotype I for PC1 and PC2, respectively, $\eta 1j$ and $\eta 2j$ are eigenvectors of environment j for PC1 and PC2, respectively, εij is the residual associated with genotype i in environment j.

RESULTS

AMMI analysis of variance

The results from the AMMI analysis of variance for grain yield showed high significance for genotypes and environments (P<0.01) (Table 2) .The large sum of mean squares for environments indicated that they were diverse in their contribution to yield of the test genotypes. The two Principal components explained 84% of interaction component though G×E interactions were not significant suggesting the presence of a scale interaction in groundnut yields.

Table 2. ANOVA using AMMI model for 20 genotypes evaluated at four sites during 2014/15 season

Source	df	SS	MS	F	F-probability
Total	159	7237729	45520	-	-
Treatments	79	6088598	77071	5.60	0.00000
Genotypes	19	623827	32833	2.39	0.00405
Environments	3	4296614	1432205	55.46	0.00000
Block	4	103294	25824	1.88	0.12320
Interactions	57	1168158	20494	1.49	0.05229
IPCA	21	609885	29042	2.11	0.00977
IPCA	19	384291	20226	1.47	0.12153
Residuals	17	173982	10234	0.74	0.74863
Error	76	1045837	13761	*	*

Genotype and environment yield performance and cross-over interactions

Across environments, the highest grain yielding genotype was G8 with an average of 485.9 kg/ha. The results show that G9 was the highest yielder with 742.3 kg/ha in the highest yielding environment Kadoma. The lowest yielding genotype across all environments was G1 with a mean yield of 250.9 kg/ha (Table 3).

Table 3. Genotype Mean and environ mean for 20 groundnut advanced genotypes for yield evaluated across 5 environments

Genotype code	Pedigree	Matopos	Lucydale	Kadoma	Gwebi	Genotype mean	IPCA1	IPCA2
G1	ICGV-SM99566	250.9	90.0	364.7	395.0	275.2	- 0.70783	6.03113
G2	ICGV-SM08586	296.7	195.3	461.7	747.4	425.3	- 9.84037	1.11078
G3	ICGV-SM01514	408.4	263.8	618.9	494.0	446.3	3.65845	4.02455
G4	ICGV-SM07544	376.1	216.3	484.3	536.9	403.4	- 1.41400	5.99547
G5	ICGV-SM00537	253.8	172.4	742.2	280.1	362.1	12.52161	-2.97802
G6	ICGV-SM06737	290.8	179.2	576.2	466.6	378.2	2.44852	0.92435
G7	ICGV-SM08583	181.1	187.9	741.7	668.1	444.7	-1.31228	-10.2379
G8	ICGV-SM07517	395.2	285.5	681.8	581.0	485.9	2.13934	0.77756
G9	ICGV-SM06637	211.1	168.0	742.3	417.4	384.7	7.47906	-6.21461
G10	ICGV-SM08572	178.5	105.5	494.3	558.5	334.2	-3.72466	-2.24915
G11	JL24	200.0	125.6	586.0	448.9	340.1	2.45402	-2.68956
G12	ICGV-SM99568	184.6	188.8	668.8	786.5	457.2	-7.09265	-9.43891
G13	ICGV-SM99537	335.9	207.0	578.3	470.9	398.0	2.77302	2.57936
G14	ICGV-SM05738	101.2	29.5	408.0	504.9	260.9	-4.74753	-2.26963
G15	ICGV-SM07540	192.8	89.9	519.5	355.3	289.4	3.92032	-0.06618
G16	ICGV-SM99551	356.0	249.9	645.3	560.9	453.0	1.55948	0.48434
G17	ICGV-SM07553	309.6	213.3	588.4	598.2	427.3	-1.53813	-0.18141
G18	ICGV-SM06525	316.7	193.3	450.9	675.2	409.0	-7.47386	3.01501
G19	ICGV-SM08577	267.1	133.6	405.0	551.7	339.3	-4.87645	3.75591
G20	ICGV-SM06519	351.0	169.3	462.4	361.1	335.9	3.77392	7.62692
Mean		272.9	173.2	561.0	522.9	382.5		
SE±		18.9	14.1	26.5	29.5			

IPCA- Interaction Principal Component, SE-Standard error of the mean

AMMI Biplot

The AMMI bi-plot showed that the four 4 environments fell into two different regions; namely a low yielding zone and the high yielding zone with most of the genotypes clustered around the midpoint (Figure 1). G6 and G9 represented average yield, G15 and G17 are very stable and found on the zero line. G8 exhibited dynamic stability as it performed well irrespective of the site and prevailing environmental conditions. Matopos (E1) and Lucydale (E2) environments were low yielding. G6 exhibits static stability (tends to maintain a constant yield across environments).
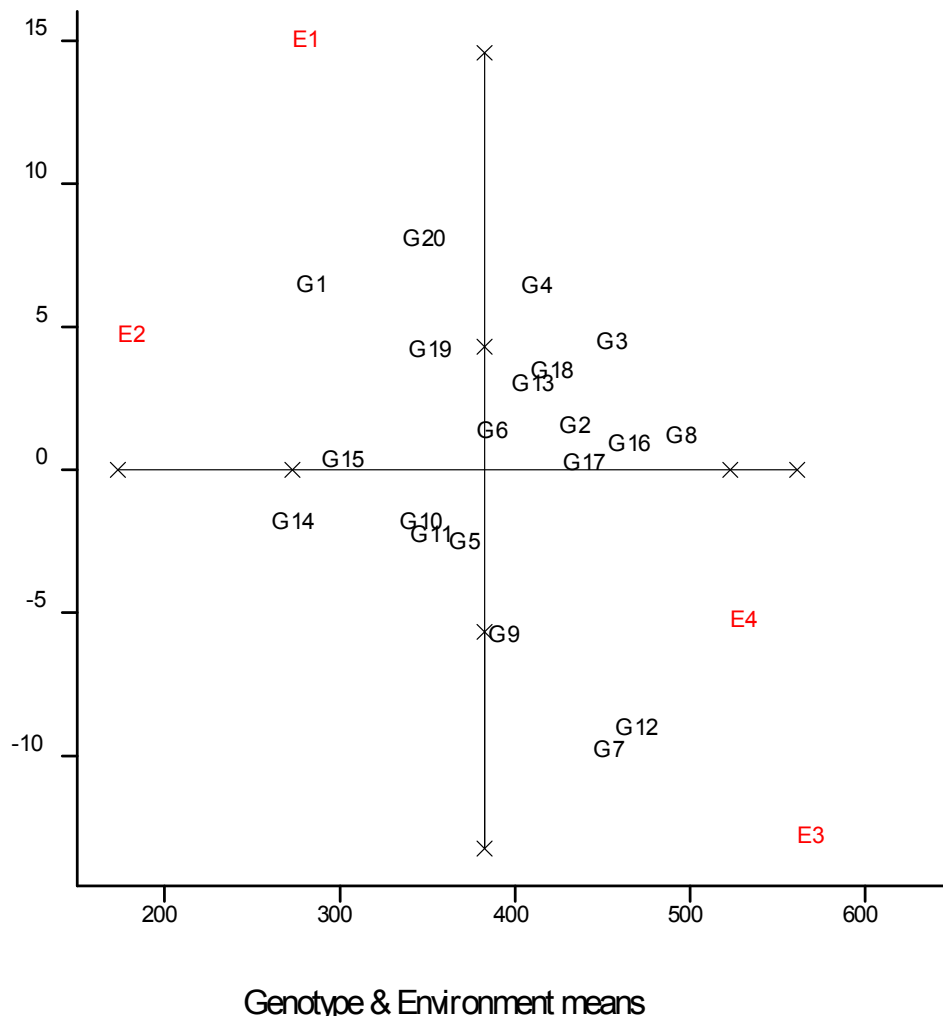
Figure 1. Biplot of Principal Component Analysis (PCA) versus Mean Yield (kg ha^{-1} of 20 genotypes grown in four test   environment during 2014-2015 seasons in Zimbabwe

MEGA ENVIRONMENT ANALYSIS

In this study three mega environment with different winning (best) genotypes were identified using a scatter plot with polygon bisectors (Figure 2). In mega-environment identification process, furthest genotypes are connected together to form a polygon, and perpendicular lines are drawn to form sectors to visualize the mega environments. Three mega environments for groundnut production were identified, Matopso (E1) and Lucydale (E2) formed one mega environment, whilst Kadoma (E3) and Gwebi (E4) formed two separate environments.

DISCRIMINATING ABILITY OF ENVIRONMENTS

The environment vector biplot identified Kadoma (E3) and Gwebi (E4) as highly discriminating for the genotypes tested as shown by the large environment vectors (Figure 3). A long environment vector represents good discriminating ability for a given environment. Lucydale (E2) was the least discriminating of the four environments, as evidenced by the short environmental vector.

Figure 2. An environment focused bi-plot showing "winning" genotypes for the different environment for grain yield at the four environments during 2014-2015 season in Zimbabwe

DISCUSSION

In this study, the results showed that the AMMI model is a useful technique in identifying groundnut genotypes with high yield performance, candidates with high stability and wider adaptation. The AMMI ANOVA also indicated a scale interaction which implies that groundnut genotypes performed consistently across the four environments. Genotype G17 was the most stable genotype and the mean across all environments was significantly higher than other genotypes therefore it can be cultivated in any of the environments without much variation on its yield. However, G8 had more dynamic stability which is a recommended attribute which allows it to respond to better environments which translates to greater yields. G6 which gives average yields has high stability across the tested environments and such a genotype can be recommended for high stability and adaptation. This genotype has static stability and therefore recommended for low input systems such as the smallholder farmer environments (Tukamuhabwa et al., 2012).

The environmental means are a true reflection of the productivity potential of the test locations. Gwebi falls under high potential area followed by Kadoma in the intermediate potential zone and Matopo and Lucydale being the least potential of them all much characterized with poor sandy soils and low rainfall. The mega-environment identification involved clustering of environments with similar performance hence Matopos and Lucydale were grouped into one environment meaning in the future costs of raising multi-locational trials will be reduced by putting that effect into consideration. Furthermore the discriminating ability of the environment for groundnut yields seems to be related to the productivity of the particular environment.

Which-won-where plot (Yan et al., 2007) identified best winners for that mega-environment or sector. So this enables the researcher to have specific and valid justification to recommend genotypes which are good for that particular environment. This also means the genotypes can be tested in those few mega-environments and still good yield data results being obtained. G8 came first despite the relatively low potential for groundnut grain yield at Lucydale, implying that it had good dynamic stability. It is an important attribute for any commercial variety. This study laid the basis for exploiting GE not only to identify stable genotypes but to classify environments into mega environments and identify the most discriminating, high yielding and stable environments for groundnut production in Zimbabwe using AMMI and GGE.

RECOMMENDATIONS AND FUTURE PERSPECTIVES

AMMI and GGE combined give a complete picture on the nature and magnitude of G×E. The best genotype for release to communal farmers is G17 and for commercial production is G8. The best testing environment for groundnuts is Kadoma.

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THE EFFECT OF ANNUAL RANGELAND FIRES ON THE SOIL SEED BANK OF HERBACEOUS SPECIES IN A SEMI-ARID AREA IN SOUTH-WESTERN ZIMBABWE

(Pages 35-43)

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ABSTRACT

The effect of veld fires was investigated in rangelands in south-western Zimbabwe. The objectives were to establish the effect of frequent veld fires on the soil seed bank of herbaceous species. The effect of fire was investigated at 0-3cm, 3-6 cm and 6-9 cm soil depth. Six plots were marked at each site. A species composition survey was done in the plots and 32 grass species were identified. The annually burned site was burned before soil collection. Soil samples were collected in sequence at soil depths of 0-3, 3-6, and 6-9 cm from both sites. The samples were spread on heat sterilized sand in a greenhouse for germination tests. A total of 1472 plants emerged but only 477 survived to stage of species identification. A total of 21 and 18 species including forbs and sedge were identified from the germination tests of unburned and burned site samples, respectively. Grasses dominated both sites and there were no significant differences (P<0.05) in germination frequencies of the plants between the burned and unburned sites. The results of the trial showed that viable seeds are abundant in the upper horizon while the middle and lower horizons did not show significant differences. The frequency of increaser and decreaser species did not differ significantly between sites. Both sites were dominated by decreaser species in the 0-3 cm depth.

Key words: decreasers, increasers, germination, frequency

INTRODUCTION

Uncontrolled rangeland fires are common in semi-arid areas of Zimbabwe and most are due to anthropogenic activities (Nyamadzawo et al., 2013, Zisadza-Gandiwa, 2014). Fires disrupt the environment by changing species composition and richness through suppression of non-fire resistant while promoting fire tolerant species (Synman, 2004). Fires may reduce biomass production (Oluwole, Sambo & Dube, 2008) due to reduced plant density, seed bank destruction and weakened species (Synman, 2005), leading to reduced rangeland productivity.

The rangeland provides primary products such as food, water oxygen and fuel to living organisms. In agriculture, rangelands provide nutrients to livestock raised under extensive systems. Productivity from rangelands can be sustained if they are able to restore primary production. Restoration of rangelands lies in seed and plant root reserves (de Villiers, vanRooyen & Theron, 2003) which ensure sustainability. A viable seed bank is considered a first step for the design of ecological restoration plans due to the ability of the seeds to germinate and emerge quickly (Zaghlou, 2008). In extensive livestock production systems, seed banks are important as they affect species regeneration and feed availability. Soil seed banks can be disturbed or lost, through deep burial, poor rangeland management practices, pathogenic destruction, granivores and rangeland fires. Fires contribute significantly to seed bank loss as fire can wipe out all upper vegetation and epigeal seeds if it occurs when vegetation is very dry (Svotwa et al., 2007).

Seed bank disturbance or loss can lead to low carrying capacity due to long term changes in plant species composition and herbage production (Synman, 2005), thus affecting the proportion of decreasers, increasers and invaders, as defined by Oudtshoorn (2014). Decreaser grass species are palatable climax grass species that are abundant in good rangelands but decline when rangeland is over or undergrazed. The increasers are divided into three groups that is increaser I, II and III where increaser I species are relatively unpalatable climax grass species that are abundant in underutilized rangelands,

increaser II species are unpalatable pioneer and sub-climax grass species which are abundant in overgrazed rangelands and increaser III species are unpalatable climax grasses found in overgrazed rangelands. The effect of fire is governed by type and intensity of fire, season of burning and frequency of burning (Trallope & Trallope, 1999). The frequency of fires in Zimbabwe has increased (EMA, 2011) and hence the effect on seed reserves needs to be known to enable restoration plans to be instituted.

OBJECTIVES

The objective of the study was to determine the extent to which annual rangeland fires affect the soil seed reserves of herbaceous species at different soil depths in a clay soil.

MATERIALS AND METHODS

Site Description

The study was carried out at two adjacent farms, Mahiye farm and Tshabalala Game Sanctuary located 20o18.288`S and 28o 32.00` E at an altitude of 1402 m. Mahiye farm is a section of Matopos Research Institute while Tshabalala Game Sanctuary is a section of the Parks and Wildlife Authority game reserve. The two farms have similar vegetation and soil types and receive average rainfall of 450 mm per annum with the possibility of severe droughts. The average maximum and minimum temperatures are 21.6oC and 11.4oC respectively. The soil type is meta-volcanic derived reddish and brownish sandy clay soils. Prevalent tree species include Acacia karoo, A. nilotica, A. rehmannia, Ziziphus mucronata and Dichrostachys cinerea while the most common grass species are Heteropogon contortus, Hyperrhenia filipendula. Hyperrhenia dissoluta, Eragrostis superba and several Aristida and Cymbopogon species. Mahiye farm had a history of annual veld fires for at least five consecutive years spanning from 2008-2012, while Tshabalala Game Sanctuary had been free of veld fires for at least four consecutive years preceding the study year.

EXPERIMENTAL DESIGN AND SAMPLING

Site preparation was done during the dry season from August to October 2013. Six transect lines were randomly sited on each of the two sites. A plot measuring 10 m x10 m was randomly fitted along each transect. Herbage in plots at the annually burned site was burned in situ to continue the annual fire regime, while that in plots at the unburned site was slashed before the onset of the rains. Each plot was protected from fire hazard by clearing 2 m around the plot perimeter. The plots were used for in-situ plant species composition assessments as well as to provide soil samples for the germination trial.

In-situ species composition assessment

In-situ species composition was assessed in March 2014 along each transect using the wheel pointer method. The plant closest to the marker was identified and recorded after each full turn. The number of hits for each species was used to calculate the frequency of occurrence.

GERMINATION TRIAL

The germination trial was a factorial experiment run in a completely randomized design. The two factors were frequency of fire and soil depth. Fire had two levels namely, unburned and annually burned sites. Soil depth had 3 levels of 0-3, 3-6 and 6-9 cm depths. Six soil samples comprising of two sub-samples from each of the three soil depths were collected from each plot. The soil samples were collected using a soil bulk density kit with cylindrical core measuring 5 cm height and 5.2 cm diameter.

The germination trial commenced in January 2014 and sand was used as the medium for germination. The sand was collected and heat sterilized by heating over an open fire to kill any seeds that may have been in the sand. Test for medium sterility was done by watering samples of the heat sterilized sand for three weeks. The heat sterilized sand was put in plastic pockets measuring 15 cm height and 20 cm diameter. Soil collected from the two sites was added on top of heat sterilized sand and spread evenly so that soil depth did not exceed 10 mm. The soil was watered to keep it moist and germination observed daily for thirty days, the period in which most germination should have occurred (Hussain, Queresh, & Shaukat, 1989; Ferrandis, Herranz & Martinez-Sanchez, 1999; Maren & Vandik, 2009). Germinants were counted every day and cumulative counts recorded. Plants were separated into broad categories of grasses, sedges and forbs. Species identification was done at earliest possible time as determined by the species.

The data was analysed using SAS for windows version 9.3 of 2014. Germination counts were log transformed before subjecting to analysis of variance. The linear model used on the transformed data was as follows;

Results

In-situ species distribution

Twenty nine species including sedges and forbs were recorded at the two sites. Grass species were dominant with 21 and 18 species recorded at the burned and non-burned sites, respectively. Grasses from the t main ecological grass groups of decreasers and increasers were among the major species at both sites (Table 1). Grass species found in low frequency of occurrence at the unburned site were Aristida congesta sub-species barbicolis, Cymbopogon pospischilii,

$\Upsilon_{ijk} = \mu + \lambda_i + \beta_j + \lambda\beta_{ij} + \varepsilon_{ijk}$, where;

Υ_{ijk} = plant species composition and abundance (representing

μ = Population mean

λ_i = Effect of fire

β_j = soil depth effect

$\lambda\beta_{ij}$ = interaction of frequency of fire and soil depth

ε_{ijk} = error term

Eragrostis superba, Setaria incrassata, Sporobolus pyramidalis, and Themeda triandra. In the burned site species of low frequency of occurrence included Ischaemum afrum, Andropogon gayanas, Eragrostis species, Hyperrhenia filipendula, Panicum maximum and Panicum natalense.

The burned site had more species diversity with six decreaser species compared to three species in the non-burned site. All the decreaser species found in the non- burned site, D. milanjiana, T. triandra and S. incrasatta were also present in the burned site. Eight increaser species were common to both sites and these were, B. insculpta, B. eruciformis, H. contortus and Urochloa mozambicensis, Loudetia simplex, S. pumila, Chloris virgata and C. pospischilii. The annual increaser II species Tragus berteronianus was identified only on the burned site while Aristida barbicolis and Melins repens were exclusive to the non-burned site. Perennial Increaser species were dominant on the burned site contributing 57.53% while decreasers, annuals and forbs and sages contributed 27.08%, 4.84% and 11.53% of the herbaceous plants respectively. On the non-burned site 38.64%, 24.79%, 15.79% and 20.78%

of identified herbaceous plants were perennial increasers, decreasers, annual increasers and forbs and sages respectively.

Table 1. Frequency of occurrence of occurrence of grass species, forbs and sedges in burned and non-burned sites

Grass species	Ecological status	Grazing value	Frequency in burned site (%)	Frequency in unburned site (%)
Brachiaria negropedata	Decreaser	High	12.18	0.00
Digitaria milanjiana	Decreaser	High	8.94	21.48
Panicum maximum	Decreaser	High	1.54	0.00
Panicum natalense	Decreaser	Low	1.22	0.00
Setaria incrasatta	Decreaser	High	1.40	0.56
Themeda triandra	Decreaser	High	1.98	2.22
Eragrostis spp	Increaser	Average	0.65	0.00
Andropogon gayanas	Increaser I	Average	0.68	0.00
Hyperrhenia filipendula	Increaser I	Average	0.07	0.00
Ischaemum afrum	Increaser I	Average	0.43	0.00
Aristida congesta subsp barbicolis	Increaser II	Low	0.00	0.53
Bothriochloa insculpta	Increaser II	Average	3.27	7.41
Brachiaria eurociformis	Increaser II	Average	21.44	12.01
Chloris virgata	Increaser II	Average	0.07	5.36
Cynodon dactylon	Increaser II	High	8.55	0.00
Eragrostis rigidior	Increaser II	Average	0.00	0.17
Eragrostis superba	Increaser II	Average	0.00	3.64
Heteropogon contortus	Increaser II	Average	18.1	2.48
Loudetia simplex	Increaser II	Average	0.50	0.63
Melinis repens	Increaser II	Low	0.00	0.07
Setaria pumila	Increaser II	Average	4.02	8.93
Sporobolus ioclados	Increaser II	Average	0.68	0.00
Sporobolus pyramidalis	Increaser II	Low	0.00	3.77
Tragus berterenonianus	Increaser II	Average	0.25	0.00
Urochloa masambicensis	Increaser II	Average	1.58	7.48
Cympopogon pospischilii	Increaser III	Low	0.61	0.36
Other grass species	-		2.62	4.77
Forbs.	-		10.81	19.32
Sages (*Cyperaceae*)	-		1.46	-

GERMINATION OF SPECIES FROM THE SOIL SEED BANK

There were no significant differences in germination frequency of grasses, forbs and sedges from soils derived from both the burned and unburned sites (Figure 1). Only 33.4% of the plants that geminated survived to a stage where they could be identified to species level.

Source of soil did not significantly (P<0.05) affect survival of plants with 53.9% and 46.1% of plants surviving on soils collected from the burned and unburned sites respectively. The number of emerging seedling decreased as soil depth increased. Eight perennial and seven annual species germinated f5rom the soil seed bank (Table 2). Only
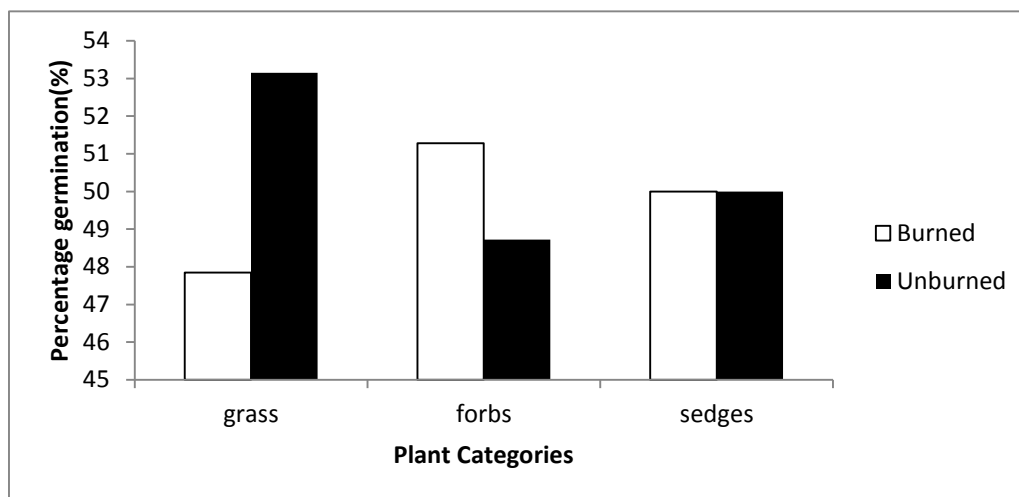
Figure 1 Germination frequencies of major herbaceous plant categories

five common major species identified in-situ were identified from the soil samples from each site. The species were Bothriochloa insculpta, Heteropogon contortus, Brachiaria eruciformis Setaria pumila and Chloris virgata. Fewer species, 18, were identified from the germination trial as compared a total of 32 identified species at the two sites. It was also observed that soils derived from the two sites yielded different herbaceous plant species. Germination of herbaceous plants was higher in the upper soil layer of 0-3cm than lower depths except for B. insculpta which had high and low germination counts from the middle and the top soil layers respectively. There were no significant differences in grass germination frequency for both sites. However, there was significant difference (P<0.05) in germination frequency of grass species when placed in ecological categories (Figure 2). The germination frequency of decreaser species decreased as the soil depth increased with highest frequencies recorded in the 0-3 cm depth layer and lowest with no decreasers germinating at 6-9 cm soil depth. The same trend was recorded for soil collected from the non-burned site.

As with decreasers, the frequency of increaser species was high at the burned site at about 30% in the 0-3 cm soil depth layer and declined to 6 % in the 6-9 cm layer depth. Invader species distribution was similar for 0-3 cm and 3-6 cm soil depth and declined to less than 10% in the 6-9 cm soil depth layer. Frequency of invader species was not significantly different (P<0.05) across soil depth for soils collected from the unburned site.

The germination trend for forbs showed an increase with increasing soil depth for the burned site and decreasing frequency with increasing soil depth in the non-burned site.

DISCUSSION
Effect of fire on in-situ herbaceous plant distribution

The greater species diversity on the burned site may be explained by the fact that plant species found in the savannas have evolved in a fire sub-climax ecosystem hence they have adapted and resist damage from surface fires (Banda, Swartz & Caro, 2006; Tainton, 1999). In these

Table 2. Germination frequencies (counts) of herbaceous species as influenced by burning and soil depth

Species	Life form	Ecological status	Burned site Depth cm)			Unburned site Depth (cm)		
			0-3	3-6	6-9	0-3	3-6	6-9
Panicum maximum	Perennial	Decreaser	3	0	0	4	0	0
Panicum natalense	Perennial	Decreaser	-	-	-	1	0	0
Setaria incrassata	Perennial	Decreaser	8	3	0	0	2	0
Bothriochloa insculpta	Perennial	Increaser II	16	6	1	6	16	9
Cynodon dactylon	Perennial	Increaser II	-	-	-	1	0	0
Hyparrhenia filipendula	Perennial	Increaser I	0	2	0	9	3	0
Digitaria ternata	Annual	Increaser II	9	1	0	-	-	-
Eragrostis superb	Perennial	Increaser I	0	1	0	1	0	0
Digitaria velutina	Annual	Increaser II	14	5	3	12	3	3
Heteropogon contortus	Perennial	Increaser II	9	5	5	9	3	0
Brachiaria eurociformis	Annual	Increaser II	9	6	7	25	17	11
Chloris virgata	Annual	Increaser II	3	1	0	-	-	-
Setaria pumila	Annual	Increaser II	1	0	0	-	-	-
Setaria verticillata	Annual	Increaser II	4	0	0	8	1	2
Tragus berteronianus	Annual	Increaser II	4	0	0	2	0	0
Cyperaceae	-	-	17	8	11	31	20	26
Forbs	-	-	10	9	64	23	10	5
Total number of plants			103	57	91	123	72	40
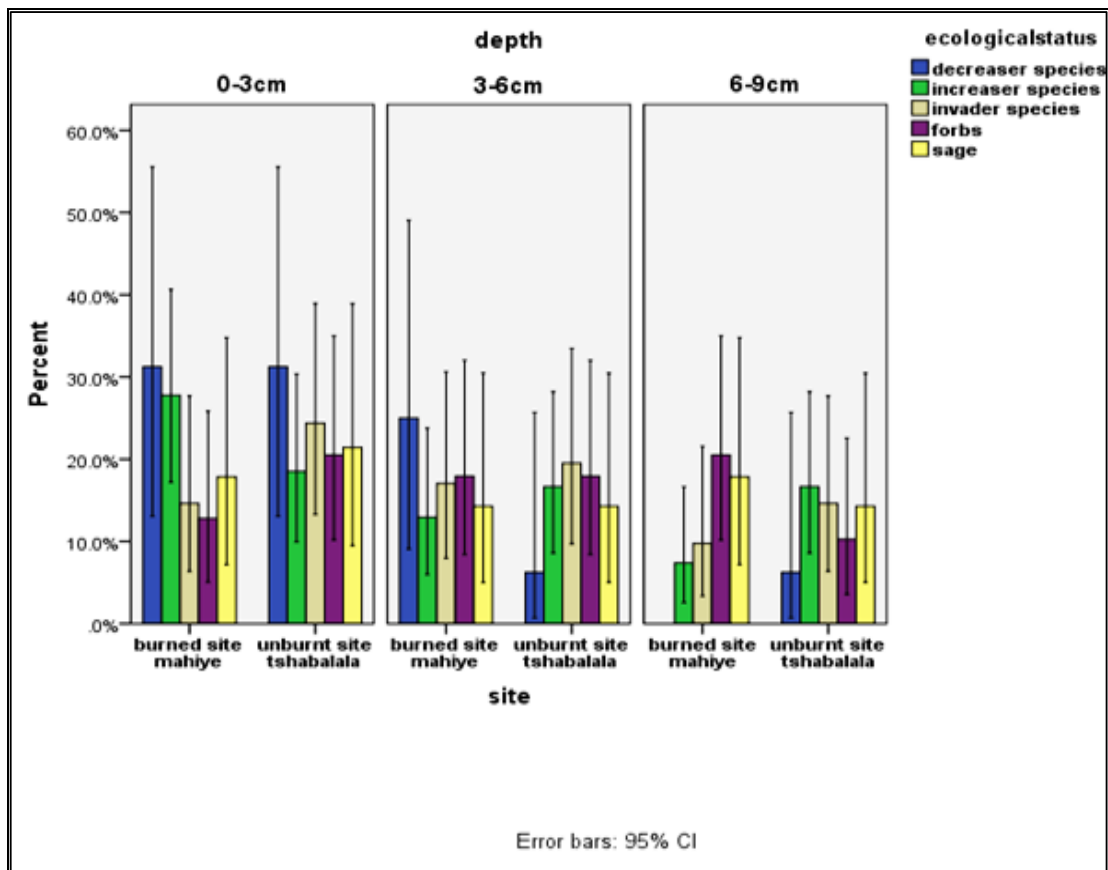
Figure 2. Germination frequency (%) of the ecological classes of herbaceous plants

ecosystems exclusion of fire for a long time can reduce regenerative potential of most species due to accumulation of dead material (Mabuza, 2011) or seed dormancy.

Seed dormancy may be broken by fire through direct heating of soil and seed bank (Tyler,1995), temporary reduction in competition by removal of vegetation (Kinloch and Friedel 2005). The domination of the unburned site by annual increaser II species may be indicative of underutilization of species through grazing and subsequent deterioration of the rangeland due to top hamper accumulation. Evidence of low veld condition is presented by the 63.4% combined decreaser increaser population compared to 75% required for veld in good condition (Ivy, undated). Under such conditions fire may be required to maintain biodiversity (van Wilgen, 2013) as evidenced by 75% decreaser and increaser proportion in the burned site. The abundance of increaser species may be indicative of little negative effect of fire on the soil seed bank. Absence of species such as S pyramidalis in the burned site suggest that fires created dry heat of more than 125oC which destroyed its seeds (Vogler, Bahnisch & Gramshaw,1988). The relatively high frequency of occurrence of H. contortus at the burned site concur with other findings where the species dominates in grasslands frequently subjected to fires (Dakar, 2016).

EFFECT OF FIRE ON SOIL SEED BANK RESERVES

The germination of Digitaria ternata , S versicolor and D. velutina which were not present at the burned and non- burned sites may be indicative that the seed persists in the soil and geminate only under favourable conditions and could be a mechanism by which plants are saved from extinction (Diaz-Villa, Maranon, Arroyo & Garrido, 2003; Elsaforil, Guma & Naur, 2011). High seedling mortalities could have emanated from low nutrient base of the growing medium as no nutrients were added. The high mortalities before identification of plants could have contributed to the results that suggest that frequent fires have no negative effect on plant species composition.

The germination results suggest that fire enhances grass seed germination as evidenced by higher germination scores for soil media from burned than non-burned site. This could be attributed to the fact that some species such as H. Contortus have seed with awns which assist seed burial by twisting in response to moisture changes (Paton, Orr & Lisle, 1992; Skerman & Riveros, 1990). Survival could be attributed to the fact that the fires that affected the burned site were head fires which move very fast thus reducing contact time with seed (Trallope, 1999). There is evidence of presence of persistent seed which ensures species regeneration when conditions are conducive. The effect of fire may have been masked by perennial plants which regenerate vegetatively as well as through seed. Soil seed bank could also have been replenished by wind and water dispersal (Lesoli, 2011) thus masking any detrimental effects fire might have had. Ecological processes are resilient hence the five year period of annual fires may be too short to cause impact on soil seed bank and herbaceous species composition.

The results which suggest that soil depth affects soil seed bank distribution is in line with other studies (Godefroid, Phartyal & Koedan, 2006). This may be due to seed shape and size with larger seed likely to be found in upper than lower soil layers. In the burned site forb seeds were more in the lower soil layers may be due to vertical transportation of seeds by worms or through cracks in the vertic soils (Espinar, Thompson & Garcia, 2005). Deeply buried seeds are older than shallow ones, Domination of lower soil layers of 3-9cm depth by B. insculpta, B. eurociformis and H. contortus is indicative of the presence of persistent increaser species seed banks that could be used for veld restoration.

CONCLUSION

The incidence of annual fires seem to favour more species diversity than low fire incidence as evidenced by more species diversity in the burned than unburned site. The exclusion of fire increases the frequency of annual incresaer compared to perennial increaser and decreaser species in the unburned sites. Soil seed banks

remain a reservoir of seeds as evidenced by germination of species that were not recorded in the burned and unburned sites. The top layer remains the main seed store for grasses in both burned and unburned sites while sedges and forbs are found in all three soil layers. Germination trials suggest however that decreaser species are abundant in the upper soil layer and may be thus vulnerable to destruction by fires or any rangeland mismanagement.

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