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Original Article

SOYABEAN RESPONSE TO RHIZOBIAL INOCULATION UNDER CONTRASTING SMALLHOLDER AGRO-ECOLOGICAL CONDITIONS IN ZIMBABWE.

T. Kainga[1] and S. Mupepereki

Abstract

Soyabean is grown widely with rhizobial inoculants on commercial farms in Zimbabwe, but its inoculation response in smallholder cropping environments is poorly characterized. Symbiotic interactions of six rhizobial strains (MAR 1305,1306,1326,1494, 1497 and 1515) from the Grasslands Rhizobium Collection were evaluated under contrasting soils and rainfall zones (natural region) in Zimbabwe. The rhizobial strains were evaluated on one specific and three promiscuous soyabean varieties (SC Saga and TGX (1740-2F/ 1987-628/ 1987-11E). The study was conducted over two rainfall seasons namely 2011-2012 and 2012-2013. Field experiments were set up as a randomized complete block design with two factors (soyabean variety and rhizobial strain), a negative control without inoculation and a positive control inoculated with commercial inoculant strain MAR 1491. All treatments were replicated three times. Nodulation was significantly (P< .0001) influenced by rhizobial strain inoculation with nodulation ranging from 28 to37 nodules per plant. Over the two seasons, soyabean inoculated with MAR 1305, 1306, 1494 and 1515 consistently gave higher grain yield higher (average of 600kg/ha) compared to that inoculated with commercial inoculant strain MAR 1491 (average of 400kg/ha). Nodulation of both promiscuous and specific varieties decreased with annual rainfall amounts in the order: Natural Region (NR)II> NRIII> NRIV. Rhizobial strains MAR 1305, 1306 and 1494 were superior in NR II and NRIII while rhizobial strain MAR 1515 was superior in NR IV. Our results show that identification of superior strains best suited to smallholder cropping environments and inoculation response are crucial for increasing soyabean productivity in these environments.

Keywords: crop productivity, inoculation response, rainfall zone, smallholder, rhizobial strain

Introduction

In Sub-Saharan Africa, soil fertility decline in smallholder cropping environments continues to threaten food, nutrition and income security (Mpepereki et al., 2000; Giller, 2008). Nitrogen (N) remains the most limiting nutrient in many cropping environments, and it is a high input cost to farmers. This is because it is added as a synthetic fertilizer whose price is dependent on the energy cost for its production, among other accessibility challenges (Peoples et al., 1989; Rothstein, 2007). Nitrogen is an integral component of all plant and animal proteins and is mainly responsible for growth and chemical processes. However, N fertilisers are seldom within the reach of most smallholder farmers as they are expensive or poorly distributed.

Legume biological nitrogen fixation has been identified as a system that could address the constraints of the limiting nitrogen in smallholder cropping systems, as it is cost effective and eco-friendly (Mpepereki et al., 2002). Biological nitrogen fixation (BNF) is a natural process in which a legume or non-legume host plant forms a symbiotic relationship

[1] *Corresponding Author: Tatenda Kainga*
Department of Soil Science, Faculty of Agriculture
University of Zimbabwe
P.O. Box MP167, Mt Pleasant, Harare, Zimbabwe.
E-mail: tatendakona49@gmail.com
+263772646772

with a nitrogen fixing micro-organism to convert atmospheric nitrogen into ammonium salts that can be used by the host plant (People et al., 1989). One such symbiotic system that has been identified is that between soyabean and rhizobia. Soyabean is a grain legume that has been identified to have multiple benefits when compared to other grain legumes. It is one of the richest plant protein sources with a protein content higher than most animal protein sources and has a high cash price which makes it a good source of income (Kolapo, 2011; IITA, 2012).

Soyabean also has a high potential of producing N rich biomass which when incorporated into the soil, provides organic matter helping to condition the soil and supply N to successive crops (Kolapo, 2011; Mpepereki et al., 2000). Because soyabean-rhizobia symbioses produce their own nitrogen supply, soyabean requires no ammonium nitrate top dressings which make its production costs lower than most crops (Seed Co, 2010). Also because soyabean produces its own N, it reduces the need for excessive use of nitrogen fertilizers which lead to ground water pollution as nitrates are leached making it significant in ecological function (Berrada and Fikri-Benbrahim, 2014). Increased and improved soyabean production relies on several factors which include good seed germplasm, effective and elite inoculant rhizobial strains, proper management and good soil and climatic conditions (Giller et al., 2011). Formation of effective symbioses between the rhizobial strains and the seed is a critical and important process in successful soyabean production (Hardson and Atkins, 2003; Douglas, 2010). Symbiosis can only occur effectively, if the seed and soil rhizobial strains are compatible and the soil conditions are conducive for rhizobial population multiplication nodule formation. Also the seed bed must present optimum conditions for good seed germination coupled with optimum climatic conditions (Rainfall and temperature) (Giraud et al., 2007; Jones et al., 2007).

Despite the knowledge of the potential and multiple benefits of soyabean-rhizobia symbioses, characterization of varieties and rhizobial strains best suited to smallholder cropping environments in Zimbabwe, and similar areas, remains poor. This may be attributed to several factors such as climate, differential soil management practices among smallholder farmers and improper storage and use of rhizobial inoculants (Zahran, 1999). Hence more information is needed to guide the targeting of soyabean production domains and associated inoculants in smallholder cropping environments if increased and improved soyabean productivity is to be achieved.Several studies were carried out in Goromonzi, Guruve and Hurungwe districts of Zimbabwe where most of the soils were sandy and sandy loams and the average annual rainfall ranging from is 700 to 1050 mm. Soils in smallholder farming areas have been found to have low rhizobial populations and inoculation has become a critical aspect in the success of soyabean production (Zingore et al., 2005). However, the success of inoculation depends on the rhizobial strain's compatibility with the host soyabean plant and its saprophytic competence under prevailing environmental conditions. Kasasa's studies (1999) suggested that use of promiscuous varieties in most low input smallholder cropping systems where rhizobial inoculants are not readily available could help improve nodulation and hence soyabean yields. However, soyabean varieties produced by commercial breeders in Zimbabwe at present are all specific requiring commercial inoculants. Although rhizobial inoculant distribution points have increased, the proper use and storage of these inoculants is still limited by insufficient knowledge. Previous soyabean inoculant promotions have not been sustained due to economic challenges.Chirinda (2003) also carried out a study to assess the yield response to rhizobial inoculation rate and concluded that soyabean yields increased steadily up to five times the recommended commercial rate. This study suggested that there was need to identify better adapted strains to the local environmental conditions to ensure economical use of the rhizobial inoculants.

Rhizobial inoculation makes soyabean production cost effective compared to maize production in that it is way cheaper to inoculate. A rhizobium sachet priced at US$5 has the potential to supply an equivalent amount of N to a crop as that supplied by three top dressing bags priced at US$ 35 each. However, because only two commercial rhizobial strains are available on the market there is need for identification of other strains to cater for the diverse soil management and climatic conditions experienced in smallholder cropping

environments. Zengeni (2003) sought to determine whether introduced rhizobia persisted after inoculation in smallholder cropping environments and concluded that populations were still high enough to sustain adequate nodulation a year or two after inoculation. However, reinoculation was recommended three years after inoculation as rhizobial populations gradually declined to levels too low to provide adequate nodulation.

Musiyiwa (2005) determined the host ranges and symbiotic effectiveness of indigenous rhizobia isolates and suggested that knowledge on these aspects was very limited and needed further study. Symbiotic effectiveness between the host soyabean and rhizobia is a crucial process in soyabean production. Hence there is need for sufficient information on which rhizobia- soyabean combinations best suited to specific environments to ensure sustainable soyabean productivity.

In (2006) Zengeni investigated the capacity of cattle manure to improve soil conditions for survival and persistence of rhizobial populations. Results showed that cattle manure application improved the rhizobial populations potentially improving soyabean yields through symbiotic N fixation. Organic matter is important for the saprophytic survival of rhizobia when the legume crop symbiont is not in the field. Farming practices that add organic materials in the form of cattle manure and composts to the soil create a suitable soil environment for the proliferation and persistence of soyabean nodulating rhizobia. Mapfumo and Mtambanengwe (2006) investigated the contribution of legumes to soil fertility and incomes of households and identified improved seed varieties and legume BNF technologies as key factors.

In spite of several studies, potential of soyabean to fix N and give significant yields to improve food security in the smallholder sector has remained low. This may be attributed to the little knowledge on rhizobia N fixation potential with indigenous and commercial varieties under field conditions in smallholder cropping environments. Little research has been done in smallholder farming areas on identifying elite rhizobial strains best suited to selected varieties and the prevailing climatic and soil conditions in these areas. Hence more research is needed to improve knowledge increasing information to guide deployment of soyabean into smallholder cropping environments.

In view of the prevailing constraining conditions in smallholder cropping environments that affect the effectiveness of legume – rhizobium symbioses this study therefore sought to evaluate superior soyabean - rhizobial strain combinations best suited to varying soils and rainfall zones in smallholder farming areas of Zimbabwe.

Materials and Methods

Study Site Selection and Characterization

The study was conducted in Murewa, Chegutu, Guruve and Mudzi districts during 2011/2012 and 2012/2013 cropping seasons. Three field sites were selected in each of the 2011/2012 and 2012/2013 cropping seasons. One field site was selected per district each season giving a total of six sites (Table 1). The fields were selected where there was no history of soyabean cultivation and/ or rhizobial inoculation. Size of available land suitable for establishment of experimental trials and the willingness of the farmer to avail their land for use during the two seasons were additional factors considered during site selection.

Table 1: Study sites location and agro-ecological characteristics in the soyabean inoculation response study during the 2011/2012 and 2012/2013 cropping seasons in Zimbabwe.

District	Location	Agro-ecological Region	Rainfall Per Annum
Murewa	17° 43'16" S 31°41'53" E 1361 m.a.s.l	II	700-1050 mm
Chegutu	18°06'48.65" S 30°44'30.50" E 1356 m.a.s.l	II	700-1050 mm
Chegutu	18° 07' 36.83" S 30°43'12.21 E 1344m.a.s.l.	III	500-800mm
Guruve	16°S 30°E 1100-1600 m.a.s.l	III	500-800mm
Mudzi	(a)17°05'14.46" S 32°46'30.29" E682 m.a.s.l (b)17°09'54" S 32°77'67" E694 m.a.s.l	IV	450-650 mm

Table 2: Soil characteristics at the rhizobial inoculation response study sites in Zimbabwe (2011/2012).

Soil Parameter	Site		
	Murewa (NRII)	Chegutu (NRIII)	Mudzi (NRIV)
pH (0.01M $CaCl_2$)	4.89	4.7	6.14
Exchangeable Ca ($cmol_c$/kg)	0.741	0.594	3.353
Exchangeable Mg (cmolc/kg)	0.327	0.372	2.03
Exchangeable Na (cmolc/kg)	0.166	0.177	0.533
Exchangeable K (cmolc/kg)	0.07	0.054	0.091
Total N%	0.07	0.10	0.06
Available P (mg/kg)	49.08	11.97	42.9
Soil Organic Carbon (SOC) %	1.95	0.5	0.81
Texture	coarse loamy sand	coarse sand	medium loamy sand
Cropping History	maize monocrop	maize-round nut-maize	maize-finger millet-round nut

Available P was measured using the Bray 1 method

During the first season, experimental trials were established in Murewa (NRII), Chegutu (NRIII) and Mudzi (NRIV) districts (Table 1). The natural regions (agro-ecological zones) are mainly differentiated according to their rainfall and temperature patterns. However different sites were used during the second season. This was because either farmers wanted to use their field or that some had removed the permanent pegs we had left which would result in experimental contamination. Sites selected during the second season were in Chegutu (NRII), Guruve (NRIII) and Mudzi (NR IV) districts. These sites had similar characteristics in many aspects to those used in the first season and were in the same natural regions (Table 1).

Table 3: Soil characteristics at the rhizobial inoculation response study sites in Zimbabwe (2012/2013).

Parameter	Site		
	Chegutu (NRII)	Guruve (NRIII)	Mudzi (NRIV)
pH (0.01M $CaCl_2$)	4.17	5.46	5.45
Exchangeable Ca ($cmol_c$/kg)	5.74	4.45	3.24
Exchangeable Mg (cmolc/kg)	3.38	1.5	0.9
Exchangeable K (cmolc/kg)	0.45	0.16	0.13
Total N%	0.08	0.06	0.04
Available P (mg/kg)	8	6.13	22.38
Soil Organic Carbon (SOC) %	2.42	2.53	1.68
Texture	Medium sandy clay	Fine loamy sand	Medium sand
Cropping History	Maize-paprika-paprika	Maize-sugar bean-maize	Sorghum-maize-maize

Available P was measured using the Olsen method

Table 5: Soyabean variety origins and characteristics in the soyabean inoculation response study in Zimbabwe (2011/2012 and 2012/2013).

Seed Variety	Origin	Characteristics
SC Saga	Zimbabwe, bred by Seed Co, Zimbabwe	Indeterminate suitable for middleveld (600- 1200 m.a.s.l) and lowveld (150-600 m.a.s.l) areas, high seed yield potential, long shatter free period, good resistance to lodging, good pod clearance, good standibility.
TGx 1740-2F	IITA/DARS‡/NCRI‡	Indeterminate, high grain yield potential, ability to smother weeds and pod load per plant. Early maturity, good resistance to lodging, bacterial blight and *Cercospora* leaf spot
TGx 1987-628	IITA/DARS/NCRI	Indeterminate, high grain yield, medium maturity, good resistance to lodging, bacterial blight and *Cercospora* leaf spot
TGx 1987-11E	IITA/DARS/NCRI	Indeterminate, high seed yield potential, good pod load and pod clearance, late maturity, good resistance to lodging, bacterial blight and *Cercospora* leaf spot

Adopted from the Seed Company Agronomy Guide (2010), and the International Institute of Tropical Agriculture (IITA), (2008).
‡ DARS - Department of Agricultural Research Services.
‡ NCRI - Nigerian National Cereal Research Institute.

Experiments were mainly researcher managed with limited farmer management. For initial characterization, soil sampling was done according to Warrick *et al* (1986) and one composite sample was collected for the whole field for uniform recommendation. The composite samples were air-dried and sieved for laboratory characterization. The soil pH was determined using the calcium chloride method (Anderson and Ingram, 1993), soil organic carbon using the Walkley black method (Nelson and Sommers, 1982), total N using the Kjeldahl method (Hesse, 1971; Bremner and Mulvaney, 1982), available P using the Bray 1 method (Olsen and Sommers,1982), exchangeable bases using the ammonium acetate method and texture using the hydrometer method as is described in Anderson and Ingram (1993). The initial soil properties are shown in Tables 2 and 3.

Land preparation and planting

Land at the selected experimental sites was ploughed soon after the first effective rains using an ox-drawn mouldboard plough. Forty-eight plots, each measuring 3m by 4m, were pegged on each field/. Planting rows with inter and intra-row spacings of 0.07m and 0.5m, respectively were marked. Basal compound L (5% N: 18% P_2O_5: 10% K_2O: 0.25% B: 8% S) fertilizer was applied by placing in the planting furrows at 150 kg ha^{-1}. Soyabean varieties planted were: SC Saga and one of the three TGx varieties (TGx 1740-2F in NR II, TGx 1987-628 in NR III and TGx 1987-11E in NR IV) (Table 5). Three different TGx varieties were used as only limited quantities of the seed could be imported from Malawi due to national restrictions and also because of the need to match the plant growth and maturity rates to the prevailing conditions of the three natural regions under study. The three

promiscuous varieties had the same growth habit but different maturities (early, medium and late). Seven *Bradyrhizobium* strains from the Grasslands Research Rhizobia Collection were used (Table 4). Six of the strains were the test strains and one was the positive control. Seed inoculation was done according to inoculant manufacturer's recommendation but at 5 times the manufacturer's rate (Zengeni et al., 2003; Chirinda et al., 2003). This was in light of previous studies that had shown that rhizobial cell mortality increased in sandy soils hence increasing the number of rhizobial cells introduced into the soil would increase the number of effective cells. Care was taken to avoid cross contamination and plasmolysis of inoculant rhizobial cells Planting was carried out from late January to early February as test strains were released late, at all the sites during the 2011/2012 cropping. During the 2012/2013 cropping season planting was done from mid-December to early January. Seeds were hand dropped into planting furrows and thinned three weeks after germination to give plant population of 285, 000 plants ha^{-1}.

Table 4: Rhizobial strain origins and characteristics in the soyabean inoculation response study in Zimbabwe (2011/2012 and 2012/2013).

Strain	Origin	Characteristics
MAR 1305	Beltsville, USA (126/CRB)	Highly effective on *G.max* cvv, Bragg, Duiker, Oribi, Roan and Sable, poorly effective on cv Nyala; 1993
MAR 1306	Beltsville, USA (138/CRB)	Highly effective on *G.max* cvv, Bragg, Duiker, Buffalo, Hernon 147, Impala, Kudu, Oribi, Rhosa and Sable, effective on Roan; 1985
MAR 1326	Isolated at Marondera, Zimbabwe, from peat inoculant from Illinois, USA	Highly effective on *G.max* cvv, Bragg, Buffalo, Geduld, Hernon 147, Kudu, Oribi, Rhosa and Roan, effective on Sable; 1985
MAR 1491†	Beltsville, USA, (110/CRB)	Grasslands' inoculant strain. Highly effective on all *G.max* cvv. Tested. Heat tolerant and therefore suitable for both high and lowveld areas of Zimbabwe; 1993
MAR 1494	Beltsville, USA, (184/CRB)	Highly effective on *G.max* cvv Duiker, Gazelle, Oribi and Sable with above average stover nitrogen content; 1993
MAR 1497	Beltsville, USA, (142/CRB)	Acid Tolerant
MAR1515	Brazil, BR 29	Acid Tolerant

Glycine max cultivars: Bragg was introduced from the USA, Geduld was introduced from South Africa and Rhosa was introduced from South Africa as a breeding line and named and released in Zimbabwe. Buffalo, Duiker, Impala, Kudu, Nondo, Nyala, Oribi, Roan and Sable were all bred in Zimbabwe.

†-refers to the reference strain used in the experiment.

Source: In-house communication compiled by staff at the Soil Productivity Research Laboratory at The Grasslands Research, Marondera, Zimbabwe

Experimental design and trial management

The experiment was set up as a randomized complete block design with two factors, soyabean variety (SC Saga and TGX (1740-2F/ 1987-628/ 1987-11E) and rhizobial strain (MAR 1305,1306,1326,1494, 1497 and 1515). Included was a negative control with no inoculation and a positive control inoculated with reference commercial strain MAR 1491. The experiment was replicated three times. Weeding was done manually using a hand hoe two weeks after germination and thereafter when necessary. Daily precipitation at each site was recorded by farmers trained to use rain gauges. Each farmer was assisted in installation of the gauge and recording of the rainfall data. . At the end of each season monthly rainfall figures for each site were calculated by simple addition using Microsoft excel.

Determination of biomass productivity, total N and nodule assessment at mid-flowering.

At mid-flowering plants were cut at the cotyledonary node on one random border row on a random position measuring 1m. Fresh weight of all biomass was measured and a weighed sub-sample collected. All sub-samples were air dried for two weeks and oven dried at 60^{o}C for 24 hours and biomass yield was calculated. The dried samples were ground and used to determine the total N using the Kjeldahl method (McDonnell and Murphy, 1952). The roots of the cut plants were removed taking care not to damage roots and nodules and the nodules on each plant counted and recorded and two nodules cut open to check for nodule internal colour. For nodule scoring and ranking, a 0 to 5 scoring scale adapted from Corby et al., 1977 modified by the N2Africa project (Bala et al., 2011) was used.

Determination of grain productivity

The middle four rows of each plot were harvested by cutting above ground biomass and pods were removed and shelled. Shelled grain was weighed and sun dried to 12% moisture content (measured using a moisture meter), reweighed and grain yield per ha calculated using direct proportion.

Data Analyses

Analysis of variance (ANOVA) to separate grain, biomass and total N yield treatment means as well as nodule numbers was conducted using SAS version 9.3 (SAS, 2010). Standard errors of differences (SED) of means were used to compare and separate the treatment means as post hoc using the Fisher' s least significant difference.

Results

Rainfall distribution

Rainfall during the 2011-2012 cropping season was evenly distributed although a few mid- and early season dry spells were experienced. The rainfall data collected from all farmers' fields fell within the average annual rainfall of the natural regions in which the fields fell in. Distribution was poor during the 2012-2013 season with the rains coming late in December and episodes of flooding and prolonged dry spells being experienced throughout the season.

Biomass and total nitrogen response to rhizobial inoculation at mid-flowering

At mid-flowering (6-8 weeks after emergence) biomass yields and total nitrogen responded significantly to the six test rhizobial strains ($p=0.0239$ and $p=0.0001$ respectively). The natural region significantly influenced the biomass yields ($p<0.0001$) and total nitrogen ($p=0.0138$). Biomass yields of up to 3550 kg ha^{-1} and 2500 kg ha^{-}were obtained in the 2011/12 and 2012/13 seasons, respectively. Total nitrogen yields ranged from 80 to150 kg ha^{-1}. Biomass yields were in the order NRII sites> NRIII sites> NRIV sites (Figures 2 and 3). Overall, soyabean biomass yields were significantly higher in the 2011/2012 than 2012/2013 cropping season (Figures 2 and 3). The cropping season also significantly influenced the total nitrogen fixed ($p<0.0001$) (Figures 4 and 5). The variety grown, however,

had no significant influence on the biomass at mid-flowering and total nitrogen fixed yields (Figures 2-5).

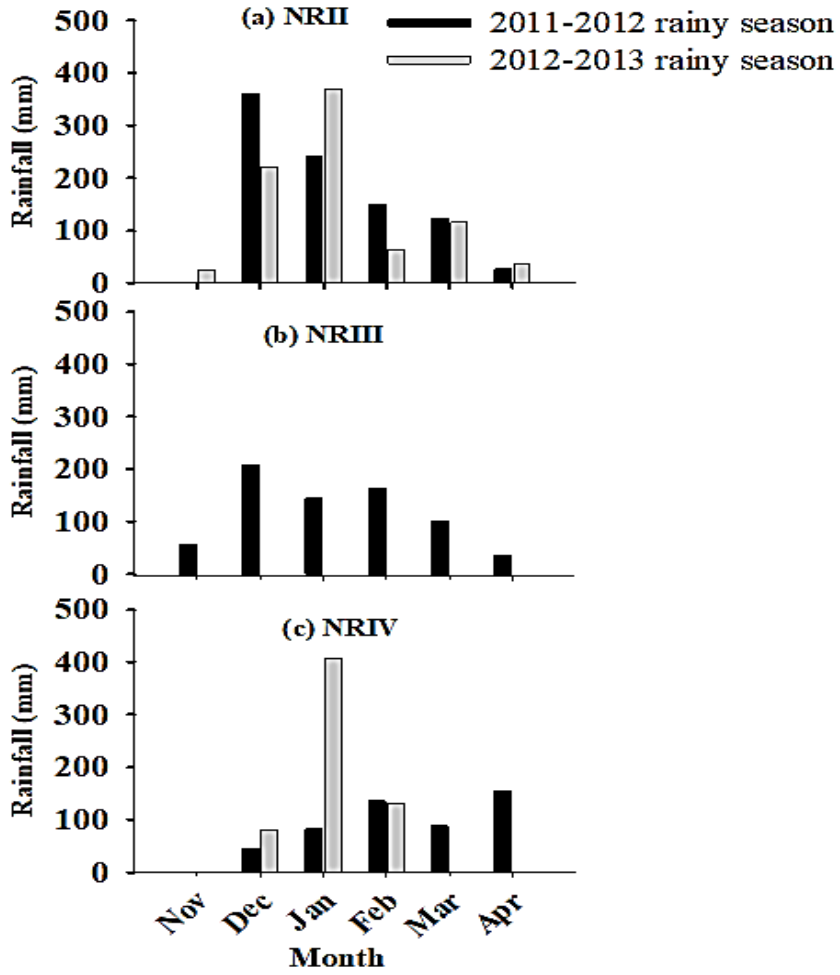
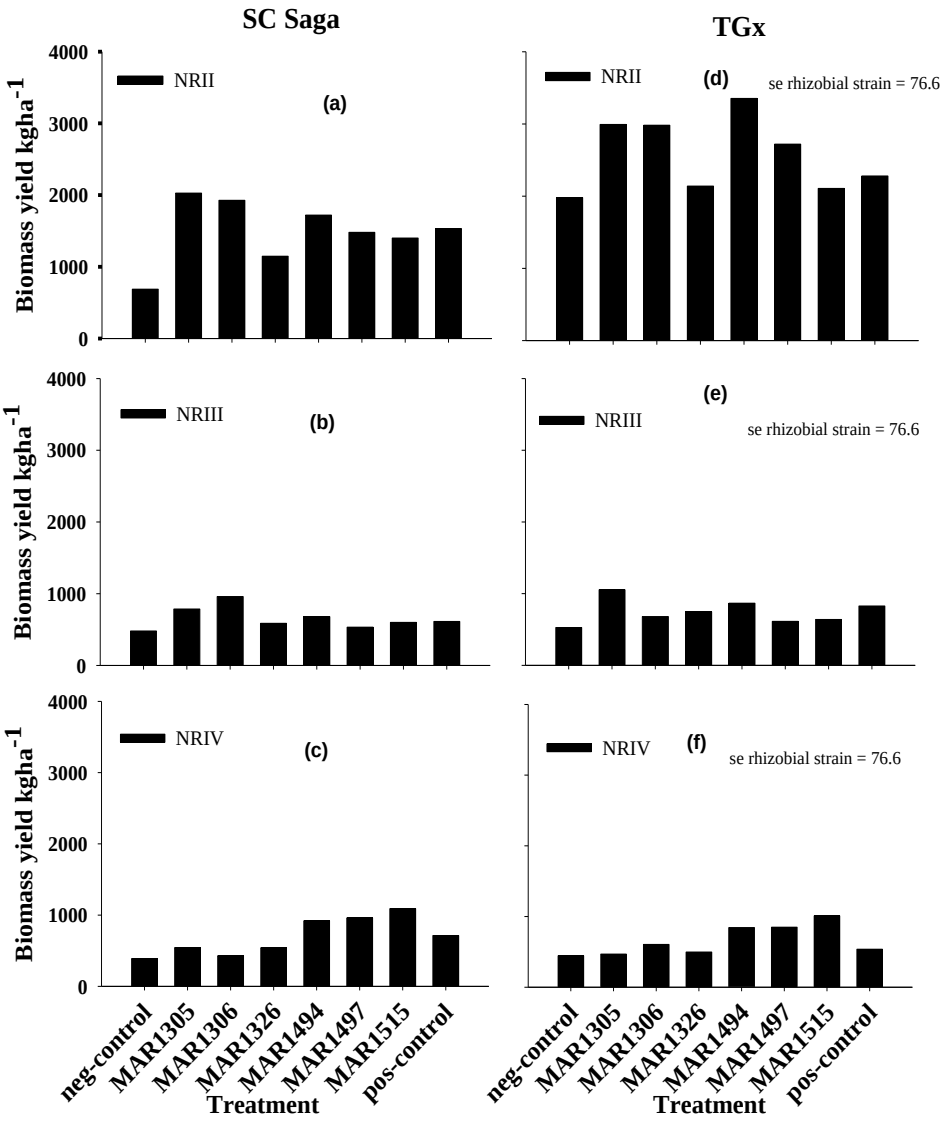
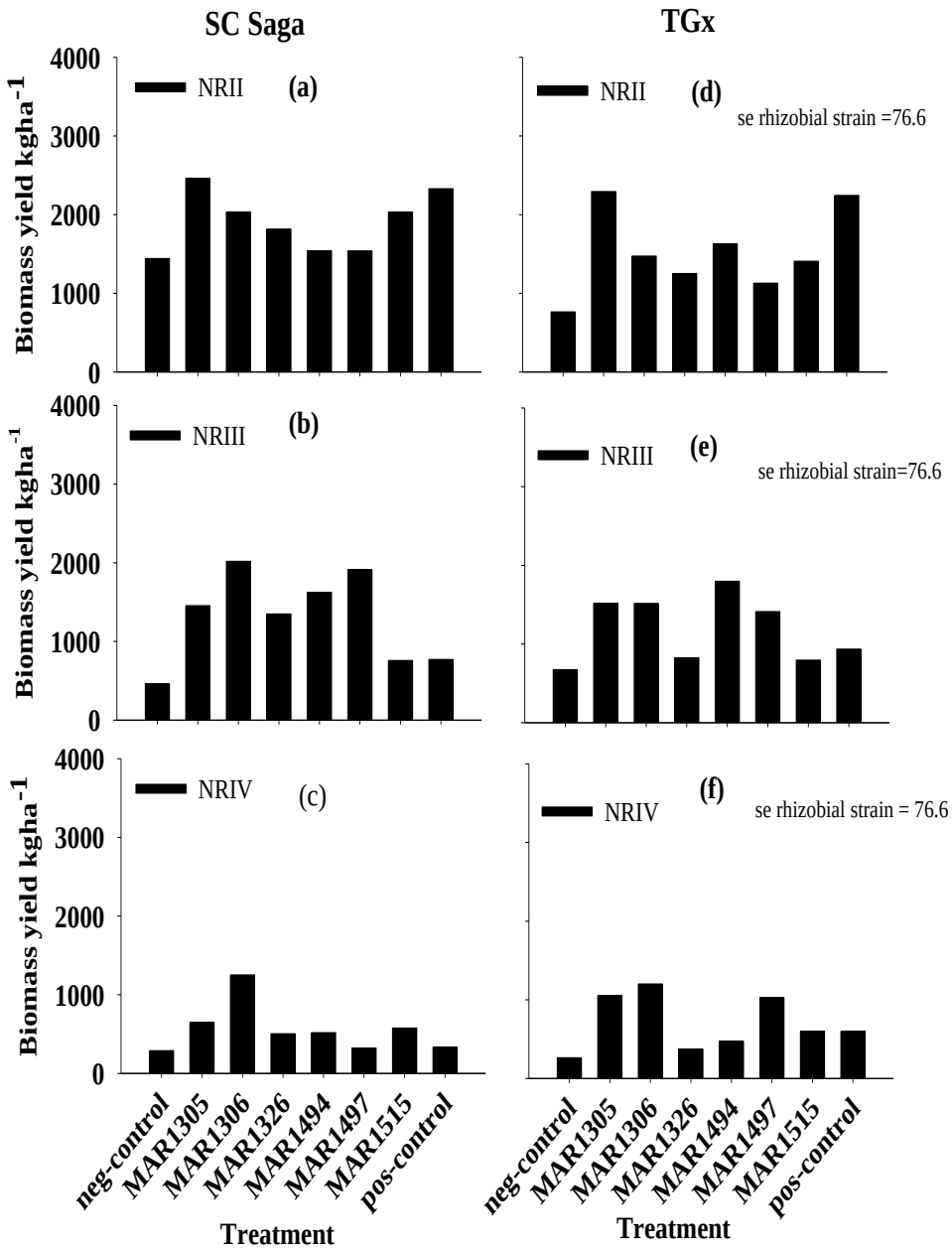


Figure 1: Monthly rainfall distribution at the inoculation response study sites in Zimbabwe (2011/2012 and 2012/2013).



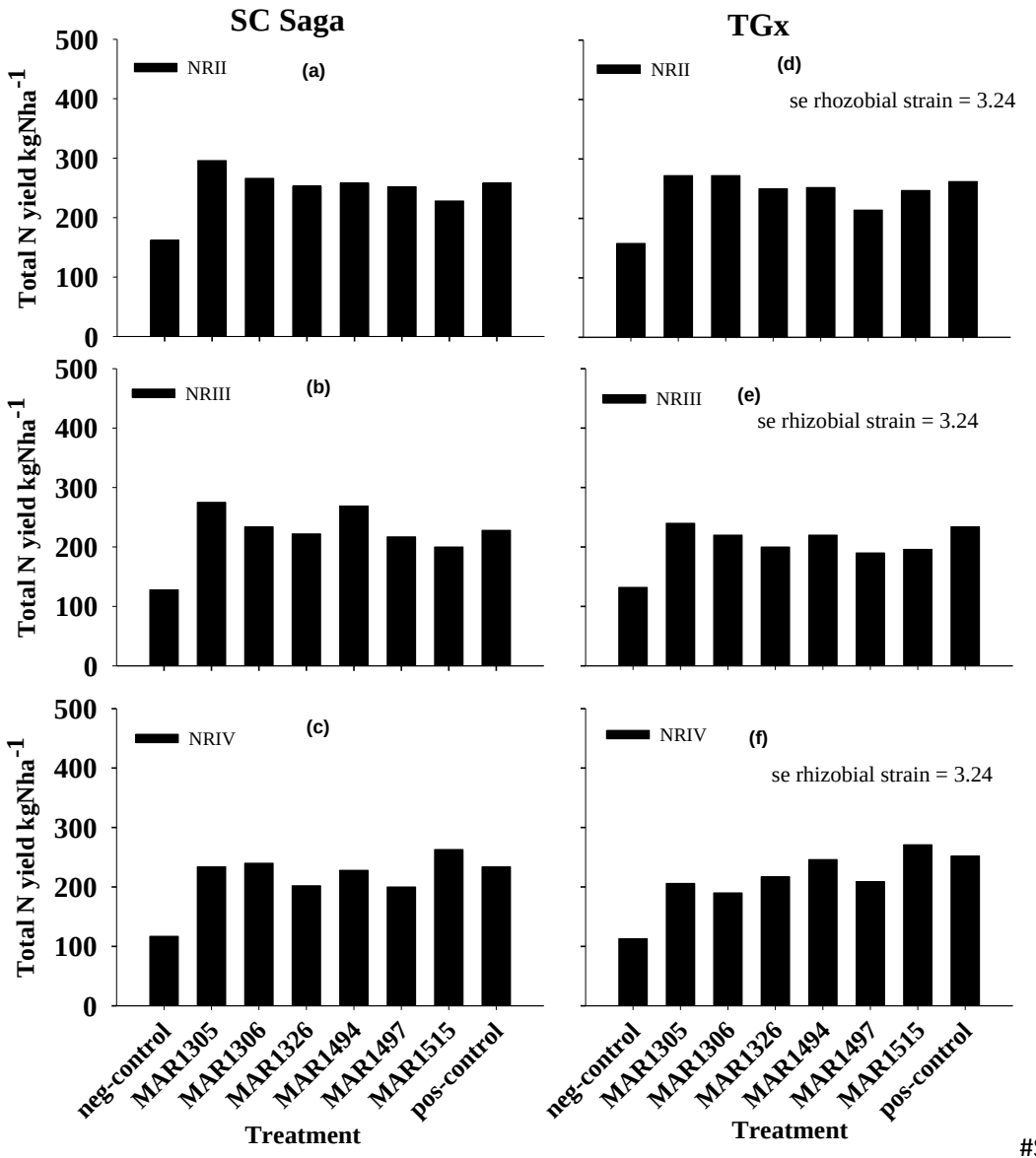
#Soyabean varieties- SC Saga and TGx

Figure 2: Soyabean biomass yield response to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2011/2012



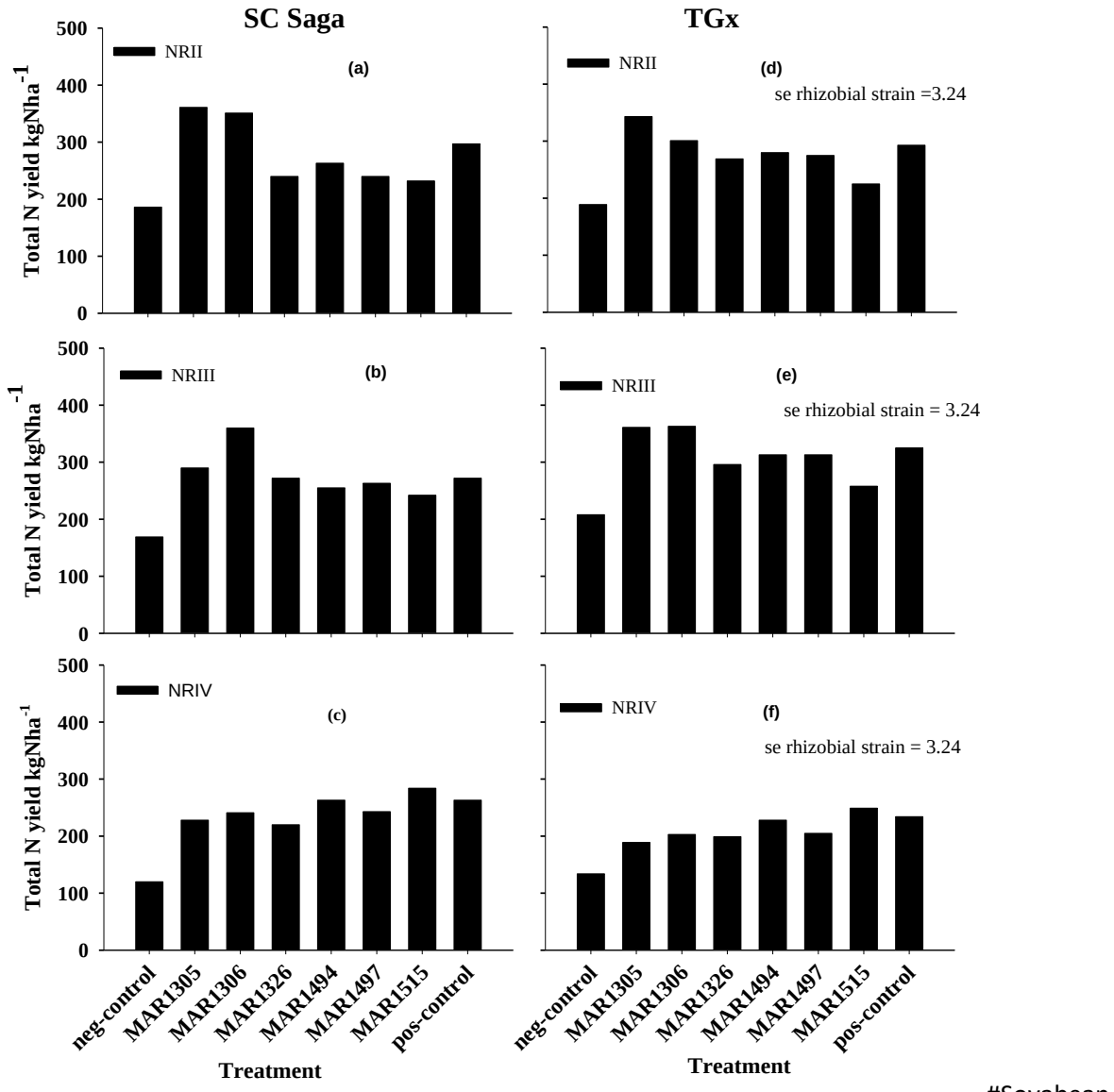
#Soyabean varieties- SC Saga and TGx

Figure 3: Soyabean biomass yield response to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2012/2013).



#Soyabean varieties- SC Saga and TGx

Figure 4: Soyabean total nitrogen yield response to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2011/2012).

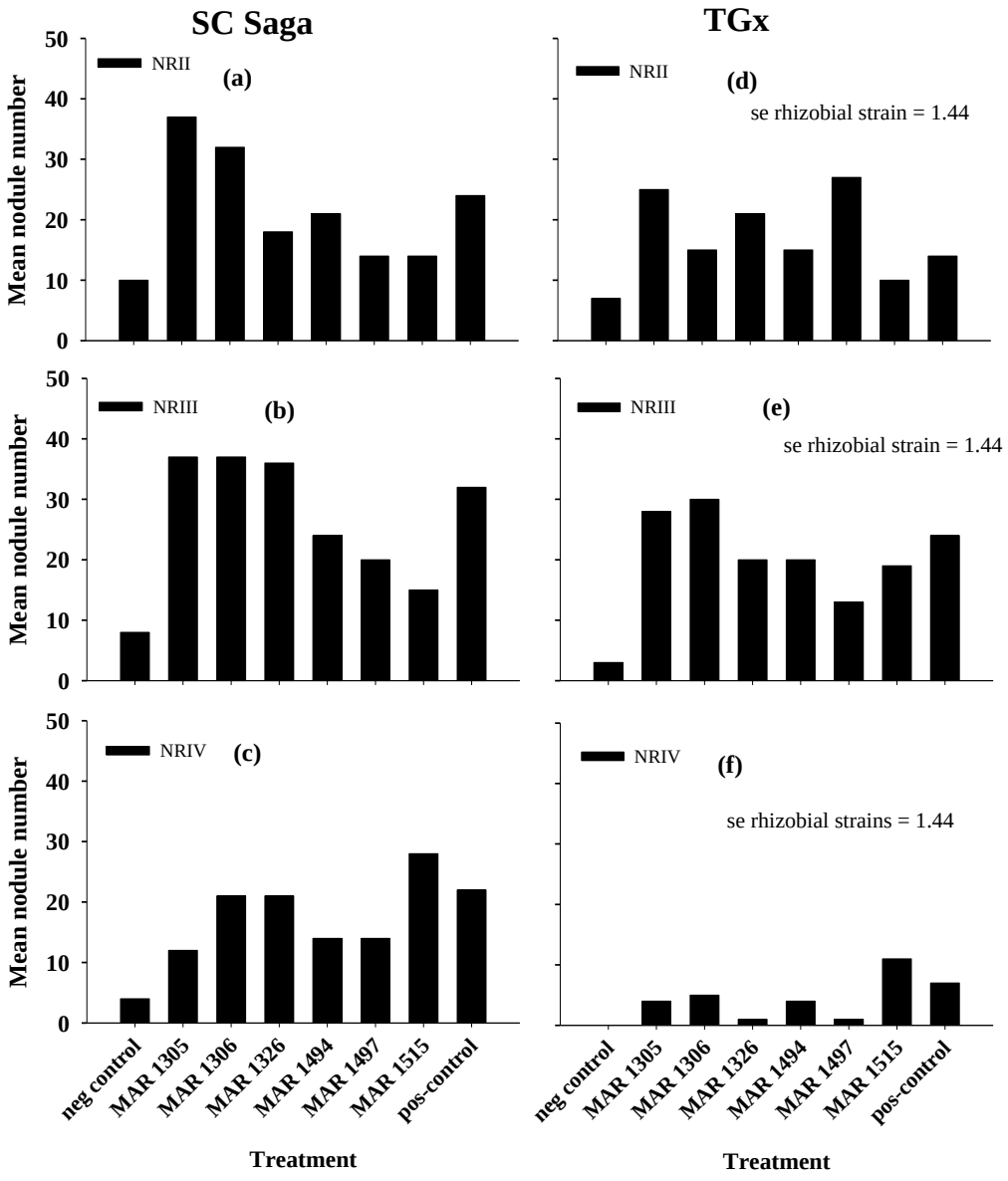


#Soyabean varieties- SC Saga and TGx

Figure 5: Soyabean total nitrogen yield response to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2012/2013).

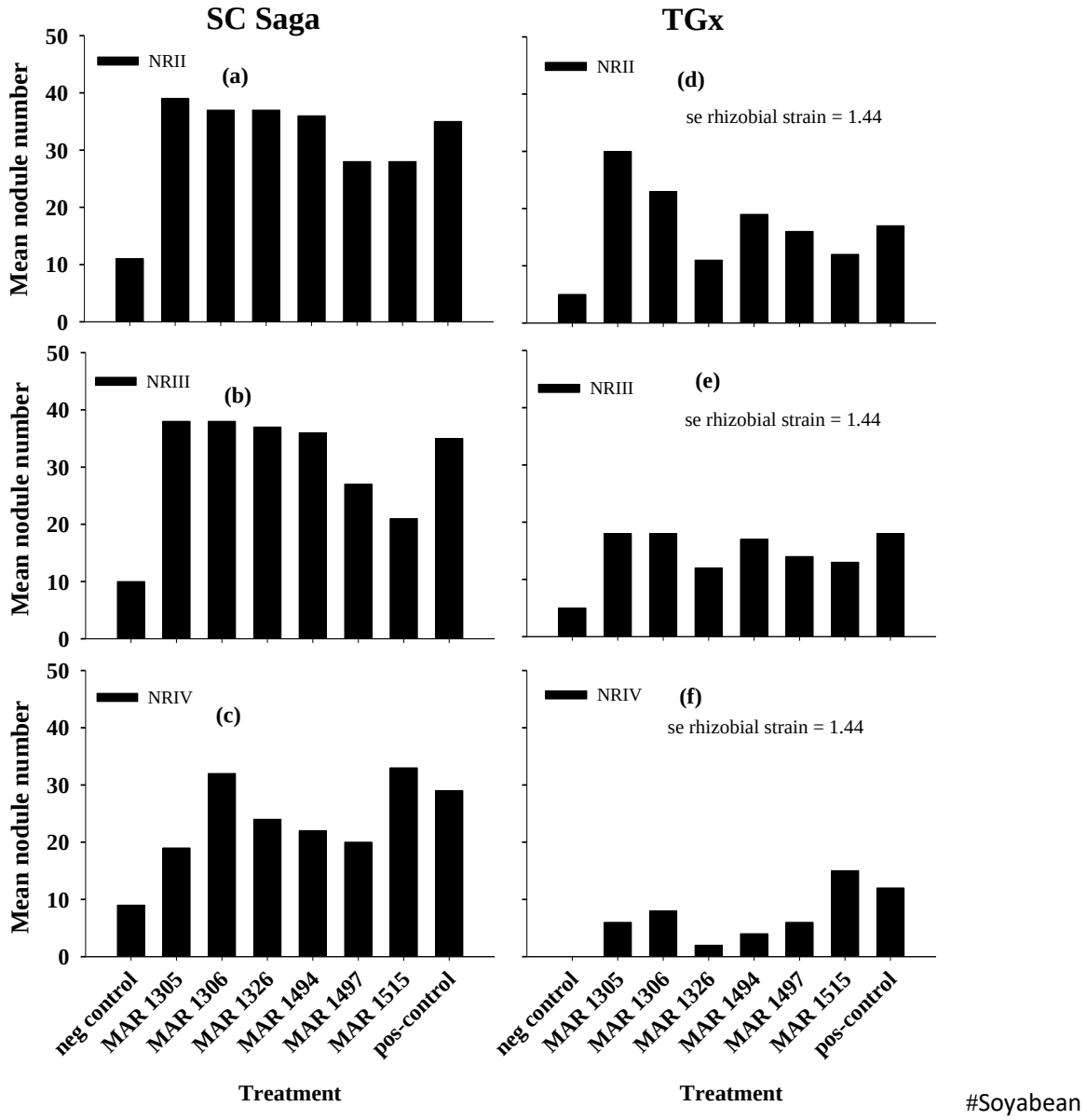
Nodulation response to inoculation with six rhizobial strains

Soyabean nodulation responded significantly to rhizobial inoculation with the test strains ($p<0.0001$). Rhizobial strains MAR 1305, 1306, 1326, 1494 and 1515 produced mean nodule numbers ranging between 28-37 nodules per plant that were significantly higher than those of the positive control (Figure 6 and 7). At sites in NRII and NRIII rhizobial strains MAR 1305, 1306, 1326 and 1494 had high mean nodule numbers while at sites in NRIV rhizobial strain inoculation with MAR 1306 and 1515 resulted in high mean nodule numbers (27-38 nodules per plant). The cropping season significantly influenced the nodule numbers ($p<.0001$), with 2011/2012 season having higher nodule numbers than 2012/2013 season.



#Soyabean varieties- SC Saga and TGx

Figure 6: Soyabean nodulation responses to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2011/2012).

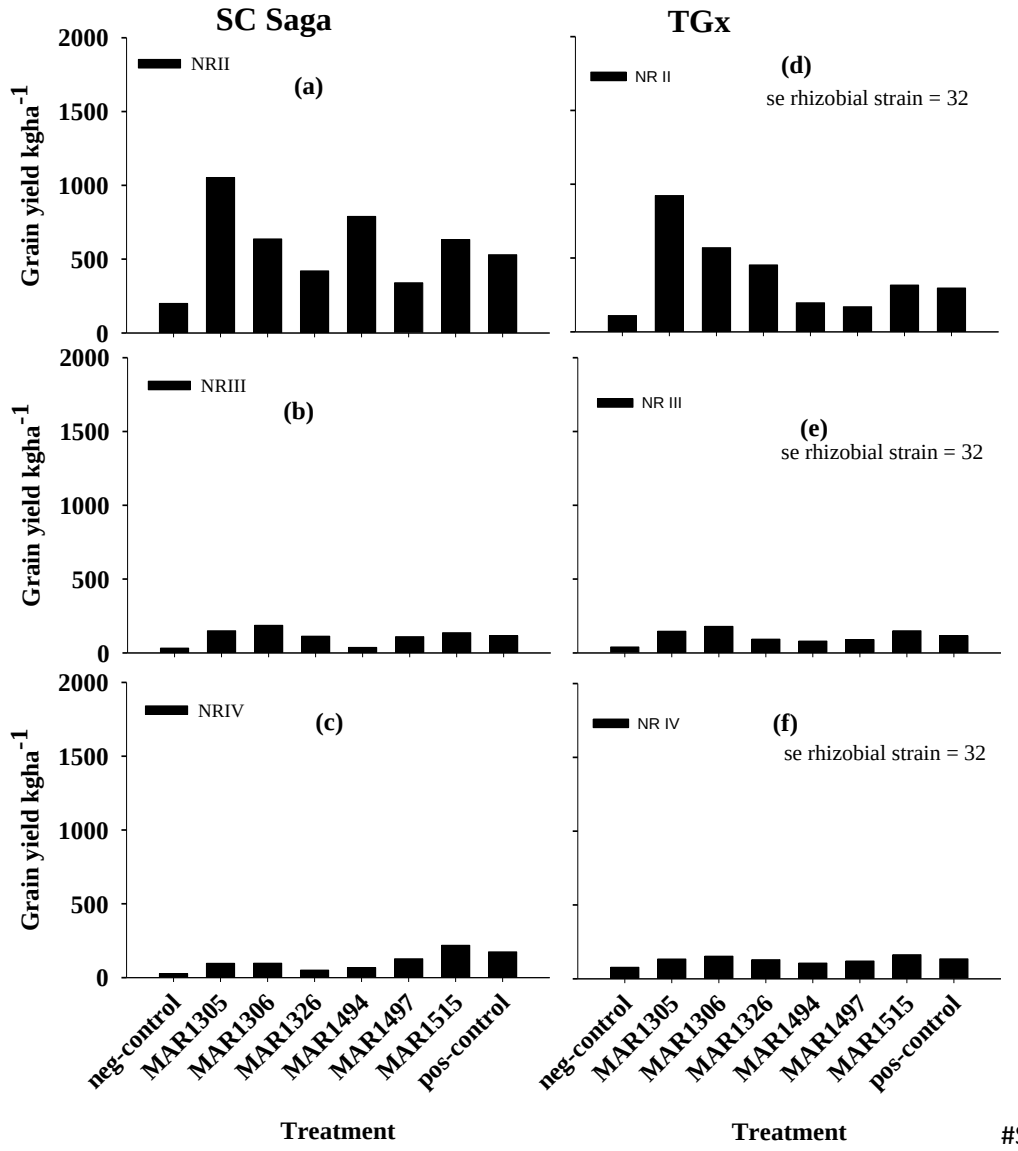


#Soyabean varieties- SC Saga and TGx

Figure 7: Soyabean nodulation responses to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2012/2013).

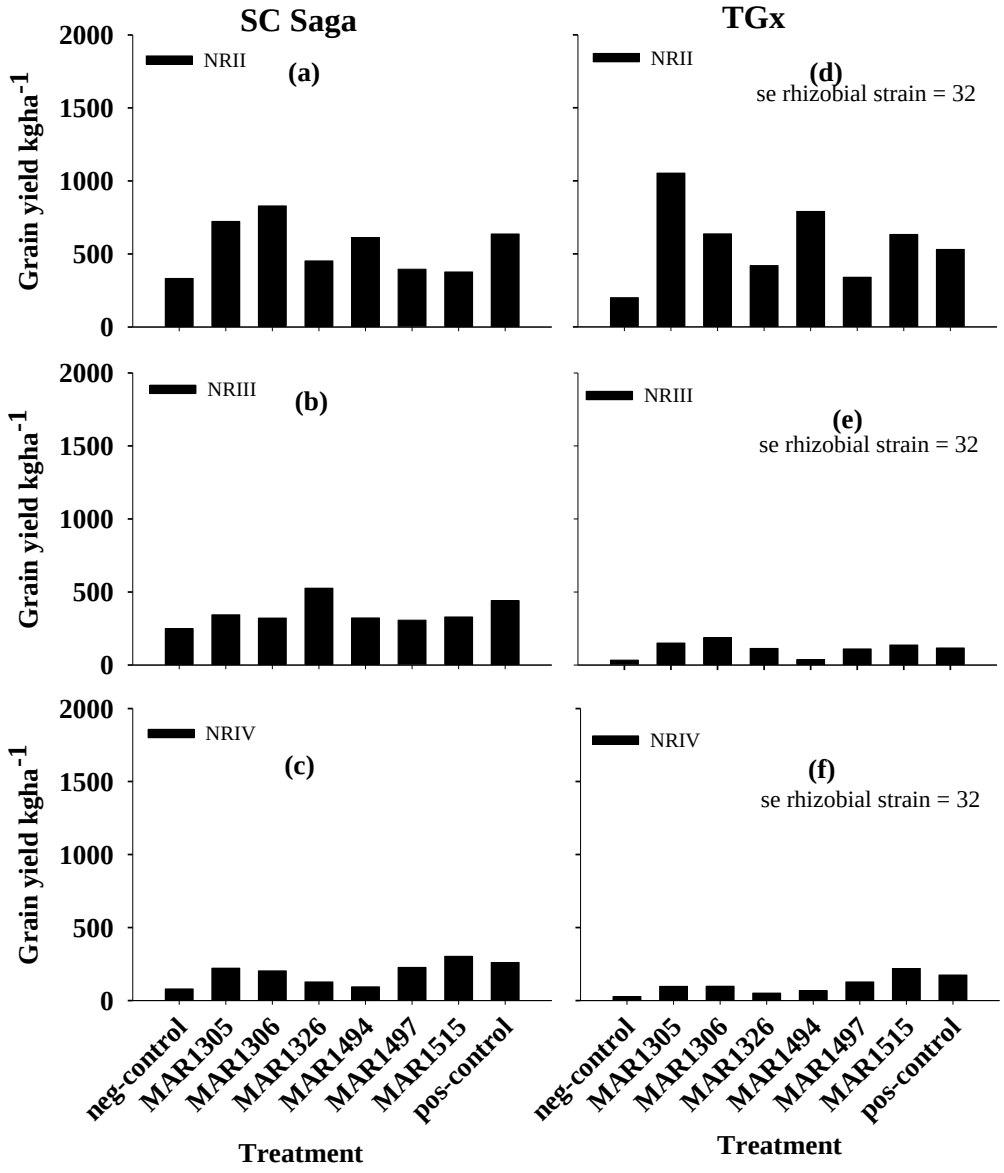
Soyabean grain yield

Grain yields were significantly influenced by the rhizobial strain ($p<0.0378$) with the highest yields attained after inoculation with rhizobial strains MAR 1305, 1306, 1494 and 1515 at sites in NRII and NRIII while at sites in NRIV, after inoculation with MAR 1515 and 1306 (Figures 8 and 9). Grain yields ranged from 150 – 1050 kg ha $^{-1}$ across the sites with an average of 600kg ha $^{-1}$ over the two seasons compared to an average of 400 kg ha^{-1} by the reference strain MAR 1491.The soybean variety also significantly influenced the grain yields achieved ($p<0.0009$) with SC saga (average 600 kg ha^{-1}) yielding higher than TGx varieties (480 kg ha^{-1}). Soyabean grain yields were significantly influenced by the agro-ecological region ($p<0.0001$) with yields in the order NRII > NRIII > NRIV.



#Soyabean varieties- SC Saga and TGx

Figure 8: Soyabean grain yield response to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2011/2012).



#Soyabean varieties- SC Saga and TGx

Figure 9: Soyabean grain yield response to rhizobial inoculation at three sites located in 3 NRs in smallholder farms in Zimbabwe (2012/2013)

Discussion

Rhizobial strain performance

Results show that soyabean varieties inoculated with rhizobial strains MAR1305, 1306, 1494 and 1515 consistently yielded and nodulated better than the commercial inoculant strain MAR 1491used as the positive control. Prior characterization of the rhizobial strains showed that they had been highly effective after being inoculated on selected varieties (Table 5.3). However, the cultivars they were tested on where no longer available commercially and hence they proved they are still effective strains after being tested on the new available cultivars.

Nodulation and total nitrogen response to inoculation

Nodulation of soyabean varieties tested responded significantly to rhizobial inoculation at all the study sites ($P<0.0001$). Nodulation is understood to be a summation of the host plant, rhizobial population and soil and climatic conditions (Bordeleau and Prevost, 1994). One

factor affecting nodulation is inoculation rate and the significant nodulation response may be attributed to the increased application rates. Rhizobia inoculum were applied at five times the manufacturers' recommended rate (Chirinda et al, 2003) after a prior study had concluded that increasing the application rate up to five times significantly increased nodulation resulting in increased yields. Increased inoculum results in increased cells in the soil. Results from our study support these findings as inoculation resulted in moderately abundant mean nodule numbers of 28-37 in soils where rhizobia had not been detected by most probable number estimations.

However, with such increased application rates expectations was that mean nodule numbers would be very abundant reaching mean nodule numbers of greater than 50. The moderately abundant mean nodule numbers of 28-37 may be attributed to several factors. The soils in which experimental trials were established had acidic soils with pH ranging from 4.17- 5.46 with the exception of one site which had a pH of 6.14. Nodulation is affected by soil acidity which can affect solubility of inorganic nutrients and induce nutrient deficiencies resulting in conditions of high and potentially toxic levels of Al and Mn and low deficient levels of Ca and P (Bell and Edwards, 1987; Bordeleau and Prevost, 1994; Dilworth et al., 2001). Calcium is critical in the permeability of cell membranes and attachment of rhizobia during the initiation and formation of nodules while P is a part of important enzyme systems responsible for nodule formation and other plant and soil process (Peoples et al., 1989; Bardin et al., 1996). Since pH was acidic this could have partially inhibited nodulation.

All the soils in which the experimental trials were conducted had low soil organic carbon percentages of lower than 2.5% with some soils having SOC % as low as 0.5 %. Soil organic carbon is important in the survival of rhizobia as they are saprophytic in the absence of their legume host. Organic matter provides rhizobia with nutrients for their multiplication in the rhizosphere before attachment to the root hairs of soyabean roots (O'Hara, 2001) particularly carbon. Low soil C content could have contributed to the relatively low mean nodule numbers observed.

The agro-ecological region in which the experimental trials were established significantly influenced nodulation response ($P<.0001$). Yields were in the order NRII> NRIII> NRIV as temperature increases and rainfall decreases in that order. Nodulation requires good soil moisture for nutrient and ion movement and this could have been affected by the sandy soils which had low water holding capacity and were susceptible to drying. Drying of soils also reduces the presence of normal root hairs resulting in short stubby root hairs which are inadequate for infection by rhizobia (Lie, 1981). This may explain why nodulation was very low in NR IV as rainfall distribution was poor with several dry spells during the season.

Nodulation decreased from NR II down to NR IV as the altitude decreased. At lower altitudes day time temperatures increase resulting in increased soil temperatures which lead to reduced photosynthesis and increased respiration as well as reduced amounts of N fixed (Waughman, 1977; Lie, 1981). Also, at high temperatures the amount of plant roots produced are usually thin and do not branch and hence have few lateral roots (Waughman, 1977) resulting in low root hair concentration in the rhizosphere. Nodulation occurs at the root hairs hence increased root hair concentration affords more rhizobia attachment sites for initiation of nodulation (Downie, 2010). Increased soil temperatures also result in reduced survival of soil bacteria (Dudeja and Khurana, 1989) and this may also have attributed to reduced nodulation in the soils particularly those in natural regions at low altitudes.

The cropping season also significantly influenced nodulation ($P<.0001$). The 2011/2012 season's crop had significantly higher mean nodule numbers than 2012/2013 season. Soyabeans have one rhizobial infectible period close to the beginning of the root hair growth and are also sensitive to weed growth. This period coincided with the heavy rains and waterlogged conditions during the 2012/2013 season making weeding difficult. Also, under waterlogged conditions carbon dioxide concentrations increase and can inhibit nodule formation (Wei et al., 2008).

The total nitrogen fixed ranged from 80 kg ha^{-1} to 150 kg ha^{-1} after rhizobial inoculation compared to the negative and positive controls

after employing the N- difference method. This observation was in agreement with previous studies done in Hurungwe and Guruve districts of Zimbabwe that found total nitrogen ranging from 60-130 kg ha^{-1} (Kasasa, 1999).

Biomass and grain productivity in response to rhizobial inoculation

Biomass yields responded to rhizobial inoculation ($p<0.0239$) as well as the agro-ecological region in which the trials were established. The TGx varieties produced higher biomass compared to SC Saga at mid-flowering consistent with the findings of previous studies which concluded that promiscuous varieties had higher biomass yields compared to specific ones (Giller, 2008).

Soyabean grain yield responded significantly to rhizobial strain inoculation ($p<0.0378$) with all varieties yielding higher than the negative control. Also, in both seasons' inoculation with rhizobial strains MAR 1305, 1306, 1494 and 1515 out yielded the recommended commercial rhizobial strain. Total nitrogen content was significantly higher than the reference strain for all varieties after inoculation. This shows that there are other strains that have better adaptation to the smallholder cropping systems than the commercially available strain and further exploration of them is important in the success of soyabean production in these cropping systems.

Soyabean grain yields were significantly influenced by the agro-ecological region ($p<0.0001$) with yields decreasing in the order NRII> NRIII> NRIV and also by the cropping season ($p<0.0001$) with 2011/2012 cropping season having better yields than 2012/2013 cropping season. The highest grain yields achieved were 1053 kg ha^{-1} and these were lower than expected yields of 2-4 t ha^{-1} after inoculation. This can be attributed to the fact that grain yields are affected by several factors which include variety selection, planting date, plant populations, nutrient deficiency, weed, disease and insect pressure and rainfall distribution (Pederson, 2007). The promiscuous soyabean varieties were imported at the beginning of the 2010/2011 season hence the seed used in the seasons was first and second generations and seeds lose vigor and genetic potential with every successive generation (Pederson, 2007). Another cause of low grain yields could have been the dry spells during the season which could have affected critical reproductive stages such as pod formation, filling and setting especially during the 2012/2013 season when the rains stopped in early march (Carlson and Knapp, 1992; Gibson and Mullen, 1996; Hu and Wiatrack, 2012).

Plant populations of 250,000 plants per hectare were used at all experimental sites but however closed canopies were achieved in a few fields mainly those in NR II. This failure of the canopy to close could be attributed to low soil fertility in which soyabean plants were established. The soils had low N, soil organic carbon, P and low pH (Table 2 & Table 3). Canopy closure is a great advantage for reduction of soil moisture loss and weed competition (Paz, Batchelor and Seild, 2000; Pederson, 2007). Hence because canopy closure was not attained this could have resulted in increased soil moisture loss as well as competition for nutrients affecting the reproductive stages such as pod formation and seed fill.

All the soils investigated had pH below 6 except one with most of them ranging from 4.17-5.46 and acidic soil conditions are known to result in nutrient deficiencies. Although a basal fertilizer containing N, P, K and S was applied and it is probable that fixation could have occurred as the soils was acidic. Phosphorus, a limiting nutrient, is important in the development of roots and nodules as well as plant energy systems and seed development and maturity hence if its fixation occurred this could have attributed to these low grain yields (Sprent and Sprent, 1990; Marschner, 1995; Vladimir, 2012). If phosphorus were low even after significant nodulation, nodule functions such as seed development and seed maturity could have been affected.

The soyabean variety significantly influenced the grain yield ($p<0.0009$). The commercial variety SC Saga yielded significantly higher than the TGx varieties. This is supported by previous findings which noted that specific varieties produced higher grain yield but lower biomass compared to promiscuous varieties (Giller et al., 2011). However, these results did not offer further support to another study which concluded that promiscuous varieties had the

potential to nodulate and produce high yields in low input cropping systems (Kasasa, 1999).

Conclusions

Achieving optimal soyabean yields in smallholder farming areas is a summation of the soyabean variety, rhizobial strain, climatic conditions and soil conditions. Good soil management practices such as the addition of organic manure which results in improved SOC and good rhizobia proliferation as well as improved soil water holding capacity are critical for sustainable soyabean production in smallholder areas. As most soils in these areas are acidic liming is important in order to improve soil health even after addition of basal inorganic fertilisers. For sustainable soyabean in NR IV supplementary irrigation is required as the incidence of dry spells in this region is increased. Inoculation is a prerequisite in these cropping systems and plans to find other carrier materials need to be explored to reduce application rates making soyabean production even more economical as well as further characterization of available strains to increase options.

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Original Article

AN EVALUATION OF THE OPERATIONAL EFFICIENCY OF PIZZA RESTAURANTS IN ZIMBABWE

P. Mukucha[2]

Abstract

The study sought to test the industry wide claim in the fast-food restaurant industry that they deliver pizza within 10 minutes of waiting. The study further sought to assess the extent to which the actual waiting period for pizza differs from the perceived waiting time. A sample of 500 pizza transactions had their order cycle time measured, and the corresponding perceived waiting time was also recorded from the surveyed respondents who had initiated the transactions. The study revealed that there are statistically significant differences between the prescribed standard waiting time and actual waiting time, and between the actual waiting time and perceived waiting time. This study therefore recommends that restaurateurs in the pizza industry must assess their human and equipment resources in order to reduce the variances in lead times. They must as well provide various materials and activities that occupy customers in order to reduce the perceived waiting time.

Keywords: prescribed standard waiting time, actual waiting time, perceived waiting time

Introduction

Pizza first appeared in the Zimbabwean fast-food market in 1994 as an initiative of Simbisa franchisee, and currently there are several pizza brands operating in the Zimbabwean fast-food market such as Pizza Inn, Pizza Hut, Pizza Slice, and Pizza Matty. Pizza is a high temperature backed savoury dish with a flattened base of dough (Limongi, Simos & Demiate, 2012) that is garnished with several savoury meats and vegetables, and topped with various ingredients such as tomatoes, cheese, pepperoni, bacon, and mushroom (Singh & Goyal, 2010). Furthermore, pizza is a distinguished confectionery product (Natal, Dantas, Vidigal, Ribeiro, Piovessan, Martino & Dias, 2014) of Italian origin (Ceccarini, 2010), that was popularised in the United States of America (USA) (Balkaran, Giampiccoli & Mtapuri, 2016), and currently ranks amongst the most popular fast foods that had received a widespread acceptance across various cultures (Caparaso, Panariello & Sacchi, 2015).

The production of pizza follows one of the two production approaches in operations management: make-to-stock and make-to-order (Chopra, Meindl & Kalra, 2016). Make-to-stock builds a pile of inventory ahead of demand resulting in the ability to instantly fulfil customer orders without any need for a lead time (Forster, Sampson, Walliam & Webb, 2019). On the contrary, make-to-order approach has got its production triggered by customer orders leading to inevitable order fulfilment lead times (Heizer & Render, 2011). The supply of pizza is one such an example of a make-to-order approach where a long-established order fulfilment lead time is 10 minutes across various pizza restaurants in Zimbabwe. It is common in the services sectors for firms to prescribe the duration of service delivery which in essence is the customer wating time (Tasar, Ventura &

[2] *Corresponding Author: Mukucha Paul*
Department of Marketing, Bindura University of Science Education,
P. Bag 1020, Bundura, Zimbabwe.
Tel: +263772129585
E-mail: paulmukucha@gmail.com

Cicekli, 2000). Customer waiting time is defined as the duration between the customer's arrival at a restaurant and the time a customer's order is ready. We often get information from operators on the duration of a journey in the passenger transport industry, duration of a hair cut in the barbershop, duration of a lecture in a classroom, and duration of performance for a live concert. Most pizza restaurants in Zimbabwe likewise indicate the duration of their order fulfilment cycle as within 10 minutes of placing an order. Order fulfilment cycle is the amount of time taken to fulfil a customer's order (Slack, Chambers & Johnston, 2010). However, such operational claims' veracity has never been tested.

Burns and Burns (2008) asserted that it is not unusual for operations management to make generalised pronouncements based on subjective, prejudiced, distorted, or unsubstantiated armchair philosophies. Therefore, there is a need to test whether the generalised order fulfilment time for pizza production in the Zimbabwean fast-food industry is indeed 10 minutes of customers' waiting time. Moreover, it is also yet to be verified whether customers can really ascertain the actual waiting time during their pizza orders' fulfilment. Therefore, the objectives of this paper are to determine whether there are statistically significant differences between standard waiting duration and actual waiting duration, and between actual waiting duration and perceived waiting duration. The rest of the study is organised as follows: literature review, followed by the methodology adopted, and then the presentation of the study results. The last sections pertain to the discussion of the results in the context of the accumulated body knowledge related to waiting time in service delivery systems.

Literature Review

This section is going to review literature related to standard waiting time, actual waiting time and perceived waiting time, and the relationship between these three concepts.

Standard Waiting Time and Actual Waiting Time

Waiting is inevitable and is the first encounter between a patron and a service provider (Bordoloi, Fitzsimmons & Fitzsimmons, 2019). Waiting is divided into three phases: pre-process waiting, in-process waiting, and post-process waiting. Pre-process waiting refers to the period before a consumer start to receive a service, in-process waiting pertains to the actual waiting for the service, while post-process waiting relates to the duration between placing an order and receiving an order. Waiting in a service outlet is a result of a less permanent mismatch between demand and capacity for services where demand exceed capacity. Waiting is a major source of customer dissatisfaction in most service delivery systems (Hwang, 2008), and it affects customers emotionally through inducing negative emotions such as high tensions, anger, shouting, hatred, and provocation of rebellious behaviours (De Vries *et al*., 2018). Therefore, the focus of operations management is usually on reducing waiting time as a way of shortening waiting lines (Taylor, 1994).

Operational processes that are meant to provide goods or services sometimes present variations from the prescribed standards (Chase, Aquilano & Jacobs, 2002). Variations related to operations in terms output volume and task completion time is usually divided into two parts: common variation and assignable variation (Slack *et al*., 2010). Common variation is an inherent part of every production process. Common variation is caused by random, but stable and predictable factors such as the type of equipment employed in performing the task (Chase *et al*, 2002). Assignable variation is generally not part of any production process. Although assignable variation is due to identifiable factors such as employees' actions and machine performance, its occurrence is extra-ordinary (Slack *et al*., 2010).

The reduction in common variation and elimination of assignable variation has a bearing in quality (Chase *et al*., 2002). Adherence to prescribed waiting leads to effective personal time management for customers who obviously are inherently disgusted by having to wait for more time than what is necessary (Maudie & Pierrie, 2006). Reducing delays in order

fulfilment cycles must be one of the key objectives of modern-day businesses in order to avoid unnecessary inconveniences to the customers (Slack *et al*., 2010). Based on the facts presented above, it is prudent to hypothesise that;
H^1: *There are statistically significant differences between actual waiting time and the prescribed standard waiting time*.

Actual Waiting Time and Perceived Waiting Time

Actual waiting time is a predictor of perceived waiting time. Waiting duration is normally perceived differently by customers (Sumaedi & Yarmen, 2015). Perceived waiting time is a duration which a customer subjectively state as the time he has waited to receive his order (Taylor & Fullerton, 2000). There are usually variances between the actual waiting time the customers had gone through and the perception of their waiting time (McGuire, Kimes, Lynn, Pullman & Lloyd, 2010). Such variations are mainly caused by the intolerance to waiting that characterise modern day customers (Zeithaml, Bitner & Gremler, 2013; Wu, Lu. & GE, 2013). Maudie and Pierrie (2006) hold a view full of superlatives that disparages the act of waiting such as agonising, frustrating, annoying, and demoralising.in a study by De Vries, Roy & De Koster (2018) it was revealed that waiting results in rebellious behaviours if perceived as excessive.

While acknowledging that it important to reduce the order fulfilment waiting time, Clow and Kurtz (2003) emphasised that it equally important to also reduce the customers' perceived waiting time. A catalogue of how perceived waiting time can be reduced has already been enumerated by Maister (2005) who suggested the manipulation of the perceived waiting environment with activities that occupy customers such as initiating group waiting, occupied waiting, in process waiting, and fair waiting. It is therefore prudent to anticipate that;
H^2: *There are statistically significant differences between actual waiting time and perceived waiting time*.

The reviewed literature on standard waiting time, actual waiting time, and perceived waiting time which culminated in the specification of the above stated hypotheses, led to the operationalisation and measurement of the study concepts as outlined in the methodology section below.

Methodology

This section presents the details about population and sampling, data collection and analysis procedures.

Population and Sampling

The population in this study was all the customers who bought pizza during the first weekend of the month of October 2019 when data collection was conducted. The unavailability of a proper sampling frame of pizza customers leads to the adoption of a convenience sampling method (Saunders *et al*., 2016). A sample size of 500 respondents was chosen. The sample was drawn from Bindura town. Bindura is the provincial capital of Mashonaland Central province of Zimbabwe and it is surrounded by productive farms and mines. In fact, the Bindura town is hosted in the bread basket province of Zimbabwe.

Data Collection Procedures

In this study the waiting period assessed is the in-process waiting which is the duration between placing an order and receiving an order. Data was collected from all the pizza producing fast foods restaurants in Bindura over a period of one month. Convenience sampling though not perfectly appropriate for this type of a study where results are meant to be generalisable (Saunders, Lewis & Thornhill, 2016; Bryman, 2016) was used for contacting the respondents since a proper sampling frame was unavailable. While data for actual waiting time was collected using unobtrusive methods, data on perceived waiting time had to be collected from consenting customers. Usually in the restaurant industry the numbers of consenting respondents are very low further justifying the use of non-probability-based sampling methods.

The study made use of research assistants in data collection exercise. The research assistants made use of a stop watch to record data related to the actual waiting time from a vantage point

in target restaurants. After collecting data on actual waiting time, the assistants would proceed to collect data on perceived waiting from consenting respondents as they left the restaurant or as they sat down to eat their pizza.

Data Analysis Procedures

Data analysis was conducted in two phases using a Statistical Package for Social Scientists (SPSS) v 25. The first phase presented an analysis of descriptive statistics for the profile of the respondents and the variables studied using the arithmetic mean and the standard deviation. The second phase tested hypotheses using paired sample t-tests. The paired sample t-test, which is also referred to as the dependent sample t-test, is a statistical procedure used to assess whether the mean difference between two observations is similar. In a paired sample t-test, each subject or entity is measured twice, resulting in pairs of observations. The common applications of the paired sample t-test statistical tool include, but not limited to repeated-measures designs. The magnitude of the differences revealed from the paired t-tests were assessed using the Cohen's d value (Cohen, 1988).

Results

The results of this study include demographic profile of respondents, statistical assumptions and descriptive analysis, and hypotheses testing.

Demographic Profile of Respondents

The demographic profile of respondents the age, gender, marital status and educational levels of the respondents and the results are shown in Table 1.

Table 1: Demographic profile of respondents

Attribute	N	%
Age		
18-29	205	41.5
30-39	148	29.6
40-49	110	22.0
50-59	20	04.0
60+	7	01.4
Total	**500**	**100.0**
Gender		
Male	220	44.0
Female	280	56.0
Total	**500**	**100.0**
Marital status		
Single	295	59.0
Married	205	41.0
Total	**500**	**100.0**
Education		
Primary	116	23.2
Secondary	264	52.8
Tertiary	120	24.0
Total	**500**	**100.0**

Table 1 showed that the age group of the young adults (18-29) was highly represented in the surveyed sample (41.5%). It seems this is the age group that frequently patronise pizza restaurants. Females (56%) also dominated the number of respondents suggesting that females prefer pizza more than men or alternatively they are the once that run the errands of purchasing pizza for the whole family including men. Unsurprisingly singles (59%) dominated the surveyed respondents since it is expected that single individuals tend to have more discretional income to patronise pizza restaurants. It should be appreciated that in Africa in general and Zimbabwe in particular pizza is a status dish that is accessible to those in the high-income bracket or those with a lot of discretional income like single working people. Lastly, the majority of the respondents (52%) have a secondary education qualification which is a general requirement for most employed urbanites.

Statistical Assumptions Testing

Although *t*-tests are quite robust, it is good practice to evaluate the degree of deviation from these assumptions in order to assess the quality of the results. In a paired sample *t*-test, the observations are defined as the differences between two sets of values, and each assumption

refers to these differences, not the original data values. The paired sample *t*-test has four main assumptions: the dependent variable must be ratio, approximately normally distributed, should not contain any outliers, and the observations are independent from each other.

The key assumptions in studies that employ the use of paired sample t tests is that data should be randomly selected from a normally distributed sample (Wegner, 2012). There are several statistical tests for determining the normality of the distribution of collected data such as the Kolmogorov-Smirnov test and the Shapiro-Wilk test which are found in most data analysis softwares (Saunders *et al*., 2016). In this study normality tests were conducted using a Shapiro-Wilk test. The results of a Shapiro-Wilk's test of normality are shown in Table 2.

Table 2: Normality tests

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Actual Time	2.848	500	.132
Perceived Time	2.874	500	.241

a. Lilliefors Significance Correction

The results in Table 2 show that all the measured data is normally distributed as evidenced by the insignificant *p* values, and therefore suitable for the preceding statistical tests.

Descriptive Analysis

The descriptive analyses of the data related to actual and perceived waiting time are shown in table 3.

Table 3: Descriptive statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Standard Time	10.00	500	.000	.000
	Actual Time	10.87	500	2.780	.124
Pair 2	Actual Time	10.87	500	2.780	.124
	Perceived Time	15.05	500	2.341	.105

The descriptive results in this study show that there is an average difference of 0.87 of a minute between standard order fulfilment time and actual order fulfilment waiting time. The differences between actual order fulfilment time and perceived order fulfilment waiting time were close to 5 minutes. The standard deviations for both actual waiting time and perceived waiting time were very low indicating there was a general consensus in the responses from the surveyed respondents. Stand deviation is a measure of dispersion of a data set (Levine, Stephan, Krehbiel & Berenson, 2013). A low standard deviation indicates the extent to which data points are close to the mean while high standard deviation cast doubt on the exact outcome (Swink, Melnyk, Cooper & Hartley, 2014). Whether these differences were statistically significant or were merely a product of chance, the section below on hypotheses testing will present a determination.

Hypothesises Testing

H^1 postulated that there are statistically significant differences between the standard waiting time for pizza delivery and the actual waiting time. The hypothesis is non-directional which implies a two-tailed test. H^2 in turn suggested that there are statistically significant differences between the actual waiting time and perceived waiting time for pizza. The hypothesis is also non-directional which implies a two-tailed test.

Table 4: Paired samples test

		Paired Differences					T	df	Sig.
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Standard Time Actual Time	-.870	2.780	.124	-1.114	-.626	-6.998	499	.000
Pair 2	Actual Time Perceived Time	-4.180	3.794	.170	-4.513	-3.847	-24.634	499	.000

The results from paired sample t-test showed that the mean difference between the standard waiting duration and the actual waiting duration (MD=-.870, SD=2.780. 95% CI [-1.114, -.626] was statistically significant at the .05 level of significance, t=-6.998, df=499, p<.001, d=.31. The null hypothesis which suggested that are no significant differences between the mean of the standard waiting duration and the mean of the actual waiting duration is rejected. The magnitude of the difference falls into the .20<.50 category which implies a weak difference.

The results from paired sample t-test showed that the mean difference between the standard waiting duration and the actual waiting duration (MD=-4.180, SD=3.794, 95% CI [-4.513, -3.847] was statistically significant at the .05 level of significance, t=-24.634, df=499, p<.001, d=1.10. The null hypothesis which suggested that are no significant differences between the mean of the actual waiting duration and the mean of the perceived waiting duration is rejected. The magnitude of the difference falls into the .80<1.20 category which implies a weak difference.

Discussion

The results from this study indicated that there is a slight unfavourable variance in terms of the standard pizza lead time and the actual lead time. This suggests that most pizza restaurants in Zimbabwe are failing to adhere to their prescribed standard order fulfilment lead times. The variability and uncertainty of restaurant demand makes waiting management complicated (Hwang, 2008). As has already been suggested in literature these variations are most probably due to either human factors or machine factors (Slack *et al*., 2010). A bi-pronged approach of assessing both human factors and machine factors is mostly appropriate for investigating the causes of adverse variances in operations management performance matrices.

Inferences as to human factors that are likely to cause these variations can be drawn from the prevailing hyperinflationary environment that is characterised by high levels of austerity measures. Generally, in struggling economic environments employees tend to be less motivated resulting in poor service delivery as evidenced by prolonged lead times. Moreover, during economic turbulences there are high employee turnovers. High employee turnovers lead to regular deployments of new employees as boundary spanners. Whenever there is a new employee at a workstation it usually takes a longer period of time to adjust to the new system and start efficiently deliver the services (Hoffman, Bateson, Wood & Kenyon, 2009). During the induction period when new employees are adjusting to the new systems operational efficiencies tend to take a nosedive. Therefore, it is advisable that restaurateurs must come up with innovative employee motivation strategies that enhance employee retention and reduce employee turnover (Sturman & Ford, 2011). In the event of a new employee recruited then quick and thorough training sessions should be conducted before they are unleashed to man the boundary spanning roles (Zeithaml *et al*., 2013).

Delays in lead times can also be attributed to inefficient production equipment that has been underserviced (McGuire, Kimes, Lynn, Pullman & Lloyd, 2010). In the prevailing austerity environment, it is not unusual to find that most business operators have exceeded the prescribed equipment operating hours before major maintenance services. Thus, lack of timely maintenance services is likely to lead to prolonged production and service delivery lead times which eventually lead to customer dissatisfaction (Fullerton & Taylor, 2015).

This study also revealed that there is an adverse variance in terms of the actual waiting time and perceived waiting time. The findings that perceived waiting duration was found to be longer than the actual waiting duration lend some empirical support to earlier studies by Lee and Lambert (2000) which had the same findings. This confirms that actual waiting time almost always differs from perceived waiting time. This variance is most likely to have been caused by shortage of initiatives that may occupy customers while they are waiting for their orders. Extant services marketing literature has suggested that unoccupied waiting feels longer (Maister, 2005). Master (2005) suggested that customers must be provided with activities that keep them occupied while waiting for their orders in the perceived waiting environment. Such activities include providing reading material such as menus and magazines, television, and more recently free internet access.

Managerial Implications

Generally, waiting is unacceptable since it affects the levels of perceived service quality, customer satisfaction, and eventually customers' revisit or repurchase intentions (Chuo & Heywood, 2014). Management should strive to keep customers' waiting to the minimum. Therefore, the fact that there were some variances between the actual waiting time and the perceived waiting time implies that management need to implement some practical measures to reduce perceived waiting time. Maister (2005; 1985) prosed a raft of psychological measures that may lessen the duration of the perceived waiting time such as avoiding waits that ae unoccupied, uncertain, unexplained, pre-process, solo, and unfair. Practically, this may mean offering complimentary beverages and providing menu lists (Taylor, 1995).

Management must also invest in technology that expedite the production and delivery of customers' orders. Such technology includes the automated pizza cutting machines which are prevalent in developed markets, but largely unavailable in most of the local pizza restaurants. The automated pizza cutting machines cut pizzas as large as 12 inches into eight equal slices in less than 20 seconds, and can also slice pizzas as large as 21 inches into 12 equal slices (Saeed, Sattar & Ferguson, 2020).

Limitations and Further Research

Waiting in restaurants has attracted attention of many researchers (Hernandez-Maskivker, Nicolau, Ryan & Valverde, 2019), but most studies including this study did not assess the causes of the failure to match the prescribed waiting time and the reasons behind the exaggerated customers' perceived waiting duration in the restaurant industry. Future researches should therefore investigate various causes of customers' waiting and possible ways of reducing the waiting duration. Moreover, there are some service experiences where waiting does not always result in negative customer outcomes (Chu et al., 2019). Therefore future studies should also investigate positive outcomes from waiting.

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THE MODERATING EFFECT OF DEMOGRAPHICS AND INSTITUTIONAL CHARACTERISTICS BETWEEN RELIGIOSITY AND COST AND MANAGEMENT ACCOUNTING PRACTICES OF RURAL SMES.

L. Mandongwe[3], D. C. Jaravaza, F. Makudza

Abstract

The main purpose of the study was to evaluate the direct and indirect effects that owner/manager demographic attributes and firm characteristics have on the relationship between religiosity and the two dependent variables, cost accounting and management accounting in Small to Medium Enterprises (SMEs) of subsistence economies. Self-administered survey was used to draw responses from 100 SMEs in Manicaland Province, Zimbabwe. To facilitate the analysis of the data, given the moderation effect that sought to be tested, both IBM SPSS Statistics v26 and the Hayes Process Macro for SPSS were used. The moderation effect was validated through general linear factorial MANOVA. The study provided evidence on the significance of education in moderating the relationship between religiosity and cost and management practices (CMAPS). However, two demographic variables (age and gender) and three firm characteristics (revenue, number of employees and years in business) were not statistically significant and therefore had no interaction effects between these independent and dependent variables. It was recommended to encourage on lifelong learning and education to entrepreneurs as a way of enhancing the use of cost and management accounting practices in subsistence markets so as to boost their financial performance.

Keywords: Cost and management accounting practices; religiosity; demographic profiles; firm characteristics

Introduction

SMEs the world over, have proved to play a pivotal role in economic development. Their contribution to employment creation and poverty reduction is uncontested (International Council of Small Business-ICSB, 2021). Many governments have channelled financial and technical resources to improve the viability of SMEs. To augment this government's objective, cost and management accounting practices (CMAPs), whose role is to facilitate quality decision making, planning, coordination and control are important. Socially, religiosity has demonstrated an extreme influence to humanity. Its impact on personal conduct and other domains of human life has been momentous. Religiosity, as a person's spirituality or belief in the existence and influence of supernatural factors has an impact on a person's life in terms of living, success or failure (Leung, Bond, de Carrasquel, Muñoz, Hernández, Murakami, Yamaguchi, Bierbrauer, and Singelis, 2002). For the purpose of this study, an SME shall be defined using the European Union's 1996 definition where an SME was understood as a firm employing less than two hundred and fifty employees (Commision, 2005).

[3] *Corresponding Author: L. Mandongwe*
Department of Accounting
Manicaland State University of Applied Sciences
P Bag 7001 Fernhill, Mutare, Zimbabwe
lucia.mandongwe@staff.msuas.ac.zw

Prior research displays minimal attention on how religiosity connects to CMAPs in subsistence markets (Ueda, 2011). Similar to big organisations, Small and Medium Enterprises (SMEs) have to embrace CMAPs to perfect their performance, survive with limited resources and enhance their competitive advantage (Lavia-Lopez and Hiebl, 2015; Bui, Le, & Nguyen, 2020). Non-financial and financial information exhibited by the CMAPs allow firms to successfully fight market rivalry and exhibit superior performance (Ahmad and Zabri, 2016; Reid and Smith, 2002).

SMEs are 90% of firms in the formal and informal sector (International Council of Small Business-ICSB, 2021). In Zimbabwe, SMEs are 70% of businesses contributing 50% to the GDP of the country (Reserve Bank of Zimbabwe, 2021). It is expected that a great deal of these SMEs are in rural areas (Gukurume, 2018). Cost and management accounting practices (CMAPs) have attracted many researchers owing to their importance in the business circles especially in cost control and decision making. However, rural SMEs accounting practices have not attracted the interest of scholars especially in subsistence economies. Additionally, accounting scholars have not embraced behavioural constructs such as religiosity in their researches, relegating these constructs as not relevant in accounting research. However, since CMAPs are a result of human effort, the influence of religiosity cannot go unheeded if an insight on SMEs accounting practices is required. The same sentiments can be said on Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standard for SMEs (IFRs (Kılıç, Uyar, & Ataman, 2014). Given this background, the study was a response to a dearth in literature on the influence of religiosity on CMAPs in most rural SMEs of developing economies like Zimbabwe.

Most studies have in fact focused on CMAPs of large corporation in developed countries which are already acquainted with this practice (Zaid, Roshaiza, Rosliza, & Wan, 2018). This then leaves SMEs in subsistence markets without the necessary attention. This study's main objective was to determine the moderating effects of owner demographic attributes as well as SME characteristics on the association between religiosity and CMAPs of rural SMEs.

Review of Literature and Development of Hypotheses

Religiosity and its interaction with human life.

Religiosity can synonymously be referred to as religiousness or simply religion (Wilkes, Burnett, & Howell, 1986). There is no universally agreed definition of religiosity (Fetzer Institute, 1999; Hackney and Sanders, 2003). However, generally, religiosity is understood as the degree of confidence in a particular religious custom and principles by an individual (Delener, 1990; Leung, et al., 2002). It is also argued that religiosity is an interconnected system of beliefs, symbols, norms and values with the aim of bringing that individual nearer to their sacred, super and ultimate power (Koening, McCullough, & Larson, 2001).

Religion has an impact on accounting due to its ability to influence culture (Lewis, 2001). The behaviour of a human being even at the work place is influenced by the social person (Crutzen and Herzig, 2012;Speckbacher and Wentges, 2012). The social person is made up of three amalgamated features which are the spirit, body and soul (Imran, Binti, Hamid, & Binti, 2017). History indicates the belief that a person's spirituality is like a jacket that can be undressed as soon as one is about to enter the work place (Roundy, 2009). Nevertheless, some researchers have indicated the impossibility of separating spirituality from work life (Imran et al., 2017; Olowookere, 2014; Roundy, 2009). The implication of this is that employee behaviour, interpretation of their job description, assessment and performance of their duties is greatly a result of their religious affiliation, customs and beliefs.

There are three major religions whose spiritual guidelines are strictly adhered to by their followers and these are Christianity, Islamism and Judaism (Olowookere, 2014; Roundy, 2009). Devotion (prayer) has proved to be a

religious element that is most common in religions. Islamic law and morals are directly linked to work as well as business and these philosophies are strictly observed. Hence there is an argument that certain employees' behavioural traits are a manifestation of their religious beliefs in which they will be seeking a reward from their supreme being in their businesses (Salem and Agil, 2012). This idea is supported as an uncontested truth that religion has an impact to human behaviour in every aspect of their lives, be it at home or at their work place.

Cost and Management Accounting Practices

Management accounting is a subdivision of accounting mainly centred on disclosing information that assists in planning, evaluation and control with the aim of producing the greatest possible performance (AlKhajeh and Khalid, 2018; Bui, *et al*., 2020; Crutzen and Herzig, 2012). On the same note, being able to account for costs entails cost accounting and is a vital tool for business survival. A business' cost accounting practice helps in providing information which will lead to knowledgeable decisions pertaining to make or buy, profitability and competitive selling price to mention just but a few (Horngren, 2009; Uyah, 2010).

Importance of CMAPs

The prevailing business environment, intoxicated by the Covid-19 pandemic, has become very dynamic, associating itself with many different products and putting much emphasis on overheads. Such an overhead intensive cost structure has taken activities as very significant as opposed to the traditional system which held volume with high esteem. It is imperative to epistle that a majority of modern cost and management accounting practices consists of financial as well as non-financial elements. These, when properly applied succours in attaining strategic goals (AbRahman, Omar, Rashid, & Ramli, 2016; Dlamini, 2020; Kaplan, 1984; Zehra and Ahmed, 2019).

2.3. Moderating factors between CMAP and religiosity

Gender of the Owner/Manager

There is a heated debate on the relationship between gender and the implementation of CMAPs or organisational success. However, gender has been observed to be very crucial in determining the operations of a business (Walker and Brown, 2004). Some scholars agree that women do not operate a business at the same wave length with their male counter parts (Isaga, 2015; Woldie, Leighton, & Adesua, 2008). In most cases, business women from an African patriarchal society have multiple roles at work and at home (Mandongwe and Jaravaza, 2020). When they get involved in business, they exert an unequal effort compared to their male counterpart due to family commitments.

However, some studies on male and female managed SMEs revealed that there was no indication that males are better in terms of assessing financial performance when compared with their female counterparts (Johnsen and McMahon, 2005). More so, Collins-dodd, Gordon, & Smart, (2004) concluded that gender has no substantial effect to the performance of business activities. Other variables may be coming into play. From a statistical perspective of 192 countries studied by the Pew Research Centre (2016), women around the world appear to be more religious than men due to the large numbers they hold in every type of religion, be it Islam, Christianity or ATR. It has also been found out that there is no country in which men surpass women in religious affiliation and activities (Pew Research Centre, 2016). We therefore hypothesise the following:

H_1: Gender moderates the relationship between religiosity and cost accounting practices of rural SME owner/managers.

H_2: Gender moderates the relationship between religiosity and management accounting practices of rural SME owner/ managers.

Age of the Owner/Manager

An acrimonious debate concerning the effect of the owner/manager's age on the adoption of CMAPs is at hand. Studies conducted on the effect of the owner/manager's age on the

financial aspects of SMEs concluded that the age of the owner/manager is negatively correlated to the growth of the SME (Isaga, 2015; Woldie, *et al*., 2008). It therefore implies that the younger owner/managers are characterised by a lot of zeal, extra energy, a lot of commitment and can try by all means to apply the necessary CMAPs in order to succeed. Their older owner counterparts on the other hand, who would have been in business for a long time, would have made it in business and therefore progression will not be all that is important.

However, since experience is the best teacher, there is an opposing group of researchers who argue that older owner/managers, despite lacking more energy, are the best in terms of experience and therefore have a higher potential to apply CMAPs (Cortes, Garcia, & Ramon, 2008). Due to the above conflicting findings some scholars were of the opinion that middle managers are the best in terms of running SMEs through CMAPs (Van Praag, 2003) . This is due to their unique qualities of possessing the younger owner/manager's energy and the older owner/manager's experience.

Turning to religion, it has been argued that religion is life and can dictate how one operates in every aspect of life (Albu and Albu, 2012; Kalifa, Triyuwono, Irianto, & Prihatiningtias, 2020, Ueda, 2011). Extensive research by the Pew Research Centre (2016), on 106 countries, indicate that people under the age of forty are less religious than their older equivalents. It is usually believed that as a person gets older, he/she is more grounded into his religious beliefs as a way of life. One may therefore pose the idea that religion can substitute CMAPs.

Basing on this heated debate, the following hypotheses are expressed:

H_3*:* Age moderates the relationship between religiosity and cost accounting practices of rural SME owners/managers.

H_4*:* Age moderates the relationship between religiosity and management accounting practices of rural SME owners/managers.

Level of Education of the Owner/Manager

The education level of the owner/manager together with the qualifications and skills of the accounting staff greatly influence the extent of adoption of CMAPs especially in subsistence markets (Albu and Albu, 2012; Butler, Henderson, & Raiborn, 2011; Crutzen and Herzig, 2012). There is a lot of support on the idea that skilled and competent accounting employees in a business produce a very good set of financial records and their financial assessment is marvellous (Al Shanti, 2019; Kosaiyakanont, 2011; Ojua, 2016). From a Malaysia manufacturing company study conducted, it was discovered that there is a positive association between the level of education of employees and the usage of the accounting information systems (Ismail and King, 2007). The implication of this conclusion the right education is important to an SME owners/managers to succeed.

However, from a religious perspective, highly religious individuals are associated with greater dedication to their supreme being (Al Shanti, 2019; Ojua, 2016). They have a proclivity to credit their business success to their supreme power.

Thus, the following hypotheses were formulated:

H_5*:* Education moderates the relationship between religiosity and cost accounting practices of rural SME owners/managers.

H_6*:* Education moderates the relationship between religiosity and management accounting practices of rural SME owners/managers.

Revenue of the SME

A number of studies discovered that the revenue of the firm, has a great bearing on the application of CMAPs (Albu and Albu, 2012; Al-Omiri and Drury, 2007; Haldma and Laats, 2002). Larger organisations are usually characterised by a large revenue base and are ordinarily very complex in nature. They are therefore often associated with the recent and highly innovative CMAPs (AlKhajeh and Khalid, 2018; Alsharari,

2019; Dlamini, 2020; Senftlechner and Hiebl, 2015). This implies that companies with a large revenue base are indispensable with CMAPs as opposed to their small counterparts with a limited revenue base.

However, since religion has been found to be a stimulus to human behaviour, it is believed to follow the individual even at the work place and impact on their job performance. It has been found out that some employees even from big companies are affected by their religious practices during employment performance. This is intrinsic religiosity which dictate their daily living (Ueda, 2011). They get into the religion and lives in it.
From this indication, the following hypothesis are claimed:

H_7: Revenue moderates the association between religiosity and cost accounting practices of rural SMEs.

H_8: Revenue moderates the association between religiosity and management accounting practices of rural SMEs.

Number of SME employees

Previous researchers revealed widespread practice of cost and management accounting in organisations with many employees (Ahmad and Zabri, 2016; Senftlechner and Hiebl, 2015). This category of SMEs is usually non-family-owned SMEs. The increased application of CMAPs in larger companies is attributed to the fact that family-owned businesses often ignore professionalism or strict accounting in their business conduct (Moilanen, 2008). One may assume that the owner/manager from the family business' belief in spiritual intervention may be the reason for ignoring CMAPs.
It has been identified that some businesses with a small number of employees have a high level of trust on each other to the extent that they will not see the need for CMAPs. Also, since family-owned businesses are not mandated to report publicly, CMAPs may be viewed as a waste of time and resources.

Hence the hypotheses can be formulated as follows:

H_9: Number of employees moderate the relationship between religiosity and cost accounting practices of rural SMEs.

H_{10}: Number of employees moderate the relationship between religiosity and management accounting practices of rural SMEs.

Duration of the SME in business

Intrinsic and extrinsic firm characteristics will determine the extent in which an SME may survive in business (AlKhajeh and Khalid, 2018; Valtakoski and Witell, 2018). Its duration in business greatly determines its adoption of the CMAPs and success (Shahzadi, Khan, Toor, & ul Haq, 2018; Essel, Adams, & Amankwah, 2019; Msomi, Ngibe, & Nyide, 2019). Firms that have been in operation for an excess of six years have proved to appreciate the importance of CMAPs (Essel, Adams, & Amankwah, 2019). Young firms (less than 5 years old) find it so challenging to implement CMAPs due to the fact that they usually face financial challenges (Al-Omiri and Drury, 2007). Their infancy stage in business hinders them access to financial assistance and hence they will fail to institute CMAPs, some of which will be requiring expensive expertise. Fernández-Olmos and Ramírez-Alesón, (2017) argue that there is no need to wait for a mature business stage to implement CMAPs.

From religious spectacles, religiosity helps individuals to find solutions to the problems they encounter in their daily lives (Tsang and McCullough, 2003; Pew Research Centre (2016). Thus, basing on the foregoing, these hypotheses were formulated:

H_{11}: Duration in business moderates the association between religiosity and cost accounting practices of rural SMEs.

H_{12}: Duration in business moderates the association between religiosity and management accounting practices of rural SMEs.

The following is the overall theorised model for this study:

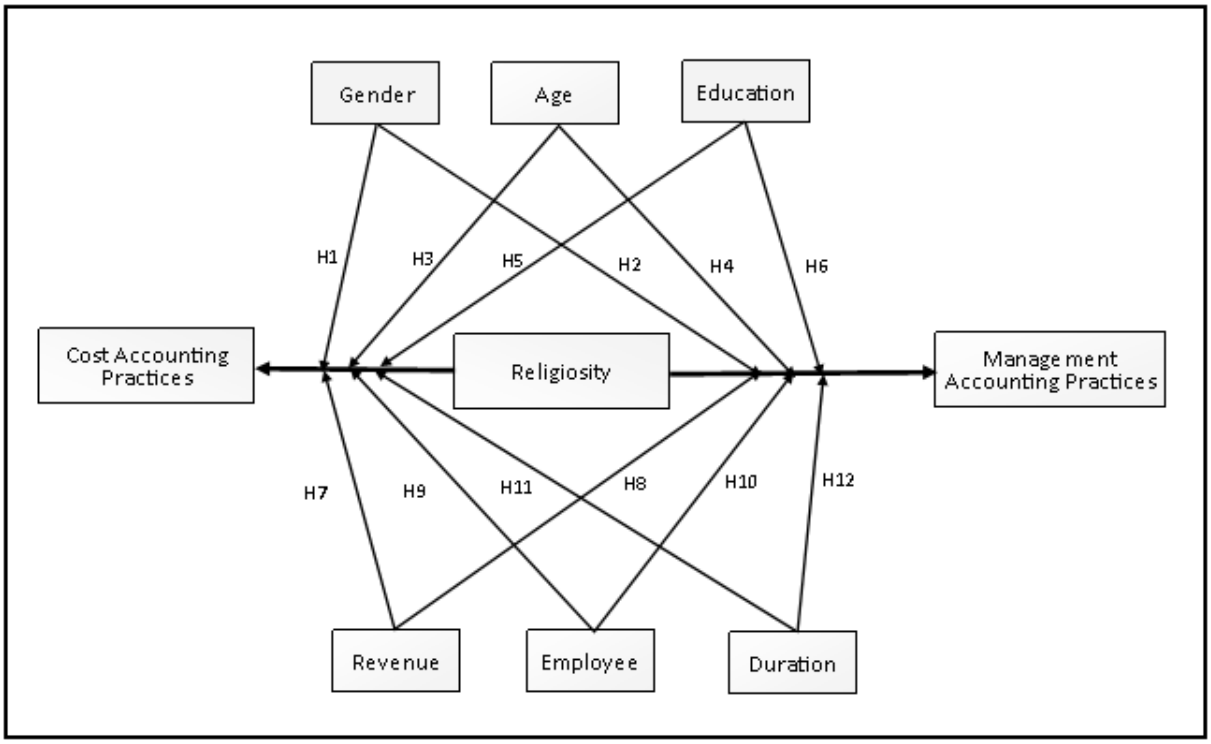

Figure 1: Theorised model
Source: Researchers' own

Methodology

The study was guided by a positivist philosophy which holds that the moderation between religiosity and CMAPs can be objectively identified. A quantitative strategy was thus followed in structuring the six moderators of the study model. The study targeted small to medium entrepreneurs in the eastern province of Manicaland in Zimbabwe. To enhance objectivity, the study used the database of registered SMEs which presented a total of 204 SMEs. Using the Morgan (1971) sample size extract, at 95% confidence interval and 5% margin of error the sample size for the study was 132 respondents. Data was collected using a self-administered, structured questionnaire in a once-off cross-sectional survey.

The moderating effect of demographic profiles of entrepreneurs and firm characteristics as well as the direct effect of religiosity on cost and management accounting practices were assessed using Hayes Process Macro in SPSS. According to Jaccard and Jacoby (2010). Moderation effect was further validated through general linear factorial MANOVA (Jaccard and Jacoby, 2010). The study followed high levels of good research ethics throughout the entire study.

Results

The study administered a total of 132 questionnaires, yet 100 were returned and validated. That gave a validated response rate of 76%. According to Siti (2013) a response rate of below 50% is unacceptable and response rate above 50% may be validated, whilst response rates above 75% are deemed adequate. To facilitate the analysis of the data, given the moderation effect that sought to be tested, both IBM SPSS Statistics v26 and the Hayes Process Macro for SPSS were used. The results are summarized in the sections below.

Demographics and SME Characteristics

For this study, three firm characteristics and three demographic variables were considered. Gender, age and highest level of education were considered for demographics whilst revenue,

number of employees as well as the duration in business were taken aboard for SME characteristics. The key findings are summarized in Table 1.

Table 1: Demographic Distribution

		Frequency	Percent	Cumulative %	95.0% LCI	95.0% UCI
Gender	Male	53	53.0	53.0	43	63
	Female	47	47.0	100.0	37	57
Age	21 – 30 Years	27	27.0	27.0	19	36
	31 - 40 Years	44	44.0	71.0	35	54
	41 - 50 Years	23	23.0	94.0	16	32
	>50 Years	6	6.0	100.0	3	12
Education	O level	26	26.0	26.0	18	35
	A level	38	38.0	64.0	29	48
	Certificate	30	30.0	94.0	22	39
	Diploma	5	5.0	99.0	2	11
	Degree	1	1.0	100.0	0	5
Revenue	< $240 000	47	47.0	47.0	37	57
	$240 000 - 1000 000	28	28.0	75.0	20	37
	> $1000 000	25	25.0	100.0	17	34
Employees	<10 Employees	36	36.0	36.0	27	46
	10 - 20 Employees	36	36.0	72.0	27	46
	21 - 30 Employees	17	17.0	89.0	11	25
	31 - 40 Employees	3	3.0	92.0	1	8
	> 40 Employees	8	8.0	100.0	4	15
Duration	< 2 Years	23	23.0	23.0	16	32
	3 - 5 Years	34	34.0	57.0	25	44
	6 - 10 Years	24	24.0	81.0	16	33
	> 10 Years	19	19.0	100.0	12	28

From the foregoing, there was a marginal difference in the distribution by gender, with males being 53% while females were 47%. With respect to the age, the majority of the respondents were middle aged, with the modal age group being those between 31 and 40 years (44%), while those aged between 21 and 30 years were 27%, and those aged between 41 years and 50 years were 23%. With respect to the highest level of education, the majority had attained Advanced level (38%), while those with a certificate were 30%, and those with an Ordinary level were 26%. The majority of the businesses had a revenue of less than $240,000 (47%), while 28% had a revenue between $240,000 and $1,000,000. The least proportion were those who had a revenue of more than $1,000,000.

With respect to the number of employees, the modal categories were those who had less than 10 employees and those with 10 to 20 employees, whose proportion was 36% respectively, making a cumulative total of 72%. The third highest category were those who had 21-30 employees, while those with 31-40 employees were merely 3%, and those with more than 40 employees were only 8%. Lastly, with respect to the number of years in operation, the modal category was comprised of SMEs who had been in operation for 3-5 years (34%), followed by those who had been in operation for

6-10 years (24%), while those who had been in operation for less than 2 years were 23%. The least proportion were those who had been in operation for more than 10 years and these were 19%.

Reliability

This study comprised of three major constructs and these were cost accounting practices, management accounting practices and religiosity. They were measured by a number of items using the 5-point Likert scale, and were thus latent variables. It was imperative for the reliability of these latent variables to be established, with the minimum acceptable being 0.7 (Carden, Camper, & Holtzman, 2019). The respective reliability tests were done using the Cronbach's alpha and the results are presented in Table 2.

Table 2: Reliability Tests

	Cronbach's Alpha	**N of Items**
Cost accounting practices	.873	7
Management accounting practices	.803	3
Religiosity	.738	3

From the outcome, the minimum alpha statistic was 0.738 for the construct religiosity, while the highest was for cost accounting practices (α = 0.873), and this was followed by management accounting practices (α = 0.803). With the alpha statistic being greater than 0.70 in all the outputs, the researchers confirm that the constructs used were reliable.

Descriptive Statistics

The descriptive summaries for the three constructs considered in this study are presented in this section. Since the 5-point Likert scale was used, the midpoint that was considered was 3.0, with mean ratings less than 3.0 indicating either infrequent use or general disapproval by the respondents and those above 3.0 indicating frequent use or general approval. Religiosity was measured using four items from the Centrality of Religiosity Scale (CRS) adapted from Huber and Huber (2012). The items for the CMAP were based on a synthesis of items from Drury, Praund, Osborne and Tayles (1993), Lamminmaki and Drury (2001) and Abdel-Kader and Luther (2006).

Cost Accounting Practices

Table 3 below summarises the distribution of the responses that measured the extent to which cost accounting practices were being applied.

Table 3: Cost Accounting Practices

	N	Mean	SD	Skewness	Kurtosis
Adding mark up to a job cost	100	2.93	1.387	.128	-1.277
Adding mark up to a batch cost	100	2.87	1.353	.066	-1.119
Recording costs of contracts	100	3.24	1.498	-.274	-1.311
Maintaining process costs	100	2.84	1.536	.018	-1.518
Making decisions basing on variable costs	100	3.12	1.499	-.117	-1.473
Making decisions basing on total costs	100	3.29	1.416	-.422	-1.074
Calculating costs basing on activities	100	2.73	1.496	.328	-1.333
Cost Accounting Aggregate	**100**	**2.79**	**.943**	**-.551**	**-.582**

The outcome shows a generally poor cost accounting practice, with four of the seven items being rated below the midpoint 3.0. The most frequent practice was the making of decisions basing on total costs (M = 3.29; SD = 1.416), followed by the recording of costs of contracts (M = 3.24; SD = 1.498). The third frequent cost accounting practice was making decisions basing on variable costs (M = 3.12; SD = 1.499). These standard deviations were very high, along with platykurtic distributions, as all kurtoses were negative and this finding shows that there

was no consensus among the respondents. On the other hand, the least frequent cost accounting practice was the calculation of costs basing on activities (M = 2.73; SD = 1.496), while the second least was the maintaining of process costs (M = 2.84; SD = 1.536), and the third least practice was adding mark up to a batch cost (M = 2.87; SD = 1.353). Adding mark up to a job cost was the fourth least rated practice (M = 2.93; SD 1.387). The aggregate for the cost accounting practices was M = 2.79 (SD = 1.387), and being less than the midpoint, this meant that cost accounting practices were not practiced frequently.

Management Accounting Practices

The distribution of management practices is presented in Table 4 below.

Table 4: Management Accounting Practices

	N	Mean	SD	Skewness	Kurtosis
Budget preparation	100	2.71	1.671	.274	-1.624
Making standard costs and analysing variances	100	2.63	1.649	.351	-1.547
Evaluating a capital investment decision	100	2.51	1.599	.466	-1.409
Management Accounting Aggregate	**100**	**2.62**	**1.389**	**.356**	**-1.163**

From the outcome, all the management accounting practices had mean ratings that were less than the midpoint, with the most frequent practice being budget preparation (M = 2.71; SD = 1.671). Making standard costs and analysing variances was the second frequent management practice (M = 2.63; SD = 1.649), while the least practiced management accounting practice was evaluating a capital investment decision (M = 2.51; SD = 1.599). Overall, the aggregate management accounting rating was below the mid-point (M = 2.62; SD = 1.389), and this shows that the respondents did not practice management accounting often. Nevertheless, the fact that the standard deviations and kurtoses were very high shows that there were high discrepancies in the responses, suggesting that while the majority tended towards the infrequent practice of management accounting, there were a few who were frequently practicing this.

Religiosity

The third construct was religiosity, and the summary statistics are presented in Table 5.

Table 5: Religiosity

	N	Mean	SD	Skewness	Kurtosis
Influence of religious beliefs to a firms' success	100	4.48	.822	1.658	2.160
Impact of religious commitment to the firm's success	100	4.47	.870	1.738	2.709
Religious sacrifices' link to business performance	99	4.37	1.055	2.025	3.613
Religiosity Aggregate	**100**	**4.44**	**.704**	**1.796**	**3.342**

From the outcome above, all the mean ratings were greater than the midpoint and this shows that the respondents did agree on the role of religion towards the success of the business. The highest rating was that religious beliefs do influence a firms' success (M = 4.48; SD = 0.822), that religious commitment has an impact on the success of the business (M = 4.47; SD =

0.870), and that there is a link between religious sacrifices' and business performance (M = 4.37; SD = 1.055). On aggregate, the overall rating for religiosity was M = 4.44 (SD = 0.704) and being greater than the mid-point, this confirmed that the majority of the respondents did agree on the significant positive role that religion plays towards the performance of the business.

Testing the Moderation Effect

The study's focus sought to evaluate the direct and indirect effects that demographic attributes have towards the relationship between religiosity and the two dependent variables, cost accounting and management accounting practices. The moderation effect was tested using the Hayes PROCESS Macro for SPSS and the model summary is presented in Table 6.

Table 6: Moderation Effect Model Summary

DV	Moderator	R	R-sq	MSE	F	df1	df2	p
CA	Gender	0.204	0.042	0.843	1.462	3	96	0.217
	Age	0.219	0.048	0.874	1.608	3	96	0.193
	Education	0.578	0.334	0.842	9.827	3	96	0.000
	Revenue	0.144	0.021	0.899	0.676	3	96	0.569
	Employee	0.138	0.019	0.900	0.618	3	96	0.605
	Duration	0.133	0.018	0.902	0.578	3	96	0.631
MA	Gender	0.209	0.044	1.902	1.463	3	96	0.230
	Age	0.143	0.020	1.949	0.667	3	96	0.574
	Education	0.621	0.386	1.928	12.341	3	96	0.000
	Revenue	0.096	0.009	1.971	0.300	3	96	0.825
	Employee	0.220	0.048	1.893	1.622	3	96	0.189
	Duration	0.194	0.038	1.799	1.525	3	96	0.219

* IV = Religiosity

From the above model summary, the highest regression coefficient was observed for the demographic variable education and this was 0.578 for cost accounting practices and 0.621 for management accounting practices. This means that education explains 33.4% of the variation in the significant relationship between religiosity and cost accounting practice ($F(3, 96) = 9.827$; $p = 0.000<0.05$). Likewise, education explained 38.6% of the variation in the significant relationship between religiosity and cost accounting practice ($F(3, 96) = 12.341$; $p = 0.000<0.05$). Nevertheless, the p-values for the other demographic variables were not significant and this suggested that there was no significant moderation effect that was played by gender, age, revenue, employee and duration in business on the link between religiosity and cost accounting practices as well as on the link between religiosity and management accounting practices. The corresponding coefficients are presented in Table 7 below:

Table 7: Moderation Effect Coefficients

DV	Moderator	β	se	t	p	LLCI	ULCI
CA	Gender	-0.227	0.268	-0.927	0.362	-1.059	0.004
	Age	0.221	0.175	1.264	0.209	-0.126	0.567
	Education	0.849	0.115	6.371	0.000	0.726	0.968
	Employee	0.057	0.116	0.487	0.627	-0.174	0.287
	Revenue	0.058	0.154	-0.372	0.710	-0.364	0.249
	Duration	-0.148	0.121	-1.222	0.225	-0.389	0.093
MA	Gender	-0.751	0.402	-1.868	0.065	-1.549	0.047
	Age	-0.243	0.261	-0.932	0.354	-0.760	0.275
	Education	0.887	0.108	9.426	0.000	0.794	0.996
	Revenue	0.015	0.229	0.063	0.950	-0.439	0.468
	Employee	0.326	0.168	1.937	0.056	-0.008	0.659
	Duration	0.173	0.171	1.012	0.314	-0.167	0.514

* IV = Religiosity

From the foregoing, again, only the moderator education had a significant moderating effect on the link between religiosity and cost accounting practices (β = 0.849 [0.726, 0.968]; t = 6.371; p = 0.000<0.05. On the other hand, again, only the moderator education had a significant moderating effect on the link between religiosity and management accounting practices (β = 0.887 [0.794, 0.996]; t = 9.426; p = 0.000<0.05. Nevertheless, the other moderating variables: gender, age, revenue, employee and duration were all not statistically significant with p-values being greater than 0.05. In other words, only education played a significant moderating role between the independent variable religiosity and both dependent variables cost accounting practices and management accounting practices. The moderating effects of demographics and SME features are shown in Figure 2:

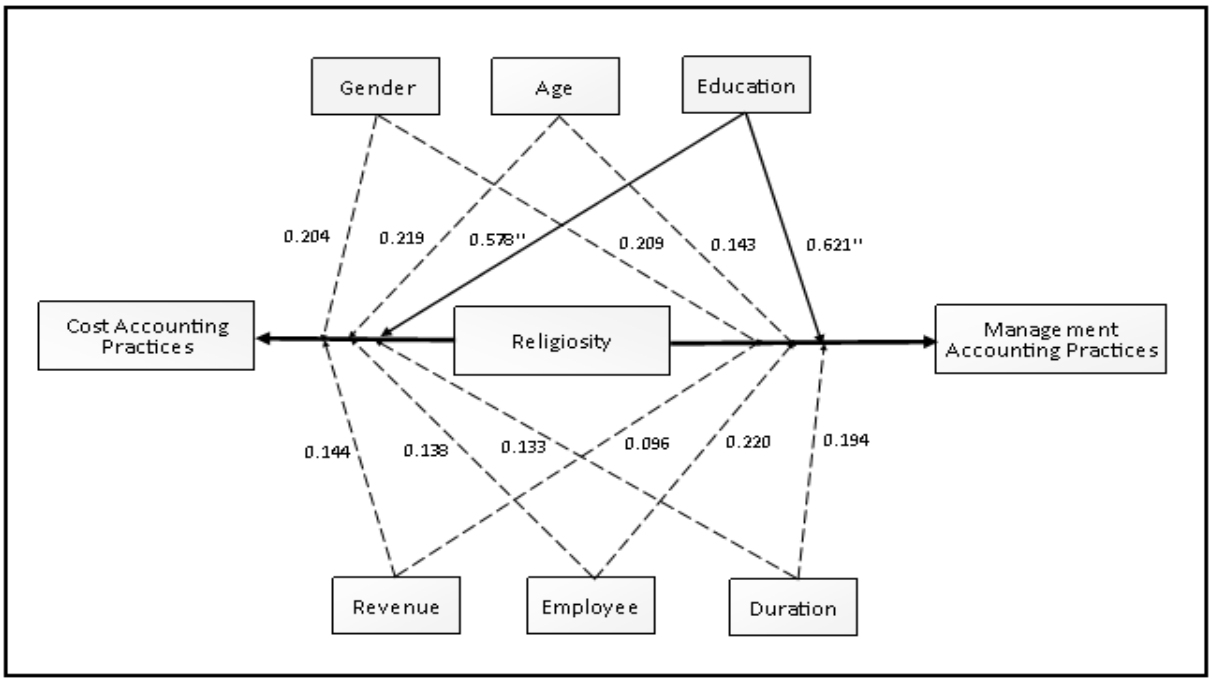

Figure 2: Moderating effects of demographics and SME features

Source: Researchers' own

Validating the Moderation Effect

Having established the existence of a moderating effect that education plays on the relationship between religiosity and the two dependent variables cost accounting practices and management accounting practices, the researchers sought to validate this relationship further using the general linear model factorial MANOVA. Nevertheless, to be able to run this test, according to Field (2016), two key tests needed to be validated and these were the Levene's test of equality of error variances, as well as the Box's Test of Equality of Covariance Matrices. The Box's test, tested the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups. The results for the test for Box's Test of Equality of Covariance Matrices are presented in Table 8.

Table 8: Box's Test of Equality of Covariance Matrices

Box's M	13.816
F	2.122
df1	6
df2	1963.001
Sig.	.148
Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.	
a. Design: Intercept + EDU + REL + EDU * REL	

From the outcome, F (6, 1963) = 2.122; p = 0.148>0.05. In this regard, because the p-value was greater than 0.05, the assumption was not violated. On the other hand, the Levine's test of equality of error variances tested the null hypothesis that the error variance of the dependent variable was equal across groups. The results are presented in Table 9 below:

Table 9: Levene's Test of Equality of Error Variances

		Levene Statistic	df1	df2	Sig.
Cost Accounting	Based on Mean	2.020	3	96	.142
	Based on Median	3.780	3	96	.013
	Based on Median and with adjusted df	3.780	3	73.922	.014
	Based on trimmed mean	6.351	3	96	.001
Management Accounting	Based on Mean	1.597	3	96	.195
	Based on Median	1.407	3	96	.245
	Based on Median and with adjusted df	1.407	3	78.479	.247
	Based on trimmed mean	1.546	3	96	.208
a. Design: Intercept + EDU + REL + EDU * REL					

From the outcome, cost accounting, F (3, 96) = 2.020; p = 0.142>0.05 and for the management accounting, F (3, 96) = 1.597; p = 0.195>0.05. In both instances, since the p-value was greater than 0.05, it followed that there was not enough statistical evidence to suggest that the error variances were different. In this regard, the assumption of the equality of error variances was, therefore, not violated. The moderation effect results are presented in Table 10 From the outcome, education had a direct significant relationship with both cost accounting (F (1, 96) = 4.158; p = 0.044<0.05; η^2 = 0.042) and management accounting (F (1, 96) = 31.316; p =

0.000<0.05; η^2 = 0.246). The direct effect of religiosity was not statistically significant, with p>0.05. However, the moderating effect EDU*REL was statistically significant for both cost accounting (F (1, 96) = 4.639; p = 0.000<0.05; η^2 = 0.216) and management accounting (F (1, 96) = 4.759; p = 0.000<0.05; η^2 = 0.249). The results are presented in Table 10 below:

Table 10: Tests of Between-Subjects Effects

Source	Dependent Variable	DD	df	MS	F	Sig.	Partial Eta Squared
Corrected	Cost Accounting	12.044[a]	3	4.015	5.067	.003	.137
Model	Management Accounting	95.636[b]	3	31.879	32.101	.000	.501
Intercept	Cost Accounting	275.100	1	275.100	347.223	.000	.783
	Management Accounting	266.157	1	266.157	268.011	.000	.736
EDU	Cost Accounting	3.295	1	3.295	4.158	.044	.042
	Management Accounting	31.099	1	31.099	31.316	.000	.246
REL	Cost Accounting	.420	1	.420	.530	.468	.005
	Management Accounting	.428	1	.428	.597	.473	.001
EDU * REL	Cost Accounting	3.050	1	3.050	4.639	.000	.216
	Management Accounting	3.059	1	3.059	4.759	.000	.249
Error	Cost Accounting	76.059	96	.792			
	Management Accounting	95.336	96	.993			
Total	Cost Accounting	864.422	100				
	Management Accounting	875.667	100				
Corrected	Cost Accounting	88.103	99				
Total	Management Accounting	190.972	99				

a. R Squared = .137 (Adjusted R Squared = .110)
b. R Squared = .501 (Adjusted R Squared = .485)

Overall, the foregoing findings do confirm that education played a statistically significant moderating role on the relationship between the independent variable religiosity and the two dependent variables cost accounting and management accounting. Basing on the partial eta square and the r-square, it is evident that the moderation effect was stronger for the link with management accounting (η^2 = 0.249; r^2 =0.501) than for the link with cost accounting (η^2 = 0.216; r^2 =0.137).

Discussion

An assessment was done on three constructs cost accounting, management accounting and religiosity. The outcome of descriptive statistics from the *first construct* indicated a generally poor cost accounting practice with high standard deviations among the different cost accounting techniques. It also had platykurtic distributions since all kurtoses were negative. This finding shows that there was no agreement among the respondents. Basing on the midpoint of 3.0, it was however identified that the most frequent practice was the making of decisions basing on total costs (M = 3.29; SD = 1.416). The aggregate for the cost accounting practices was M = 2.79 (SD = 1.387), and being less than the midpoint, this implies that cost accounting practices were not practiced frequently. Since most of the respondents were not highly educated, the aforementioned outcome is in agreement with the results of Albu and Albu (2012), Adams and Amankwah (2019), Ahmad and Zabri, (2016) as well as Msomi, *et al.* (2019) who concluded that education is crucial in determining the success of an operation.

The *second construct*, management accounting practices was also analysed basing on the same midpoint of 3.0, descriptive statistics were shown. Since the aggregate management accounting rating was below the mid-point (M = 2.62; SD = 1.389), it is an indication that the respondents did not practice management

accounting often. Nonetheless, the fact that the standard deviations and kurtoses were very high, it is an indication that there were high discrepancies in the responses. The suggestion is that while the majority tended towards the infrequent practice of management accounting, there were a few who were frequently practicing this. Such results were also identified by Zehra and Ahmed (2019) in their Pakistan SMEs study and Bui, *et al.,* (2020) in their Vietnamese SMEs research in which when they all opine that SMEs prefer the conventional MAPs as compared to the recent MAPs.

The *final construct* religiosity was evaluated and all the mean ratings were greater than the midpoint (3.0) and this was a signal that the respondents agreed on the role that religion perform towards the success of the business. The highest rating was that religious beliefs do influence a firms' success (M = 4.48; SD = 0.822). Such a conclusion was arrived at by many scholars, (Lewis, 2001; Roundy, 2009; Olowookere, 2014), who highlighted that religion has an impact on accounting due to its ability to influence culture.

The study also analysed three firm characteristics and three demographic variables and results confirmed that there was a marginal difference in the distributions by gender. More males were found to be in business than females by 6%. This means that there are more males in SMEs in subsistence economies than females. This observation was supported by other contemporary researchers, (Isaga, 2015; Essel, *et al*., 2019), who agreed that males produce successful businesses than their female colleagues due to the level of dedication that they exert in the business. That is why they are found in business in large numbers. However, Collins-dodd *et al.* (2004)'s study was in agreement with Johnsen and McMahon (2005) on the notion that gender has no substantial effect on the performance of business activities.

In terms of age, the results indicated that the middle age group surpassed all the ages (with the modal age group being those between 31 and 40 years (44%). This outcome corresponds with the findings of Van Praag (2003) as well as Cortes *et al.,* (2008) who contended that middle owner/managers are the best in terms of running SMEs through CMAPs. This is attributed by their unique qualities of possessing the younger owner/manager's energy and the older owner/manager's experience. When it comes to education, most of the entrepreneurs had passed Advanced level (38%). This means they had not attained the highest level of education but were average in terms of literacy.

Most businesses studied had less than 10 employees and those with 10 to 20 employees, whose proportion was 36% respectively. This means that most of the SMEs were not very big. With respect to the number of years in operation, the modal category was comprised of SMEs who had been in operation for 3-5 years (34%). This is an indication that most of the businesses were still young businesses.

Hypotheses numbers *one to six* were related to demographic characteristics of the owner/manager of the SME. A test was conducted using the Hayes PROCESS Macro for SPSS to examine the direct and indirect effect that demographic attributes have towards the relationship between religiosity and the two dependent variables, cost accounting and management accounting practices. The summary of results indicate that the highest regression coefficient was observed for the demographic variable education and this was 0.578 for cost accounting practices and 0.621 for management accounting practices. However, the p-values for the other demographic variables were not significant and this suggested that there was no significant moderation effect that was played by gender and age on the link between religiosity and CMAPs. To add on to this, when it comes to the moderation effect coefficients, only the moderator education had a significant moderating effect on the link between religiosity and cost accounting practices ($\beta = 0.849$ [0.726, 0.968]; $t = 6.371$; $p = 0.000<0.05$.) and similarly, the same moderator education had a significant moderating effect on the link between religiosity and management accounting practices ($\beta = 0.887$ [0.794, 0.996]; $t = 9.426$; $p = 0.000<0.05$.).

The implication of this outcome is that education greatly moderates the relationship between religiosity and CMAPs. These results are in tandem with Albu and Albu (2012) as well as Essel, Adams and Amankwah (2019) who concluded that education plays a pivotal role in

determining the success of an operation. In the same vein Ahmad and Zabri, (2016) as anchored by Msomi, *et al.*, (2019) actually supported idea that an owner/manager with the relevant expertise and skills has minimum challenges in implementing CMAPs.
Furthermore, when scholars like Isaga (2015) and Woldie *et.al.* (2008), studied the effect of age on business success, they found that the age of the owner/manager was negatively correlated to the growth of the SME. This is in disagreement with the findings of this study. On the contrary, Cortes, *et.al.* (2008) found out that an older entrepreneur is a perfect match for firm's success due to the experience and challenges that he/she would have encountered which create strength.

Hypotheses numbers *seven to twelve* were linked to firm characteristics of the SME. The Hayes PROCESS Macro for SPSS was also used to evaluate the direct and indirect effect of firm characteristics towards the relationship between religiosity and the two dependent variables, cost accounting and management accounting practices. The results from the Hayes PROCESS Macro for SPSS indicate that there was no substantial moderating effect that was indicated by firm characteristics (revenue, employee and duration in business) on the link between religiosity and cost accounting practices as well as on the link between religiosity and management accounting practices. On the same vein, the moderation effect coefficients revenue, employee and duration in business were all not statistically significant with p-values being greater than 0.05.

This outcome differs from some previous empirical studies on the relationship between revenue and the firm's success and the link with the number of employees (Albu and Albu, 2012; Al-Omiri and Drury, 2007; Ahmad and Zabri, 2016; Dlamini, 2020). Our study also diverged from studies which focused on the association between an SME's duration in business and financial performance, which may include CMAPS; (Shahzadi, Khan, Toor, & ul Haq, 2018; Essel, Adams, & Amankwah, 2019; Msomi, Ngibe, & Nyide, 2019). In summary, all these studies reached the same conclusion that revenue, number of employees and duration in business has an effect on an SME's success encompassing the implementation of CMAPs.

All in all, the study unearthed that basing on the partial eta square and the r-square, it is evident that the moderation effect was stronger for the link with management accounting ($\eta^2 = 0.249$; $r^2 = 0.501$) than for the link with cost accounting ($\eta^2 = 0.216$; $r^2 = 0.137$).

Conclusion, Limitations and Future Research

Conclusion

It also sought to evaluate the direct and indirect effects that demographic attributes and firm characteristics have on the relationship between religiosity and the two dependent variables, cost accounting and management accounting practices. The results suggested that education plays a pivotal role in moderating the relationship between religiosity and CMAPs. There was however, no statistical evidence to suggest that other demographic variables (gender and age) or firm characteristics (revenue, number of employees and duration in business) have moderating effect between religiosity and CMAPs.
Overall, the study established the importance of religiosity diversity on CMAPs. This therefore follows that if SMEs aspire to attain high levels of CMAPs, they should have inclusive structures which foster religion as an anchor and driving force for improved accounting standards and compliance. Education moderates the association between religiosity and CMAPs implementation, and therefore for SMEs to attain compliance in good CMAPs, they should embrace educational diversity. Owner/manager training and retraining should be embraced as a culture to enhance their education and CMAPs expertise.

Theoretical Contribution

The study brings rural CMAPs and religiosity into the accounting literature. Most prior studies were mainly based on developed and emerging economies in urban markets set up but this study extend into a subsistence economy with a unique socio-cultural setting. Previous studies were mainly concerned with the relationship between religion and financial accounting but this study delved on the direct and indirect effects of

demographic attributes and firm characteristics on the relationship between religiosity and the two dependent variables CMAPs.

The study validated religiosity and CMAPs scales in subsistence market in Sub-Saharan Africa. This was done using the general linear model factorial MANOVA. In order to be able to run this test, according to Field (2016), two key tests were validated and these were the Levene's test of equality of error variances, as well as the Box's Test of Equality of Covariance Matrices. The Box's test, tested the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups. On the other hand, the Levine's test of equality of error variances tested the null hypothesis that the error variance of the dependent variable was equal across groups.

Practical Contribution

When running SMEs or any other business, it is critical to take into consideration religiosity so as to enhance CMAPs implementation. Education needs to be considered when driving CMAPs using religiosity. However, other demographic variables like age and gender may not be necessary for the success of the enterprise. Financial institutions may not need to assess these when evaluating potential entrepreneur loans or bank overdraft applicants.

Limitations and Future Research

This study was performed only on rural SMEs hence the results cannot be generalised on urban SMEs. Future studies on the link between religiosity and CMAPs using different methodology is necessary for example using ethnography especially on demographic variables like age and gender. This is suggested due to the fact that results of this research are inconsistent with prior researches which stated that demographic variables have an impact on accounting (Albu and Albu, 2012; Al-Omiri and Drury, 2007a; Ahmad and Zabri, 2016). Additionally, personality traits may also be assessed to bring out a comprehensive model to identify CMAPs in SMEs of subsistence economies. Finally, there is need to encourage on lifelong learning and education to entrepreneurs as a way of enhancing the use of cost and management accounting practices in subsistence markets.

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THE INFLUENCE OF OUTBOUND LOGISTICS ON UTILITY

P. Mukucha[4], B. E. Mushanyuri, F. Chari

Abstract

Outbound logistics is one of the prime business functions that are pillars in customer value delivery. In this study the investigation sought to determine the influence of outbound logistics on economic utility: form utility, place utility, time utility, and possession utility. A Sample of 300 respondents was surveyed from the residents of Bindura urban area using convenience sampling method. ANOVA and Tukey's HSD post hoc multiple comparisons tests were used for hypotheses testing. The study revealed that outbound logistics for bread has a significant effect on all the forms of economic utility save for possession utility. It was therefore recommended that bakeries must deliver their bread through the use of tuck-shops, convenience stores and supermarkets with their order of importance in order to enhance the perceived value in the form of economic utility that accrues to the customers who buy bread.

Keywords: utility, logistics, physical distribution, supply chain management.

Introduction

Bread is one of the products whose production and distribution is of strategic importance because it is a perishable staple food (Vutete & Bobo, 2015). Bread is one of the outputs of the confectionery industry. The confectionery industry in Zimbabwe is an oligopoly in nature. An oligopoly is a market that is characterised by a large number of buyers (Hubbard & O'Brien, 2013) as evidenced by numerous households that consume bread for breakfast, and a few suppliers who command a large portion of market share (Case, Fair & Oster, 2013). In the Zimbabwean bakery industry the major players are Bakers Inn Ltd, Lobels Ltd, and Proton Ltd who supply bread to the market at recommended and gazetted uniform price with on-spot remittances (Vutete & Bobo, 2015). An oligopoly market structure is also associated with high barriers to entry (Salvatore & Srivastava, 2011). It requires a lot of capital expenditure to set up a bakery whose production output enables a firm to break-even. Lastly, an oligopoly is identified by relatively homogenous products (Mankiw & Taylor, 2008). In the bakery industry bread supplied to the market is basically similar, with very limited differentiation.

Bakeries supply backed standard bread every morning to customers scattered around the country through various logistical configurations. Logistics is the management function that deals with the flow of materials from the places of origin to the place of final consumption (Browersox, Closs & Cooper, 2010). Logistics is divided into two parts, namely inbound logistics and outbound logistics (Porter, 1985). Inbound logistics refers to the movement of resources from several sources to manufacturers, while outbound logistics which

[4] *Corresponding Author: Mukucha Paul*
Department of Marketing,
Bindura University of Science Education
P. Bag 1020,
Bundura, Zimbabwe.
Tel: +263772129585
E-mail: paulmukucha@gmail.com

is also known as marketing logistics, physical distribution or marketing channels pertains to the flow of products from the producer to the final consumers (Kotler & Keller, 2016). Marketing channels are coordinated firms whose functions add utility to a product (Jonsson, 2008; Pride & Ferrell, 2008). Logistics involves the distribution of products through channel members or intermediaries that would eventually interface with the final consumers (Ballou, 2007). In the case of Bakeries, they normally use First-Party Logistics (1PL) in the form of one-level channel intensive distribution that involves the retailers as the only intermediary through different types of retail outlets such as supermarkets, convenience stores, and tuck-shops.

Bakeries' daily use of several retail outlets in the supply chain of bread is likely to generate differential outcomes for customers' perceived value which is also known as economic utility. However, a search in the extant logistics and marketing literature did not yield any empirical study that has sought to determine the differential effects of using several retail outlets in the logistics management system on economic utility. This research gap if filled will provide practical solutions to logistics practitioners in the bakery and confectionery industry on the best physical distribution options for their products. The findings are equally important in providing some theoretical grounding to the body of knowledge in the discipline of logistics. The rest of the article is organised as follows: literature review that leads to the specification of study hypotheses, the methodology that was followed in testing the specified hypotheses, and the presentation of results. The last section of the study focuses on discussion of the results in the context of similar previous researches and managerial implications.

Literature Review

The logistics function has always been a shared responsibility between the procurement department and the marketing department, with the former restrictively relegated to inbound logistics, and the later exclusively confined to outbound and reverse logistics. Outbound logistics is defined as the key component of supply chain management process that involves the planning, organising and controlling the movement of goods and services from the point of production to the point of consumption (Swink, Melnyk, Cooper & Hartley, 2014; Jonsson, 2008) leveraging on different functions such as order processing, packaging, warehousing, information technology, transportation, and customer service (Kotler & Keller, 2016). In other words logistics is the flow of finished products to the market. Retail outlets are part of the most important logistics function configurations. Retail outlets comprises of supermarkets, convenience stores, and tuck-shops.

A supermarket is a form of retail outlet that has a relatively large shop floor, and is associated with grocery and household products that are of low cost and low margins, but sold in large volumes (Kotler & Keller, 2016). A convenience store which is also known locally as a general dealer shop is a relatively small retail outlet that carries a limited line of products that are sold over the counter (Chpora, Meindl, Kalra, 2016; Berman & Evans, 2010). Convenience stores are usually located in the shopping centres that are found in residential areas and they tend to operate for long periods of hours per day (Levy & Weitz, 2012). A tuck-shop also known as a Spaza shop in South Africa is a very small retail outlet with a very limited range of products with short purchase cycles which are confined to low cost grocery items (Basardien, Parker, Bayat, Hendry & Mukaddam, 2018). Tuck-shops are usually located within the residential stands of the operators or along high pedestrian traffic streets in the residential areas (Olawale, 2016).

The importance of retail outlets in the logistics system of supply chain management include, but not limited to cost savings, keeping track of inventory, and enhancing customer value in the form of economic utility (Christopher, 2011). Economic utility is one of the outcomes of logistics management particularly when presented in the form marketing channels (Piennar & Vogt, 2011) and is premised in the orthodox micro-economic and utilitarian theories. Utility is defined as the capacity of goods to meet and satisfy customer needs and wants. In simple terms utility can be regarded as satisfaction, benefit or pleasure derived from the

purchase and consumption of a product. Marketing channels create four types of economic utility: form utility, place utility, time utility, and possession utility (Herin, Hartley & Rudelius, 2009; Pride & Ferrell, 2008).

Form Utility

Form utility refers to the transformation of a product along the logistics channels into a more useful state and condition desired by the customers. Form utility is generated through altering the structure, shape, or composition of a product (Piennar & Vogt, 2011). Form utility is usually associated with the production of a product, but channel members can also create form utility through packaging, preservation, and bulk breaking (Coyle, Bardi & Langley jr, 2003). Bulk-breaking is the splitting of goods into smaller shipping that suit individual orders (Swink *et al*., 2014). While supermarkets, convenience stores and tuck-shops all break bulk (Levy & Weitz, 2012), tuck-shops tend to take the lead in breaking bulk to the smallest possible forms. It is this breaking of bulk that tends to provide more form utility to the customers (Coyle *et al*., 2003). It is therefore expected that the identified channel members provide differential form utility.

H^1: There are significant differences in form utility created by different distribution channels.

Place Utility

Place utility pertains to the provision of products where customers can conveniently purchase them (Jonsson, 2008). This means ensuring the availability of a product at a place that is convenient to the customers through transporting them or causing their transportation from the manufacturers to the retail centres (Piennar & Vogt, 2011). Retail outlets can attain the provision of place utility by having enough stocks that meet demand that may arise at any given time (Fernie & Sparks, 2009). This can be achieved through investing in adequate warehousing facilities that are equipped to hold right quantities of a product or having frequent deliveries (Berman & Evans, 2010). Place utility is also enhanced through conveniently locating the retail outlet in places that customers can easily access (Coyle *et al*., 2003). Place utility derived by customers tends to increase along the closeness with which a retail outlet is located to the customers. It is therefore expected that the place utility of products tend to increase as one drift away from supermarkets to convenience stores and eventually tuck-shops. This is due to the fact that tuck-shops are located very close to the majority of customers, followed by convenience stores, and lastly supermarkets (Levy & Weitz, 2012).

H^2: There are significant differences in place utility created by different distribution channels.

Time Utility

The issue of time is core in the logistics system (Jonsson, 2008). Time utility relates to the value that customers attain as a result of accessing products at convenient times (Piennar & Vogt, 2011). This means making sure of the availability of products when desired by the customers (Coyle *et al*., 2003). Time utility is provided by the retail outlets through investing in appropriate and efficient transport system that ensures that the products are delivered to the customers' access points so that the customers can acquire them without delays (Berman & Evans, 2010), or strategically locating buffer stock warehouses (Piennar & Vogt, 2011). Most retail outlets are now providing time utility through operating 24/7 or at least through opening early and closing late. In developed nations the serendipitous emergence of e-commerce at the turn of this century has also enabled most retail outlets to meet the time utility needs of their customers. Since different types of retail outlets have got varying operating hours per day, they are expected to provide varying levels of time utility. In terms of operating hours tuck-shops tend to open for long periods in terms of hours, followed by convenience stores, and lastly supermarkets (Tereblanche, Beneke, Bruwer, Corbishley, Frazer, Nel, Pentz & Venter, 2017). The same order also applies to their speed of service.

H^3: There are significant differences in time utility created by different distribution channels.

Possession Utility

The place and time utility provided by logistics systems are the pre-requisites for attaining possession utility (Coyle *et al*., 2003).

Possession utility is the value that accrues to the customers as a result of being able to own and use products after purchasing them. It is generated through the transference of ownership from a buyer to a seller (Coyle *et al*., 2003). Possession utility is influenced by the payment terms associated with a product. Possession utility provided by different forms of channel members is expected to vary due to the management systems associated with those channels. Shopping in a supermarket is more formalised (Berman & Evans, 2010) and possession is usually afforded to customers after paying the required amount of money using the prescribed modes of payment. However, convenience stores and a tuck-shop tend to be more amenable to less conventional modes of payment like barter trade and acceptance of credit requests. This makes possession and use of a product faster hence higher possession utility than in the case of supermarkets.

H^4: There are significant differences in possession utility created by different distribution channels.

Methodology

This section presents the surveyed population characteristics and the sampling procedures adopted, as well as the measures adopted for data collection. The section also elaborated the data analysis procedures followed.

Population and Sampling

The population for this study are the residents in the town of Bindura situated 89 km north of the capital city Harare. A sample of 300 respondents was surveyed. The sample size was determined based on the requirements of the statistical tools used for data analysis (Bryman, 2016). Factor analysis which was used for measurement scale validation requires a sample of 300 and above (Hair., Black., Babin., Anderson. & Tathan, 2014). Convenience sampling was used to target the respondents. Ideally a probability based sampling method should have been used (Saunders, Lewis & Thornhill, 2016), but due to the absence of a proper and valid sampling frame attention was turned to more suitable non-probability sampling methods (Struwig & Stead, 2013).

Data Collection Methods and Measures

Data was collected using a self-administered questionnaire from the respondents who were intercepted outside retail outlets soon after purchasing bread over a period of 7 days. The items for measuring all the forms of utility were distilled from the extant logistics and mainstream marketing literature (e.g. Kotler & Keller, 2016; Kotler & Armstrong, 2013; Zeithaml, 1988). However, it must be acknowledged that utility is a slippery concept whose measurement is characterised by ambiguity and lack of consensus amongst both academics and practitioners alike. Earlier attempts by Jeremy Bentham toyed around the idea of a measurement scale termed the utilometer, but which unfortunately never saw the light of the day. To this day utility measurement is still elusive, but proximate measures can be extracted from the synthesised microeconomics, logistics and marketing literature.

Data Analysis Procedures

Data analysis was conducted in three phases. The first phase involved the validation of the measures representing latent variables (constructs) using exploratory factor analysis (EFA). EFA is a multivariate statistical tool that is used in the development of parsimonious psychometric measures through the stages of extraction, rotation, and interpretation (Hair *et al*., 2014; Williams, 2010). Extraction refers to the determination of the number of factors that best explain a data set's observed covariation matrix (Field, 2013). Rotation relates to the maximisation of the factor loadings of the items to their respective factors in order to generate a parsimonious structure (Tabachnick, & Fidell, 2012). Interpretation pertains to the naming of extracted factors using psychological knowledge associated with common feature among the related items (Field, Miles & Field, 2012).

The second phase pertained to the testing of hypotheses. Hypotheses testing were done using the One-way Analysis of Variance (ANOVA). ANOVA is a parametric statistical tool that is used to determine whether there are any significant differences between the arithmetic means of three or more independent groups

(Sekeran & Bougie, 2009; Fisher, 1925). One-way ANOVA comprises of a categorical independent variable which acts a grouping dimension (Salkind, 2010), and a metric dependent variable (Cooper & Schindler, 2008). ANOVA assumptions of normality and homoscedasticity were tested using a Levene's test, and Kolmongrov-Siminov test and Shapiro-Wilk test respectively prior to hypotheses testing.

The third phase relates to post-hoc tests. One-way ANOVA is an *omnibus* test statistic which cannot tell the specific groups that are significantly different from each other (Field, 2013). The rejection of the null hypothesis in ANOVA does not tell where the differences are. It only gives information that at least two groups were different. Therefore, differences on groups were determined using a Tukey's HSD post-hoc test. A Tukey's HSD test is superior over other ANOVA post-hoc tests in that it controls type 1 error. It can also cater for a situation where there is an unequal number of subjects across cells using its extension called the Tukey-Krammer test.

Results

The demographic profile of the respondents are shown in Table 1.

Table 1: Demographic profile of respondents

Attribute	N	%
Age		
18-30	136	45
31-40	63	21
41-50	51	17
51-60	30	10
60+	20	7
Gender		
Male	122	41
Female	178	59
Residential area		
High density	240	80
Low density	60	20

Table 1 reveals that most of the respondents in this study are in the age group of 18-30 (45%), reflecting the demographic age group that mostly buy bread in Zimbabwe. The age group of 31-40 years was represented by 21%, 41-50 (17%), 51-60 (10%), while the 60+ year age group had 7% only. The gender of the respondents was 41% male, and 59% female. Lastly, the majority of the respondents (80%) reside in high density suburbs, while 20% are residents in the low density suburbs.

Measurement Scale Validation

The data was tested for factorability using the Kaiser-Meyer-Olkin (KMO), and the Bartlett's test of sphericity (Bartlett, 1954). As indicated in Table 2, the KMO index was 0.884, and the Bartlett's test of sphericity was $X^2(270)=1247.487$, p=0.00 (Kaiser, 1974). All these tests indicated that the data was suitable for factor analysis.

Having ensured that the data was suitable for factor analysis, all the 13 items measuring economic utility of bread were entered into a dialogue box of factor analysis. Orthogonal rotation was used for extraction of factors. Orthogonal rotation is preferable where factors are expected to be unrelated (Watkins, 2018; Costello & Osborne, 2005). Table 2 shows that 4 factors were extracted with all the items loading on their respective factors.

Table 2: Final Rotated Factor Matrix

	Factors			
	Form	Place	Time	Possession
Bread supplied was fresh	.765			
The bread was in good shape	.761			
The bread was tasty	.745			
I got my preferred pack size of bread	.745			
I always get the bread where I want it		.837		
I travel a short distance to get bread		.832		
My preferred outlet always has bread		.837		
Bread is always available at my usual retail outlet			.822	
My preferred retail outlet sell bread at convenient times			.796	
It is easier to get bread from my preferred retail outlet outside normal hours			.710	
I always get bread after paying				.757
Where I buy my bread they accept different forms of payment				.703
Where I buy bread they accept cert terms for buying bread				.673
Cronbach's alpha coefficient	0.877	0.870	0.794	0.783

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.
b. KMO index 0.884
c. Bartlett's test of sphericity $X^2(270)=1247.487$ (p=0.000)

These extracted components and their naming corresponded with priori constructs in literature. The loading of items on their respective factors and the absence of cross loadings as indicated in Table 2 provided evidence of convergent and discriminant validity respectively for all the factors (Costello & Osborne, 2005). All the four extracted factors shown on Table 2 had a Cronbach's alpha coefficient above 0.7 which is the threshold for reliability (Zikmund & Babin, 2013; Cronbach & Meehl, 1955).

Hypotheses Testing

Hypotheses testing were conducted using ANOVA, after having tested the three ANOVA assumptions which are namely independence, normality and homoscedasticity (Field, 2013). The first assumption of independents was catered for during the sampling design stage Saunders *et al*., 2016). In order to ensure that the was independents among the respondents of different groups the surveyed responds were chosen on the basis of patronising only one type of retail outlet for the purposes of buying bread.

Validating the normality assumption is of paramount importance for statistical analysis using parametric methods (Yap & Sim, 2011). The test of normality was conducted using a Shapiro-Wilk's test (Shapiro & Wilk, 1965). A Shapiro-Wilk test is a regression and correlation based test which asymmetric distribution test (Yap & Sim, 2011).

Table 3: Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
Form_Utility	.175	300	.38	.892	300	.36
Place_Utility	.284	300	.29	.302	300	.27
Time_Utility	.302	300	.47	.292	300	.45
Possession_Utility	.148	300	.36	.935	300	.34

a. Lilliefors Significance Correction

Table 3 indicates that all the dependent variables in this study are normally distributed as evidenced by the insignificant p values (P >0.05) on both Kolmogrov-Smirnov and the Shapiro-Wilk tests for the collected data categories. An insignificant p value implies that the data collected is not normally distributed (Field, 2013; Yap & Sim, 2011).

After the test of data normality, a test for homoscedasticity was carried out. Homoscedasciticity is a requirement for homogeneity of variance in ANOVA tests (Zikmund & Babin, 2013). A Levene's test of equality of variance was used to test for homoscedasticity (Levene, 1960). Levene's test compares the variance of a metric variable across levels of a nonmetric variable (Hair *et al*., 2014). Table 4 reveals the results for homoscedasticity tests. A statistically insignificant level of confidence (i.e., p>0.05) indicate that the group variances are equal.

Table 4: Test of Homogeneity of Variances

	df1	**df2**	**Sig.**
Form_Utility	2	297	.119
Place_Utility	2	297	.114
Time_Utility	2	297	.112
Possession_Utility	2	297	.113

After ensuring that all the assumptions of one-way ANOVA were satisfied (Philips, 1982), the researcher went on to test the postulated hypotheses (Zikmund., Babin., Carr & Griffin, 2010). The results from hypotheses testing are shown in Table 5.

Table 5: Analysis of Variance

		Sum of Squares	df	Mean Square	F	Sig.
Form Utility	Between Groups	248.420	2	124.210	35.737	.000
	Within Groups	1032.260	297	3.476		
	Total	**1280.680**	**299**			
Place Utility	Between Groups	246.167	2	123.083	31.089	.038
	Within Groups	1294.580	297	5.194		
	Total	**1340.747**	**299**			
Time Utility	Between Groups	236.560	2	118.280	27.787	.056
	Within Groups	1896.010	297	5.219		
	Total	**1932.570**	**299**			
Possession Utility	Between Groups	10.007	2	5.003	1.851	.159
	Within Groups	802.910	297	2.703		
	Total	**812.917**	**299**			

After caring out an ANOVA test, a Tukey's HSD post hoc test was conducted to determine the pairs that had the differences (Toothanker, 1993). Table 6 shows the results of post-hoc multiple comparisons test.

Table 6: Turkey's HSD multi-comparisons test

Dependent Variable	(I) Type of outlet	(J) Type of outlet	Mean Difference (I-J)	Std. Error	Sig.
Form Utility	Tuck-shop	Convenience stores	.530	.264	.111
		Supermarket	2.140*	.264	.000
	Convenience stores	Tuck-shop	-.530	.264	.111
		Supermarket	1.610*	.264	.000
	Supermarket	Tuck-shop	-2.140*	.264	.000
		Convenience stores	-1.610*	.264	.000
Place Utility	Tuck-shop	Convenience stores	-.600	.651	.627
		Supermarket	1350	.264	.001
	Convenience stores	Tuck-shop	.600	.651	.627
		Supermarket	1.950	.263	.012
	Supermarket	Tuck-shop	-1.350	.264	.001
		Convenience stores	-1.950	.263	.012
Time Utility	Tuck-shop	Convenience stores	.1680	.267	.012
		Supermarket	-.2150	.262	.000
	Convenience stores	Tuck-shop	-.1680	.267	.012
		Supermarket	-.820	.681	.452
	Supermarket	Tuck-shop	.2150	.262	.000
		Convenience stores	.820	.681	.452
Possession Utility	Tuck-shop	Convenience stores	-.440	.233	.143
		Supermarket	-.290	.233	.426
	Convenience stores	Tuck-shop	.440	.233	.143
		Supermarket	.150	.233	.795
	Supermarket	Tuck-shop	.290	.233	.426
		Convenience stores	-.150	.233	.795

H^1 had indicated that there are significant differences in form utility derived by customers buying bread from different retail outlets. The results from hypotheses testing shown in Table 5 supported that assertion. The study revealed that there are statistically significant differences in the form utility derived by customers from bread bought in different retail outlets (F=35.373, p = 0.000). A Tukey post-hoc test revealed that form utility derived in tuck-shops is not statistically different from the one derived in convenience stores (0.530, p=0.000), while statistically significant differences were recorded on the tuck-shops and supermarkets utility (2.140'p=0.000), and the convenience stores and supermarkets utility (1.610, p=0.000).

H^2 indicated that there are significant differences in place utility derived by customers from buying bread from different retail outlets. The results from hypotheses testing are shown in Table 5 supported that hypothesis. The study revealed that there statistically significant differences in place utility derived by customers

from bread bought in different retail outlets (F=31.089, p = 0.038). A Tukey post-hoc test revealed that place utility derived in tuck-shops is not statistically different from the one derived in convenience stores (600, p=0.627), while statistically significant differences were recorded on the tuck-shops and supermarkets utility (1.350, p=0.001), and the convenience stores and supermarkets utility (1.950, p=0.012).

H^3 indicated that there are significant differences in time utility derived by customers from buying bread from different retail outlets. The results from hypotheses testing shown in Table 5 supported that hypothesis. The study revealed that there statistically significant differences in time utility derived by customers from bread bought in different retail outlets (F=27.787, p = 0.056) at 0.1 level of significance. A Tukey's post-hoc test revealed that time utility derived in tuck-shops is statistically different from the one derived in convenience stores (1.680, p=0.012), and supermarkets (2.150, p = 0.000), while statistically insignificant differences were recorded on convenience stores and supermarkets utility (0.820, p=0.452).

H^4 indicated that there are significant differences in possession utility derived by customers from buying bread from different retail outlets. The results from hypotheses testing are shown in Table 5 did not support that hypothesis. The study revealed that there are no statistically significant differences in possession utility derived by customers from bread bought in different retail outlets (F=1.851, p = 0.159). Given that the alternative hypothesis was rejected and the null hypothesis was accepted, a post-hoc multi-comparison test was no longer necessary.

Discussion

The findings in this study reveal that marketing channels create utility for the customers. These findings lend empirical support to various conceptual models about the relationships between marketing channels and economic utility (e.g. Lambert, Stock & Ellram, 1988) . The findings in this study reveal that the use of tuck-shops as channel members in the distribution of bread creates utility in its various forms than all other conventional distribution channels studied. Convenience stores were ranked second in providing better utility followed by supermarkets.

The fact that tuck-shops are small in size provides them with some form of flexibility that makes it possible for them to break-bulk (Olawale, 2016). Through breaking bulk tuck-shops are able to provide form utility as customers who cannot afford a full loaf of bread can purchase a half-bread. However, convenience stores and supermarkets seem to be unable to offer such a service since it may be too minor for them.

It can also be deduced from this study that the closer the retail outlet is to the customers, the more it provides place utility. This is based on the fact that tuck-shops are located in the residential areas where customers can easily access their bead without travelling for long distances (Olawale, 2016). In most suburbs tuck-shops are located within the vicinity of their clientele base. However, there was no statistically significant difference between place utility derived in tuck-shops and convenience stores. This may be due to the fact that convenience stores are located as closer to the customers as the tuck-shops.

Inferences made from this study are that tuck-shops also provide more time utility since they operate for more hours than other forms of distribution channels. Usually most supermarkets shut-down around 19:00 and convenience stores around 20:00 as regulated by their shop licenses. However, tuck-shops in general are not regulated by any form of licensing; hence they tend to have flexible operating hours which provide more convenience to their customers (Olawale, 2016).

No statistically significant differences were noted on possession utility from the surveyed retail outlets. Tuck-shops were expected to offer more possession utility than other forms of channel members analysed in this study. This stems from the fact that tuck-shops are run along flexible payment terms that can affords customers to purchase on credit, using barter trade, and above all they tend accept most forms of payment like Eco-cash, and non-conventional foreign currencies. However, due to the prevailing hyper inflationary environment and

the disappearance of hard currency, most tuck-shops had side-steped the flexible payment terms they used to offer. More over the fact that possession utility was found not to be significantly different across all the forms of retail outlets support the assertion common in the extant literature that logistics provides all other forms of utility, while possession utility is a function of sales and marketing efforts (e.g. Piennar & Vogt, 2011).

The discussion results attained in this study and the discussion that followed lead to the conclusion that there are varying degrees in all the forms of utility that are generated by different types of retail outlets. It is therefore recommended based on the findings from this study that all bakeries operating in Zimbabwe should make use of tuck-shops as the prime channel members in the distribution of their bread if they are to provide some forms of utility to their customers. External validity of the findings in this study can also be extended to other product lines in the product category of grocery items such as milk and sugar which are inherently complimentary to bread. Suppliers of such products are encouraged to formulate their logistics systems around the findings and recommendations of this study.

Limitations and Future Research Agenda

The study was conducted in the Bindura urban area. However, Bindura town is just one of the several urban settlements in Zimbabwe and the consumption patterns of the consumers in that town might be different from those of customers in other geographical areas. This limitation needs to be ameliorated in future studies by replicating this study in other geographical settlements where there is consumption of commercial bread.

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Original Article

MIGRATION DYNAMICS AND THE DEVOLUTION AGENDA IN MATABELELAND SOUTH PROVINCE OF ZIMBABWE

N. Mtombeni and V. M. Matiza[5]

Abstract

Economic challenges in Zimbabwe have seen most people relocating to different countries in a bid to earn a decent living. These movements are done at all levels, whether learned or general/ domestic workers. In doing so, a lot of brain drain is witnessed where many technical and expert personal are no longer offering their services to their home countries but elsewhere. The government of Zimbabwe has come up with a statutory instrument to grow the Zimbabwean economy at Provincial level so as to become an upper middle economy by 2030. With this challenge at hand, migration of these people has a lot of implication on the government's devolution agenda as the local people are moving away from developing their area. Against this backdrop, the paper seeks to bring out migration dynamics in Matabeleland South Province which may hinder government efforts in achieving the agenda in the Province. Most of the people in the province are a source of cheap labour in the neighbouring South Africa and possibly Botswana. Using qualitative research methods, the researchers purposively sampled some families in Gwanda and conveniently selected some government departments to establish the purpose and impact of the devolution program. Through some interviews carried out, the research established that many people especially youths in the Province migrate to South Africa as cheap labour and that impacts negatively on the devolution agenda and the vision 2030 in the Province. As a result the researchers therefore recommend that the government of Zimbabwe should put in place stringent measures at the boarder places so that the easy flow of human traffic as boarder jumpers is curbed.

Keywords: migration, brain drain, devolution agenda, Zimbabwe, Matabeleland South

Introduction

Migration is a common occurrence in most developing countries in the world because most of these countries lack political will to solve problems that affect their economies. Zimbabwe is not an exception in the matter hence statistics and a lot of researches show that it is one of the country with a lot of immigrants in various countries, (Human Rights Watch, 2008). The reason that most developing countries face are a combination of economic and political challenges so as a result of these many educated and skilled people migrate to other countries to better their lives. This phenomenon in Zimbabwe is peculiar all over the country but Matabeleland South has been chosen in this case because it has so many immigrants who migrate to South Africa, (South African Migration 2006, Polzer, 2009). The area is dominated by the Nguni spoken languages hence by virtue of their history that point back to South Africa, a lot of people find themselves going back because of the commonality in their language use. It is because of this rampant movement that this research is given impetus because devolution

[5] *Corresponding Author: Vimbai M. Matiza*
Department of African Languages and Culture
Midlands State University, Gweru, Zimbabwe
matizavimbo@gmail.com/matizavm@staff.msu.ac.zw

agenda by the government will be affected in terms of employment creation for the local people. The article therefore analyses migration dynamics and how they eventually impact on the government's agenda to empower the Province through devolution.

Understanding devolution and its agenda in Zimbabwe

It is critical at this point to spell out what devolution is and the agenda for the program. Beris (2008:47) defines devolution as a situation where central government transfers legislative, executive, administrative and financial decision making authority to local government that have clear and legally recognized jurisdictions within which they provide public services to constituents to whom they are accountable. The idea is to decentralize power to the local people through their council and making them observe their economic potentials. Thus devolution is therefore an important medium to achieving national economic growth. More so, Madanhire (2019) in a newspaper article alludes to the idea that Zimbabwe's devolution programme is largely founded on the principle of empowering provincial government councils to spearhead economic and social development projects in their areas by leveraging on local resources. These local resources in the paper involve the use of human capital thus the emphasis on Matabeleland South province. Devolution emphasizes on economic development and not political power which remains in the hands of central government under the country's unitary state structure.

Devolution of power is enshrined in Chapter 14 of the Zimbabwe's 2013 Constitution as one of the country's founding values and principles. Zimbabwe's statutory objectives for the devolution of governmental powers and responsibilities include:

(a) to give powers of local governance to the people and enhance their participation in the exercise of the powers of the State and in making decisions affecting them (b) to promote democratic, effective, transparent, accountable and coherent government of Zimbabwe as a whole (c) to preserve and foster the peace, national unity and indivisibility of Zimbabwe (d) to recognise the right of communities to manage their own affairs and to further their development (e) to ensure the equitable sharing of local and national resources (f) to transfer responsibilities and resources from the national government in order to establish a sound financial base for each provincial and metropolitan council and local authority.

In accordance with the above devolution constitutional vision, political power, policy making decisions, resource raising and distribution, as well as administrative and governance responsibilities are meant to be devolved through three tiers of government. These include: (1) the national government; (2) provincial and metropolitan councils; and (3) local authorities (which include urban councils and rural councils). The national government is composed of national Ministers who constitute the Cabinet (the executive arm of government). These Cabinet Ministers are directly elected Members of the National Assembly (MPs), Senators or non-constituency Ministers appointed by the President in terms of the new Constitution. The second tier of government - provincial and metropolitan councils - is composed of directly elected and proportional representation public representatives elected using constitutional provisions contained in chapter 14 (2:268) (for provincial councils) and chapter 14 (2:269) (for metropolitan councils). The third (and by no means the least) tier of government is that of the local authorities. These are the grassroots level urban councils and rural councils. These councils are composed of ward councilors directly elected using constitutional provisions contained in chapter 14 (3:277) read together with chapter 14 (3:274) (for urban councils) and chapter 14 (3:275) (for rural councils). In broad terms, rural councils are expected to represent and manage the affairs of people in rural areas within districts into which Zimbabwe's provinces are divided, while urban councils do the same in urban areas. The small size of wards from which councilors (who make up the council) are drawn enables councilors to be in continuous close contact with their constituents. This potentially provides an avenue for local citizens to access their political representatives thereby enabling their voice to be heard in decision making that affects their local service delivery and local development.

In theory, Zimbabwe's three tiers of government are predicated on a constitutional provision

within which they will implement their functions in a cooperative manner. A co-operative framework in which the three tiers of government inform, consult, harmonise and co-ordinate on matters of common national and public interest is thus imagined in the new Constitution. While such co-operation among the three tiers is possible, its success or failure will depend on how an Act of Parliament (which is yet to be crafted, debated and enacted) will define the mechanisms and procedures to facilitate co-ordination between central government, provincial and metropolitan councils and local authorities.

With regards to this article, narrowing down of economic powers maybe welcomed by the local people as it creates employment at local level and make people understand the economic values and resources within their Provinces. The argument in the paper is centered on the rate of migration by the Matabeleland South population and the government plan to empower Provinces economically. This means the local people are to be considered first and yet the local people in the Province are providing their labor elsewhere.

Migration and Devolution

It is of paramount importance to elaborate on the issues of migration and how it affects the devolution agenda. By way of definition, generally migration is the movement of people from one place to the other for a reason. This movement could have been necessitated by a plethora of reasons among them natural disasters, war among others. Also of importance to note is that migration can be internal where people can migrate from their place of origin to another place within the same country. Then migration which takes place between countries. In relation to this article, migration is discussed at the external level and Kennedy (1985) postulates that migration has to do with individual behaviors that produce a population outcome, and that outcome provides the selection acting back on individuals. Although migration can be *defined* only for individuals (behavior, syndromes), it can be *described* in terms of population outcomes (dynamics, trajectories, displacements). On the other hand, migration can be viewed as an adaptation specific of arenas in which changes inhabitant quality in different regions occur asynchronously so that movement allows a succession of temporary resources to be exploited as they arise. More so, Gando and Michalakis (2001) further assert that migration is movement away from the home range that does not cease, at least not initially, when suitable resources or home ranges are encountered. Eventually, however, the migrant is primed to respond to appropriate resources. It is in this circumstance that the immigrants eventually are considered to be using the expertise from their home country to tape the resources found in other countries and that impacts negatively on the devolution agenda in the home country.

King (2012) notes that migration inevitably shapes the demographic and environmental contexts of both the areas of out-migration and in-migration. Out-migration in this case refers to the place where the immigrants are coming out of. Making reference to this article, the out - migration is the Matabeleland South Province and movement of people to the neighboring country shapes negatively on the labor that is supposed to be provided by the local people towards their development. On the other and in-migration is the place where the immigrants would have gone to stay. In this regard it is South Africa or Botswana. This raises a lot of problems as both parties are affected. Of interest in this paper are the effects of migration on out-migration as there are repercussions on achieving the devolution agenda to grow the local economy with the absent of the local people. Kallio (2016) notes that humans have been migrating for millennia, and while data are increasingly captured on human migration flows, with the advent of devolution agenda by the government of Zimbabwe, there is a challenge of achieving the later with the local people failing to participate in their projects for economic prosperity. Migration is inherent for the human species, and while we can seek to prevent some types of migration through policy and sustainable livelihood practices, much of human migration is inevitable, thus posing contests on achieving the set goals in the Province. More so, many definitions of migration specifically state that migration is the crossing of a political or administrative boundary for a certain period of time (Castles, 2000; Richard and Sabine, 2012). It is evident

that, with the formation of modern states and borders, defining migration has become much more politicized and complex (Castles, 2000; King, 2012). Hence failure of the devolution agenda to be participated by the local people will be envisaged as political sabotage, whilst there are many circumstances that necessitates these movements by the native people.

On the other hand, proponents of devolution such as Chigumira et al. (2019) and Fonshell (2018) argue that devolution curbs corruption and inefficiency. According to Ngigi and Busolo (2019), devolution helps to establish institutions that are more accountable and an effective system of good governance. The fact the local government in Zimbabwe in entrusted with the role of promoting public participation in local governance in the first objective 264 (2a), also means that the good governance systems that are created are bound to be more efficient and transparent. When resources are distributed to local communities, it makes it easier to manage them in an accountable and transparent manner (Chikerema, 2013). It is this advantage of devolution which involves the native communities that the article is debating the factors that necessitates migration and consequently affects the implementation of the devolution agenda in Matabeleland South Province in Zimbabwe.

Matabeleland South Province

Matabeleland South Province is one of Zimbabwe's ten provinces situated South West of the country bordering with Botswana to the West, Midlands Province to the North east, to the South east is Masvingo and South Africa to the South. Its Provincial capital is Gwanda which is 132.7kms from Bulawayo and 197.3kms from Beitbridge. It is the country's least populous province despite constituting 13,86% of the total area of Zimbabwe. Matabeleland South sits on the edge of the Kalahari desert giving it an arid climate not favorable to agriculture. The economic activities that happens in the province are subsistence farming and livestock farming. This results in droughts and lack of economic opportunities which has seen people migrating from the Province for greener pastures. Despite the arid climate patterns in the province, the place has vast mineral deposits which could equally sustain the economic status of the inhabitants of the province.

Research Methodology

The article is guided by qualitative research paradigm grounded on Denzin and Lincoln (2005)'s definition that: qualitative research aims to gather comprehensive understanding of human behaviours and the resources that govern it. This visibly highlights that qualitative researchers study cases in an effort to make sense of or strive to interpret occurrences according to implications people afford them in their natural settings. More so, the choice of the research paradigm is necessitated by Creswell (2003) who argues that a qualitative study is, 'an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting' which is contrary to quantitative research. The target population of the study are people in Matabeleland South Province and participants are sampled using both convenience and purposive or judgemental sampling. Convenience sampling is a type of non-probability sampling which involved the selection of the sample that is convenient and readily available but drawn from part of the population under study. The province is chosen because it has a high rate of people who migrate to South Africa in search of jobs. Local government workers from the Provincial capital of Gwanda are the ones conveniently selected on the basis of their understanding and involvement in the devolution process and the nature of livelihoods in the areas around. Besides being readily available some respondents failed to have adequate knowledge about the subject matter so the researcher also enco-operated purposive sampling where choice was according to Olivier (2006) based upon a variety of criteria which may include proficient knowledge of the research issue, or capacity and willingness to participate in the research. In that regard, the researchers purposively sampled some youths in the Province who happen to be the target of employment that will be created by the devolution process.

Data was collected using interviews which Kvale (1996) says its sole purpose is to gather descriptions of life-world of the interviewee

with respect to interpretations of meanings of the described situation. An interview is a direct verbal data collecting tool which gives room for face to face interaction between the researcher and the respondents. The researchers used face to face interviews to solicit data from the selected people. This tool was useful in the exploration of deep unknown data from the respondents that is; their expectations, values and knowledge of the situation about development of their area. Furthermore, this tool was useful because even those respondents who cannot read or write can be included and more questions can be asked as rapport can be established with the respondents.

Migration dynamics and its effects on devolution agenda in Matabeleland South

The section is presenting dynamics in migration and consequently the implications it has on the devolution agenda in Matabeleland South Province.

Proximity of the Province to the borders of Botswana and South Africa

Matabeleland South Province shares borders with South Africa and Botswana. The Province also hosts Beitbridge and Plumtree which are entry points to South Africa and Botswana respectively. The fact that there is no infrastructure to demarcate the borders make it easy for the residents to just cross imaginary lines and be on the other side of the border. This way people need not to have passports to pass through any formal entry/exit points to get to the other side so that makes the Province lose a lot of people to the neighboring countries, especially the youths. One of the respondents in the study commented;

Umumo okulesi sigaba ungani uyahlupha ngoba siduzane lomungxele owamazwe amabili. Kunzima ukhuthi abantu bahlale phakhathi kobunzima ngoma indaba zomnotho lapha eZimbabwe kazimanga kuhle, kantike eBotswana lase South Africa impilo ingcono ukwedlula lapha ekhaya njalo lemisebenzi itholakhala kalula, Njengomngxele wona vele singathi kawuko ngoba ngugwaqonje kombe okuyisifudlana. Sibanye.

(The situation is very tricky in this Province because of our proximity to the two borders. It is difficult for our people to continue holding on to this difficult economic situation in Zimbabwe when they know you can lead a better life across the road. The border between Zimbabwe and Botswana or South Africa here is just marked by a road or a small river so it is easy for these young ones to just move and find themselves on the other side of the border where they can secure employment. After all we are one people)

The submission above by one respondent clearly shows that brain drain is inevitable in the Province. The young generation who are not patient with the economic environment in Zimbabwe carry the highest population of people who migrate to either South Africa or Botswana for better living conditions. In the process brain drain is high as their skills are being used elsewhere while their Province needs them. In the spirit of wanting to achieve upper middle income economy by 2030 through the devolution agenda, it may be difficult for the Province to tape from their local human resource because of this high rate of migration in the Province. Thus Jager and Mutusva (2015) contend that significant numbers of migrants have been heading south in response to the crisis with the perception of economic opportunity in Botswana and South Africa.

Besides crossing to the neighboring countries in search of better economic opportunities, a lot of illegal economic activities and dirty deals are rampant in the border towns of Beitbridge and Plumtree such that many youths resort to those activities at the expense of formal employment. It is difficult for somebody who has been involved in illegal foreign currency dealings at either Beitbridge or Plumtree border post to join say the road construction industry because to them money has been made easy to get by just standing at a corner. Some are into fuel selling, some are facilitating people to jump the borders to the neighboring country among other deals. This has been confirmed by another respondent who vowed that even if the government has plans to empower communities he will never join formal employment because of other

opportunities found in the border towns. He says verbatim;

Impilo inhle lapha emngxeleni. Umuntu okhala ngokuswela umsebenzi kacabangi ngoba indlela zokwenza imali zinengi lapha ebhirijinuni. Ngiyazisola ngesikhathi engasimotshayo ngisiya esikholo ngoba imisebenzi enginika imali khayifuni isikholo. Ukucaphisa abantu abangela amapasiphoti umngxele akufuni isikhola ngoba ngisebenzisa ulwazi lwendawo njengesizalwane.Njalo ngiyathengisa amafutha awezimota ngithola imali enengi. Angitsho akhula amafutha awezimota lapha eZimbabwe.

(Life is good here. There is nothing good as staying in a border town. Complaining of unemployment will be your own failure to think of plans to make money. I even regret why I spent all that time at school because things that we do here do not even need school. For example facilitating people to cross over to the other side just needs my knowledge of the place as a bona fide citizen of the area. We earn a lot through that because passports are not easy to get in Zimbabwe at the same time life is not rose so people go out without these travelling documents. With the current fuel shortages in the country, fuel business is brisk here. Transport business, foreign currency exchange and many other things. We can spend the whole day).

Above is a narration by one respondent who earns a living through various illegal activities in the border town of Beitbridge. The respondent exploits the harsh economic conditions in the country. It is evident that many youths now regret having gone to school to learn certain skills which they cannot use due to unemployment resulting from economic challenges in Zimbabwe. In other words the skills that they have learnt at various institutions are likely not going to be used in the Province's devolution agenda because the populace seems to be comfortable with opportunities they derive from illegal synonymous with being a border Province. It is because of this factor that the researchers in the paper argue that devolution agenda may be difficult to achieve in Matabeleland South province in Zimbabwe considering its proximity with both Botswana and South Africa.

On the same note, even government officers from the local government confirmed that proximity to the border is quite a challenge in achieving the devolution agenda in the Province. The interviewed officer reiterated that, '…it is actually heartbreaking that jobs are taken by youths from other Provinces whilst the owners of the jobs are nowhere to be found. The other thing is we have challenges in communicating with the local people. If we had youths who grew up in the area they would help spearhead some projects and help by explaining to the general populace and elderly in the language that they best understand…'. These concerns are still pointing to the absent of youths in the area to be involved in the projects that are initiated by devolution in their places.

Drought prone area

Another important point to take note of about the challenges of Matabeleland South being part of the government's plan in achieving an upper middle economy through devolution agenda is their climate situation. Matabeleland South sits on the edge of the Kalahari desert giving it an arid climate not favorable to agriculture. In other words it is a drought prone area where little agricultural activities are done. People in the Province are into subsistence agriculture where they can carry out agriculture activities for their own consumption. Then they are into livestock rearing because at least they can take care of their cattle to send their children to school among other things. This clearly shows that for their source of livelihood, they go outside the Province because there is little that the province can offer. In this case migration is prone to happen and that will culminate into brain drain as people move out to go and fetch for better things elsewhere because even if they do subsistence farming they have no guarantee that they will have food. Jager and Musuva (2015) acknowledge that migration has become a crucial response of the poor, the better-off, the skilled and the unskilled to Zimbabwe's protracted crisis. To this effect another informant said:

Indawo yakhithile iwomile izulu khalini kuhle. Imizamo yonke esiyizamayo eyokhulima ayiphumeleli ngenxa yokuswelakhala kwezulu. Ihloko yomuzi nje ngami kangingeke ngayekhela imuli yami ibulawa indlala ngihlezi lapha.

Akulalapho engingaya khona lapha eZimbabwe ngoba ukhula misebenzi.
Intonje yikhuthi ngicaphe ngiye eGoli khona ngiya tholela imuli ukhudla lemali yesikholo.

(This place is dry, there is no water in the area to the point that even when we do agricultural activities for our own consumption, we have no guarantee that we will harvest. A head of a family like me cannot sit down and watch my family suffer. I have to leave the place go elsewhere to work for them…in this case where do we go in Zimbabwe with these hardships? We cross the border and go to South Africa. At least that way I can send food back home and my children can go to school)

Van Hear (2011: 2) notes that the notion of mixed migration has gained recognition over the last two decades as people … move to escape intolerable living conditions, they may move to better themselves, or they move for these and other reasons. Poor living conditions have led to migration as the above informant has confirmed. The Province has a challenge that even when government programs come they are least considered for example they have been allocated funds to construct one dam during the 2019 Infrastructural investment plan when it is known that the place is dry, people there need more water resources to carry out more agricultural activities for their upkeep, (Ministry of Finance and Economic Development, 2019 Infrastructure Investment Plan). By giving them money to build one dam in six districts, little confidence is built among the people so they end up migrating away thereby defeating the devolution agenda.

Supporting the same view. Another government officer in an interview reiterated that these dry conditions in the province have made people shun farming at all costs because they are convinced that they buy the food not plough the food. In an effort to buy the food, every child who finishes school has to go and look for employment elsewhere so as to assist those at home.

Province has the least population in the country

Matabeleland South Province is the least populous province in Zimbabwe with an estimated population of 683, 893 as of the 2012 census. Being the least populous province, and has the highest rate of migration, this is a cause for concern because effective implementation of devolution will need manpower and skilled people from the Province. If the idea is to build a source of livelihood for people, then it will be difficult without the involvement of people from Matebeleland South. Tevera and Zinyama (2002: 7) note that prior to 2000 better-educated and skilled whites dominated the migration population. This has since changed to black Zimbabwean professionals as well as an increase in skilled labor migration. All these are economically motivated moves where people would want to earn a living out of their qualifications as a result brain drain is be high. Although Jager and Musuva (2015) note that there has been a change in the ethnic composition of the Zimbabwean community in South Africa. Historically Zimbabwean migrants to South Africa tended to be from the Ndebele community or white settlers. This has necessitated debate in the article as the population of people from Matabeleland South is high hence impacting on the devolution agenda by the government as the program calls for the participation of the local people within the area, thereby creating employment.

Furthermore, allocation of funds for devolution takes cognisance of the numbers of people in the Province. If the numbers are low that will also guarantee allocation of less funds hence impacting on the agenda to empower the local people. Even the huge deposits of minerals in the Province, if there is no manpower and skilled people, the resources within the Province will be exploited by people from other areas thus giving a negative signal on the devolution agenda which calls for participation of the local communities.

Historical political conflicts

Historically, Matabeleland South has almost constantly been a victim of unrest. During the war of liberation the Province suffered from the effects of battles which occurred between the

Rhodesian Security Forces and the Freedom fighters. It was equally affected by follow up operations which were carried out by the South African Defense Forces as they pursued the South African Freedom Fighters who used the then Rhodesia as their passage into South Africa for their operations. When Zimbabwe attained independence in 1980, the Province once again became a war zone during the 1983-87 post-independence hostilities which occurred in parts of the Midlands and the Matebeleland Provinces. During this period a number of people fled Matebeleland Province into neighboring Botswana and South Africa. From that time to date some people of Matebeleland South Province have never trusted a government led by a Shona speaking leader. They have always felt marginalized and regard all government programs as less meaningful to them. When one respondent was asked to comment about money which the government allocated for devolution in 2019, this is what was said:

Uhulumende lo, vele thina abantu base Matebeleland khasinanzi. Sizwa khuthiwa imali edlula i300 million yabelwa uhlelo lukha zibuse wezabelo, kodwathina lapha eMatebeleland South sanikwa imali engaphansi kwe3million. Ezinye izabelo ezinje nge Nkabazwe zathola imali endlula i40million okutshingisela ukubana uhlelo lolu alusoze lwaphumelela lapha kwekakithi. Ngakho akhula sizatho sokumelela into zobandlulo.

(This government does not care about people of Matebeleland South. We understand that more that 300million was allocated for devolution but Matebeleland South was allocated only money below three million dollars whereas other provinces like the Midlands were allocated more that forty million for a similar program. Therefore there is no reason to wait for issues of segregation.)

On checking with relevant authorities it turned out to be true that the devolution program was allocated 310 million in 2019 and Matebeleland South was allocate 2, 7 million dollars for all the six districts yet the Midlands Province was allocated 41,6million dollars. Although there could be some other considerations which might have necessitated the disparities in the allocation of the funds to the Provinces, the government needs to explain these differences especially to those who have always felt marginalized to avoid cases of negative perceptions which could affect the success of devolution in Zimbabwe.

Conclusion

The paper has managed to spell out migration dynamics and the devolution agenda in the Matabeleland South Province. It can be concluded that economic motivated migration leads to brain drain hence making it difficult to achieve the devolution agenda which the government has set to achieve especially in Matabeleland South Province. From the results obtained in the study, Matabeleland South has proved to be a challenging case since factors such as proximity to border towns, drought prone, least populous and political history makes it difficult for the Province to achieve its agenda to improve the livelihoods of these people through devolution. The researchers came to conclusion that if the government is to achieve on the devolution issue, it has to carry out a strong campaign to win back the hearts of the people of the Province so that they regain the confidence needed for development of economies. In principle the devolution agenda in Matabeleland South Province is likely to be implemented by people from other Provinces at the expense of the local people. After a thorough interrogation of the concerns of the people of Matabeleland South Province which are centered around their lack of faith in the government of Zimbabwe's public programs, the people of the Province will not stop their migration to South Africa to support the devolution agenda and thus devolution is likely not to succeed in Matabeleland South Province of Zimbabwe. Even if it may succeed, its implementation will be done by people from outside the Province.

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Original Article

THE EFFECT OF DIFFERENT SUBSTRATES FOUND IN ZIMBABWE ON THE GROWTH AND YIELD OF OYSTER MUSHROOM *PLEUROTUS OSTREATUS*

G. Zhou[6] and W. Parawira

Abstract

The research was carried out to investigate the effect of different substrates on the growth and yield of *P. ostreatus*. Locally available agricultural wastes such as saw dust (S1), cotton waste (S2), wheat straw (S3) and corncob (S4) were tested for parameters such as days required for spawn run, primordial formation, harvest days, total yield and biological efficiency. Biological Efficiency (BE) was calculated as the ratio of fresh fruiting body weight (g) per dry weight of substrates (g), expressed as a percentage. Before substrates were used in this study they were subjected to nutritional (C, N, P, K, Ca, Mg and Zn) analysis. The highest yield of 1275.45 g was obtained in saw dust and the lowest yield of 1058.7 g was obtained in cotton waste. The highest carbon to nitrogen (C/N) ratio was found in saw dust (53:0.1) and the least C/N ratio was found in cotton waste (39:1). There were 19 spawn run days in saw dust and 24 spawn run days in cotton waste. Stem width (2.6 cm) and cap diameter (9.7 cm) were greatest in cotton waste and low in saw dust with stem width (2.3 cm) and cap diameter (7.4 cm). Substrates with a higher C/N ratio had the greatest yield and biological efficiency. The higher C/N ratio favoured mycelium growth and lower carbon to nitrogen ratio favored fruiting body growth. In this study saw dust had the highest C/N ratio and it had the greatest yield and low spawn run days yet cotton waste had the least C/N ratio but its fruiting body measurements were very high. There was no significant difference at $p \leq 0.05$ between wheat straw and corn cob in terms of growth parameters and yield as their C/N was significantly high at (44:1) and (49:1) respectively. The results signifies that apart from soya beans and maize stalk which were widely used by farmers as substrates of choice, saw dust, cotton waste, corn cob and wheat straw were good alternatives for the growth of *P. ostreatus* mushrooms. Saw dust was very good in the total yield obtained but cotton waste had the best quality of mushrooms with very big stipes and cap diameter. These locally available substrates in Zimbabwe were recommended for use by small scale farmers for sustainable production of oyster mushrooms as they produced good yields at low cost.

Keywords: Lignocellulosic, Substrates, Oyster mushroom, *Pleurotus ostreatus*, Growth, Yield, and Biological Efficiency.

Introduction

Oyster mushroom (*Pleurotus species*) belongs to the family of Tricholomataceae and is the second widely cultivated mushroom worldwide following the *Agaricus bisporus* (Sanchez, 2010 and Kües *et al*, 2000). *Pleurotus* species are popular and widely cultivated throughout the world mostly in Asia, America and Europe because of the simple,

[6] *Corresponding Author: G. Zhou*
Department of Biological Sciences,
Bindura University of Science Education,
P Bag 1020,
Bindura, Zimbabwe.

low cost production technology used to produce them and their high biological efficiency (BE) (Mane *et al.*, 2007). The interest in oyster mushroom is also increasing largely due to its rich taste and nutritional composition of protein, minerals (P, Ca, Fe, K, and Na) and vitamin (thiamine, riboflavin, folic acid, and niacin) (Szabová *et al.*, 2013). Apart from food value, their medicinal value for diabetics and in cancer therapy has been emphasized (Shah *et al*., 2004 and Zireva *et al.*, 2007). Several species of oyster mushrooms act as strong antioxidant while *Pleurotus ostreatus* possesses antitumor activity (Li and Chang, 2007). Oyster mushrooms can efficiently degrade agricultural wastes and they grow at a wide range of temperatures (Sanchez, 2010). In comparison to other edible mushrooms, *Pleurotus* species has a short growth time and their fruiting bodies are not often attacked by diseases and pests (Tesfaw *et al.*, 2015 and Baysal *et al.*, 2003). Small scale farmers in Zimbabwe produce oyster mushroom because it is cheap to grow and it uses agricultural wastes such as maize straw and corn cobs which are readily available since maize is a staple food crop (Chitamba, 2007).

In Zimbabwe, agricultural waste, if not utilized is either left to rot in the field or disposed through burning and thus constitute environmental hazards and hide out for pests. According to Mutema *et al* (2019) research findings showed that small scale producers specialises in oyster mushroom production and it accounted for 60% of total annual production, while large scale farmers specialise in white button mushroom of which 75% were commercialized (Chiroro, 2004). Due to the nutritional and medicinal importance of oyster mushrooms and its ability to utilize agricultural wastes there is need to upscale its production.

Oyster mushrooms require carbon, nitrogen and inorganic compounds as their nutritional sources. The main nutrients are less nitrogen and more carbon so materials containing cellulose, hemicellulose and lignin (i.e., rice and wheat straw, cotton seed hulls, sawdust, waste paper, leaves, and sugarcane residue among others) can be used as mushroom substrates (Chitamba, 2007). While oyster mushroom can grow on a wide variety of substrates, the yield and the quality of oyster mushroom depend on the chemical and nutritional content of substrates (Badu *et al.*, 2011 and Patil *et al.*, 2010).

In Pakistan, it was discovered that sawdust was the best among others with respect to yield, quality and efficiency (Shah *et al.*, 2004). In separate studies it was also found that pinhead formation, fruiting body maturation and time of spawn running were earlier on mushrooms growing on sugarcane bagasse (Shah *et al*., 2004). In Turkey, the shortest mycelium growing time, the shortest harvest time and total harvested amount were realized on soybean stalk, while the longest for harvesting and growing times for mycelium and the total lowest harvested amount were obtained with cotton stalk (Nunes *et al*., 2012). In Nigeria, it was discovered that agricultural wastes produced higher yields as compared to other substrates like saw dust (Adedokun, 2014). According to Mutema *et al.,* (2019) mushroom producers in Zimbabwe used substrates such as maize stalk (53.3%), followed by Soya bean (43%), then wheat straw (36.7%). Other substrates included cotton hulls (10%) and banana leaves (6%) and saw dust (3%).

Information such as the nutritional composition of substrates, shortest mycelium growing time, the shortest harvest time and total harvested amount of mushrooms per each substrate used in mushroom production and the effects of different locally available substrates on the growth and yield of *P. ostreatus* is lackings yet vital if oyster mushrooms were to be produced at an industrial scale in Zimbabwe. Muposa (2013) noted that lack of knowledge by Agriculture Extension Workers was one of the problems faced by mushroom producers in Zimbabwe. The objective of the study was to compare the effects of different locally available agro-wastes on the growth and yield of Oyster mushroom *Pleurotus ostreatus* with the view of increasing the substrate options and providing knowledge on the best substrate and alternative substrates for effective commercial cultivation of oyster mushrooms. Since Zimbabwe is an agro based economy, it was necessary to explore the potential use of the abundant agro-wastes as additional substrates for mushroom production.

Materials and Methods

A mixed approach method was employed in gathering and analysing data. The experiment was conducted in a custom made growth room in a backyard in Masvingo, Zimbabwe (House Number 2654, Rujeko). Mushroom house conditions were partially controlled. Relative humidity and room temperature were monitored and maintained with a hydrometer and six's thermometer respectively. Relative humidity was maintained between 80 and 85 % by spraying fine mist of water occasionally (Oei, 2003). Response variables such as days of spawn run, days of primordial formation, harvest days, stem length, stem width and cap diameter were compared based on the different types of the substrates used, that is, sawdust (S1), cotton waste (S2), wheat straw (S3) and corncob (S4) in the production of oyster mushroom.

Spawn source

Pleurotus ostreatus 10kg spawn was obtained from Mustella spawn laboratories situated in Marlborough, Harare. The prices were $6/Kg (RTGS) or $1.4/kg (USD). The minimum quantity sold was a10kg spawn.

Substrate sources

Four different substrates namely, sawdust (S1), cotton waste (S2), wheat straw (S3) and corncob (S4) were evaluated for growing oyster mushroom in this study. Saw dust was collected from a local sawmill at Rank timber market in Masvingo. The maize residues, that is, the corncob was abundantly available from local farms. Cotton waste was purchased from farmers in Zambia since it was not available locally during the time of the study. Wheat straw was obtained from a local mushroom farmer in Mashava area

Nutritional Analysis of the Substrates

Nutritional analysis for all the four substrates used in the investigation was conducted at the University of Zimbabwe, Department of Biological Sciences in Harare. The nitrogen, carbon, phosphorus, calcium, magnesium, and zinc contents for each of the four substrates that is wheat straw, corn cob, cotton waste and saw dust was determined. Thirty samples of each substrate were obtained from different randomly chosen sources. All the samples were ground into a fine powder using pestle and mortar before being analyzed for their nutritional content, that is, according to (Onyango *et al.,* 2011). After grinding to powder, 100g of each sample was mixed to make a composite sample where after thorough homogenization or mixing 100g sample for each substrate was taken for analysis. The nutritional analysis was done according to standard methods in Table 1.

Table 1 Summary of the method used in the nutritional analysis of substrates

Parameter	Method used	Instrument
Nitrogen	Wet digestion-Calorimetry	Spectrophotometer
Carbon	Modified Walkly-Black	Spectrophotometer
Phosphorus	Wet digestion-Ascorbic Acid	Spectrophotometer
Ca, Mg. K and Zn	Atomic Absorption	Spectrophotometer

Digestion Mixture for Nitrogen and Phosphorous

Selenium dust (0.42 g) and lithium sulphate (14 g) were added to 350 ml of 30% hydrogen peroxide. The mixture was slowly added with care to 420 ml of concentrated sulphuric acid while cooling in an ice bath. The mixture was stored at temperatures of 2ºC for 4 weeks.

Digestion Procedure

A sample of 0.1g of each substrate was weighed into a digestion tube, and the weight was recorded. After that, 4.4 ml of digestion mixture was added to each tube. Blanks were included for standard compensation. Heat was applied in the digester block at 360ºC for 3 hours until the solution was colourless and free from plant materials. The mixture was removed from the block and allowed to cool to room temperature. Distilled water 25ml was added and was mixed well with a vortex mixer, until no more sediment dissolved and it was allowed to cool. Distilled water was added to make up to 100 ml level. The supernatant was allowed to settle so that a clear solution was taken from the top of the tube for

analysis of Nitrogen and Phosphorous using standard methods mentioned above.

Preparation and Pasteurisation of Substrates

Wheat straw was cleaned and excess soil was removed by dipping the straw in clean tape water in a 200 litre drum. The procedure was also done with corn cob, cotton waste, and saw dust. Wheat straw and corn cob were then chopped into small pieces of five to seven centimeters using a machete and a wooden block. A digital balance (Ohaus Scout SPX2201) was used to weigh 415g of powdered hydrated lime as well as 20kg of each substrate used in this investigation. The hydrated lime powder was dissolved in 50 litre tap water in a 100 litre plastic drum. The wheat straw (20kg) was added immediately, completely submerged and the drum covered with a lid. The straw was left to soak for 12 hours, unloaded onto a sterilised plastic sheet and allowed to drain excess water. The procedure was repeated in preparing all the three substrates, that is, sawdust, cotton waste and corn cob.

Sterilisation of spawning equipment

A sodium hypochlorite solution for sterilisation of apparatus was made by mixing 50ml of 5% sodium hypochlorite with 20 litre of water in a 20 litre plastic bucket. All equipment and working surfaces were sterilised by soaking in or washing with the sodium hypochlorite solution. The spawn bags were also dipped in the solution for five minutes and placed on a sterilised surface prior to spawning.

Spawning

This is the process of adding the 'mushroom seed' to the pasteurized substrate. The recommended rate of inoculation (spawning) used was 3-7% of substrate (dry weight) (Stamets, 1993). Heat resistant (10 kg) polythene bags were filled with a bottom layer of pasteurized substrate followed by uniform distribution of the spawn. The bottom ends of the bags were folded to enable them to stand without any form of support. An empty bottle was used to compress the substrate and spawn mixture as more was added to a final weight of 10 kg. A piece of cotton wool was plugged at the neck of the bags. About (6–8) holes were punched on the sides of the plastic bags to facilitate cross-sectional ventilation. Finally, a total of 6 polythene bags from each substrate type were inoculated with a spawn and the experiment was done in duplicates. After the holes were punched, two openings were cut at the base of the bags to improve drainage.

The bags were then incubated for spawn running and tied in a mushroom growing house under complete darkness at controlled temperature of 25°C. The humidity of the bags was maintained constant by spraying with water twice a day. The thickening of the mycelia in the bags (colonization of the bags) was an indication of the end of the incubation period and that the bags were to be opened for fruiting. The procedure was done for all the substrates on the same day so as to maintain uniform conditions during the investigation.

Maintenance during spawn run

The following conditions were maintained for the success of this stage; little aeration, or windows closed, darkness, high humidity and optimum temperature range of 23-28ºC (SIRDC, 2017). Air humidity was maintained between 80-90% with the use of a hygrometer to monitor the moisture. Watering of the floor was done at least once daily using a horse pipe. The mushroom house temperature was measured using a six's thermometer at 6am, 12pm and 6pm daily.

Maintenance during fruiting

After the substrate has been fully colonized and has become white, free circulation of air was maintained by opening the door and louvers on the sides of the mushroom house. High humidity was attained through watering daily and misting the bags (SIRDC, 2017)

Maintenance during harvesting

Good ventilation was maintained by opening the windows. A lot of light was required at this stage and it was achieved by opening the doors and windows during the day. High humidity was obtained through watering and misting of the mushrooms daily.

Experimental design

A completely randomized design (CRD) with four replicates , that is , (saw dust (S1), cotton waste (S2), wheat straw (S3) and corn cob (S4) was used.

CRDs were used for studying the effects of one primary factor without the need to take other nuisance variables into account. It simply compared the values of a response variable based on the different levels of that primary factor. The response variables such as days of spawn run, days of primordial formation, harvest days, stem length, stem width and cap diameter were compared based on the different types of the substrates used.

Data collection

Determination of the number of days to complete spawn run

The date of spawning was marked as day one for the mycelia to begin colonizing the straw. Mycelial growth was observed daily and the number of days taken to completely cover the substrate was recorded for each bag. The numbers of days for complete spawn run were determined by counting from day one to the day when all substrate was completely covered by mycelia

Determination of the number of days to complete primordia formation

The days of completion of colonisation of substrate were noted. The number of days taken to produce first visible primordia was determined by counting the number of days from completion of colonisation to the day that the first primordia was observed, for each bag**.**

Determination of the number of harvesting days

The days of primordial emergence were noted. The number of days for the first flush was determined for each bag by counting from day one to the last day that the fruit was harvested on the bag and that was repeated for all the four treatments.

Length, thickness of stem and diameter of cap

The growth parameters were measured in centimetres using a tap measure and the measurements were done for all the four treatments. The findings were recorded in the table of results.

Determination of the yield of first flush (YFF) and biological efficiency (BE)

The fresh weight of mushrooms was determined using a digital balance (Ohaus Scout SPX2201) and the results were recorded for each bag on each harvest day. The mean weight of mushrooms harvested was calculated for each substrate used and they were tabulated. Total yields and biological efficiencies were calculated for each substrate at the end of the first fruiting flush.

Data Analysis

To evaluate the growth performance of mushroom on different substrates, yield and biological efficiency was calculated. Accordingly, biological yield (g) was determined by weighing the whole cluster of fruiting bodies without removing the base of stalks, and Economic yield (g) was determined by weighing all the fruiting bodies on a substrate after removing the base of stalks. After the last harvest the dry weight of the spent substrate was determined by exposing it to direct sunlight until there was no further change in weight for 3 consecutive days. The data collected was subjected to statistical analysis using Analysis of Variance (ANOVA) on Genstat version 9 (Hilbe, 2007). Mean values of all the parameters and the standard errors of each parameter were separated using LSD at 5 % level of significance using Duncan's multiple range test.

Biological efficiency (BE)

Biological efficiency is the percentage measurement of the yield of fresh mushrooms from the dry weight of the substrate. BE was calculated as follows:

$$\%BE = \frac{FWm}{DWs} * 100\ \%;$$

Where, BE = Biological Efficiency (%);

FWm = Total fresh weight (g) of mushroom yield across all flushes, and

DW = Substrate dry weight (g).

Validity

The data obtained was analysed using one way ANOVA. For normality testing, the ShapiroWilk

or Kolmogorov-Smirnov test was used to test for a normally distributed population within the samples. In Equal Variance Testing, SigmaPlot was used to test for equal variance by checking the variability about the group means. For the *P* values for normality and equal variance, the *P* value determined the probability of being incorrect in concluding that the data was not normally distributed (*P* value was the risk of falsely rejecting the null hypothesis that the data is normally distributed). If the *P* computed by the test was greater than the *P* set here, the test passed. To strictly adhere to normality and or equal variance, the *P* value was low. The parametric statistical methods were relatively robust in terms of detecting violations of the assumptions,the suggested value in SigmaPlot was 0.050. Larger values of *P* (for example, 0.100) required less evidence to conclude that the data was normal.

Consistency

Internal consistency reliability was a way to gauge how well a test or investigation was actually measuring what it was meant to measure. In this study all other conditions for oyster mushroom production were maintained at their optimum levels. The type of the substrate was the only varied factor among all the treatments.

Results and Discussions

Nutritional analysis of substrates

Table 2: Nutritional analysis of substrates used in the study.

Parameter tested	Wheat straw (dry weight)	Corn cob (dry weight)	Cotton Waste (dry weight)	Saw Dust (dry weight)
% Nitrogen	0.763	0.752	1.06	0.071
% Carbon	43.89	49.09	39.07	53.46
Carbon: Nitrogen	**44**:**1**	**49**:**1**	**39**:**1**	**53**:**0.1**
Total Phosphorus mg/kg	0.866	15.41	52.46	312.55
Calcium mg/kg	6.64	17.99	375.76	144.57
Magnesium mg/kg	30.76	63.69	32.49	85.77
Potassium mg/kg	130.45	630.63	370.91	907.05
Zinc mg/kg	0.411	0.146	0.209	0.572

The results of the nutritional analyses of the different substrates are shown in Table 2. The highest carbon to nitrogen ratio was found in saw dust (53:0.1) followed by corn cob (49:1) and wheat straw (44:1). The least carbon to nitrogen ratio was found in cotton waste (39:1) as indicated in Table 2. All the substrates used in the growth of oyster mushroom in this investigation were all suitable since they all exhibited a significantly higher ratio of carbon to nitrogen at (P=0.029). According to Chang and Miles (2002), *Pleurotus* species require carbon, nitrogen and inorganic compounds as their nutritional sources. Oyster mushroom can grow on a wide variety of substrates, however, the yield and the quality of oyster mushroom depend on the chemical and nutritional content of substrates (Badu *et al.,* 2011 and Patil *et al.,* 2010). The main mineral components (Ca, K, Mg, P, Zn) were present in the substrates however, in significantly different amounts. Saw dust contained the highest phosphorus, magnesium, and potassium as indicated in Table 2. Cotton waste contained the highest calcium amount. There was no significant difference in the mean values of zinc across all the substrates. The mean amount of zinc in all the substrates was extremely very low at 0.334mg/kg. Generally saw dust was the substrate with the highest carbon to nitrogen ratio as well as the highest percentage of mineral components. The second best substrate after saw dust was corn cob with the highest carbon to nitrogen ratio as well as magnesium and potassium amounts. Cotton waste was the third substrate with high phosphorus and potassium amounts however, its carbon to nitrogen ratio (39:1) was the least as compared to all the four substrates but significant for the growth of *P. ostreatus.* According to the studies conducted by Hoa *et al* (2015), it was confirmed that the mineral elements (Ca, Cu, Fe, K, Mg, Mn, P, and Zn) were naturally present in all the substrate used in this study, that is, saw dust,

cotton waste, wheat straw, corn cob. Among substrate formulas used saw dust contained the maximum amount of Ca (521.28 mg/100 g). Calcium content in corn cob was the second highest and not significantly different with Ca content in sugarcane bargasse. In general, Cu and Zn contents of all substrate formulas were low.

The amount of calcium obtained in saw dust according to Hoa *et al* 2015 were significantly higher as compared to the calcium content of the substrates used in this study. Thus the mineral content of substrates might vary from one region to another thus a research like this one would be important to inform farmers to choose the best substrate types before mushroom cultivation. The results of zinc contents of substrates were significantly very low and the results were the same with that of Hoa *et al*., (2015). Zinc is not required in large amounts for the growth of mushrooms. In terms of mineral composition, corn cob was the second best substrate followed by cotton waste and lastly wheat straw.

Studies conducted by Adenipekun (2006) suggested that *P. ostreatus* grew best on the medium containing macro nutrients. It was concluded that the medium without Ca and Mg gave lowest mycelial dry weight (Adenipekun *et al*, 2006). In this study cotton waste contained the highest calcium content whereas corncob was the second best in magnesium content from sawdust. Calcium has the better ability to support growth of *P. ostreatus* and that was largely attributed to its role in the fungus metabolic processes such as glycolysis and respiration (Adenipekun *et al*., 2006).The mineral components of substrates plays an important role in the growth of *P. ostreatus* mushrooms and the mineral composition of these substrates vary from one place to another. In terms of mineral composition, corn cob was the second best substrate followed by cotton waste and lastly wheat straw.

Growth parameters of P. ostreatus

Spawn run, Primordia formation and first harvest days for P. ostreatus

Table 3: Growth Parameters of P. ostreatus under different substrates in the study

Treatments	Spawn Run (days)	Primordia Formation (days)	Harvest (days)	Stem Length (cm)	Stem Width (cm)	Cap diameter (cm)
Sawdust	19	19	22	4.1	2.3	7.4
Cotton waste	24	26	30	7.2	2.6	9.7
Wheat straw	23	25	28	6.6	2.1	6.6
Corncob	27	23	25	4.6	1.9	7.1

The substrates showed significant differences in terms of days required for spawn run as shown in Table 3. The days required for spawn run in saw dust was 19 days, which was followed by 23 days in wheat straw and 24 days cotton waste. Maximum days required for spawn run were 27 days obtained in corn cob. Minimum days required for primordial formation were 19 days in sawdust, which was followed by 23 days, 25 days and 26 days in corncob, wheat straw and cotton waste, respectively.

The minimum duration required for first harvest was 22 days obtained in saw dust followed by 25 days in corn cob and 28 days in wheat straw. Maximum days required for first harvest were on cotton waste that is, 30 days based on the results in Table 3. Duncan's One Way Analysis of Variance at 5% level of significance was used to compare the means of the growth parameters of *P. ostreatus*. The differences in the mean values among the substrates groups were not good enough to exclude the possibility that the differences were due to random sampling

variability; there was not a statistically significant difference for (P = 0.394). According to Hoa *et al* (2015) the results can be explained by the differences in carbon to nitrogen ratio of the substrates. In the study, saw dust had the highest carbon to nitrogen ratio followed by corn cob. The fastest rate of mycelial growth was obtained in sawdust and wheat straw as indicated by least number of spawn run days of 19 and 23 respectively. The results were similar to the findings of Alborés *et al.,* (2006) who revealed that there was a positive correlation between the carbon and nitrogen ratio of substrate and mycelium growth rate. Naraian *et al.,* (2009) also reported that mycelium growth and primordial development of *Pleurotus ostreatus* were dependent on the lignocellulosic materials, especially the carbon to nitrogen ratio. Mycelium growth patterns were also in agreement with the findings of Dahmardeh *et al.,* (2010) that colonization period of oyster mushroom took three weeks and fruiting bodies appeared after 2 to 5 days when saw dust, cotton waste and wheat straw were used as substrates. The results of this study were also similar with the finding of Hoa *et al.,* 2015 who found that the first fruiting body occurred on different days depending on the type of substrate used. For instance, in this study the premordia formation days were 19 in saw dust but 26 in cotton waste, thus the formation of fruiting bodies depended on the type of substrate used.

Based on the results of Duncan's one way ANOVA at 5% level of significance, the differences in the mean values of days to spawn run, primordial formation days and first harvest days among the substrates groups were not great enough to exclude the possibility that the differences were due to random sampling variability; there was no significant difference for (P = 0.394).The result implied that the effect of different substrates on the growth parameters of *P ostreatus* were the same.

Stem Length, Width and Cap diameter

The greatest stem length of 7.2 cm was recorded in cotton waste (S2), followed by 6.6 cm in wheat straw (S3) and 4.6 cm corn cob (S4). In saw dust minimum stem length of 4.1 cm was recorded. The results showed the maximum stem width of 2.6 cm on cotton waste and minimum width of 1.9 in corn cob. Mushrooms growing in saw dust had the best stem width of 2.3cm followed by stem width of 2.1cm in wheat straw. The highest cap diameter of 9.7 cm was recorded in cotton waste which was followed by 7.4cm in saw dust and 7.1cm in corn cob (S4). Lowest cap diameter of 6.6 cm was recorded in wheat straw as shown in Table 3. Based on Duncan's One Way Analysis of Variance at 5% level of significance, there was significant difference between the means of cap diameter versus stem width, cap diameter versus stem length and stem length versus stem width in all the four substrates used in the *P. ostreatus* mushroom.

The greatest stem length and cap diameter of *P. ostreatus* was obtained in cotton waste yet from the nutritional analysis of substrates cotton waste had the least carbon to nitrogen ratio. Saw dust had the minimum stem length yet its carbon: nitrogen ratio was largest as compared to all substrates. These findings were similar to the results reported by Yang (2000) that higher carbon to nitrogen ratio favored the mycelium growth, and lower carbon to nitrogen ratio favored the fruiting body growth. The results from this study showed that apart from saw dust which was widely used by farmers as the substrate of choice, cotton waste, corn cob, and wheat straw were also possible agro-waste materials for oyster mushroom production.

Yield and Biological efficiency parameters of P. ostreatus

The result on total yield and biological efficiency of *Pleurotus ostreatus* by using different substrate were presented in Table 4. The differences in the BE and yield mean values among the substrate groups were greater than would be expected by chance at $p<0.001$). The highest yield of 1275.45 g was obtained by using saw dust as substrate (S1) which was followed by a yield of 1208.8g in corn cob (S4) and (1178.5 g) was obtained in wheat straw (S3). Cotton waste (S2) had the lowest yield of 1058.7 g. Maximum BE that is 115.9 % was obtained in saw dust and minimum B.E. of 94.3 % was obtained in wheat straw as illustrated in Table 4.

Table 4: Yield and biological efficiency of P . ostreatus per substrate used.

Treatment	First Harvest (g)	Second Harvest (g)	Third Harvest (g)	Total Yield	Biological Efficiency (%)
Saw Dust	757	336.45	181	1274.45	115.9
Cotton Waste	657	267.3	134.4	1058.7	70.6
Wheat Straw	702	302.7	156	1178.5	94.3
Corn Cob	715	320	173.8	1208.8	100.7

One way ANOVA of the first, second and third harvest of P. ostreatus.

The differences in the mean values of the first, second and third harvest among the substrate groups were greater than would be expected by chance; there was a statistically significant difference (P = <0.001) as indicated in Table 5. According to Duncan's multiple comparison procedures, the critical differences between first harvests versus third harvest, first harvest versus second harvest and second harvest versus third harvest across all the substrates was significantly high.

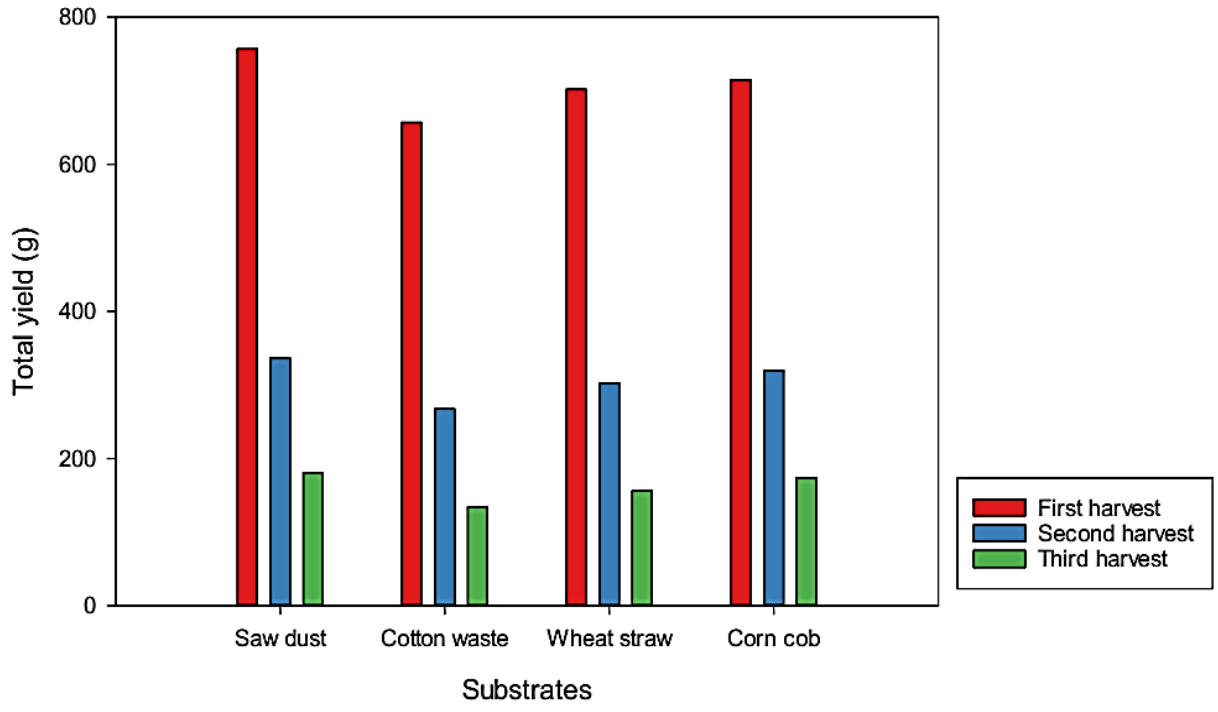
Table 5: One way ANOVA for the first, second and third harvest on each substrate.

Group Name	N	Missing	Mean	Std Dev	SEM
First harvest (gm)	10	6	707.75	41.177	20.589
Second harvest	10	6	306.613	29.61	14.805
Third harvest	10	6	161.3	20.785	10.392
Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Between Groups	2	640846	320423	319.958	<0.001
Residual	9	9013.07	1001.45		
Total	**11**	**649859**			
Comparison	**Diff of Means**	**p**	**q**	**p**	**p<0.050**
First harvest vs Third harvest	546.45	3	34.535	<0.001	Yes
First harvest vs Second harvest	401.137	2	25.352	<0.001	Yes
Second harvest vs Third harvest	145.313	2	9.184	<0.001	Yes

Yield per flush of P. ostreatus in all the four substrates

Fig 1 show the different yield per each flush/harvest for all the four substrates used in the production of oyster mushroom. Saw dust produced the best first flush yield of 757 g followed by corncob with 715 g and 702 g on wheat straw. Cotton waste had the least first flush yield of 657 g. There was a gradual decrease in the yield of mushrooms from the first harvest to the third harvest in all the four substrates. In cotton waste for instance, the first harvest was 657g followed by second harvest of 267.3g and lastly the third harvest of 134.4 g. The trend was the same in all the four substrates. The gradual decrease in the yield of mushroom was clearly shown in Fig 1.

Fig 1: The yield per flush of P. ostreatus in all the four substrates.



One way ANOVA analysis for yield and biological efficiency of P. ostreatus

Duncan's ANOVA was used at 5% significance level to test the variance of means for yield and Biological efficiency for all the four substrates and the results were outlined in Table 6 below. The differences in the mean values among the substrate groups were greater than would be expected by chance; there was a statistically significant difference at $p<0.001$. As indicated in Table 6, the critical difference between yield and biological efficiency was very high at $p<0.05$.

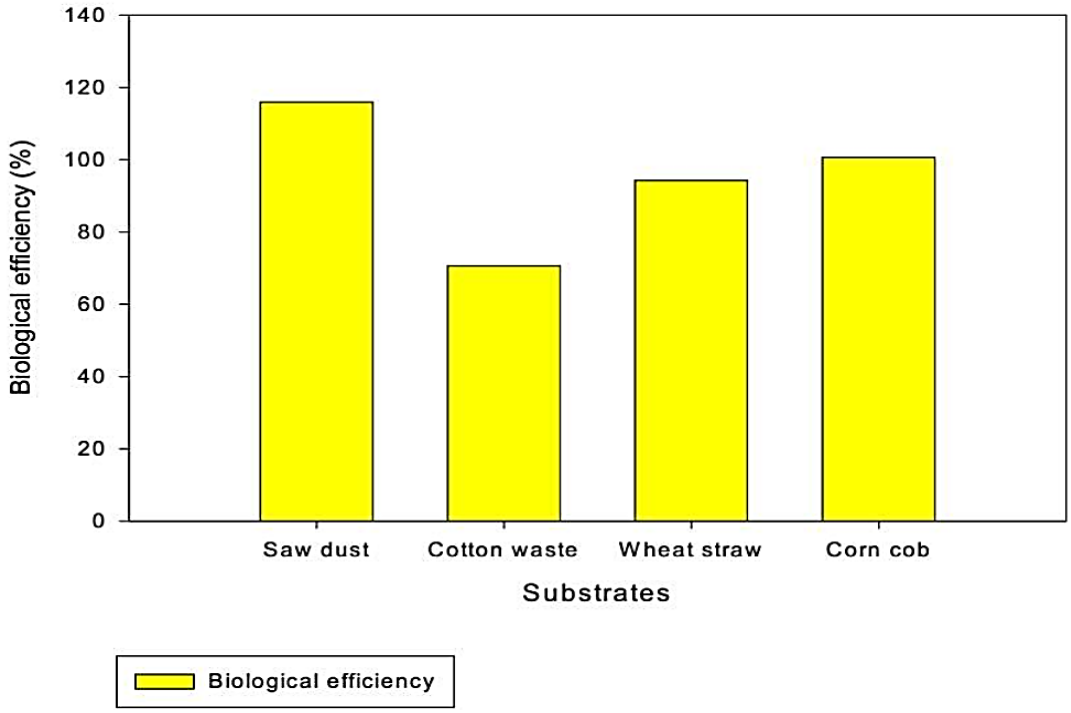
Table 6: One way ANOVA for the yield and biological efficiency of P. ostreatus

Group Name	**N**	**Missing**	**Mean**	**Std Dev**	**SEM**
Yield (gm)	10	6	1180.113	90.307	45.154
B.E %	10	6	95.375	18.838	9.419
Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
Between Groups	1	2353310.89	2353310.89	553.054	<0.001
Residual	6	25530.719	4255.12		
Total	7	2378841.61			
Comparison	**Diff of Means**	**p**	**q**	**p**	**p<0.050**
Yield vs B.E	1084.738	2	33.258	<0.001	Yes

Biological efficiency of P. ostreatus on each substrate

Biological Efficiency (BE) is the ratio of fresh fruiting body weight (g) per dry weight of substrates (g), expressed as a percentage. In this case the mean values of BE for each substrate were used to draw the graph in Fig 2. The highest biological efficiency was obtained in saw dust followed by corncob and wheat straw. Cotton waste was the substrate with the lowest biological efficiency. The results in this study were in agreement with Hoa *et al* 2015 who obtained quite a significant high mushroom yield of *P. ostreatus* from the first flush, followed by the second flush and the trend gradually decreased at next flushes. In general, substrates that gave the higher yields also gave the higher value of BE. According to Hoa *et al.*, 2015, the total yield of *P. ostreatus* ranged from 232.54 to 270.60 g/flush. On substrate yield, corn cob gave the highest total yield (270.60 g/bag) followed by sugarcane bargasse and sawdust (258.82 and 257.70g/bag, respectively). However, in this study, the total yield per flush was 757g/flush in saw dust and 715g/flush in corn cob thus the yield was too high as compared to the study by Hoa *et al.*, (2015). The differences in terms of yield and BE of both oyster mushrooms grown on different substrate types were due to the differences in physical and chemical composition of substrate formulas such as cellulose/lignin ratio and mineral contents, pH, and nutritional analysis of the carbon to nitrogen ratio.

Fig 2. Biological efficiency of Pleurotus ostreatus on each substrate.



Duncan's ANOVA was used at 5% significance level to test the variance of means for yield and Biological efficiency for all the four substrates. The differences in the mean values among the substrate groups were greater than would be expected by chance at $p<0.001$. The different substrates had an effect on the growth and yield of *P. ostreatus*. The yield obtained varied with the substrate type used in the investigation with sawdust having the highest total yield of 1274.45 g followed by corn cob with 1208.8g. Wheat straw was the next with 1178.5 g and cotton waste had the lowest yield of 1058.7g. Biological efficiency also followed the same trend; the highest

biological efficiency was obtained in saw dust followed by corncob and wheat straw. Cotton waste was the substrate with the lowest biological efficiency.

The findings on this study were similar to the results of the investigations conducted in Pakistan where the highest biological efficiency, total yield and quality of *P. ostreatus* were obtained using saw dust as substrate (Shah *et al.*, 2004). However investigations conducted in Nigeria produced different results with higher yields obtained using agricultural wastes than saw dust (Adedokun, 2014).Thus further investigations were required using a wide range of different saw dust obtained from different plant species as well as agricultural wastes to determine the most efficient substrate in the production of oyster mushrooms. Saw dust produced higher yields in this investigation however agricultural wastes were readily available ,cheap and more sustainable to use since they can be obtained without causing any harm to the environment such as deforestation, global warming and climate change. Use of saw dust and agricultural wastes in mushroom production was a sustainable way of recycling dead organic matter. *Pleurotus ostreatus* was found to utilize all the agricultural wastes and the substrates were suitable for spawn run, yield and biological efficiency (Das *et al.*, 2000). The large sized fruit bodies were considered to be of good quality and rated highly in mushroom production (Onyango *et al.*, 2011).

The growth of oyster mushrooms was significantly affected by the Carbon/nitrogen ratios of the substrates. Higher yield and biological efficiency were obtained from saw dust. Low yield and BE were obtained in cotton waste which had the least carbon to nitrogen ratio of (39:1). Although the ratio of carbon to nitrogen obtained in the study was significantly high, the results were supported by the research findings of Adenipekun (2006). In their study, the carbon to nitrogen ratios significantly affected growth of *P. ostreatus* and growth at 5:1 (C/N) was the best. The least mycelia growth was 21.7mg/30cm³ recorded in basal medium with C/N ratio of 1:5 which was not significantly different from the control at $p \leq 0.01$. If the ratio of carbon to nitrogen was low, then the yield was also very low and vice versa. Thus there was direct relationship between the yield of mushrooms and the carbon to nitrogen ratios in the substrates.

Conclusions

The four substrates used in the investigation had the potential to be used as alternative substrates in the production of oyster mushrooms without compromising on the yields and quality. Saw dust and cotton waste were the best substrates of choice for the mushroom farmers. Saw dust was good for faster growth rates and higher yield whereas with cotton waste it took long to reach maturity but it was good for producing mushrooms of good quality with large cap diameter and stipe length. It was recommended that further studies should be done to determine the effect of different substrates on nutritional content of the mushroom produced.

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Conflicts of Interest

The authors declare no conflict of interest.

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