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Comparative Performance of New Agronomic Technology on the Yield Potential of Groundnuts (*Arachis hypogaea* L.) under Rainfed Agriculture in Guruve District, Zimbabwe

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A B S T R A C T

The study was carried out to assess the yield performance of groundnuts grown on ridges and non-ridges by communal farmers of ward 8 in the Guruve district of Mashonaland Central province, Zimbabwe. Interviews, surveys, questionnaires, and observation methods were used for data collection. A sample of 60 respondents was selected from a list of groundnut farmers in the ward. The results showed that 43% of the respondents were growing groundnuts on ridges, while 57% of the respondents were growing groundnuts on non-ridges. No farmers used both farming practices. The results showed that more yield per hectare was obtained by farmers who used ridged farming practices than non-ridging techniques. The area planted with groundnuts varied significantly (P<0.001) with the farming practice (ridging and non-ridging) and the farming seasons. The rate of adoption of the ridging farming technology was affected by the age of the household head, level of education of the household head, sex, and age of the household head. More females participated in the growing of groundnuts than their male counterparts. In conclusion, groundnut yield was comparatively higher on ridged farming technology than on non-ridging technology; farmers are encouraged to plant groundnuts on ridges to cherish the highest production benefits. However, more training is needed for farmers to take upon new farming technology and regard groundnuts as a cash crop rather than a women's crop as well as to improve the household income.

INTRODUCTION

Groundnuts (*Arachis hypogaea* L.) is a popular source of food throughout the world. In Zimbabwe, groundnuts are consumed as confectionary snacks, roasted, salted, or peanut butter or crushed nuts in sweets and used as groundnut oil. They can also be boiled for consumption either as shelled or unshelled nuts. Groundnuts are an economically important oilseed, feed, and food crop which

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is widely cultivated in tropical and subtropical regions of the world (Variath & Janila, 2017). Groundnuts are shelled either at the household or factory level. At the household level, shelling is done either by hand or hand-operated shelling machines to separate nuts from the shells (Ajeigbe et al., 2014). Groundnut cake and haulms (straw stems) are used as livestock feed. Groundnuts in Zimbabwe are principally grown by communal and resettlement farmers as a cash crop in Natural farming regions 2 to 3 under dryland conditions. The principal growers of groundnuts are smallholder farmers, and in this farming sector, the crop is predominantly considered a woman's crop (Tsusaka et al., 2016). The crop takes about 4 to 6 months to grow, depending on the variety and the region it is planted on. Groundnuts are also grown in regions 4 and 5 under the irrigation scheme. In Zimbabwe, smallholder groundnut growers are estimated to be above 1.5 million, and commercial groundnut producers are estimated to be below ten thousand farmers (Tsusaka et al., 2016).

Groundnut is grown on 26.4 million hectares worldwide, with a total production of 38.2 million metric tonnes (Gutu et al., 2019). All parts of the plant can be used for various purposes. In many developing countries, groundnuts are the principal source of digestible protein (25 to 34 %), cooking oil (44 to 56 %), and vitamins like thiamine, riboflavin, and niacin (Naidu et al., 1999; Singh et al., 2021). Groundnut is a high-value crop that can be marketed with little processing; however, it is extremely versatile and can be used in a wide range of products. Groundnut is used to make oils, and it is the second largest source of vegetable oils next to soybeans (Ayoola et al., 2012). The oil can be used for cooking, as a base for confectioneries, and to make peanut butter. According to Nagaraj (2009), processed groundnut is used in diversified ways, including groundnut butter which is used as spread for bread or biscuits, in cookies, sandwiches, candies, and frostings or icings. It is a good source of calcium, iron, and vitamins. Groundnuts are also a significant source of cash income in developing countries that contribute significantly to food security and poverty alleviation (Odendo et al., 2011). As a legume, groundnuts help improve soil fertility by fixing nitrogen in the soil, thereby increasing the productivity of the semi-arid cereal cropping systems (Okello et al., 2013).

Tulole et al. (2008) reveal that the groundnuts yield in Africa is relatively lower (980 kg ha^{-1}) than the average world groundnuts yield (1200 kg ha^{-1}). Lower yields are attributed to abiotic, biotic, farming systems and socio-economic factors (Majola et al., 2021; Tulole et al., 2008). In warm climates, grains are easily infected with toxigenic microorganisms. The most known contaminators of groundnuts are aflatoxins, which are metabolic by-products of the moulds of different *Aspergillus* species (Mwakinyali et al., 2019; Singh et al., 2021). Aflatoxin is a major problem in many tropical countries, including Zimbabwe. The moulds are common saprophytic fungi found in seeds and soils throughout the major groundnut-producing areas of the world (Naidu et al., 1999). The export market of groundnuts from Zimbabwe collapsed mainly due to the reduced groundnuts production by farmers, low farmer support, poor pricing, and high levels of aflatoxin contamination which also led to subsequent increase in imports of groundnuts by the processing companies (Chakoma & Chummun, 2019; Variath & Janila, 2017).

Contamination of groundnuts with fungi and aflatoxin endangers the health of humans and animals and lowers the market value (Elseed, 2014). Humans are primarily exposed to aflatoxins through the dietary intake (Leong et al., 2012). However, there is some evidence for the association of aflatoxin contamination with Reye's syndrome, Kwashiorkor, and acute hepatitis (Chakoma & Chummun, 2019). More recently, aflatoxin exposure early in life has been associated with impaired growth, particularly stunted growth (Elseed, 2014). Thus, aflatoxin contamination is a problem for farmers as well as consumers. However, the most significant contamination usually occurs prior to harvesting during periods of stress in late-seasoned droughts when groundnuts are fully developing (Elseed, 2014).

In southern Africa, groundnuts production is characterized by low productivity, low-input use, and limited access to markets (Majola et al., 2021), and in developed countries, groundnut yield has been increasing through the development, dissemination and efficient use of technology coupled with improved varieties whose yield range from 2.8 to 6.1 tonnes per hectare (Usman et al., 2013). In Africa, groundnut yields on flat ground are as low as 0.5 to 1.0 tonnes per hectare, implying depressed output; hence the considerable need for varying planting methods. Little attention has been recorded on the yield performance of groundnuts grown on ridges and non-ridges in Zimbabwe. The objective of this study was, therefore, to assess the yields obtained from groundnuts grown on ridges and non-ridges from both the planting methods. The study aims to equip smallholder groundnut farmers with knowledge for the best farming practices to improve crop yield.

MATERIALS AND METHODS

Site description

This study was carried out in Guruve district (30° 35ˈE 16° 20ˈS, altitude), in ward 8 (Shayabvudzi) in Mashonaland Central Province, Zimbabwe. The ward is located closer to the Guruve growth point, about 15km southeast along Guruve-Mvurwi road. Ward 8 was selected for the study because it produces higher groundnuts in the Guruve district. The district falls in Agroecological region IIb and receives an annual rainfall ranging from 650mm to 800mm, with temperatures ranging from 18-30°C in summer (Central Statistical Office, 1999). The area is characterized by sandy loam soils, with some parts of the district having deep red soils. The soils are ideal for maize, groundnuts, cotton, soya beans, horticulture, and livestock ranching. Rainfall is somewhat less reliable, particularly at its onset.

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Research design

The survey type of research was carried out in this study. The study triangulated both quantitative and qualitative research techniques. Qualitative methods used in the study included: focus group discussion, key informant interviews, and observation. On the other hand, a survey and documentary review were used to gather quantitative information. The survey was conducted during the two farming seasons (2018/19 and 2019/20). The respondents were met at their homesteads and were voluntarily participating in the study.

Sampling techniques

A sample size of 60 farmers was selected (heads of the household) from a sampling frame of 1160 groundnut farmers as supplied by AGRITEX officers of the ward. Records from Agricultural extension officers provided for a number of groundnut farmers. Myers et al. (2013) define a sample as a portion of the overall population that one wishes to study. The sampling procedure adopted a combination of different approaches, including multistage, simple random sampling (SRS), and purposive sampling. Multistage sampling was used to identify areas of the survey, that is, wards and villages. A stratified sampling technique was applied to get groundnut growers on ridges and non-ridges. A simple random sampling of farmers who grow groundnuts on ridges and non-ridges was done.

Data collection

Primary data was collected from participating farmers, such as demographic characteristics, acreage, sources of inputs, crops grown in the area, the yield obtained, and challenges faced in groundnut production. Primary data were collected using the survey method.

Data Analysis Techniques

The data was analyzed using Statistical Package for Social Science (SPSS) computer software. The collected data from interviews were presented in an expository form. Statistics in the form of tables and graphs were used to present the collected data. Comprehensive explanatory titles were given, showing headings of tables and figures.

RESULTS AND DISCUSSION

Gender and groundnuts production in Guruve District

Results from the study show that 30% of the respondents were males and 70% were females (Table 1a). It was observed that 80% of the respondents were married. The results of this study are in agreement with a study by Tsusaka et al. (2016), who observed that groundnut production is taken as a female or women's crop since more females are seen to be active in its production. This also suggests that women participate more in the growing of groundnuts than men. This may be due to the fact that men participate more in bigger crops with more value (maize, tobacco, and soya beans, among others). A study by Motamed & Singh (2003) suggests that gender-linked differences in the adoption of a technology result from differences in access to information. This suggests that females have better access to information than males. This may be due to the active participation of females in different agricultural programs like attending farmer training by extension agents (AGRITEX/NGOs), farming demonstrations and attending field schools.

Educational levels and groundnuts production in Guruve District

Table 1b shows that 55 % of the respondents were educated up to the primary school level, 20% to the secondary school level, 10% to the tertiary level, and 15% had not attended any schooling. The minimum level of education for these households was primary, while the highest level attained by some household heads was up to tertiary education. The farmer's education was included in this study to examine the adoption rate of the new technology in the growing of groundnuts. Education showed a positive and significant relationship with the adoption level of the farmers. Mwangi & Kariuki (2015) hypothesized that farmers with low levels of education are usually slow or non-adopters of new technology. Paustian & Theuvsen (2017) reported that the higher the level of education a farmer has, the higher the adoption rate. A farmer with a higher level of education becomes more change prone and looks into the innovative practices to be adopted at the farm level (Mwangi & Kariuki, 2015).

Farming experiences of the respondents in Guruve District

About 40% of the respondents had between 11-15 years of groundnuts farming experience, while 25% had 16-20 years of farming experience, 15% had 6-10 years of farming experience, 10% had 1-5 years of farming experience, and 10% had more than 21 years of groundnuts farming experience (Table 1c). The study coincides with Collier & Dercon (2014) results, who reported that farmers with vast years of farming experience are better equipped with knowledge and skills to improve crop production and groundnut quality. According to Motamed & Singh (2003), farming experience helps an individual to think in a better way and makes a person more mature in making decisions. Farming experience shows a positive and significant relationship with the adoption of technology, like the use of ridging farming practices to grow groundnuts.

Table 1. Gender, educational level, and farming experiences of the respondents (n = 60).

Variable	Percent
1a. Gender	
Male	30
Female	70
1b. Educational level	
No schooling	15
Primary level	55
Secondary level	20
Tertiary level	10
1c. Farming experiences (years)	
1 – 5	10
6 – 10	15
11 – 15	40
16 – 20	25
Over 21	10

The age of farmers and the farming method used in the growing groundnuts

About 43.3% of the respondents (including 10% males and 33.3% females) were using ridging farming practices, whilst 56.7% were using non-ridging or flat ground farming practices (including 18.3% males and 38.3% females), and no farmer used both methods. About 84% of the farmers who had adopted the on-ridging growing of groundnuts are between 31-40 and 41-50 years (Table 2). These age groups are also very active in farming activities in rural communities. Motamed & Singh (2003) postulated that the age of the main decision maker within a household might positively or negatively affect technology adoption in any farming program. The results indicated that farmers aged above 50 years are unmoved by new farming practices and tend to stick to their old ways of growing groundnuts (that is, on flat ground). The old aged people may adopt new technology after seeing someone doing it with some attached positive benefits (Mwebaze & Mugisha, 2011). This may be attributed to poor access to information than young farmers who often attend some meetings, training, and visual learning tours and have access to social media platforms. This is supported by Addai et al. (2021), who indicated that senior farmers are late adopters of the world of technology compared to their younger compatriots. This indication tends to differ with Siemens & Tittenberger (2009), who noted that young people are fast learners and adopters of technological innovation.

Table 2. The age of farmers and farming practices used by the respondents (n = 60).

Age of farmers (years)	Farming practice used (%)		Overall %
	Ridging	Non-ridging	
20-30	3.3	1.7	5.0
31-40	16.3	6.7	23.0
41-50	20.0	35.0	55.0
Above 50	3.7	13.3	17.0
Overall %	43.3	56.7	100.0

Contribution of different crops to household income in Guruve District

Results from the study show that maize largely contributes (67%) to household income, followed by soya beans (62%), tobacco (58%), groundnuts (55%), horticulture (52%), sugar beans (47%) and cotton contributing to 44% (Table 3). All of the respondents indicated that their major crops were maize, tobacco, soya beans, cotton, sugar beans, horticulture, and groundnuts. Maize is a staple food for Zimbabweans, and groundnuts and other cash crops increase household income for the family. Katema et al. (2017) also reported that edible oilseed crops comprising of soya bean, groundnut, and sunflower had experienced growth in recent years, although yields have been relatively low. According to the Zimbabwe comprehensive agricultural policy framework (2012-2032), groundnuts have been the second major food security crop in rural areas, following maize.

Table 3. Major cash crops grown by the respondents in Guruve district (n = 60).

Type of crop	Percent (%)
Maize	67
Tobacco	58
Cotton	44
Soya beans	62
Groundnuts	55
Sugar beans	47
Horticulture	52

Access to information by groundnuts farmers

The result of the study shows that farmers get information on the growing of groundnuts from different sources. Figure 1 shows that 50% of the respondents get information from Agricultural technical and extension services, while 30% from Non-governmental organizations (NGOs)/private sector and 20 % from farmer-to-farmer activities, that is, they learn from other farmers through demonstrations. Farmers can adopt new technology at different times due to different behaviors, preferences, and access to information. Pannell et al. (2006) reported that some farmers might want to learn from other farmers before they venture into any new farming practice (late adopters). Some farmers are risk takers and adopt so fast without any fear (early adopters), while some farmers are laggards and do not change or adopt the new technology. Factors limiting the adoption of technology include the conservative old age of the farmer, sex, level of education, weak beliefs, low family income, lack of or poor access to information, and farmer behaviour (Motamed & Singh, 2003; Siemens & Tittenberger, 2009). Addai et al. (2021) reported that the extent of adoption adjustment or rejection depends on the farmer's behaviour. Adoption of innovation is the process by which a particular farmer is exposed to, considers, and finally rejects or practices a particular innovation (Chi & Yamada, 2002).

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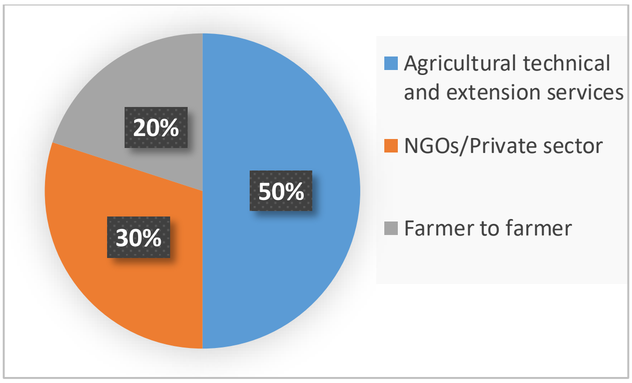

Figure 1. Agents for the provision of extension services to groundnut farmers in Guruve District.

Groundnuts grow on ridges and non-ridges in Guruve District

Results from the study show that the groundnut yield was relatively higher on ridges than on non-ridges. For an area of below 0.2 hectares planted, the mean yield for the ridge-planted groundnuts increased by 0.05 tonnes in the 2019/20 farming season, while a decrease of 0.05 tonnes was observed on non-ridges (Table 4). Similarly, an increase in groundnut yield for the below 0.2ha of area planted between the on-ridging and non-ridging in the 2018/19 farming season could be attributed to the addition of organic manure on the non-ridged cropping field. The mean groundnuts yield from an area between 0.2 - 0.5 increased by 0.15tonnes from the 2018/19 to 2019/20 farming season for on-ridged grown groundnuts, while 0.15 tonnes yield increase was observed for non-ridged grown groundnuts during the same time period. A similar observation of relatively higher marked yield on-ridged grown groundnuts (0.3 tonnes) was observed for more than 0.5ha of land planted with groundnuts between the 2018/19 and 2019/20 farming seasons. Though a notable yield increase was observed for non-ridged grown groundnuts on more than 0.5ha area of land planted between the two farming seasons, the yields were favourably lower than that of ridged-grown groundnuts. Table 4 below shows that yields were comparatively higher for ridged-grown groundnuts than non-ridged-grown groundnuts. The differences in the yield may be due to good root penetration and good pegging of groundnuts, and loose soils, which improves drainage and aeration of the soil for groundnuts grown on ridges. This agrees with Haile & Keith (2017), who mentions that ridges are recommended if water logging is a problem. This also concurs with findings by Kugedera et al. (2020), who reported that tied ridges significantly affect maize yield in dry regions of Zimbabwe. The highest groundnuts yield was recorded on more than 0.5ha area planted with on-ridged groundnuts (1.0tons) in the 2019/20 farming season, whilst the least groundnuts yield on-ridged grown groundnuts was recorded on below 0.2ha area planted in 2018/19 farming season (Table 4).

Results from the study reveal that greater yields were obtained from groundnuts grown on the ridges than on non-ridges for the two consecutive farming seasons. In a study conducted by Sujatha (1992) on the response of groundnut grain yields when grown on raised ridges, the oxygen content at varying soil depths on ridges and flat ground treatments differed slightly. They observed that the oxygen content mentioned in the above depths was slightly higher on ridges than on flat ground throughout the cropping season. Air-filled pores in the upper 15 cm layer of ridges were found to be significantly higher than for the flat system during wet spells (Subrahmaniyan et al., 2006).

This study's results show a significant (P<0.001) difference in the area planted, ridging and non-ridging, and the farming seasons. This concurs with a study by Caliskan et al. (2008), who found that planting groundnuts on the ridges gave higher pod yield than those grown on flat ground. Probably, due to higher bulk densities in flat ground, the pod yields were less than on ridges as a result of unfavourable conditions for peg penetration, pod setting, and development in the surface soil layers of flat seed beds. Mvumi et al. (2018) found higher groundnut yields on ridges than on flat-ground farming practices. These variations could be attributed to various factors. Ridges increase the total infiltration and depression storage and thus slow down the flow velocity of surface runoff, increasing moisture retention. Mvumi et al. (2018) indicated that the ridges result in uniform rainwater recharge of the profile and increased moisture for extended periods. Ridges, therefore, appear to overcome drought effects due to dry spells during the rainy season, and they thus increase the extractable soil moisture even from the deeper layers. Dapaah et al. (2014) revealed that growing crops on ridges helps promote root penetration, moisture retention, crop growth, and yield.

Table 4. Area planted and mean groundnut yield produced during the 2018/19 and 2019/20 farming seasons (n=60).

Area Planted with Groundnuts (hectares)	Mean Groundnuts Yield (t/ha) Farming Seasons			
	2018/19		2019/20	
	On ridges	Non-ridges	On ridges	Non-ridges
Below 0.2	0.3	0.35	0.35	0.3
0.2-0.5	0.45	0.35	0.6	0.5
More than 0.5	0.7	0.65	1.0	0.75
SEM	0.121	0.128	0.101	0.116
P-value	<0.001	<0.001	<0.001	<0.001

Challenges faced by groundnuts farmers in Guruve District

Most respondents cited erratic rainfall as the biggest challenge (60%), with 44% of them coming from non-ridging farming practices and 16 % from on-the-ridge farming practices (Table 5). The problem of aflatoxin, cited by 57% of the farmers interviewed, came in as the second most disturbing challenge faced by farmers, with a greater percentage coming from non-ridging farming practices (50.3 %). Table 5 shows that 46% of the farmers cited inadequate inputs and labor as the third challenge in growing groundnuts. Limited access to information was cited as a problem by 44% of the farmers, with 25% under ridging farming practices and 19% from non-ridging farming practices. Rodents and birds were a challenge to 40% of the farmers, with a greater percentage coming from non-ridging farming practices. Soil capping was

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considered to be a problem by 38% of the farmers. According to Barbier (2000), the non-ridging farming practice has less labour, cost, and time required to complete planting, although there is a problem of diseases, poor drainage, and soil capping resulting in challenges during digging or pulling out the peanuts. Caliskan et al. (2008) revealed that growing groundnuts on ridges help improve drainage and reduce the incidents of waterlogging, which results in lower incidents of aflatoxin and diseases. Ridges increase the total infiltration more than non-ridges. On the flat ground or non-ridges, there is poor drainage which promotes disease development resulting in poor-quality of groundnuts. Many legumes are sensitive to water logging including groundnuts and growing on ridges help avert this problem.

This study also concurs with a study by Katema et al. (2017), who indicated that inadequate labour, aflatoxin, and poor extension services were the reported challenges in groundnut production in Chegutu District, Zimbabwe. Erratic rainfall and limited access to information may drastically affect groundnut yield. Poor rainfall and soil crusting are common problems in Sub-Saharan soils, and this may negatively affect crop yield due to problems in water storage and root penetration (Bationo et al., 2008). This can be corrected by adding organic matter and varying ploughing depths in crop fields. Pests, including rodents, birds, bucks, and worms, can adversely affect groundnut yield by eating the nuts before they are harvested (Ajeigbe et al., 2014). Rodents even go to the extent of eating the harvested and stored output if the storage facilities are prone to bite. The use of integrated pest management practices, baits, and traps is the most important way of reducing crop damage by birds and rodents (Ajeigbe et al., 2014; Bonabana-Wabbi, 2002). The use of reflectors and hanging ragged clothing in crop fields can drive away birds.

Table 5. Challenges faced by farmers in the production of groundnuts with respect to two farming methods (n = 60).

The challenge faced by farmers	Farming method (%)		Overall %
	Ridging	Non-ridging	
Erratic rainfall	16	44	60
Aflatoxin	6.7	50.3	57
Inadequate inputs and labour	20	26	46
Limited access to information	25	19	44
Rodents and birds	13	27	40
Soil capping	0	38	38

Ways of improving groundnuts production in Guruve District

About 90 % of the interviewed farmers indicated that they sell their groundnuts to the local markets like other farmers. Groundnut production can be improved through the use of certified seeds, good market prices, the use of new technology in planting groundnuts, and also the availability of groundnut markets (Haile & Keith, 2017). They also indicated that they still need more training about the growing of groundnuts to help with the improvement of both the yield and quality of the groundnuts.

CONCLUSIONS

The study concluded planting groundnuts on ridges showed higher yields than on non-ridges. An improvement in groundnut yield was observed between the two farming seasons (2018/19 and 2019/20). Growing groundnuts on ridges ensure that there is good drainage which promotes groundnut quality than on non-ridged farming practice. Growing groundnuts on ridges also ensure that there is a reduction in aflatoxin. Farmers are still adopting the groundnut ridging farming practice as a new technology that the AGRITEX department is promoting. The adoption rate of the ridging farming technology by farmers can be affected by the age of the household, level of education, sex, and also access to information. The results also showed that more females participated in the growing of groundnuts than males. Farmers are faced with many challenges in groundnut production, including erratic rainfall, limited labour, poor access to information, pests, and soil capping. However, there is a need for further studies on market response to different agronomic technologies from communal areas and the impact of post-harvesting techniques on groundnut quality.

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