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THEME:

"Advancing food systems resilience through climate smart agriculture, innovation, agroprocessing, ecosystem based and locally led adaptation actions."

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Theme 1: Food and Nutritional Security

1.1 An assessment of factors affecting production and profitability of small-scale pig farmers in the selected areas of the Khomas and Hardap regions, Namibia

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Introduction

In several nations in sub-Saharan Africa, famine and malnourishment are prevalent as a result of a shortage of animal protein by a significant proportion of the rural population(Ajala & Adesehinwa, 2007). Pig farming is a significant enterprise that provides opportunities as an income-generating activity for small-scale farmers, particularly in developing countries (Karimuribo *et al*., 2014).

According to Ume *et al.,* (2020) pig production is amongst one of the fastest means of increasing animal protein to battle animal protein shortage in the human diets of the majority of people in rural areas of developing nations. This could be because of inherent features possessed by pigs such as; their adaptive characteristics to survive in situations where other domestic animals fail to thrive, they are good utilizers of domestic waste, pigs give birth to a high number of piglets per sow, pigs are more efficient carcass yielders than cattle, sheep and goat, compared to the 52.5% dressing percentage of cattle and 50% dressing percentage of goats and sheep, pigs have a high dressing percentage of about 70% and an efficient conversion of fodder energy to body energy (Osondu *et al.,* 2014,).

According to Petrus *et al.,* (2011) the Namibian Pig production industry has enormous growth potential. Apart from protein, pork is high in animal fat, a commodity with numerous applications. Furthermore, pigs can be grown together with other livestock in harmony through integrated farming practices (Petrus *et al.,* 2011).

Pigs found primarily in rural regions are known variously as native, scavenging, indigenous, and local or village pigs. These labels are used to differentiate them from more exotic varieties raised in intense commercial production systems (Petrus *et al.*, 2011) They are also more resistant to common infections and parasites. Furthermore, as compared to exotic breeds, native breeds can tolerate long periods of feed and water restriction (Drucker & Anderson, 2004). Native pigs are typically robust and capable of reproduction and survival on low levels of nutrition (Adjei *et al.*, 2015).

Method

The study was conducted in selected areas of Khomas and Hardap regions in Namibia, focusing on Groot Aub, Daan Viljoen, Duineveld, Tsumis, and selected areas of Rehoboth. The Khomas region, with a population of 480,136, is characterized by major commercial farms, former Baster Administration lands, and small holdings. Windhoek, the capital, is a key national manufacturing center. The Hardap region, with 80,000 inhabitants, is known as an agricultural hub, hosting the Hardap dam.

The research used a survey research design, employing a snowball sampling technique with a sample size of 60 small-scale pig farmers. Data were collected through face-to-face interviews using a structured questionnaire. The analysis utilized both quantitative and qualitative methods, employing descriptive and inferential statistics. The study aimed to understand the socio-economic characteristics, production challenges, marketing practices, and profitability of small-scale pig farmers in the selected areas.

Objective one involved analyzing socio-economic characteristics influencing production and profitability using descriptive statistics. Objective two employed multiple linear regression analysis to identify factors affecting production. Objective three used descriptive statistics to identify production challenges. Objective four employed descriptive statistics to describe marketing channels, primary products sold, quantity, quality, and constraints faced. Objective five utilized a multiple regression model to analyze factors influencing the profitability of small-scale pig farmers in the study area.

Results

The study found that majority of the small-scale pig farmers were male (71.7%) and the minority female (28.3%). The majority of individuals in this population are aged between 40 to 50 years, with significant representation in the 51-61 age range as well. Married individuals make up the largest marital group, while secondary education attainment is prevalent, followed closely by tertiary degrees. Employment stands as the primary source of income for a third of the population, complemented by diverse contributions from livestock sales, with goat farming notably prominent. Almost half of the population earns more than 10000 monthly. Household sizes predominantly consist of five or more members, reflecting larger family structures.

The study found that the factors that affect the production of small-scale pig farmers are presented in (Table 4). The results show that gender, marital status and level of education amongst all factors had a significant effect on the production of small-scale pig farmers. While the registration status and farming system were not significant. All significant variables were tested at a p-value of <5%.

The study found that the primary production challenges pig farmers are experiencing were feed shortages, diseases, and infrastructural challenges, while the marketing challenges were poor market infrastructure, low market prices, and a lack of demands. The findings revealed that the primary marketing channel used was directly selling products to consumers.

The study also found that gender, marital status and level of education amongst all factors had a significant effect on the production of small-scale pig farmers, while gender, marital status and level of education amongst all factors had a significant effect on the profitability of small-scale pig farmers. All significant variables were tested at a p-value of <5%.

Conclusion

In conclusion, the study provides valuable insights into the demographic characteristics, production factors, challenges, and profitability of small-scale pig farmers. The majority of these farmers are male, aged between 40 to 50 years, and married, with a notable representation in the 51-61 age range. Education levels are generally moderate, with a prevalence of secondary education. Employment is the primary source of income, supplemented by livestock sales, particularly in goat farming.

The study identifies gender, marital status, and education as significant factors influencing both production and profitability, with non-significant impacts observed for registration status and farming systems. The primary production challenges include feed shortages, diseases, and infrastructural issues, while marketing challenges involve poor market infrastructure, low prices, and a lack of demand. The predominant marketing channel is direct selling to consumers.

These findings emphasize the importance of addressing gender, marital, and educational disparities to enhance the overall productivity and profitability of small-scale pig farming. Additionally, tackling key challenges such as feed shortages and marketing obstacles is crucial for the sustainability of this sector.

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1.2 COVID-19 impact on income and food security of households participating in Urban agriculture in the informal settlements of Windhoek, Namibia

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Introduction

Food insecurity and insufficient household income are amongst the major challenges faced by inhabitants of informal settlements globally. Food supply can be jeopardised by natural disasters, such as pandemics, leading to disruptions in food distribution (Agamile, 2022). Urban agriculture (AU), defined as all forms of agricultural production (food and non- food) occurring within or around cities (Lal, 2020), is essential in building a resilient urban food system that can withstand and recover from disruptions and hence provide a reliable source of food (Yoshida & Yagi, 2021). However, the covid-19 pandemic has disrupted the operations of urban agriculture, which has led to food insecurity and income loss for many urban farmers (Lal, 2020). Informal settlements are particularly vulnerable to the impacts of the pandemic due to their poor living conditions and lack of access to resources. The study therefore sought to determine the impact COVID 19 had on income and food security of households involved in urban agriculture in the informal settlements of Windhoek.

Method

The study was carried out in informal settlements of Windhoek City, Khomas Region in two constituencies of Samora Machel and Tobias Hainyeko which were purposively selected using stratified two-stage probability sampling design within each constituency to select the study sites and sample respondents. Yamane (1967) sample size calculation formula was used to determine the sample size. A total of 59 households interviewed using a structured questionnaire with both open- and closed-ended questions. Descriptive statistics, logistical regression, the Household Food Insecurity Access Scale (HFIAS) and multinomial regression analysis in JAMOVI statistical software, were used to analyse the data.

Results

All households that participated in the study were engaged in UA with 60.4% being male- and 39.6% female-headed households. Most AU farmers in the selected constituencies (67.3%) experienced a reduction in household income during the pandemic. Households who earned >N$4000 per month decreased by 7.3% while those who earned <N$1000 increased by 8%, post covid period. Reduction in income was attributed to loss of closure of open markets (37.6%) as well as loss of employment (32.6%). The study further found that 71.2% of the participants were food insecure, and (28.2%) were food secure during the pandemic. Of the food insecure, 50.8% were severely food insecure, while 19,4% were mildly moderately food insecure. AU farmers who engaged in family-owned businesses were relatively food secure (24.1%), while those who had no own businesses (36.2%) were significantly food insecure.

Table 1: Association of income and food security before, during and post Covid-19

Variable	Characteristic	Food secure	Mildly food insecure	Moderately food secure	Severely food insecure	Total	χ² - value	df	p-value
HH Income Pre-Covid	1001-2000	4(6.9)	1(1.7)	0(0.0)	8(13.8)	13(22.4)	14.6	12	0.265
	2001-3000	3(5.2)	0(0.0)	1(1.7)	3(5.2)	7(12.1)			
	3001-4000	5(8.6)	0(0.0)	0(0.0)	2(3.4)	7(12.1)			
	<1000	2(3.4)	4(6.9)	2(3.4)	8(13.8)	16(27.6)			
	>4000	3(5.2)	3(5.2)	1(1.7)	8(13.8)	15(25.9)			
HH income during Covid	No change in income	2(3.4)	1(1.7)	1(1.7)	7(12.1)	11(19)	11.6	12	0.477
	income ceased	0(0.0)	1(1.7)	1(1.7)	3(5.2)	5(8.6)			
	income decreased	11(19)	3(5.2)	1(1.7)	12(20.7)	27(46.6)			
	income decreased slightly	3(5.2)	3(5.2)	0(0.0)	6(10.3)	12(20.7)			
	income increased	1(1.7)	0(0.0)	1(1.7)	1(1.7)	3(5.2)			
HH Income Post-Covid	1001-2000	5(8.5)	3(5.1)	0(0.0)	7(11.9)	15(25.4)	10.4	12	0.578
	2001-3000	2(3.4)	0(0.0)	1(1.7)	2(3.4)	5(8.5)			
	3001-4000	4(6.8)	1(1.7)	0(0.0)	2(3.4)	7(11.9)			
	<1000	3(5.1)	2(3.4)	2(3.4)	14(23.7)	21(35.6)			
	>4000	3(5.1)	2(3.4)	1(1.7)	5(8.5)	11(18.6)			

Conclusion

The results suggest that COVID 19 impacted income and food security of urban agriculture households in the informal settlements of Windhoek. COVID 19 measures implemented to curb spread of COVID 19 had negative impacts on many households as majority lost sources of livelihoods including employment and income. There is therefore a need to improve urban planning to cater for urban agriculture as majority of households turned to urban agriculture for sustenance after losing jobs during Covid 19.

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1.3 Enhancing Food Security and Nutrition through Innovative Value Addition of Agricultural Products: A Case Study of Vegetable Drying in Okapundja Village, Kunene Region.

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Introduction:

This study aims to investigate the effectiveness of shade drying as a sustainable method to enhance the shelf life and retain the nutritional value of various vegetables produced by a community member garden in Okapundja, Kunene region. However, Johnson, M., et al. (2018), stated that vegetable drying is a common practice for food preservation, but traditional methods such as sun drying can lead to nutrient losses and may not be feasible in all regions. According to Smith, J. (2021), shade drying offers a potential solution to these challenges, as it provides a controlled environment that minimizes nutrient loss while extending the shelf life of vegetables. By exploring the benefits of shade drying, this research aims to contribute to developing sustainable post-harvest techniques in agriculture.

Method:

The research employed a comprehensive approach known as the Post-harvest Vegetable Preservation Study. The study collected vegetables, including spinach, cabbage, tomato, green pepper, and spring onion, at their peak freshness from local farms. These vegetables were then exposed to shade drying under controlled conditions. According to Jones, L., et al. (2019), drying involves placing the vegetables in a shaded area with good airflow to facilitate moisture removal while minimizing nutrient loss. Throughout the drying process, quantitative data was collected by monitoring changes in moisture content, shelf-life extension, and nutrient retention (Johnson, M., et al. 2018).

Results:

The study found that shade drying effectively extended the shelf life of vegetables compared to traditional drying methods. The drying process significantly reduced moisture content, resulting in a longer shelf life and reduced post-harvest losses.

Table 1. Quantitative Data for Shade-Dried Vegetables:

Vegetable	Moisture Content Before Drying (%)	Moisture Content After Drying (%)	Shelf-Life Extension (days)	Nutrient Retention (%)
Spinach	90	5	7	n/a
Cabbage	92	6	10	n/a
Tomato	95	8	5	n/a
Green Pepper	88	4	8	n/a
Spring Onion	93	7	6	n/a

Sensory evaluations were also conducted to assess the acceptability of the shade-dried products. Table 1 provides essential quantitative data on the effectiveness of shade drying as a method for enhancing the shelf life and preserving vegetables' quality, expressed in percentages. It reveals a significant reduction in moisture content after shade drying, contributing to extended shelf life, with different vegetables showing varying degrees of extension. For instance, tomato moisture content decreased from 95% to 8%, indicating an 87% reduction. While specific nutrient retention percentages are not provided in the table, the results underscore the potential benefits of shade drying in reducing post-harvest losses and enhancing the preservation of vegetables.

Table 2. Sensory Evaluation of Shade-Dried Vegetables:

Vegetable	Taste (1-10)	Texture (1-10)	Overall Quality (1-10)
Spinach	8	9	8
Cabbage	7	8	7
Tomato	9	7	8
Green Pepper	8	9	8
Spring Onion	7	8	7

Table 2 provides sensory evaluation ratings, expressed on a scale of 1 to 10, for the taste, texture, and overall quality of shade-dried vegetables. The results show that consumers found the shade-dried vegetables generally acceptable regarding sensory attributes. For instance, spinach received taste, texture, and overall quality ratings of 8, 9, and 8, respectively. Cabbage, tomato, green pepper, and spring onion also received favourable ratings, indicating that consumers found these shade-dried vegetables to be satisfactory in taste, texture, and overall quality. According to Martinez, C., et al. (2016), the sensory evaluations suggest that shade-dried vegetables are likely to meet consumer preferences and expectations, essential for marketability and consumer adoption.

Sensory evaluations indicated that consumers found the shade-dried vegetables acceptable in terms of taste, texture, and overall quality, demonstrating the potential marketability of these products (Thompson, S., et al. 2017).

Conclusion:

The research concludes that shade drying is a sustainable and innovative value-adding technique that can improve the shelf life and preserve the nutritional value of vegetables. Shade drying contributes to food security and economic sustainability by reducing post-harvest losses and maintaining nutritional quality. This technique can be particularly beneficial in resource-constrained areas where traditional drying methods may not be feasible. The study suggests that adopting shade drying in agriculture can promote food preservation, nutrition, and economic sustainability.

Further research is recommended to explore the application of shade drying to other vegetables and to optimize the drying process for maximum efficiency.

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1.4 Managing animal feed from available vegetation and crop residues while improving food security and generating income

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Introduction

The management and availability of affordable livestock feed in Namibia, especially in the North and North-western parts of Namibia is a major concern. Animal feed is essential for the survival of livestock; without proper consideration of livestock feed the farmers are likely to fail. However, it is established that livestock feeding is undoubtedly the most complex and costly practice on a farm amongst others in Namibia (Ngaruka, 2019). Most farmers in the country primarily depend on rangeland as it is freely available for the nutrition of their livestock, however, climate change has constantly destabilised the rangeland ecosystem (Coppock et al., 2022).

Most rangelands or grazing areas had their productivity potentials and values compromised by poor rainfall activities, overgrazing, and bush encroachment amongst others. The situation prompts a need for the farmers to find a solution towards livestock feed shortage due to scarcity of rain. Ngaruka (2019) suggests farm fodder production and processing at the kraal level using cheaper, user-friendly, and effective techniques should be fully explored and adopted as one possible way to lessen the impact of drought on farmers. For this reason, the study will explore the opportunity to identify suitable vegetation to produce fodder for livestock. Also, the researchers will seek advice from livestock owners, and feed producers on the relevant methods of mixing harvested grass and crop residues to mitigate climate change.

Method

This intervention project intends to explore sustainable ways to produce livestock feed from the existing vegetation surrounding the University of Namibia (UNAM) – Rundu Campus through interviews and document analysis methods. The researchers will use observation methods to identify the variety of vegetation available in order to select the most appropriate vegetation suitable for making livestock feed. Group discussions will be held with key stakeholders such as small-scale farmers and the Ministry of Agriculture, Water and Forestry (MAWF) to strengthen existing efforts to produce animal feed so the impact of climate change on livestock can be mitigated. The researchers will also analyze documents to explore ways to promote continuous, affordable, and sustainable livestock feed to ensure food security in Namibia. Discussions will also be held to establish the possibility of creating a livestock feed bank for drought relief.

Results

This envisioned project is designed in response to the United Nations sustainable development goal number two. The management of livestock feed is going to contribute to the efforts to end hunger, achieve food security and improved nutrition for livestock, and promote sustainable agriculture through the regular supply of livestock feed in dry seasons. The project intends to create employment for the unemployed Rundu residents while generating income for UNAM. Preliminary results of the project in Figure 1, indicate the current situation in Namibia and the existing vegetation from which livestock feed is intended to be produced.

Figure 1: Current situation in Northern Namibia.

At the moment, newspaper headlines (New Era) indicate that some farmers are allowing their livestock to graze on dumpsites. Meanwhile, this study displays the available vegetation around UNAM – Rundu Campus that can be turned into livestock feed.

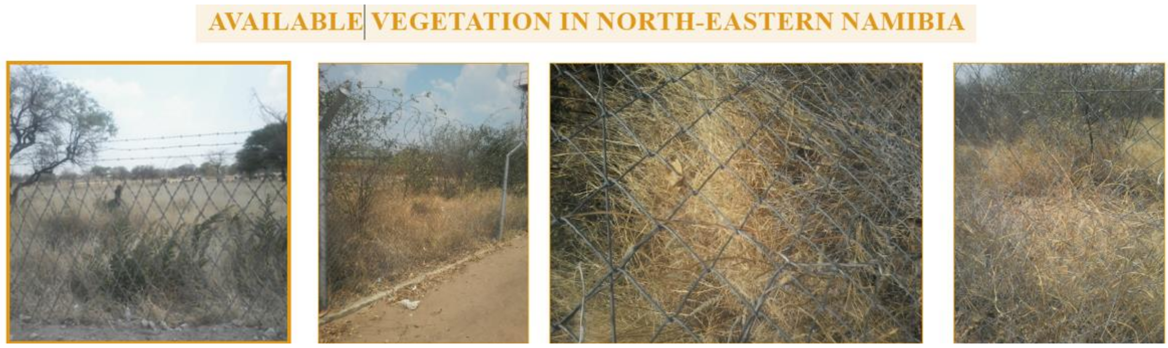

Figure 2: Available vegetation.

Conclusion

The loss of livestock due to a shortage of animal feed, caused by drought as a result of little rainfall, can be mitigated by producing livestock feed in areas where grass and other nutritious feeds are available. Thus, the outlined project implores to production of affordable livestock feed to mitigate the impact of climate change on livestock while generating income for the University of Namibia and creating employment for the unemployed residents surrounding UNAM - Rundu Campus.

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1.5 Constraints and coping strategies employed by households participating in urban agriculture during COVID-19 in the informal settlements of Windhoek, Namibia

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Introduction

Urban Agriculture (UA) is all forms of agricultural production occurring within cities and has the potential to contribute to resilient and sustainable food systems in cities (Lal, 2020). Due to its short supply chain, urban agriculture has potential to generate income and improve livelihoods amongst the poor urban people (Bisaga et al., 2019). In Namibia, UA is still taking shape although over 70% of the residents in towns practice UA in one way or the other for own consumption, and income generation (Dima et al., 2002). The global outbreak of the COVID-19 pandemic has led the governments to contain the virus by imposing stringent restrictions and implemented preventative measures to prevent further spread of COVID-19. The stringent restrictions and preventive measures taken to control the pandemic hindered the production and distribution of agricultural products as it brings out inefficiencies in these activities resulting in loss of employments and livelihoods, and constrained UA practices globally resulting in food insecurity (Workie et al., 2020; Sridhar, 2022). Considering the COVID 19 pandemic and its economic impact, it was imperative to investigate how UA activities were impacted and how the AU participants coped with COVID-19. Therefore, this study investigated the impact of COVID-19 on AU practices in the informal settlement of Windhoek, Namibia. The specific objectives of this study were to identify the constraints and to delineate coping strategies employed by households participating in urban agriculture during covid-19 in the informal settlement of Windhoek, Namibia.

Method

The study was carried out in informal settlements of Windhoek City, Khomas Region in two constituencies of Samora Machel and Tobias Hainyeko which were purposively selected using stratified two-stage probability sampling design within each constituency to select the study sites and sample respondents. Yamane (1967) sample size calculation formula was used to determine the sample size. A total of 59 households interviewed using a structured questionnaire with both open- and closed-ended questions. Descriptive statistical analyses were performed to identify constraints and coping strategies employed by urban farmers in informal settlements.

Results

All households that participated in the study were engaged in UA with 60.4% being male- and 39.6% female-headed households. Urban agricultural farmers in the selected constituencies engaged in different Agro enterprises such as horticultural crop production (67.2%), mixed urban farming (18.2%) and poultry farming 11% (Table 1).

Table 1: Urban farmer Agro enterprise

Urban farmer Agro enterprise	Counts	Percentage (%)
Horticultural crops	37	67.2%
Mixed	10	18.2%
Poultry	6	11%
Others	2	3.6%

Constraints faced by urban farmers in the informal settlement of Windhoek City during the COVID-19 pandemic are presented in Table 2. The major constrains identified were cost of accessing inputs (74.6%), inadequate land for production (61%), and unavailability of water (59%).

Table 2: Urban agriculture constraints during COVID- 19

Constraints	Descriptive Statistics Frequency	%
Inadequate land for agriculture	36	61.01
Unavailability of water	35	59.32
Cost of inputs	44	74.58
Theft	19	32.20
Forbidden by municipality by laws	10	16.95
Other constraints	19	32.20
Lack of knowledge	24	40.68
Lack of markets	26	44.07

The major copying strategies used by urban farmers during COVID-19 were increased/started production (43%), use of alternative locally available inputs and resources (22%), changed marketing strategy (11%), reduced hired labour (8%), and starting a small business (8%).

Conclusion

Covid 19 measures pushed many residents into UA as a livelihood and coping strategy after job losses and Covid 19 impacts. There is need to consider land use and infrastructure planning impact on urban food production and access for households, and to incorporate both informal and formal food systems into urban planning and policy efforts.

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1.6 Participation of smallholder livestock farmers in contract farming: A systematic review

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Introduction

Globally there are 400 million Smallholder farmers (SHFs), of which 80 million are in Africa (Ncube, 2020), characterised by vicious cycle of subsistence-oriented farming, low yields, and insufficient profits (Meemken & Bellemare, 2020). Contract Farming (CF) a pre-harvest agreement between farmers and contractors, has been largely believed to have the ability to promote the chances of smallholder farmers to participate in intensive agricultural production and lucrative markets, thereby integrating them into the latest way of doing agri-business. This paper tries to answer the following questions: what are the key drivers of smallholder livestock farmers' participation in contract farming? What are factors contributing to success or failure of smallholder livestock contract farming? What are opportunities offered by contract farming to smallholder livestock farmers? Literature shows that review studies related to CF are generally focused on crop production and poultry production (Liang et al., 2023; Agir & Akbay, 2022). Hence this study will fill the gap by focusing on livestock (cattle) production.

Methods

This study is purely qualitative in nature, making use of literature from research articles published in journals. The papers were obtained from search engines that includes SCOPUS, Agricola, Web of Science and google scholar. To find relevant papers, search keywords such as "contract farming" with "livestock and cattle" and "smallholder or small scale or communal" were combined using Boolean connectors OR & AND to form search string. A total of 2325 journal papers were obtained, CADIMA a systematic review tool was used for screening papers and selecting relevant papers for the study following the PRISMA selection criteria. Only 15 papers met the selection criteria and were used for this study.

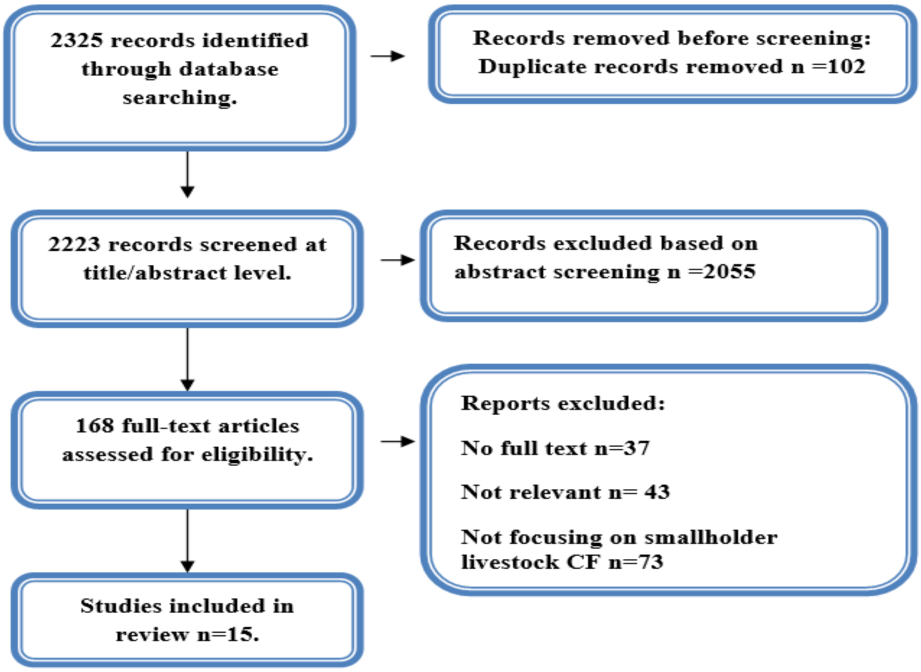

Figure1: PRISMA Flow chat identifying included and excluded studies.

Results

This review indicates that, firstly Demographic characteristics for example farmer's age, farming experience, level of education, household size (Hipersa et al. 2020; Mwambi et al., 2016). Secondly, Farm structure and farm characteristics such as farm productive assets, Number of cattle (Agir & Akbay, 2022). Lastly, Small holder attitudes towards CF such as economic incentives, financial gains, risk aversion. CF participation led to 10% increase in income (Agir & Akbay, 2022) and 14.91% (Liang et al., 2023).

Factors such as Side marketing, Breach of contract, bias towards larger farms by contractors and Gender preference contributes to failure of CF. On the other hand, Access to better market, production resources, Extension services, credit and improved technology contribute to success of CF. CF come along with opportunities such as access to high value markets, Reduced production and marketing costs, Improved technology, Reduced price fluctuation Risks and Access to credit (Andersson et al., 2015; Mwambi et al., 2016; Liang et al., 2023)

Conclusion

One of the more significant findings to emerge from this review is that contract farms have more assets than non-contract farms and they are likely to participate in contract farming. In conclusion CF, has the capacity to improve the agricultural production of smallholder livestock farmers and their incomes.

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Theme 2: Climate risks, international trade, conflicts, and food systems

2.1 Assessment of farmers' willingness to pay for weather-index crop-based insurance in Namibia: a case of Ondangwa rural constituency in Oshana region

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Introduction

Food insecurity is one of the major concerns which have an impact on the economy of many countries / many developing countries including Namibia. When a country is food self-insufficient, it implies that the country cannot produce enough food to suffice the needs of its population hence the country will then have to import more food products from foreign producers. Climate change results in a shift in domestic agricultural food production and this generally exposes smallholder farmers to natural hazards inclusive of drought, excess/ shortage rainfall & and hail (Kathiravan et al., 2019). Adverse weather events have a detrimental impact on the agriculture, livelihood, and food security of developing countries (Beillouin et al., 2020).

Therefore, this study sought to determine farmers' willingness to participate in the weather index of crop-based insurance as a risk-mitigating strategy. The second objective was to determine the influential factors which impact the insurance uptake by communal farmers and to denote the premium payment amount that smallholder farmers intend to pay, upon their willingness to participate in the insurance scheme.

Method

A survey was conducted in the Ondangwa rural constituency, whereby several 70 people were surveyed. A Simple Random Sampling Technique was used; hence this technique allows each element of a population to stand an equal chance of sampling. Data was analyzed using descriptive statistics and the Binary logistic regression model was run.

Results

Table 1: farmers' willingness to pay

Willingness to pay	Dummies	Percent
No	0	54.3%
Yes	1	45.7%

Of the farmers that were interviewed, only 45.7% showed a positive response in participating in the agricultural insurance while 54.3% of the interviewed farmers indicated not to be participating in an insurance scheme.

Table 2: Independent variables

Variables	Score	df	Sig.
Employment status	3.540	1	0.060*
Farmers' adaptability	58.809	1	<0.001***
Government subsidy	4.534	1	0.033**
Period of payment	38.235	1	<0.001***
Premium payment	44.598	1	<0.001***

Hint: P< (0.1)*, P< (0.05) **, P< (0.001) ***

The variable "Adaptability to insurance" was significant at a 0.01% confidence level depicting farmers' adaptability to agricultural insurance which signifies a need for weather-index agricultural insurance among smallholder farmers this then seems to be a strong predictor of farmers' willingness to participate in the insurance. This contradicts the findings of a study done in Nepal lowlands by Budhathoki et al. (2019)

who denoted low insurance adaptability & and uptake by farmers despite a 75% government (subsidy) contribution.

"Government subsidy" was significant at 5% and this remains a greater incentive that could encourage farmers to participate in the insurance program. Government subsidies positively impact the farmers' participation in agricultural insurance hence aligning with literature by Rippo and Ceronni (2023), which underscored the government support for insurance. Employment status was statistically significant at a 1% confidence level hence this serves as an indicator that, as more people are employed the more willing, they could be to participate in the agricultural insurance program. Age was significant with younger farmers indicating a higher participation in the agricultural insurance, this was consistent with literature which stipulated an implicit relationship between age and the insurance uptake (Kaunda & Chowa, 2022).

Gender was insignificant, this complemented literature which stipulated that gender had no significant impact on the insurance uptake (Adjabui et al., 2019). Interviewed farmers had indicated to pay an average premium amount of N$ 1807.17 respectively. Most respondents presented Mahangu as the most crop grown (staple crop) although some indicated that they practice a mixed production which includes a combination of Mahangu crops with sorghum, Beans, and Maize which is known as intercropping.

Conclusion

The hypothesized factors to impact the uptake of weather-based insurance were Employment status, Income source (farm & and non-farm income), Household income, Education level, and Government subsidy to insurance and Farming experience, which based on the analysis, statistically significant factors include Employment status, Government subsidy, non-farm income, and "Farmers' adaptation to insurance" hence these factors impact smallholder farmers' participation in the insurance scheme.

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2.2 Optimizing Cowpea Cultivation for Enhanced Yield and Climate Resilience in the North Central Regions of Namibia: A Comparative Study of Two Improved Varieties Across Different Sowing Dates

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Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is a globally important grain legume, thriving in arid and semi-arid regions due to its drought tolerance and adaptability to sandy and poor soils (Alidu, 2019; Ezeaku et al., 2015). Namibia, particularly the North-Central regions, relies on cowpea cultivation for food, forage, and soil nitrogen preservation, with a shift towards reduced dependence on expensive commercial fertilizers (Fleissner & Bagnall-Oakeley, 2001; Horn et al., 2015; Rasche et al., 2023).

Namibia has witnessed a decline in cowpea production due to issues like low yields, lack of improved seed varieties, drought stress, and pest damage (Horn et al., 2015). Studies have emphasized the importance of adopting enhanced crop varieties and precise planting dates to mitigate pest damage and boost productivity (Ezeaku et al., 2015). Optimized planting timing harnesses favourable growth factors like temperature and solar radiation for higher yields (Ichi et al., 2013).

So far, there is no local scientific data concerning the effect of sowing date on cowpea yield. Thus, this study aims to evaluate the impact of planting dates on two cowpea varieties, Nakare (IT81D-98) and Bira (IT87-453-2) and identify the best planting time for Namibia's unique conditions.

Methods

A field experiment was conducted at the UNAM Ogongo Campus from January to June, spanning two years (2018 and 2020). Soils in North-Central Namibia are characteristically sandy and deficient in essential plant nutrients. The university experiences an annual temperature exceeding 22°C in summer and colder temperatures in winter, with an average annual rainfall of approximately 400-500 mm. The experiment was organized in a split-plot design with four replications, where Nakare and Bira were cultivated in plots measuring 4 m × 3 m, with a 1 m gap between blocks. The inter-row spacing was set at 75 cm, and the intra-row spacing at 40 cm. NPK (2:3:2) fertilizer, with 360 grams per plot was applied. Sowing was done on January 1st, January 15th, February 1st, February 15th, and on March 1st. Data were collected from the inner two rows within each replicate, focusing on parameters including the number of pods per plant, days to 50% flowering, 100-seed weight, and grain yield. Data analysis was carried out using GenStat, and an Analysis of Variance (ANOVA) was performed to evaluate significant differences among the treatment means.

Results

Total rainfall during the experiment period at the Ogongo Campus was 288 mm in 2018 and 486 mm in 2020. The Analysis of Variance revealed a significant difference in the interaction effects of varieties and sowing dates on grain yield in 2018. However, in 2020, there was no interaction between variety and sowing date indicating that the effect of Bira and Nakare varieties on grain yield was consistent regardless of the sowing date.

The interaction effects of varieties and sowing dates on grain yield for the year 2018 are depicted in **Figure 1**. Bira, sown on January 1st, exhibited the highest grain yield. Grain yield for both varieties decreased as the sowing time was delayed. However, Bira experienced a slightly smaller decrease compared to Nakare, suggesting its resilience to lower rainfall.

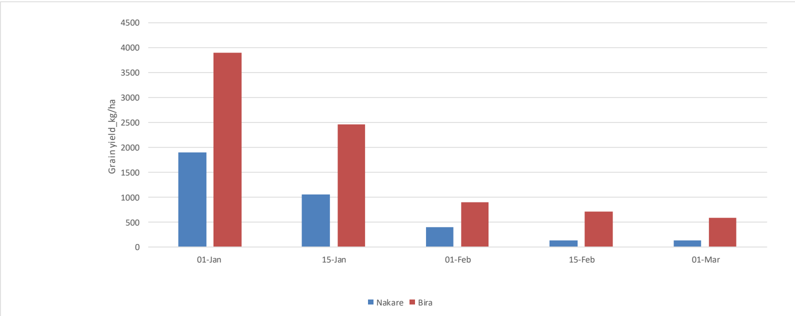

***Figure 1**: Interaction effects of sowing date and variety on grain yield for 2018.*

Conclusion

We assessed how different planting dates influenced the performance of two improved cowpea varieties, Nakare and Bira. Our findings demonstrated that early planting could boost cowpea yields and contribute to greater climate resilience, with Bira consistently outperforming Nakare throughout the planting season.

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Theme 3: Biodiversity management and utilization

3.1 Assessment of biomass yield and nutrient composition of crops and forages grown on abandoned kraals in Namibia's Eastern Zambezi Region

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Introduction

In sub-Saharan Africa, persistent food insecurity is a result of factors like soil infertility due to intensive land use and inadequate fallow periods, compounded by poor soil management and erosion. The demand for food will increase as well as the need to produce more food on declining soil fertility and globally food production must be doubled by 2050 (Hailu et al., 2015). The use of bomas/kraals to pen cattle overnight alters the ecosystem functions through the redistribution of nutrients within the terrestrial ecosystem (Haruba et al., 2022, Momberg et al., 2023). Approximately 70% of Namibia's population engages in farming, with about 23% employed in agriculture (Mushendami, 2006; Taapopi et al., 2018; Awala et al., 2019). This impacts smallholder farmers in Namibia, where agriculture is significant but national cereal production remains low, leading to a reliance on maize imports.

In Namibia's Eastern Zambezi Region, agriculture is vital for rural communities, but they face challenges such as low crop productivity, soil degradation from mono-cropping, and unreliable rainfall, resulting in low crop yields (Von Hase, 2013). Improving staple crops like maize, pearl millet, sorghum, Bambara nut, and cowpeas is crucial, as is enhancing forage production for livestock. The quality of manure depends on various factors, and kraals play a key role in this.

A research study was conducted in the Eastern Zambezi region, where communal farmers practice kraal rotation (Sibanda et al., 2016). Kraals serve as enclosures for livestock and are essential for nutrient cycling in agroecosystems. They accumulate vital nutrients like nitrogen, phosphorus, and potassium. The study aims to explore the use of indigenous kraals for crop cultivation, focusing on maize, cowpeas, buffalo grass, Lucerne, and sunflower on abandoned kraal sites, with the goal of improving soil fertility, agricultural activities, and food security in the Eastern Zambezi Region.

Method

The field trials were carried out in Namibia's Zambezi Region, in the northeastern part of the country, specifically at Isize village and the Kalimbeza farm, located about 40 km from Katima Mulilo town. This region experiences annual rainfall between 500 and 700mm, with summer temperatures of 32-35°C and moderate winter temperatures of 18-25°C. These sites were selected within the NILALEG Project landscape due to the prevalence of indigenous kraals in the communities.

Soil samples were collected at a 30cm depth before planting in October 2022, following a stratified sampling method. Soil analysis was conducted according to Okalebo et al. (2002), examining nutrients (N, P, K, Mg, Ca, S, Na, Mn, Cu, Zn, and Fe) and other parameters (pH, OC, CEC, BS, BD, and texture).

A Randomized Complete Block Design (RCBD) was used with a factorial arrangement, three replicates at each location, and different sites serving as the blocking factor. There were five treatments, each replicated six times. Each treatment consisted of 30 plots measuring 4 x 4 meters, with 1-meter spacing between plots and 2-meter spacing between blocks. The treatments included two forage legume species (Cowpeas and Lucerne), a food crop (Maize), and pasture grass (Buffalo grass). The three sites were Kraal A (constructed in 2018, used for livestock sheltering for 5 years), Kraal B (constructed in 1994, measuring 50m by 27 meters), and Kalimbeza (designated for irrigated agricultural production in 2005, measuring 50m by 23m).

Data were collected from five plants in the central two rows of each plot, measuring stem height and biomass yield per hectare to assess crop productivity. Soil composite samples were analyzed for texture at the MAWF soil laboratory in Windhoek, Namibia. Laboratory analysis of forage and crop samples is planned for 2023.

Results

Kraal A had higher soil chemical properties than Kalimbeza, while both had lower means compared to Kraal B. These differences in soil properties (pH, ECW, P, K, Ca, Mg, Na, and N) can be attributed to geographical locations. Momberg et al. (2023) found that kraaling doubled soil concentrations of C, N, P, and K, and slightly increased pH, with statistically significant differences ($p < 0.005$).

Kraal A had the highest values in multiple soil chemical properties, especially potassium. This suggests enriched soil due to various factors like local environmental conditions. Haruba et al. (2022) noted that soil nutrients decline in nutrient-enriched hotspots over time after kraal use.

In contrast, Kalimbeza had the lowest means, implying lower nutrient concentrations, possibly influenced by geological factors, soil formation processes, or land management practices.

Soil properties vary among the three locations due to geological, environmental, and land use factors. Kraal A benefits from cattle dung, enriching the soil with nutrients, and organic matter, and enhancing pH and microbial activity. Kalimbeza may have higher calcium levels due to inorganic fertilizer use, while maintaining consistent organic carbon levels, essential for soil health. Soil chemistry interpretation should consider local conditions, agricultural practices, and land management.

Soil texture analysis showed that Kalimbeza has more sand, while Kraal A and Kraal B have even more. In terms of clay content, Kraal A has the least, followed by Kraal B and Kalimbeza. Statistical values like R2, SE, and p-values confirm the data's reliability and significance. Low p-values show significant soil texture differences. These findings help understand soil variations, which are vital for agriculture and land use planning.

Conclusion

A research study in the Eastern Zambezi Region focused on the use of indigenous kraals for crop cultivation, aiming to improve soil fertility, agricultural activities, and food security. The study found that kraals significantly impacted soil properties, enriching them with essential nutrients. Soil nutrients decline in nutrient-enriched areas after kraal use. For instance, they peak within 24 months of kraal use and then decrease. This nutrient loss affects grass quality, which, in turn, influences grazers' patch selection. Grazer use of nutrient-enriched areas is expected to be high for the first two years after kraal use but then decline over time. Investigating the impact of time after kraal use on large herbivores' utilization of these areas can provide insights into rangeland manipulation benefits. Above-ground grass biomass and height in nutrient-enriched areas are influenced by soil nutrients and herbivore grazing. Studies highlight the significance of kraals in traditional livestock systems, especially in marginal ecosystems, where they serve as nutrient reserves for food crop and forage production.

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3.2 Avian species identification and counts at the University of Namibia - Ogongo campus rice fields, Omusati Region, Namibia

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Introduction

Rice (*Oryza sativa*) is one of the most significant crops on the planet. Rice is grown in flooded environments and can provide crucial habitat for wetland species if handled properly. Rice fields or paddies are used by waterfowl, wading birds, shorebirds, and other water birds for a number of reasons, including foraging, nesting, and staging during migration (Elphick et al., 2010; Park et al., 2011).

Rice farmers see birds as pests and use harmful farming methods that destroy birds' habitats which sometimes disturb the ecosystem/biodiversity. Information that will be provided by this study will help serve as a resource base to other researchers interested in carrying out further research in this field to broaden studies on the relationship between rice fields and wetland birds in Namibia. Limited studies have attempted to assess the possible role of UNAM Ogongo rice fields as a habitat for wetland birds, thus there is no documented information on the type of bird species that utilize these rice fields. The objectives of the study were to [1]identify the bird species associated with the cultivation and harvesting seasons,

[2]compare the species richness and abundance during cultivation and harvesting seasons and [3]compare species diversity during cultivation and harvesting seasons. Therefore, the study's aim was to identify and document the different birds' species during the cultivation and harvesting seasons.

Method

The research was conducted at the UNAM Ogongo Campus, in the Biological Diversity Transect Analysis (BIOTA) Observatory, Ogongo, which is about 50 kilometers northwest of Oshakati, in north-central Namibia (Fransiska Ndiiteela Kangombe, 2008). Data was collected on a 3.4 hectares land with 29 rice paddies each with an area of 1250 m^2. The area was divided into seven counting blocks, with 5000 m^2 each. Quantitative data was collected; focusing on collection of numerical data. To cover the entire area, data was collected using point counts and line transects.

Figure 1 Rice paddies counting blocks (research design)

Results

A combined total number of 1124 birds were recorded in all seasons whereby 763 (table 1) individual birds were recorded during the cultivation season compared to 361 (table 2) recorded during the harvesting season. During the cultivation season, 13 species were recorded while 15 different species were identified during the harvesting season. This shows that the species abundance was high during the cultivation season.

Table 1 Species recorded during cultivation season

Species common name	**Frequency occurrence**
Red- billed buffalo weaver	32
Blue waxbill	6
Black-chested prinia	10
Southern red bishop	3
Monteiro's hornbill	2
Southern yellow billed hornbill	12
Cattle egret	17
Red headed finch	4
Scaly feathered finch	6
Swainson's spur fowl	4
Cape turtle dove	4
Red-billed quelea	137
Laughing dove	2
Black faced waxbill	120
Yellow crowned bishop	2
Total	**361**

Table 2: Species recorded during harvesting season

Species common name	**Frequency occurrence**
Black-chested prinia	16
Blue waxbill	117
Common moorhen	5
Dusky sunbird	18
Red-billed quelea	437
Red-billed teal	22
Southern-red bishop	36
Southern Masked Weaver	9
Hose sparrow	3
White-browed scrub robin	3
Great sparrow	22
Yellow crowned bishop	48
Cattle egret	27
Total	**763**

Conclusion

Majority of recorded species as well as the high numbers of individual birds were not water birds but rather birds attracted by the available rice. Ripened rice grains attracted more species during the harvesting season accounting for a higher species diversity relative to the cultivation season.

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3.3 The role of fungi in biodiversity management and utilization

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Introduction

Fungi are an integral component of biologically diverse and healthy ecosystems due to the role that they play in global nutrient cycling. However, their conservation has been largely neglected (Nic Lughadha et al., 2020; Pasailiuk et al., 2022). In this literature review, the authors will discuss the central role that fungi play in biodiversity management and utilization.

Method

Phrases related to the topic were used to retrieve articles from Google Scholar. Inclusion criteria were articles that were peer reviewed and available as full articles. Filters were applied so that articles not older than 2019 were included.

Results

Fungi are the most important decomposers of organic matter on earth. They display elaborate genetic and metabolic diversities, colonizing a wide range of substrates in the most complex environments. Fungal species are heterotrophic, depending on their host for nutrition and survival (Naranjo-Ortiz & Gabaldón, 2019).

In addition to nutrient cycling, fungi form symbiotic associations with plants, resulting in arbuscular mycorrhiza and ectomycorrhiza, facilitating access to, and exchange of water and minerals (Johnson et al., 2023; Shi et al., 2023). The utilization and conservation of fungi are thus central in advancing resilient food systems. Fungi provide food to humans and animals directly as mushrooms or through applications in the food and beverage industry to produce yoghurt, bread and beer to name a few. These applications extend to the pharmaceutical industry, providing medicinal products (Amara & El-Baky, 2023).

Food systems are influenced by fungi from the field all the way to the plate. Many fungal species are plant pathogens, causing huge ecological and economic losses. Rusts and smuts can cause a farmer to lose their entire crop (Manoharachary & Deshaboina, 2021; Vega et al., 2023). Management is thus an integral part of sustainable agriculture and food systems, causing mycotoxin contamination such aflatoxins in food storage (Manoharachary & Deshaboina, 2021).

Conclusion

Fungi are interdependent to their ecosystem, where one cannot exist or thrive without the other.

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Theme 4: Livestock and Crop Improvement

4.1 Assessment of Extension staff perception on Constraints to Effective Delivery of Agricultural Extension Services in the Northern Central Areas (NCAs) of Namibia: A case of Omusati and Oshana Region

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Introduction

The agricultural sector plays an important role in contributing to socio-economic development in many countries in terms of employment creation, poverty reduction as well as improving the standard of living of people. In Africa, most people acquire their livelihood directly or indirectly from agriculture (Patric *et al*, 2021). Agricultural production is affected by erratic rainfall, low soil fertility, limited access to credit, high incidence of pests and diseases as well as low uptake of new agricultural innovations as well as low productivity. Agricultural extension plays a crucial role in agricultural development and supporting farmers as well as rural communities and remains a powerful strategy for enhancing agricultural productivity (FAO, 2018; Conceicao *et al*, 2016). However, effectiveness of extension service depends on the relevancy, good quality services, capability, and provision of timely information (Maake and Atwi, 2022). This study assessed the views of agricultural extension staff on the major constraints to effective agricultural extension services in Omusati and Oshana regions.

Method

The study was undertaken in two regions of North Central Areas of Namibia namely Omusati and Oshana region, geographically adjacent to each other. Omusati region borders Kunene region to the west, Oshana borders Oshikoto region to the south- east, Ohangwena region to the north and north-east while both regions border Kunene region to the south. A qualitative-quantitative research design was used for this study. This study was based on both primary and secondary data. Moreover, to elicit information on the constrains of agricultural extension agents to effectively carry out extension activities, a mixed methods approach was used, including survey questionnaire, focus group discussions and key informants. Quantitative data from the structured questionnaires were analysed using the Statistical Package for Social Science (SPSS 21) software, using appropriate descriptive analysis such a frequency, percentages, means and standard deviation. While qualitative data was thematically analysed using content analysis (Creswell and Creswell, 2022).

Results

Survey and key informants' interviews results highlighted several constrains confronting agricultural extension agents' efforts aiming at assisting small scale farmers to improve their agricultural production in Omusati and Oshana region.

Table 1: Major constraints to effective extension service

Constraints	Mean	Standard Deviation	Rank order
Large area coverage	1.13	0.35	1
Limited Budget	1.33	0.62	2
Limited Kilometers	1.53	0.64	3
Lack of transport	1.6	0.63	4
Poor linkage between extension and Research	1.8	1.15	5
Lack of technology	2.07	0.79	6
Low farmers' participation	2.13	1.13	7
Lack of technical support	2.6	1.12	8
Lack of supervision	2.87	0.92	9
Limited technical skills	3	1.36	10
Time	3.93	1.28	11
Language barrier	4.47	1.41	12

Major constrains were identified as large area coverage, limited budget, lack of transport, low farmers' participation, Limited budget for extension activities, poor linkage with researchers, lack of technical support, lack of technology, lack of supervision and limited technical skills.

Conclusion

The study showed that agricultural extension staffs are confronted with several constrains that impend the effective delivery of agricultural extension services. It is therefore recommended that the government avail more financial and human resources in terms of operational budget for logistical support as well as for staff complement and continuous capacity building.

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4.2 Yield Performance of Groundnut Genotypes for the Agro-Ecologies of Northern Namibia

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Introduction/Purpose

Generation groundnut (*Arachis hypogaea* L.) varieties are vital for food production and income generation in low, erratic and unpredictable rainfall distribution of the semi-arid regions (Gangurde et al., 2019; Bakoye et al., 2019; Sinare et al., 2021). High yield performing groundnut genotypes with drought tolerance traits are important for cultivation in dry regions, including Namibia (Upadhyaya et al., 2006; Janila et al., 2013). Systematic studies and documentation on groundnut production, constraints, farmers' and market preferred varieties is limited. Currently, the Namibia have no record on groundnut varieties developed and officially released and majority of farmers use landrace cultivars (farm-saved seed). The objective of the study was to select groundnut genotypes with higher performing yield and yield-components for production in the agro-ecologies of Namibia.

Method

The study evaluated 20 groundnut genotypes under field tests condition at Mannheim Crop Research Station, Tsumeb in Namibia (19°10'09.2"S 17°45'51.4"E) to select higher performers with yield and enhancing yield-component traits. The 20 groundnut genotypes involving 12 ICRISAT bred lines and 8 newly selected genotypes from local germplasm collected from farmers in groundnut production regions that are stored and the NBRI in Namibia. Experiments were laid out in a randomized complete block design with three replications cultivated for two seasons (2019 and 2020). Data were collected on haulm yield (HY), number of pods per plant (NPP), kernel yield (KY), shelling percentage (%S), 100-kernel weight (HKW), kernel length (KL) and kernel width (KW). Collected data were subjected to combined analysis of variance (ANOVA) using Genstat 18th edition (Payne et al., 2015), Pearson's correlation coefficients using IBM SPSS Statistics version 27.0., principal component analysis (PCA) using R version 4.2.3 (R Core Team, 2020).

Results and discussion

The combined analysis of variance revealed significant interaction effects of genotype and season on shelling percentage and 100-kernel weight only, indicated stability of tested genotypes for selection of higher performing genotypes (Table 3). Higher proportion of variation among assessed genotypes was attributed to 100-kernel weight (0.887), kernel length (0.881), kernel width (0.865) and number of pods per plant (-0.643) with principal component 1 indicated genetic variation for selection (Table 6). Genotypes NAM 4433, NAM 888/2, NAM 1747/1, ICGV 15266, ICGV 02266 and NAM 676/2 were selected for higher pod yield (> 1.55 t/ha), haulm yield and kernel yield (Table 4). The six genotypes were recommended for multi-location trials under agro ecologies of Namibia.

Cultivated groundnut cultivars viz., Runner, Virginia, Spanish and Valencia are of varying shoot and root system architectures, pod and seed belonging to two subspecies, subsp. *fastigiata* Waldron (varieties *vulgaris, fastigiata, peruviana* and *aequatoriana*) and subsp. *hypogaea* Krap. et. Rig. (varieties *hypogaea* and *hirsuta*) (Janila et al., 2013; Janila et al., 2016; Thangthong et al., 2019; Zhu et al., 2022). These present genetic diversity opportunities for improvement of yield and adaptation for cultivation in wider environment (Mace et al., 2008; Diome et al., 2013; Zaiya Zazou et al., 2018; Yadav et al., 2023). Significant variation effects of genotype and season found in the present study on tested groundnut yield-components is agreeing with previous studies on groundnut by Nautiyal et al. (2012), Yol et al. (2018), Belayneh and Chondie (2022), Bekele et al. (2022) and Yadav et al. (2023). In the present study, ICRISAT bred lines ICGV 15266 and ICGV 02266 were among the top five pod yield performer (> 1.55 t/ha) recommended for large-scale production and further improvement of the crop for cultivation in Namibia and similar agro ecologies.

Groundnut yield-components associated with kernel weight are important to enhanced yield, quality and market preference (Olajide & Igbeka, 2003; Akcali et al., 2006). In the present study, hundrend kernel weight positively and significantly correlated with KL ($r = 0.57$; $p \leq 0.01$) and KW ($r = 0.66$; $p \leq 0.01$), whereas KL positively and significantly correlated with KW ($r = 0.67$; $p \leq 0.01$). Genotypes identified for higher kernel weight (> 51 g/100-kernel weight) and ICGV 15266, ICGV 15301 and NAM 4433. Genotypes NAM 4433, ICGV 15301, NAM 4330 and NAM 1747/1 were selected for higher kernel length (> 1 cm), whereas higher kernel width (> 0.6 cm) genotypes are NAM 4433, ICGV 15266 and ICGV 15301.

Table 3: Mean-squares values and significant tests for yield and yield-components of 20 groundnut genotypes

Sources of variation	**d.f.**	**HY**	**NPP**	**PY**	**KY**	**%S**	**HKW**	**KL**	**KW**
Replication	2	0.016	37.26	0.376	0.052	61.05	8.94	0.02	0.02
Genotype	19	1.519 ***	119.90 ***	0.241 ns	0.048 ns	95.24 *	444.01 ***	0.15 ***	0.04***
Season	1	1.106 ns	0.49 ns	0.013 ns	0.031 ns	27.01 ns	105.28 *	0.29 ***	0.27***
Genotype × Season	**19**	**0.381 ns**	**36.60 ns**	**0.311 ns**	**0.072 ns**	**120.00 *****	**61.14 *****	**0.03 ns**	**0.01ns**
Residual	78	0.331	29.72	0.204	0.041	43.82	25.06	0.02	0.01

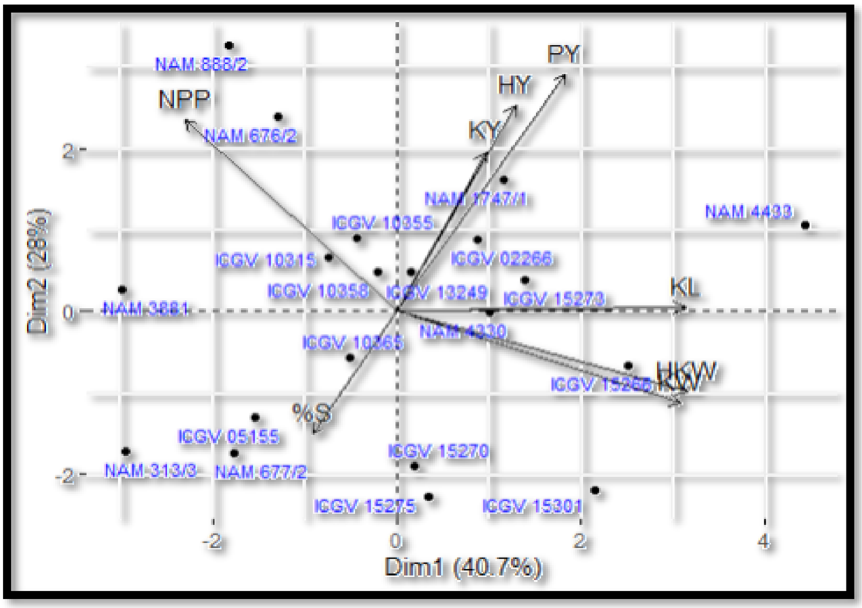

Figure 1: Biplot showing grouping of yield and yield-components.

Conclusion

Groundnut genotypes with greater yield and yield-components are important for improvement of the crop. The study selected groundnut genotypes NAM 4433, NAM 888/2, NAM 1747/1, ICGV 15266, ICGV 02266 and NAM 676/2. The genotypes are genetic resource for yield-components for further improvement of groundnut. The genotypes are recommended for cultivation in Namibia.

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4.3 Effects of abandoned kraals on soil physical and chemical properties in Eastern Zambezi Region, Namibia

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Introduction

In sub-Saharan Africa, persistent food insecurity is attributed to numerous factors, including infertile soils caused by intensive land use, poor soil management, and erosion, leading to low crop yield. However, the demand for food has been increasing. Thus, global food production must be doubled by 2050. Cattle kraals alter ecosystem functions by redistributing nutrients within the terrestrial environment (Haruba et al., 2022; Momberg et al., 2023). Approximately 70% of Namibia's population practice farming, with about 23% employed in agriculture (Mushendami, 2006; Taapopi et al., 2018; Awala et al., 2019). This statistic is vital for local smallholder farmers who depend on agriculture. However, national cereal production remains low, leading to a reliance on maize and wheat imports to complement domestic cereal production.

In Namibia's Eastern Zambezi Region, agriculture is vital for rural communities; however, they face multiple production challenges, including soil degradation from mono-cropping and unreliable rainfall, resulting in low crop yields (Von Hase, 2013). Improving yields of staple crops (maize, pearl millet, sorghum, Bambara nut, and cowpeas) and forage crops is crucial in ensuring human food and livestock feed security in the region. Manure quality depends on various factors, and kraals play a vital role in the local cropping system. Kraals, enclosures used to handle livestock, especially at night, contribute to nutrient cycling in agroecosystems through the deposition of cow dung. They accumulate nutrients such as nitrogen, phosphorus, and potassium for normal crop growth.

The present study investigated the potential use of abandoned indigenous kraals in the Eastern Zambezi Region to cultivate crops such as maize, cowpea, buffalo grass, Lucerne, and sunflower.

Method

A soil survey was carried out in October 2022 at Isize village and the Kalimbeza Farm in Namibia's Eastern Zambezi Region. The farmers are located about 40 km away from Katima Mulilo Town. These sites were selected within the NILALEG Project landscape due to the prevalence of indigenous kraals in the communities. Average annual rainfall in the Zambezi region ranges from 500–700 mm, with summer temperatures of 32–35°C and winter temperatures of 18–25 °C. Soils were sampled at 30 cm depth before planting and were analyzed by the Soil Laboratory; Ministry of Agriculture, Water Water and Land Reform, Windhoek. Soil chemical-physical analyses included N, P, K, Mg, Ca, S, Na, Mn, Cu, Zn, Fe, pH, OC, CEC, BS, BD, and texture.

Results

Kraal A had higher soil chemical properties (pH, ECW, P, K, Ca, Mg, Na, and N) than Kalimbeza, while both had lower means than Kraal B. The differences in soil properties may be due to geographical locations. Momberg et al. (2023) found that kraaling doubled soil concentrations of C, N, P, and K and slightly increased pH. Kraal A had the highest values in multiple soil chemical properties, especially potassium, implying an enriched soil, presumably due to local environmental conditions. Haruba et al. (2022) stated that soil nutrients decline in nutrient-enriched hotspots after kraal use. In contrast, Kalimbeza Farm had the lowest means, implying lower nutrient concentrations, possibly influenced by geological factors, soil formation processes, or land management practices.

Soil properties vary among the three locations due to geological, environmental, and land use factors. Soils in Kraal A were nutrient-enriched by cow dung, enhancing soil organic matter, pH, and microbial activity. Kalimbeza Farm may have higher calcium levels due to inorganic fertilizer use at the farm while maintaining consistent organic

carbon levels, which are essential for soil health. Soil chemical property interpretation should consider local conditions, agricultural practices, and land management.
Soil texture analysis showed that soils at Kalimbeza Farm were sandy, while Kraal A and Kraal B were much sandier. In the case of clay content, Kraal A had the least content, followed by Kraal B and Kalimbeza Farm. These results help understand local soil variations, vital for agriculture and land use planning.

Conclusion

The study assessed the potential use of indigenous kraals in the Eastern Zambezi Region for crop cultivation, aiming to improve soil fertility, agricultural activities, and food security. The study found that kraals significantly impacted soil properties and enriched soil with essential nutrients. Soil nutrients decline in nutrient-enriched areas after kraal use. For instance, they peak within 24 months of kraal use and then decrease. This nutrient loss affects crop and grass quality, which, in turn, influences grazers' patch selection. Grazer use of nutrient-enriched areas is expected to be high for the first two years after kraal use but then decline over time. Investigating the impact of time after kraal use on large herbivores' utilization of these areas can provide insights into rangeland manipulation benefits. Soil nutrients and herbivore grazing influence above-ground grass biomass in nutrient-enriched areas. Several studies highlight the significance of kraals in traditional livestock systems, especially in marginal ecosystems, where they serve as nutrient reserves for food crops and forage production.

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4.4 Effect of fermented feed on growth performance of broiler chickens

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Introduction

The global poultry industry is experiencing rapid growth due to the increasing demand for animal-based protein (Mottet and Tempio, 2017). However, poultry farmers worldwide encounter numerous challenges, with high feed prices being a significant concern. In fact, feeding accounts for over 70% of the total cost of raising intensively kept animals (Chatterjee and Rajkumar, 2015). To address these challenges, fermented feed has gained recognition as an alternative method to enhance the growth performance of chickens. Feed fermentation is a technique that not only improves feed quality but also increases feed bulk, making feeding more efficient and enhancing overall animal performance (Moran, 2001). Despite its potential benefits, literature on fermented liquid feed for poultry is limited, largely because of concerns about its suitability for poultry and potential issues related to feeding hygiene and wet litter (Forbes, 2003). This research aims to investigate how fermenting poultry feed influences the growth performance of broilers, focusing on key parameters such as feed intake, average daily gain, and feed conversion ratio. The hypothesis posited that incorporating fermented feed into chicken diets may result in improved growth rates due to the enhanced digestibility and nutrient availability of the fermented feed. This study was expected to provide valuable insights into the potential advantages of fermented feed in poultry production, ultimately assisting in the development of efficient and cost-effective feeding strategies for poultry farmers.

Method

Management of the birds:

A week before the arrival of one-day-old Sasso chicks, the facilities and equipment were thoroughly cleaned and disinfected. Infrared bulbs were used to preheat the brooder house, with wood shavings on the floor. The chicks were bought from a local poultry producer and given a vita-stress pack upon arrival. They were fed a starter diet for the first four weeks, followed by dry grower feed from the fifth to the seventh week. In the eighth week, they were gradually introduced to fermented feed, and the official experiment ran from the ninth week to the twelfth week, spanning a total of four weeks.

Fermented Feed preparation:

The fermented feed in this study was prepared using the fermented liquid feed method, which involves mixing feed with water at a ratio of 1:1.5 to 1:4 and fermenting it for approximately three to four days until it reaches a stable condition (Brooks et al., 2003; Chae, 2000). To begin the process, a weighed amount of commercial feed (Grower) was used, ensuring it met the daily requirement for all the chickens. Water was added to this feed at a ratio of 1:3, ensuring complete submersion to prevent mold formation. The container was then sealed with a lid and left to ferment for three days. To prevent the chickens from going hungry, the fermented feed for each day was prepared three days in advance. Importantly, excess water from the buckets was not discarded to prevent nutrient loss.

Research Design: A Complete Randomised Design (CRD) was used to place the broiler chickens in the different treatment levels. The experimental unit was a pen containing five chickens. Each treatment was replicated three times. The treatments were T1 (Control group fed on dry commercial feed), T2 (Wet commercial feed), T3 (50% fermented commercial feed + 50% dry commercial feed) and T4 (100% fermented commercial feed).

Data collection: The quantity of feed served to the chickens were weighed. Left over feed collected per group every morning was weighed and recorded. The feed intake was calculated by finding the difference between the known quantities of feed given to the birds and the leftover feed weighed the next day. Weighing of the birds was done weekly on individual basis and in the morning when their crops are virtually empty. At the end of the trial, the body weight gain was calculated per replicate by subtracting the initial body weight from the final weight. The average daily gain was determined by dividing the body weight gain with the number of days the experiment lasted. The feed conversion ratio (FCR) was computed by dividing the average daily feed intake (ADFI) by the ADG.

Results

Although not significant, T2 tended to have the highest average daily gain and feed intake followed by T1, T4 and T3 respectively. Furthermore, treatment 1 (T1) tended to have the lowest feed conversion ratio, making it the most efficient, followed by T2, T3 and T4 respectively. Despite all these results observed in table 1, it is important to note that no significant differences were observed in all the parameters (ADG, FI and FCR) at 5% level of significance.

Conclusion

Overall, while this study did not find a significant effect of fermented feed on the growth performance of broiler chickens, it contributes to the existing knowledge base on the topic. It highlights the need for further research to better understand the potential benefits and limitations of using fermented feed in broiler chicken production. By addressing the limitations, future studies can provide more conclusive evidence on the impact of fermented feed on broiler chicken growth performance.

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4.5 In-vitro propagation of local and exotic sweet Potatoes (ipomoea batatas) genotype using nodal explant.

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Introduction

Sweet potato (*Ipomoea batatas*) is a valuable root vegetable cultivated for its nutritional attributes, adaptability to various climates, and potential contribution to food security and sustainable agriculture (FAO, 2022). In Namibia, as in many African countries, sweet potatoes play a significant role in providing a source of nutrition, especially in rural areas (MATOMOLA et al., 2007). However, the traditional methods of propagating sweet potatoes are associated with disease transmission and low multiplication rates, limiting their widespread production (Dumba, 2018). In-vitro propagation of sweet potato genotypes using nodal explants presents a promising alternative for producing high quality planting materials, but this area of research requires further exploration (El-Afifi et al., 2012a). This study aims to assess the feasibility of in-vitro propagation using nodal explants for the mass production of local and exotic sweet potato genotypes. It also seeks to evaluate the response of agro-morphological traits in in-vitro plantlets and determine the relationship among these traits.

Method

The research was conducted at the Plant Tissue Culture Laboratory of the University of Namibia-Ogongo Campus, Omusati Region. Nodal explants were collected from two local sweet potato genotype (NAM-White and NAM-Red) and two exotic sweet potato genotypes (Buea-White and Dschang-White). These explants were surface sterilized using a series of solutions, and then placed in

Murashige and Skoog (MS) basal medium with vitamins and sucrose. The culture was grown at a temperature of 25±2°C, with a 16/8hour light/dark photoperiod.

Results

The research revealed that there were no significant differences among the sweet potato genotypes in terms of the day of first shoot and root development. This suggests that the initiation of shoot and root formation in in-vitro conditions was relatively consistent across all genotypes, aligning with Dolinski & Olek, (2013); Abubakar et al., (2018) results. However, significant variations were observed among the genotypes in terms of shoot length, the number of roots, and the number of leaves. Buea-White exhibited rapid shoot initiation, quick rooting, the longest shoot and root lengths, and a higher number of roots and leaves, indicating its robust growth potential. On the other hand, the survival rate, which reflects the percentage of non-contaminated plantlets, did not show significant differences among the sweet potato genotypes. This suggests that the in-vitro propagation process was successful in producing viable plantlets across all cultivars.

Table 1: Analysis of Varience for Nodal Expalnt Culture of Four Sweet Potato Genotypes after 7 Weeks of Culturing with Basal MS Media with no PGH

		Day of First Shooting		**Day to First Rooting**		**Shoot Length**		**Root Length**		**Number of Roots**		**Number of leaves**	
Source	DF	MS	$P_{0.05}$	MS	$P_{0.05}$	MS	$P_{0.05}$	MS	$P_{0.05}$	MS	$P_{0.05}$	MS	$P_{0.05}$
Treatment	3	2.733	0.682	2.867	0.624	1.973	0.029*	58.091	0.115	6.0	0.0023**	15.733	0.0059**
Residuals	16	5.375		4.775		0.505		25.130		0.8		2.600	

Table 2: Table of Means

	Day to First Shooting	Day to First Rooting	Shoot Length	Root Length	Number of Roots	Number of leaves
Buea-White	5.40b	4.00ab	3.57a	14.03a	4.00a	6.20a
Dschang-White	6.20b	4.00a	2.05b	6.34b	1.40b	2.20b
NAM-Red	7.20b	4.40b	2.63b	7.98b	2.80b	3.00ab
NAM-White	6.40b	5.60b	2.65b	7.80b	2.20b	3.00b

Means with the same letter in the same column are non-significant at 5% significant level.

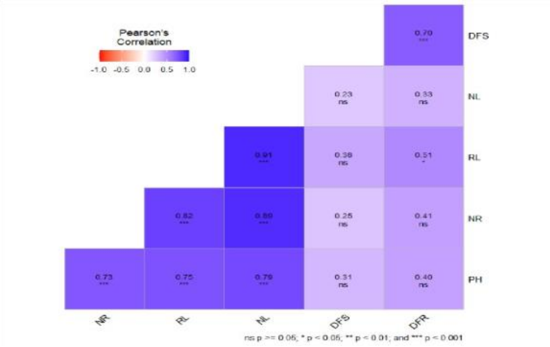

Figure 1: Pearson's Correlation Graph

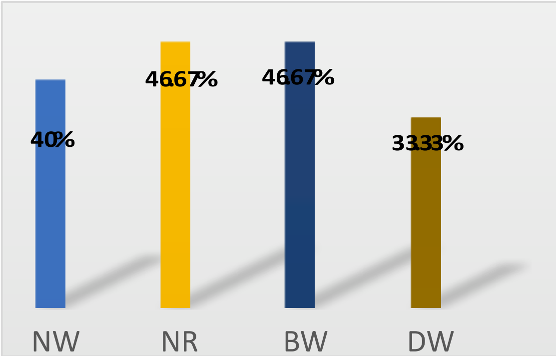

Figure 2: Survival Rate

Conclusion

Buea-White stood out as a valuable candidate for further investigations, potentially leading to accelerated regeneration and multiplication processes. The study offers valuable insights and lays the groundwork for future research endeavors, ultimately contributing to enhanced food security and sustainable agricultural practices in Namibia.

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4.6 The effect of inter and intra-row spacing on growth and yield of cowpea (Vigna unguculate (l) walp.) Genotypes under field conditions

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Introduction

The world's most important crop is the cowpea, which greatly relieves resource-constrained farmers in the vast majority of developing nations (Gnanamurthy et al., 2012). In many people's diets, the crop is also used as a source of protein (17 to 25%). (Ibro et al., 2014). It was an option to many monoculture production systems due to its resistance to climatic change, adaptability in a variety of edaphic climate conditions, and capacity to fix atmospheric nitrogen into the soil (Onuh and Donald, 2009). In Namibia cowpea is the third most crucial staple crop after pearl millet (*Pennisetum glaucum* (L.) R. Br.) and sorghum (*Sorghum bicolor)* (McDonagh and Hillyer, 2003). It is grown by more than 90 percent of small holder farmers in ten regions of the country (Fleissner and Bagnall-Oakeley, 2001). Compared to the yields (1.5 to 3.0 t ha^{-1}) obtained from elsewhere in the world, the yields of cowpea in Namibia have been 3 times lower ranging from 100-599 kg/ha (Horn *et al.,* 2015; Gbave and holloway 2011). There are many constraints to cowpea production and productivity in Namibia including but not limited to; lack improved varieties; low soil fertility levels; persistent drought; pests and diseases; limited access to agricultural inputs and poor management practices i.e. planting density, inter and intra row spacing. Manipulation of Inter-row and intra-row spacing would enhance plant growth factors such as crop yield, crop production and reduced competition among crops. Inter-row and intra-row spacing information is limited among communal farmers. There is scanty information available on the effect of inter and intra row spacing on cow pea crop under northern Namibian conditions. Therefore, this study evaluated the effect of spacing on the performance of two improved cowpea genotypes to propose the best cowpea spacing for optimal production.

Method

The field experiment was conducted during the 2022 and 2023 cropping seasons at the Mannheim Crop Research Station (Ministry of Agriculture, Water and Land Reform) in the Tsumeb District in the Northern Region of Namibia. The experiment design was laid out in a split-split plot design arranged in randomized complete block design (RCBD) with thirty-six (36) treatments at three replications. Treatments included three cowpea genotypes (Bira, Nakare and NkR8P9), four inter (100, 75, 50 and 25cm) and three intra (20, 30 and 40cm) row spacing totaling to 108 experimental units. The inter row constituted the main plot while the intra row and cowpea genotypes constitute subplot and sub-subplot respectively. A uniform dose of recommended urea (46%N), single super phosphate (SSP) (10.5%P_2O_5) and potassium chloride (51% K_2O) fertilizers were applied to all treatments during planting. All the other agronomic practices were followed as per the recommendation for the crop. Growth and yield data collected included days to 50% flowering, seed weight, seed yield per plant and harvest index.

Results

The effect of inter-row spacing on cow pea genotypes; revealed a highly significant effect ($P<0.05$) on days to 50% flowering (Table 3). An inter-row spacing of 50 cm (48 days) was the earliest to reach 50 % flowering, while 100 cm (49 days) took the longest.

Table 3: Days to 50% flowering

	Inter-row (cm)			
	25	**50**	**75**	**100**
Days to 50% flowering	**49.15ab**	**48.44a**	**49.89b**	**49.33ab**

Inter-row spacing had a significant effect on 100 seed weight for all cow pea varieties (Table 4). Bira variety performed better at 25 cm inter row spacing, while Nakare and NkR8P9 performance increased with increased spacing with both recording high 100 seed weight at 100 cm (15.99 and 15.49) respectively. Decreased plant population lead to an increased 100-seed weight, which may be due to increased availability in both moisture and nutrients. This finding concurs with those reported by Ahmed (2010).

Table 4: 100 seed weight

100 seed weight (g)	Genotypes		
Inter_row	**Bira**	**Nakare**	**NkR8P9**
25	11.36abcd	10.97abc	10.23abc
50	8.64ab	12.07cd	11.83bcd
75	8.32a	15.85e	14.65de
100	8.75ab	15.99e	15.49e

Seed yield per unit area was significantly affected (P<0.05) by spacing. Narrowing inter-row decreased seed yield per plant in cow pea. In contrast, seed yield increased with increased spacing. Seed yield was highest for Nakare at inter row spacing of 100 cm (15.99 g) and intra row spacing 40 cm. These findings are contrary to results obtained by Augustine (2006), who reported high seed yield with increased plant density. The increase in plant population at narrow spacing increased competition and plant grown further apart allowed for growth without interference.

Similarly, plant spacing revealed a significant influence on harvest index. Nakare recorded the highest harvest index with (0.25) at 100 cm spacing. Increased plant population reduced harvest index as a result of greater shoot dry matter. Lower harvest index, with population density was also recorded by Ahmed, (2010).

Conclusion

The results from the study indicated that inter row spacing and intra row spacing had influence on cow pea genotypes specifically on growth, yield components and yield production in cowpea. Narrow spaced grown plants affect growth factors and overall yields through competition for nutrients, moisture, air and radiation. Hence, the study concluded that inter-row spacing at 100 cm showed the highest seed yield per plant, and the cowpea genotype Bira showed the highest yield performance. The study recommends promoting Bira planting under field conditions for improved cow pea production. However, as this is one season experiment at one location, the experiment needs to be further replicated over locations and seasons with inclusion of more varieties to reach at a more reliable conclusion.

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5.1 Bush to feed production and utilisation in beef cattle in Okongo communal area, Ohangwena Region

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Introduction

The process of thickening and/or growing woody species in open savanna and woodland vegetation types is referred to as "bush encroachment," and it ultimately leads to a reduction in rangelands and grazing carrying capacity(Eldridge et al., 2011; Van Auken, 2009). Encroacher bushes currently occupy 32% of Namibia's surface area, affecting nearly 45 million hectares of savanna ecosystems(Shikangalah & Mapani, 2020; Uchezuba et al., 2019). Rangeland's ability to support livestock production in Namibia has been reduced by up to two-thirds due to bush encroachment(De Klerk, 2004). Agriculture in Namibia is mainly dominated by livestock production with cattle production on the top of the list followed by goats and sheep. However there has been a reduction in cattle production over the past years due to shortage of feed in the veld due to bush encroachment and also incessant droughts. Therefore the production of cattle feed from encroacher bushes would be an ideal value chain which also reduces the current high cost of stock feeds (Shiimi, 2020). The objective of this study is therefore to investigate the potential of encroacher bush as a feed resource for beef cattle. Specifically, it examines the nutritional value of the encroacher bush as a feed source as well as its effect on beef cattle performance and productivity. In addition, the study also assesses the economic viability of using encroacher bush as a feed source in beef cattle production in the region.

Method

The study will employ mixed methods research method. Incorporating evidence from surveys, proximate analysis experiments and feeding trials, the study demonstrates the benefits of using encroacher bushes as cattle feed. The research will use focal point discussions to carry out the base line survey to determine the different bush browser species that have been used to feed livestock in the area by the farmers. This will involve holding focus groups with livestock farmers to discuss their perceptions of bush feed and their willingness to adopt it and 30 participants will be randomly selected from the community. Samples of the encroacher bushes species will be collected from the field. The samples will be collected from a variety of locations to ensure that they are representative of the different types of encroacher bushes that are present in the area and then send to the laboratory for nutritional and chemical analysis. Three different diets and a control diet will be formulated, and a total of 20 animals will be fed their respective diets for a period of 90 days. Feed intake, daily average weight gain and growth performance will be measured.

Results

The results of this study are expected to prove that use of encroacher bushes as a feed source, has positive significant impact on beef cattle performance and productivity as well as the development of alternative livestock feed sources to improve beef cattle productivity and income levels for local communal communities.

Conclusion

The research will equip the communal farmers with knowledge on feed formulation from encroacher bushes thereby increasing the productivity of the livestock industry hence increased income levels for the communal farmers.

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5.2 Effects of dietary inclusion of dried orange peels on nutrient intake and digestibility in boer goats

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Introduction

Ruminant animals play a vital role in Namibia's agricultural economy, contributing significantly to the livestock sub-sector. However, this sector faces several challenges, including issues such as poor grass quality, drought, and overgrazing, which are currently posing threats to livestock productivity (Alabi et al., 2013). These challenges are particularly pronounced among Namibian farmers in communal areas, who frequently experience shortages of both high-quality and sufficient feed resources, especially during the dry season (Aka, 2016). As a result, there is a decline in the crude protein content and dry matter in available feed resources (Aka, 2016). Consequently, these challenges have resulted in slow growth rates, reduced body weights, lower birth weights, increased susceptibility to diseases, and higher mortality rates among young animals (kids) (Alabi et al., 2013). Numerous research studies have confirmed that incorporating locally available by-product feedstuffs, such as orange peels, into the diets of small ruminants offers mutually beneficial outcomes. This study was conducted to assess the nutrient intake and digestibility in growing Boer goats whose diet consisted of 35% dried orange (Citrus sinensis) peel. Eight animals, approximately six months old with an average body weight of 26.1 kg, were allocated to two dietary groups: T1 received Ram-lamb pellets (control), while T2 received Ram-lamb pellets supplemented with 35% orange peels. This allocation was achieved through a completely randomized block design (CRBD), with four goats per treatment. Over a 28-day period, the goats were provided with clean drinking water and grass hay as a basal diet ad libitum. Data collection occurred over a seven-day period.

Methods

Orange peels sourced from Windhoek homestead were subjected to a three-month sun-drying process on polythene sheets. Following this, the dried samples were transferred to the University of Namibia, Neudamm Campus, where they were subjected to comprehensive analysis.

Eight Boer goats aged 6 months were used in a study sourced from the Neudamm farm. They were individually housed in metabolic cages designed for separate collection of faeces and urine. The study likely aimed to monitor their diet and metabolic processes.

Analyses were conducted on samples of feed provided, leftover and faces to determine various components, and these results were used to calculate the nutrient intake and digestibility as per AOAC, (2005).

Results

Diet containing orange peels (T2) had no significant effect on nutrient intake of the measured nutrient parameters (DMI, OM, CP, EE, and NDF). However, numerically, T2 had the highest Crude protein nutrient intake value of (133 %) compared to control (T1) with (119%), which may be due to that orange peels are rich in dietary fiber, which can contribute to the overall nutrient profile. This fiber may contain proteins that contribute to the crude protein calculation. Furthermore, T1 had the highest dry matter nutrient intake value compared to T2 with 35% which might be as a result of palatability of the diet, nature of diet preparation and the nutrient content of the diet which make the goats to consume more to meet up with their energy and protein requirement.
There was no statistical difference on nutrient digestibility of the two dietary treatments, However Goats fed with pellets (T1) numerically demonstrated the highest apparent nutrient digestibility, particularly in terms of dry matter digestibility (DMD), signifying that T1 was more easily digested compared to the diet in T2. This enhanced digestibility in T1 could be attributed to the higher protein content in the pellets, which provided a richer nitrogen source for microbial utilization. The inclusion of 35% in the diet did not have an impact on crude protein digestibility (CPD) in goats. This may be attributed to the presence of tannin and saponin in the diet, which could

have minimized protein degradation in the rumen. As a result, a substantial amount of protein remained available for post-ruminal digestion (Aka, 2016).

Conclusion

In conclusion, up to 35% of dried orange peels could be fed to Boer goats as a replacement for Ram-lamb-ewe pellets during dry season without any significant negative effects on nutrient intake and digestibility.

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5.3 Effects of pre-sowing treatment methods on the germination of *baikiaea plurijuga*

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Introduction

Forests provide multiple ecosystem services spanning from local livelihoods and socio-economic development related goods and services such as food, wood, and water to the global ecological and economic services. However, deforestation and forest degradation are causing a significant reduction in the provisioning of valuable ecosystem goods and services from forests in developing countries (Kyere-Boateng et al, 2021). Baikiaea plurijuga also referred to as African teak, is one of the valuable afrotropical tree species from the Fabaceae family of legumes that originates in southern Africa. Mapaya et al, (2020) said, the wood is heavy, even textured, hard, strong, durable, dark red-brown and slow drying. It is used for furniture, flooring, railway sleepers and mining timber and is exported from southern Africa in considerable quantities. Due to heavy logging over the past 50 years, Baikiaea plurijuga's forests in Namibia have been significantly diminished and are now considered to be Near Threatened (De Cauwer et al, 2016). In Namibia, it is protected by law. Mapaya et al, (2022) said, population increase demand more food, forest and land and thus cause the species to be categorized as near threatened. Botsheleng et al, (2014) said, the main problem encountered in propagating seedlings of most indigenous trees including *Baikiaea plurijuga* in arid and semi-arid areas is dormant seeds. Dormancy has evolved differently across species through adaptation to the prevailing environment, to allow seeds to germinate only when conditions are likely to be favourable for a new plant to establish itself. Little is known about the germination requirements of indigenous trees species in Namibia and the aim of this study was to investigate the impact of different pre- sowing treatment methods (hot water (9 minutes), hot water (6 minutes), nicking and a control on the germination rate of *Baikiaea plurijuga*, to determine the optimal pre-sowing treatment method(s) that enhance the germination success of *Baikiaea plurijuga,* To assess the effects of pre-sowing treatments on the height of *Baikiaea plurijuga* seedlings. To determine survival percentages of Baikiaea *plurijuga* seedlings.

Method

The study was conducted at the University of Namibia, Ogongo campus (Nursery) in Omusati Region, in north-central Namibia. It is located halfway between the Oshikuku and Outapi Townships along the C46 route, B1 about 50 kilometers from Oshakati. The Campus is located on a farm of 4,350 ha, 1000 ha of which are used as a game park. Due to this, nearly all student field experiences can now be held on campus. The study was conducted within 3 months period as from June to September. The experiment was carried out in Completely Randomized Design (CRD) in the University of Namibia, specifically in Ogongo campus.

Germination percentage (%) indicates the percentage of germination which was derived by dividing the total number of seed germinated by the total number of seed sown and then multiply by 100, the formula is

$GP = NSG/TNS\ X\ 100 \ldots.$ Where: GP = Germination percentage, NSG = Number of seeds germinated and TNSS = Total number of seeds sown. Maximum germination was observed in hot water 9 minutes treatment which was (65 %) followed by nicking in which it was (59.26 %), hot water 6 minutes treatment with (57.41%) and lowest germination percentages was recorded in a control with (55.56%).

A maximum survival percentage (60%) was recorded in hot water 9 minutes as compared to (51%) in hot water 6 minutes treatment, 45% control and lowest in Nicking with 40%

Conclusion

The results obtained in this study entail the important role of pre-treating Baikiaea plurijuga seeds prior to sowing for enhanced germination. soaking the seeds in hot water enhances germination. Similarly, nicking the seed coat also promotes germination, plant height in hot water treatments was also high followed by Nicking and least is the control. However, survival percentages of nicking were less compared to other pre-sowing treatments methods. From the above results, it can be inferred that dormancy of seeds of *B. plurijuga* is associated with the seed coat, since the treatments that induce germination were those that can effect disruption of the seed coat.

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Theme 6: Waste Management

6.1 The effect of food waste compost on the growth and biomass of beans (Phaseolus vulgaris), unam ogongo campus

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Introduction/Purpose

Food wastes have become an environmental problem at both local and global scales. About one third of global food wastes are generated per year. One potential solution is to recycle food waste through composting to enhance soil fertility and reduce landfill waste. This study investigated the use of cooked and uncooked food waste as an organic compost for the growth of beans (*Phaseolus vulgaris*) in Ogongo campus.

Method

In this research, two distinct types of compost were prepared; cooked food waste and uncooked food waste. For three months, the uncooked food waste was placed in 1m x 1m pit and composted naturally, while the cooked food waste was placed in a 20L bucket and 500g of bokashi powder was added. A Completely Randomised Design with three treatments, (uncooked food waste compost, cooked food waste compost and pure soil (control) were used to grow beans in a controlled experimental condition. Each treatment was replicated 20 times using different ratios. Various growth parameters, such as plant height, leaf area, number of leaves, and overall biomass, were recorded.

Results

The water holding capacity of all two-food waste compost reached their maximum water retention capacity (50%). Fresh biomass study showed that both food waste compost had not significantly affected the fresh biomass of beans at $P<0.05$. The statistical analysis showed that both food waste compost had significantly affected the growth of beans at $P<0.05$. Beans treated with uncooked food waste compost attained the highest plant height; number of leaves and area of a leaf compared to beans treated with cooked food waste compost. However, 60g of uncooked food waste compost decreased the growth parameters.

Conclusion

Beans treated with 110g of uncooked food waste compost demonstrated better growth rate compared to those treated with cooked food waste compost. This suggest that uncooked food waste compost may be more beneficial for plant growth.

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Theme 7: Sustainable agriculture and green hydrogen

7.1 Effects of fertilizer types and pearl millet intra-row spacing regimes on weed growth in North–Central Namibia

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Introduction

Arable weeds encourage diseases, host pests and pathogens, disrupt harvesting operations, raise production expenses, reduce crop quality and yield (Tabot, 2015). Additionally, weeds compete with crops for limited space, water, nutrients, and light resources, all of which are vital for crop growth and development (Adesina et al., 2012; Gidesa et al., 2016). Given the absence of documentation concerning cost-effective cultural methods for managing weed in pearl millet, Namibia's staple crop, we investigated the influence of fertilization and pearl millet intra-row spacing on weed growth and density in North-Central Namibia

Methods

The field trials were conducted in 2018 and 2021 at the University of Namibia–Ogongo Campus. Treatments comprised three fertilizer types (cattle manure, NPK chemical fertilizer, and no fertilizer, as a control) and four pearl millet intra-row spacing configurations (20, 40, 60, and 80 cm). A 3 × 4 factorial experiment in randomized complete block design with four replications was using. Thirty days after within the 2 middle rows in each plot (Figure 1). Weed density was determined by counting all the weeds in the quadrate; weed biomass was obtained from the dry weight of the weeds.

Results

In in 2018, the application of NPK did significantly affect weed density and biomass. However, the application of manure resulted in a numerical decrease in both weed density and biomass compared to the NPK-fertilized and control plots. Moreover, the 20 cm intra-row spacing significantly suppressed weed biomass. While in 2021, plots treated with manure and sown at 80 cm, the widest spacing produced the lowest weed biomass. In contrast, the control plots sown at 40 cm spacing displayed the highest weed biomass. Furthermore, the control plots sown with 80 cm spacing showed the lowest weed density, while the highest weed density was recorded in control plots sown at a 40 cm spacing. These findings underscore the significant influence of both spacing and manure application on weed arable weed management.

The findings revealed that fertilization did not have a significant impact on weed density and biomass. This lack of effect was attributed to a severe dry spell during crop establishment (Figure 1B & C), preventing the dissolution of fertilizers in the soil and nutrient absorption thereof, eventually reducing weed growth. However, cattle manure appeared to reduce the parameters under investigation. This effect could be attributed to enhanced soil aeration, leading to increased soil drying. Weed growth in plots with manure likely proceeded slowly due to increased aeration and reduced soil moisture content. These results align with previous studies, such as Shiyam et al. (2011), who reported weed growth suppression by sawdust in plantain/cocoyam intercrop. Additionally, weed suppression under narrower intra-rows has been reported (Nwagwu, Effa, and Osai, 2015).

Conclusion

These findings underscore the potential of narrower intra-row spacing in pearl millet cultivation to effectively suppress weed growth compared to wider spacing. Thus, adjusting the intra-row spacing of pearl millet could be an essential component of integrated weed control for sustainable crop production. This study contributes valuable insights into sustainable pearl millet production practices for the region.

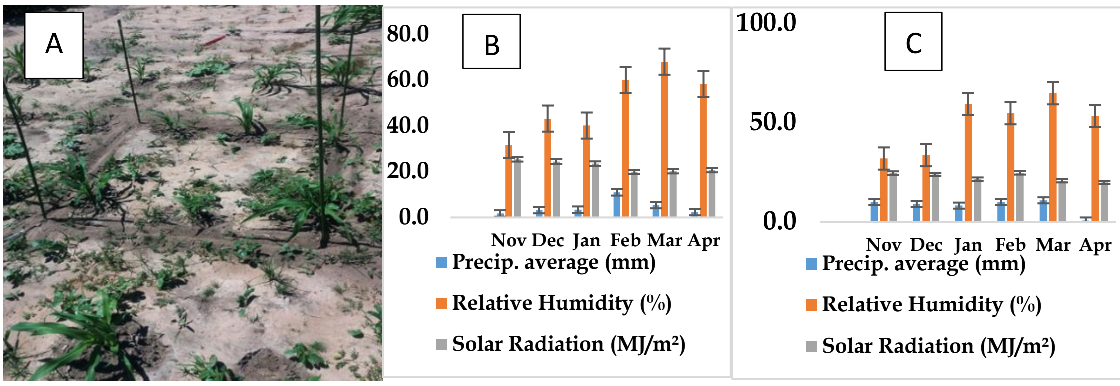

Figure 3. A. Sampling zone; quadrat location in the field; B and C, weather conditions for the growing seasons 2018 and 2021.

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7.2 Evaluating the effects of soil amendment on soil chemical properties

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Introduction

Global soil degradation threatens food production, security, and food-price instability. To prevent this, nutrient management systems can conserve soil resources. Climate change requires reducing greenhouse gas emissions and improving small farm productivity. Higher temperatures and extreme weather events negatively impact soil quantity and fertility. Soil conditioners can improve soil quality. Proper care is crucial for future generations (Craswell and Lefroy, 2001). The objectives of the study were therefore; to establish the interaction of soil amendments on the soil chemical properties, compare different types of soil amendments, and provide recommendations for sustainable soil management.

Methods

The experiments were located at the experimental research sites; namely Ogongo agricultural campus (17° 40' 51.24.S, 15° 0' 0" E), Zambezi DAPEES office field (17°29'.32.4S, 24°16.'44.4E), Mannheim research station (19°10'06.8S, 17°45.'45.4E) -

and Tsumis research Station (23°.73'08 S, 17°.19'87E). Namibia's climate varies by location, with Ogongo having sandy soil, Zambezi having loamy loam, Mannheim having clay loam, and Tsumis having sandy loam.

The design of this experiment was a Split plot design with 2 water regimes, replicated 3 times in each regime with the following treatments: Be-Grow, Zeolites, Biochar, Horn and Hoof plus bone meal, Compost and NPK.

The study involved collecting 168 soil samples from four study sites to assess soil fertility before and after amendments, with baseline samples collected at different depths. Soil samples were analyzed using spectral analysis at the GIZ and Ministry of

Agriculture mobile soil laboratory. The results showed the impact of organic amendments on soil quality, after air-drying, grinding, and pulverizing. The soil data were analyzed using analysis of Variance (ANOVA) using the general statistical analysis tool - GENSTAT. All Soil chemical property data were subjected to a one-way analysis of variance to test variations between different treatment sites.

Results

The study found that compost, organic carbon, calcium, cation exchange capacity, and pH were the highest in Ogongo, while biochar had a lower Cation exchange capacity (CEC) than compost. CEC as an indicator for soil fertility, the results show a positive increase of CEC from all conditioners. The control had the lowest Zn concentration, indicating the importance of soil amendments in enriching soils with essential nutrients (Davis, 2005).

Furthermore, the study revealed that compost, when used as a soil supplement, enhances soil organic carbon content, particularly when combined with reduced watering, similarly, to a study by Reeves (1997). The maximum concentration of organic carbon was found in decreased irrigation with compost, while biochar had the highest phosphorus content. However, this is dependent on the soil type.

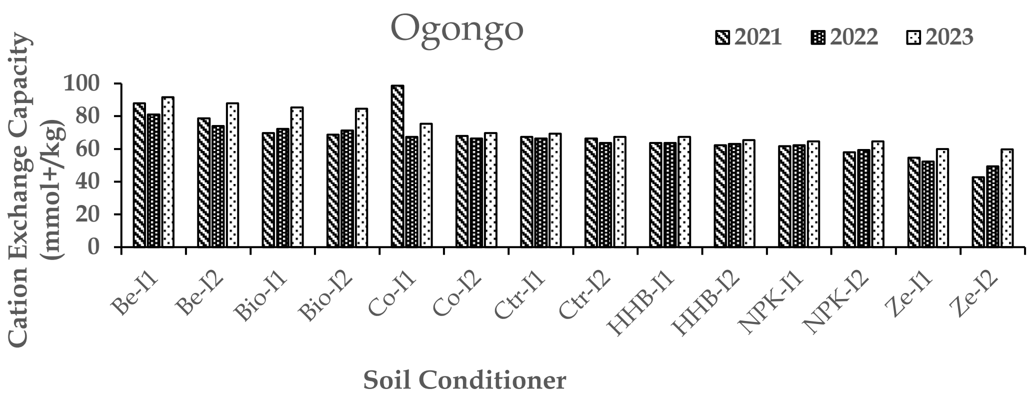

Figure 4. The effect of amendment on CEC over the three seasons.

Conclusion

Soil amendment improves agricultural productivity, but their effectiveness depends on their selection, application, and continuous soil monitoring of the soil's fertility status through soil testing.

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7.2 Evaluating the impact of rice straw compost mixed with different urea levels on the growth and yield of carrots *(Daucus carota subsp. Sativus)* in northern Namibia

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Introduction

Namibia, a predominantly semi-arid country characterized by low rainfall (Awala et al., 2019), is faced with several agricultural production limiting factors such as, erratic rainfall, floods and more critically, poor soils. Northern Namibian soils being predominantly sandy, successful vegetable production requires effective soil amendment. Composting is reported to influence the quality of the soil by improving the soil structure and texture, increasing soil micro-organisms and soil aeration (McGrath et al., 2020), these soil properties improve soil productivity which results in improved plant growth as well as sustainability in agricultural production (Duong, 2013). In 2007, Namibia started producing rice (Magadza, 2010), with the presence of extensive seasonal wetlands locally known as Iishanas, therefore the possibility of accelerated rice production is very high. Rice straw materials have been used in compost making (Li et al., 2008; Mahmoud et al., 2009; Roca-Pérez et al., 2009) to improve soil quality. Agriculture continues to be the backbone of the Namibian economy. However, the country is not self-food sufficient and relies on imports to meet local food demands. Vegetable production in Namibia remains deficient due to low rainfall and poor soils. Rice straw compost is a good soil enhancer, and it is cheaper, as it is readily available, and easy to make. Whereas, chemical fertilizers are not readily available, they are expensive and have a harmful effect on the environment. This study comparatively evaluated the effects of rice straw composts mixed with different urea levels on the growth and yield of carrots grown on the sandy, alkaline soils in north-central Namibia. The objectives of the study were to [1]evaluate the effect of rice straw compost on plant growth characters (plant height, root shape, root length and the number of leaves per plant) of carrots,[2]to test the effect of rice straw compost mixed with different levels of urea treatment on the yield of carrots (roots), and [3]to evaluate the effect of rice straw compost mixed with different urea levels on the biomass.

Method

The study was carried out at the experimental field of Ogongo UNAM Campus. The experimental farm is situated in the north central part of Namibia in Omusati region. A complete randomized block design (RCBD) was used having 6 treatments with a combination of the kuroda variety and 6 different percentages of urea solution. The six treatments of urea solution were as follow; 0% (control),0.1% ,0.5%,1.0%,1.5%, and 2.0% of urea solution. Approximately 200 kg of un-chopped rice straw was stacked in blocks 1m height × 1m wide ×2m long) and then sprinkled with either of the six treatments of urea solution. Each block was covered with thick polythene sheets to conserve moisture, and the level of moisture was maintained at 60% water holding capacity by adding water at different intervals of composting. The material was allowed to decompose for three months, and two turnings was given at 15th and 30th days of composting. Data was collected on the plant height, root shape, root length, the number of leaves per plant, root weight and dry weight of the leaves which was randomly selected from the 360 plants. The leaves were counted whereas the plant height was measured from the soil level to the tip of the longest plant.

Results

Table 1. ANOVA table

Source	DF	Mean Square	F Value	Pr > F
Plant height	5	8.62609	3.41	0.0465
Root length	5	0.64637	0.34	0.8769
No of leaves	5	0.33458	0.43	0.8149
Fresh stem weight	5	878095	9.36	0.0016
Tuber weight	5	55658.8	1.55	0.2683

Table 1 indicates that there is highly significant difference among treatments for the parameter plant height and fresh root weight. There was, however, no statistical difference among treatments for the other parameters.

Conclusion

The research pertaining to the use of rice straw compost for vegetable production in Namibia is very limited. So far, no research has been conducted on the evaluation of rice straw compost mixed with different levels of urea on the growth of carrots in northern Namibia. Therefore, the goal of this experiment was to evaluate the utilization of rice straw compost mixed with different levels of urea and the effect it has on the growth parameters of carrots. The study showed that there a significant difference on the plant height and fresh weight of roots for carrots under compost mixed with 1% of urea. However, no significant difference was observed among treatments on the parameter root length, number of leaves and fresh stem weight. Thus, from these results we can then conclude that the compost mixed with 1% of urea gave the maximum record for plant height and root weight. Further to that, we recommend the experiment to be conducted again to confirm the validity of the experiment.

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7.3 Evaluation of new bread wheat *(Triticum aestivum)* varieties in Namibia on grain yield and quality

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Introduction

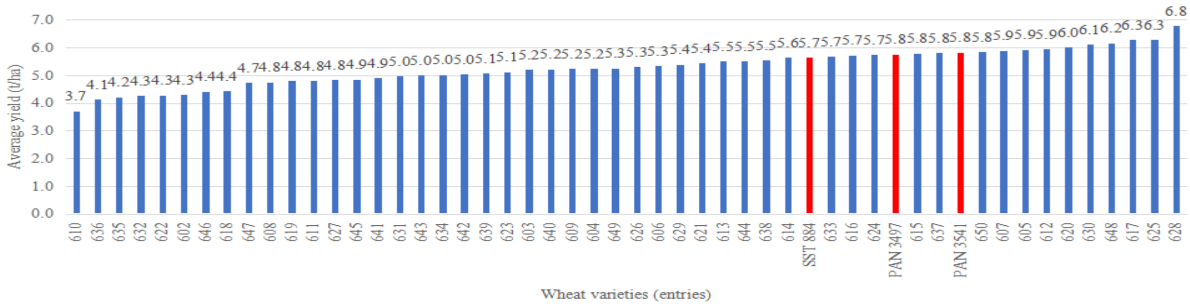
In Namibia, wheat is a vital cereal crop, but only 13% of the wheat demand is met locally, with 87% being imported due to a shortage of locally adapted crop varieties. Introducing high yielding and quality wheat varieties is seen as a significant step in increasing local wheat production and food security.

Method

The study was carried out in Mannheim, Hardap, and Mashare districts over two consecutive winter seasons (2021-2022). It employed a randomized complete block design (RCBD) with three replications and included 52 bread wheat lines (49 CIMMYT lines and 3 local commercial varieties). Data on quantitative traits (plant height, spike length, 1000 seed weight, and grain yield) were collected and analyzed using SAS statistical software. Qualitative traits, such as days to 50% heading and days to 50% maturity, were also recorded. In addition, quality testing, including hectolitre mass, moisture content, protein content, amylase content, and flour extraction rate, were conducted on the top-performing varieties from each site.

Results

Figure 1: Average grain yield of wheat varieties - Hardap, Mashare and Meinnheim)



Note: Local varieties in red bars.

Table 1: Summary of yield and quality Properties of wheat varieties

ENTRY	Mean Falling Number (s)	Mean Hectolitre mass (kg/hl)	Mean Protein Crude (%)	Mean Extraction %	Mean Moisture (%)	Mean grain yield (t/ha)	Rank based on grain yield	Days to Maturity	Classification of maturity*	Classification of quality based on grain Crude protein
ENT 633	409	71	17.3	49.3	10.0	5.7	18	109	Medium	
ENT 650	417	76	17.1	51.5	10.5	5.8	14	111	Medium	Super Grade
ENT 612	416	72	14.9	49.9	9.9	5.9	9	108	Medium	
ENT 607	363	75	14.6	56.9	10.2	5.9	8	107	Medium	
ENT 644	404	76	14.6	57.4	9.8	5.5	22	109	Medium	Super Grade
ENT 615	445	76	14.0	57.1	10.2	5.8	12	104	Early	Super Grade
ENT 613	485	79	13.9	56.7	9.9	5.5	20	105	Early	Super Grade
ENT 648	365	80	13.8	55.7	9.6	6.2	4	109	Medium	Super Grade
ENT 617	322	81	13.5	55.1	10.1	6.3	2	107	Medium	Super Grade
ENT 628	410	80	13.4	58.2	9.9	6.8	1	108	Medium	Super Grade
ENT 614	418	76	13.4	57.8	10.3	5.6	19	106	Medium	Super Grade
ENT 630	456	79	13.2	58.3	9.9	6.1	5	111	Medium	Super Grade
ENT 637	400	77	12.4	58.0	10.1	5.8	13	109	Medium	Grade 1
PAN 3541	415	80	12.3	61.6	10.1	5.8	11	108	Medium	Grade 1
ENT 624	408	79	12.1	62.7	9.5	5.7	17	107	Medium	Grade 1
ENT 625	395	78	12.1	56.6	10.0	6.3	3	105	Early	Grade 1
ENT 616	310	81	11.8	58.8	9.9	5.7	16	108	Medium	Grade 1
ENT 620	377	81	11.8	56.5	10.0	6	6	121	Late	Grade 1
SST 884	407	82	11.7	59.3	10.0	5.7	15	105	Early	Grade 1
PAN 3497	432	82	11.3	64.4	10.1	5.8	10	109	Medium	Grade 2
ENT 638	347	84	11.0	61.9	9.4	5.5	21	109	Medium	Grade 2
ENT 605	404	85	10.7	55.4	10.0	5.9	7	106	Medium	Grade 2

	>12.5%;	Super Grade,
	11.5 – 12.4%	Grade 1
	10.5 – 11.4%	Grade 2
	< 10.5	Grade 3

Note: Bars labelled red represent varieties downgraded by the Hectoliter mass of less than 75 Kg/hl.

Hardap produced the highest average grain yield (7.1 t/ha). This was followed by Mashare (5.3 t/ha) and Mannheim (3.5 t/ha). Each is significantly different from the other at 95% confidence. The highest combined mean grain yield was recorded by the varieties "628" (6.8t/ha) followed by "625" (6.3t/ha), and "617" (6.3 t/ha) (Figure 1). It was of interest to evaluate the grain quality of bread wheat varieties which had attained a mean grain yield of over 5.5 tonnes/ha. Except for 3 new varieties of bread wheat which were downgraded by the Hectoliter mass of less than 75 Kg/hl (variety 633, 612 and 607), based on the grain crude protein content nine (9) varieties attained Super grade, five (5) attained Grade 1, and three (3) qualified for Grade 2 (Table 1).

Conclusion

Upon analyzing the data across three environments, the early maturity variety 625, the medium maturity varieties 628, 717, 648 and 630 present a great promise for Namibia, based on both yield and quality parameters tested and recommendable.

Recommendation: It is recommended that agricultural sites implement streamlined management practices, aiming to raise grain protein levels, enhance grain density, and minimize pre-harvest sprouting. Key strategies involve timely planting and harvesting, along with effective soil fertility management.

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7.4 The effect of different plant growth regulator levels in potatoes *(Solanum tuberous l.)* Var Montreal by micropropagation

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Introduction

Potato (Solanum tuberosum L.) is a major industrial crop used for a variety of purposes around the world (Karp et al., 1987). It is a member of the Solanaceae family and is grown in 160 countries and regions around the world. It is the world's third most consumed crop, after wheat and rice, and Africa's fourth, with maize ranking third (Ahmet Metin KUMLAY, Canan KAYA, 2021). According to a Namibia Agronomic Board market intelligence report (2020), Asia produces approximately 50% of all potatoes, while Europe produces 30%. Africa, America, and Oceania account for 7%, 12.6%, and 0.5% of the total. Potato is the most popular horticultural product in Namibia, accounting for 39% of total horticultural fresh produce consumption. Considering the country's long history of production and good environmental conditions for the development of high-yielding and high-quality potato tubers, the national average productivity (10.30 tons/ha) is extremely low (NAB, 2021b). Tissue culture is one of the most fascinating aspects of biotechnology. The approaches of in-vitro plant production are primarily devoted to solving two basic problems: keeping plant cells and organs free of microorganisms (bacteria and fungi) (Attia & El-hallous, 2016) and ensuring desirable cell and organ growth by supplying sustainable nutritional media and other environmental conditions (Attia & El-hallous, 2016). In vitro propagation strategies based on sprouts and nodal cutting are more dependable in preserving the genetic integrity of multiple clones (Kapiel, 2017). The purpose of this study was to develop an efficient and dependable strategy for in vitro propagation.

Method

Experiments on the effect of different concentrations of certain growth regulators and their combinations on the tissue culture of potato (Solanum tuberosum L.) plantlets using nodal cuttings as explants were carried out from May 2023 to October 2023 at the Plant Tissue Culture Laboratory, Ogongo Campus, University of Namibia. The study employed MS medium containing vitamins as control, 1L of water, MS 4.43 g/L, sucrose 30%, and agar 7g/L. After adding all medium elements except agar, the pH was regulated to 5.8 by applying 1.0 N HCl or 1.0 N NaOH for balancing. After the pH was stable, agar was added to solidify the growth media and autoclaved at 121 ℃ for 20 minutes. The experiment had 4 levels of different concentrations of PGRs as treatments and were Complete Randomized Design replicated 4 times. The treatments are T1 - MS medium +30 sucrose g/L+7g/L agar; T2-T1 + 0.1 mg/L a-naphthaleneacetic acid (NAA+ 0.25 mg/L of benzyl aminopurine (BAP); T3 -T1 + 0.1mg/L NAA + 0.5 mg/L BAP; T4- T1 + 0.1mg/L NAA + 0.75 mg/L; T5- T1 + 0.1mg/L NAA + 1 mg/L BAP. The explants were rinsed under running tap water for 30 mins. For one hour, these explants were immersed in 0.3 g of antibiotic and a few drops of fungicide. The surface sterilization method of explant then was performed in a laminar airflow cabinet with 70% alcohol used. The explants were also submerged in water with a few drops of tween 20 and sodium hypochlorite for 5 minutes and swirled rapidly, this procedure was carried out three times. The explants were cultured for three months and then subculture every 21 days. The explants were kept in a culture environment at room temperature, with a photoperiod of 24 hours. The growth of potato plantlets was monitored. Data collection was on, number of explants, days to shoot formation, Number of Shoots, Shoot Length, Number of Roots and Root Length per explant. The acquired data was statistically examined using one-way analysis of variance (ANOVA) and LSD at the 5% level of significance by using R 4.3.0 software.

Results

For biometric parameters measures of Montreal on all the treatments, formation and development of shoots were observed in all MS medium, with or without BAP. Most of treatments were found statistically insignificant ($P>0.05$) except in Days to Shooting ($P<0.05$) where 0.1mg/L + 0.5 mg/L BAP has performed better with the highest number of leaves (21) and Shoot length (6.5 cm), and the others have also show positive results. The results showed that the PGR applications were efficient to shorten days to shoot initiation compared to regeneration on control medium. All the PGRs had root initiation (5.5 days), and the least amount of time to shooting (3 days). The results are in partial agreement with Kapiel, (2017) who recorded significant consequences of BAP on in vitro-grown potato nodal explants in terms of shoot induction. In another study, it has been illustrated that days to shoot appearance started 11.75 days earlier on MS medium including 0.25 mg/L BAP compared to the controls (Moon et al., 2021). The treatments had a meaningful influence in the days to root initiation compared to regeneration on control medium which has did not root at all. Despite the insignificant of data in some of the parameters, it is believed that most of the potato cultivars respond favourably to MS medium alone, (Kumar & Reddy, 2011). This is also in agreement with (Amiri & Mohammadi, 2021).

Conclusion

While some treatments in this study may not have shown statistical significance, the study highlights the potential of the 0.1mg/L + 0.5 mg/L BAP treatment for enhancing potato growth. Further research and experimentation are warranted to better understand the implications of these findings and to optimize potato cultivation practices for improved yield and quality. The findings of this research are useful in improving potato production by potato producers and closing the gap in food insecurity.

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