A Hidden Potential of Pigeon Peas Cultivation Practices to Curb Household Food Insecurity in Rural Areas of Eastern Southern Tanzania

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Abstract

Pigeon pea (Cajanus cajan) is a tropical legume with significant potential for enhancing food security and nutrition, particularly in semi-arid regions. This study assessed the impact of pigeon pea cultivation practices on household food security, dietary diversity, and economic wellbeing in two villages, Mibure (Ruangwa) and Mitumbati (Nachingwea), in the Lindi region of Tanzania. The study involved 300 farming households, with data collected through household surveys focusing on crop production practices, food availability, dietary diversity, and disposable crop income. Two major models were employed: (i) the direct effects of pigeon pea cultivation methods on household wellbeing indicators (adequate household food availability, household dietary diversity, disposable crop income, and calorie and protein production) and (ii) the effects of crop income and calorie production on adequate food availability and dietary diversity. Results revealed that 72% of maize-growing smallholders also grew pigeon peas, along with other legumes like beans and cowpeas. Intercropping was the predominant cropping practice, with over 50% of households using cereal-legume intercropping, while crop rotation was less common. Intercropping pigeon peas with cereals was significantly associated with increased household food availability and dietary diversity. Households practicing intercropping achieved higher disposable crop income and produced more calories and protein, contributing to improved food security and dietary outcomes. The study concludes that pigeon pea intercropping is an effective strategy for enhancing food and nutrition security in semi-arid regions of Tanzania. The results suggest that promoting legume-based intercropping systems could improve household food availability, dietary diversity, and economic wellbeing.

Keywords: Pigeon pea, food security, dietary diversity, intercropping, smallholder farmers, Tanzania, legume

Introduction

Pigeon pea *(Cajanus cajan)* has a substantial potential to increase food and nutrition security in semi-arid areas. Food insecurity is still a serious issue in these areas, especially in the sem-iarid regions of Lindi, Tanzania. Food availability varies seasonally, causing seasonal hunger gaps that can result in malnutrition and other related health problems (Msuya *et al.* 2018). Pigeon pea is an important source of protein, carbohydrates, crude fiber, essential amino acids, and micronutrients like calcium, iron, and manganese (Bhardwaj and Poonia, 2020; Kumar *et al*., 2020; Singh and Bharati, 2021). As a promising crop for semi-arid sub-Saharan Africa, pigeon pea is a drought-tolerant and nitrogen-fixing legume that also enhances soil fertility and offers a valuable food source in areas where food insecurity is a problem (Muthoni *et al*., 2020). Pigeon pea farming provides a resilient agricultural solution by enhancing food availability and household nutrition in light of the region's frequent droughts and erratic rainfall patterns (Shiferaw

et al. 2007).

Pigeon pea's high protein content is one of its main advantages; this is especially important in areas where diets are primarily composed of cereals and frequently do not provide enough protein (Singh and Subrahmanyam, 2014; Waldroup *et al*., 2004). Pigeon peas can serve as a nutritional safety net for smallholder farmers, boosting food security and producing more calories and protein. Also stated by Tiwari *et al*., (2014) that pigeon pea farming enhances dietary diversity in households by supplementing diets based on cereals, which are generally deficient in important nutrients. Pigeon pea increases soil fertility, which promotes the growth of other crops in intercropping systems because it is a nitrogen-fixing legume (Snapp *et al.*, 2002). Pigeon peas are frequently grown in Tanzania through intercropping systems alongside other staple crops like sorghum and maize. Due to its ability to optimize land use and enhance food production without the need for additional inputs, smallholder farmers frequently use intercropping, the practice of growing two or more crops together in the same field (Mkonda and He, 2018; Woomer *et al*., 2014).

Although pigeon pea has been shown to have numerous health benefits, little is known about how various agricultural practices, like crop rotation and intercropping, impact dietary diversity and household food security, especially in semi-arid areas. While incorporating legumes into cereal-based systems has been highlighted in previous research, few studies have examined the precise mechanisms by which these practices affect household food availability and nutrition outcomes in Tanzania (Msuya *et al*. 2018).

The objective of this research is to fill this gap by exploring the influence of common pigeon pea farming methods on household food security in the semi-arid districts of Ruangwa and Nachingwea in Lindi. It explores the correlation between pigeon pea intercropping and household dietary variety, surplus agricultural income, and the generation of protein and energy. By deciphering these connections, policy-makers and agricultural advisors can more effectively assist small-scale farmers in integrating agricultural methods that boost food and nutrition security.

Materials and methods

Study design

In two semi-arid Tanzanian villages, this study used a cross-sectional research design to examine the effects of distinct pigeon pea farming practices on different dimensions of household food security and well-being.

Description of the study area

The study was carried out in Lindi region of Tanzania in Mitumbati village in Nachingwea District and Mibure village in Ruangwa District. Because of their semi-arid climate and high smallholder farming density, these areas were chosen to offer an appropriate context for evaluating the effects of pigeon pea cultivation on food security.

Study population and sampling

Within the chosen villages, smallholder farming households made up the study population. The head of the household served as the primary respondent in the survey. A stratified random sampling technique was employed to select households, guaranteeing a representative sample of households engaged in various farming practices such as intercropping and monocropping systems.

The sampling procedure involved stratification where households were stratified based on their farming systems, such as intercropping, monocropping, and other methods. This stratification ensured that various farming practices are adequately represented in the study. Then followed random selection where within each stratum, households were selected randomly to eliminate selection bias and maintain the generalizability of the results. A total of 300 households participated in the study. This size provides sufficient statistical power to analyze differences among the various agricultural practices.

Data collection

Structured interviews with heads of households were used to collect data. The questionnaire asked about a number of topics such as:

- Demographic data, such as age, family size, and educational attainment.

- Crop practices: the kinds of crops cultivated, the methods used (crop rotation, monocropping, and intercropping).
- Household dietary diversity scores and months of sufficient food availability as two indicators of household food security.
- Economic indicators: Food expenses and disposable crop income.

Measurements

- Food Availability in the household: Measured by the number of months in which the household produced enough food on its own.
- Dietary diversity within the household: This is the number of food groups consumed by the household, as determined by a 24-hour dietary recall method.
- Disposable crop income: Remaining after production expenses are subtracted from crop sales proceeds.
- Calorie and protein production: Based on yield data, local food composition tables are used to convert harvested crop quantities into estimates of calories and protein.

Data Analysis

Data analysis was done using SPSS software Version 29 (SPSS Inc. USA (Chicago, IL). The farming methods and demographic traits were compiled using descriptive statistics. The associations between pigeon pea farming practices and the results of food security were analysed using inferential statistics, logistic regression models and chi-square tests. Two main models were computed: the Direct Effects Model which evaluated the direct effects of pigeon pea farming on household food availability, income, dietary diversity, and nutritional output and the Indirect Effects Model that looked at the relationship between dietary diversity and overall food availability as well as income and nutritional production.

Ethical Considerations

The Tanzania National Institute for Medical Research provided ethical approval for this study (NIMR/HQ/R.8a/Vol. IX/3040). Before data collection, informed consent was obtained from each participant, guaranteeing their voluntary participation and maintaining confidentiality.

Results

Cultivation practices

Results showed that pigeon peas were grown by a significant majority (72%) of smallholders who also grew maize, along with other legumes like beans and cowpeas. Cultivating through intercropping was the most common technique, used by more than half of the households. Crop rotation, on the other hand, was less common, used by less than 10% of the households.

Intercropping and food security

Comparing the farming practices of households practicing cereal-legume intercropping to those using monocropping or less diverse cropping systems, the analysis revealed that the former reported significantly higher months of adequate household food availability and increased dietary diversity (Table 1).

Table 1: Impact of intercropping on food security measures

Measure	Intercropping households	Non-Intercropping households	p-value
Months of adequate food supply	8.2 ± 3.1	5.6 ± 2.5	<0.001
Household Dietary Diversity	6.5 ± 1.4	4.7 ± 1.3	<0.001

Values are mean ± SD. Dietary diversity scores range from 0-10, with higher scores indicating greater diversity

Economic outcomes

Compared to their counterparts, intercropping households reported better protein and calorie production as well as higher disposable crop income. Increased food security measures were positively correlated with these economic gains ($p<0.001$) (Table 2).

Table 2: Economic outcomes and nutritional production

Economic Indicator	Intercropping Users	Non-Intercropping Users	p-value
Disposable crop income (USD)	320 ± 80	150 ± 60	<0.001
Calorie production (kcal)	12000 ± 3000	7500 ± 1800	<0.001
Protein production (kg)	150 ± 45	90 ± 30	<0.001

Values are mean ± SD. All economic values are approximated to the nearest dollar

Effects of pigeon pea cultivation practices on household food security

The regression models offered insights into the influence of pigeon pea farming techniques on domestic food security, highlighting both direct and indirect effects. The model corroborated the substantial role (p-value less than 0.001) of intercropping in improving food availability and dietary choices by increasing income from crops and nutritional benefits (Table 3).

Table 3: Influence of pigeon pea cultivation practices on household food security

Variable	Coefficient	95% CI	p-value
Months of adequate food availability	2.4	1.8 - 3.0	<0.001
Household dietary diversity	1.7	1.2 - 2.2	<0.001
Disposable crop income	170	120 - 220	<0.001
Calorie production	4500	3000 - 6000	<0.001
Protein production	60	40 - 80	<0.001

Coefficients represent the increase in the dependent variable per unit increase in the predictor variable, holding other factors constant.

Discussion

This study investigated how different aspects of household food security, dietary diversity, and economic wellbeing were affected by pigeon pea cultivation practices in two semi-arid districts of Lindi, Tanzania. The results showed that improving household food availability, dietary diversity, and economic outcomes were significantly enhanced by intercropping pigeon peas with cereals, a practice that was adopted by over half of the participating households. These findings emphasize the value of intercropping systems based on legumes for improving food security and nutritional status in rural areas with limited resources.

The leguminous crop pigeon peas is an excellent crop to address micronutrient deficiencies in vulnerable populations because it provides essential nutrients like protein, iron, and fiber that are crucial for food security and nutrition (Nedumaran *et al*. (2015). In this study, households growing pigeon peas reported producing more protein and calories, especially through intercropping, which increased dietary diversity and prolonged periods of sufficient food availability. The results are consistent with earlier research that highlighted the nutritional value of pigeon peas in low-income environments, where they are an essential source of micronutrients and plant-based protein (Mula and Saxena, 2010). The increased yield of pigeon peas grown in intercropping with cereals was found to be significantly associated with improved household food security.

The fact that intercropping households produce significantly more protein and calories attests to the practice's ability to improve food security. The increased production of these nutrients indicates that intercropping pigeon peas with cereals could help address both macro- and micronutrient deficiencies in rural communities, as calories and protein intake are important indicators of nutritional wellbeing (Nedumaran *et al.*, 2015).

The current study discovered that intercropping was connected with significantly higher crop income that could be used for other purposes besides nutrition. Regarding crop income, households that intercropped reported almost twice as much as those that did not. These financial gains most likely result from crop

output diversification, which gives households more crops to sell in nearby markets in addition to food for consumption (Rao *et al*., 2017). Households may be able to invest in other food and non-food resources thanks to the financial benefits of intercropping, thus improving their general well-being. This research highlights how legume-based intercropping systems can support food and income security, which is important to take into account in areas where smallholder farmers depend on agriculture as their main source of income (Akinnifesi *et al*., 2010).

The low prevalence of monocropping and crop rotation systems found in this study may reflect the difficulties smallholder farmers in semi-arid areas face in accessing resources like water and agricultural inputs. Crop rotation has been demonstrated to enhance soil health and raise yields over time, but study households continue to adopt it at a low rate. This could be a result of ignorance or inability to obtain extension services that support these behaviours (Giller *et al*., 2009). However, this study's findings about the advantages of intercropping over monocropping emphasize how crucial it is to support sustainable and inexpensive farming methods like intercropping in order to increase agricultural productivity and food security.

Conclusions and Recommendations

Conclusion

This study emphasizes how intercropping pigeon peas can enhance household food security, dietary diversity, and economic results in Tanzania's semi-arid regions. The significance of legume-based cropping systems for improving the well-being of smallholder farming households is demonstrated by the positive correlations observed between intercropping and increased food availability, dietary diversity, and crop income. According to these results, pigeon pea intercropping could be a major solution to the problem of food and nutrition insecurity in rural Tanzania and other comparable settings. The results underscore the significant potential of integrating pigeon peas into cereal-based cropping systems to improve food security, dietary diversity, and economic outcomes among smallholder farming households in semi-arid regions. These findings provide empirical support for promoting legume intercropping as a strategic intervention to enhance household well-being in rural Tanzania.

Recommendations

The results of this research hold significant implication for policymakers and agricultural extension specialists seeking to enhance food stability and productivity in semi-arid areas. Considering the favourable influence of pigeon pea intercropping on household food provision and financial prosperity, initiatives should be undertaken to propagate this method via tailored agricultural extension projects. Authorities should likewise prioritize bettering farmers' access to essential resources like seeds and fertilizers, as well as offering technical guidance to guarantee the effective implementation of intercropping tactics (Sperling & McGuire, 2010).

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Conflict of interest

The authors of this article declare no conflicts of interest.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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References

Akinnifesi, F.K., Chirwa, P.W., Ajayi, O.C., Sileshi, G., Matakala, P., & Kwesiga, F.R. (2010). Contributions of agroforestry research and development to livelihood of smallholder farmers in Southern Africa: 1. Taking stock of the adaptation, adoption and impact of fertilizer tree options.

Agricultural Journal, 5(1), 58-75.

Bhardwaj, R., & Poonia, A. (2020). Nutritional and Health Benefits of Pigeon Pea (*Cajanus cajan* (L.) Millsp.). International Journal of Current Microbiology and Applied Sciences, 9(3), 2907-2919. https://doi.org/10.20546/ijcmas.2020.903.332

FAO. (2016). Minimum dietary diversity for women: A guide for measurement. Rome: FAO.

Giller, K.E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114(1), 23-34.

Kumar, S., Pandey, G., & Singh, N. (2020). The Role of Pigeon Pea (Cajanus cajan L.) in Nutritional Security: A Review. Legume Research: *An International Journal*, 43(5), 652-659. https://doi.org/10.18805/LR-450

Mkonda, M.Y., & He, X. (2018). Conservation agriculture in Tanzania: Sustainable farming practices for improving crop productivity and resilience to climate change. Sustainability, 10(12), 4386. https://doi.org/10.3390/su10124386

Mligo, E.S., Kangile, J.R., & Lupenza, E.E. (2016). Intercropping cereals with legumes: A strategy for enhancing food security and climate change adaptation in Tanzania. Agricultural Sciences, 7(9), 599-611.

Msuya, J.M., Kinabo, J., & Mamiro, P.S. (2018). The impact of agricultural practices on household food security and nutritional status in Tanzania. Food and Nutrition Bulletin, 39(4), 564-573.

Mula, M.G., & Saxena, K.B. (2010). Lifting the level of awareness on pigeonpea: A global perspective. SAT eJournal, 8, 1-19.

Muthoni, R., Mburu, J., & Onyango, C. (2020). Pigeon pea [Cajanus cajan (L.) Millsp.]: A Sustainable Food Security Crop in Drought-Prone Sub-Saharan Africa. Agriculture and Food Security, 9(1), 12. https://doi.org/10.1186/s40066-020-00248-3

NBS & ICF. (2016). Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16. Dar es Salaam, Tanzania, and Rockville, Maryland, USA: NBS and ICF.

Nedumaran, S., Abinaya, P., Jyosthnaa, P., Shraavya, B., Parthasarathy Rao, P., & Bantilan, M.C.S. (2015). Grain legumes production, consumption and trade trends in developing countries. ICRISAT Research Program Market, Institutions, Nutrition and Diversity (MIND), 1-34.

Rao, P.P., Jones, R.B., & Ryan, J.G. (2017). Pigeonpea as a key to food security and sustainable land use in India. Agroecology and Sustainable Food Systems, 41(3), 227-248.

Saxena, K.B., Kumar, R.V., & Rao, P.V. (2002). Pigeonpea nutrition and its improvement through conventional and molecular approaches. Plant Foods for Human Nutrition, 57(3), 347-370.

Shiferaw, B., Kebede, T.A., & You, L. (2007). Technology adoption under seed access constraints and the economic impacts of improved pigeonpea varieties in Tanzania. Agricultural Economics, 36(3), 281-292.

Singh, I., & Bharati, A. (2021). Nutritional Composition and Functional Properties of Pigeon Pea: A Critical Review. *Journal of Food Science and Technology,* 58(10), 3730-3742. https://doi.org/10.1007/s13197-021-05091-y

Snapp, S.S., Silim, S.N., Kanyama-Phiri, G., & McKnight, S. (2002). Pigeonpea diversity for improved food security and natural resource management in semi-arid Africa. Field Crops Research, 75(1), 69-78.

Sperling, L., & McGuire, S.J. (2010). Understanding and strengthening informal seed markets. Experimental Agriculture, 46(2), 119-136.

Tiwari, A., Amane, M., & Nagda, A. (2014). Pigeonpea: An overview of its growth and production. *Indian Journal of Agricultural Research,* 48(4), 292-299.

Waldroup, P. W., Jiang, Q., & Fritts, C. A. (2004). The use of feedstuffs in poultry diets: Pigeonpea as a protein source. Poultry Science, 83(5), 723-728.

Woomer, P.L., Mulei, W.M., & Alemu, B.M. (2014). Adoption and spread of improved pigeonpea in Eastern and Southern Africa. *Journal of SAT Agricultural Research*, 12, 1-9.