International Journal of Scientific Multidisciplinary Research (IJSMR)
Vol.3, No.1, 2025: 65-78

Pre-Extension Demonstration and Evaluation of Maize (Zea Mays l.) -Haricot Bean (Phaseolus Vulgaris L.) Intercropping Practices in Midlands of Guji Zone, Southern Oromia, Ethiopia

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A R T I C L E I N F O

Keywords: Demonstration, Intercropping Metrics, Farmers' Preference

Received : 12 November
Revised : 17 December
Accepted: 20 January

A B S T R A C T

The Planting two or more crops at the same time and location is known as intercropping. During the 2019 primary rainy season, the work was done in the Guji Zone in Oromia, Ethiopia, as well as the districts of Adola Rede and Odo Shakiso. Calculating the yield output and cost-benefit ratio of haricot bean and maize intercropping techniques under farmer conditions, as well as the preferences of farmers and other stakeholders, are among the objectives of the demonstration. A district's two Kebeles, or sites, were chosen depending on their potential to produce maize and haricot beans. Fifteen farmers were picked from each Kebele/site and placed in a single FRG. As a result, four FRGs with 60 farmers (15 women and 45 men) were formed. Better haricot bean (Haramaya) and maize (BH-546) cultivars have been shown by growing the crops alone in 100 m2 plots of each species, with the necessary amounts of seed and fertilizer placed 40 cm apart from one another and 10 and 75 cm apart for the haricot bean and maize, respectively. Field days, technological reviews, exchange visits, and training enhanced farmer-to-farmer knowledge of haricot bean-corn intercropping methods. Intercropping metrics, measurement, in-person interviews, and observation were employed to obtain the information. Descriptive statistics and a qualitative examination of the farmers' preferences were used to analyze the data. According to the demonstration results, a net return of 28,007.67 ETB/ha was achieved by producing 2.746 tons of maize and 2.323 tons of haricot beans per hectare

DOI: https://doi.org/10.55927/ijsmr.v3i1.9901
ISSN-E: 2986-5042
https://journal.formosapublisher.org/index.php/ijsmr

INTRODUCTION

Food security in the developing world is being threatened by the massive global demand for agricultural commodities brought on by population expansion and shifting consumption patterns, which calls for higher output. Increased food production area, sometimes the first tactic to boost productivity is to sacrifice other land uses, such as pasture and forest areas. This technique is not practical for most smallholder agricultural systems, because additional land is scarce. The best course of action would therefore be to intensify production by finding methods to increase agricultural productivity per unit area of available land by expanding in both space and time combination. Smallholder farmers may be able to benefit from the method by increasing yields and lowering risk of crop failure and enhance the fertility of the soil.

In the developing world, Intercropping legumes and cereals, especially maize and beans, is common and can be the ideal choice for farmers with limited resources who want to guarantee sustainable production and food security. In tropical places, particularly in Africa, intercropping has been practiced for over a millennium, and smallholder farmers still utilize it today. Intercropping systems are preferred by farmers over monoculture systems for a number of reasons is their ability to produce more, especially in developing nations where resource-constrained and subsistence agriculture systems are more common. Here, the term "overyielding" describes the increased yield that can be obtained by intercropping species as opposed to monoculture [9]. Complementarity in the usage of environmental resources like land and soil could be one reason for the overyielding occurrence in intercropping systems nutrients, light, and water, as a result of niche partitioning and decreased interspecies competition.

Ethiopia's main staple crops are maize and haricot beans, which are classified as pulses and cereals, respectively. Maize is a staple grain crop for family meals. It is utilized worldwide as animal feed and is a major source of carbohydrates for human meals in developing nations. Haricot beans' quick maturity and simplicity of intercropping make them a crucial component of smallholder agricultural methods. Long-term soil fertility enhancement depends on its ability to fix nitrogen. Intercropping, which offers greater financial stability than single cropping, is simple to implement on labor-intensive smallholder farms.

The feasibility of Ethiopia's crop production system depends on the amount and distribution of rainfall. The production of crops for domestic use was directly impacted by the midland Guji Zones' land scarcity and moisture stress. An ever-growing human population has always been fed by land, a limited resource. Therefore, intensifying this fixed resource for higher production and farm return is the most successful intercropping approach. Nowadays, there is a shortage of land for growing different crops. Certain land areas are underutilized, despite the fact that certain crops are advised. In the study areas, farmers cultivated cereal crops year after year without rotation, growing haricot beans and maize in the same row as before. But such actions can lead to decreased soil fertility and low output. Legumes-cereal rotation and appropriate maize-haricot bean intercropping are hence crucial. Thus, it is crucial to demonstrate maize-haricot bean intercropping in the Guji zone's midland prior to extension.

LITERATURE REVIEW

The dissatisfaction from the 1980s gave rise to the establishment of so-called participatory methods to development, aiming at integrating the beneficiaries in the process of development. " Development participation is the process by which all stakeholders are fairly and actively included in the creation of development policies and strategies as well as in the planning, analysis, execution, monitoring, and assessment of development activities entails. This approach still promotes "empowerment" and "transformation," two important facets of social movements [17], but participation is more of an alternative type of development than an alternative to development, just like social movements are. It's a process. Any stage of development initiatives can benefit from the application of participatory methodologies argued for the advantages of a participatory Development projects become more effective when a linear approach is used because of the following benefits: "increased mobilization of stakeholder ownership of policies and initiatives; improved social cohesion, efficiency, and understanding; more affordable services; higher accountability and transparency; greater empowerment of the underprivileged and impoverished; and bolstering of people's learning and action capacities."

Before new technology are widely distributed to farmers, demonstrations are a useful way to assess their efficacy. Farmers can observe the advantages of the technology directly during these demos, enabling them to make well-informed judgments regarding their adoption [21The demonstration method is an extension teaching strategy that teaches a group of people how to execute an old or entirely new skill in a more effective manner. The farmer is guided through each phase of the demonstration.

METHODOLOGY

Description of Study Areas

About 470 and 490 kilometers south of Addis Ababa lie the districts of Adola Rede and Odo Shakiso, respectively. Districts are defined by three agroclimatic zones: Kola (low land), Weina dega (midland), and Dega (high land). With varying degrees of cover, each zone is ideal for growing a variety of crops. The Districts typically receive 1000 mm of precipitation and 26°C of annual temperature. This situation led to the heavy use of two farming seasons. The primary farming season, Arfasa, begins in March and ends in April. Barley, wheat, haricot beans, and maize are the most often grown crops during this time. The second cropping season, known as Gana (short cropping season), began after the main cropping season's harvest. historically utilized to employ small-scale cereals like wheat, barley, and tef for double cropping. Mining, mixed farming, and the production of forest products are the primary sources of income in the study area.

Site Selection

A The Guji Zone's Odo Shakiso and Adola Rede districts hosted a pre-extension demonstration of maize-haricot bean intercropping techniques. Two Kebeles were particularly chosen from each area based on their ability to grow maize and haricot beans. From each kebele, fifteen farmers were selected.

Hosting Farmers' Selection

The Farmers and groups under hosting farmers were selected using the farmer's research group (FRG) technique. The four FRGs had 15 female members and 45 male members. Out of the FRG members, one FTC and twelve (12) interested hosting farmers were selected. Having sufficient space for the tests, making the effort to conduct the activity in a high-quality way, being near highways, and being willing to share the technology with others were the criteria used to select the hosting site farms.

Materials Used and Field Design

Two treatments—a haricot bean variety (Haramaya) and an adapted and suggested maize variety (BH-546)—were planted in 100 m2 plot sizes on the property of chosen hosting farmers during the main cropping season. It was shown that haricot bean and maize types may be grown exclusively as a control. A maize variety was sole-planted at a distance of 75 cm between rows and 25 cm within rows. The seed rate for the solo and intercropping plots was 25 kg/ha. The intercropping plots were planted in a single row between two rows of maize crop at a seed rate of 50 kg/ha for the intercropping plot and 100 kg/ha for the solo haricot bean distance of 10 cm inside each row. 40 cm by 10 cm between the plant and the row, respectively.

At Assuming that the haricot bean would benefit from nitrogen fixation, At the time of Following sowing, all maize and single haricot bean plots received 121 kg/ha of NPS, intercropped haricot bean plots received 50 kg/ha, and maize-specific urea was sprayed 50 kg/ha. The maize was given 50 kg/ha of nitrogen in the form of urea once it had reached the knee-height development stage. each plot. This approach was used because simultaneous haricot bean and maize intercropping produced better results and was more cost-effective than subsequent inter-seeding [22]. Weeding by hand was completed on schedule twice.

Data Types and Methods of Data Collection

Face-to-face interviews, measurements, and direct field observation were used to gather both qualitative and quantitative data. Grain and economic data were collected using data collection sheets. Face-to-face interviews were used to gather feedback using a checklist.

Intercropping Metrics

Monocropping and intercropping systems can currently be compared using a wide range of parameters. Regardless of the evaluation method employed, A comparison between the direct short-term performance of the intercrop and that of the monoculture is always the essential premise. Since the majority of research designs incorporate monoculture representations for each intercropped species, the advantages of intercropping can be compared within the framework of monocultures. The generally used metrics and their calculation methods, which are listed in Table 1, have been used to assess intercropping advantage.

Table 1. Frequently Employed Measures for Assessing the Benefits of Intercropping Example Metrics Show Two Species of Intercrops

Metrics	Description	How to Measure?	Decision Criteria	Reference
Land Equivalent Ratio (LER)	determines the proportion of acreage needed to cultivate the same amount of each crop species in the mixture if they were cultivated as monocultures as opposed to companion plants.	$LER_1 = \frac{Y1c}{Y1m}$, $LER_2 = \frac{Y2c}{Y2m}$, $LER = LER_1 + LER_2$	LER > 1 indicates an intercropping advantage.	[23]
Land Equivalent Coefficient (LEC)	evaluates how components interact with one another crops in the mixture.	$LEC = LER_1 \ x \ LER_2$	Yield advantage is obtained if the LEC value is > 0.25.	[24]
Relative Yield of Mixture (RYM)	evaluates the intercropping system's yield in relation to the monocropping system.	$RYM = \frac{Y1c + Y2c}{[(Y1m + Y2m)/2]}$	RYM > 1 indicates an intercropping advantage.	[25]
System Productivity Index (SPI)	uses a mono-crops yields ratio to translate the yield of one component crop into terms of another crop	$SPI = \frac{Y1m}{Y2m} \ Y2c + Y1c$	If SPI of intercrops > SPI of monocrops. It's advantageous	[26]

	in the combination.			
Crop Equivalent Yield (CEY)	based on prices, standardizes the yield of one of the mixture's component crops in relation to another component crop.	$CEY1 =$ Y1c + Y2c $\frac{P2}{P1}$	Advantageous if CEY of intercrops > CEY of monocrops.	[27]
Relative Value Total (RVT)	evaluates how much the intercropping system is worth in relation to the two most valuable monocultures.	RVT $= \frac{P1Y1c + P2Y2c}{P1Y1m}$ If P1Y1m > P2Y2m	RVT > 1 indicates intercropping advantage.	[28]

Where, Y1c or Y2c = Expected yield of crop 1 or 2 as a companion; Y1m or Y2m = Expected yield of crop 1 or 2 as a monoculture; P1 and P2 are the expected market prices of crops 1 and 2

Data Analysis Methods

Descriptive statistics were employed for the analysis of the gathered agronomic data. NFI (net farm income) was also used to calculate each treatment's profitability, and a qualitative analysis of farmers' preferences for the methods that were offered was also conducted. Intercropping measurements were used to compare the advantages of monocropping versus intercropping systems.

RESULTS AND DISCUSSION

Capacity Building on Maize-Haricot Bean Intercropping Practice

Selected members of the To enhance their understanding of the intercropping techniques between maize and haricot beans, the Farmers Research Group, Development Agents (DAs), and Subject Matter Specialists (SMSs) received training. Brief field days, exchange visits, and technological evaluation were conducted to increase farmer-to-farmer understanding of the production and management of maize-haricot bean intercropping. Farmers used solo cropping to evaluate the practice as well. During training, exchange visits, field days, and technology evaluations, multidisciplinary teams—including the Cereal, Pulse, and Extension Research teams—as well as other stakeholders—including the Offices of Agriculture and Natural Resources—actively contributed their expertise. A breakdown of the number of farmers, development agents, district office agricultural experts, and other participants who attended field days, training, exchange trips, and technological assessments of the practice of bean-maize-haricot demonstrations.

Table 2. Attendance and Capacity Building Strategies for the Haricot Bean and Maize Intercropping Practice Demonstration

Capacity building methods	Participants	Number of participants		
		Male	Female	Total
A. Training	Farmers	45	15	60
	Das	7	1	8
	SMSs	8	-	8
B. Exchange Visit	Farmers	20	-	20
	Das	3	1	4
	SMSs	3	1	4
	Others	4	1	5
C. Mini field day	Farmers	24	6	30
	Das	2	-	2
	SMSs	2	-	2
	Others	2	-	2

Own data result, 2019

DAs = development Agent, SMSs = subject matter specialist

Role of Farmers and Other Stakeholders in the Technology Demonstration and Evaluation

Table 3 below shows the responsibilities that researchers, farmers, extension agents, and other shareholders played during the technological demonstration.

Table 3. The Contribution of Farmers and Other Stakeholders to the Display of Technology

Actors	**Roles**
FRG members	engaged in managing, preparing the land, planting, assessing yield, and giving comments.
Hosting farmers	providing trail land, maintaining records, encouraging member participation, field monitoring, reporting in an emergency, and giving feedback.
Research teams	agronomic data collecting, field monitoring, social data gathering and analysis, training for FRG members and other actors, and creation of extension materials.
Extension workers	Community organization and facilitation are achieved by information sharing, monitoring, and feedback.
Other stakeholders	Information sharing, community facilitation, technological backup, and input supply.

The Yield Performance of Maize-Haricot Beans Demonstrated

The maize-haricot bean intercropping demonstration's outcomes showed that growing both crops together improves agricultural yield per unit area and is more advantageous than growing them individually. Compared to equivalent lone cropped yields of 2.71 tons/ha for maize and 3.35 tons/ha for haricot beans, the mean grain output of intercropping plots was 2.75 tons of maize and 2.32 tons of haricot beans per hectare. The following table (Table 4) shows the average yield performance of maize-haricot beans.

Table 4. Mean Yield Performance of Maize and Haricot Bean (Ton/Ha)

Treatments	Mean yield of maize and haricot bean (ton/ha)		
	N	Mean	Std. Deviation
BH-546 Sole	13	2.71	3.86
Haramaya Sole	13	3.35	10.72
BH-546 Intercropped	13	2.75	3.89
Haramaya Intercropped	13	2.32	6.08

Source: Own data result, 2019

BH-546 = maize variety, Haramaya = haricot bean variety, ton/ha = ton/hectare

Intercropping Metrics Analysis

The LER values ranged from 1.65 to 1.75, with The maize-haricot bean demonstration's average land equivalent ratio was 1.70 (Table 5). This result outperformed the findings of [29], which showed that the LER of common beans and maize in Ethiopia ranges from 1.29 to 1.69. Similarly, [30] found that intercropping maize and common beans had an LER of 1.43-1.54. Intercropping maize and haricot beans was more advantageous than single planting, as indicated by the Total Land Equivalent Ratio of 1.70. in terms of land utilization. In other words, compared to intercropping, monoculture of either of the component crops would require more acreage to produce the same yield.

A multiplicative indicator of the interaction between the two crop species in the intercropping system is the land-equivalent coefficient (LEC). The LEC result was 0.71, as Table 5 demonstrates. Since the LEC value is higher than 0.25, intercropping is more beneficial than growing a single crop.

The ratio of the overall production of the intercrop to the mean yield of the pure crops, known as the relative yield of mixtures (RYM), was 1.68 (Table 5). In terms of the intercropping system's relative yield in comparison to the monocropping system, the RYM result showed that maize-haricot bean intercropping was more advantageous than single cropping.

Table 5 shows that the system productivity index (SPI) value was 4.11. suggested using SPI to equalize a component crop's yield relative to another crop in the mixture [26]. Because SPI uses the yield ratio of monocrops to convert a component crop's yield into that of another crop in the mixture, the SPI of intercrops is greater than the SPI of monocrops. Therefore, it is beneficial to demonstrate maize-haricot beans prior to extension.

Crop equivalent yield, or CEY, is a statistic that standardizes component crop 2's output in relation to crop 1 using produce market values. Consequently, the CEY result for the intercrop was 5.78 (Table 5). In terms of the yield of one of the mixture's component crops in comparison to another, the prices show that the maize-haricot bean pre-extension example was advantageous

The relative value total (RVT) result was 1.99, as indicated in Table 5. It is necessary to compare the intercrop to the more valuable of the two monocultures. When a producer is worried about monetary worth. Therefore, pre-extension demonstrations of maize-haricot beans were beneficial due to 1.99. Due to the outcome of RVT is greater than 1

Table 5. Summary of Intercropping Metrics Analysis

Treatments	Grain yield ton/ha	LER	LEC	RYM	SPI	CEY	RVT	P1	P2
Sole maize	2.71	-	-	2.71	2.71	-	2.71	**7**	-
Sole haricot bean	3.35	-	-	3.35	3.35	-	3.35		8
Maize intercropped	2.75	1.01	1.01	2.75	2.75	2.75	2.75	-	-
Haricot bean intercropped	2.32	0.70	0.70	2.32	2.32	2.32	2.32	-	-
Total		**1.70**	**0.71**	**1.68**	**4.11**	**5.78**	**1.99**	**7**	**8**

Source: Computed From Own Data, 2019

Cost-Benefit Analysis of Maize-Haricot Bean Intercropping

The production costs and returns for the intercropping demonstration of haricot beans and maize were supplied by the hosting farms. Throughout the production process, both fixed and variable costs were incurred. Variable costs include things like clearing the land, buying seeds and fertilizer, planting, weeding, harvesting, and transporting. The fixed expense was the cost of land. During the production season, the fixed cost of land at the study site was 2500 ETB/ha for one season. During the 2019 production season, the average farm-gate prices for haricot beans and maize were 8 and 7 ETB/Kg, respectively. In the research area, the haricot bean (Haramaya) cultivar was much sought after for domestic consumption but not for the market. Farmers made money from the pre-extension demonstration of intercropping maize and haricot beans. yielding 28,007.67 ETB/ha, which is higher than the yields of 19,069.23 ETB/ha for haricot beans and 11,453.84 ETB/ha for maize. The economics of cultivating maize and haricot beans together are presented in Table 5.

Table 6. Shows the Profitability Analysis of the ETB Demonstration of Intercropping Maize and Haricot Beans/Ha

Items	Treatments		
	Sole maize	Sole haricot bean	Maize-haricot bean intercropping
Total Fixed cost	2,500	2,500	2,500
Total variable costs	5,000	5,200	7,300
Total Cost (TFC + TVC)	7,500	7,700	9,800
Average Revenue (P x Q)	18,953.84	26,769.23	37,807.67
Average Gross margin (TR-TVC)	13,953.84	21,569.23	30,507.67
Net Profit (GM-TFC)	**11,453.84**	**19,069.23**	**28,007.67**

Source: Own Data Result, 2019

Farmers' and other Stakeholders' Feedback on Maize-Haricot Bean Intercropping Practice

During the demonstration of Future studies on intercropping methods, such as maize-haricot bean intercropping, benefit greatly from the input that farmers supply. Every farmer has an own perspective. Farmers favored early-matured varieties, double cropping, economic advantage, and efficient land use during the technology evaluation yield. The results of the intercropping of maize and haricot beans as well as the matching maize and haricot bean individual crops were compared by farmers. in order to assess intercropping practices.

More crops are produced per unit area when maize and haricot beans are interplanted, as opposed to when they are grown separately. Stated differently, in order to get the same yield as their intercropping, more acreage will be needed for the monoculture of either of the component crops. Intercropping is also crucial for farmers to recuperate from a harvest loss brought on by unfavorable weather conditions while harvesting the remaining produce.

CONCLUSIONS AND RECOMMENDATIONS

Farmers were unaware of the crops to be interplanted, when to sow them, or the intercropping system, despite the fact that intercropping is practiced in the research region. They merely carried on with their previous methods, which resulted in lower farm productivity and return. While alternative row intercropping has numerous benefits, such as less competition between maize and haricot beans for light, space, and ease of maintenance, few farmers actually adopt row intercropping, which involves planting both crops on the same row. In the Guji zone's midland district, issues with moisture stress and land shortage are prevalent. A return of 28,007.67 ETB/ha was produced by the maize-haricot bean demonstration (27.46 qt/ha of maize plus 23.23 qt/ha of haricot bean). Intercropping maize with haricot increased its grain output. bean as opposed to growing only one crop. The addition of nitrogen from haricot beans to improve soil fertility may be the cause of this outcome. But when haricot beans were planted alone, they produced more than when they were interplanted with maize. This could be the haricot bean's exposure to maize's shading effect. For small-scale farmers, maize-haricot bean intercropping was advised based on yield, financial gain, and efficient land usage. Therefore, in the midland of Guji and comparable agroecologies, intercropping maize and haricot beans is advised to boost crop yields and reduce the impact of moisture stress and land shortages.

Author Contributions: The study's conception and design, material preparation, sowing, growing technique, and data gathering were all completed by the authors. B.K. and D.K. provided feedback on earlier iterations of the text, while Mr. G. A. conducted statistical analysis and wrote the first draft. All authors have approved the manuscript after reading the published version.

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