

Adoption and Impact of Wheat Row Planting Practice on Yield of Smallholder's Farmers in Arsi and West Arsi Zones, Oromia National Regional State, Ethiopia

Ibsa Dawid^{1*}, Ephrem Boka²

Oromia Agricultural Research Institute, Ethiopia

Corresponding Author: Ibsa Dawid dawidibsa33@gmail.com

ARTICLE INFO

Keywords: Adoption, Endogenous Switching Regression, Row-planting, Yield, Ethiopia

Received : 14 September 2025

Revised : 18 October 2025

Accepted: 21 November 2025

©2025 Dawid, Boka: This is an open-access article distributed under the terms of the [Creative Commons Attribution 4.0 International](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

Wheat row planting has been promoted in Ethiopia as an improved agronomic practice to enhance productivity and resource-use efficiency. However, its adoption and impact remain limited among smallholder farmers in the study area. This study assessed the adoption intensity, determinants, and impact of wheat row planting on yield among smallholder farmers. Utilizing both primary and secondary data, a multistage sampling technique was employed. Data collected via semi-structured questionnaires were analyzed using descriptive statistics, an adoption index, and an endogenous switching regression model. The results indicated that adoption of wheat row planting remains moderate, with 39.6% of farmers adopting the practice to varying degrees as low, medium, and high levels. The adoption decision was positively influenced by cultivated land size, livestock ownership, access to improved seed, frequency of extension contact, participation in training, labor availability, and fertilizer use, whereas market distance had a negative effect. Impact analysis revealed that adopters achieved a 13% higher wheat yield than if they had not adopted, while non-adopters could potentially increase yield by about 9.7% through adoption. Therefore, wheat row planting significantly improves productivity among smallholder farmers. Policymakers and researchers should strengthen extension and training services, ensure timely access to improved inputs, and promote labor-saving technologies to enhance adoption and maximize the practice's impact in the study area.

INTRODUCTION

Agriculture remains the backbone of most developing countries, particularly in Sub-Saharan Africa (SSA), where economic policy has long depended on the sector to drive growth and reduce poverty (World Bank, 2014). However, agricultural production and productivity in SSA remain low, largely due to limited adoption of improved technologies and continued reliance on traditional practices (Abraham et al., 2014; Gashaw et al., 2014). Ethiopia is the leading wheat producer in SSA, benefiting from favorable agro-ecological conditions. Despite this potential, wheat yields under smallholder farming systems remain below attainable levels because of several production constraints, including low productivity, minimal use of improved inputs, and heavy reliance on rainfall and traditional farming practices (Mulu et al., 2022). Ethiopia's annual wheat production is estimated at 5.8 million tons, with an average productivity of 3 tons per hectare, well below the attainable yield of about 5 tons per hectare (CSA, 2021; Zegeye et al., 2020). The growing domestic demand for wheat has outpaced national production, forcing the country to import an estimated 1.5 million tons annually to meet consumption needs (FAOSTAT, 2018). This dependence on imports poses a serious challenge to food security and the national economy.

To address this challenge, the Ethiopian government and development partners have promoted various improved agricultural practices, such as wheat row planting, which has gained increasing attention. Wheat row planting has emerged as a promising agronomic practice for improving yields and input-use efficiency. Unlike traditional broadcasting, row planting uses lower seed rates, facilitates better weed control, reduces intra-plant competition, and enhances nutrient uptake and tillering (Chauhan et al., 2014). According to Sarah (2014), empirical studies have shown that farmers who use row planting can get yields that are 75–80% higher than those who use traditional methods. Consequently, extension programs have been actively promoting wheat row planting across major wheat-growing regions of Ethiopia, including Amhara, Oromia, SNNPR, and Tigray (Gashaw et al., 2014; Sarah, 2014).

In Oromia, particularly in the Arsi and West Arsi zones, often referred to as Ethiopia's "wheat belt," wheat row planting has been extensively promoted through the extension system. According to the Arsi Zone Agriculture Office (AZAO, 2024), of the total 281,678 hectares of cultivated land, 135,318 hectares (48%) were planted with wheat, and about 62% of this area was managed under row planting using manual, animal-drawn, or tractor-assisted methods. Despite this expansion, substantial yield gaps persist, and challenges such as high labor requirements, limited access to inputs, and inadequate technical knowledge continue to constrain the full benefits of row planting (Vandecastelen et al., 2013).

Although wheat row planting is widely known as a promising practice for enhancing production and productivity, its adoption remains uneven. Moreover, empirical evidence on adoption intensity, the determinants of adoption, and the actual impact of row planting on wheat yield among smallholder farmers in the Arsi and West Arsi zones is limited. This lack of information makes it difficult

for policymakers and extension agents to design effective, evidence-based strategies that can accelerate adoption and improve productivity. Therefore, this study aimed to assess the adoption and impact of wheat row-planting practices on smallholder farmers' wheat yield in the Arsi and West Arsi zones of Ethiopia. The study further aimed to provide empirical evidence to inform strategies for improving wheat productivity and enhancing smallholder livelihoods.

RESEARCH METHODOLOGY

Description of the study area

This study was conducted in the Arsi and West Arsi zones of Oromia Regional State, Ethiopia. The Arsi zone is divided into twenty-five administrative districts and one administrative town, Asella. The zone is located in central Oromia, 175 km southeast of Addis Ababa, and covers an estimated area of 19,825.22 km² (1,982,522 ha). The mean annual temperature ranges from 20°C to 25°C in the lowlands and from 10°C to 15°C in the central highlands. Mixed farming is the dominant agricultural system in the zone (AZAO, 2024). Similarly, the West Arsi zone is situated about 250 km south of Addis Ababa and is divided into eleven districts and one administrative town, Shashamane, which serves as the zonal capital. The zone has a land area of approximately 1,177,440 hectares (12,938 km²). Across the highlands, midlands, and lowlands, crop-livestock mixed farming, pastoralism, and agro-pastoralism are commonly practiced (WAZAO, 2024). Wheat is one of the major food and cash crops in both zones and plays an important role for household consumption and market supply.

Data types, sources, and methods of data collection

The data for this study were collected from both primary and secondary sources. Cross-sectional data were obtained through a survey of randomly selected sample farmers. The primary data were gathered using a semi-structured questionnaire and included both quantitative and qualitative information. In addition, focus group discussions and key informant interviews were conducted to supplement and triangulate the information obtained through the questionnaire. Secondary data were obtained from published and unpublished materials, including reports from district agriculture offices and kebele administration offices.

Sampling procedures and sample size

A multi-stage sampling technique was used to select representative farm households for this study. Both purposive and random sampling methods were applied at different stages to ensure the selection of households that adequately represented the study population. In the first stage, two districts from each of the Arsi and West Arsi zones were purposively selected, in consultation with zonal agricultural experts, based on their high wheat production potential and the prevalence of wheat row-planting practices. Purposive selection ensured that the study focused on areas where row planting had been introduced and widely disseminated, thereby enabling a meaningful assessment of adoption and impact. In the second stage, within the selected districts, two kebeles from each district were purposively selected in consultation with district agricultural

experts. In the third stage, households in the selected kebeles were stratified into adopters and non-adopters of wheat row-planting practices. Thereafter, a simple random sampling technique was applied to select 202 representative households, proportionally allocated to the population size of each kebele. Of the total sample, 80 households were adopters of wheat row planting, whereas 122 were non-adopters. The sample size was determined using Cochran's (1977) formula. Assuming a 95% confidence level ($Z=1.96$), an estimated proportion of households adopting wheat row planting ($p=0.40$) and non-adopters ($q=0.60$). The corresponding margin of error for this sample size is approximately 6.7%, which ensures a representative sample while accounting for the total population size. Thus, the sample size was calculated as:

$$n_0 = \frac{z^2 * p * q}{e^2} = \frac{3.84 * 0.4 * 0.6}{(0.067)^2} = \frac{0.9216}{0.00456} = 202$$

METHODOLOGY

Descriptive statistical analysis

The descriptive statistics such as mean, minimum, maximum, percentage, and frequency were used to summarize the adoption status of wheat row planting practices.

Estimation of adoption intensity or adoption index

The adoption index was used to measure the level of adoption under row planting for each sample household at the time of the survey. The adoption index score was calculated by dividing area allocated for wheat production using row planting to total cultivated area for wheat production by the i^{th} farmer. The rationale for calculating the adoption index was to know the level of adoption of row planting for wheat production in the study area following the work of Dinku and Beyene (2019). The adoption index for each respondent farmer was calculated as:

$$AI_i = \frac{\text{Total wheat Area under row planting}}{\text{Total Area Allocated for wheat production}}$$

Where: AI_i is the adoption intensity or index of the i^{th} farmer, and i represents farmers. Following the computation of AI scores, respondents were categorized as low, medium, high, or non-adopters based on their AI value. The actual adoption index score ranges from 0 to 1. Based on this index, farmers were categorized into four groups: non-adopters (0), low adopters (0.01–0.33), medium adopters (0.34–0.66), and high adopters (0.67–1.00).

Endogenous Switching Regression (ESR)

To estimate the impact of technology adoption and farm practices, several studies have applied econometric models such as Propensity Score Matching (PSM) and Instrumental Variable (IV) approaches. However, aside from the selection bias associated with non-random participation in technology adoption (such as row planting in this study), heterogeneity in the impact of technologies across farmers remains an important econometric dare. Many impact assessment methods fail to adequately capture both observable and unobservable factors influencing technology adoption and outcomes.

The PSM approach is effective only when differences between adopters and non-adopters can be fully explained by observable variables. If unobservable characteristics affect both adoption decisions and outcome variables, PSM results become biased. Similarly, IV methods account for unobserved heterogeneity but assume a parallel shift in outcome variables as the treatment effect (Ahmed et al., 2017). Moreover, conventional regression models that pool adopters and non-adopters are inadequate because they assume that the same set of explanatory variables affects both groups equally.

In contrast, the Endogenous Switching Regression (ESR) model effectively addresses both selection bias and heterogeneity. The ESR framework is therefore well-suited to this study's objectives of identifying the factors influencing smallholder farmers' adoption of wheat row planting practices (first stage) and estimating its impact on wheat yield (second stage). The ESR model corrects for self-selection bias arising from both observed and unobserved factors that simultaneously influence adoption and yield (Sileshi et al., 2019). There are two phases in the ESR framework.

In the first stage, a probit model is used to estimate the determinants of wheat row planting adoption. The model assumes that a farmer adopts wheat row planting if the expected utility from adoption exceeds that from non-adoption, i.e. if $P_i^* = u_p - u_{np} > 0$, where, u_p is the utility from adoption and u_{np} is the utility from non-adoption. Since these utilities are unobservable, adoption is modeled as a latent variable determined by observable household characteristics:

$$P_i^* = \alpha Z_i + \varepsilon, \quad P_i = \begin{cases} 1 & \text{if } P_i^* > 0 \text{ (adopter)} \\ 0 & \text{if otherwise (non-adopter)} \end{cases}$$

Where P_i^* is the latent adoption variable, Z_i is a vector of explanatory variables, and ε is the error term.

Because unobserved characteristics affecting adoption may also influence yield, the selection equation is potentially endogenous, resulting in biased estimates. To correct for this, **instrumental variables (IVs)** are included that influence adoption but not yield directly. Following previous evidence (Jaleta et al., 2018 and Sileshi et al., 2019), *frequency of extension contact* and *training on row planting* were used as instruments. These variables are expected to affect adoption through information and awareness creation rather than directly influencing wheat yield.

A **falsification test** was performed to verify instrument validity. The results showed that the selected instruments were jointly significant in explaining adoption ($\chi^2 = 33.83$, $p = 0.000$), confirming their relevance. In contrast, they were insignificant in yield equations for both adopters ($F = 0.23$, $p = 0.7966$) and non-adopters ($F = 0.61$, $p = 0.5460$), supporting their validity under the exclusion restriction.

In the second stage, yield equations are estimated separately for adopters and non-adopters using Ordinary Least Squares (OLS), incorporating selectivity correction terms (inverse Mills ratios) obtained from the first stage. The two outcome equations can be written as:

$$y_1 = X_1\beta_1 + \varepsilon_1, \text{ if } P_i = 1 \quad (\text{Adopters})$$

$$y_0 = X_0\beta_0 + \varepsilon_0, \text{ if } P_i = 0 \quad (\text{Non-adopters})$$

Where y_i and y_0 are estimated outcome variable (wheat yields in kg/ha) for adopters and non-adopters, respectively, β_1 and β_0 are parameters to be estimated, X_1 and X_0 are the vector of independent variables that influence wheat yield, and ε_1 and ε_0 are the error terms for adopters and non-adopters, respectively. The error terms of the selection and outcome equations are assumed to follow a trivariate normal distribution with mean zero and covariance matrix:

$$\text{cov}(\varepsilon, \varepsilon_1, \varepsilon_0) = \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon\varepsilon_1} & \sigma_{\varepsilon\varepsilon_0} \\ \sigma_{\varepsilon_1\varepsilon} & \sigma_{\varepsilon_1}^2 & \cdot \\ \sigma_{\varepsilon_0\varepsilon} & \cdot & \sigma_{\varepsilon_0}^2 \end{bmatrix}$$

The correlation between the selection and outcome errors $\sigma_{\varepsilon\varepsilon_1}$, $\sigma_{\varepsilon\varepsilon_0}$ captures the presence of selection bias. If these correlations are statistically significant, self-selection exists. Using the inverse Mills ratios λ_1 and λ_0 , the outcome equations are re-specified as:

$$y_1 = X_1\beta_1 + \sigma_{\varepsilon_1\varepsilon}\lambda_1 + \mu_1, \text{ for } P_i = 1$$

$$y_0 = X_0\beta_0 + \sigma_{\varepsilon_0\varepsilon}\lambda_0 + \mu_0, \text{ for } P_i = 0$$

Where, λ_1 and λ_0 are derived from the standard normal density and cumulative distribution functions and serve as selectivity correction terms.

The ESR framework enables the estimation of actual and counterfactual outcomes.

$$\text{For Adopters} \quad E(y_1 | P_i = 1) = X_1\beta_1 + \sigma_{\varepsilon_1\varepsilon}\lambda_1$$

$$E(y_0 | P_i = 1) = X_1\beta_0 + \sigma_{\varepsilon_0\varepsilon}\lambda_1$$

$$\text{For Non-adopters} \quad E(y_0 | P_i = 0) = X_0\beta_0 + \sigma_{\varepsilon_0\varepsilon}\lambda_0$$

$$E(y_1 | P_i = 0) = X_0\beta_1 + \sigma_{\varepsilon_1\varepsilon}\lambda_1$$

The Average Treatment Effect on the Treated (ATT) and Average Treatment Effect on the Untreated (ATU) are computed as:

$$ATT = E(y_1 | P_i = 1) - E(y_0 | P_i = 1)$$

$$ATU = E(y_1 | P_i = 0) - E(y_0 | P_i = 0)$$

These measures capture the difference between actual and counterfactual wheat yields, quantifying the productivity impact of wheat row planting among adopters and the potential gains for non-adopters if they had adopted the practice. Even though the households in this group have adopted wheat row planting practices, it is possible that they were inherently more productive than non-adopters due to unobservable characteristics. These factors might have contributed to higher wheat yields, independent of the adoption decision itself. This phenomenon is captured through the **base heterogeneity effect**, which measures the difference in expected outcomes between adopters and non-adopters under the same production regime, thereby reflecting underlying yield

differences that are not directly observable. The base heterogeneity for adopters and non-adopters as follows:

$$\text{Base heterogeneity for adopters } BH_1 = E(y_1 | P_i = 1) - E(y_1 | P_i = 0)$$

$$\text{Base heterogeneity for non-adopters } BH_0 = E(y_0 | P_i = 1) - E(y_0 | P_i = 0)$$

Transitional heterogeneity (TH) measures whether the productivity impact of wheat row planting is greater for those who actually adopted the practice compared to non-adopters in the hypothetical scenario that they had adopted. $TH = ATT - ATU$

Variables definition and description

Dependent variable: Adoption of wheat row planting practices, it is a dummy variable that takes the value 1 if the household adopted wheat row planting practices and 0 otherwise.

Outcome variable: It is a continuous, measured as the total wheat yield (in quintals per hectare) per household.

Explanatory variables: Are those hypothesized to influence either the adoption decision or the productivity outcome. The variables were selected based on economic theory, previous empirical studies, and contextual relevance. They are presented and described briefly in Table 1.

Table 1. Description of the explanatory variables and their signs (direction)

Explanatory variables	Category	Measurements	Expected sign
Sex of the household head	Dummy	1=Male 0=female	±
Age of the household head	Continuous	Number of years	-
Education level of household head	Continuous	Years	+
Family size of the households	Continuous	Adult equivalent	±
Livestock ownership	Continuous	TLU	+
Distance to nearest market	Continuous	Hour	-
Total cultivated land	Continuous	Hectares	+
Access to credit services	Dummy	1= yes, 0= No	+
Access and use of improved seed	Dummy	1= yes, 0= No	+
Access to market information	Dummy	1= yes, 0= No	+
Frequency of extension contact	Continuous	Numbers	+
Cooperative membership	Dummy	1= yes, 0= No	+
Participation in training	Dummy	1= yes, 0= No	+
Availability of farm labor	Dummy	1= yes, 0= No	+
Participation in non/off-farm	Dummy	1= yes, 0= No	±
Use of chemical fertilizers	Dummy	1= yes, 0= No	+

RESULTS AND DISCUSSION

Adoption status of wheat row planting practices

In this study, farmers who did not produce wheat using row planting were considered as non-adopters, whereas the farmers who produced wheat using row planting were taken as adopters. According to the results, out of the total respondents, 80 (40%) were adopters of wheat row planting practices, whereas 122 (60%) were non-adopters of wheat row planting (Table 2).

Table 2. Adoption status of wheat row planting practices in the study area

Category of the respondents	Frequency	Percent
Non-adopters	122	60.40
Adopters	80	39.60
Total	202	100.00

Source: Computed from own survey data (2025)

According to adopters of wheat row planting practices, the adoption of this technology has had a positive impact on wheat production by increasing productivity and household income, while also reducing the seeding rate. On the other hand, non-adopter households reported several reasons for not adopting wheat row planting. These included the perception that the practice is time-consuming during plowing and sowing, shortage of labor, unsuitability of cultivated land, lack of personal interest, and limited farm size. Other challenges mentioned were the shortage of row planters (**limited availability of row planters**) and delays or insufficient supply of agricultural inputs.

Furthermore, during focus group discussions, participants emphasized that both governmental and non-governmental organizations should strengthen their support by providing wheat row planter technologies. This would help substitute for labor shortages and minimize the time required for sowing operations.

Adoption intensity of wheat row planting practices

The results in Table 3 indicate that about **60.4%** of the respondents were non-adopters, whereas **39.6%** had adopted wheat row planting to varying degrees. Among adopters, **8.9%** were low-level adopters, **14.9%** medium adopters, and **15.8%** high-level adopters. The majority of adopters fell within **medium and high adoption levels**, suggesting a positive trend toward more complete adoption among those who had already embraced wheat row-planting practices. The **mean adoption index** was **0.35**, implying that, on average, households allocated **35%** of their wheat land to row planting. This finding indicates that although adoption is relatively widespread, the **intensity of adoption remains moderate**, reflecting partial implementation of the technology among adopters.

Moreover, it implies that, at the community level, most farmers use row planting on a moderate portion of their wheat fields. Variations in the area allocated to wheat row planting may be attributed to differences in landholding size, stage of adoption, access to resources, labor availability, and the level of institutional support among smallholder farmers in the study area.

Table 3: Distribution of sample households by level of adoption of wheat row planting

Adoption category	No.	%	Adoption index (AI)	Mean of AI	Min	Max
Non-adopters	122	60.40	0.00	0.00	0.00	0.00
Low adopters	18	8.91	0.01 - 0.33	20.02	10.0	31.3
Medium adopters	30	14.85	0.34 - 0.66	45.16	33.3	60.0
High adopters	32	15.84	0.67 - 1.00	94.53	66.7	100
All households	202	100.00	0.00 - 1.00	35.25	0.00	100

Source: Computed from own survey data, 2025

Econometric Model Results

Determinants of wheat row planting adoption practices

To identify the factors influencing households' decisions to adopt wheat row-planting practices, the first-stage results of the ESR binary probit model, along with their marginal effects, are presented in Table 4. The Wald chi-square statistic of the probit model indicates that the explanatory variables jointly and significantly affect the probability of adopting wheat row planting at the 1% significance level [Wald χ^2 (16) = 67.04; P = 0.000]. The effects of the significant explanatory variables on the adoption of wheat row-planting practices in the study area are discussed as follows.

Livestock ownership: Livestock ownership, measured in tropical livestock units (TLU), had a positive and significant effect on the adoption of wheat row planting practices at the 10% significance level. The marginal effect indicates that, holding other factors constant, a one-unit increase in TLU increases the probability of adopting wheat row planting by 1.6% (Table 4). This indicates that households with larger livestock holdings are more economically stable and capable of investing in improved agricultural technologies. Livestock also provides manure and serves as a major source of draft power and income, which can alleviate liquidity constraints and enhance a household's ability to purchase agricultural inputs required for row planting. This finding is consistent with previous studies by **Tamirat et al. (2019)**, **Mentire et al. (2017)**, and **Hailu et al. (2014)**, who also reported that livestock holdings positively influence smallholder farmers' decisions to adopt improved agricultural technologies.

Distance to nearest market: Distance to the nearest market had a negative and significant relationship with probability of adopting wheat row planting practices at 5% level of significance. The model result indicates that as the distance from the nearest market increase by one minute, keeping other things constant the probability of adopting wheat row planting practices decreases by 0.3% (Table 4). This means that farmers located farther from markets are less likely to adopt wheat row planting practices, likely due to higher transaction costs, reduced access to inputs, and limited exposure to market information. This is in line with previous studies by Amare (2018) and Beri and Degefu (2024) who found farmers who live closer to all-weather roads are respectively better prone to participate in new agricultural technologies.

Total cultivated land: It was found that cultivated land size had a positive and significant influence on the farmer's decision to adopt wheat row planting at less than 5% level of significance, meaning that the likelihood of participation increased with larger farm size. The result also showed that one more unit (hectare) increase in cultivated land size increases the probability of adoption of wheat row planting practices by 4.7% (Table 4). This indicated that farmers with larger landholdings are more likely to adopt improved agricultural technologies because they can better allocate part of their land for experimentation and bear potential risks associated with new practices. This result is consistent with the findings of **Tamirat et al. (2019)**, and **Hailu et al. (2014)**, who reported that land size enhances the likelihood of adopting improved technologies.

Access and use of improved seed: Access to and use of improved seed had a positive and significant relationship with adoption of wheat row planting

practices at less than 5% level of significance. The result shows that farmers who have access and use of improved seed are more likely to adopt wheat row planting practices by 17.2% than their counterparts (Table 4). This implies that farmers who have access and use of improved seed varieties are generally more exposed to extension services and better understand modern agronomic practices. Improved seeds often complement row planting methods for achieving higher productivity, so farmers with access to such inputs are more inclined to adopt the practice. This findings aligns with studies by Dinku and Beyene (2019), and Donkor et al. (2018) which indicated that availability and access to improved wheat seed have a positive effect on adoption of row planting for wheat production.

Frequency of extension contact: The result of the study indicated that, the frequency of extension contact was found to have a positive and statistically significant effect on the adoption of wheat row planting practices at the 1% significance level (Table 4). This finding suggests that regular interaction with extension agents enhances farmers' access to information, technical skills, and confidence in adopting improved agricultural technologies. This result aligns with the views expressed during focus group discussions, where participants noted that farmers with more frequent contact with development agents are more likely to adopt wheat row planting because they receive timely and relevant information about its advantages. This is in line with Beri and Degefu (2024), and Tolosa et al. (2014) who found that, extension contact has an influence on farm households' adoption of new technology.

Participation in training: The results indicated that participation in training had positively and significantly influenced the probability of adoption of wheat row planting practices at less than 1% significant level (Table 4). The marginal effect result indicates that farmers who participated in training were about 16.6% more likely to adopt wheat row planting compared to those who did not attend training. This finding suggests that farmers who frequently attend training sessions organized at Farmers' Training Centers or demonstration sites gain a better understanding of the benefits, techniques, and management practices associated with row planting. This finding is consistent with the results of Amare (2018) and Mentire et al. (2017), who reported that farmers who participated in training programs were more likely to adopt improved agricultural technologies such as row planting, as training positively influences farmers' decisions to adopt new practices.

Availability of farm labor: Availability of farm labor had a positive and statistically significant relationship with the adoption of wheat row planting practices at the 5% significance level (Table 4). This finding suggests that the presence of more working family members increases the likelihood of adopting the practice. Since wheat row planting is relatively labor-intensive, particularly during planting and weeding stages, households with adequate labor are more capable of implementing this improved practice than those facing labor shortages. This finding agrees with Dinku and Beyene (2019), and Beri and Degefu (2024), who also noted that labor availability promotes adoption of labor demanding agricultural technologies.

Table 4. Decision to adopt wheat row planting practices: first stage of ESR
 (Probit model)

Variables	Coefficien t	Robust std. err.	Z	P> z	Marginal Effects
Sex of the household head	-0.052	0.447	-0.12	0.908	-0.014
Age of the household head	-0.014	0.010	-1.38	0.168	-0.004
Educational level	0.042	0.035	1.18	0.239	0.011
Family size of the household	-0.033	0.042	-0.78	0.438	-0.008
Livestock ownership	0.062*	0.034	1.84	0.066	0.016
Distance to nearest market	-0.010**	0.005	-2.11	0.035	-0.003
Total cultivated land	0.176**	0.078	2.26	0.024	0.047
Access to credit services	0.149	0.271	0.55	0.581	0.039
Access and use of improved seed	0.651**	0.311	2.09	0.036	0.172
Access to market information	0.095	0.252	0.38	0.706	0.025
Frequency of extension contact	0.357***	0.109	3.28	0.001	0.095
Cooperative membership	0.090	0.251	0.36	0.720	0.024
Participation in training	0.629***	0.233	2.70	0.007	0.166
Availability of farm labor	0.569**	0.238	2.38	0.017	0.151
Participation in non/off-farm	0.326	0.233	1.40	0.161	0.086
Use of chemical fertilizers	0.517*	0.274	1.89	0.059	0.137
Constant	-2.349	0.880	-2.67	0.008	
Number of obs = 202			Pseudo R2 = 0.2987		
Wald chi2(16) = 67.04			Log pseudo likelihood = -95.111454		
Prob > chi2 = 0.0000					

***, **, and * indicates significant at less than 1%, 5%, and 10% level, respectively
 Source: Computed from own survey data, 2025

Use of chemical fertilizers: Use of chemical fertilizers positively and significantly affected the likelihood of adopting wheat row planting practices at less than 10% level of significance (Table 4). This indicating that farmers who apply chemical fertilizers have a higher probability of planting their wheat production in rows. A possible reason is that the row-planting method facilitates the effective and convenient application of agrochemicals, as the spaces between rows allow easier movement for applicators compared to the broadcast method. Thus, fertilizer use complements row planting, as both practices aim to increase yield and input efficiency. This finding is consistent with the studies of **Mossie (2022)** and **Donkor et al. (2016)**, who also reported a positive association between fertilizer use and the adoption of improved agricultural technologies.

Impact of wheat row planting on wheat yield

The results obtained from the second stage of the ESR model, which present the mean yields under actual and counterfactual scenarios for both adopters and non-adopters, are summarized in **Table 5**. The results revealed that adoption of wheat row planting practices had a **positive and statistically significant impact** on wheat yield. The average treatment effect on the treated indicated that adopters of wheat row planting obtained a mean yield of **43.21 quintals per hectare**, while their expected counterfactual yield if they had not adopted was **38.22 quintals per hectare**. This implies a gain of **4.99 quintals per hectare**, statistically significant at the 1% level. Indicates that, adoption of wheat row planting increased wheat yield among adopters by about **13%** due to adoption.

Similarly, the average treatment effect on the untreated shows that non-adopters would have achieved **40.45 quintals per hectare** if they had adopted the practice, compared to their actual yield of **36.88 quintals per hectare**, resulting in a potential yield increase of **3.58 quintals per hectare**, also significant at the 1% level, suggests that non-adopters could potentially increase their wheat yield by about 9.71% if they adopted wheat row planting (Table 5).

Furthermore, the **base heterogeneity effects** also indicated that adopters would have produced **1.34 quintals per hectare more** than non-adopters even without adopting the technology (BH_0). Similarly, if both groups had adopted wheat row planting, adopters would still outperform non-adopters by **2.76 quintals per hectare** (BH_1) (Table 5). A positive TH value indicates that the technology yields a higher return for actual adopters than for non-adopters, suggesting that adopters are better positioned due to either observable or unobservable factors such as skill, experience, or management ability to benefit from the technology. These findings are consistent with earlier studies such as Wolde (2016), Donkor et al. (2016), and Tamirat (2020), who also reported that the adoption of improved agricultural practices, including row planting, significantly improves crop productivity.

Table 5. Impact of wheat row planting adoption on wheat yield (ESR Model Results)

Outcome variable	Treatment effect category	Decision stage		Treatment effect	Treatment effect (%)
		To adopt	Not to adopt		
Wheat yield	ATT (Adopters)	43.21	38.22	4.99***	13.06
	ATU (Non-adopters)	40.45	36.88	3.58***	9.71
Heterogeneity effects $BH_1 = 2.76^{***}$			$BH_0 = 1.34^{**}$	$TH=1.42$	

Note: *** and ** indicates significance at 1% and 5% significance level, respectively

Source: Computed from own survey data, 2025

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study evaluated the adoption intensity of wheat row planting practices, identified the factors influencing adoption decisions, and assessed the impact of these practices on wheat yield among smallholder farmers in the selected districts of the Arsi and West Arsi zones, Ethiopia. Both primary and secondary data were utilized, and an Endogenous Switching Regression model was employed to account for both observable and unobservable factors that influence farmers' decisions to adopt and the corresponding impact on wheat yield. The findings revealed that the overall adoption intensity of wheat row planting remains moderate, with a majority of sampled households (60.4%) practicing traditional methods, while 39.6% adopted row planting to varying degrees. The average adoption index indicated that a moderate proportion of the

total wheat land was cultivated using row planting, suggesting partial rather than full adoption among most adopters in the study area. Determinant analysis from the ESR model indicated that farmers with greater land and livestock resources, better access to improved inputs and information, and more labor availability are more likely to adopt wheat row planting, while those located farther from markets are less likely to adopt wheat row planting in the study area. The study found that adopting row planting significantly increased wheat yields, with adopters achieving an average yield of 43.21 qt/ha, compared to 38.22 qt/ha if they hadn't adopted, indicating a 13% yield gain.

Recommendations

Based on the study results, several recommendations were proposed to enhance the adoption of wheat row planting practices. Key suggestions include organizing regular agricultural training sessions and awareness programs to boost farmers' knowledge, strengthening farmer-to-farmer learning to facilitate technology diffusion, and ensuring timely access to improved inputs like seeds and fertilizers. Additionally, addressing labor shortages by promoting affordable wheat row planters, increasing contact with extension agents for ongoing support, and enhancing extension services are crucial to driving adoption and improving wheat productivity among smallholders.

ADVANCED RESEARCH

Future research should expand on this study by incorporating longitudinal data to examine the long-term sustainability and productivity impacts of wheat row planting practices across different agro-ecological zones in Ethiopia. Further studies may also integrate climate variability, soil quality indicators, and gender dimensions to better understand how environmental and socio-economic factors interact with adoption decisions. In addition, exploring the cost-effectiveness and adoption potential of mechanized row planters and labor-saving technologies would provide valuable insights for policy and extension programs. Employing mixed-method approaches that combine quantitative models with qualitative field assessments could also deepen understanding of behavioral, institutional, and market-related constraints influencing full adoption of wheat row planting among smallholder farmers.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Oromia Agricultural Research Institute and the Asella Agricultural Research Center for providing the financial support. Thanks to the interviewees, the enumerators, and Arsi and West Arsi zones Agriculture Office.

Conflict of interest: The authors declare that there is no conflict of interest.

REFERENCES

- Abraham, B.; Araya, H., Berhe, T., Edwards, S., Gujja, B., Khadka, R.B., Koma, Y.S., Sen, D., Sharif, A., Styger, E. and Uphoff, N. 2014, The system of crop intensification: reports from the field on improving agricultural production, food security, and resilience to climate change for multiple crops. *Agri & Food Sec*, 3(1): p.4.
- Ahmed, M.H.; Geleta, K.M.; Tazeze, A. and Andualem, E. 2017, the impact of improved maize varieties on farm productivity and wellbeing: Evidence from the east Hararghe zone of Ethiopia. *Devet Stu Res*, 4(1): 9-21.
- Amare, Y. 2018, Determinants of Adoption of Wheat Row Planting: The Case of Wogera District, North Gondar Zone, Amhara Regional State. *J Agri Sci Food Res*, 9, p.250.
- AZAO (Arsi Zone Agriculture Office). 2024, Annual reports of crop production.
- Beri, G. and Degefu, S. 2024, Factors Affecting Adoption of Wheat Row Planting Technology in Girar Jarso Woreda, North Shewa Zone, Oromia, Ethiopia. *MERJEManag*, 4(2): 27-34.
- Chauhan, H.; Anuruddhika S, Manoja D, Sakinda and B. 2014, Effect of rice establishment methods on weedy rice infestation and grain yield of cultivated rice In Sri Lanka Crop.
- Cochran, W.G. 1977, Sampling Techniques. 3rd Edition, John Wiley & Sons, New CSA (Central Statistical Agency). 2021, Agricultural sample survey: Report on area and production of major crops. Volume I Statistical Bulletins 590, Addis Ababa, Ethiopia.
- Dinku, A. and Beyene, F. 2019, Adoption determinants of row planting for wheat production in Munesa District of Oromia Region, Ethiopia. *J Agri Ex & Rurl Depmnt*, 11(2): 25-34.
- Donkor, E.; Owusu-Sekyere, E., Owusu, V. and Jordaan, H. 2016, Impact of row-planting adoption on productivity of rice farming in Northern Ghana. *Rw of Agri & App E*, 19(2):19-28.
- FAOSTAT. 2018, Agriculture Organization of the United Nations. Rome: Statistical database.
- Gashaw, T.; Alan B, Nicholas M, and Tanguy B. 2014, the impact of the use of new technologies on farmers' wheat yield in Ethiopia. Interl Food Policy Research Institute. Washington.

- Hailu, B.K.; Abrha, B.K. and Weldegiorgis, K.A. 2014, Adoption and impact of agricultural technologies on farm income: Evidence Southern Tigray, Ethiopia. *IJFAEC*, 2(4): 91-106.
- Jaleta, M.; Kassie, M.; Marennya, P.; Yirga, C. and Erenstein, O. 2018, Impact of improved maize adoption on household food security of maize farmers in Ethiopia. *FSec*, 10(1): 81-93.
- Mentire, W. and Gecho, Y. 2017, Factors affecting adoption of wheat row planting technology: The case of sodo zuriya woreda, wolaita zone, southern Ethiopia. *ISDE*, pp.2222-1727.
- Mossie, W.A. 2022, The Impact of Climate-Smart Agriculture Technology on Productivity: Does Row Planting Matter? Evidence Southern Ethiopia. *The Sci Wrld Jour*, (1): 3218287.
- Mulu, N.; Hussein S, Isack. M, Seltene A. 2022, Wheat production in the highlands of Eastern Ethiopia: opportunities, challenges and coping strategies of rust diseases Pages 563-575 received 20 Nov 2021, Accepted 20 Dec 2021, Published online: 09 Jan 2022
- Sarah, M. 2014, IFPRI evaluates a new wheat package rollout in Ethiopia.
- Sileshi, M.; Kadigi, R.; Mutabazi, K. and Sieber, S. 2019, Impact of soil and water conservation practices on household vulnerability to food insecurity in eastern Ethiopia: endogenous switching regression and propensity score matching approach. *FSecurity*, 11(4): 797-815.
- Tamirat, N. 2020, Impact analysis of row planting teff crop technology on household welfare: A case study of smallholder farmers of Duna District in Hadiya Zone, Ethiopia. *Journal of Economics and Sustainable Development*, 11(5): 4-9.
- Tamirat, N.; Jemal, A. and Endeg, T. 2019, Determinants of Wheat Crop Production Row Planting Technology Adoption in Duna Woreda, Hadiya Zone, Ethiopia.
- Tolesa, A.; Bezabih E, Jema H, Belaineh L. 2014, Impact of Wheat Row Planting on Yield of Smallholders in Selected Highland and Lowland Areas of Ethiopia.
- Vandercasteenlen, J.; Mekdim D, Mintlen B, Alemayehu S. 2013, The impact of the promotion of row planting on farmers' teff yields in Ethiopia. Ethiopia Strategy Support Program II, ESSP research note 27. International Food Policy Research Institute.

WAZAO (West Arsi Zone Agriculture Office). 2024, Annual Report.

Wolde, E.Y. 2016, Effect of wheat row planting technology adoption on small farms yield in Ofla Woreda, Ethiopia. *Int J Agric Extension Social Dev*, 3(5):184-196.

World Bank. 2014, Ethiopia poverty Assessment. Document of the WB for official use only.

Zegeye, F.; Alamirew, B. and Tolossa, D. 2020, Analysis of wheat yield gap and variability in Ethiopia. *Int Jou of Agric Econs*, 5(4): 89-98.