Muş Alparslan Üniversitesi
Uygulamalı Bilimler Fakültesi

MUŞ ALPARSLAN ÜNİVERSİTESİ / MUŞ ALPARSLAN UNIVERSITY

www.alparslan.edu.tr

e-ISSN: 2822-3500
Mart/March 2025
Cilt/Volume: 5
Sayı/Issue: 1

TARIM ve DOĞA DERGİSİ

JOURNAL of AGRICULTURE and NATURE

M U Ş A L P A R S L A N U N I V E R S I T Y
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Muş Alparslan University Journal of Agriculture and Nature (MAUJAN) is a scientific journal publishing high-quality papers in all aspects of agriculture and nature.

Muş Alparslan University Journal of Agriculture and Nature (MAUJAN) started its publishing life in January 2021 with the name ***Muş Alparslan University Journal of Agricultural Production and Technologies*** (E-ISSN: 2757-8763), and its name changed in March 2022.

MAUJAN aims to contribute to the scientific literature by publishing recent research on agriculture and nature all around the globe as open-access articles by applying the double-blind peer-review process.

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Hetland, B., McAndrew, N., Perazzo, J., & Hickman, R. (2018). *A qualitative study of factors that influence active family involvement with patient care in the ICU: Survey of critical care nurses*. PubMed Central, *Preprint*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5736422/?report=classic

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Conference Proceedings:

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An old tradition and a new technology have converged to make possible an unprecedented public good. The old tradition is the willingness of scientists and scholars to publish the fruits of their research in scholarly journals without payment, for the sake of inquiry and knowledge. The new technology is the internet. The public good they make possible is the worldwide electronic distribution of peer-reviewed journal literature and completely free and unrestricted access to it by all scientists, scholars, teachers, students, and other curious minds. Removing access barriers to this literature will accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and the quest for knowledge.

The literature that should be freely accessible online is that which scholars give to the world without expectation of payment. Primarily, this category encompasses their peer-reviewed journal articles, but it also includes any unreviewed preprints that they might wish to put online for comment or to alert colleagues to important research findings. There are many degrees and kinds of wider and easier access to this literature. By "open access" to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.

While the peer-reviewed journal literature should be accessible online without cost to readers, it is not costless to produce. However, experiments show that the overall costs of providing open access to this literature are far lower than the costs of traditional forms of dissemination. With such an opportunity to save money and expand the scope of dissemination at the same time, there is today a strong incentive for professional associations, universities, libraries, foundations, and others to embrace open access as a means of advancing their missions. Achieving open access will require new cost recovery models and financing mechanisms, but the significantly lower overall cost of dissemination is a reason to be confident that the goal is attainable and not merely preferable or utopian.

To achieve open access to scholarly journal literature, we recommend two complementary strategies.

I. Self-Archiving: First, scholars need the tools and assistance to deposit their refereed journal articles in open electronic archives, a practice commonly called, self-archiving. When these archives conform to standards created by the Open Archives Initiative, then search engines and other tools can treat the separate archives as one. Users then need not know which archives exist or where they are located in order to find and make use of their contents.

II. Open-access Journals: Second, scholars need the means to launch a new generation of journals committed to open access, and to help existing journals that elect to make the transition to open access. Because journal articles should be disseminated as widely as possible, these new journals will no longer invoke copyright to restrict access to and use of the material they publish. Instead, they will use copyright and other tools to ensure permanent open access to all the articles they publish. Because the price is a barrier to access, these new journals will not charge subscription or access fees and will turn to other methods for covering their expenses. There are many alternative sources of funds for this purpose, including the foundations and governments that fund research, the universities and laboratories that employ researchers, endowments set up by discipline or institution, friends of the cause of open access, profits from the sale of add-ons to the basic texts, funds freed up by the demise or cancellation of journals charging traditional subscription or access fees, or even contributions from the researchers themselves. There is no need to favor one of these solutions over the others for all disciplines or nations, and no need to stop looking for other, creative alternatives.

Open access to peer-reviewed journal literature is the goal. Self-archiving (I.) and a new generation of open-access journals (II.) are the ways to attain this goal. They are not only direct and effective means to this end, but they are also within the reach of scholars themselves, immediately, and need not wait on changes brought about by markets or legislation. While we endorse the two strategies just outlined, we also encourage experimentation with further ways to make the transition from the present methods of dissemination to open access. Flexibility, experimentation, and adaptation to local circumstances are the best ways to assure that progress in diverse settings will be rapid, secure, and long-lived.

The Open Society Institute, the foundation network founded by philanthropist George Soros, is committed to providing initial help and funding to realize this goal. It will use its resources and influence to extend and promote institutional self-archiving, to launch new open-access journals, and to help an open-access journal system become economically self-sustaining. While the Open Society Institute's commitment and resources are substantial, this initiative is very much in need of other organizations to lend their effort and resources.

We invite governments, universities, libraries, journal editors, publishers, foundations, learned societies, professional associations, and individual scholars who share our vision to join us in the task of removing the barriers to open access and building a future in which research and education in every part of the world are that much more free to flourish.

For various reasons, this kind of free and unrestricted online availability, which we will call open access, has so far been limited to small portions of the journal literature. But even in these limited collections, many different initiatives have shown that open access is economically feasible, that it gives readers extraordinary power to find and make use of relevant literature, and that it gives authors and their works vast and measurable new visibility, readership, and impact. To secure these benefits for all, we call on all interested institutions and individuals to help open up access to the rest of this literature and remove the barriers, especially the price barriers, that stand in the way. The more who join the effort to advance this cause, the sooner we will all enjoy the benefits of open access.

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In the pre-evaluation process, the field editors examine the studies, introduction and literature, methods, findings, results, evaluation and discussion sections in detail in terms of journal publication policies, scope and authenticity of study. Study which is not suitable as a result of this examination is returned to the author with the field editor's evaluation report within four weeks at the latest. The studies which are suitable for the journal are passed to the referee process.

3. Referee Process

The studies are sent to the referees according to their content and the expertise of the referees. The field editor examining the study may propose at least two referees from the pool of *Muş Alparslan University Journal of Agriculture and Nature* Advisory Board or referee pool according to their field of expertise or may propose a new referee appropriate to the field of study.

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The period given to the referee for the evaluation process is 15 days. Proposals for corrections from referees or editors must be completed by the authors within 1 month according to the "correction instruction".

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3. Findings: The evaluation report includes opinions on the presentation of the findings obtained in the frame of the method, the correctness of the analysis methods, the aims of the research and the consistency of the findings, the presentation of the required tables, figures and images and the conceptual evaluation of the tests used.

4. Evaluation and discussion: The evaluation report includes the opinion on the subject based on findings, relevance to research questions and hypotheses, generalizability and applicability.

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MUŞ ALPARSLAN ÜNİVERSİTESİ
TARIM VE DOĞA DERGİSİ

MUŞ ALPARSLAN UNIVERSITY
JOURNAL OF AGRICULTURE AND NATURE

Cilt: 5 **Sayı: 1** **E-ISSN: 2822-3500**
Volume: 5 **Issue: 1** **E-ISSN: 2822-3500**

İÇİNDEKİLER / TABLE OF CONTENTS

MAUN J AGR NAT (2025) 5(1): 1-13
DOI: 10.59359/maujan.1251422
e-ISSN: 2822-3500

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MUŞ ALPARSLAN UNIVERSITY
JOURNAL OF AGRICULTURE AND NATURE

Analysis of farm households' Savings: a case of small-scale tomato farmers in Akwa Ibom State, southern region of Nigeria

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Please cite this paper as follows:
Akpan, S.B., Edet, G.E., Charlie, E.E. (2025). Analysis of farm households' Savings: a case of small-scale tomato farmers in Akwa Ibom State, southern region of Nigeria. *Muş Alparslan Üniversitesi Tarım ve Doğa Dergisi*, 5(1), 1-13. https://doi.org/10.59359/maujan.1251422

Research Article

Article History
Received: 02.06.2024
Accepted: 25.03.2025

Keywords:
Capacity to save,
Decision to save,
Household savings,
Nigeria,
Tomato farmers,

ABSTRACT

The study analyzed decision to save and saving capacity of small-scale tomato farmers in Akwa Ibom State in the Southern Region of Nigeria. One hundred and twenty tomato farmers were randomly selected using multistage sampling technique. A well designed structured questionnaire was used to obtain the required data. The Heckman two-step selection method was used to analyze the data. The result of the first step estimation (Probit estimates) showed that age (18-35 years), marital status, family size and family dependent ratio were significant negative determinants of the probability to save among tomato farmers; whereas adult farmers (> 35 years), membership in social organization, farming experience, owned farm land, farm income, non-farm income, farmers' sex and years of formal education were positive determinants. Also, the result of the second step estimation indicated that a youthful age (18-35 years), marital status, family size and dependent ratio were significant negative determinants of savings capacity of the tomato farmers, while adult age (>35 years), farming experience, membership in a social organization, owned farm land, non-farm income, farm income, farmers' years of education were positive determinants To enhance the likelihood of saving and the saving capacity among tomato farmers in the region, it is recommended to promote formal education, encourage the formation of social groups, facilitate land ownership, and support the development of diversified income sources for the farmers.

1. Introduction

In Nigeria, similar to other countries in sub-Saharan Africa, the majority of rural farmers are resource-poor (Sadiq et al., 2023; Akpan et al., 2023a; Yahya and Ogunyemi 2024). Agricultural productivity is low in the country when compared to some countries in the northern and southern regions of Africa (Asfaw 2021, Akpan et al., 2022). The agricultural sector's low productivity has been a persistent issue, which many researchers attribute to poor financial sector and credit mismanagement from the formal sector of the economy (Mu'azu and Lawal 2017, Fowowe, 2020, Adewale et al., 2022, Akpan et al., 2023b, Akpan et al., 2024a). Most rural farmers lack the capacity to fulfil the credit requirements available in the formal sector (Akpan et al., 2020 and Adewale et al., 2022). Consequently, these farmers heavily rely on informal credit sources to enhance their farm production. However, the

shortcomings and inefficiencies of the informal system have compelled farmers to turn to the most accessible and reliable alternative, which is saving their plough back profits from previous farming seasons. Given the challenging credit environment in Nigeria (Ubon et al., 2016, Umoren et al., 2016a, Umoren et al., 2016b, Umoren et al., 2018, and Umoren and Akpan 2021), it is evident that cultivating a culture of farm income savings is crucial for ensuring sustainable agricultural production both now and in the future.

Savings mobilization refers to the portion of household disposal income that is not allocated towards household consumption. It plays a crucial role in the economic development of developing nations, as it significantly influences the circular flow of income within the economy. According to Wieliczko et al. (2020), Strzelecka and Zawadzka (2023), and Aidoo-Mensah (2023), savings serve as a vital means to enhance the well-being of farmers, providing them with insurance against unforeseen disasters or risks, and offering a buffer to navigate through times of crisis. The maintenance of household savings enhances the potential for future investments at both the micro and macro levels of the economy.

The significance of saving within farming households in developing countries, particularly Nigeria, is evident. Various challenges such as banditry, terrorism, kidnapping, and conflicts between herdsmen and farmers have become prevalent in the agricultural landscape of the country (Udemezue & Kanu 2019, Bello and Abdullahi 2021, Adisa et al., 2022). These detrimental activities inculcate fear, amplify uncertainties, and contribute to risky situations in agricultural production. Unfortunately, government intervention programs that occasionally offer financial assistance to farmers are scarce and often subject to political influences and lacking a sustainable plan. To mitigate the impact of these adversities and ensure the continuity of farming operations, farmers must prioritize saving. Another factor that underscores the necessity of saving among Nigerian farmers is the volatility of input and output prices. The country currently experiences an unstable inflation rate and exchange rate (Central Bank of Nigeria (CBN), 2024). In many instances, farmers must save in order to offset any shortfall in their farm incomes and manage unexpected expenses. By building a savings buffer, farmers can safeguard their livelihoods and maintain a level of financial stability amidst the uncertainties of the agricultural sector.

The significance of savings within farming households can be examined from various perspectives, all of which contribute to the sustainability of the agricultural sector in the country. One such perspective is the critical role that household savings play in assessing the creditworthiness of rural farm households. Drawing from the principles of classical economists, saving is a significant factor in determining economic growth. The mobilization of savings is a crucial element in stimulating domestic investment. Research conducted by Lidi et al. (2017) and Wieliczko et al. (2020) indicates that farming households with higher savings rates are more likely to accumulate farm assets, embrace innovative practices, and demonstrate resilience. The accumulation of farm assets serves as a solution for expanding farms or achieving economies of scale, ultimately facilitating the transition from subsistence farming to commercial agricultural enterprises. Additionally, farm household savings provide a safety net for precautionary purposes and enable access to social services, among other benefits.

Despite the multifaceted importance of savings for farmers' well-being and the economy, it is evident that small-scale farmers in Nigeria face challenges in mobilizing savings (Adebayo et al., 2010, Akpan et al., 2011, Obalola et al., 2018, Isiorhovoja et al., 2020, Lawal et al., 2021). This results in low real income, high consumption expenditure, and limited development opportunities for these farmers (Wieliczko et al., 2020). In the specific context of tomato *(Lycopersicom esculentum)* production in southern Nigeria, savings mobilization is crucial for enhancing welfare, smoothing consumption patterns, and enabling the acquisition of depreciable and non-depreciable assets.

Tomato, a highly popular and widely consumed vegetable in Nigeria, holds a significant position in the daily vegetable consumption of Nigerians. Its consumption is diverse, and it offers various medicinal benefits due to its rich content of vitamins, minerals, fiber, antioxidants, and beta-carotene. The cultivation of tomatoes is predominantly carried out by small-scale farmers in the southern region of the country. Tomato production is an emerging agro-enterprise that has attracted young farmers and it also one of the preferred components in most of the youth intervention programmes in the region. The success and sustainability of this agricultural enterprise depend, in part, on the extent of savings mobilization among farmers. However, the mobilization of savings is influenced by multiple factors, including economic conditions, farmers' specific circumstances, and climate conditions. Given that household savings is expected to play a crucial role in ensuring the sustainability of tomato production in the region, it becomes imperative to identify the significant factors that determine savings mobilization among tomato farmers (Amurtiya & Adewuyi 2020; Norbert et al., 2023; Bolarinwa et al., 2024; Raaijmakers et al., 2018, Snoek et al., 2022; Adeosun et al., 2022; Ali et al., 2020, Campestrini et al., 2019).

Several studies have explore the factors that influence saving behaviour among arable crop farmers

in developing countries. Researchers such as Akpan et al. (2011); Lidi et al. (2017); Saliya (2018); and Geta (2020) have utilized various econometric methods to identify key determinants of savings mobilization among farming households in Africa. These determinants include household income, tax obligations, credit usage, farming experience, educational attainment, family size, participation in social groups, age of the household head, household size, proximity to formal financial institutions, employment status of the household head, and dependency ratio of the household. In addition to the factors mentioned earlier, Odoh et al. (2020), Isiorhovoja et al. (2020), Nwosu et al. (2020), Mazengiya et al. (2022), Lusaya and Mulunda (2022), Balcha et al. (2022), and Sisay (2023) have broadened the scope of determinants influencing farming household savings mobilization. These include household farm size, land ownership, marital status of the household head, location of the farm household, access to agricultural extension services, gender of the household head, household annual expenditure, financial literacy, and non-farm income.

The literature examined did not provide adequate details on savings mobilization and its determinants among vegetable farmers in the southern part of Nigeria. Moreover, the limited information available from other crop enterprises in different regions of the country may not be directly applicable to the southern region due to varying climatic conditions, farmers' income levels, poverty rates, and consumer preferences, among other factors. Tomato cultivation, as an emerging agricultural sector among youth farmers, holds significant potential for creating employment opportunities, enhancing food security in the region, and contributing to the achievement of Sustainable Development Goal Number 2 (Akpan and Okon, 2019; Akpan et al., 2024b). Therefore, ensuring the sustainability of tomato production and involving youth in this sector necessitates providing insights into savings mobilization practices among farmers in the area. Based on these considerations, this study was specifically designed to investigate the determinants of decision to save and saving capacity of tomato farmers as well as develop policy recommendations to enhance production sustainability.

2. Material and Methods

Study Area

The study was carried out in the two agricultural zones of Akwa Ibom State, namely: Abak and Ikot Ekpene agricultural zones. Ikot Ekpene Agricultural Zone consist of five (5) local government areas namely: Ini, Obot Akara, Ikot Ekpene, Ikono and Essien Udim. Abak agricultural zone is made up of five local government areas namely; Abak, Etim Ekpo, Ika, Oruk Anam and Ukanafun. The people are predominantly farmers producing food crops and vegetables such as pepper, tomato, cucumber, fluted pumpkin, melon, sweet potatoes among others.

Sampling Techniques and Sample Size

A multistage sampling procedure was adopted in selecting tomato farmers in the study area. A list of registered tomato farmers was obtained from Akwa Ibom State Agricultural Development Programme (AKADEP) office in both agricultural zones selected. In the first stage, Abak and Ikot Ekpene Agricultural Zones were purposively selected from the existing six Agricultural Zones due to their prominence as primary hubs for commercial tomato cultivation within the State. In the second stage, a sample frame of one hundred and seventy three tomato (173) farmers from the two zones were obtained from the list of registered tomato farmers. In the next stage, the representative sample size (Sn) was obtained using the formula developed by Yamane, (1967) as thus:

$$S_n = \frac{N}{1 + N(e^2)} = \frac{173}{1 + 173(0.05^2)} = 120 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where; Sn = representative sample size; N = sample frame; e = absolute error at 5% probability level of type 1 error

Hence, a total of one hundred and twenty (120) registered tomato farmers were needed for the study. The third stage involved a random selection of one hundred and twenty (120) tomato farmers from the merge list using a ballot system. In the final stage, the selected tomato farmers were contacted and interviewed to obtain the necessary data for the study.

Data source

The data for this study were collected through the use of a well-designed structured questionnaire. A cross sectional data were collected from the small-scale tomato farmers. The data collected includes; social and economic data, farm specific and production data.

The conceptual framework

The conceptual framework of the study was based on the concept of the Keynesian saving function. The concept relates savings to disposal income and consumption. This relationship postulates that individual will save if the disposal income exceed consumption expenditure. Implicitly, the relationship can be expressed as thus:

$$S = Y_d - C \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$S = f(Y_d, C) \ldots\ldots\ldots\ldots\ldots (3)$$

Incorporating the consumption function into equation 2 produces Keynesian explicit saving function as thus:

$$S = Y_d - (\alpha + \beta Y_d) \ldots\ldots\ldots\ldots\ldots (4)$$

$$S = -\alpha - (1-\beta)Y_d \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Hence, the Keynesian saving function signifies a relationship between the disposable income of a household and savings. This function show the amount of saving a household will save when the disposal income increases. The coefficient α represents savings at zero income, while β is the marginal propensity to consume. Nonetheless, household saving decisions in reality is influenced by several factors aside the disposal income and consumption expenditures. The Keynesian saving function serves as a foundational framework from which a more intricate saving function can be developed. Essentially, a saving function illustrates how household savings respond to variations in influencing factors. In accordance with this principle, equation 5 was revised as:

$$S = -\alpha - (1-\beta)Y_d + \delta Z_i \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where δ is a parameter of other factor Z that affect savings. Hence the saving function can be expanded to accumulate other necessary variables.

Analytical technique

The study used two-step Heckman model (Heckman, 1979) to analyze the objective of the study. The model is basically designed to detect, correct, and expunge the sample selection bias problem. Since the tomato farmers were selected from the list of registered tomato farmers in the study area within a period, then there are possibilities that other non-registered tomato farmers were omitted resulting to a possible sample bias. Sample selection bias occurs when the representative sample does not confers the true characteristics of the population resulting in unfair or bias estimates. Hence, the model provides a means of correcting for non-randomly selected samples. The Heckman model is based on the assumptions that, the error terms of the selection and the main or outcome equations are correlated and the first stage decision dominates the second one. Also, the model assumes that both explanatory variables in both equations are independent or uncorrelated with the error terms.

In the first step, a probit model or selection equation is estimated (using maximum likelihood estimation method) to predict the probability of savings among tomato farmers. A vector of inverse Mills ratios (estimated expected error) is jointly generated from the estimated parameters (Greene, 2000). The probability of saving among tomato farmers is given in equation 7:

$$Q_i^* = X_{1i}'\beta_1 + U_i, \qquad U_i \sim N(0,1) \ldots\ldots\ldots\ldots (7)$$

where Q_i^* *is* 1, *when a farmer chooses to save and* 0, *otherwise*

Note, Q_i^* *is* the latent discrete savings choice variable that denotes binary censoring, X_{1i}' is a vector of explanatory variables hypothesized to influence the probability of savings among tomato farmers and β_i is a vector of parameters. U_i is the standard error term. The variable Q_i^* is observed and is equal to unity when a farmer chooses to save and is unobserved or zero when a farmer chooses otherwise.

In the second step, the Inverse Mill Ratio (IMR) (i.e. λ, lamda) generated in the first step is incorporated in a saving capacity function and estimated using the Ordinary Least Squares (OLS) estimation method. The model is specified as thus;

$$SAV_i = \alpha_0 + X_i\theta_i + \delta_i\lambda_i + V_i \qquad V_i \sim N(0,1) \ldots (8)$$

Where: SAV_i amount of money a tomato farmer saved in a planting season, X_i are the explanatory variables, θ_i is unknown parameters to be estimated, δ_i is the coefficient of the inverse mill ratio. Greene (2000), asserted that the IMR term corrects the problem of sample selection bias. If the term (δ_i) is not statistically significant, then sample selection bias is not a problem (Heckman, 1979). The statistically significant value of δ_i means that significant correlation exists between the farmer's decision to save and saving capacity of tomato farmers in the region. V_i is the error term. Assuming the error terms in (7) and (8) are correlated and have a bivariate normal distribution, it can be written as thus:

$$\begin{pmatrix} U_i \\ V_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho\delta \\ \rho\delta & \delta^2 \end{pmatrix}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Since the occurrence of the second step depends on the outcome of the first step, (i.e. the actual amount save by a tomato farmer depends on the farmer's decision or choice to save), hence this dependency relationship can be expressed as shown in equation 10.

$$\rho = \frac{Cov(V_i, U_i)}{\sqrt{Var(V_i)\,Var(U_i)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Note, If ρ = 0, then there is dominancy (the zeros obtained in the first step are only associated to those tomato farmers who do not save and not standard corner solutions). The implication of this is that once the first step is passed, censoring is no longer appropriate, as those tomato farmers who choose to save their income would not report zero farm income. The Heckman two-step selection model with dependent error terms can be estimated by the following log-likelihood function (Flood and Grasjo, 1998; Aristei et al, 2007):

$$LogL = \sum_0 In[1 - \emptyset(X_{1i}'\beta_i)\phi] + \sum In\left[\phi\left(\frac{X_{1i}'\beta_i + \frac{\rho}{\delta}(Q_i - X_{1i}'\beta_i)}{\sqrt{1-\rho^2}}\right)\frac{1}{\delta}\phi\left(\frac{Q_1 - X_{1i}'\beta_i}{\delta}\right)\right] \ldots (11)$$

Explicitly, the empirical model used to estimate the Probit and the savings capacity function is given below;

$$DS_r = SAC = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}X_{14} + U_i \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

The explanatory variables are described in Table 1.

Table 1: description of explanatory variables

S/n	Variable	Symbol	Unit	Expected sign
1	Decision to save	DS	Dummy; 1= farmers that save	Nil
2	Savings capacity	SAC	Amount of money save/annum (naira)	Nil
3	Age (Adult > 35years)	X_1	Years	–
4	Age (youth 18-35 years)	X_2	Years	+
5	Marital status	X_3	dummy: 1 = marrıed	–
6	Farming experience	X_4	Years	+
7	Socialization	X_5	Years	+
8	Family size	X_6	Number	–
9	Dependent ratio	X_7	-	–
10	Owned farm land	X_8	Dummy; 1=own land	+
11	Farm size	X_9	Hectare	+
12	Non-farm income	X_{10}	Naira/year	+
13	Farm income (total)	X_{11}	Naira/year	+
14	Farmer's sex	X_{12}	Dummy: male =1	+
15	Education (≤ 12 years)	X_{13}	Years	+
16	Education (> 12 years)	X_{14}	Years	+

Source: Prepared by the authors. Note, dependent ratio = Children less than 15 years plus

3. Results and Discussion

Determinants of the decision to save and savings capacity of tomato farmers

The Heckman's two-step method was employed to analyze the factors influencing the decision to save and the savings capacity of small-scale tomato farmers. In the first step, the dependent variable was represented by a binary variable, with a value of one for farmers who chose to save and zero for those who did not. The subsequent step involved estimating the savings capacity function. Additionally, the value of lambda was utilized to address any potential selection bias in the sampling process.

The results of the Heckman two-step selection estimates are presented in Tables 2 and 3. It is important to note that these estimates were simultaneously determined but separated for the purpose of clarity in explanation. Furthermore, the slope coefficients in the selection equation were determined after the two-step estimation (post-estimation). The empirical findings revealed a Wald chi2 (14) value of 22.50, which is statistically significant at a 10% probability level. This suggests that the Heckman two-step selection model estimation is appropriate and exhibits a good fit. The coefficient of lambda (inverse mill ratio) is also statistically significant at a 5% probability level, indicating a relationship between the error terms of the selection and outcome equations. This confirms the presence of sample selection bias during the sampling process. Moreover, these results validate the use of the Heckman two-step selection model, which effectively addresses and eliminates the issue of sample selection bias in the estimation procedures. The statistically significant nature of the lambda coefficient further implies that if the household savings capacity function had been estimated without considering the decision of tomato farmers to save, a sample selection bias would have occurred among tomato farmers in the study area. Additionally, the negative values of lambda and rho indicate a negative relationship between the desire or decision to save and the savings capacity of tomato farmers. In other words, an increased desire to save does not lead to an increase in the savings capacity of tomato farmers in the region. Alternatively, the decision to save is not dependent on an increase in savings capacity.

(a) Determinants of the decision to save (first-step or selection equation)

The estimation of the probit model indicated that the likelihood of saving among tomato farmers in the region is negatively influenced by factors such as youthful age (18-35 years), family size, and family dependent ratio. Therefore, an increase in these variables would result in a decrease in the probability of saving among tomato farmers.

An increase in the age of tomato farmers within the range of 15-35 years is associated with a decrease in the likelihood of saving by 0.0053 units. This indicates that the propensity to save diminishes among young tomato farmers. This outcome may be linked to the high demand for resources among youths and their tendency towards extravagant lifestyles. Additionally, many young farmers may view tomato production as a temporary or transitional job, leading them to not prioritize long-term savings. Furthermore, the

perception of agricultural work as a low-status occupation among youths in the area could also contribute to this trend. Furthermore, the energetic nature of youth, which is typically focused on investment rather than saving, during this active period of life may also play a role. This finding aligns with the results of Lidi et al. (2017).

Table 2: First Step estimation (Selection equation)

Variable	coefficient	Std. error	Z-value	Prob.	Slope
Constant	-0.874	1.431	-0.611	0.5413	-
Age (Adult > 35years)	0.018	0.010	1.754*	0.0877	0.0031
Age (youth 18-35 years)	-0.030	0.010	-3.028**	0.0035	0.0053
Marital status	-0.201	0.358	-0.563	0.5735	0.0370
Farming experience	0.108	0.034	3.129***	0.0018	0.0188
Socialization	0.057	0.012	4.956***	0.0000	0.0099
Family size	-0.013	0.002	-8.733***	0.0000	0.0023
Dependent ratio	-0.139	0.048	-2.910***	0.0107	0.0242
Owned farm land	0.418	0.129	3.230***	0.0010	0.0705
Farm size	0.323	0.679	0.475	0.6347	0.0561
Non-farm income	1.81e-06	1.01e-06	1.789*	0.0810	3.148e-07
Farm income	1.98e-06	1.01e-06	1.952*	0.0510	3.441e-07
Male farmers	0.602	0.360	1.673*	0.0943	0.1123
Education (≤ 12 years)	0.081	0.025	3.313***	0.0009	0.0141
Education (> 12 years)	0.041	0.011	3.736***	0.0001	0.0071

Note: This step was generated simultaneously with the second step. The slopes are post estimation estimates. Asterisks *, ** and *** signify 10%, 5% and 1% significant level respectively.

Furthermore, an increase in the size of a family would result in a decrease of 0.0023 units in the likelihood or inclination of tomato farmers to save. This outcome indicates that as the family size of tomato farmers grows, their inclination to save diminishes. This finding is unsurprising as an increase in family size leads to higher daily consumption expenses for the family, thereby limiting the farmers' ability to save. This finding aligns with the research conducted by Akpan et al. (2011) and Nwosu et al. (2020).

The coefficient of the dependent ratio, which stands at 0.0242, exhibits a negative correlation and is statistically significant at a 1% probability level. A one-unit increase in the dependent ratio is likely to result in a reduction of approximately 0.0242 units in the likelihood of tomato farmers saving in the region. This result suggests that a high dependent ratio discourages the desire to save among tomato farmers. This finding is in line with expectations, as a high dependent ratio is associated with increased household expenditure, which in turn reduces the propensity for farm household savings.

On the contrary, the outcomes indicated that adult farmers (> 35 yearrs), membership in social organizations, farming experience, ownership of farm land, farm income, non-farm income, gender, and farmers' education are positively and significantly correlated with the likelihood of saving among tomato farmers. This suggests that an increase in these factors would also increase the likelihood of saving among tomato farmers. For instance, a one-unit increase in adult farmers would lead to a 0.0031 increase in the likelihood of saving. This implies that the desire or decision to save among adult farmers, particularly those over 35 years old, is influenced by household needs and preferences. Household savings are often used to address unexpected financial obligations within the farm household. Therefore, the household head typically prioritizes saving to meet the family's precautionary needs. These findings are consistent with previous studies by Lidi et al. (2017) and Balcha et al. (2022).

Furthermore, the coefficient for membership in social organizations is positive and statistically significant at a 1% probability level. A one-unit increase in years of membership in a farm social organization would result in a 0.0099 unit increase in the likelihood of saving. Joining a social organization as a tomato farmer enhances the probability of saving a portion of farm income. Increased socialization provides tomato farmers with access to more information, while group cohesion fosters confidence and a propensity to save. This finding is supported by Akpan et al. (2011).

The positive and significant coefficient of farming experience indicates that an increase in tomato farmers' experience would lead to a higher probability of saving. This increase in experience is associated with improved managerial capacity, enabling farmers to better navigate risks and uncertainties in tomato production. Additionally, as farmers gain more experience, they become more confident in decision-making, further

enhancing their propensity to save. This finding is supported by Akpan et al. (2011).

In addition, the variable "owned farm land" shows a significant positive correlation with the decision to save. An increase in the number of farmers owning land is linked to a higher probability of saving. Ownership of farm resources is believed to strengthen the decision-making process related to saving, as it reduces farm expenses and expands profit margins, particularly for small-scale farmers. Furthermore, owning farm resources helps mitigate the impact of farm risks, thereby influencing farmers' decision to save. This result is corroborated by Odoh et al. (2020), Nwosu et al. (2020), and Mazengiya et al. (2022).

Moreover, the coefficients of farm income and non-farm income are also positive and significant at conventional probability levels. Farmers with higher aggregate income are more likely to save for precautionary reasons, such as addressing farm risks and meeting family needs. This finding is consistent with the Keynesian absolute income hypothesis and the permanent income hypothesis, which suggest that the decision to save increases as household disposable income rises. This result is supported by Akpan et al. (2011), Lidi et al. (2017), Lusaya and Mulunda (2022), and Sisay (2023).

The positive and statistically significant coefficient of gender suggests that an increase in the proportion of male farmers in the region leads to a higher likelihood of saving. This can be attributed to the fact that tomato production requires time, resources, and physical strength, qualities that are often associated with male farmers in the region. Additionally, male farmers are typically the primary decision-makers in farming households in the region. These findings align with the research conducted by Balcha et al. (2022).

Furthermore, the coefficient of years of formal education (≤ 12 years and > 12 years) demonstrates a significant positive relationship with the probability of saving. One possible explanation for this result is that education enhances farmers' knowledge and understanding of production techniques, as well as exposes them to more income-generating opportunities. Therefore, farmers with a higher level of formal education are more likely to make the decision to save. This finding is supported by the studies conducted by Akpan et al. (2011), Lidi et al. (2017), Mazengiya et al. (2022), and Sisay (2023).

(b) Determinants of tomato farmers savings intensity or capacity (outcome equation)

The findings indicated that individuals in the younger age group (18-35 years), those who are married, have larger family sizes, and higher dependent ratios tend to have lower savings capacity. This suggests that an increase in these factors leads to a decrease in the ability to save money.

The adverse impact of youthful age (18-35 years) on the saving capacity of tomato farmers in the region is evident from the negative and statistically significant coefficient at a 5% probability level. An increase in youthful age among tomato farmers is associated with a decrease in saving capacity. The decline in saving desire among youth farmers, as observed in the previous step, contributes to this adverse relationship with savings capacity in the outcome equation. This trend can be attributed, in part, to the inadequate orientation that youths received regarding participation in agricultural activities. Consequently, many youths engaged in agricultural production lack full commitment due to the perceived low earnings, laborious work, low societal status in comparison to other professions, among other factors. This deduction finds support in the research conducted by Lidi et al. (2017) and Nwosu et al. (2020).

The marital status of tomato farmers exhibits a negative correlation with their saving capacity. An increase in the marital status of tomato farmers leads to a decrease of N59910 in their annual savings. This outcome aligns with expectations, as a significant portion of married farming households in the region tend to have higher consumption expenditures that limit their ability to save. This finding is corroborated by the studies of Nwosu et al. (2020) and Balcha et al. (2022).

The household size coefficient exhibits a negative and statistically significant relationship at a 10% probability level. This finding indicates that a one-unit increase in household size would lead to a reduction of N2132 in aggregate savings per year. The results demonstrate that tomato farmers with larger households experience a decrease in their savings or saving capacity. This outcome is expected, as an increase in household size corresponds to higher household expenses and the added burden of dependent family members. Consequently, the ability to save within the household is constrained. These findings align with previous studies conducted by Lidi et al. (2017) and Mazengiya et al. (2022).

The negative slope coefficient of the dependent ratio is also significantly associated with the saving capacity of tomato farmers. This implies that a one-unit increase in the dependent ratio of the household results in an average decrease of N160893 in the saving capacity of tomato farmers in the region. This suggests that tomato farmers with higher dependent ratios in their households experience a reduction in their saving capacity. This result is consistent with expectations, as an increase in the dependent ratio reflects higher household expenses and subsequently diminishes the

ability to save. Saliya (2018) also reported a similar finding.

Contrary to this, the variables such as adult age (>35 years), farming experience, membership in a social organization, owned farm land, farm size, non-farm income, farm income, number of male farmers, farmers with less than 12 years of formal education, and those with more than 12 years of formal education exhibit a significant positive association with the saving capacity of tomato farmers in the region. Specifically, the coefficient of age (adult group, > 35 years) shows a positive and statistically significant relationship at a 1% probability level. This implies that an increase in the age of adult farmers by one unit would lead to a rise in the saving capacity by N4216. The findings indicate that adult tomato farmers tend to save a higher proportion of their farm income compared to youth farmers. This trend can be attributed to the precautionary savings motive prevalent in adult households, as they are more likely to save for unforeseen future events. This aligns with the research of Lidi et al. (2017) and Balcha et al. (2022).

Table 3: Second step estimates (outcome or saving function)

Outcome model				
Variable	**coefficient**	**Std. error**	**Z-value**	**Prob.**
Constant	328142	442260.00	0.742	0.4581
Age (Adult > 35years)	4215.83	1258.57	3.350***	0.0003
Age (youth 18-35 years)	-3704.79	1662.00	-2.229**	0.0398
Marital status	-59910.40	12966.00	-4.621***	0.0000
Farming experience	19166.00	11447.90	1.674*	0.0979
Socialization	26503.40	11365.30	2.332**	0.0327
Family size	-2131.65	1105.20	-1.929*	0.0489
Dependent ratio	-160893.00	95886.00	-1.678*	0.0970
Owned farm land	30895.60	12557.00	2.460**	0.0271
Farm size	-11751.10	204087.00	-0.058	0.9541
Non-farm income	0.5206	0.1174	4.435***	0.0000
Farm income	0.1695	0.1007	1.683*	0.0930
Male farmers	-132880.00	165149	-0.805	0.4210
Education (≤ 12 years)	4505.04	13273.30	1.982**	0.0443
Education (> 12 years)	6172.23	3258.68	1.894*	0.0582
Lambda (inverse mill ratio)	-510204.00	210563.00	-2.423**	0.0296
rho	-1.000	Wald chi(14)	22.500	
Sigma	510204	Prob.>chi2	0.067	

Note: This step was generated simultaneously with the first step. The asterisks *, ** and *** signify 10%, 5% and 1% significant level respectively.

Moreover, the slope coefficient of farming experience is positively related to saving capacity. This suggests that an increase in farming experience by one unit corresponds to a N19166 increase in saving capacity. Experienced farmers are often more willing to take risks, enabling them to navigate challenging situations on the farm to generate income. Additionally, experienced farmers are more inclined to save for potential risks in the future. Furthermore, an experienced tomato farmer is likely to embrace innovative practices that enhance farm income generation and can make strategic farm management decisions to boost income and saving capacity. These results are consistent with the findings of Akpan et al. (2011), Odoh et al. (2020), and Isiorhovoja et al. (2020).

Membership in a social organization is positively correlated with the saving capacity of tomato farmers. Socialization plays a crucial role in building social capital and creating opportunities for increased access to productive resources, ultimately leading to higher farm income and a culture of saving. The research suggests that for each additional year of membership in an organization, there is an average increase of N26503 in the saving capacity of farmers. Enhanced socialization facilitates information sharing, enabling farmers to improve their farm income and saving capacity.

Formal education also has a significant positive impact on the saving capacity of tomato farmers. The study indicates that as the number of years of formal education increases (≤ 12 years and > 12 years), so does the saving capacity of farmers. Longer periods of formal education are associated with a greater likelihood of adopting innovations in farming practices. Furthermore, improving education levels enhances farmers' analytical skills and provides them with better access to markets for inputs and outputs, as well as financial and non-financial incentives like credit, information, training, and research opportunities. Therefore, enhancing the educational background of

tomato farmers contributes to the development of their management skills, leading to increased income and saving capacity. This finding is supported by previous studies conducted by Akpan et al. (2011), Lidi et al. (2017), Hailu and Geta (2020), Odoh et al. (2020), Isiorhovoja et al. (2020), and Sisay (2023).

The saving capacity of tomato farmers in the region is significantly influenced by their farm income. As farm income increases, so does the saving capacity of these farmers. This is because higher farm income provides them with the necessary financial resources to invest in modern technology, equipment, and inputs that can enhance productivity and resource efficiency. For example, by adopting precision farming techniques, automation, and other advanced technologies, farmers can optimize resource utilization and increase both production and farm income. Additionally, increased farm income enables farmers to access training programs, extension services, and research initiatives that enhance their technical skills. It is important to note that these findings align with the Keynesian absolute income hypothesis. This validates the research conducted by Akpan et al. (2011), Lidi et al. (2017), Hailu and Geta (2020), Odoh et al. (2020), Lusaya and Mulunda (2022), and Sisay (2023).

Furthermore, the coefficient of non-farm income also has a significant positive impact on the saving capacity of tomato farms. This implies that diversifying sources of farm income through non-farm activities can provide farmers with financial stability and resilience. By engaging in non-farm activities, farmers can invest in modern technologies, equipment, and training that improve production and farm income. Moreover, non-farm income can serve as an additional source of financing for farm activities, enabling farmers to afford inputs, machinery, and infrastructure that enhance farm efficiency and income. This result affirms the postulate of Keynesian absolute income hypothesis. It is consistent with the research conducted by Akpan et al. (2011), Lidi et al. (2017), Hailu and Geta (2020), and Lusaya and Mulunda (2022).

The test of multicollinearity

The multicollinearity occurs when the explanatory variables correlated with each other. This is a common econometric problem of the cross sectional analysis. Variance Inflation Factor (VIF) and the tolerance factors were used test for the multicollinearity in the results. The estimates of the VIF and the tolerance factors are presented in table 5. The result of the VIF results revealed that, for each explanatory variable, the VIF was less than 10 unit which is the threshold mark. This implies that the problem of multicollinearity was not significant, hence the results are unbiased and sufficient.

Table 4: Test of multicollinearity of explanatory variables

Variable	Variance Inflation Factor (VIF)	Tolerance factor
Age (Adult > 35years)	7.740	0.1292
Age (youth 18-35 years)	7.264	0.1377
Marital status	1.285	0.7782
Farming experience	1.215	0.8230
Socialization	1.550	0.6452
Family size	1.566	0.6386
Dependent ratio	1.092	0.9158
Owned farm land	1.147	0.8718
Farm size	1.178	0.8489
Non-farm income	1.838	0.5441
Farm income	1.529	0.6540
Male farmers	1.300	0.7692
Education (≤ 12 years)	1.420	0.7042
Education (> 12 years)	1.367	0.7315

Note: the minimum value of VIF is 1.0. However, any VIF > 10.0 shows possible multicollinearity issue. The VIF(i) = 1/(1 - R(i)^2), where R(i) is the multiple correlation coefficient between variable i and the other independent variables in the model.

The tolerance factors is less than unity for each explanatory variable and is within the range of insignificant presence of multicollinearity.

4. Conclusion

Small-scale agriculture plays a crucial role in the agricultural system of sub-Saharan Africa. The sustainability of smallholder farming relies heavily on the ability of farmers to mobilize savings. Unfortunately, the financial and credit management systems have not been effective in providing the necessary financial support to rural farmers. As a result, farmers have turned to saving as a means of ensuring financial security during times of risk and uncertainty. Given the current challenges such as poverty, malnutrition, price volatility, farm insecurity, and high

youth unemployment, the need for saving mobilization among rural farmers has become even more pressing. This study specifically examined the saving mobilization practices of small-scale tomato farmers in southern Nigeria. The Heckman two-step method was employed, with maximum likelihood estimates in the first step and Ordinary Least Squares (OLS) estimates in the second step. The estimated parameters were found to be unbiased, efficient, and consistent. Diagnostic statistics supported the use of the Heckman model and indicated that farmers' decision to save was correlated with their saving capacity. Probit estimates highlighted that factors such as age (18-35 years), marital status, family size, and dependency ratio had a negative impact on the likelihood of saving among tomato farmers. Conversely, factors such as age (>35 years), membership in social organizations, farming experience, land ownership, farm income, non-farm income, gender, and education level were identified as positive determinants of saving capacity among tomato farmers. The subsequent analysis indicated that being in the age range of 18-35 years, being married, having a larger family size, and having a high dependent ratio were all factors that negatively impacted the saving capacity of tomato farmers. Conversely, being older than 35 years, having experience in farming, being a member of a social organization, owning farm land, having a larger farm size, having non-farm income, having farm income, having a higher number of male farmers, and having more years of formal education were all factors that positively influenced savings capacity. It is suggested that tomato farmers in the area should focus on enhancing their formal education, participating in social organizations, and diversifying their sources of income in order to improve their decisions to save and their saving capacity. It is highly advisable to implement the adult education programme for tomato farmers in the region as a way of enhancing their savings mobilization. Additionally, collaborating with local organizations will significantly improve the savings mobilization for tomato farmers.

COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgements

The tomato farmers we interviewed during our research were greatly appreciated by the authors. Additionally, we extend our heartfelt gratitude to the staff of the agricultural development Programme in Akwa Ibom State for their unwavering cooperation.

Compliance with Ethical Standards

a) Authors' Contributions

Authors contributed equally to this paper.

b) Conflict of Interest

The authors declare that there is no conflict of interest.

c) Ethical approval:

For this type of study, formal consent is not required.

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MAUN J AGR NAT (2025) 5(1): 14-20
DOI: 10.59359/maujan.1581506
e-ISSN: 2822-3500

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MUŞ ALPARSLAN ÜNİVERSİTESİ
TARIM VE DOĞA DERGİSİ

MUŞ ALPARSLAN UNIVERSITY
JOURNAL OF AGRICULTURE AND NATURE

Gemlik Anacına Aşılanan Bazı Zeytin Çeşitlerinde Aşı Uyuşmazlığı ile Fenolik Bileşiklerin İlişkisi

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Please cite this paper as follows:
Yaman, İ., Toplu, C., Yıldız, S. N., (2024). Gemlik Anacına Aşılanan Bazı Zeytin Çeşitlerinde Aşı Uyuşmazlığı ile Fenolik Bileşiklerin İlişkisi. *Muş Alparslan Üniversitesi Tarım ve Doğa Dergisi*, 5(1), 14-20. https://doi.org/ 10.59359/ maujan.1581506

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi: 08.11.2024
Kabul Tarihi: 29.11.2024

Anahtar Kelimeler:
Uyuşmazlık,
Floem,
Fenolik bileşikler,
P-kumarik asit

ÖZET

Zeytin çeşitleri pratikte delice denen yabani zeytinlere aşılanarak çoğaltılmaktadır. Gemlik zeytin çeşidi sertifikalı anaç olarak belirlenmiş olmasına rağmen bazı çeşitlerin Gemlik anacı üzerinde uyuşmazlık yaşadığı çalışmalarla kanıtlanmıştır. Bu çalışma, Hatay Zeytincilik Araştırma Enstitüsü Hassa lokasyonunda yürütülmüştür. Tesadüf blokları deneme desenine göre 3 tekerrürlü olarak yürütülen çalışmada Gemlik, Sarı Haşebi, Halhalı (Hatay), Saurani ve Kilis Yağlık zeytin çeşitleri, çelikten üretilmiş Gemlik (1 yaş) anacına yama aşı yöntemi ile aşılanmıştır. 1 yaşına gelen aşılı fidanların floem dokularından örnekler alınarak etüvde 65 °C de kurutulmuş ve porselen havanda öğütülerek analize hazır hale getirilmiştir. Ardından 1 gr örneğe 10 ml metanol eklenerek hazırlanan süzüntü HPLC ye enjekte edilerek analizler yapılmıştır. Zeytinde yoğun olarak bulunan fenolik bileşiklerin (protokateşik asit, kafeik asit, p-kumarik asit, ferulik asit, rutin trihidrat ve kuersetin) bulunma durumları belirlenmiştir. Çalışma sonuçları incelendiğinde; protokateşik asit, kafeik asit, rutin trihidrat ve kuersetin aşı noktasının üzerinde yüksek düzeyde tespit edilirken p-kumarik asit, ferulik asit aşı noktasının altında daha yüksek düzeyde belirlenmiştir. Zeytinde yürütülen aşılama çalışmalarında ferulik asit ve p-kumarik asidin aşı kaleminde yüksek oranda bulunmasının uyuşmazlıkla sonuçlandığı değerlendirilmektedir. Yürütülen çalışmada ferulik asit ve p-kumarik asidin tüm kombinasyonlarda aşı noktasının altında daha yüksek oranlarda bulunması kombinasyonların polifenol durumları açısından uyuşur olduğunu göstermektedir.

Relationship Between Graft Incompatibility and Phenolic Compounds in Some Olive Varieties Grafted onto Gemlik Rootstock

Research Article

Article History
Received: 08.11.2024
Accepted: 29.11.2024

Keywords:
Incompatibility,
Floem,
Phenolic compounds,

ABSTRACT

Olive varieties are practically propagated by grafting to wild olives called delice. Although the Gemlik olive variety has been designated as a certified rootstock, it has been proven by studies that some varieties have disputes on the Gemlik rootstock. This study was conducted at the Hassa location of Hatay Olive Cultivation Research Institute. In the study conducted in 3 repetitions according to the randomized blocks trial pattern, Gemlik, Sarı Haşebi, Halhalı (Hatay), Saurani and Kilis Yağlık olive varieties were grafted with patch graft method on Gemlik (1 year

P-coumaric acid

old) rootstock. Samples were taken from the phloem tissues of grafted seedlings that reached the age of 1 and dried at 65 °C in the study and ground in a porcelain mortar to make them ready for analysis. Then, analyses were performed by injecting the filtrate prepared by adding 10 ml of methanol to 1 g of sample into HPLC. Conditions of the presence of phenolic compounds (protocatechic acid, caffeic acid, p-coumaric acid, ferulic acid, rutin trihydrate and quercetin), which are found intensively in olives

1. GİRİŞ

Meyvecilikte tohumun heterozigot yapısından dolayı genellikle vejetatif çoğaltma teknikleri kullanılmaktadır. Zeytin çelikle çoğaltılabilen bir bitki olmasına rağmen rejenerasyon yeteneklerinin farklı olması bazı çeşitlerde çoğaltma için aşılamayı zorunlu hale getirmektedir. Günümüzde, meyvelerin (ve bazı sebzelerin) ticari üretiminin çoğu aşılamaya dayanmakta olup, toprak kaynaklı patojenlere, abiyotik streslere direnç sağlamak ve ayrıca bodurluk elde etmek gibi amaçlarla aşılama yapılmaktadır. Başarılı bir aşılama için aşı uyuşması fevkalade önemlidir. Meyve ağaçlarında anaç kalem kombinasyonlarının başarılı olması için iyi bir birleşme gereklidir (Errea vd., 2001). Başarılı bir aşı birleşmesi, anaç ve kalem arasında kallus oluşumu, vasküler kambiyumun gelişmesi ve fonksiyonel bir iletim demetinin oluşmasıyla mümkündür (Pina ve Errea, 2008). Aksi durumlarda aşıda başarısızlığın en önemli nedenlerinden biri olan aşı uyuşmazlığı meydana gelmektedir. Bazı nedenlerle (kalem ile anaç arasındaki genetik farklılık, anatomik, fizyolojik, biyokimyasal farklılıklar veya hastalık ve zararlı etkisi) başarılı bir kaynaşma meydana gelememekte ve kompakt bir bitki oluşamamaktadır. Farklı araştırmacılar tarafından yapılan çalışmalarda aşı uyuşmasının/uyuşmazlığının tespit edilebilmesi amacıyla değişik yöntemler kullanılmıştır. Bazı araştırmacılar aşı uyuşmasının tespitinde bitkilerin gösterdiği dış semptomları önemsemiştir (Hartmann vd., 1997). Bazıları aşı noktasının altında biriken fenolik bileşikleri aşı uyuşmazlığının nedeni olarak bildirilmiştir (Usenik vd., 2008). Hartmann vd., (1971) Mission zeytin çeşidi için Manzanilla çeşidini anaç olarak kullanılmışlar ve bodur bitkiler elde edildiğini bildirilmişlerdir. Fabbri vd., (2004) zeytinde yaptıkları aşılama çalışmalarında herhangi bir uyuşmazlık belirtisine rastlanmadığı bildirilmişlerdir. Hudina vd., (2014) armutta yaptıkları çalışmada arbutin, kateşin, prosiyanidin B1, klorojenik asit ve flavanollerin aşı uyuşmazlığında etkili olabileceğini bildirmişlerdir.

Çalışmamızda Gemlik anacı üzerine aşılanan Sarı Haşebi, Halhalı (Hatay), Saurani ve Kilis Yağlık zeytin çeşitlerinde aşı uyuşmasının, aşı noktasının altından ve üstünden alınan floem dokusunda bulunan fenolik bileşiklerle ilişkisi belirlenmeye çalışılmıştır. Bu amaçla bir yaşına gelen fidanların aşı noktasından alınan floem dokularındaki fenolik bileşikler belirlenmiştir. Kombinasyonların aşı başarısı ile belirlenen fenolik bileşikler arasındaki ilişki irdelenmiştir.

2. MATERYAL

Anaç materyali olarak örtü altında köklendirilen çeliklerden elde edilen Gemlik zeytin fidanları ve aşı materyali olarak Halhalı (Hatay), Saurani, Kilis Yağlık, Sarı Haşebi ve Gemlik zeytin çeşitlerine ait aşı kalemleri kullanılmıştır.

3. YÖNTEM

Yama göz aşısı yöntemi kullanılarak zeytin çeşitleri, 1 yaşındaki Gemlik fidanlarına aşılanmıştır (5 Ağustos 2020). Deneme, tesadüf blokları deneme desenine göre kurulmuştur. Kontrol grubu ile birlikte (Gemlik/Gemlik) 5 farklı kombinasyon (Halhalı (Hatay)/Gemlik, Saurani/Gemlik, Sarı Haşebi/Gemlik ve Kilis Yağlık/Gemlik) oluşturulmuştur. Her bir kombinasyondan 3 tekerrürlü olmak üzere toplam 120 adet aşı yapılmıştır. Bir yaşına gelen fidanlarda fenolik bileşen analizleri yapılmıştır.

3.1 Fenolik Bileşenlerin Analizi

1 yaşına gelen aşılı fidan (5 Ağustos 2021) kombinasyonlarından 3 tekerrürlü olarak aşı noktasının altından ve üstünden kabuklar bilezik şeklinde soyularak alınmıştır. Kabuk örnekleri etüvde 65 °C de sabit ağırlığa gelinceye kadar kurutulmuştur. Kurutulan örnekler porselen havanda öğütülerek analize hazır hale getirilmiştir. Analize hazırlanan numunelerden 1 gram tartılıp üzerine 10 ml metanol eklenmiştir. 1 saat ultrasonik banyoda, 1 saat çalkalayıcıda bekletildikten sonra Whatman süzgeç kağıdından süzülmüştür. Süzüntü 0,45 µm lik filtreden geçirilip 20 µL'si HPLC cihazına enjekte edilmiştir (Gomes ve ark., 1999). Shimadzu marka HPLC cihazına standart olarak öngörülen fenolik bileşikler verilmiştir. Agilent Eclipse XDB-C18 (250*4,60 mm) 5 mikron kolon kullanılmıştır. Kolon sıcaklığı 30 °C olup okumalar 90 dakikada gerçekleştirilmiştir. Mobil faz olarak A: %3 asetik asit, B: Metanol kullanılmıştır. Aşı noktasının altında ve üstünde fenolik bileşiklerin içeriği µg g-1 olarak belirlenmiştir.

3.2 İstatistik Analiz

Çalışma sonunda elde edilen veriler tesadüf blokları deneme desenine göre SAS istatistik paket programı

kullanılarak varyans analizine tabi tutulmuş ve ortalamalar arasındaki farklılıklar Tukey Testi ile P< 0.05 önem seviyesinde gruplandırılmıştır (SAS, 1999).

3.3 Bulgular ve Tartışma

Gemlik anacı üzerine aşılanan Halhalı (Hatay), Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerine ait aşı kombinasyonlarında belirlenen protokateşik asit miktarları sunulmuştur (Tablo 1). Kombinasyonlar arasından ve aşı elemanları arasında belirlenen ortalama protokateşik asit miktarları istatistiksel olarak önemli bulunmuştur. Aşı elemanları arasında belirlenen ortalama protokateşik asit miktarı bakımından en yüksek miktar Sarı Haşebi/Gemlik kombinasyonunda (323.05 µg g-1) tespit edilmiştir. Kilis Yağlık/Gemlik (318.65 µg g-1), Halhalı (Hatay)/Gemlik (194.95 µg g-1) ve Gemlik/Gemlik (178.35 µg g-1) kombinasyonları takip etmiştir. En düşük protokateşik asit miktarı ise Saurani/Gemlik kombinasyonunda (146.55 µg g-1) tespit edilmiştir. Protokateşik asit miktarı bakımından kombinasyonlarda önemli farklılıklar olmuş, aşı noktasının altında tespit edilen miktar ortalamaları (211.50 µg g-1), aşı kaleminde tespit edilen ortalama değerlerden daha düşük (253.12 µg g-1) bulunmuştur.

Tablo 1. Gemlik anacı üzerine aşılı Halhalı, Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı noktasında protokateşik asit (protocatechic acid) miktarları (µg g^{-1})

Table 1. Protocatechic acid amounts (µg g^{-1}) at the grafting point in Halhali, Sari Hasebi, Gemlik, Saurani and Kilis Yaglik varieties grafted onto Gemlik rootstock

Kombinasyonlar	Aşı noktasının altı	Aşı noktasının üstü	Ortalama *
Gemlik/Gemlik	151.15	205.55	178.35 d
Halhalı/Gemlik	263.20	126.70	194.95 c
K. Yağlık/Gemlik	282.05	355.25	318.65 b
Saurani/Gemlik	171.70	121.40	146.55 a
S.Haşebi/Gemlik	189.40	456.70	323.05 e
Ortalama	211.50 b	253.12 a	

Farklı harf ile gösterilen değerler Tukey testi uyarınca P< 0.05 önem seviyesinde farklıdır.

Gemlik anacı üzerine aşılanan Halhalı (Hatay), Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı bileşenlerinde belirlenen kafeik asit miktarları sunulmuştur (Tablo 2). Aşı kombinasyonları arasında ve aşı elemanları arasında belirlenen ortalama kafeik asit miktarları istatistiksel olarak önemli bulunmuştur. Aşı noktasında belirlenen ortalama kafeik asit miktarlarına bakıldığında maksimum kafeik asit değeri Sarı Haşebi/Gemlik kombinasyonunda (53.42 µg g-1) belirlenmiştir. Ardından; Kilis Yağlık/Gemlik kombinasyonu (43.82 µg g-1), Gemlik/Gemlik kombinasyonu (41.45 µg g-1) ve Halhalı/Gemlik (41.02 µg g-1) kombinasyonu izlemiştir. Minimum kafeik asit ise Saurani/Gemlik kombinasyonunda (39.32 µg g-1) tespit edilmiştir. Yapılan analizler sonucunda ortalama kafeik asit miktarının aşı noktasının üzerinde daha yüksek düzeyde (46.37 µg g-1) olduğu belirlenmiştir. Canas vd. (2015) tarafından, üzümde, kafeik asidin, kalemde daha yüksek miktarda bulunmasından dolayı uyuşmazlıkta dikkate değer bir rolü olduğu, Skocajic vd, (2021) kafeik asidin kiraz aşılarında uyuşmazlığının bir belirteci olduğu bildirilmiştir.

Tablo 2. Gemlik anacı üzerine aşılı Halhalı, Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı noktasında kafeik asit (caffeic acid) miktarları (µg g^{-1})

Table 2. Caffeic acid amounts (µg g^{-1}) at the grafting point in Halhali, Sari Hasebi, Gemlik, Saurani and Kilis Yaglik varieties grafted onto Gemlik rootstock

Kombinasyonlar	Aşı noktasının altı	Aşı noktasının üstü	Ortalama *
Gemlik//Gemlik	34.80	48.10	41.45 c
Halhalı/Gemlik	36.15	45.90	41.02 c
K.Yağlık/Gemlik	44.25	43.40	43.82 b
Saurani/Gemlik	46.05	32.60	39.32 d
S.Haşebi/Gemlik	45.00	61.85	53.42 a
Ortalama	41.25 b	46.37 a	

Farklı harf ile gösterilen değerler Tukey testi uyarınca P< 0.05 önem seviyesinde farklıdır.

Gemlik anacı üzerine aşılanan Halhalı (Hatay), Sarı Haşebi, Gemlik, Sauranı ve Kilis Yağlık çeşitlerinde aşı bölgesinde p-kumarik asit değerleri sunulmuştur (Tablo 3). Kombinasyonlar arasında; anaçta ve kalemde tespit edilen ortalama p-kumarik asit miktarları istatistiksel olarak önemli bulunmuştur. Maksimum p-kumarik asit değeri (17.05 μg g^{-1}) Gemlik/Gemlik kombinasyonunda tespit edilmiştir. Ardından; Sarı Haşebi/Gemlik kombinasyonu (14.15 μg g^{-1}), Kilis Yağlık/Gemlik kombinasyonu (12.90 μg g^{-1}) ve Halhalı/Gemlik kombinasyonu (12.72 μg g^{-1}) takip etmiştir. Minimum p-kumarik asit miktarı da Saurani/Gemlik kombinasyonunda (10.15 μg g^{-1}) tespit edilmiştir. Anaçta belirlenen p-kumarik asit değerleri aşı kaleminde belirlenen miktarlardan daha yüksek çıkmıştır. Usenik vd. (2006) uyuşmayan kayısı kombinasyonlarına ait kalemlerde p-kumarik asit birikimini, Skocajic vd. (2021) in vitroda aşılı kirazlarda aşı elemanları arasında belirlenen fenolik maddelerin kallus oluşumuna etkisini değerlendirmiştir. Ferulic asit ve p-kumarik asidin gecikmiş aşı uyuşmazlığının belirlenmesinde kullanılabileceğini belirtmektedir.

Tablo 3. Gemlik anacı üzerine aşılı Halhalı, Sarı Haşebi, Gemlik, Sauranı ve Kilis Yağlık çeşitlerinde aşı noktasında p-kumarik (p-coumaric acid) asit miktarları (μg g^{-1})

Table 3. P-coumaric acid amounts (μg g-1) at the grafting point in Halhali, Sari Hasebi, Gemlik, Sauran and Kilis Yaglik varieties grafted onto Gemlik rootstock

Kombinasyonlar	Aşı noktasının altı	Aşı noktasının üstü	Ortalama *
Gemlik//Gemlik	16.50	17.60	17.05 a
Halhalı/Gemlik	11.25	14.20	12.72 c
K.Yağlık/Gemlik	15.00	10.80	12.90 c
Saurani/Gemlik	13.70	6.60	10.15 d
S.Haşebi/Gemlik	14.15	14.15	14.15 b
Ortalama	14.12 a	12.67 b	

Farklı harf ile gösterilen değerler Tukey testi uyarınca P< 0.05 önem seviyesinde farklıdır.

Gemlik anacı üzerine aşılanan Halhalı (Hatay), Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı bölgesinde belirlenen ferulik asit miktarları sunulmuştur (Tablo 4). Aşı kombinasyonları arasında ve aşı bileşenlerinde belirlenen ortalama ferulik asit miktarları istatistiksel olarak önemli bulunmuştur. Maksimum ferulik asit miktarı Gemlik/Gemlik kombinasyonunda (155.25 μg g^{-1}), minimum ferulik asit miktarı ise Halhalı (Hatay)/Gemlik kombinasyonunda (111.32 μg g^{-1}) belirlenmiştir. Kilis Yağlık/Gemlik kombinasyonunda bu miktar 142.17 μg g^{-1}, Sarı Haşebi/Gemlik kombinasyonunda ise 135.05 μg g^{-1} ve Saurani/Gemlik kombinasyonunda da 113.25 μg g^{-1} belirlenmiştir. De Cooman vd. (1996) Eucalyptus gunnii mikro aşılamalarında aşı uyuşmazlığının neticesinde, aşı elemanları arasında gallik asit, ellagik asit, gentisik ve p-kumarik asidin birikmiş olduğunu bildirmiştir. Uyuşur aşı kombinasyonlarında daha düşük miktarda fenolik bileşiğin biriktiği belirtilmektedir. Çalışma kapsamında değerlendirilen tüm kombinasyonlarda ferulik asit miktarının aşı noktasının altında daha yüksek düzeyde olduğu belirlenmiştir.

Tablo 4. Gemlik anacı üzerine aşılı Halhalı, Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı noktasında ferulik asit (ferulic acid) miktarları (μg g^{-1})

Table 4. Ferulic acid amounts (μg g^{-1}) at the grafting point in Halhali, Sari Hasebi, Gemlik, Saurani and Kilis Yaglik varieties grafted onto Gemlik rootstock

Kombinasyonlar	Aşı noktasının altı	Aşı noktasının üstü	Ortalama *
Gemlik//Gemlik	156.80	153.70	155.25 a
Halhalı/Gemlik	137.95	84.70	111.32 e
K. Yağlık/Gemlik	181.85	102.50	142.17 b
Saurani/Gemlik	141.00	85.50	113.25 d
S.Haşebi/Gemlik	180.55	89.55	135.05 c
Ortalama	159.63 a	103.19 b	

Farklı harf ile gösterilen değerler Tukey testi uyarınca P< 0.05 önem seviyesinde farklıdır.

Gemlik anacı üzerine aşılanan Halhalı (Hatay), Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı bölgesinde belirlenen rutin trihidrat değerleri sunulmuştur (Tablo 5). Kombinasyonlar ve aşı elemanları arasında tespit edilen ortalama rutin trihidrat değerleri arasında istatistiksel olarak önemli farklılıklar bulunmuştur. Maksimum rutin trihidrat değeri Gemlik/Gemlik kombinasyonunda (206.67 μg g^{-1}), minimum miktar ise Kilis Yağlık/Gemlik kombinasyonunda (145.27 μg g^{-1}) tespit edilmiştir. Halhalı/Gemlik kombinasyonunda 170.45 μg g^{-1}, Sarı Haşebi/Gemlik kombinasyonunda 166.75 μg g^{-1} ve Saurani/Gemlik kombinasyonunda 154.80 μg g^{-1} rutin trihidrat düzeyleri tespit edilmiştir. Ortalama rutin trihidrat miktarlarının anaçta daha yüksek düzeyde (202.79 μg g^{-1}) olduğu belirlenmiştir.

Tablo 5. Gemlik anacı üzerine aşılı Halhalı, Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı noktasında rutin trihidrat (rutin trihidrat) miktarları (μg g^{-1})

Table 5. The amounts of routine trihydrate (routine trihydrate) at the grafting point in Halhali, Sari Hasebi, Gemlik, Saurani and Kilis Yaglik varieties grafted onto Gemlik rootstock (μg g^{-1})

Kombinasyonlar	Aşı noktasının altı	Aşı noktasının üstü	Ortalama *
Gemlik//Gemlik	203.00	210.35	206.67 a
Halhalı/Gemlik	189.60	151.30	170.45 b
K. Yağlık/Gemlik	206.70	83.85	166.75 c
Saurani/Gemlik	192.80	116.80	154.80 d
S.Haşebi/Gemlik	221.85	111.65	145.27 e
Ortalama	202.79 a	134.79 b	

Farklı harf ile gösterilen değerler Tukey testi uyarınca P< 0.05 önem seviyesinde farklıdır.

Gemlik anacı üzerine aşılanan Halhalı (Hatay), Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık zeytin çeşitlerinde aşı bölgesinde kuersetin (quercetin) miktarları sunulmuştur (Tablo 6). Çalışılan aşı kombinasyonlarında belirlenen ortalama kuersetin miktarları kombinasyon ve aşı elemanları arasında istatistiksel olarak önemli bulunmuştur. Maksimum ortalama quercetin miktarı Saurani/Gemlik kombinasyonunda (346.02 μg g^{-1}), minimum kuersetin miktarı da Gemlik/Gemlik kombinasyonunda (206.30 μg g^{-1}) tespit edilmiştir. Halhalı (Hatay)/Gemlik kombinasyonunda kuersetin miktarı 332.75 μg g^{-1}, Kilis Yağlık/Gemlik kombinasyonunda 237.25 μg g^{-1} ve Sarı Haşebi/Gemlik kombinasyonunda 228.15 μg g^{-1} belirlenmiştir. Yapılan değerlendirmede kombinasyon ortalamalarına göre aşı noktasının üstündeki kuersetin miktarının daha yüksek olduğu belirlenmiştir.

Tablo 6. Gemlik anacı üzerine aşılı Halhalı, Sarı Haşebi, Gemlik, Saurani ve Kilis Yağlık çeşitlerinde aşı noktasında kuersetin (quercetin) miktarları (μg g^{-1})

Table 6. The amounts of quercetin (quercetin) at the grafting point in Halhali, Sari Hasebi, Gemlik, Saurani and Kilis Yaglik varieties grafted onto Gemlik rootstock (μg g^{-1})

Kombinasyonlar	Aşı noktasının altı	Aşı noktasının üstü	Ortalama *
Gemlik//Gemlik	218.65	193.95	206.30 e
Halhalı/Gemlik	253.25	412.25	332.75 b
K. Yağlık/Gemlik	228.55	245.95	237.25 c
Saurani/Gemlik	326.80	365.25	346.02 a
S.Haşebi/Gemlik	205.45	250.85	228.15 d
Ortalama	246.54 b	293.65 a	

Farklı harf ile gösterilen değerler Tukey testi uyarınca P< 0.05 önem seviyesinde farklıdır

Çalışma kapsamında oluşturulan kombinasyonlarda belirlenen polifenollerden kuersetin, protokateşik asit ve kafeik asidin aşı kaleminde, p-kumarik asit, ferulik asit ve rutin trihidratın anaçta yüksek düzeyde olduğu belirlenmiştir. Loupit vd. (2022) tarafından, aşılı fidanlarda dış görünüme bakılarak aşılama başarısına karar verilebileceği fikrinin aksine fenolik bileşiklerin aşı uyuşmazlığının belirteci olarak kullanılabileceğini bildirilmektedir. Fenolik bileşiklerin aşı başarısındaki rolü ile ilgili çalışmalar incelendiğinde; Prabpreea vd. (2018) fenolik bileşiklerin varlığının, aşı kalemi ve anaç

arasındaki uyuşmasının/uyuşmazlığının değerlendirilmesinde önemli bir belirteç olduğunu bildirmiştir. Andrews ve Marquez, 1993; Errea vd. 1994, aşı kaleminde fazla oranda polifenol bulunmasının aşı elemanları arasındaki kambiyum dokularının ilerlemesinde durmaya neden olabileceğini ve fenolik bileşiklerin (kayısıda-flavanoid) kallus gelişimini engellediğini bildirmişlerdir. Aşı bölgesindeki polifenollerin durumu ile ilgili olarak; Karadeniz vd. (1997) aşı uyuşması ile aşılanacak kalemin fenolik içeriği arasında bir bağlantı olmadığını bildirmiştir. Buna karşın; Gebhardt ve Feucht (1982) kalemde fenolik madde birikmesinin aşı uyuşmasını azalttığını bildirilmişlerdir. Mng'omba vd. (2008) aşı birleşme yüzeyinde fenolik bileşiklerin birikmesinin aşı uyuşmazlığına neden olduğunu bildirmişlerdir. Errea vd. (2001)'e göre aşılamanın erken döneminde fenolik bileşiklerin tespit edilmesi önemlidir. Çünkü polifenoller anaç ve kalem arasında vasküler kambiyum dokuları arasındaki vasküler bağlantıyı engelleyebilirler. Canas vd. (2015) tarafından iletim demetlerinin baştan oluşması konusunda yaptıkları incelemeler polifenollerin önemini ortaya koymuştur. Nitekim Azimi vd. (2016) yaptıkları çalışmada. ferulik asidin Gemlik çeşidi ile aşı uyuşmazlığı riski taşıdığı varsayılan "Domat" ve "Ayvalık" kobinasyonlarının kalemlerinde daha yüksek konsantrasyonlara sahip olduğunu belirlemişlerdir.

4. SONUÇ

Bu çalışmada öngörülen bazı fenolik bileşiklerin aşı noktasındaki durumları belirlenmiştir. Ferulik asit ve p-kumarik asit farklı araştırmacılarca detaylı bir şekilde incelenmiş ve aşı kaleminde yüksek oranda bulunmasının uyuşmazlığa neden olduğu belirlenmiştir. Çalışmamızda aşı kombinasyonlarından elde edilen aşı başarısından bağımsız olarak, incelenen tüm kombinasyonların anaç kısmında ferulik asit ve p-kumarik asit daha yüksek düzeyde bulunuştur. Fakat aşı başarısı en düşük olan Kilis Yağlık/Gemlik (102.50 μg g^{-1}) kombinasyonunun aşı kaleminde belirlenen ferulik asit miktarı, Sarı Haşebi/Gemlik (89.55 μg g^{-1}), Saurani/Gemlik (85.50 μg g^{-1}) ve Halhalı (Hatay)/Gemlik (84.70 μg g^{-1}) kombinasyonlarının aşı kalemlerinde belirlenen miktara göre daha yüksektir. Aşı kaleminde yüksek düzeyde ferulik asit bulunmasının, düşük aşı başarısına işaret ettiği tespit edilmiştir. Çalışma kapsamında incelenen kombinasyonların fenolik bileşikler bakımından uyuşur olduğu belirlenmiştir.

ETİK STANDARTLAR İLE UYUM

Teşekkür

Yazarların Katkısı

Yazarlar makaleye eşit oranda katkı sağlamış olduklarını beyan ederler.

Çıkar Çatışması

Mevcut herhangi bir çıkar çatışması burada verilmelidir.

Herhangi bir çelişki yoksa, yazarlar şunları belirtmelidir:

Çıkar Çatışması: Yazarlar herhangi bir çıkar çatışması olmadığını beyan ederler.

Etik onay: Etik kurul kararına gerek yoktur.

Etik onay: Bu tür bir çalışma için resmi onay gerekli değildir.

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MAUN J AGR NAT (2025) 5(1): 21-32
DOI: 10.59359/maujan.1585443
e-ISSN: 2822-3500

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MUŞ ALPARSLAN ÜNİVERSİTESİ
TARIM VE DOĞA DERGİSİ

MUŞ ALPARSLAN UNIVERSITY
JOURNAL OF AGRICULTURE AND NATURE

Sürdürülebilir Tarım ve İklim Değişikliği

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Please cite this paper as follows:
Duru, S., (2025). Sürdürülebilir Tarım ve İklim Değişikliği. *Muş Alparslan Üniversitesi Tarım ve Doğa Dergisi*, *5*(1), 21-32. https://doi.org/ 10.59359/maujan.1585443

Derleme Makalesi

Makale Tarihçesi
Geliş Tarihi: 14.11.2024
Kabul Tarihi: 08.04.2025

Anahtar Kelimeler:
Doğal Kaynaklar,
Gıda Güvencesi,
İklim Değişikliği,
Sürdürülebilir Kalkınma,
Tarımsal Üretim

ÖZET

Dünyadaki nüfus artışıyla tüketimin artmasına rağmen, doğal kaynakların sınırlı olması ve gelecek nesillere kalıcı olarak aktarılabilmesi gerektiği için sürdürülebilirlik kavramını ortaya çıkarmıştır. Kalkınmanın çevresel, sosyal ve ekonomik yönlerinin farklı disiplinleri bir araya getirerek, insan refahının korunmasını ve geliştirilmesini sürekli hale getirmeyi hedeflemesi de sürdürülebilir kalkınma kavramını oluşturmuştur. Birleşmiş Milletler, sürdürülebilir kalkınmayı sağlamak amacıyla 17 küresel amaç belirlemiş olup iklim eylemi de bu amaçlardan biri olmuştur. Küresel çapta belirlenen iklim eylemi, temel olarak iklim değişikliği ile mücadeleyi amaçlamıştır. İklim değişikliği temel olarak insanoğlu faaliyetleri sonucu oluşan sera gazı emisyonlarından kaynaklı olup sıcaklık artışı, kuraklık, sel gibi çevresel olaylara neden olmaktadır. Tarımsal üretimin, doğa koşullarına bağlı olması ve buna bağlı olarak iklim değişikliği sonucu sıcaklık, yağışın zamanı ve miktarı, havadaki karbondioksit (CO_2) miktarı, güneş ışınımındaki ve toprak yapısındaki değişimlerden etkilenmesinin yanı sıra konvansiyonel (yoğun) tarım uygulamaları da iklim değişikliğine neden olmaktadır. Bu durum tarımsal faaliyetlerin Ekosistem Tabanlı Uygulamalarla (ETU) uyumlu yapılmasına ve organik tarım, iyi tarım uygulamaları gibi çevre dostu tarımsal uygulamaların yaygınlaşmasını sağlamıştır. Bu tarımsal üretim uygulamalarında temel amaç sürdürülebilir tarımsal faaliyetlerin yürütülmesi ve gıda güvencesinin sağlanmasıdır. Sürdürülebilir tarım, karbon salınımının azaltıldığı, girdi kullanımının kontrol edildiği ve bu sayede tarımsal faaliyetlerin iklim değişikliğine etkisini azaltıldığı, doğal kaynakların gelecekte de kullanılmasını sağlayan tarımsal yapıyı oluşturmaktadır. Bu derlemede, iklim değişikliği kapsamında sürdürülebilir tarımın önemi tarımsal üretim ve gıda güvencesi kavramları ile açıklanmış olup dünyadaki gelişmeler ve beklentiler değerlendirilmiştir. Çalışma sonucunda sürdürülebilir tarımın uygulanması için iklim değişikliğinin olumsuz etkileri ve geniş çapta benimsenmesinin zaman almasına yönelik engellerin ortadan kalkması için uygulayıcılar ve politikacıların birlikte hareket etmesi gerekli olduğu belirlenmiştir.

Sustainable Agriculture and Climate Change

Review Article

Article History
Received: 14.11.2024
Accepted: 08.04.2025

ABSTRACT

Despite the increase in consumption to population growth in the world, it is been emerged from concept of sustainability because natural resources are required to limited and must be transferred permanently

to future generations. With bringing together different disciplines in the ecological, social and economic aspects of development, the aim to continuously to protecting and improving human well-being has compose the concept of sustainable development. The United Nations have been determined to 17 global goals to ensure sustainable development; climate action has also been one of these goals. Globally has been determined climate action, basically on aimed at combating climate change. Climate change is sourced by greenhouse gas emissions basically on human activities, it has been caused environmental events such as temperature increase, drought and flood. As well as agricultural production is dependent on natural conditions and as well as to accordingly result of climate change is affected by changes in temperature, time and amount of precipitation, amount of carbon dioxide (CO_2) in the air, solar radiation and soil structure as a result of climate change, conventional (intensive) agricultural practices is brought about climate change. This situation has enabled agricultural activities to be carried out in accordance with Ecosystem Based Practices (ETU) and environmentally friendly agricultural practices such as organic farming and good agricultural practices to become widespread. The main purpose on these agricultural production practices is to carry out sustainable agricultural activities and ensure to food security. Sustainable agriculture is been consist of agricultural structure in which reduces carbon emissions, input use is checked and thus agricultural activities reduce the impact of climate change with natural resources are used in the future. In this review, the importance of sustainable agriculture within the scope of climate change is explained with the concepts of agricultural production and food security, and developments and expectations in the world are evaluated. As a result of the study, it was determined that practitioners and politicians need to act together to eliminate the obstacles to the implementation of sustainable agriculture, such as the negative effects of climate change and the time it takes for its widespread adoption.

Keywords:
Agricultural production,
Climate change,
Food security,
Natural Resource,
Sustainable development

1. GİRİŞ

Dünyada tarım ve gıda üretim sistemleri; nüfus artışı, doğal kaynakların aşırı kullanımı, israf ve iklim değişikliği gibi nedenlerden dolayı engeller ile karşı karşıya kalmaktadır (FAO, 2021). Bu nedenler doğrudan veya dolaylı olarak insan eylemleri sonucu oluşmakta olup doğal kaynaklar üzerindeki baskıyı artırmakta ve üretim süreçlerini tehlikeye atmaktadır (Tahat ve ark., 2020). Bu durum hem bugünkü hem de gelecekteki nesillerin doğal kaynak ihtiyaçlarını karşılama yeterliliğini tehlikeye atmakta, tarım ve gıda üretiminde sürdürülebilir sistemlere geçişini zorunlu kılmaktadır (Sırma, 2023).

Literatürde sürdürülebilirlik kavramı ilk olarak 1987'de Birleşmiş Milletler Brundtland Komisyonu raporunda gelecek nesillerin kendi ihtiyaçlarını karşılama yeteneğini tehlikeye atmadan bugünün ihtiyaçlarını karşılamak olarak tanımlanmıştır (Birleşmiş Milletler, 1987). Günümüzde sürdürülebilirlik alanında farklı disiplinlerdeki çalışmalardan dolayı birçok tanımı bulunmakla birlikte bu tanımlar en dar kapsamda insan faaliyetlerinin ekosistemi koruyacak şekilde sürdürülmesi ve bu yaşam tarzının hayat koşullarının değişme olasılığını optimize edebilmesidir (Abson ve ark., 2014; Geissdoerfer ve ark., 2017). Sürdürülebilirlik kavramı çevresel, sosyal ve ekonomik yönleri bütünleştirerek insan refahını koruyan ve geliştirmeyi amaçlayan sürdürülebilir kalkınma ilkesini ortaya çıkarmıştır (Jeronen, 2020). Sürdürülebilir sistemlerin, sürdürülebilir kalkınmaya imkân vermesi için alt sistemleri bir bütün olarak çalıştırması ve en üst düzeyde katkı sağlaması, bu iki terimin birbirini tamamlayan yakın ilişkiye sahip olduğunu göstermektedir (Glavič ve Lukman, 2007).

Sürdürülebilir kalkınma ilkesi, Birleşmiş Milletler tarafından 2030 yılına kadar ulaşılması amaçlanan 17 ana alanı ve 169 alt amacı kapsayan küresel bir amaç haline gelmiştir. Bu 17 alanı kapsayan temel amaçlar açlığın ve yoksulluğun sona erdirilmesi ile refahın eşit bir şekilde paylaşımı gibi sosyal ve ekonomik amaçların yanı sıra, çevrenin korunması ve iklim krizine karşı önlem gibi çevresel amaçları içermektedir (Tarım ve Orman Bakanlığı, 2021; Birleşmiş Milletler Türkiye, 2023). Ancak bu amaçların yazılı olarak raporlaştırılmasının ötesinde ortak amaçlara yönelik

ilerlemenin doğru şekilde uygulanmasını ve izlenmesini sağlamak amacıyla küresel ortaklıkların güçlendirilerek hareket edilmesi önemlidir (Ortiz ve ark., ark., 2021). Dünyada iklim değişikliğiyle mücadele amacıyla 1990 sonrası dönemde Birleşmiş Milletler çatısı altında yürütülen küresel ortaklıklar 1992 yılında Rio de Janerio'da tertiplenen BM Çevre ve Kalkınma Konferansında imzaya açılan BM İklim Değişikliği Çerçeve Sözleşmesi ile başlamış olup 1997 yılındaki Kyoto Protokolü ve 2015 yılındaki Paris Sözleşmesi ile iklim değişikliğiyle mücadelede devletlerarası işbirliğine resmiyet kazanmıştır (Erdoğan, 2018, Dışişleri Bakanlığı, 2022). Küresel ortaklıkların oluşmasında önemli rol oynayan Avrupa Birliği tarafından oluşturulan Avrupa Yeşil Mutabakatı, karbondan arınma ile iklim değişikliği azaltma veya uyum ve sürdürülebilir sanayiyi desteklemeyi amaçlamasında vatandaşları ve toplumun tüm kesimlerini iklim eylemine dahil etme örneği olarak gösterilebilir (Fetting, 2020).

İklim değişikliği, insan faaliyetleri sonucu açığa çıkan sera gazlarının atmosfer yapısını bozarak ortalama sıcaklıklarda yaşanan büyük ve uzun vadeli değişimin yanı sıra; kuraklık, sel baskınları, deniz seviyesinin yükselmesi gibi çevresel olayların görülme sıklığını artırmaktadır (Polat ve Dellal, 2016; Duru ve Parlakay, 2021). İklim değişikliği doğrudan veya dolaylı olarak insan sağlığına etkilerinin yanı sıra çevresel ve sosyal etkilere, iş kaybına, gıda ve su kıtlığı ile maliyetlerin artışına neden olmaktadır (McMichael, 2013). Ancak insanlığın bilimsel anlayışa, teknolojik kapasiteye ve finansal araçlara sahip olması iklim değişikliğinin etkilerini azaltmada ve uyum sağlamada yardımcı olabilmektedir (Owen, 2020).

Birleşmiş Milletler tarafından belirlenen Sürdürülebilir Kalkınma Amaçlarından iklim krizi ile ilgili mücadele, 13 nolu iklim eylemi kapsamında yürütülmektedir. İklim değişikliğinin doğuracağı olumsuz sonuçlara ilişkin uluslararası bir kuruluşun eylem planının bulunması, küresel çapta konunun öneminin ve mücadele edildiğinin göstergesidir. İklim değişikliğinin etkilerinin dünya genelinde ve sektörler üzerinde farklılık göstermesine karşın tarım sektörünün en fazla etkilenen sektör olması nedeniyle iklim değişikliğine ilişkin genel politikalar, ülkelerin tarımsal üretim faaliyetlerini destekleme veya korumacılığı olarak ön plana çıkarmaktadır (Kıymaz, 2016; Hayaloğlu, 2018). Başta iklim değişikliği olmak üzere Sürdürülebilir Kalkınma Amaçlarına ulaşmak için gıda güvencesinden ödün vermeden gelecekteki gıda güvencesive sürdürülebilirliğimiz için yeni çözümlere ihtiyaç bulunmaktadır (Vågsholm ve ark.,2020). Bu amaçla başta Birleşmiş Milletlere bağlı uluslararası kuruluşlar, ülkelerde tarım dahil tüm sektörlerde iklim değişikliğine ilişkin ulusal düzeyde sürdürülebilir uyum planı oluşturulmasına teknik ve mali destek sağlayarak katkıda bulunmaktadır (Aryal et.al., 2020).

İklim değişikliğinin tarıma etkileri ile ilgili ulusal literatürde çalışmalar son yıllarda yoğunlaşmaya başlamıştır. Bu araştırmalar iklim değişimin tarım sektörüne (Bayraç ve Doğan, 2016), hayvansal üretime (Koyuncu ve Nageye, 2020), bal verimine (Duru ve Parlakay, 2021), bitkisel üretime (Bayraktar, 2023) ve toprak yönetimine (Topçu ve Erpul, 2017) etkileri, iklim değişikliği tarım etkileşiminin iki yönüyle incelenmesi (Akyüz ve Atış, 2016), iklim değişikliğinin ekonomik büyümeye ve tarımsal katma değere etkileri (Hayaloğlu, 2018) konularında gerçekleştirilmiştir. Uluslararası literatürde ise iklim değişikliğinin tarıma etkilerine yönelik çalışmalar daha öncesinde başlamış olup bu araştırmalarda; sürdürülebilir tarım uygulamalarının iklim değişimine uyum stratejileri (Wall ve Smit, 2005), iklim değişikliğinin organik tarım yöntemi ve entegre tarım sistemi ile tarım sektöründe etkisinin azaltılması (Scialabba ve Lindenlauf, 2010; Gil ve ark., 2017); iklim değişikliğinin toprak verimliliğine (Mondal, 2021) ve tuzluluğuna (Mukhopadhyay ve ark., 2021) etkisi, iklim değişikliğinin gıda güvencesine neden olacak riskleri azaltması (Campbell ve ark., 2016), üreticilerin iklim değişimine uyumu (Torres ve ark., 2020) şeklinde özetlenebilir.

Bu çalışmada iklim değişikliğinin tarımsal üretime ve gıda güvencesine etkisini daha net bir şekilde ortaya koyabilmek için iklim değişikliğinin tarım ve gıda sektörüne yönelik son 20 yılda yapılan ulusal ve uluslararası literatürdeki araştırma makaleleri, derlemeler ve uluslararası kuruluş raporları taranmıştır. Literatür taraması sonucu iklim değişikliğinin nedenleri, doğal kaynaklara etkileri, tarımsal üretimde ve gıda güvencesinde meydana getireceği sonuçlardan bahsedilmiş olup sürdürülebilir tarım yöntemlerinin iklim değişikliğiyle mücadeleye karşı önemi ortaya konmaya çalışılmıştır.

2. İKLİM DEĞİŞİKLİĞİ

İklim değişikliği esas olarak doğal sistemlerden ve insanoğlunun üretim faaliyetlerinden kaynaklanmaktadır. Bununla birlikte son yıllarda insan faaliyetleri ile küresel ısınma arasındaki ilişkinin iklim değişikliğine etkilerinden daha fazla kaygı duyulmaktadır. İnsan faaliyetlerinden kaynaklanan küresel ısınmanın asıl nedeni toplam sera gazı emisyonlarının fazlalığından kaynaklanmakta olup bunun nedeninin fosil yakıt ve arazi kullanımındaki değişikliklerden kaynaklandığı gözlenmektedir (McMichael, 2013; Xi-Liu ve Qing-Xian, 2018).

Sera gazı, kızılötesi radyasyonu emen ve yayan bir gaz olarak dünya yüzeyi ve atmosferi ısıtarak yağış miktarı, buzul ve deniz seviyesinde önemli etkilere sahiptir (Easterbrook, 2016). Sera gazı etkisi, sera gazlarının atmosferin alt katmanlarına birikmesi

sonucu katmanların ısınmasına bağlı olarak dünya yüzeyinde sıcaklık artışına yol açan ve iklim değişikliğinde Dünya'nın manyetik alanındaki değişimle birlikte en önemli etken olan faktördür (Mikhaylov ve ark., 2020). Sera gazları iklim değişikliğinde etkili faktörler olup bunların başında karbondioksit (CO_2), azot oksit (N_2O) ve metan (CH_4) gelmektedir (Shah ve ark., 2024).

İklim değişikliğinin etkileri hava koşullarındaki istatistiksel değişimle daha iyi ortaya konmaktadır. Sanayi devrimi süreciyle birlikte üretim faaliyetlerinin yoğun olduğu son 300 yıllık dönemde ortalama sıcaklık artışı 1°C olmasına karşın gelecek 25 yılda bu artışın 1.5°C'ye, 21. yüzyıl sonunda ise 5.8°C'ye ulaşması beklenmektedir (Wu ve ark., 2016; Fawzy ve ark., 2020). Yağış rejiminde ise küresel ısınmanın genellikle şiddetli sağanak yağışlar meydana getirdiği gözlenmekte olup bazı yağış endeks hesaplamalarına göre ise her 1°C artışın yağış miktarında %7'lik artışa neden olduğu hesaplanmıştır (Martel ve ark., 2021).

2.1. İklim Değişikliğinin Tarımsal Üretime Etkileri

İklim değişikliğinin meydan getirdiği sıcaklık, yağışın zamanı ve miktarı, havadaki karbondioksit (CO_2) miktarı, güneş ışınımındaki değişimler tarımsal üretimi etkileme potansiyeline sahiptir (El-Ramady ve ark., 2013). Bu etkiler, ürüne veya bölgeye göre doğrudan ya da dolaylı şekilde değişmektedir. Tarım arazilerinde verimin ve ürün kalitesinin düşmesi, kuraklığa bağlı olarak sulama ihtiyacının artması, yabani ot vb. zararlılarının etki alanının genişlemesi iklim değişikliğinin tarıma olan etkileri arasındadır (Dantas ve ark., 2020; Bayraktar, 2023). Bu etkilerin azaltılmasının yanı sıra mevsimlerde meydana gelen sıcaklık ile yağış düzeni ve miktarındaki değişimlere dayanıklı mahsul çeşitlerinin yetiştirilmesini zorunlu kılmaktadır (Thornton ve ark., 2014). Üreticilerin iklim değişikliğinin olumsuz etkilerine yönelik farkındalıklarının bulunmasıyla bu olumsuzlukları azaltmaya yönelik tarımsal uygulamaları benimsemelerini kolaylaştırmaktadır (Hayran ve ark., 2021).

İklim değişikliğinin tarımsal üretimde meydana getirdiği en önemli değişikliklerden birisi de toprak yapısındaki değişimdir. İklim değişikliği en çok toprak pH'ı, tuzluluk, katyon değişim kapasitesi, besin döngüsü ve kazanımı gibi toprağın kimyasal özelliklerini etkilemektedir. Özellikle kurak bölgelerde iklim değişikliği ile toprak sıcaklığının artması toprağın fiziksel özelliklerinin değişim yoluyla bitki örtüsüne ve ürünün cinsine bağlı olarak tohumun çimlenmesini etkilemektedir. Toprağın bu kimyasal ve fiziksel özelliklerindeki değişim toprağın karbon ve besin döngüsünü, dolayısıyla toprağın verimliliğini dengeleyen toprağın biyolojik özelliklerini de olumsuz yönde etkilemektedir. (Dantas ve ark.,2020; Mondal, 2021).

Küresel çapta tüketilen suyun %70'inin tarımsal faaliyetlerde kullanılması nedeniyle tarımsal üretimde su kaynaklarının yönetimi önem arz etmektedir (Rasul ve Sharma, 2016). Dünyada su kaynaklarının varlığı bölgelerin biyofiziksel özelliklere göre değişiklik göstermesi nedeniyle iklim değişikliğinin su kaynaklarına etkisi konusunda ise görüş farklılıkları içermesine karşın 2°C sıcaklık artışının dünya nüfusunun %5 ile %20'sini su kıtlığına maruz bırakabilmektedir (Schewe ve ark., 2014). Küresel ısınma ile su kaynaklarında oluşacak bu kıtlık, tarım ile diğer sektörler arasında su kullanımı açısından rekabete neden olacağından su kaynaklarının planlanmasını zorunlu kılmaktadır (Mancosu ve ark., 2015). Özellikle sulama tarımının verim üzerinde baskı oluşturması ve çevre üzerinde olumsuz etki bırakması nedeniyle bölgeye göre ürün yetiştirme ve türlerinde değişiklikler veya daha az su kullanan yenilikçi teknolojiler gibi temel adaptif önlemler kullanılması gerekmektedir (Misra, 2014).

İklim değişikliği, tarımsal faaliyetleri özellikle üretim miktarı açısından olumsuz yönde etkilemektedir. Ancak küresel olarak artan nüfus nedeniyle tarımsal verimlilik sağlamak açısından kimyasal girdilerin ve su kaynaklarının yoğun kullanımı şeklinde yürütülen konvansiyonel (yoğun) tarım uygulamaları da iklim değişikliğine neden olmaktadır. Bu etkiler tarımsal üretim sonucu doğal kaynakların tükenmesinin yanı sıra sera gazlarının atmosfere salınmasından da kaynaklanmaktadır. Atmosferdeki sera gazı emisyonlarının %25'ini tarım ve ormancılık gibi arazi kullanım faaliyetleri oluşturmakta olup bu sera gazlarının başında Azot protoksit ya da Nitröz oksit (N2O) gelmektedir. Söz konusu sera gazları son 10 yılda atmosferde %1'lik emisyon artış meydana getirmiştir (Arora, 2019; Fawzy ve ark., 2020; Leal Filho ve ark., 2023). CO2 ise atmosfer sistemindeki küresel karbon döngüsünde önemli bir rol oynamakta olup ağırlıklı olarak fosil yakıtların kullanımı ve ormansızlaştırma gibi insan faaliyetleri sonucu 400 ppm konsantrasyonunu aşmıştır (Shakoor, 2021).

Taze meyve ve sebze ürünlerinin üretimi ve kalitesi iklim değişikliğine neden olan yüksek sıcaklık artışı ve karbondioksit ve ozon gibi sera gazı emisyonları doğrudan veya dolaylı olarak etkilemektedir. Bu etkiler sebze ve meyvelerde farklılık göstermekte olup sebzelerde CO2 üretim artışı sağlamakta ancak ürün kalitesinin bozulmasına neden olurken, meyvelerde ise 35 °C kadar yüksek sıcaklıklarda normal şekilde olgunlaştığı bilinirken, daha yüksek sıcaklıklar olgunlaşma süreçlerini engellemektedir (Hribar ve Vidrih, 2015; Bisbis ve ark., 2018). Sonuç olarak iklim değişikliğinin düşük verim ve kaliteye neden olması çiftçi gelirlerinin düşmesine neden olması nedeniyle

ürün veriminin, çiftlik gelirlerinin ve gıda güvencesinin iyileştirilmesinin bir yolu olan sürdürülebilir tarım uygulamalarını öne çıkarmaktadır (Abdallah ve ark., 2021)

2.2. İklim Değişikliğinin Gıda Güvencesine Etkisi

Dünya genelinde gıda güvencesinin birçok farklı tanımı olsa da küresel olarak Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO) tarafından tüm insanların her zaman, aktif ve sağlıklı bir yaşam için beslenme ihtiyaçlarını ve gıda tercihlerini karşılayan yeterli, güvenli ve besleyici gıdaya fiziksel, sosyal ve ekonomik erişime sahip olması şekilde tanımlanmıştır (Engler-Stringer, 2022). Nüfus artışı, iklim değişikliği, kentleşme ve küreselleşme, arazi kullanımındaki değişimler, su kıtlığı, gelir artışı, beslenme eğilimleri, küresel enerji arzı ve dünya gıda ticareti eğilimleri gibi faktörler küresel olarak gıda güvencesini etkileyen faktörler olarak değerlendirilmektedir (Mokhtar ve ark., 2022). Gıda güvencesini etkileyen bu faktörler genel olarak iklimsel ve iklim dışı stres faktörleri olarak ikiye ayrılmakta olup özellikle gelişmekte olan ülkelerde iklimsel faktörler daha belirleyici konumdadır (Baig ve ark., 2022).

İklim değişikliğinin ekosistemin bozulmasına bağlı olarak tarımsal üretimde görülen miktar baskısı oluşması; açlığa, yetersiz beslenmeye, kaynak çatışmasına ve göçlere neden olması beklenmektedir (Wu ve ark., 2016). İklim değişikliğinin tarım sektörüne bu yöndeki etkilerinin yanı sıra gıda arzındaki kesintilerin meydana gelmesi gıda güvencesinin dört boyutu olan bulunabilirlik, erişim, kullanım ve istikrar üzerine etkilerini de beraberinde getirmektedir (Campell ve ark., 2016). İklim değişikliğinin bu olumsuz etkilerinin yanı sıra özellikle gelişmekte olan ülkelerde nüfus ve ücret artışı, 2050'li yıllarda dünya nüfusunun 9,7 milyara ulaşmasının beklenmesi ile gıda talebindeki artışın %80'inin, gelişmekte olan ülkelerden kaynaklanacağının öngörülmesi de gıda güvencesini tehdit eden bir durum haline gelmiştir (Muhie, 2022).

Birleşmiş Milletlerin belirlediği Sürdürülebilir Kalkınma Amaçlarından açlığa (SKA2) ve yoksulluğa (SKA1) son, sağlıklı bireyler (SKA3) ile temiz su ve sıhhi koşullar amaçları (SKA6) gıda güvencesini kapsaması küresel boyutta önem verildiğinin göstergesidir. İklim değişikliğinin gıda güvencesine etkisi Paris Anlaşması'nda yer alan "gıda güvencesini koruma altına almak ve açlığı sonlandırmanın temel amacı olduğunu ve iklim değişikliğinin olumsuz etkilerine karşı gıda üretim sistemlerinin belirli hassasiyetinin bulunduğu" ibaresi ile doğrudan iklim değişikliği-gıda güvencesi arasındaki ilişkinin uluslararası boyutta önemini ortaya koymaktadır (Dellal, 2016).

İklim değişikliği sonucu meydana gelen gıda güvencesi sorununa karşı gıda sistemlerinin en geniş anlamıyla ele alması ve dünya çapında tarımın gelişimine entegre edilmesi gerekmektedir (Wheeler ve Von Braun, 2013). Ancak bu entegrasyonun tam sağlanabilmesi için gıda sistemlerinin multidisipliner çalışmalar ile daha geniş bir perspektifte analiz edilmesini zorunlu kılmaktadır. Özellikle bu çalışmalarda çevre-tarım-ticaret sistemi içindeki etkileşimlerin daha iyi anlaşılmasıyla küresel olarak belirlenen Sürdürülebilir Kalkınma Amaçları ve artan dünya nüfusunun talebini destekleyecek şekilde gıda sistemlerinin oluşturulması önem arz etmektedir (Ortiz ve ark., 2021). Çevre-tarım-ticaret sistemlerinin etkileşimine yapılan çalışmalarda sulama sistemleri ile tarım ve gıda ticareti arasındaki ilişkinden, gıda fiyatları ile ülke içerisindeki iç çatışmalar arasındaki ilişkiye kadar farklı alanlara etkileri incelenmiştir. Sonuç olarak bu etkiler iklim değişikliğinde gıda güvencesi sağlanması için gıda israfı ve beslenme konularında daha fazla çözüm beklenildiğini ortaya koymuştur (Campell ve ark., 2016).

Küresel olarak gıda güvencesinin sağlanmasının yanı sıra ekolojik bozulmanın önlenmesi için sürdürülebilir tarımsal üretim sistemleri benimsenmelidir. Ancak araştırmalar üreticilerin sürdürülebilir tarım uygulamalarının hem ekonomik hem de ekolojik açıdan faydalı olduğunu uzun dönemde benimsendiğinin ortaya çıkarması nedeniyle geçiş politikaları bu yönde belirlenmelidir (Dessart ve ark., 2019; Piñeiro ve ark., 2020). Sürdürülebilir tarım uygulamalarında tarım politikalarının kapsayıcı olmasının yanı sıra üretici tercihlerinin dikkate alınması, geliştirilmesi ve ürün çeşitliğinin teşvik edilmesi göz önünde bulundurulmalıdır (Torres ve ark., 2020). Sürdürülebilir tarımın Sürdürülebilir Kalkınma Amaçlarından açlığa son (SKA2) amacıyla gıda güvencesini ve gelişmiş beslenmeye sağlaması nedeniyle gıda güvencesiyle de yakın ilişkide bulunmaktadır (Gil ve ark., 2019).

3. SÜRDÜRÜLEBİLİR TARIM

Sürdürülebilir tarım, evrensel olarak sürdürülebilir gıda ile tanımlanan bir kavramdır. Gıda ve tarımın sürdürülebilir olması için tarımsal üretimin karlılığı, çevre sağlığı ile sosyal ve ekonomik eşitliği sağlamakta iken, gıdanın ise herkes için besleyici ve erişilebilir olması şartını sağlaması gerekmektedir. Bu özellikler şimdiki neslin ihtiyaçlarını karşılamasının yanı sıra gelecek nesillerin de doğal kaynak ihtiyaçlarını destekleyecek şekilde ekosistemin yönetilmesidir (FAO, 2021; FAO, 2023). Bu amaçla FAO tarafından yayınlanan "Gıda ve tarımın geleceği: eğilimler ve zorluklar" raporunda dünya nüfusunun artmasıyla meydana gelen gıda talep artışının sürdürülebilir tarım yoluyla yeterli ve uygun fiyatlı gıda tedarikinin

sağlanmasına yönelik gereklilikler belirlenmiştir (FAO, 2017).

Birleşmiş Milletler tarafından belirlenen 17 adet Sürdürülebilir Kalkınma Amaçlarından doğrudan sürdürülebilir tarımı ilgilendiren başlıklar yoksulluğa-açlığa son verme, insana yakışır iş ve ekonomik büyüme, sudaki yaşam, sorumlu üretim ve tüketim gibi alanları içermektedir (UNDP, 2021). FAO tarafından gıda ve tarımda sürdürülebilirliğin beş temel ilkesi ise gıda sistemlerinde verimliliği, istihdamı ve katma değeri artırma; doğal kaynakları koruma ve genişletme; geçim kaynaklarını iyileştirme ve kapsayıcı ekonomik büyümeyi teşvik etme; insanların-toplulukların ve ekosistemlerin dayanıklılığını artırma ile yönetimi yeni zorluklara uyarlama şeklinde belirlemiştir (FAO, 2023). Sürdürülebilir tarımda FAO'nun belirlediği ilkeler doğrultusunda ekonomik, sosyal ve çevresel amaçları bulunmakta olup bu amaca yönelik sürdürülebilir tarımın sağlayacağı faydalar Tablo 1'de verilmiştir.

Tablo 1. Sürdürülebilir tarım amaç ve faydaları
Table 1. Goals and Benefits of Sustainable Agriculture

Sürdürülebilir Tarım Amaçları	**Sürdürülebilir Tarım Faydaları**
Ekonomik	Girdi maliyetlerini azaltma Verim ve ürün kalitesini artırma Üreticilere makul gelir sağlama
Sosyal	Yoksulluğu azaltma Gıda güvencesini sağlama Tarımda dijitalleşmeyi sağlama
Çevresel	Doğal kaynakların daha verimli kullanımı Sera gazı emisyonunu azaltma İklim değişikliğine adaptasyon Tarımsal ekosistemleri koruma Temiz enerji ve su sağlama Topraktaki organik madde artışı sağlama

Kaynak: Adegbeye ve ark., 2020; Piñeiro ve ark., 2020; Tahat ve ark., 2020

Gıda sistemlerinin sürdürülebilirliğinin sağlaması küresel bir öncelik olup sistemin sürdürülebilirliğinde verimliğinin yanı sıra iklim değişikliği göz önünde bulundurularak, talep kısıtlaması ve gıda sistemlerin dönüşümüyle birlikte bir yaklaşım içermelidir (Garnett, 2014). Ayrıca gıda sistemlerinin sera gazı emisyonunun oluşumunda yer almasının iklim değişikliğine etkileri nedeniyle yeni süreçler ve yönetişimi de önem kazanmaktadır (Zurek ve ark., 2022). Ancak iklim değişikliğinin gıda kalitesi ve miktarına olumsuz etkisinin yanı sıra gıda talebindeki sürekli artış, gıda sistemlerinin baskı altında olmasına neden olmaktadır (Myers ve ark., 2017). Sera gazı emisyonlarının azaltılması iklim değişikliğinin risklerini azaltmak için gerekli olup gıda atıklarının azaltılmasının emisyonu azaltması nedeniyle gıda sistemleri küresel nüfus için yeterli ve dengeli gıda sağlamaya uyum sağlamalıdır (Bajželj ve ark., 2014). Bu baskı sürdürülebilir tarımın yanı sıra tarımsal üretimde sürdürülebilir büyümenin de sağlanması gerektiğini ortaya koymaktadır. Bu iki koşulun sağlanması ise tarımsal araştırma ve geliştirmeye (AR-GE) yapılan yatırımların teknolojik yenilikler üreten ve geleneksel tarım girdilerinde verimliliği artıracak şekilde oluşturulmasıdır (Baldos ve ark., 2020).

Sürdürülebilir tarım ve gıda sistemlerine geçişte eko-verimliliğin artırılması, girdilerin ikamesi ve sistemin yeniden tasarlanması gibi üç adımın atılması hedeflenmiştir (Barrios ve ark., 2020). Sürdürülebilir tarım, tarım-çevre arasında dengeyi sağlayarak, tarımsal girdi kullanım miktarının kontrol edildiği ve doğal kaynakların gelecek kuşakların da yararlanmasını sağlayarak sosyal, ekonomik ve çevresel etkilere de sahip bir kavram haline gelmiştir (Eryılmaz ve Kılıç, 2018). Bu nedenle sürdürülebilir tarım biyofiziksel kaynakların yanı sıra insan kaynaklarını da etkin bir şekilde kullanımını sağlayarak girdilerin minimalize edilerek içsel kaynaklardan en iyi şekilde faydalanmayı sağlamaktadır (Sırma, 2023).

Sürdürülebilir tarım uygulamalarının yürütülmesinde tarımsal sulama önemli bir rol oynamakta olup bu alanda son 25 yıllık dönemde yapılan çalışmalarda iklim değişikliğinin tarımsal sulamaya etkileri üzerinde yoğun bir şekilde durulmuştur (Velasco-Muñoz ve ark., 2019). Günümüzde dünya nüfusunun yaklaşık yarısı yılın en azından bir bölümünde ciddi su kıtlığı yaşaması ve gelecekte bu oranın daha fazla olmasının öngörülmesi basınçlı sulama sistemi başta olmak üzere su kıtlığının yaşandığı yerlerde su kaynağı olarak görülmeyen alternatiflerin kullanımını zorunlu hale getirmiştir (Nikolaou ve ark., 2020; Birleşmiş Milletler, 2024). Bu amaçla su kaynağı olmayan atık suyun tarımsal sulamada kullanımının gübre ile yapılması su tasarrufunun yanı sıra kimyasal girdilere bağımlılığı da azaltarak sürdürülebilir tarım yöntemlerinin yaygınlaşmasına katkı sağlayacaktır (Chauhan veKumar, 2020).

İklim değişikliği sonucunda tarımsal üretim miktar ve kalitesindeki azalma iklim değişikliklerine uyum sağlayacak şekilde tarımsal üretim biçimlerinin yeniden gözden geçirilmesi ihtiyacı doğurmaktadır. Bu geliştirilen yaklaşımlar Ekosistem Tabanlı Uygulamalar (ETU) terimi altında adlandırılmakta olup en genel anlamda biyolojik çeşitlilik, ekolojik süreç veya hizmetlerden yararlanarak tarımsal üretimde yer alan

bitki ve hayvanların iklim değişikliğine uyumunu sağlamaktadır (Topçu ve Erpul, 2017; Aydın ve Aktuz, 2023).

Ekosistem Tabanlı Uygulamalardan (ETU) küresel olarak en yaygın kullanılan yöntemlerden biri koruyucu tarımdır. Koruyucu tarımda temel amaç girdilerin korunarak doğal kaynaklar üzerindeki etkinin minimize edilmesidir (Aydın ve Aktuz, 2023). Sürdürülebilir tarım yöntemlerinin temelini oluşturan koruyucu tarımın ilkeleri ise minimum toprak bozulması, ürün rotasyonu ve toprak örtüsüdür (Malhi ve ark., 2021). Bunun yanında sürdürülebilir tarımın sağlanması için ürün ıslahının teşvik edilmesi, tarım sigortası mekanizmalarının geliştirilmesi ve diğer yenilikçi tarım uygulamaları ve arazi yönetimi gereklidir (Aryal ve ark., 2020).

Sürdürülebilir tarım kavramı, İyi Tarım Uygulamaları (İTU) ve organik tarım gibi uygulamaların ön plana çıkmasını sağlamıştır (Akyüz ve Atış, 2016). İyi tarım uygulamaları ile gıda güvencesinin sağlanması ve tarımsal ürün kalitesinin yükselmesi amaçlanmaktadır. Organik tarım ise sentetik gübre, pestisit ve ilaç kullanımını önlemesi sayesinde karbonu toprakta tutarak salınımını önleme ve toprakta Azot Peroksit (N_2O) miktarını azaltma sayesinde iklim değişikliğini azaltma açısından önemli katkılar sağlamaktadır (Scialabba veLindenlauf, 2010).

İklim değişikliğinin hayvansal üretim faaliyetlerini de etkilemesi ve bu etkiyi en aza indirmek için uygulanmakta olan bitkisel ve hayvansal üretimin entegrasyonu olan entegre tarım sistemi, sürdürülebilir tarım sistemi olarak kabul edilmektedir. Entegre tarım sistemi, tarım ve hayvancılık faaliyetlerini birleştirerek toprak-bitki-hayvan-atmosfer etkileşimiyle toprağın kimyasal, fiziksel ve biyolojik özelliklerinin iyileştirilmesini teşvik etmesinin yanı sıra girdi bağımlılığını azaltma ve doğal kaynak verimliliğini artırmasıyla sürdürülebilir tarım faaliyetinin temelini oluşturur. Bu sistem ayrıca ekolojik duyarlılığı, ekonomik faydayı ve sosyal açıdan uygun olmasıyla sürdürülebilir kalkınmanın gelişimine katkı sağlar (Gil ve ark., 2017; Sekaran ve ark., 2021; Leal Filho ve ark., 2023).

İklim dostu tarımsal uygulamaların küresel çapta başarıya ulaşması için, FAO'nun "Sürdürülebilir Gıda ve Tarım Hedefleri" vizyonu ile uyumlu olmalıdır. Bu tarımsal uygulamalara örnek olarak sürdürülebilir tarım uygulamalarının yanı sıra; ani sıcaklık ve yağışlara karşı dayanıklı ürün çeşitlerinin geliştirilmesi, biyotik (canlı) stres faktörlerine karşı bitki büyümesini teşvik eden rizobakteriler (PGPR) ile bunların metabolizması sonucu ortaya çıkan ürünleri kullanan biyoaşılayıcıların/biyogübrelerin kullanımı örnek olarak gösterilebilir (Arora, 2019).

Sonuç olarak, iklim değişikliği, tarımsal üretim miktarında düşmeye neden olarak gıda arzının yetersiz olmasına ve gıda güvencesinin sağlanmasına engel olacaktır (Kulakoğlu, 2020). İklim değişikliğinin biyolojik çeşitlilik ve doğal kaynaklar üzerindeki olumsuz etkileri sürdürülebilir tarıma ve dolayısıyla küresel gıda güvencesinin önündeki başlıca engellerden biri olup özellikle bu engelin az gelişmiş ülkelerde tarımsal üretimi daha fazla etkilemesi küresel gıda güvencesini daha da ciddi hale getirmektedir (Farooq ve ark., 2019; Mukhopadhyay ve ark., 2021; Saleem ve ark., 2024).

4. GENEL SONUÇLAR

İnsanoğlu faaliyetleri sonucu doğal kaynakların tükenmesinin yanı sıra sıcaklık, yağış ve atmosferdeki değişimler iklim değişikliğine yol açmaktadır. İklim değişikliğinin etkileri dünya genelinde farklılık göstermesine rağmen iklim değişikliğiyle mücadele sürdürülebilir kalkınma ilkeleriyle ve bunu destekleyen anlaşmalarla küresel çapta eylem haline gelmiştir. İklim değişikliğinden en çok tarım sektörünün etkilemesi tarımsal politikaların bu yönde şekillenmesini sağlayacaktır.

İklim değişikliği en başta çevresel etkilere neden olmakta ve bu etkiler bölgeden bölgeye değişmekle birlikte en çok tarımsal faaliyetlerde verimlilik kaybına neden olmaktadır. Tarımsal üretimin iklim değişikliğinden olumsuz etkilenmesinin yanı sıra gelişmekte olan ülkelerin gıda talebinin artması ve gıda israfı gıda güvencesi sorununu ortaya çıkarmaktadır. Bu sorunların aşılmasında en iyi çözüme ulaşmak amacıyla çevrenin korunmasını ve doğal kaynakların sürdürülebilirliğini sağlamayı temel amaç olarak hedefleyen ve ekonomik, sosyal ve çevresel fayda sağlayan sürdürülebilir tarım yöntemlerine geçilmelidir.

Tarımsal üretimde iklim değişikliğinin etkilerinin ürüne veya bölgeye göre farklılık göstermesi nedeniyle sürdürülebilir tarımsal üretim yöntemlerinin uygulanması için geniş çapta araştırmaların yapılması önem arz etmektedir. Ancak iklim değişikliğinin biyolojik çeşitlilik ve doğal kaynaklara olumsuz etkisi sürdürülebilir tarımın başta gıda güvencesini sağlamak üzere Sürdürülebilir Kalkınma Amaçlarına ulaşmaya engel teşkil etmektedir. Sürdürülebilir tarım uygulamaları tarımsal üretimde sağlayacağı verimlilik ve kaliteye katkısının yanı sıra üretim yönteminin doğal yollarla sağlanması iklim değişikliği ile mücadeleye de katkı sağlayacaktır. Bu temel amaca ulaşmak için sürdürülebilir tarım yönteminin uygulanması için iklim değişikliğinin etkilerini azaltmak ve üreticilerin benimsemesi için uygulayıcılar ve politikacıların birlikte hareket etmesinin yanı sıra, bu uygulamaların temel düzeyde yapılmasıyla istenilen amaca ulaşılacaktır.

ETİK STANDARTLAR İLE UYUM

Teşekkür

Yazarların Katkısı

SD çalışmayı tasarladı ve yazdı.

Çıkar Çatışması

Yazar herhangi bir çıkar çatışması olmadığını beyan etmektedir.

Etik Onay

Yazar bu tür bir çalışma için resmi etik kurul onayının gerekli olmadığını bildirmektedir.

Veri Kullanılabilirliği

Veri setleri ile ilgili sorular için, sorumlu yazar ile iletişime geçilmelidir.

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MAUN J AGR NAT (2025) 5(1): 33-40
DOI: 10.59359/maujan.1590667
e-ISSN: 2822-3500

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MUŞ ALPARSLAN ÜNİVERSİTESİ
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MUŞ ALPARSLAN UNIVERSITY
JOURNAL OF AGRICULTURE AND NATURE

The Role of Digital Financial Literacy in Promoting Financial Inclusion for Rural Women Agripreneurs in Nigeria

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Please cite this paper as follows:
Sadıq, S., (2025). The Role of Digital Financial Literacy in Promoting Financial Inclusion for Rural Women Agripreneurs in Nigeria. *Muş Alparslan Üniversitesi Tarım ve Doğa Dergisi*, *5*(1), 33-40. https://doi.org/ 10.59359/maujan.1590667

Research Note

Article History
Received: 24.11.2024
Accepted: 13.02.2025

Keywords:
Agripreneurs,
Digital,
Finance,
Literacy,
Women,
Rural

ABSTRACT

Digital financial literacy (DFL) is increasingly recognized as a critical factor in promoting financial inclusion, particularly for marginalized groups such as rural women agripreneurs in developing nations like Nigeria. This study explores the relationship between DFL and financial inclusion among rural female agricultural entrepreneurs, examining how digital skills impact access to financial services and economic empowerment. Through an extensive review of empirical literature, this paper addresses the unique challenges faced by these women, the role of DFL in overcoming these challenges, and the broader economic and social benefits of increased financial inclusion. Results highlight the importance of targeted educational initiatives, digital infrastructure development, and supportive policy frameworks to foster sustainable growth. This paper concludes with recommendations for stakeholders, including government agencies, non-governmental organizations (NGOs), and financial institutions, to prioritize DFL as a foundational tool for fostering inclusive economic development in rural Nigeria.

1. INTRODUCTION

Financial inclusion has gained increasing attention as a powerful tool for reducing poverty, fostering economic development, and promoting equitable access to resources, especially in marginalized and rural communities (Demirgüç-Kunt ve ark., 2018; Ovwigho et al., 2024). This concept goes beyond simply having access to financial services; it encompasses affordable and timely access to a full range of services-such as savings, loans, insurance, and digital payments-that are critical for financial stability and economic growth. In Nigeria, rural women engaged in agriculture, commonly referred to as agripreneurs, represent a significant portion of the agricultural workforce and are central to food security and local economic growth (Efobi et al., 2017; Adefare et al., 2024). Yet, their participation in the formal financial system remains minimal due to structural challenges, socioeconomic factors, and inadequate access to tailored financial services (Olowa and Olowa, 2020; Gumbo et al., 2023).

Financial exclusion among rural women agripreneurs limits their ability to access credit and savings mechanisms, impeding their capacity to invest in resources, manage risks, and scale their agricultural enterprises. This exclusion is often exacerbated by limited literacy, restrictive cultural norms, and low income levels that confine them to informal financial practices (Afolabi, 2020; Ogbari et al., 2024). Furthermore, rural women's restricted access to information and communication technology (ICT) resources, which could otherwise facilitate connections to broader markets and financial services, compounds their exclusion (Oloyede, 2018; Obisesan et al., 2023). Many financial institutions tend to focus their services in urban centers, leaving rural areas underserved, which adds to the challenges rural women face in joining the formal financial system.

In recent years, the digitalization of financial services has emerged as a transformative solution for achieving broader financial inclusion (World Bank, 2022). With innovations such as mobile banking, digital wallets, and online payment platforms, even the most remote populations have the potential to access a variety of financial products and services without physical banking infrastructure. For rural women agripreneurs, digital financial services (DFS) present opportunities to bypass conventional barriers, access credit, save, and make secure transactions directly from their mobile phones. However, leveraging these opportunities effectively depends on digital financial literacy (DFL)-the understanding, skills, and confidence to use digital tools safely and efficiently. DFL enables women to understand their financial products, assess risks, protect their data, and interact with the digital financial ecosystem more independently.

Unfortunately, rural women agripreneurs in Nigeria face particular challenges in acquiring DFL. Literacy levels remain low among this group, and sociocultural norms may discourage women from using digital tools, limiting their exposure and comfort with technology (Akinlo and Akinlo, 2019; Alabi et al., 2022). Moreover, the high costs of mobile data, limited internet infrastructure in rural areas, and intermittent electricity make it difficult for many rural women to access or consistently use digital devices (Odum et al., 2018; Modiba et al., 2024; Oyekanmi, 2024). These barriers restrict their integration into digital finance, despite the potential benefits for income generation and economic resilience.

Given the substantial hurdles, there is a critical need to assess the current state of DFL among rural women agripreneurs in Nigeria. Enhancing DFL through targeted interventions-such as tailored training programs, community-based digital education, and gender-sensitive policies-could bridge the existing gaps and lead to significant improvements in financial inclusion. Governmental policies that support infrastructure development, along with partnerships between financial institutions and NGOs, could make digital services more accessible and relevant to rural women's unique needs (Odularu and Okhale, 2024). A comprehensive approach involving stakeholders across sectors can empower rural women agripreneurs to actively participate in the digital financial ecosystem, fostering inclusive economic growth and reducing poverty at the grassroots level. Thus, the specific objectives of this research review were to identify the barriers to digital financial literacy among rural women agripreneurs; assess the impact of digital financial literacy on financial inclusion; and identify the challenges and opportunities in promoting digital financial literacy.

2. THEORETICAL FRAMEWORK

The theoretical framework for this study draws on multiple theories to understand the connection between Digital Financial Literacy (DFL) and financial inclusion for rural women agripreneurs. Each theory provides insights into the factors influencing the adoption of digital financial services (DFS) and the broader socio-economic impacts of enhanced DFL on financial empowerment.

2.1. Diffusion of innovations theory (Rogers, 2003)

Rogers' Diffusion of Innovations Theory is instrumental in explaining how new ideas, technologies, or practices spread within a community. Digital financial services (DFS) are relatively new in rural areas, especially among women agripreneurs who may face specific challenges in technology adoption due to limited education, traditional financial habits, or societal expectations. According to this theory, factors such as relative advantage (the perceived benefits over traditional methods), compatibility with existing values and experiences, complexity (ease of use), trialability (ability to experiment with the service), and observability (visible benefits observed by others) all influence the rate of adoption (Rogers, 2003). In this context, the adoption of DFS among rural women agripreneurs could be fostered by demonstrating how digital tools are compatible with existing financial practices and beneficial in terms of saving time and improving economic outcomes. Additionally, social networks and community leaders often play a crucial role in influencing adoption rates in rural settings by endorsing new technologies.

2.2. Human capital theory (Becker, 1964)

Becker's Human Capital Theory asserts that investing in human capital, such as education and skill development, improves individual productivity and economic outcomes. This theory is central to understanding how DFL can empower rural women agripreneurs. Enhancing digital literacy increases their capacity to interact with financial services, assess risks, manage transactions, and make informed decisions. By increasing their human capital, rural women can access financial resources that were previously out of reach, fostering business growth and economic participation. Human capital investments, including DFL training, contribute to a virtuous cycle where increased skills lead to greater confidence in handling financial tasks, which in turn promotes sustained engagement with financial services and an enhanced likelihood of business expansion.

2.3. Capability approach (Sen, 1999)

Sen's Capability Approach underscores the importance of enabling individuals to achieve well-

being by expanding their abilities and freedoms. In the context of financial inclusion, the capability approach highlights how DFL can empower rural women agripreneurs by enhancing their ability to access, understand, and manage financial resources independently. Rather than merely providing financial services, it emphasizes empowering women to effectively use and benefit from these services. For example, DFL enables women to make better savings decisions, access credit on more favorable terms, and plan for future investments. This empowerment process builds a foundation for economic independence, thus enabling rural women to make meaningful contributions to their households and communities. In addition, this theory emphasizes that the success of DFL initiatives depends on addressing external constraints-such as social norms, infrastructure, and policy barriers-that may restrict women's ability to utilize their capabilities fully.

These theoretical perspectives collectively provide a nuanced understanding of the dynamics through which DFL can impact financial inclusion and the adoption of DFS. They suggest that successful digital financial inclusion for rural women requires a multi-dimensional approach, addressing both internal factors (such as skills and knowledge) and external factors (such as social and cultural environments).

3. CONCEPTUAL FRAMEWORK

The conceptual framework for this study situates DFL as an essential component for achieving financial inclusion among rural women agripreneurs. It proposes that financial inclusion is a multi-dimensional construct, influenced by three key components: Digital Financial Literacy, Access to Digital Financial Services, and Socioeconomic and Cultural Factors.

3.1. Digital financial literacy

Digital Financial Literacy (DFL) encompasses knowledge, skills, and confidence in using digital financial services securely and effectively. For rural women, DFL includes:

- **Knowledge of digital platforms:** Understanding how to navigate mobile banking, e-wallets, and other DFS interfaces.
- **Awareness of digital financial products:** Being aware of services like mobile loans**,** digital savings accounts, and insurance options available through DFS.
- **Skills for secure online financial transactions:** Knowing how to carry out transactions safely, protect personal information, and identify potential fraud risks.

DFL plays a foundational role in financial inclusion, as it enables rural women to confidently engage with digital financial services and make informed decisions. Without DFL, women are more vulnerable to fraud and may experience increased financial stress, which could deter further usage of DFS.

3.2. Access to digital financial services

Access to DFS is the availability and ease with which rural women agripreneurs can use digital banking, mobile money, digital wallets, and other financial services tailored to their needs. Key aspects include:

- **Infrastructure:** Reliable internet access, affordable mobile devices, and the availability of DFS providers in rural areas are essential.
- **Affordability:** The cost of accessing DFS, including mobile data costs and transaction fees, should be reasonable for rural women to sustain regular use.
- **Relevance of services:** DFS offerings must be designed with rural women's needs in mind. For instance, flexible loan products, low-balance savings accounts, and accessible customer service channels can encourage adoption and sustained use.

Access alone, however, is insufficient if the services are not adapted to the unique needs and contexts of rural women. Platforms that do not consider cultural preferences, usability concerns, or cost barriers are unlikely to achieve broad adoption.

3.3. Socioeconomic and cultural factors

Socioeconomic and cultural factors play a moderating role in how DFL and access to DFS influence financial inclusion. These factors include:

- **Literacy levels:** Basic literacy and numeracy skills are prerequisites for understanding and using DFS. Rural women with limited literacy may struggle with text-heavy applications and financial terminology, which inhibits adoption.
- **Gender norms:** In many communities, women's participation in financial matters is limited by cultural expectations. Gender roles may discourage women from independently handling finances or interacting with technology, affecting their confidence in DFS.
- **Social networks:** Peer influence and community norms significantly shape perceptions of digital finance. Women who observe other agripreneurs benefiting from DFS are more likely to adopt these services, while those in communities skeptical of digital finance may face social pressure to abstain.

Socioeconomic and cultural factors thus mediate the effectiveness of DFL and DFS access, shaping whether and how rural women engage with digital financial tools. Recognizing these influences is essential for designing interventions that address the unique constraints of rural women and create a supportive environment for DFS adoption.

Each step outlines the interconnection between **Digital Financial Literacy (DFL)**, **Access to Digital Financial Services (DFS)**, and **Socioeconomic and Cultural Factors**, leading to the desired outcome of **financial inclusion for rural women agripreneurs.**

Step 1: Digital Financial Literacy (DFL)

Objective: Equip rural women with the necessary knowledge, skills, and confidence to effectively and securely use digital financial services.

Key Features:

1.Knowledge of Digital Platforms: Familiarity with mobile banking, e-wallets, and other DFS interfaces.

2.Awareness of Digital Financial Products: Understanding options like mobile loans, savings accounts, and insurance.

3.Skills for Secure Transactions: Proficiency in protecting personal data, avoiding fraud, and conducting safe transactions.

Outcome of Step 1: Enhance women's ability to confidently engage with DFS, reduce vulnerability to fraud, and build trust in digital finance.

Step 2: Access to Digital Financial Services (DFS)

Objective: Ensure rural women have practical and affordable access to DFS tailored to their specific needs.

Key Features:

1.Infrastructure: Availability of reliable internet, mobile devices, and service providers in rural areas.

2.Affordability: Reduce costs such as transaction fees and mobile data expenses.

3.Relevance of Services: Design products for rural women, e.g., flexible loans, low-balance accounts, and accessible customer support.

Outcome of Step 2: Facilitate the widespread adoption of DFS by addressing cost, infrastructure, and relevance barriers.

Step 3: Socioeconomic and Cultural Factors

Objective: Address moderating factors that influence the effectiveness of DFL and DFS access on financial inclusion.

Key Features:

1.Literacy Levels: Basic literacy and numeracy skills required for using text-heavy apps and financial tools.

2.Gender Norms: Cultural expectations and roles that may limit women's independence in financial matters.

3.Social Networks: Influence of community norms and peer behavior on DFS adoption.

Outcome of Step 3: Create a supportive social and cultural environment that enables rural women to overcome structural barriers and confidently adopt DFS.

Step 4: Financial Inclusion

Objective: Achieve comprehensive financial inclusion by integrating DFL, DFS access, and cultural considerations.

Key Outcomes:

•**Economic Empowerment:** Increased financial autonomy and income for rural women agripreneurs.

•**Enhanced Livelihoods:** Access to savings, credit, and insurance improves resilience to financial shocks.

•**Community Development:** Empowered women serve as role models, fostering broader adoption of DFS in rural communities.

4. DİAGRAMMATİC REPRESENTATİON OF THE FRAMEWORK

4.1. Input Factors:

- Digital Financial Literacy
- Access to Digital Financial Services
- Socioeconomic and Cultural Factors

4.2. Process:

- Implementation of tailored training and services.
- Addressing cultural and infrastructural barriers.

4.3.Output Factors:

- Increased DFS usage
- Economic empowerment of rural women agripreneurs.

4.4.Outcome:

- Comprehensive financial inclusion for rural women agripreneurs.

This breakdown emphasizes the interaction between the core components and their collective impact on financial inclusion. A visual representation is shown below.

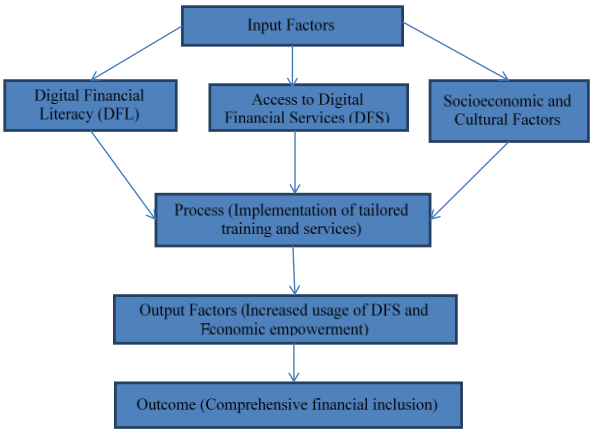

Figure 1: Conceptual framework

Here is the visualization of the conceptual framework:

4.4.1.Inputs:

- Digital Financial Literacy (DFL)
- Access to Digital Financial Services (DFS)
- Socioeconomic and Cultural Factors

4.4.2.Process:

Implementation of tailored training and services to address literacy, accessibility, and cultural barriers.

4.4.3.Outputs:

Increased usage of DFS and economic empowerment for rural women agripreneurs.

4.4.4.Outcome:

Comprehensive financial inclusion that improves livelihoods and fosters community development.

This diagram highlights the flow from input factors to the final outcome, showing how each component interlinks to drive financial inclusion.

5. RESEARCH METHODOLOGY

The study draws information from journals, conference proceedings, monographs, edited books, newspapers, etc. to deduce an insight on the role of digital financial literacy in promoting financial inclusion among rural women agripreneurs in Nigeria.

6. RESULTS AND DISCUSSION

6.1. Barriers to digital financial literacy among rural women agripreneurs

6.1.1. Limited access to ICT infrastructure: Rural areas in Nigeria are often underserved in terms of digital infrastructure, which is essential for accessing Digital Financial Services (DFS). Internet connectivity is limited, and access to affordable mobile devices is a major barrier (Oloyede, 2018; Akpuokwe et al., 2024). The high cost of mobile data and irregular electricity supply make it challenging for women to consistently access digital tools, thus limiting their participation in digital finance. Research shows that only about 30% of rural areas in Nigeria have reliable internet, with mobile data costs being prohibitive for the average rural household (Uduji & Okolo-Obasi, 2022). Consequently, lack of ICT infrastructure disproportionately affects women agripreneurs, who are often unable to afford the devices or the ongoing connectivity costs necessary for financial inclusion.

6.1.2. Low digital and financial literacy levels: Many rural women agripreneurs in Nigeria have limited educational backgrounds, which affect both their financial literacy and digital skills. Digital literacy is closely linked to general literacy levels, which remain low in many rural Nigerian communities (Akinlo & Akinlo, 2019; Ugwuja et al., 2020). For many women, even basic mobile banking applications are difficult to navigate due to limited familiarity with digital interfaces and financial terminology. This lack of foundational skills creates a barrier to using digital financial tools effectively, preventing rural women from making informed financial decisions, accessing credit, or managing savings. Additionally, the limited availability of educational resources focused on digital finance in rural areas further perpetuates this gap, as there are few local training programs specifically designed to teach these skills (Uduji & Okolo-Obasi, 2018; Oyekanmi, 2024).

6.1.3. Gender and cultural norms: Socio-cultural norms in many Nigerian communities often restrict women's roles in financial decision-making and may discourage women from participating in digital finance due to security and privacy concerns (Efobi et al., 2017). In some households, women have limited control over income and financial resources, which restricts their ability to make independent financial decisions. Social norms may discourage women from engaging with digital platforms, as there are often societal expectations that prioritize men's access to financial resources (Olowa & Olowa, 2020). Additionally, there may be concerns around women's privacy and security in digital spaces, which further complicates their willingness to engage with digital financial services. Thus, the cultural environment often becomes a barrier to women's financial autonomy, reinforcing a cycle of exclusion.

6.2. Impact of digital financial literacy on financial inclusion

6.2.1. Enhanced financial access and saving: Digital literacy opens up new avenues for rural women agripreneurs to engage with financial services, which are typically inaccessible through traditional banking channels. With improved digital skills, women can use mobile banking, mobile money, and digital wallets to save small amounts, accumulate capital over time, and build a financial safety net (Demirgüç-Kunt et al., 2018; Rani & Kumar, 2024). Studies show that when women have access to digital financial tools, they are more likely to save regularly and increase their economic resilience (Chinelo & Ayodeji, 2022). Mobile money platforms like Paga and Firstmonie in Nigeria have demonstrated success in helping rural populations engage in financial activities such as savings and microloans, providing women agripreneurs with vital resources to sustain their businesses.

6.2.2. Improved business management and growth: Digital financial literacy equips women agripreneurs with the skills to efficiently manage their finances and business operations. For instance, digital tools enable women to access real-time market information, track expenses, and make secure transactions. These capabilities are especially valuable in agriculture, where market prices and supply chains can be highly variable (Olowa & Olowa, 2020). Digital skills empower agripreneurs to make more informed business decisions, expand their market reach, and respond to economic opportunities. Furthermore, digital literacy enables them to access e-commerce platforms where they can sell their produce beyond local markets, thus boosting their income and market visibility (Oloyede, 2018; Maigari & Yelwa, 2023).

6.2.3. Economic empowerment and social capital: Beyond financial inclusion, digital financial literacy has profound social implications. As women gain confidence in using digital tools to manage their finances, they become more autonomous in household financial decisions, which can lead to shifts in traditional gender dynamics (Afolabi, 2020; Soetan & Mogaji, 2024). Digital financial literacy enhances women's social capital by enabling them to join digital communities, participate in online forums, and network with other entrepreneurs, which fosters a sense of community and shared purpose. These connections increase their exposure to new ideas and resources, further reinforcing their economic and social empowerment. As women in rural communities adopt digital finance tools, they often serve as role models, inspiring others to follow suit and gradually changing perceptions around women's economic roles (Rutashobya et al., 2021; Uduji & Okolo-Obasi, 2022).

6.3. Challenges and opportunities in promoting digital financial literacy

6.3.1.Educational initiatives and capacity building: Effective DFL programs that are specifically designed for rural women agripreneurs can close the digital literacy gap. Localized and practical training, offered through community centers or partnerships with local leaders, can help address the literacy challenges that women face (Oloyede, 2018; Gichuki & Kamau, 2022). The integration of audio-visual aids, which require minimal reading skills, is particularly effective in digital financial literacy training in low-literacy contexts. Programs that include practical, hands-on training and focus on specific digital financial tools are more likely to empower women to use these tools independently. Partnerships with NGOs, microfinance institutions, and local cooperatives can expand the reach of such programs and ensure their long-term sustainability.

6.3.2.Policy and institutional support: Governmental policies that prioritize ICT infrastructure in rural areas are essential for increasing DFS access. By incentivizing telecommunications and financial institutions to expand digital infrastructure and services, the government can make DFS more accessible in underserved regions. Financial institutions can partner with NGOs to develop gender-sensitive DFL programs that address the unique challenges rural women face (Hassan, 2022; Ogunrinde, 2024; Oyekanmi, 2024). Furthermore, targeted subsidies and incentives for mobile data usage can alleviate the financial burden of accessing DFS for low-income rural women. Policy interventions can also include mandates for gender inclusion in financial literacy programs, ensuring that these efforts are inclusive and reach rural women.

6.3.3.Building trust and addressing security concerns: Trust and security are foundational for successful adoption of DFS among rural women. Many rural women have concerns regarding the safety of digital financial transactions, and overcoming these fears is critical to increasing their engagement with digital platforms (Akinlo & Akinlo, 2019; Mohamud & Mohamed, 2023). Educating women about cybersecurity practices-such as recognizing phishing scams and securely storing digital credentials-can help mitigate these concerns. Institutions can further build trust by establishing customer support services in local languages and providing troubleshooting assistance to ensure women feel supported as they navigate digital platforms. Additionally, financial service providers can use community-based "digital champions" to promote trust and provide peer-to-peer assistance, which helps build credibility for digital financial services.

6.3.4.Technology adaptation for low-literacy users: Financial services providers can enhance DFL by adapting mobile interfaces and applications to accommodate users with low literacy. Simple, icon-based navigation, voice prompts in local languages, and interactive tutorials can make digital platforms more accessible to rural women agripreneurs who have limited reading skills. For example, apps that provide visual cues and minimize text can help users navigate complex transactions without needing to rely on literacy skills.

6.3.5.Collaborative approach involving community leaders: Community leaders and local influencers play a crucial role in influencing social norms. Engaging these leaders in DFL initiatives can facilitate community buy-in and support for women's digital financial engagement. Leaders can advocate for women's use of digital finance tools, challenge restrictive norms, and encourage family support for women's financial autonomy. This approach also helps create a supportive environment for women to learn and use digital tools within their cultural context.

6.3.6.Monitoring and evaluation of DFL programs: Continuous monitoring and evaluation of DFL initiatives is essential for assessing their impact and identifying areas for improvement. By tracking the effectiveness of DFL programs through metrics such as service usage rates, income changes, and savings behaviors, stakeholders can gauge the success of interventions and refine them to better serve rural women. This data-driven approach ensures that DFL programs remain responsive to the evolving needs of rural women agripreneurs.

7. CONCLUSION AND RECOMMENDATIONS

Enhancing digital financial literacy among rural women agripreneurs is essential for achieving inclusive financial growth in Nigeria. Digital skills enable these women to access a range of financial products, manage their finances more effectively, and enhance their entrepreneurial potential. This study emphasizes the need for targeted educational interventions, improved ICT infrastructure, and supportive policy measures to address the specific barriers faced by rural women. Further, the following recommendations are proffered:

- **Educational programs:** Tailored DFL training that addresses the digital and financial literacy needs of rural women should be developed in collaboration with community leaders and NGOs.
- **Infrastructure development:** The government should prioritize digital infrastructure in rural areas to make DFS more accessible.
- **Supportive policy frameworks:** Policymakers should create policies that encourage financial institutions to offer products suited to the needs of rural women agripreneurs.
- **Social campaigns to shift gender norms:** Awareness campaigns that promote the economic benefits of women's financial inclusion could help to shift cultural norms and empower rural women.
- **Enhanced security education:** Programs that educate women about online security practices are critical to building trust in DFS.

By implementing these recommendations, Nigeria can empower rural women agripreneurs, improving not only their financial well-being but also that of their families and communities.

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