

# Farmers' perceptions and level of adoption of technological innovation in shallot cultivation

Sri Wahyuni Budiarti<sup>1</sup>, Hermawati Cahyaningrum<sup>2</sup>, Haryuni Haryuni<sup>3</sup>, Rahayu Widowati<sup>4</sup>, and Arif Anshori<sup>1,\*</sup>

<sup>1</sup> Research Center for Food Crops, KST Soekarno, Cibinong, Indonesia

<sup>2</sup> Research Center for Horticulture Crops, KST Soekarno, Cibinong, Indonesia

<sup>3</sup> Tunas Pembangunan University Surakarta, Central of Java, Indonesia

<sup>4</sup> Academy of Agriculture Yogyakarta, Indonesia

**Abstract.** Shallot is one of the staple commodities in Indonesia. Increasing consumption needs and high demand for shallots represent a potential market opportunity for farmers to increase shallot production. The research aimed to determine farmers' perceptions, the influence of farmers' internal and external characteristics on perceptions of applying shallot cultivation technology, and trends in technology adoption. The research was conducted in Karang Kalasan Village, Kalasan District, Sleman Regency, D.I. Yogyakarta from March to May 2021. Data was collected through a survey using a questionnaire from 25 participants. Data were analyzed descriptively, percentages, frequency tables, Likert scales, and Spearman Rank correlation. The research showed that farmers had a positive perception of technological innovation in shallot cultivation. Farmers considered that shallot cultivation technology is profitable, suits people's needs, is not complicated, is triable and the results are observable. The characteristics of gender, length of experience in shallot farming, farmer income, availability of infrastructure, and institutional support significantly influenced farmers' perceptions on the application of technology innovation in shallot cultivation. Adoption trends indicate that some components will be adopted in the next growing season.

## 1 Introduction

Farmers' perceptions and adoption of agricultural technology in the context of farming are closely related to the dissemination and application of technology ultimately related to achievement in production. Understanding perceptions will be useful in providing a real picture of farmers' level of attention to agricultural technology innovation [1; 2].

Shallot is a type of vegetable with many benefits and high economic value. The demand for fresh shallots for household consumption and raw materials for domestic processing industries continues to increase every year in line with the growth of the population and the food industry. Therefore, the production of quality shallots must be increased throughout the year to ensure the availability of supplies and to avoid price fluctuation. Shallot farming is

---

\* Corresponding author: [arif056@brin.go.id](mailto:arif056@brin.go.id)

extremely risky. There are many challenges and obstacles faced in its cultivation that can thwart the harvest. Low plant productivity with increasing pest and disease attacks generally occurs in shallot planting during the off-season [3; 4].

Cultivation of shallot commodities requires the fulfillment of various technical requirements to be produced regularly throughout the year with optimal production and quality. Its development must be detailed by implementing appropriate planting patterns or production systems, using quality seeds, proper fertilization, controlling plant pest organisms that follow optimal integrated pest management (IPM) principles, and other plant management that applies technology under Standard Operating Procedures (SOP) and Good Agriculture Practices (GAP) [5; 6].

The technology dissemination process is carried out through demonstration plots or pilot areas, experiment station visits, counseling, and training to farmers and regional stakeholders, so technological innovations can be easily adopted [1; 7]. However, farmers take into consideration various factors in forming perceptions because before adopting technological innovation, farmers will find it easier to apply it if they have seen firsthand the advantages of the innovation itself. [8] dan [9] stated farmers' perceptions of technological information can be positive, negative, or even neutral.

Positive farmer perceptions will encourage adoption, conversely, if negative perceptions are formed, farmers will reject the technology offered to them. Technology adoption is influenced by some factors such as risks, facilities, and infrastructure, as well as institutional support for smallholder farmers [10], and in other cases, it is influenced by gender, land ownership status, irrigation, access to credit, and interactions with extension workers [11]. The research aimed to determine farmers' perceptions, the influence of farmers' internal and external characteristics on perceptions of the application of shallot cultivation technology, and trends in technology adoption.

## **2 Research method**

The research was conducted in Karang Kalasan Village, Kalasan District, Sleman Regency, D.I. Yogyakarta. The research was carried out from March to May 2021. This research used a quantitative approach with survey methods. The sampling technique was carried out using random sampling method on 25 participants who participated in the Field School (SL) for shallot cultivation activities, representing three farmer groups. Data collection was carried out using a survey method with a questionnaire instrument [12; 13; 14; 15; 16].

Respondents were farmers participating in SL for shallot cultivation activities who were selected purposively to test the level of perception and adoption of the application of technological innovations in shallot cultivation. The questionnaire included respondents' internal and external characteristics, perceptions, innovation characteristics, and adoption tendencies for technological innovations in shallot cultivation. The assessment of farmers' perceptions of the characteristics of innovation in shallot cultivation technology was based on five characteristic variables, namely, (1) relative advantage; (2) level of suitability; 3) complexity; 4) triability; 5) observability [17; 18; 19]. The data collected were analyzed using descriptive analysis, percentages, frequency tables, Likert scales, and Spearman correlation [12; 14; 15; 20; 21; 22; 23].

## **3 Results and discussion**

### **3.1 Internal and external characteristics of farmers**

#### *3.1.1 Internal characteristics of farmers*

Internal characteristics of farmers observed as inherent characteristics of farmers include gender, occupation, age, education, farming experience, land area, land ownership, and

farmer income. The distribution of internal characteristics of farmers in Table 1 shows that most farmers are male and are productive laborers, own relatively narrow land, and are quite experienced in farming, but most still have less than 5 years of shallot farming experience.

**Table 1.** Frequency distribution of internal characteristics of farmers

Characteristics	Indicators	Frequency	Percentage (%)
Gender	Men	20	80.00
	Women	5	20.00
Occupation	Farmers	25	100.00
	Other than Farmers	0	0.00
Age	≤ 30	4	16.00
	31-45	6	24.00
	46-59	12	48.00
	≥ 60	3	12.00
Education	No School	0	0.00
	Elementary School	3	12.00
	Junior High School	6	24.00
	Senior High School	12	48.00
	Bachelor's degree	2	8.00
	Others	2	8.00
Farming Experience (in years)	< 5	5	20.00
	6 - 10	4	16.00
	> 10	16	64.00
Shallot Farming Experience (in years)	< 5	24	96.00
	6 - 10	1	4.00
	> 10	0	0.00
Land Area (Ha)	< 0.5	14	56.00
	0.5 - 1	11	44.00
	> 1	0	0.00
Land Ownership	Owner	14	56.00
	Tenant	3	12.00
	Sharecropper	8	32.00
Farmer Income (IDR)	< 1.000.000	8	32.00
	1.000.000 - 2.000.000	12	48.00
	2.000.000 - 3.000.000	3	12.00
	3.000.000 - 4.000.000	1	4.00
	4.000.000 - 5.000.000	1	4.00
	> 5.000.000	0	0.00

Land ownership characteristics show that around 56.00% have an arable land area of <0.5, 44% have an area of 0.6-1 ha, and no farmers have an arable area of >1 ha. The land is the main source of livelihood for farmers. The small size of arable land identifies the level of risk as the main obstacle for farmers in adopting technological innovation. The more land used for farming; the more motivated farmers are to adopt new technology [18; 24; 25; 26].

The research results show that 56% of farmers are farmer owners. Farmers' land cultivation activities are hereditary, making it easier to make decisions to adopt new technology [27]. This is different from tenant farmers (12%) and sharecroppers (32%) who must obtain approval from the landowner first before trying or using new technology [28; 29]. The research shows that 48.00% of farmers have an IDR 1,000,000 – IDR 2,100,000 income. The amount of income obtained will be a consideration in making decisions. The higher the income, the higher the desire to adopt new technology because they have a high income to try new things [24; 30; 31; 32; 33].

### 3.1.2 External characteristics of farmers

The distribution of external characteristics of farmers in Table 2 shows that 44% of farmers had a high frequency of interaction with the instructors, 10-12 times/year. The higher the frequency of interaction with the instructors, as much as 48% where farmers interact 7-12 times, the faster the farmers adopt new innovations. The instructors can increase farmers' interest in adopting new technology through extension programs [24; 34; 35]. [36] stated that the results of data analysis show that there is a propensity for a relationship between the level of adoption and support for consultation, where if support for consultation is perceived as low, then the level of adoption is also relatively low, if the perception of support for consultation is moderate then there is a propensity for the level of adoption to be medium.

**Table 2.** Frequency distribution of external characteristics of individual farmers

Characteristics	Indicators	Frequency	Percentage (%)
Frequency of interactions with instructors (times/year)	1-3	5	20.00
	4-6	8	32.00
	7-9	1	4,00
	10-12	11	44.00
Determinants of decision making in cultivating plants	Independent/Alone	0	0.00
	Group	25	100.00
Farmer group membership	Participate	25	100.00
	Do not participate	0	0.00
The availability of facilities and infrastructure supports farmers' smooth adoption of technology	Very less	0	0.00
	Not sufficient	3	12.00
	Sufficient	9	36.00
	Available	9	36.00
	Very available	4	16.00
Institutional support such as farmer groups and government support such as instructors' agencies	Very less	0	0.00
	Not enough	1	4.00
	Enough	6	24.00
	Available	14	56.00
	Very available	4	16.00

Farmer groups are learning forums and forums for making decisions to improve the fate of farmers. The research showed that 100% of farmers participated in farmer groups. Farmers who take part in it will benefit from several activities that can support their farming business and can increase their potential and abilities for the success of their farming business [24; 37].

The research indicated that 72% of farmers stated that the facilities and infrastructure were sufficiently available. The availability of facilities and infrastructure supports farmers' smooth adoption of technology so that it can influence their decision to adopt new technology [24; 38]. 72% of farmers stated that institutional support was available. The availability of institutions such as farmer groups and government support such as extension agencies will speed up the dissemination of information to make it easier to adopt technology. Farmer groups are institutions that can strengthen farmers' position in dealing with other institutions, such as agro input and marketing institutions [24; 39].

### 3.2 Farmers' perceptions of technological innovation in shallot cultivation

Farmers' perception of technological innovation involves the process of organizing and interpreting the information they receive before deciding whether to accept or reject the innovation. According to [17; 40; 41], the extent to which an innovation is adopted depends on how the adopter perceives its characteristics. Key attributes that influence the adoption

level include (1) relative advantage, (2) level of suitability, (3) level of complexity, (4) tryability, and (5) observability. Characteristics of farmers' perceptions of technological innovation in shallot cultivation can be seen in Table 3.

**Table 3.** Characteristics of farmers' perceptions of technological innovation in shallot cultivation.

Variables	Variable dimensions	Score*	Category
A. Relative advantage	1. Integrated crop management can increase shallot production	3.52	Excellent
	2. The things taught in shallot field school activities provide benefits to farmers	3.52	Excellent
	3. The shallot cultivation technology taught is able to provide advantages	3.40	Excellent
	<b>Average score for relative advantage</b>	<b>3.49</b>	Excellent
B. Level of Suitability	1. Suitability of farming with onion cultivation technology	3.28	Very Appropriate
	2. Suitability of shallot cultivation to be developed in paddy fields	3.16	Appropriate
	3. Suitability of shallot cultivation technology materials with the wishes or needs of farmers	3.24	Appropriate
	<b>Average score for level of suitability</b>	<b>3.23</b>	<b>Appropriate</b>
C. Complexity	1. Understanding cultivation technology according to the shallot Field School is not difficult	3.88	Easy
	2. Applying cultivation technology according to the shallot Field School is not difficult	3.84	Easy
	3. Being skilled in applying red cultivation technology is not difficult	3.68	Easy
	<b>Average score for complexity</b>	<b>3.80</b>	<b>Easy</b>
D. Triability	1. Shallot cultivation technology can be carried out on a small scale	4.12	Able
	2. The program needs to be tried out first by instructors	4.12	Able
	3. Shallot farming is a risky business	3.96	Able
	<b>The average score of triability</b>	<b>4.07</b>	<b>Able</b>
E. Observability	1. The results of shallot farming can be see quickly	3.12	Good
	2. Satisfaction with the results obtained	3.16	Good
	3. The results of farming can help household needs	3.28	Good
	<b>The average score of observability</b>	<b>3.19</b>	<b>Good</b>

\*Perception category: 1.00-1.75 = less/not appropriate/can't; 1.76-2.50 = enough/less appropriate/less able; 2.51-3.25 = good/appropriate/able; 3.26-4.00 = excellent/very appropriate/very able

### 3.2.1 Relative Advantage

Based on Table 3 part A, farmers thought that technological innovations in shallot cultivation provided benefits because they were able to increase production and quality of crops to gain profits and benefits for farmers. The farmer's perception score based on relative advantage ranges from 3.40-3.52 for the three variables measured, which indicates that the higher the relative advantage score, the better the perception.

Based on the relative advantage score value, it can be seen that the average is 3.49, meaning that farmers' perceptions of the relative advantage of technological innovation in shallot cultivation are included in the profitable or very good category. This is in line with the research results by [42] where farmers' perceptions of the relative advantage of the lowland rice SL-PTT program are in the very good category (profitable).

### **3.2.2 Level of Suitability**

The impact of agricultural technology on farmers' well-being can vary, influenced by the specific type of technology implemented and how well it aligns with farmers' existing practices [9]. The relevance of an innovation depends on how well it aligns with socio-cultural values, existing beliefs, or previously introduced ideas, and how it meets the needs of farmers [40]. The perception scores of farmers regarding the suitability of the innovation ranged from 3.16 to 3.28 across the three variables assessed. The greater the level of suitability, the more effectively farmers will absorb the information shared by both instructors and fellow farmers.

The average technology suitability score for farmers from Table 3 part B data is 3.23, in the appropriate category. This shows that farmers' perceptions based on the level of suitability were that they felt the suitability in the application of technological components ranging from seed selection to post-harvest handling with the farmers' social and economic conditions. [17] said that the suitability of innovation can be differentiated into: (1) suitability to the environment where farmers live; (2) customs concerning procedures, cultural values or habits of farmers; and (3) needs, in the form of desires that are suitable with the farmer's conditions. Thus, farmers will adopt innovation more quickly if it is compatible with their needs.

### **3.2.3 Complexity**

Complexity refers to how difficult an innovation is perceived to be in terms of understanding and implementation. The more complex an innovation, the harder it will be for farmers to accept it. Conversely, if an innovation is simple to implement, it will be easier to put into practice, leading to a quicker adoption process [42; 43].

Farmers' perception scores based on complexity ranged from 3.68-3.88 for the three variables measured (Table 3 part C). The average score for farmers' complexity regarding shallot cultivation technology is 3.80, which means that farmers' perception of complexity is that it is not difficult to apply the technology. Technology that is easy and simple but provides better results will be accepted by farmers. The simpler the technology, the easier it will be adopted by farmers, provided they see evidence of whether the technology is successful or not [42].

### **3.2.4 Triability**

The ability of farmers to easily test new innovations is linked to the availability of resources. The more straightforward it is to implement a new technology, the quicker farmers will adopt it. Farmers are more likely to embrace innovations if they have had the opportunity to trial them on a small scale on their own land and have demonstrated clear benefits, rather than adopting them on a larger scale, due to the inherent risks associated with innovation [40].

Table 3 part D shows the farmers' perception scores based on their triability ranged from 3.96-4.12 for the three variables measured with a mean score of 4.07. This indicated that implementing technology on a small scale is not difficult to try. In general, the ability of a technology to be tried in various conditions is very important for farmers who have various characteristics. Through the trial process, it makes it easier for farmers to make decisions regarding the benefits and risks of this technology.

### **3.2.5 Observability**

Adoption decisions in technological innovation are influenced by a mix of both observable and unobservable factors [44; 45]. Farmers' observations of innovation can be observed and

seen by others. Within a certain period of time, innovations that impact farmers' income will gain attention even without the help of instructors. According to [46] ease of observation is the ease with which an innovation can be seen or observed in the results. [40] and [47] states that innovation can be observed from several things: (1) products produced using technology; (2) quality produced by technology; and (3) revenue/cost reduction used through the application of technology.

Table 3 part E shows perceptions based on observability, where farmers' perception scores based on observability ranged from 3.12-3.28 for the three variables measured with a mean score of 3.19, meaning that perceptions regarding observability are categorized as good based on the visibility of farming results. The impact of applying technology will be seen from the appearance of plant growth. Yields increase and the frequency of pest and disease attacks is lower with the application of technology.

### 3.3 The relationship between internal and external characteristics of farmers on farmers' perceptions of technological innovation in shallot cultivation

Table 4 shows the results of the Spearman rank correlation test analysis for the relationship between each of the six internal characteristics of individual farmers (occupation, age, education, farming experience, land area, land ownership) with perceptions about technological innovation in shallot cultivation, which showed that there was no significant correlation. This indicates that the six internal characteristics of farmers do not influence farmers' perceptions of the application of shallot cultivation technology.

**Table 4.** Distribution of the relationship between farmers' internal characteristics and farmers' perceptions about technological innovation in shallot cultivation.

Internal Characteristics of Farmers	Correlation coefficient ( <i>r</i> )				
	Level of Relative Advantage	Level of Suitability	Complexity	Triability	Observability
Gender	-0.53**	0.22	0.44*	-0.25	-0.04
Work	0.28	-0.31	0.18	-0.10	-0.08
Age	0.15	-0.25	0.28	0.23	-0.39
Education	0.02	0.05	-0.04	0.27	0.19
Farming Experience	0.02	0.11	0.12	-0.20	-0.12
Farming Shallots	0.10	0.60**	0.22	-0.19	0.35
Land Area (Ha)	-0.12	0.03	-0.03	-0.10	0.35
Land Ownership	-0.30	-0.22	0.19	-0.16	-0.25
Farmers' income	-0.11	0.418*	0.00	-0.06	0.27

Remarks: \*\*Significant (<0.01), \*significant (<0.05)

However, three individual farmer internal characteristic variables (gender, shallot farming experience, and farmer income) correlated with the farmer's perception variable regarding the application of shallot cultivation technology. Table 4 shows that gender characteristics had a significant relationship with the variables of level of relative advantage and complexity. This indicates that these three variables influenced farmers' perceptions of the application of shallot cultivation technology.

Based on statistical tests, the correlation coefficient value was -0.53, so it can be stated that the gender characteristics of farmers had a significant unidirectional relationship with the variable of level of relative advantage. Meanwhile, gender characteristics had a significant unidirectional relationship with the complexity variable.

The characteristics of time in farming shallots and farmer income had a significant correlation coefficient of 0.60 and 0.418, so it can be stated that the characteristics of time in

farming shallots and farmer income had a unidirectional relationship with the variable of level of suitability. This indicates that the longer the farmer's experience in cultivating shallots and the higher the farmer's income, the higher the value of the farmer's perception of the variable of level of suitability. The results of research conducted by [24] stated that the predictor variables of age, education, land area, land ownership status, income, and cosmopolitan influenced farmers' decisions to adopt TSS technology. The results of research conducted by [40] and [48] stated that income characteristics were quite strongly correlated with a correlation coefficient value of 0.4, however, the coefficient was negative, which means that the higher the income, the lower the farmer's perception.

Table 5 shows that two external factors (availability of infrastructure and institutional support) correlated with farmers' perceptions of technology. The variable of availability of infrastructure and institutional support had a significant correlation coefficient of 0.52 and 0.489, so it can be stated that the availability of infrastructure and institutional support had a unidirectional relationship with the variable of level of suitability. The characteristics of the availability of facilities and infrastructure also had a significant correlation coefficient of 0.43, which indicates that a significant influence on the perceived level of complexity can be observed. The results of this study are not in line with those reported by [24] where the institutional support variable had a significance value of 0.016 which indicates a significant influence on TSS technology adoption. The regression coefficient value for the institutional support variable had a negative relationship, so that the higher the score for the institutional support variable (the more available it is), the lower the possibility of adopting TSS technology.

**Table 5.** Distribution of the relationship between farmers' external characteristics and farmers' perceptions about technological innovation in shallot cultivation.

External Characteristics of Farmers	Koefisien korelasi (r)				
	Level of Relative Advantage	Level of Suitability	Complexity	Triability	Observability
Frequency of interactions with instructors (times/year)	0.38	-0.07	-0.22	0.38	-0.21
Determinants of decision making in cultivating plants	-	-	-	-	-
Farmer group membership	-	-	-	-	-
The presence of facilities and infrastructure facilitates a smooth adoption of technology by farmers	0.01	0.52**	-0.12	0.01	0.43*
Institutional support such as farmer groups and government support such as instructors' agencies	0.02	0.489*	-0.11	0.01	0.39

Remarks: \*\*Significant (<0.01), \*significant (<0.05)

### 3.4 Trends in adoption of technological innovations in shallot cultivation

Technology adoption is a mental process and behavioral change in the form of farmers' knowledge, attitudes, and skills from when they know about it until they decide to implement

it [18; 49]. The level of propensity to adopt components of shallot cultivation technology innovation can be seen in the table.

Table 6 shows the percentage of technology component adoption trends ranging from 76-88% to be implemented in the next growing season. Based on the level of adoption propensity, farmers who have currently decided against adoption are expected to experience a change in crop type in the next growing season or decide that they still need a time to adopt. To continue to increase the adoption of this innovation, education regarding shallot cultivation technology still needs to be carried out, because several components that farmers consider applicable must be socialized. [50] and [51] highlighted that the main factors affecting the adoption of agricultural technology for sustainable farming are socioeconomic status, cultural, institutional support, compatibility of the technology, psychological readiness, and sectoral factors. These elements are essential for improving resource management and ensuring ongoing productivity.

**Table 6.** The level of adoption propensity for technological innovations in shallot cultivation.

Technological components	Adoption propensity*(proportion of adopters)		
	Direct	Indirect	Not applied
Using superior varieties of seeds	76.00	24.00	0.00
Seed treatment before planting	76.00	24.00	0.00
Making beds	80.00	12.00	8.00
Using silver black plastic mulch (MPHP)	84.00	12.00	0.00
Applying organic base fertilizer	88.00	8.00	0.00
Applying chemical base fertilizer	80.00	12.00	4.00
Administering dolomite	88.00	8.00	0.00
Administering Trichoderma	80.00	8.00	4.00
Planting barrier plants/ fences/edges	76.00	16.00	0.00
Using plant spacing	84.00	16.00	0.00
Fertilization with balanced doses	84.00	16.00	0.00
Fertilization using the shaker method	88.00	12.00	0.00
Watering/balanced watering	84.00	16.00	0.00
Control/cleaning of weeds	84.00	16.00	0.00
Using pesticides based on the pest and dose	80.00	20.00	0.00
Using plant-based pesticides	76.00	16.00	8.00
Using yellow traps	76.00	20.00	4.00
Harvest time and treatment as recommended	88.00	12.00	0.00

\*Information: Direct = To be applied in the upcoming growing season; Indirect = To be applied, but not in the next growing season (with a time frame for implementation); Not applied = No intention to use it up to the time of the interview.

[8; 52; 53] argued that to reach this level of adoption, demonstration plots like these need to be continuously implemented. Adoption innovation follows a mental process that begins with gaining attention, then developing interest, and eventually generating a desire to experiment with the innovation. This progression prompts adopters to make decisions and ultimately leads to their efforts to apply the technology, a process known as adoption.

## 4 Conclusion and recommendation

Farmers' perceptions of technological innovation in shallot cultivation are that it is profitable, meets community needs, is not complicated, is triable and the results are observable. Gender characteristics, length of experience in shallot farming, farmer income, availability of infrastructure, and institutional support significantly influenced farmers' perceptions of the

application of technological innovation in shallot cultivation. Adoption trends indicate that some components will be adopted in the next growing season.

## References

1. A. Ma'suf, A. Abdul, and I. A. Ririen, Proceeding Seminar Nasional Mewujudkan Kedaulatan Pangan Melalui Penerapan Inovasi Teknologi Pertanian Spesifik Lokasi Pada Kawasan Pertanian, Badan Penelitian dan Pengembangan Pertanian (2018)\
2. C. A. K. Dissanayake, W. Jayathilake, H. V. A. Wickramasuriya, U. Dissanayake, K. P. P. Kopyawattage, and W. M. C. B. Wasala, Human Behavior and Emerging Technologies, 9258317 (2022)
3. A. Manongko, C. B. D. Pakasi, and L. Pangemanan, AgriSosio Ekonomi **13**, 2A (2017)
4. Saptana, E. Gunawan, A. D. Perwita, S. G. Sukmaya, V. Darwis, E. Ariningsih, and Ashari, PLoS ONE **16**, 9 (2021)
5. Helena da Silva and M. Kote, Proceeding Seminar Nasional: Mewujudkan Kedaulatan Pangan pada Lahan Sub Optimal Melalui Inovasi Teknologi Pertanian Spesifik Lokasi, Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian (2017)
6. D. Dinakaran, G. Gajendran, S. Mohankumar, G. Karthikeyan, S. Thiruvudainambi, E. I. Jonathan, R. Samiyappan, D. G. Pfeiffer, E. G. Rajotte, G. W. Norton, S. Miller, and R. Muniappan, Journal of Integrated Pest Management **4**, 2 (2013)
7. A. Adesina and M. M. Zinnah, Agricultural Economics **9**, 4 (1993)
8. R. Hendayana, Persepsi dan Adopsi Teknologi (Teori dan Praktek Pengukuran), Ed.1 (IAARD Press, Jakarta, 2016)
9. M. Abdul-Majid, S. A. Zahari, N. Othman, and S. Nadzri, Heliyon **10**, 2 (2024)
10. F. D. Mackenzie, Land Use Policy **20**, 3 (2003)
11. B. K. Hailu, B. K. Abrha, and K. A. Weldegiorgis, Int. Journal of Food and Agricultural Economics **2**, 4 (2014)
12. E. Iskandar and H. Nurtilawati, Jurnal Agribisnis Terpadu **12**, 2 (2019)
13. A. Wulandari, F. Rahman, N. Pujianti, A. R. Sari, N. Laily, L. Anggraini, F. I. Muddin, A. M. Ridwan, V. Y. Anhar, M. Azmiyannoor, and D. B. Prasetio, Jurnal Kesehatan Masyarakat Indonesia **15**, 1 (2020)
14. S. W. Budiarti and C. A. Wirastri, Proceeding SEMNAS HITEK Book 2, Fakultas Pertanian dan Bisnis, UKSW (2021)
15. S. W. Budiarti, H. Cahyaningrum, E. Ratnaningsih, R. Widowati, J. Riyanto, and I. M. P. Adiwijaya, Jurnal Pertanian Agros **15**, 650 (2023)
16. A. A. Asriadi, M. Salam, R. A. Nadja, L. Fudjaja, D. Rukmana, M. H. Jamil, M. Arsyad, Rahmadanih, and R. Maulidiyah, Sustainability **16**, (2024)
17. Edwina and E. Maharani, Indonesian Journal of Agricultural Economics **2**, 1 (2010)
18. I. A. Fachrista and M. Sarwendah, Agroekonomika **3**, 1 (2014)
19. W Adiyoga. IOP Conf. Series: Earth and Environmental Science, FSSAT-4 (2023)
20. F. Muchlis, D. N. Amalia, A. S. Jamil, A. Zainuddin, R. P. Destiarni, and A. Meilin. E3S Web of Conferences 444, IConARD UMY (2023)
21. R. A. Suleiman, S. Abdulrahman, O. C. Ariyo, O. D. Adelani. Australian Journal of Science and Technology **5**, 3 (2021)

22. M. F. Umar, I. Nugroho, Darmadji, and Suwarta, *Journal of Socioeconomics and Development* **3**, 1 (2020)
23. T. Duong, T. Brewer, J. Luck, and K. Zander, *Agriculture* **9**, 1 (2019)
24. P. R. Pratiwi, I. S. Siswanto, and R. Wiludjeng, *AGRARIS: Journal of Agribusiness and Rural Development Research* **4**, 1 (2018)
25. S. Ruzzante, R. Labarta, and A. Bilton, *World Development* **146**, (2021)
26. R. Valdes, D. Gómez, and L. Barrantes, *Agriculture & Food Security* **12**, 45 (2023)
27. I. Ukrita, F. Musharyadi, and Silfia, *Jurnal Penelitian Lumbung* **10**, 2 (2011)
28. Suharyanto and I. K. Kariada, *Jurnal Pengkajian dan Pengembangan Teknologi Pertanian* **14**, 1 (2011)
29. S. D. D. D. Karunathilaka and A. Thayaparan, *Journal of Economics and Sustainable Development* **7**, 12 (2016)
30. E. Rastiyanto, A. Surachmanto, and A. Pullaila, *Buletin Ikatan* **4**, 1 (2014)
31. R. E. Putri, L. T. W. Astuti, and N. Yanti, *Agrica Ekstensia* **10**, 2 (2016)
32. V. Theresia, A. Fariyanti, and N. Tinaprilla, *Journal of Agribusiness and Rural Development Research* **2**, 1 (2016)
33. F. Wu, *PLoS ONE* **17**, 4 (2022)
34. S. Narti, *Jurnal Professional FIS UNIVED* **2**, 2 (2015)
35. J. F. Becerra-Encinales, P. Bernal-Hernandez, J. A. Beltrán-Giraldo, A. P. Cooman, L. H. Reyes, and J. C. Cruz, *Sustainability* **16**, (2024)
36. N. Huda, B. Suharjo, and A. Suryani, *Manajemen IKM* **8**, 2 (2013)
37. S. S. Hariadi, *Jurnal Ilmu-Ilmu Pertanian* **3**, 2 (2007)
38. R. Hanafie, *Pengantar Ekonomi Pertanian*, Ed.1 (CV Andi Offset, Yogyakarta, 2010)
39. Priyono, M. I. Shiddieqy, D. Widiyantoro, and Zulfanita, *Informatika Pertanian* **24**, 2 (2015)
40. S. H. Junaidi and Gunawan, *Proceeding Seminar Nasional : Membangun Kemandirian Korporasi Petani Indonesia Menuju Kedaulatan Pangan dan Launching SIMIA Cerdas, STPP Malang* (2018)
41. Z. Bozbay and B. Yasin. *The International Journal of Technology, Knowledge and Society* **4**, 4 (2008)
42. W. Lestari, D. Rabesdini, and J. Yusri, *Respon petani terhadap program Sekolah Lapang Pengelolaan Tanaman Terpadu (SL-PTT) padi sawah di Desa Pulau Birandang Kecamatan Kampar Timur Kabupaten Kampar (Fakultas Pertanian, Universitas RIAU, 2012)*
43. T. C. Mardiyanto, R. Pangestuti, B. Prayudi, and R. Endrasari, *Jurnal Ilmu-Ilmu Pertanian* **24**, 1 (2017)
44. T. M. Elisabeth and S. Martin, *African Scientific Journal* **03**, 15 (2022)
45. L. Jie, *Journal of Innovation & Knowledge* **7**, 3(2022)
46. M. E. Wulanjari and Acima, *Proceeding Seminar Nasional Agribisnis, Universitas Diponegoro and PERHEPI* (2015)
47. Juan, C., Pomaquero., José, F., Lopez., José, L., Lopez, *Revista ESPACIOS* **40**, 13 (2019)
48. C. K. Jha and V. Gupta, *Environmental and Sustainability Indicators* **10**, (2021)
49. F. Masimba and T. Zuva, *Indiana Journal of Humanities and Social Sciences* **2**, 9 (2021)

50. G. Khaspuria, A. Khandelwal, M. Agarwal, M. Bafna, R. Yadav, and A. K. Yadav, *Journal of Scientific Research and Reports* **30**, 7 (2024)
51. A. Adams and E. T. Jumpah. *Cogent Economics and Finance* **9**, (2021)
52. H. Ainissyifa, E. R. Wulan, A. Muhyiddin, and M. A. Ramdhani, *IOP Conf. Ser.: Mater. Sci. Eng.* 434 012247, 3rd Annual Applied Science and Engineering Conference (AASEC) (2018)
53. S. Liang, M. Hsub, and W. Chen, *Journal of Computer Information Systems* **63**, **5** (2023)