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Intercropping and farmer income: a case study of onion farmers in Tawangmangu

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ABSTRACT

Onion farmers in Tawangmangu are currently experiencing difficulties due to changes in rainfall. As a result, they are planting garlic and then intercropping with shallots. This decision will have a direct impact on farmers' income. This study aims to determine the effect of farmers' decisions in intercropping garlic with shallots on farmers' income in the Tawangmangu District. This research was conducted in Tawangmangu District with a simple random sampling method to determine the sample size of 49 respondents. The method of data analysis used a two-stage least square. The decision to intercrop shallot and garlic does not affect farmers' income. The age of the farmer influences the decision to do intercropping. A farmer's income is influenced by land area and the use of Phonska fertilizer. To increase farmers' income, using fertilizers with similar elements must be paid more attention to when fertilizing plants.

KEYWORD

garlic, intercropping, shallots, two-stage least square

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1. INTRODUCTION

Development is a series of changes in the direction of progress; these changes are planned based on certain norms (Yulihastin *et al.*, 2011). In essence, development is aimed at economic growth and improving the quality of human life in a better direction. Development for developing countries such as Indonesia places more emphasis on economic development because economic development will encourage development in other fields. The agricultural sector is an engine of growth, providing raw materials, employment opportunities, food ingredients, and purchasing power for products produced by other sectors. Agriculture in general and horticultural commodities, in particular, are expected to contribute to each region's economic growth and gross regional domestic income (GRDP) (Sitanggang, 2015).

The development of the horticultural crop sub-sector is an integral and inseparable part of agricultural development to realize the national economic development program (Cipta *et al.*, 2017). Indonesia's natural wealth is a natural resource the state owns in developing this sub-sector. Indonesia, which has an area topography with an altitude between 0–1000 m above sea level, is suitable as a location for horticultural plantings such as fruits, vegetables, and flowers.

The development of market-oriented agricultural development policies is a determinant of the direction of sector development at the regional level in the future. Local commodities will face tougher market competition in type, quality, and quantity. This condition shows the tendency of market-oriented policies, deregulation, and decreasing government intrusion into productive activity. Furthermore, environmental sustainability is a global demand that cannot be avoided and will impact policies on the use of chemical inputs and materials that cannot be tolerated by the environment (Anugrah *et al.*, 2014).

Garlic is a horticultural agricultural commodity that many people in the world need, mainly used as a flavoring additive or fragrance for several types of food. Besides being an important vegetable, garlic (*Allium sativum L.*) is also a source of new economic growth in agricultural development. Garlic is a potential commodity, especially for import substitution and foreign exchange savings. The need (consumption) for garlic from year to year continues to increase in line with the increasing population, the improving national economy, and the increasing public knowledge of the importance of nutrition for these commodities (Prasetyo *et al.*, 2019).

Karanganyar Regency is one of the garlic and shallot-producing areas in Central Java. Karanganyar Regency is a large area for growing garlic and shallots because it has a production of 25,658 quintals for a land area of 184 hectares. Tawangmangu District is a center for garlic production in Karanganyar Regency, with the most significant harvest area of 108 hectares in 2018, with productivity reaching an average of 13 tons/ha (Badan Pusat Statistik, 2020).

Recently, climate change has occurred, and there has also been an increase in the frequency and intensity of extreme weather events. This weather condition eventually resulted in two main things happening in the lowest layer of the atmosphere, namely high rainfall fluctuations and sea level rise. Onion farmers in Tawangmangu are currently experiencing difficulties due to changes in rainfall. As a result, they speculate on growing garlic and intercropping with shallots. Intercropping is an option because onion farmers cannot predict the arrival of rain that will fall because there is a difference in the age of harvesting garlic and red, which reaches one month. The price of garlic is currently higher than that of shallots, but garlic will have a greater risk of crop failure if the crop is harvested when it enters the rainy season (Rahmawati and Jamhari, 2019).

The intercropping pattern in its implementation must choose two or more suitable plants to utilize space and time as efficiently as possible and reduce the competitive effect as little as possible. The productivity level of intercropping plants is higher, with harvest profits of between 20 and 60% compared to monoculture cropping patterns (Chai *et al.*, 2021). Based on the description above, it is necessary to know whether the farmer's decision after intercropping affects the income of garlic farmers. This study aims to determine the effect of farmers' decisions in intercropping garlic with shallots on farmers' income in the Tawangmangu District.

2. METHODOLOGY

This research was conducted from March to May 2022 in Tawangmangu District. The primary method used in this research is the descriptive-analytical method. This method focuses on solving problems that exist in the present. It is carried out by compiling data that has been collected, compiled, explained, analyzed, and then concluded and supported by theory—also supported by previous research (Arikunto, 2010). The research technique used is survey research. Survey research is a form of research that takes a sample from one population and uses a questionnaire as a primary data collection tool. The questionnaire collects information from respondents (Siregar and Harahap, 2019).

The sampling method was carried out using the simple random sampling method. The sample in this study uses a confidence level of sampling using the slovin formula. For example, in a study with a 90% confidence level, the error rate is 10% so that it can determine the minimum sample limit that can meet the 10% margin of error requirement by entering the error margin into the slovin formula.

$$n = N / (1 + (N \times e^2)).$$

$$n = 96 / (1 + (96 \times 0.1^2))$$

$$n = 96 / (1 + (96 \times 0.01))$$

$$n = 96 / (1 + 0.96)$$

$$n = 48.97(\text{rounded to } 49)$$

The data analysis method used two-stage linear regression analysis (two stages least square), which was used to determine the magnitude of the influence of the independent variable on the dependent variable. Mathematically, the influencing variables can be seen in the equation below:

$$D = \alpha_0 + \sigma_{i=1}^4 \frac{\alpha_i \alpha_i}{\alpha_i \alpha_i} + \sigma_{i=1}^4 \frac{\alpha_i \alpha_i}{\alpha_i \alpha_i} + \sigma_{i=1}^6 \frac{\alpha_i \alpha_i}{\alpha_i \alpha_i} + \epsilon_1 \quad (1)$$

$$I = \alpha_0 + \frac{\alpha_1 \alpha_1}{\alpha_1 \alpha_1} + \sigma_{i=1}^4 \frac{\alpha_i \alpha_i}{\alpha_i \alpha_i} + \frac{\alpha_1 \alpha_1}{\alpha_1 \alpha_1} \sigma_{i=1}^4 \frac{\alpha_i \alpha_i}{\alpha_i \alpha_i} + \epsilon_2 \quad (2)$$

Where D is the farmer's decision to intercrop with shallots, C is the characteristic vector of the farmer's household. Farmer household characteristics consist of the farmer's age (years), land area (Ha), an education level (years). F is a vector of supporting facilities consisting of distance from the location to the market, government programs, and the use of cellular phones. The value of the supporting facilities variable is one if it has or is near (0–5 km) the facility and 0 if it does not have or is far from the market (more than 5 km). M is a vector of the ability of human resources to overcome pests and diseases and behavioral patterns affecting the microclimate. A score of 1 is given if the farmer considers himself capable of managing pest-disease attacks and microclimate. Then a value of 0 is given if the farmer cannot manage pests and microclimates. I am a vector of farm income. B is a vector of farming costs for seeds, fertilizers, pesticides, and labor. α , β , φ , and δ are the estimated coefficients, and ϵ_i is the residual, which includes other factors outside the scope of the independent variables used for this analysis.

The model is estimated using a two-stage least square with instrumental variables to overcome heteroscedasticity. Multicollinearity between independent variables was tested using a correlation matrix (or Pearson correlation). The linear model tests marginal effects and independent variable relationships (autocorrelation). The model's statistical significance and parameters were tested with error rates of 1, 5, and 10%.

3. RESULTS AND DISCUSSION

Table 1 shows the model results of the estimated regression results of factors influencing farmers' intercropping decisions in the Tawangmangu District. The coefficient of determination is 0.380, which means age, land area, education level, distance to markets, government programs, cell phone use, and the ability of human resources to control pests and diseases explain 38% of farmers' intercropping decisions. Other variables outside the model explain 62%. Other variables include environmental factors, agro-ecological practices, and organizational policies. The low correlation value between independent variables, below 0.234, indicates no multicollinearity in the model. The model equation is significant at the 95% confidence level based on the F test. The F test states that the vector characteristics of the farmer's household, facilities, and the ability of human resources to control pests and diseases in a single unit affect the decision of farmers to intercrop between garlic and shallots in the Tawangmangu District.

Table 1. Intercropping decision regression results

Variable	Coefficient		t-value	Sig
	Actual	Standard		
Constant	1.222			
Age	-0.009	0.003	-2.584	**
Land area	-0.918	1.018	-0.902	ns
Level of education	0.017	0.016	1.099	ns
Distance to Market	0.128	0.121	1.062	ns
Government program	-0.113	0.147	-0.772	ns
Cell Phone Usage	0.108	0.075	1.449	ns
HR	-0.026	0.089	-0.287	ns
R ²			0.380	
F-test			2.607	**

Note: **= significant at 95% confidence level, ns= not significant

The estimation results show that one variable significantly influences the decision to intercrop garlic and shallot, namely the farmer's age. Age has a negative relationship with farmers' intercropping decisions. The age of farmers who are getting older tends to make farmers feel comfortable with the current situation (Andriani *et al.*, 2019). The comfort zone limits farmers' ability to change according to time and technology. Technical information on cultivation is widely available on the internet, but its utilization has not reached farmers properly. The higher the age of farming experience, the better so that farmers will realize that intercropping between garlic and shallots will not have better benefits when compared to monoculture farming of garlic or shallots.

Land area, education level, distance to market, government programs, and use of cellular telephones have no significant effect on the decision to intercrop garlic and shallots. A field is a place where farmers cultivate crops. The narrow or large area of land does not affect the decision of farmers to carry out intercropping cultivation. Management is the responsibility of the farmers themselves, so the land is a place for the realization of actions by farmers, not the primary consideration for monoculture or intercropping. The government program does not influence the decision to intercrop because the current government program is to produce garlic as an import substitution (Mardianto, 2020). The presence or absence of current government programs does not affect farmers' decisions. Although there is no government program, farmers will continue to plant garlic because they feel they will benefit from planting onions. The government program does not oblige or regulate the intercropping of onions. The

program only discusses planting to increase domestic production, not explicitly mentioning whether planting is monoculture or intercropping.

The level of education does not affect the decision to intercrop garlic and shallots because formal education encourages creative farmers and responds to the business being run when facing a rapidly changing situation like now. In an era where everything is done online, like now, education will play an essential role in the absorption of cultivation innovations that are more effective and efficient (Kusumo *et al.*, 2018). The farmers' decision to intercrop between garlic and shallots is inseparable from applying innovative agricultural practices. Although technically, intercropping cultivation is not recommended for cultivating similar plants, farmers still carry out such intercropping due to previous experience with it. The use of the internet has become a mandatory thing to do to support the decision to intercrop. Through social media, modern intercropping cultivation techniques are widely discussed in virtual groups so that they can assist in the distribution of knowledge. The use of mobile phones that have internet capacity (smartphones) is currently expected. Still, their use has not been able to be used as a source of knowledge or information that can influence farmers' cultivation decisions.

Distance to the market does not affect farmers' decisions to intercrop garlic and shallots in Tawangmangu District. A market is a place for buying and selling transactions. Farmers who are closer to the market (less than five kilometers) will easily make buying and selling transactions (Rasmikayati *et al.*, 2021). All cultivation needs and crops can be obtained and sold from the market so that if there is an urgent need in cultivation techniques or marketing, farmers can obtain them directly (Ramadhani and Rasmikayati, 2017). If there are obstacles, farmers should be able to buy their needs in the market so that the selection of garlic and shallot intercropping does not occur because the main reason for carrying out intercropping activities is due to pest and disease attacks.

Farmers feel that the seasonal changes have resulted in increasingly sporadic pest attacks on onion plants. This result can be seen in table two, where farmers use many pesticides to cultivate garlic and shallots. Farmers feel they can take action to handle pests and diseases on their land and feel that they have no difficulty in controlling these pests (Suswadi & Prasetyo, 2022). Human resources who know pest control make them not concerned about intercropping or not, so that intercropping decisions are not affected by pest control choices due to changes in micro seasons. Farmers said that they feel safer intercropping shallots and garlic because there is one month between the two crops to be harvested, and it makes pest control easier because the pesticides used are of the same type.

Table Two shows the impact of the decision to intercrop agriculture on the income of onion farmers in the Tawangmangu District. No multicollinearity was detected in the model. Based on the F test, the model equation is significant at the 99 percent confidence level, with a coefficient of determination of 68.1 percent. The estimation model shows that the decision to intercrop shallot and garlic does not lead to a significant increase in income. This result shows that the decision to intercrop does not positively impact the lives of farmers in the Tawangmangu District. Yuliana and Nadapdap's (2020) research states that education level and innovation characteristics influence farmers' decisions in adopting new techniques or innovations and perceptions. This study's findings are different from those of Yuliana, as evidenced in table one, where the level of education does not affect the adoption of innovations. The characteristics of innovation in the form of similar plants and different harvest ages are the choice of farmers to adopt the intercropping of shallots with garlic. Farmers feel that if all garlic is planted in monoculture, the rainy season may come sooner, so there is a more significant potential for crop failure. Farmers also hope that the onion harvest

within three months can bring in faster income so that the financial condition of the farmer's household is also more secure.

Table 2. Onion farmer income regression

Variabel	Koefisien		t-value	Sig
	Actual	Standard		
Intercropping Decision	2949546,77			
Age	1280920,24	1943464,55	0,659	ns
Land area	-16068,68	42506,90	-0,378	ns
Level of education	56261183,97	21338195,02	2,637	**
Seed	-89840,14	159332,75	-0,564	ns
Manure	11162,45	40724,30	0,274	ns
Urea Fertilizer	706,97	900,50	0,785	ns
NPK Fertilizer	-7434,02	14717,21	-0,505	ns
Phonska Fertilizer	-5133,57	12879,45	-0,399	ns
ZA	-28733,92	16347,82	-1,758	*
TSP	-38859,72	23770,84	-1,635	ns
Diphenconazole pesticides	-7526,00	12555,52	-0,599	ns
Pesticide Mankozeb	-666720,74	1779749,33	-0,375	ns
Pesticide Chlorphenapir	127600,24	766265,42	0,167	ns
Dimethoate Pesticide	3193653,71	2414339,42	1,323	ns
Abamectin Pesticide	-81835,70	846029,44	-0,097	ns
Glue	-759566,24	1081324,85	-0,702	ns
Labor	886768,81	603297,87	1,47	ns
Intercropping Decision	-6458,60	38391,49	-0,168	ns
R ²			0,681	
F-test			3,558	***

Note: Significant level ***= 99%; **= 95%; *= 90%; and ns= not significant

The results of the partial effect test using the t-test showed that the decision to apply land area and phonska fertilizer had a significant effect on the income of onion farmers. Meanwhile, farmer age, education level, seeds, manure, urea, NPK fertilizer, ZA fertilizer, TSP fertilizer, pesticides with active ingredients Difenconazol, Mankozeb, Chlorphenapir, Dimethoate, Abamectin, adhesives, and labor did not significantly affect the income of garlic farmers. The coefficient value of the land area variable has a positive value of 56261183.966, indicating that if the land area increases by one hectare, it will increase farmers' income by 56261183.966 per hectare of planted land. Land area is the main factor that is important in farming production activities. Land area affects the number of plants that farmers can plant. The larger the land area, the greater the number of plants planted, so the production of garlic and shallots is also more significant. The production amount will determine garlic farmers' income if other factors are considered constant (*ceteris paribus*). This fact follows several findings, which show that onion farmers' income is influenced by land area.

The coefficient value of the phonska fertilizer variable is -28733,915. This value shows that if there is an increase in phonska fertilizer by one kilogram, it will reduce the income of onion farmers by 28,733.915 rupiahs. The decrease in income occurred due to overlapping with other fertilizers provided by farmers. Phonska contains NPK and sulfur; of course, the substance content is the same as the pearl NPK fertilizer provided by farmers. Farmers also apply ZA fertilizer, which has a higher sulfur content than phonska. The application of

phonska fertilizer will not increase income because the function of the fertilizer does not increase production but instead indicates an excess of fertilizer given by farmers to their land.

The variables of age and education level have no significant effect on the income of onion farmers. Increasing age will reduce the ability of farmers to cultivate garlic farming. The ability of the energy and minds of farmers has begun to decrease, and there is no willingness to change the current methods of cultivation and marketing methods so that they cannot increase farmers' income. The use of seeds does not affect farmers' income because seed varieties do not directly affect production and income and are more influenced by the number of plants planted. The average area of onion planting in the Tawangmangu District is only 0.07 ha, with new varieties of Tawangmangu garlic and local or Balinese shallots. A narrow planting area will undoubtedly make the costs incurred by farmers for seeds ineffective and tend to be more expensive when compared to buying seeds in large quantities for a large planting area. At the same time, the productivity for each planted variety will not differ significantly due to the wide planted area.

The level of education does not affect the income of onion farmers. The level of education does not affect the output produced by the garlic plant. Education affects the way farmers think but is not a direct input related to crop production. Labor does not affect farmers' income because the narrow land area makes the use of labor inefficient. The average use of labor for farming companies reaches 30 HOK per growing season. This labor is paid by farmers and does not include workers from within the farmer's family. The use of a reasonably high number of workers is found in labor for land processing, weeding, and harvesting. This finding is different from the findings of Wanderi *et al.* (2019), which state that the level of education is very influential on farmers' income.

The use of manure, urea, NPK, Za, and TSP did not significantly affect the income of onion farmers in the Tawangmangu District. Appropriate fertilizers will undoubtedly increase the production and income of farmers if other factors are considered constant (*ceteris paribus*). These findings are in line with Listiani *et al.* (2019), which stated that fertilizer, seed, and labor costs did not affect the income of rice farmers in Mlonggo District, Jepara Regency. Fertilizers are based on the fulfillment of essential nutrients for plants. Still, the use of fertilizers in the research location experiences the use of the same elements, so the number of doses will be excessive for each type of fertilizer used. Nitrogen elements are contained in urea, NPK, ZA, and phonska fertilizers. Excess nitrogen causes plants to be easily attacked by pests, which is reflected in the amount and type of pesticides used in controlling pests and diseases. This amount and type also mean that the use of pesticides does not affect farmers' income. Excessive use of fertilizers and pesticides causes inputs for farm inputs to be significant, so it will be more efficient if fertilizers and pesticides can be optimized.

4. CONCLUSION

The conclusion drawn based on the research results is that the decision to intercrop shallot and garlic does not affect farmers' income. The technique of cultivating shallots and garlic in monoculture and intercropping does not have a significant effect on farmers' income. The age of the farmer influences the decision to do intercropping. A farmer's income is influenced by land area and the use of phonska fertilizer. Fertilizers and pesticides must be more efficient to increase farmers' income. Elements of similar fertilizers must be paid more attention to when fertilizing; urea, NPK, Za, and Phonska fertilizers can be reduced and selected according to the needs of garlic and shallots.

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