Production Risk Analysis for Organic Cabbage Farming in Semarang District, Central Java

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Abstract. There is some risk and uncertainty involved with purchasing organic cabbage. Farming is highly susceptible to natural phenomena such as high rainfall and pest infestations. It will have consequences for the development of the harvested area, and fluctuations in production can indicate a risk to agricultural production. This study aims to determine the factors that influence organic cabbage production and to determine the factors that affect the risk of organic cabbage production in Getasan District. The Semarang Regency, where this study was conducted, is the largest cabbage market. A total of 73 farmers were selected using a census-based sample from four INOFICE-certified organic farmer groups: Batur Village, Wates Village, Tajuk Village, and Kopeng Village. The analysis method utilized the Just and Pope production risk function and the Cobb-Douglass type production function. The Cobb-Douglass production function analysis revealed that land area, seeds, manure, and cropping patterns all positively and substantially affected organic cabbage production, but only to a limited extent. According to the Just and Pope production risk function, the risk associated with farming organic cabbage could be mitigated by increasing land area and diversity in cropping patterns.

1 Introduction

Protein, vitamins A, C, B1, B2, and Niacin are just a few of the many nutrients in cabbage (*Brassica oleracea L.*). Cabbage needs a cool, damp environment to thrive, such as the highlands at 800–2000 meters above sea level. Soil with a pH between 6-7 rich in humus, loose, and porous is ideal for producing cabbage. Planting can be performed at the beginning of the rainy or dry seasons. With much extra work, cabbage can be grown year-round. Cabbage is generally ready to be harvested 55 days after transplanting [1].

Organic and conventional cabbage farming are the two most well-known methods. Farmers' enthusiastic reception of organic farming practices bodes well for the industry's future in Indonesia [2]. It is spurred on by the growing number of organic agricultural advocacy groups and organizations [3,4] and the general public's acceptance of organic food consumption as part of a healthy, sustainable lifestyle. The environmental consciousness of

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some consumers is also fueling the expansion of organic farming methods. This strategy is thought to be more effective in combating climate change, eutrophication in freshwater, and the depletion of fossil fuels [5]. There must be a time of progressive conversion for land to become free of residues of chemical synthetic materials before it can be used for organic farming. Soil moisture, organic C content, and soil respiration improve noticeably after five years in an organic farming system [6]. Implementing organic fertilizers like manure, green manure, bokashi, and natural insecticides for integrated pest control [6] and planting with superior local non-hybrid seeds capable of optimal output are all great ways to conserve resources [7, 8].

Organic farming refers to the cultivation of agriculture that does not use synthetic chemicals or cultivation using natural components and applies more environmentally friendly land-management techniques [9]. Organic farming follows the principles of health, ecology, environmental balance, justice, and environmental protection with varied systems and models [10, 11].

The Semarang Regency is one of the most fertile regions in Indonesia, making it ideal for producing a wide variety of crops, notably those used in the horticultural industry. Semarang Regency's districts are well-suited to cultivating many high-quality horticulture products, including cabbage, shallots, potatoes, chilies, and carrots. Cabbage is one of the best agricultural products in that region. Plants in the Brassicaceae family, of which cabbage is a member, thrive in cool temperatures, between 800 and 2000 meters above sea level, and produce an annual vegetable [12].

Semarang Regency has the highest cabbage commodity production in Getasan District [13]. Efforts to increase cabbage production can be made through the adoption of new technology and the effective use of available resources [14]. Since 2016, the government has launched a program to develop organic agricultural technology through the "Go Organic" Program to create segmented organic farming areas for domestic and foreign markets. In this case, Semarang Regency is number one regarding the certified organic land area in Central Java, with an organic land area of 332.76 hectares [15]. Organic materials used in organic farming are expected to improve the quality and quantity of cabbage crop production. Organic farming can also provide a solution to dependence on chemical fertilizers and pesticides to maximize costs incurred for farming inputs [16, 17].

Getasan District, located at the southern tip of Semarang Regency, is considered to have rapid development in organic farming. The continued increase in farmer groups engaged in organic farming and the topography of areas located in the highlands support the community's ability to carry out organic vegetable farming with the "Indonesian Organic Farming Certification" (INOFICE) certification [15]. Many types of vegetables are produced, especially organic cabbage. Even so, farmers still have difficulty understanding the application of organic farming, and farmer readiness is required to decide about implementing organic farming [18, 19].

Farmers' difficulties in implementing organic farming can be seen in the use of non-optimal farming inputs. Using non-optimal inputs can affect production and not achieve technical, economic, and allocative efficiency [20]. Using the Cobb-Douglass production function in the production of cabbage farming in Pagar Alam City demonstrates that the production factors of cabbage farming significantly affect land ownership and manure [21]. Other research focused on the North Ulin Platform only factors of land area, seeds, and labor that directly influence the results of mustard farming. Organic fertilizers, inorganic fertilizers, and pesticides did not affect production results [22].

Farmers often ignore the rationality of using organic fertilizers, botanical pesticides, and labor inputs. Farmers often employ too much or too little input. Based on previous research, farmers in the Getasan District utilized excessive labor input, making it insignificant and reducing production [23].

Risks and unknowns are involved in farming organic cabbage in Getasan District. A farming enterprise relies heavily on natural factors like abundant rainfall and the threat of pest and disease infestations. Further, changes in output can signify a production risk in farming, and the use of insufficient or excessive production inputs will ultimately affect the growth of the harvested area. In light of this background information, a question emerged. In the Getasan District, where organic cabbage is grown, what factors influence production and affect the production risk?. This study aims to determine the factors that influence organic cabbage production and to determine the factors that affect the risk of organic cabbage production in Getasan District

2 Research Method

This research was conducted on organic cabbage farmers in Getasan District, Semarang Regency, Central Java, considering the largest level of cabbage production in this regency [13]. Another reason was that several farmer groups cultivate cabbage organically and have organic vegetable certification from INOFICE. The respondents were 73 farmers from four farmer groups with INOFICE organic vegetable certification.

This study utilized the analysis of the cobb-douglass type production function and the risk function of the Just and Pope model , tested statistically by testing the coefficient of determination (R^2), F test, and t-test. The model was formulated as follows.

Cobb-Douglass type production function :

$$Y=\beta_0 X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} D^d \varepsilon \quad (1)$$

Production risk function:

$$\sigma^2 = \theta_0 X_1^{\theta 1}\, X_2^{\theta 2}\, X_3^{\theta 3}\, X_4^{\theta 4}\, X_5^{\theta 15}\, D^d \varepsilon \quad (2)$$

Equations 1 and 2 were converted into multiple linear forms to make estimating them easier.

Production Function:

$$LnY = ln\ b_0 + b1\ lnX1 + b2\ lnX2 + \ldots + b5\ lnX5 + dD + \boldsymbol{\varepsilon} \quad (3)$$

Production risk function:

$$Ln\sigma^2 = ln\theta_0 + \theta 1\ lnX1 + \theta 2 lnX2 + \ldots + \theta 5\ lnX5 + dD + \boldsymbol{\varepsilon} \quad (4)$$

Description:

Y = Organic cabbage production output
σ^2 = Risks of organic cabbage production
bi = Regression coefficient of the production function
θi = Regression coefficient of the risk function
d = Dummy variable regression coefficient
X1 = Land (M2)
X2 = Seed (stem)
X3 = Manure (Kg)
X4 = Botanical pesticide (L)
X5 = Labor (daily work equivalent to men)
D = Dummy cropping pattern (D : Intercropping 1; Monoculture 0)
$\boldsymbol{\varepsilon}$ = Element of error

3 Research Results and Discussion

3.1 Farmer Identity

Farmer identity refers to their inner characteristic, a benchmark for managing farming and accepting innovation. The identity of the farmers in this study described 73 respondents who were organic cabbage farmers in Getasan District, including their age, gender, education level, farming experience, and land ownership area.

Table 1. Identity of Organic Cabbage Farmers in Getasan District

Profile	Total	Percentage (%)		Profile	Total	Percentage (%)
Age				**Farming Experience**		
26-38	7	9,59		1-9	23	31,50
39-51	31	42,46		10-18	25	34,25
52-64	21	28,77		19-27	17	23,29
65-77	13	17,81		28-36	7	9,59
78-90	1	1,37		37-45	1	1,37
Gender				**Land Area (m^2)**		
Male	50	68,49		100-1080	35	47,95
Female	23	31,51		1081-2061	19	26,03
Education Level				2062-3042	13	17,81
No School	4	5,48		3043-4023	4	5,48
Elementary School	37	50,68		4024-5000	2	2,74
Junior High School	19	26,03				
Senior High School	10	13,70				
Higher Education	3	4,11				

Most organic cabbage farmers in Getasan District were between 39-51 (42.72%), meaning they were of mature, productive age, with physical and mental abilities and a good capacity to receive information and innovation. It enabled them to manage production factors and implement organic farming to boost production [24].

Male farmers dominated organic cabbage farming in Getasan District because organic cabbage farming involved heavy physical activity. Women's labor was only employed to assist in seeding, planting, and harvesting. However, the research results unveiled that women played a role in organic cabbage farming because the husband, as head of the family, had a main job other than farming.

The educational level of organic cabbage farmers in Getasan District was mostly elementary school, reaching 50.68%. It implies that the education level of organic cabbage farmers in Getasan District still needs to be higher. However, a low level of education does not mean that farmers have less knowledge. These farmers learned much about organic farming through farmer group activities or extension programs.

Only between 10 and 18 years of farming experience have been devoted to organic cabbage. Batur Village's farmers, who were among the movement's earliest pioneers, have been at it the longest; farmers in Wates Village, Tajuk Village, and Kopeng Village, on average, only began organic farming in the 2010s. This finding suggests that organic cabbage farmers in Batur Village had a more refined understanding of managing production parameters and assessing the risks associated with their enterprise than their counterparts in other villages. Longer experience implies means better farmer managerial skills [25].

3.2 Analysis of Production Function and Production Risk Function

The production function of organic cabbage was analyzed using the Cobb-Douglas type production function model, while the production risk analysis employed the Just and Pop approach. Factors influencing the production and production risk of organic cabbage farming encompassed land area (X1), seeds (X2), manure (X3), botanical pesticides (X4), labor (X5), and cropping patterns (Dummy) on organic cabbage production (Y). Table 2 depicts the regression coefficient value of the Cobb-Douglass type production function and production risk function.

Table 2. Regression Coefficient of Production Function and Risk Function of Organic Cabbage Production in Getasan District

Variable	Regression Coefficients	
	Production Function	**Risk Function**
(Constant)	6,242 ***	1,431 ***
Land Area (X1)	0,097 **	-0,039 ***
Seed (X2)	0,592 ***	-0,005 NS
Manure (X3)	0,115 *	0,007 NS
Botanical Pesticides (X4)	0,034 NS	-0,029 NS
Labor (X5)	-0,048 NS	0,001 NS
Planting System (Dummy)	0,552 ***	-0,044 *
R^2	0,890	0,273
F-Count	89,141 ***	4,130 ***

Description: *** : Significant α= 1% ; **: Significant α= 5%; * : Significant α=10% ; and NS: Non significant

The regression analysis results obtained an R2 (Coefficient of Determination) of the production function of 0.890, meaning that the ability of the independent variable land area (X1), seeds (X2), manure (X3), pesticides (X4), labor (X5) and planting systems (Dummy) could explain the dependent variable organic cabbage production (Y) of 89.0%. In contrast, the remaining 11% was explained by other factors excluded in the model. Conversely, the regression coefficient of the risk function was only 27%, indicating that production risk was not only influenced by production factors but also other factors not explained by the model, such as rainfall, cultivation techniques, input prices, cabbage prices, and others.

The F test revealed that the independent variables significantly affected the dependent variable in the production and risk functions. Thus, this model could be continued with the t-test. Based on the regression analysis results, the factors that significantly influenced the production of organic cabbage comprised land area, manure seeds, and cropping pattern dummy variables. The only significant effect on the risk of cabbage production was land area and the dummy variable.

The effect of the dummy variable on the cropping system, both on the production function and the risk function, as well as showing a significant regression coefficient, signifies a difference in the effect of the use of production factors on organic cabbage production and the risk of organic production between organic cabbage grown in intercropping and monoculture. However, the dummy variable of the cropping system in the production function was positive. Hence, production factors of organic cabbage grown in intercropping gained higher production than that of organic cabbage grown in monoculture. The finding was in accordance with Li et al. [26] that stated that the intercropping system showed an increase in yield. Conversely, the dummy variable in the risk function had a negative value, meaning that the use of production factors of organic cabbage grown in intercropping possessed a lower production risk than production of organic cabbage grown in monoculture.

The intercropping cropping system has served as an alternative to integrated pest control, which could boost natural enemies to suppress and control pest populations. Farmers intercropped organic cabbage with commodities such as chicory, bok choy, carrots, radishes, and beetroot. Pest and disease attacks are often found on organic cabbage included thrips caterpillars, capers, whiteflies, clubroot, and water rot. The application of intercropping should consider the spacing and harmony of roots between plants to prevent overlapping roots from absorbing nutrients. Plants with larger roots were dominant in absorbing nutrients, whereas plants with smaller roots suffered rot and died.

The regression coefficient of land area had a positive and significant effect on organic cabbage production but had a negative and significant effect on production risk. Increasing land area would enhance production and reduce the risk of organic cabbage production. The land area was still small, but it was not scattered, helping farmers manage their land for production. There was an opportunity for farmers to increase their land ownership because, in the research area, agricultural land was still available. Farmers can produce optimally if they expand their land ownership and manage it well. The results of this study are in contrast to research in Chhattisgarh, India and Cameroon which revealed that the production factor for land area had a negative coefficient and was not significant for cabbage production in that area [27, 28]. This difference occurs due to farmers in these two countries mostly still have inadequate technical knowledge, so when the land is expanded, they will encounter difficulties in management. Moreover, adding a land ownership area as an alternative for organic cabbage farmers in Getasan District reduced production risk. The more land a farmer owns, the lower the level of production risk because farmers can manage risk better. This study's results align with research on water spinach in Mranggen, Demak; adding land area reduced production risk [29].

The use of seeds had a positive and significant regression coefficient on organic cabbage production. It harmed production risk even though it was insignificant. In other words, adding seeds and other factors increased organic cabbage production and reduced organic cabbage production risk. Cabbage farmers in Getasan District could boost organic cabbage production by adding quality seeds according to the area of land managed. The seeds used must also be quality, disease-resistant, and able to adapt without the additional use of chemicals to reduce risk. The results of this study support previous research that the seed production factor was positive and significant for cabbage production in Getasan District [30] and research in Sikur District, East Lombok, that the regression coefficient of large chili seedlings declined production risk [31].

The addition of manure and other production factors boosted the production of organic cabbage. However, on the other hand, it raised the risk of production. Sufficient manure could fulfill macro and micronutrients to help plants grow perfectly to form cabbage heads. These results are under a study of cauliflower in Maharashtra [32]. However, the manure processing process could be better. In that case, it would inhibit the growth of cabbage plants, such as in research on chrysanthemum flowers in Bandungan District, Semarang Regency, where adding manure significantly raised the risk of production [33].

Botanical pesticides statistically did not affect organic cabbage production or production risks because not 50% of farmers employed this production factor. However, judging from the regression coefficient value, adding vegetable pesticides, while other production factors remained constant, tended to increase organic cabbage production. The results of this study are slightly contradictory in that the use of botanical pesticide production factors was insignificant and harmed cabbage production in Kaduna, Nigeria [34]. Judging from the risk function, adding plant-based pesticide production factors declined production risk. Thus, adding organic pesticides escalated production and lowered the risk of organic cabbage production. Using botanical pesticides following the SOP in the organic farming system was another factor to consider. It must be appropriate, timely, and targeted, requiring patience and tenacity. This study's results of estimating plant pesticide production factors contrast the use of liquid pesticides in shallot farming in Bagor District, Nganjuk Regency. Liquid pesticides are inorganic. If used excessively, they will significantly raise production risks [35].

The use of labor was seen from the production and risk functions; statistically, these production factors had no effect. The regression coefficient for organic cabbage production depicted a negative result, meaning that adding labor while other production factors remain the same will still reduce organic cabbage production. The use of labor for organic cabbage farming in Getasan District mostly employed large amounts of family labor even though the land owned was relatively small. Hence, this excessive labor decreased production and increased the risk of organic cabbage production, as demonstrated in the regression coefficient, where risk functions have a positive value. This excessive and non-optimal use of labor was carried out by farmers when transporting the harvest, lacking supervision and causing shrinkage or damage to the harvest. These findings are in contrast to research in Manikganj, revealing that labor production factors had a significant and positive influence on mustard production [36]. Meanwhile, the increase in risk due to additional labor is in line with research on spinach farming in Siantan Hilir and beans farming in Bangladesh, disclosing that additional labor increased production risk and was insignificant to production risk [37, 38].

4 Conclusion

1. Land area, seeds, manure, and dummy planting system positively and significantly influenced organic cabbage production in Getasan District. There were production differences between organic cabbage grown in intercropping and monoculture.
2. Land area, seeds, vegetable pesticides, and dummy planting systems affected the risk of organic cabbage production. Differences existed in the risk of organic cabbage production with intercropping and monoculture cropping systems. Adding land production factors declined risks, while adding manure and labor production factors raised risks.

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