Jurnal Manajemen & Agribisnis, Vol. 19 No. 2, July 2022
Permalink/DOI: http://dx.doi.org/10.17358/jma.19.2.175

Available online at
http://journal.ipb.ac.id/index.php/jmagr

CAN ADOPTION OF CHEMICAL PESTICIDE-FREE FARMING PRACTICES BENEFIT TO FARMERS? AN EMPIRICAL STUDY IN SHALLOT PRODUCTION IN CENTRAL JAVA, INDONESIA

Netti Tinaprilla[*)1], **Anisa Dwi Utami**[*)], **Suprehatin Suprehatin**[*)]

[*)] Department of Agribusiness, Faculty of Economics and Management, IPB University
Jl. Kamper Wing 4 Level 5, Dramaga Campus, Bogor 16680, Indonesia

Article history:

Received
25 May 2022

Revised
13 June 2022

Accepted
27 June 2022

Available online
29 July 2022

Abstract: This study aims to provide empirical evidence in the shallot production in Indonesia, what drives farmers to adopt chemical pesticide-free production as sustainable agricultural practices and its impacts on farmers' income. By using national agricultural survey in 2014, this study employed logit regression and regression analysis to estimate the determinants and impacts of adoption of chemical pesticide-free farming practices among shallot farmers in Central Java. The results of a logit regression model showed that level of education, type of land ownership, participation in farmers group, source of fund, certified seed cost, and cost production were significantly associated with decisions to adopt chemical pesticide-free farming practices. The results of a regression model showed that farmers who adopted chemical pesticide-free farming practices had higher income. Aside the chemical pesticide-free adoption factor, the results showed that farmers' income from shallot farming were influenced by level of education, harvested area, type of land ownership, cooperative membership, access to credit, access to extension services, and cost of certified seed. Future research may consider the different level of usage of non-chemical inputs among shallot farmers as the adoption is a process and dynamic, taking into account both other potential determinants of adoption and other potential factors affecting farm profitability, and focusing on shallot traders, wholesalers, retailers, and consumers.

Keywords: agricultural production, famers income, pesticide-free, shallot, sustainable agricultural practice

Abstrak: *Penelitian ini bertujuan memberikan bukti empiris dalam produksi bawang merah di Indonesia apa faktor yang mendorong petani mengadopsi sistem usahatani bebas pestisida kimia sebagai praktik pertanian berkelanjutan dan dampaknya terhadap pendapatan petani. Dengan menggunakan survei pertanian nasional tahun 2014, penelitian ini menggunakan analisis regresi logit dan regresi untuk menganalisis determinan dan dampak adopsi sistem usahatani bebas pestisida kimia pada petani bawang merah di Jawa Tengah. Hasil estimasi model regresi logit menunjukkan bahwa faktor-faktor yang memengaruhi petani mengadopsi sistem usahatani bebas pestisida kimia adalah tingkat pendidikan, jenis kepemilikan lahan, partisipasi dalam kelompok tani, sumber dana, biaya benih bersertifikat, dan biaya produksi. Hasil estimasi model regresi menunjukkan bahwa petani yang mengadopsi sistem usahatani bebas pestisida kimia memiliki pendapatan yang lebih tinggi. Selain faktor adopsi sistem usahatani bebas pestisida kimia, keuntungan petani bawang merah juga dipengaruhi oleh faktor tingkat pendidikan, luas panen, jenis kepemilikan lahan, keanggotaan koperasi, akses kredit, penyuluhan, dan biaya benih bersertifikat. Penelitian selanjutnya dapat mempertimbangkan tingkat penggunaan input non-kimia yang berbeda di antara petani bawang merah karena adopsi adalah proses dan dinamis, mempertimbangkan faktor penentu potensial lainnya dari adopsi dan faktor potensial lainnya yang mempengaruhi profitabilitas, dan berfokus pada pedagang bawang merah, grosir, pengecer, dan konsumen*

Kata kunci: *bawang merah, bebas pestisida kimia, pendapatan petani, praktik pertanian berkelanjutan, produksi pertanian*

[1] Corresponding author:
Email: netti_tinaprilla@apps.ipb.ac.id

INTRODUCTION

Problems of global food hunger and malnutrition has led to the development of agricultural production technology across the world with the aim of increasing agricultural productivity. Following this development, global agricultural sector is mainly characterized by the intensive use of inputs and soil tillage, which, in addition to conventional practices of the removal and burning of stubble, have spurred nutritional degradation, physical erosion, and the loss of organic matter (Bopp et al. 2019). The development of agricultural technologies to increase food production is mainly focused on the use of fertilizers to increase soil fertility, irrigation to distribute water required to grow crops, pesticides to protect crops from pests and diseases, breeding to produce high-yielding crop varieties and agricultural machinery to increase speed and scale of farming activity (Lakitan, 2018).

Technologies developed during the Green Revolution effectively increased food production and are still in use today (Pielke and Linnér, 2019). Advances in agricultural technology are essential to increasing agricultural productivity and promoting economic growth and quality of life in rural communities (Chavas and Nauges, 2020; Takahashi et al. 2020). Since the Green Revolution, modern agricultural technologies have gradually replaced traditional agricultural technologies, and the excessive use of pesticides and fertilizers has become a common and long-term phenomenon in developing countries (Wang et al. 2018). However, over the past few decades, several empirical findings have detected a declining trend in the agricultural production, such as found in certain rice producing countries in China. In addition, the availability of arable land and water resources suitable for agricultural production has been declining in China (Lakitan, 2018; Xie et al. 2021). Although pesticides and fertilizers play a very important role in increasing crop yields and ensuring food security, their excessive use may pose a series of risks to humans, animal and the environment (Stehle and Schulz, 2015; Szöcs et al. 2017; Wang et al. 2018). Therefore, reducing agricultural chemical use to an optimal level is important to the sustainable agricultural development (Wu et al. 2018).

The demand for food with additional food safety and quality assurance is growing (Flynn et al. 2019; Reisch et al. 2013) in line with increasingly concerned of consumers about food production methods (Peschel et al. 2019). Several empirical studies report evidence of demand for agricultural products with safe and sustainable standard such as pesticide free (Edenbrandt 2018; Khan et al. 2018), organic (Garcia-Yi, 2015; Rahman et al. 2021) and other safe produce (Joya et al. 2022; Yin et al. 2019). For these safe and sustainable food products, consumers were interested to pay higher prices. These evidence indicate that farmers have an opportunity to respond to this rapid growth of safe and sustainable food demand by adopting new sustainable farming practices. Therefore, encouraging farmers to adopt such sustainable food production systems is important.

Within the existing literatures, there have been several empirical studies investigating the farmers behaviour in adoption (Pannell and Claassen, 2020; Pratt et al. 2021; Suprehatin, 2021) including in using agricultural input of production such as seed, fertilizer, and pesticides. Many of them have referred to the framework of neoclassical production theory assuming that rationale farmers will allocate their resources with the profit maximization-oriented behaviour. According to this framework, many farmers especially small farmers would likely neglect the environmental risk resulted from their on-farm management while focusing only on the economic profit. Dessart et al. (2019) proposed that the low farmers adoption to sustainable agricultural practices is related to the resistant behaviour to change and the economic objectives. Conversely, the adoption would be higher when the farmers have sufficient knowledge and competences and perceive that the practices will bring environmental and financial benefits with limited risks (Huffman, 2020). Following this situation, this study attempts to investigate the determinants of farmers' decision to adopt chemical pesticide-free production and its impacts on farmers' income in the context of shallot as one of the strategic high value agricultural products for Indonesia.

Currently, the level of consumption of shallots in Indonesia continues to increase. According to Susenas data (Centra Statistics Agency, 2019a), the average consumption of shallots for the Indonesian population is 27.72 kg/capita/year. The demand for shallots will continue to increase in line with the increasing needs of the community due to the increase in population, the development of the processed product industry made from shallots (fried onions, cooking spices) and market development. In terms of production, shallots have been cultivated in almost all parts of Indonesia (33 provinces), except in DKI Jakarta, in the last 10 years (2010-2019). Based on data sourced from the 2019 Horticultural Crop Statistics, the Central Statistics Agency (2019b), the six main shallot-producing provinces are Central Java, East Java, West Nusa Tenggara, West Java, West Sumatera, and South Sulawesi. Production from each of these provinces reached more than 100 thousand tons and in total the six provinces contributed 93.38 percent of the total national production of shallots which reached 1.6 million tons. The data from the 1970–2019 time series show a fluctuating annual production of shallots, but indicate a significant trend of increasing production with an average growth rate of 4.07% per year. The highest growth rate of harvested area (3.98%) occurred in the period 1990–1999, decreased in the 2000–2009 period and increased again in the 2010–2019 period. Productivity growth showed the highest rate in the period 1980–1989, then declined in the following periods. In two periods (2000–2009 and 2010–2019), the national shallot productivity has not moved from the range of 8.5–10.5 tons/ha which indicates a tendency for productivity stagnation to occur.

METHODS

This study uses data from national agricultural survey conducted in 2014 which focuses on farmers in Central Java as one of the main shallot producers in Indonesia. The total number of observations is 1659 farmers which consists of 1484 farmers that use chemical pesticide and 175 farmers do not use chemical pesticide respectively. Following the aims of this study, there are two analyses to address the study objectives.

First, the logistic regression analysis was used to identify the significant determinants that influence the farmers' decision to adopt chemical pesticide-free input in their shallot farmings. This approach assumes that the dichotomous choice of whether or not to adopt chemical pesticide-free (yes = 1; no = 0) can be represented by a logistic regression model which explains the probability of adoption (Gujarati 2004) as follow:

$$Y_i = \ln \left[\frac{P_i}{1 - P_i}\right]$$

$$Y_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots.. + \beta_8 X_8 + \varepsilon$$

where Y the dependent variable of dichotomized with a value of 1 if a farmer was an adopter of chemical pesticide-free inputs and 0 if otherwise, X_1 is farmers' age (years), X_2 is farmer's education (level education from 1 is not entering school, 2 is primary school, to 7 is postgraduate), X_3 is partnership with off-taker (1 if farmers have partnership with off-taker, otherwise 0), X_4 is farmers group membership (1 if farmers are members of farmer groups, otherwise 0), X_5 is type of planting system (1 if the planting system is monoculture, otherwise 0), X_6 is internal source of capital (percentage of internal source of capital), X_7 is total production cost of shallot farming on one season (the Indonesian Rupiah, IDR), and X_8 is cost of certified seed in one planting season (IDR). Following the previous literature (Doss, 2006; e.g. Feder and Umali 1993; Suprehatin 2021), in this study we hypothesized X_1, X_2, X_3, X_4, X_6 and X_8 are greater than 0, and X_5 and X_7 are less than 0.

Second is estimating the revenue function by using regression analysis, whether the use of chemical pesticide-free input has affected the shallot farming profit along with the other independent variables. A linear regression model is used to estimate the shallot farming profit function with nine independent variables representing farmer and farm characteristics as explained in the following equation.

$$LnY = Ln\beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \ldots + \beta_9 LnX_9 + e$$

where Y is net profit of shallot farming in one production period as the dependent variable, X_1 is adoption of chemical pesticide-free inputs (1 if farmers adopted chemical pesticide-free in their shallot farmings, otherwise 0), X_2 is harvested area (ha), X_3 is type of farmed-land (1 if the farmers' land type is field, otherwise 0), X_4 is type of planting system (1 if the planting system is monoculture, otherwise 0), X_5 is internal source of capital (percentage of internal source of total capital), X_6 is farmers group membership (1 if farmers are member of farmers group, otherwise 0), X_7 is partnership with off-taker (1 if farmers have partnership with off-taker, otherwise 0), X_8 is farmers' education (level education from 1 is not entering school, 2 is primary school, to 7 is postgraduate), and X_9 is cost of certified seed in one planting season (IDR). All the independent variables, from X_1 to X_9 are hypothesized greater than 0.

RESULTS

Descriptive Statistics

The characteristics of respondents of shallot farmers are listed in Table 1. Regarding the demographic aspect, in general the characteristics of respondents who adopt the chemical pesticide and non-chemical pesticide are relatively similar. The average age of respondents is 48 years old with a male dominance of 95 percent. Meanwhile, from the level of education, most of the respondents have low level of education which mostly have only finished primary school. In contrast to the demographic characteristics, several differences were found regarding the on-farm characteristics of respondents who use chemical and non-chemical pesticides. As presented in the Table 1, most non-chemical pesticides adopters have larger land than the chemical adopters which is dominated by the type of field. Additionally, the chemical pesticides adopters mostly applied the monoculture system, while the non-chemical pesticides adopters applied the polyculture system. However, regarding the mechanization, both non-chemical pesticides and chemical pesticides adopters have mostly used two-wheel tractors for the soil tillage. Furthermore, related to the institutional aspects, most respondents do not participate in a farming group or cooperative as well as have no kind of partnerships with other organization. Therefore, most respondents have not received any assistance or subsidies particularly from the government.

Table 1. Characteristics of respondents shallot farmers in Central Java

Characteristics	Measurement	Chemical Pesticide-Free Adopters (n=175)	Non-Adopters (n=1484)
Gender	1 if farmer is male, otherwise 0	0.95	0.94
Age	Age of the farmers (years)	48.67	47.94
Education	The level of education (1 = not entering school, 2 = primary school, 3 = junior high school, 4 = senior high school, 5 = diploma, 6 = undergraduate, 7 = postgraduate)	2.15	1.97
Internal capital	Percentage of internal source of capital	90.60	72.36
Harvested area	Total of harvested area (000 ha)	1.74	2.68
Type of land	1 if the farmers' land type is field, otherwise 0	0.43	0.89
Type of mechanization	1 = 4 wheel tractor, 2 = 2 wheel tractor, 3= animals, 4 = manual	2.00	1.99
Planting system	1 = monoculture, 0 = polyculture	0.69	0.89
Aid	1 = receiving aid, 0 = not receiving	0.64	0.65
Fertilizer aid	1 = receiving aid, 0 = not receiving	1.00	0.98
Seed aid	1 = receiving aid, 0 = not receiving	0.36	0.37
Pesticide aid	1 = receiving aid, 0 = not receiving	0.36	0.35
Extension services	1 = receiving aid, 0 = not receiving	0.09	0.25
Financial aid	1 = receiving aid, 0 = not receiving	-	0.01
Partnership with off-taker	1 if farmers have partnership with off-taker, otherwise 0	0.35	0.25
Farmer group membership	1 if farmers are member of farmer groups, otherwise 0	0.43	0.57
Credit	1 if farmers have access to credit, otherwise 0	0.75	0.49
Production cost	1 = if higher cost than higher prices, 0 = otherwise	0.81	0.88
Level of pest attack	1 = high level, 0 = low level	0.51	1.00

Determinants Factors of Adoption of Chemical Pesticide-Free Farming Practices Among Shallot Farmers

The first purpose of this study was to examine the significant determinants that influence the decision of shallot farmers to adopt chemical pesticide-free farming practices. To address it, we used logit regression analysis as presented in Table 2. The empirical results show that there are five significant determinants that affect shallot farmers adoption of chemical pesticide-free inputs namely education, type of farmed-land, internal source of capital, production cost and partnership. The level of education has positive and significant influence on the chemical pesticide-free adoption decision. This finding reflects the fact that farmers with higher education level are more likely to adopt new agricultural technology compared to those with a low education level (Huffman, 2020; Suprehatin, 2019; Yokamo, 2020). Similar to education, partnership with off-taker has also positive and significant effect on shallot farmers decision to adopt non-chemical pesticides. It perhaps that the off-takers have required less pesticide use in the shallot production to fulfil the growing demand for safe food (Flynn et al. 2019; Joya et al. 2022) including shallot.

Farmers who finance mostly from themselves are more likely to adopt chemical pesticide-free farming practices. Similar to internal source of capital, farmers who have higher production costs are more likely to adopt less chemical pesticide. It is logical to expect that if a farmer is more self-financed in their expenditure and has high production costs, then the farmer is likely to decide to minimise the use of agricultural inputs such as chemical pesticides (Constantine et al. 2020).

Profitability of Shallot Farming Under Adoption of Non-Chemical Inputs and Its Determinants

The second objective of this study was to examine the impacts of shallot farmers adoption of chemical pesticide-free farming practices. To address it, we used production cost structure analysis (Tables 3 and 4) and regression analysis (Table 5). The total production cost of non-chemical adopters is 46,327,750 IDR per hectare in average which is mostly contributed from the cost of seed i.e. 33.62 percent (15,576,080 IDR per hectare), and the labor cost i.e. 29.66 percent (13, 738.56 IDR per hectare). As presented in the Table 3, similar to the non-chemical pesticide adopters, the cost of production of chemical pesticides adopters is also dominated by the cost of seed and the cost of labor (33.85 percent and 29.86 percent respectively). However, in general the cost of seed and labor were higher for the chemical pesticide adopters. Meanwhile, the use of non-chemical pesticides has costed only 1 682,220 IDR per hectare or contributed 3.63 percent from the total production costs. This value is lower than the cost of fertilizer which may imply that the use of non-chemical pesticides provides more efficient cost production. Moreover, applying chemical pesticides has costed 1,213,960 IDR per hectare or is equivalent six times the cost of non-chemical pesticides.

Table 2. Logit regression model estimates of coefficients associated with adoption of pesticide-free farming practices

Independent Variable	Estimate	Std. dev.	Wald-statistic	Significance
Age	0.013	0.008	2.293	0.130
Farmer's education	0.373	0.098	14.586	0.000***
Partnership with off-taker	0.469	0.194	5.862	0.015**
Membership of farmer group	-0.010	0.185	0.003	0.958
Type of farmed-land	-1.767	0.200	78.181	0.000***
Internal source of capital	0.013	0.004	9.285	0.002***
Production cost	0.000	0.000	21.642	0.000***
Cost of certified seed	-0.001	0.000	2.380	0.123
Constant	-2.643	0.632	17.484	0.000***
X^2 statistic with 9 df	47.74***			
Pseudo R^2	0.20			

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 3. Production cost structure of shallot production

Cost	Pesticide-Free Adopters (000 IDR)			Non-Adopters (000 IDR)		
	Mean*	Per Ha	%	Mean*	Per Ha	%
Seed	2,711.38	15,576.08	33.85	6,579.88	24,521.94	40.56
Fertilizer	797.35	4,580.57	9.96	1,289.44	4,805.49	7.95
Pesticides	292.83	1,682.22	3.66	1,213.96	4,524.20	7.48
Shading net	21.37	122.77	0.27	22,94	85.48	0.14
Mulch	233.82	1,343.21	2.92	118.64	442.14	0.73
Labour	2,391.51	13,738.56	29.86	4,126.49	15,378.65	25.44
Packaging	100.27	576.05	1.25	201.35	750.39	1.24
Land rent	1,164.06	6,687.17	14.54	1,964.18	7,320.13	12.11
Equipment rent	103.81	596.37	1.29	311.14	1,159.55	1.92
Interest rate	130.05	747.11	1.62	206.83	770.79	1.27
Depreciation	14.84	85.25	0.18	64.75	241.32	0.39
Tax PBB	35.52	204.05	0.44	70.12	261.31	0.43
Retribution	8.12	46.65	0.10	26.29	97.99	0.16
Electricity	3.87	22.22	0.05	25.48	94.96	0.16
Fuel	55.61	319.47	0.69	160.99	599.99	0.99
Total cost	8,008.81	46,008.28	100.00	16,221.51	60,454.37	100.00

Note: *the average production area for non-chemical and chemical shallot farming practices are (1,740.73 m^2) and (2,683.26 m^2) respectively

Table 4. Revenue and profit of shallots production

Cost	Pesticide-Free Adopters (000 IDR)		Non-Adopters (000 IDR)	
	Mean*	Per Ha	Mean*	Per Ha
Total revenue	8,931.30	51,307.76	16,954.58	63,186.39
Total cost	8,008.81	46,008.28	16,221.51	60,454.37
Profit	922.49	5,299.48	733.08	2,732.03
R/C	1.12	1.12	1.05	1.05

Note: *the average production area for non-chemical and chemical shallot farming practices are (1,740.73 m^2) and (2,683.26 m^2) respectively

Table 5. The results of regression analysis of profit function

Variables	Coefficient	Standard deviation	P-value
Chemical pesticide-free adoption	2,346.726	1,106.526	.034**
Harvested area	2.233	0.121	.000***
Type of farmed-land	1,788.995	1,041.836	.086*
Type of planting system	-853.034	1,018.464	.402
Internal source of capital	1.662	11.128	.881
Membership of cooperative	7,710.140	1,639.047	.000***
Partnership with off-takers	1,176.710	711.043	.098*
Farmers education	627.893	320.194	.050**
Cost of certified seed	-0.720	0.103	.000***
Constant	-7,697.281	1,550.512	.000
X^2 statistic with 8 df	22.95***		
R^2	0.30		

Notes: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

In terms of farming revenue, farmer adopters and non-adopters have IDR 51.3 million per hectare and IDR 63.2 million per hectare respectively (Table 4). However, with a lower total cost (Table 3), farmer adopters have a higher profit and more efficient (higher R/C) than non-adopters. It indicates that shallot farming practices with lower chemical inputs have potential economic benefits. This findings similar to other empirical studies in Indonesia showing that more sustainable agricultural practices can generate higher profits such as in shallot organic farming (Vebriyanti et al. 2018) and organic rice farming (Anggita and Suprehatin, 2020).

In terms of determinants of shallot farming profits, the regression results show that there are seven significant determinants that affect shallot farming profits which are chemical pesticide-free adoption, harvested area, membership of farmer groups, cost of certified seed, education, partnership with off-taker, and type of farmed-land (presented in the Table 4). Adoption of chemical pesticide-free input has positive and significant impact on shallot farming profit. By adopting chemical pesticide-free inputs, farmers can reduce the shallot production costs and are able to reduce the dependency on chemical pesticide inputs which is more costly (Constantine et al. 2020; Wahida, 2015).

The type of paddy field can further increase profits compared to non-paddy land (e.g. fields, dry land). This is because shallots need water for maximum growth to produce high productivity. In addition, cooperative membership has also positive relation to the farming profitability. This is because cooperatives can facilitate the farmers for purchasing the inputs with cheaper prices, as well as providing several assistances from the government, and have a potential role as off takers for the harvests. Partnerships with off-takers also significantly affect the profitability. This kind of contract farming with off-takers can offer potential benefit by providing market guarantees for farmers such as accommodate the harvest at an agreed price within a certain period of time (Bellemare and Lim, 2018). With the guarantee of price certainty in time, farmers will avoid falling prices during the main harvest.

Education also significantly increase farm profitability. The higher the education of farmers, the wider their thinking in cultivation (Huffman, 2020), the use of new technologies and farm management (e.g. marketing, finance) are more profitable (Kilpatrick, 1997). Meanwhile, the cost of certified seeds significantly can affect to decreasing profitability. The greater the cost of certified seed, it means that farmers dare to use certified seeds for their farming. The greater the cost of seed, the greater the total cost of production so that the profit becomes smaller. Certified seeds are very important in shallot production, especially the drought-resistant and pest-resistant seeds. The more certified seeds are used, the higher the productivity is expected to increase the total revenue. In the end, although the total cost of production increases due to the use of certified seeds, if the revenue increases, the profit will be higher. Moreover, if the price of certified seeds can be reduced, production costs will decrease and profits will increase.

Managerial Implications

Indonesian shallot farmers have potential beneficial economic impacts of adopting chemical pesticide-free. However, shallot farmer adoption of this more ecologically farming practices is still relatively low which is only 175 of 1659 shallot farmers (about 10.5%) in Central Java as one of the main shallot productions in Indonesia. In relation to this relatively low adoption rate of chemical pesticide-free input, therefore, better targeted programs and more intensive support are needed to promote greater participation of Indonesian farmers in more sustainable farming practices. This can be achieved, for example, by (1) developing educational programs to improve better knowledge and attitude of farmers about integrated pest management (IPM) and benefits and risks of the use of chemical pesticides, (2) improving the effectiveness of extension services promote more sustainable agricultural practices among farmers, (3) linking farmers with off-takers in order to guarantee their safe and sustainable products are marketable and receive premium price, (4) provide support and assistance for farmers to access certified seed for shallot with affordable price, (5) strengthening the role of farmer groups or cooperative to attract and increase farmers' participation. However, to reduce chemical pesticides and the risks with associated with pesticide use, effectively and holistic policies are needed at macro, meso and micro levels (Kvakkestad et al. 2021; Möhring et al. 2020).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results showed that level of education, type of land ownership, participation in farmer group, source of fund, certified seed cost, and cost production were significantly associated with decisions to adopt chemical pesticide-free farming practices. The results also showed that farmers who adopted chemical pesticide-free farming practices had higher income. Aside the chemical pesticide-free adoption factor, the results also showed that farmers' income from shallot farming were influenced by level of education, harvested area, type of land ownership, cooperative membership, access to credit, access to extension services, and cost of certified seed.

Recommendations

Future research may consider the different level of usage of non-chemical inputs among shallot farmers as the adoption is a process and dynamic. Within a relatively low R-square of the model, we suggest future studies take into account both other potential determinants of adoption and other potential factors affecting farm profitability. In addition, this study only examined issues of safe and sustainable agricultural practices from farmers (producers) perspective. Therefore, further research may also be conducted to focus on shallot traders, wholesalers, retailers, and consumers.

REFERENCES

Anggita AH, Suprehatin S. 2020. Apakah usahatani padi organik lebih menguntungkan? Bukti dari desa Pringkasap kabupaten Subang. *Jurnal Ekonomi Pertanian dan Agribisnis* 4:576–592.

Bellemare MF, Lim S. 2018. In all shapes and colors: Varieties of contract farming. *Applied Economic Perspectives and Policy* 40:379–401.

Bopp C, Engler A, Poortvliet PM, Jara-Rojas R. 2019. The role of farmers' intrinsic motivation in the effectiveness of policy incentives to promote sustainable agricultural practices. *Journal of Environmental Management* 244:320–327.

Central Statistics Agency. 2019a. *2019 National Socio-economic Survey (SUSENAS)*. Jakarta: Central Statistics Agency.

Central Statistics Agency. 2019b. *2019 Horticultural Crop Statistics.* Jakarta: Central Statistics Agency.

Chavas J, Nauges C. 2020. Uncertainty, learning, and technology adoption in agriculture. *Applied Economic Perspectives and Policy* 42:42–53.

Constantine KL, Kansiime MK, Mugambi I, Nunda W, Chacha D, Rware H, Makale F, Mulema J, Lamontagne-Godwin J, Williams F. 2020. Why don't smallholder farmers in Kenya use more biopesticides? *Pest Management Science* 76:3615–3625.

Dessart FJ, Barreiro-Hurlé J, van Bavel R. 2019. Behavioural factors affecting the adoption of sustainable farming practices: A policy-oriented review. *European Review of Agricultural Economics* 46:417–471.

Doss CR. 2006. Analyzing technology adoption using microstudies: Limitations, challenges, and opportunities for improvement. *Agricultural Economics* 34:207–219.

Edenbrandt AK. 2018. Demand for pesticide-free, cisgenic food? Exploring differences between consumers of organic and conventional food. *British Food Journal* 120:1666–1679.

Feder G, Umali DL. 1993. The adoption of agricultural innovations: A review. *Technological Forecasting and Social Change* 43:215–239.

Flynn K, Villarreal BP, Barranco A, Belc N, Björnsdóttir B, Fusco V, Rainieri S, Smaradóttir SE, Smeu I, Teixeira P. 2019. An introduction to current food safety needs. *Trends in Food Science and Technology* 84:1–3.

Garcia-Yi J. 2015. Willingness to pay for organic and Fairtrade certified yellow chili peppers: Evidence from middle and high income districts in Lima, Peru. *British Food Journal* 117:929–942.

Gujarati D. 2004. *Basic Econometrics.* New York: The Mc-Graw Hill.

Huffman WE. 2020. Human capital and adoption of innovations: policy implications. *Applied Economic Perspectives and Policy* 42:92–99.

Joya, K, Ramli NN, Shamsudin MN, Kamarulzaman NH. 2022. Consumers' willingness to pay for food safety attributes of tomato. *British Food Journal* 124:701–717.

Khan J, Khanal AR, Limm KH, Jan AU, Shah SA. 2018. Willingness to pay for pesticide free fruits: Evidence from Pakistan. *Journal of International Food & Agribusiness Marketing* 30:392–408.

Kilpatrick S. 1997. Education and training: impacts on profitability in agriculture. Aust. New Zeal.

Journal of Vocational Education Research 5:11–36.

Kvakkestad V, Steiro ÅL, Vatn,A. 2021. Pesticide Policies and Farm Behavior: *The Introduction of Regulations for Integrated Pest Management. Agriculture* 11:828–845.

Lakitan B. 2018. Research and technology development in Southeast Asian economies are drifting away from agriculture and farmers' needs. *Journal of Science and Technology Policy Management* 10:251–272.

Möhring N, Ingold K, Kudsk P, Martin-Laurent F, Niggli U, Siegrist M, Studer B, Walter A, Finger R. 2020. Pathways for advancing pesticide policies. *Nature Food* 1:535–540.

Pannell DJ, Claassen R. 2020. The roles of adoption and behavior change in agricultural policy. *Applied Economic Perspectives and Policy* 42:31–41.

Peschel AO, Grebitus C, Alemu MH, Hughner RS. 2019. Personality traits and preferences for production method labeling–A latent class approach. *Food Quality and Preference* 74:163–171.

Pielke R, Linnér B-O. 2019. From green revolution to green evolution: A critique of the political myth of averted famine. *Minerva* 57:265–291.

Pratt B, Tanner S, Thornsbury S. 2021. *Behavioral Factors in The Adoption and Diffusion of USDA Innovations*. New York: USDA.

Rahman SME, Mele MA, Lee Y-T, Islam MZ. 2021. Consumer preference, quality, and safety of organic and conventional fresh fruits, vegetables, and cereals. *Foods* 10:105–122.

Reisch L, Eberle U, Lorek S. 2013. Sustainable food consumption: an overview of contemporary issues and policies. *Sustainability: Science, Practice and Policy* 9:7–25.

Stehle S, Schulz R. 2015. Agricultural insecticides threaten surface waters at the global scale. *Proceedings of the National Academy of Sciences of the United States of America* 112:5750–5755.

Suprehatin S. 2021. Determinants of agricultural technology adoption by smallholder farmers in developing countries: perspective and prospect for Indonesia. *Jurnal Penelitian dan Pengembangan Pertanian* 40:21–30.

Suprehatin S. 2019. Characteristics of farmer adopters of high value horticultural crops in Indonesia. *Jurnal Manajemen & Agribisnis* 16:181–191.

Szöcs E, Brinke M, Karaoglan B, Schäfer RB. 2017. Large scale risks from agricultural pesticides in small streams. *Environmental Science & Technology* 51:7378– 7385.

Takahashi K, Muraoka R, Otsuka K. 2020. Technology adoption, impact, and extension in developing countries' agriculture: A review of the recent literature. *Agricultural Economics* 51: 31–45.

Vebriyanti D, Antara M, Effendy E. 2018. Analisis komparatif produksi dan pendapatan usahatani bawang merah organik dan non organik di desa Oloboju kecamatan Sigi Biromaru kabupaten Sigi. *Agritrop : Jurnal Ilmu-Ilmu Pertanian* 25:259–264.

Wahida. 2015. Food system transformation in Indonesia: factors influencing demand and supply for alternative pest management farming systems. University of Adelaide.

Wang J, Chu M, Ma Y. 2018. Measuring rice farmer's pesticide overuse practice and the determinants: A statistical analysis based on data collected in Jiangsu and Anhui Provinces of China. *Sustainability* 10:677–693.

Wu Y, Xi X, Tang X, Luo D, Gu B, Lam, SK, Vitousek PM, Chen D. 2018. Policy distortions, farm size, and the overuse of agricultural chemicals in China. *Proceedings of the National Academy of Sciences of the United States of America* 115:7010–7015.

Xie H, Huang Y, Choi Y, Shi J. 2021. Evaluating the sustainable intensification of cultivated land use based on emergy analysis. *Technological Forecasting and Social Change* 165:120449.

Yin S, Han F, Wang Y, Lv S. 2019. Chinese consumers' willingness to pay for safety-certified tomatoes: Evidence from random nth-price auctions. Di dalam: Tomato Chemistry, Industrial Processing and Product Development. hlm 153–165.

Yokamo S. 2020. Adoption of improved agricultural technologies in developing countries: Literature review.*International Journal of Food Science and Agriculture* 4:25–36.