SOCA: Jurnal Sosial Ekonomi Pertanian
Vol. 16, No. 3, September 2022, Page 255 - 265
ISSN: 2615-6628 (E), ISSN: 1411-7177 (P)
Accredited SINTA 2

https://ojs.unud.ac.id/index.php/soca

Impact of Technology Introduction on Shallot Farming Performance in Central Java

Joko Mariyono[1]✉, Agus Setiadi[1], Siswanto Imam Santoso[1], Paul Horne[2], Victor Afari-Sefa[3]
[1]Agribusiness Study Program, Diponegoro University, Semarang, Indonesia
[2]IPM Technology, Pty., and La Trobe University, Bundoora, Victoria, Australia
[3]The World Vegetable Center, Central and West Africa Office, Arusha, Tansania
✉Corresponding author: jokomariyono@lecturer.undip.ac.id

Submitted: 7th July 2022 ; Accepted: 2nd November 2022

Abstract

Technological improvement, particularly to prevent yield loss, will benefits shallot farmers. Technology packages related to crop protection have been introduced to shallot farmers in three shallot-producing areas namely Brebes, Tegal and Pemalang, Central Java. This study aimed to analyze the effect of technology package introduction on the performance of shallot farming. The analysis is carried out using a difference-in-difference approach which ensures the real impact of the technology. The fundamental analysis is economic threshold theory. A total of 160 samples consisting of 112 adopters and 48 non-adopters in this study were spread over three regions. A simple paired and independent t-tests were applied to the hypotheses. Agricultural performance indicators include productivity, costs of production and net income. The results showed that the performance of shallot farming increased significantly due to technological improvements. The technology packages have been able to increase productivity, reduce costs of production and enhance net income of shallot farming. This result is very important because the reduction of pesticides can improve environmental quality and health.

Keywords: shallot farming, difference-in-differences, crop protection, technological package, pseudo-quasi controlled trial

How to Cite (APA 6th Style):
Mariyono, J., Setiadi, A., Santoso, S. I., Horne, P., & Afari-Sefa, V. (2022). Impact of Technology Introduction on Shallot Farming Performance in Central Java. SOCA: Jurnal Sosial Ekonomi Pertanian, 16(3), 255-265. https://doi.org/https://doi.org/10.24843/SOCA.2022.v16.i03.p03

INTRODUCTION

Agriculture contributes to rural jobs that still dominate with proportion of about 60% of the non-poor and around 75 % of the poor people who work in agricultural sector (BPS, 2020). Shallot is one of the important horticultural crops in Indonesia. It has provided significant contribution to farmer income (Dewi et al., 2021) and employment for women farmers (Mariyono et al., 2020). Commercialization of the commodity can improve farmer welfare (Abdullah *et al.*, 2019; Dong, Campbell and Rabinowitz, 2019). However, the productivity of shallot is still sub-optimal because of many constraints. One of the main constraints of shallot productivity is yield loss associated with pests and diseases (Mariyono, 2019). Both happened during wet and dry seasons, and the farmers do not necessarily mean ignoring the insect pests (Fang et al., 2018).

The productivity of shallot in Central Java is still lower than other provinces in Java (BPS, 2021). One of the significant limiting factors is pest and disease infestations (Mariyono, 2016). Farmers have been long adopting by pesticides to control pests and diseases. But, the result is unpredictable and cause adverse impacts (Suswati, Agustin and Mariyono, 2006; Saeed *et al.*, 2017). This means that there is still a potential to increase the productivity of shallot by improving technology, particularly for crop protection.

Integrated pest and disease management (IPDM) that consolidates compatible techniques to manage the population of pests and incidence of diseases at save level is one of the best alternative technologies (Norton et al., 2016). As the disease incidence likely occurs in wet season, it needs to be introduced to farmers during the wet season (Atan et al., 2018). Improvement of technology means that the production leads to a more efficient process. It could be an increase in production using the same level of costs; or the same level of production could be achieved using lower level of costs; or even the production increases while the costs of production decrease (Feder & Savastano, 2017).

An introduction of a package applied on shallot farming is named Practical IPDM technology. It has been implemented by farmers year-round. The components of the technological package consist of *Baccilus turingiensis* (*Bt*) and several insecticides that have low toxicity and narrow spectrum, such that they are not detrimental to natural enemies. *Bt* and such insecticides were applied based on fortnightly observation of agroecosystem. When the field observation found insect pests, *Bt* and such insecticides were applied accordingly. Other mechanical control by hand and other tools accompanied the spray when the population insect pests (*Spodoptera. exigua* and *Lyriomisa sp.*) is still manageable.

In Indonesia, many studies on IPDM have been conducted on various crops and commodities (Supriatna, 2006; Iqbal, 2016; Supriatna and Sadiin, 2004; Elizabeth and

Hendayana, 2005) as well as in other countries (Jayasooriya and Aheeyar, 2016; Williamson, Ball and Pretty, 2008; Gautam *et al.*, 2017). However, the studies might be biased since the selection of farmers as respondents were not selected randomly. It could be the case that the impact is not purely attributable to the IPDM technology, because there is no comparison within IPDM adopter at different time. Another drawback of most studies on IPDM is that fundamental theory underpinning the analysis is weak.

Compared to the previous studies, this study has novelty in terms of using economic threshold theory as fundamental analysis and employing difference-in-differences approach to mitigate the biases. The objective of this study is to analyse the impact of IPDM introduction on productivity, costs of production and profit of shallot farming in three regions of Central Java.

RESEARCH METHODS

Study site and samples

This study was carried out in western coastal areas of Central Java covering areas of Brebes, Tegal and Pemalang. The areas are central shallot-producing regions at the national level, which share about 25% of the national shallot production in the country, and the areas have been introduced with practical integrated pest and disease management (IPDM). This study was conducted during April to September 2021.

Population of the study is shallot farmers that have adopted technological package of practical IPDM. The total number of farmers adopting the technological package was 112 farmers, which were distributed in Brebes (40 farmers) Pemalang (17 farmers), and Tegal (55 farmers). A control group of 48 farmers was selected at the neighboring lands for comparison. The control group has no access to the technological packages simultaneously. Thus, the total number of observations was 160. Data related to study were compiled using direct observation and interview, guided using structured questionnaire.

Theoretical and Analytical methods

Theoretical framework used in this study is a concept of economic threshold. There are many terms related to the economic threshold of pests (Budiasa, 2010). The economic threshold used in this study is defined as:

Definition of ET: For any levels of pests (and diseases), there exist a maximum acceptable level of attacks (from pests and diseases) such that the costs associated with controlling pests and diseases are equal to the value of yield lost to such pests and diseases (Mariyono, 2007).

Farmers will apply pesticides when they observe that the level of pests (and diseases) slightly exceeds the P^*, which is the *ET*. When the level of pests (and diseases) is still lower than *ET*, they do not need to apply pesticides. Figure 1 describes the *ET*.

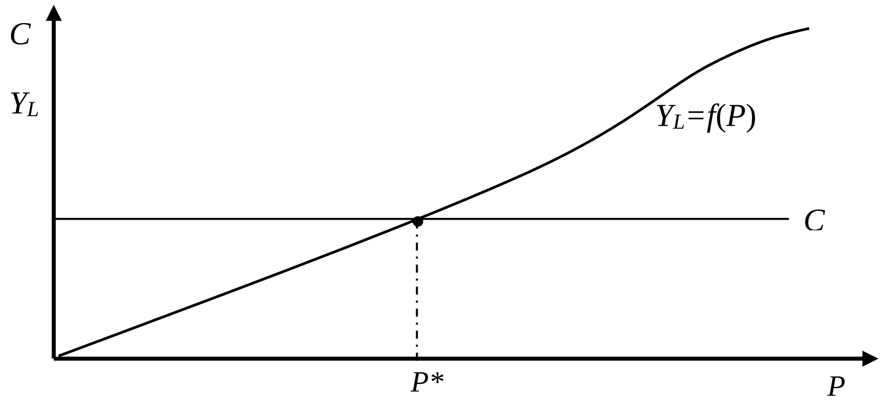


Figure 1. Concept of economic threshold

Farmers will apply pesticides less frequently when the ET is low and vice versa. *ET* is not constant since it depends on the type of crop, price of the crop, and cost of pesticides. Pests and diseases on shallot have low *ET* such that farmers will apply pesticides more frequently. This happens when the price of shallot is high. For diseases, the *ET* is very low, such that farmers apply fungicides before observing symptoms of disease attacks. For pests, the *ET* depends on farmers' knowledge of pests and natural enemies. With such IPM training, farmers are introduced with natural enemies such that the subjective *ET* increase, and farmers reduce the frequency of sprays. Farmers need to conduct regular observation of crops.

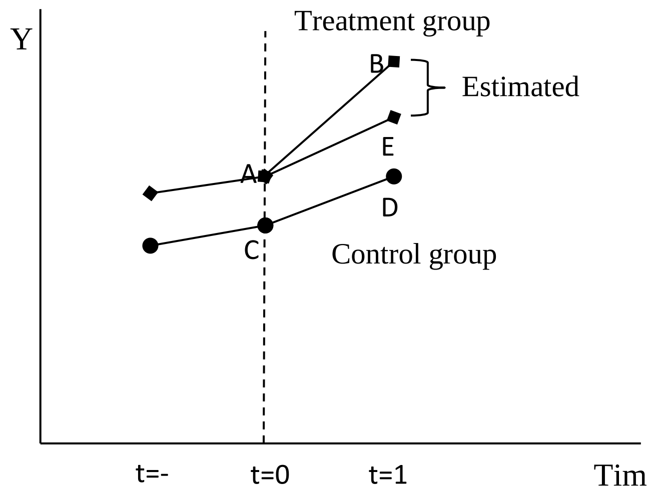
In the fundamental economic analysis of farming, profit or net income is used as an outcome indicator. The profit can be formulated as follows

$$\pi \equiv R - C \qquad (1)$$

where π is net income, R is revenue and C is total cost of farming. R is constructed with yield multiplied with the prevailing price when produce is harvested; C is almost fixed because it has been mostly spent before harvesting the produce. The technological package considers all three components as farming performance indicators. The goals of technological introduction are better quality of produce, lower cost and eventually higher profit.

This analysis uses the difference-in-differences (*DiD*) technique. It is strongly recommended to employ this approach when the intervention program less clearly determines the target (Gertler et al., 2016). The *DiD* approach requires comparison of two groups namely treatment group, which obtain intervention program, and a counterfactual group, which not get access to the program. Figure 2 provides illustration of the *DiD* approach for analyzing an outcome of intervention program. Suppose that at point t=0 is the initial condition before intervention, with Y as the targeted outcome. In t=1, a group enrolls in the program intervention; while a counterfactual does not enroll. The level of outcome for the group enrolling the program intervention before the program starts moves from *A* to *B* when the program starts. While the outcome for the counterfactual moves from *C* to *D* at the same time periods. The two estimates the difference in outcomes before and after the intervention for group enrolling the program

(*B*−*A*) and the difference in outcomes after the intervention between the different groups (*B*−*D*).



Source: Gertler *et al.* (2016)

Figure 2. Graphical explanation of *DiD*

In *DiD*, the counterfactual estimate is the change in outcomes for the control group (*D*−*C*), and then deducting the number from the change in outcomes for group enrolling the program (*B*−*A*). In summary, the program's impact is basically calculated as the divergence between two changes, formulated as follows.

$$DiD = (B - A) - (D - C) \quad (2)$$

Using the deterministic calculation of *DiD,* which is expressed in equation (2) has potentially robust estimation since other factors embedded in farmers are cancelled out when the factors are deducted before and after intervention.

In many studies, there are factors considered as confounding factors that influence the outcome variable. The confounding variables include techno-socio-economic factors both from internal and external characteristics. The internal confounding factors representing human capacity consist of education, experience, age, and knowledge. Studies prove that the factors potentially affect performance of farming, particularly in allocating inputs and targeting production (Athipanyakul & Pak-uthai, 2012). The external factors cover agronomic technologies in the form of crop type and hybrid seeds. With availability of credit facility, the adoption of technology improves the performance of farming. It has been shown that land acquisition (Ahmed 2012; Deb et al. 2016), farming size, and location of farm from the accessible market (Raut et al., 2011) potentially influence farmers in operating their farms. Studies by Coventry et al. (2018) and Riar et al. (2017) show that factors related to agroecosystem have strong relationship with many agricultural aspects. Thus, the impact is not attributable purely to the intervention program if the analysis does not employ *DiD* approach. As this study use the approach, such control variables are not included in the analysis because they have been cancelled in the first difference of time (Gertler et al., 2016).

Testable hypothesis

The hypothesis of in this study can be formulated as follows.

H_0: $DiD_{productivity} = DiD_{cost\ of\ production} = DiD_{profit} = 0$

H_1: $DiD_{productivity} > 0$; $DiD_{cost\ of\ production} < 0$; $DiD_{profit} > 0$

The hypothesis is tested using combination of paired t-test for each group with different time (*D-C*) and *(B-A*), independent sample t-test for overall *DiD* (StataCorp, 2013). The test use at least 95% confidence intervals, and STATA ver.13 was employed to run the t-tests.

RESULT AND DISCUSSION

Productivity

Table 1 shows the productivity of shallot 2021. We can see that both the control group and technology adopters underwent an increase in productivity. The increase in productivity of shallot farming operated by farmers who were not adopting technology was about 1%, while the increase in that adopting the technology was about 32%. This means that the increase in productivity because of the technological package was 31%. The increase was about 4550kg/ha.

Table 1. Productivity of shallot

Farmers	Productivity (kg/ha)			
	Before IPDM	After IPDM	Change	% Change
Control group	7095.2	7161.4	66.2*	1.1%
Adopter group	14268.7	18884.7	4616.0*	32.1%
DiD			4549.8*	31.4%

Source: authors' analysis (2022)

*) Significant at 95% confidence interval of t-test.

Costs of production

Table 2 shows the costs of production. We can see that the costs of shallot farming operated using conventional practices increased by 20%. While the costs of shallot farming operated using the technological package dropped by 11%. This means that adopting the technological package could reduce the costs of production by 32%. The reduction of costs came from the less frequent application of pesticides. Farmers perceived that the level of pests (and diseases) was low, or still below *ET*, such that farmers delayed spraying (Mariyono, 2011). While, farmers using conventional practices sprayed pesticides regularly without observing the pests and condition of the crop.

Table 2. Costs of production

Farmers	Cost of production (IDR/ha)			
	Before Adoption	**After Adoption**	**Change**	**% Change**
Control group	48,685,500	58,479,800	9,794,300 *	20.2%
Adopter group	63,425,500	56,179,700	(7,245,800)*	-11.3%
DiD			(17,040,100)*	-32.4%

Source: authors' analysis (2022)
*) Significant at 95% confidence interval of t-test.

Revenue and net income of farming

Table 3 provides information on the revenue (gross income) of shallot farming. The revenue is defined as production multiplied by the prevailing farm-gate price. Since the production of shallot increases, it is expected that the revenue will increase if the prevailing price was constant. On average, the revenue of shallot farming increased by 82% for farmers with conventional practices and 137% for farmers with the technological package. Thus, the increase in revenue attributable to the technological package is 55%.

Table 3. Revenue of shallot farming

Farmers	Revenue (gross income) (IDR/ha)			
	Before adoption	**After Adoption**	**Change**	**% Change**
Control group	81,894,500	149,231,500	67,337,000*	82.1%
Adopter group	146,585,600	348,056,100	201,470,600*	136.8%
DiD			134,133,600*	55.1%

Source: authors' analysis (2022)
*) Significant at 95% confidence interval of t-test.

It is important to note that the magnitude of the increase in revenue was also affected by the prevailing price. Even though farmers who did not adopt the technology, they gained an increase in income by 82%, because they might get a reasonable price. While, farmers adopting the technology gained an increase in income by 137%, which makes sense. The price of shallot is quite volatile; thus, different time of harvest leads to the different price taken by the farmer. If the prices were the same for all farmers, then the technological package would provide higher income due to a higher increase in production.

Table 4. Net income of shallot farming

Farmers	Net income (IDR/ha)			
	Before Adoption	After Adoption	Change	% Change
Control group	33,209,000	90,751,700	57,542,600*	172.8%
IPDM Adopter	83,160,000	291,876,400	208,716,400*	250.7%
DiD			151,173,700*	78.4%

Source: authors' analysis (2022)
*) Significant at 95% confidence interval of paired t-test.

The increase in revenue and decrease in production costs provided a resultant in an increase in profit or net income. Table 4 shows that increase in income attributable to the technological package was about IDR 151,174,000/ha, which accounted for about 78%.

Overall, studies conducted in other agrarian countries support the findings of this study. Adopting the technological package significantly improve the production and productivity as a consequence of being efficient in implementing pest management strategies (Ali & Sharif, 2012). Berg et al. (2020) and Berg and Tam (2012) show a substantial reduction in the average use of pesticides by adopters, compared the counterparts. While, David & Asamoah (2011) provide evidence that farmers who adopted the IPM practices has been able to strengthen social cohesion, and enhance their capacity to work more effectively in groups and extend their networking.

CONCLUSION

The study shows that the introduction of technological packages, which is called practical integrated pest and disease management on shallot farming has positive impacts. The introduction of technological package simultaneously increases the productivity of shallot, reduces the costs of production, and improves the profit generated from shallot farming.

RECOMMENDATION

IPDM is still one of the best practices to reduce pesticides in intensive farming, and thus it is recommended to disseminated the technological packages to other farmers in Indonesia. Another study might be conducted in other areas to verify the technology as well as the research methodology.

ACKNOWLEDGEMENT

The authors thank the Faculty of Animal and Agricultural Sciences Diponegoro University for providing funding of this research project. The authors also thank farmers who have provided time and other resources related to the shallot farming and the application of practical IPDM. The authors are responsible for all interpretation and any potential shortcomings of the study.

REFERENCES

Abdullah, Rabbi, F., Ahamad, R., Ali, S., Chandio, A. A., Ahmad, W., Ilyas, A., & Din, I. U. (2019). Determinants of commercialization and its impact on the welfare of smallholder rice farmers by using Heckman's two-stage approach. *Journal of the Saudi Society of Agricultural Sciences*, *18*(2), 224–233. https://doi.org/https://doi.org/10.1016/j.jssas.2017.06.001

Ahmed, S. (2012). *Agricultural Land Tenancy in Rural Bangladesh: Productivity Impact and Process of Contract Choices*. University of Adelaide.

Ali, A., & Sharif, M. (2012). Impact of farmer field schools on adoption of integrated pest management practices among cotton farmers in Pakistan. *Journal of the Asia Pacific Economy*, *17*(3), 498–513. https://doi.org/10.1080/13547860.2012.694706

Atan, R., Alam, M. M., Said, J., & Zamri, M. (2018). The impacts of environmental, social, and governance factors on firm performance: Panel study of Malaysian companies. *Management of Environmental Quality: An International Journal*, *29*(2), 182–194. https://doi.org/10.1108/MEQ-03-2017-0033

Athipanyakul, T., & Pak-uthai, W. (2012). *Determinants of Good Agricultural Practices (GAP) Adoption in the Chili Production System in Northeastern Thailand: A Case of Participatory Approach*.

Berg, H, & Tam, N. T. (2012). Use of pesticides and attitude to pest management strategies among rice and rice-fish farmers intheMekong Delta, Vietnam. *International Journal of Pest Management*, *58*(2), 153–164. https://doi.org/10.1080/09670874.2012.672776

BPS. (2020). *Indonesia Year Book. Jakarta.*

BPS. (2021). *Statistics of Horticulture 2021* (R. Setiawati & T. H. Marpaung (eds.)). BPS RI/BPS-Statistics Indonesia.

Budiasa, I. W. (2010). Analisis Ambang Ekonomi dalam Pengelolaan Hama Terpadu Untuk Diversifikasi Insdustri Berbasis Tebu. *SOCA: Jurnal Sosial Ekonomi Pertanian*, *10*(2), 128–133.

Coventry, D. R., Poswal, R. S., Yadav, A., Zhou, Y., Riar, A., Kumar, A., Sharma, R. K., Chhokar, R. S., Gupta, R. K., Mehta, A. K., Chand, R., Denton, M. D., & Cummins, J. A. (2018). A novel framework for identifying the interactions between biophysical and social components of an agricultural system: a guide for improving wheat production in Haryana, NW India. *The Journal of Agricultural Education and Extension*, *24*(3), 263–284. https://doi.org/10.1080/1389224X.2018.1435420

David, S., & Asamoah, C. (2011). The Impact of Farmer Field Schools on Human and Social Capital: A Case Study from Ghana. *The Journal of Agricultural Education and Extension*, *17*(3), 239–252. https://doi.org/10.1080/1389224X.2011.559076

Deb, U., Pramanik, S., Patan, E., & Bantilan, C. (2016). Tenancy and Agricultural Productivity in Southern India: Nature, Extent, Trends and Determinants. *Journal Of Rural Development*, *35*, 435–464.

Dewi, H. A., Daroini, P. B., Ndaru, R., Negoro, A. A., & Latifah, E. (2021). Analysis of agribusiness performance of top five vegetable farming in East Java. *IOP Conf. Series: Earth and Environmental Science 892 (2021) 012003*, 1–8. https://doi.org/10.1088/1755-1315/892/1/012003

Dong, H., Campbell, B., & Rabinowitz, A. N. (2019). Factors impacting producer marketing through community supported agriculture. *PLOS ONE*, *14*(7), e0219498. https://doi.org/10.1371/journal.pone.0219498

Elizabeth, R., & Hendayana, R. (2005). Peran Dan Peluang SL-PHT Komoditi Lada Mempengaruhi Kognitif Petani Perkebunan Rakyat (Studi kasus: Propinsi Lampung). *SOCA: Jurnal Sosial Ekonomi Pertanian*, *5*(2), 38–49. https://ojs.unud.ac.id/index.php/soca/article/view/4087

Fang, S., Ji, X., Ji, X., & Wu, J. (2018). Sustainable urbanization performance evaluation and benchmarking: An efficiency perspective. *Management of Environmental Quality: An International Journal*, *29*(2), 240–254. https://doi.org/10.1108/MEQ-07-2017-0063

Feder, G., & Savastano, S. (2017). Modern agricultural technology adoption in sub-Saharan Africa: Four country analysis. In P. Pingali & G. Feder (Eds.), *Agriculture and Rural Development in a Globalizing World: Challenges and Opportunities* (pp. 11–25). Eartscan from Routlegde.

Gautam, S., Schreinemachers, P., Uddin, M. N., & Srinivasan, R. (2017). Impact of training vegetable farmers in Bangladesh in integrated pest management (IPM). *Crop Protection*, *102*, 161–169. https://doi.org/https://doi.org/10.1016/j.cropro.2017.08.022

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., Vermeersch, & J., C. M. (2016). *Impact Evaluation in Practice, Second Edition*. World Bank and IDB.

Iqbal, M. (2016). Relationship Between Farmers' Participation And Empowerment In The Coffee IPM-SECP In East Java Province. *SOCA: Jurnal Sosial Ekonomi Pertanian*, *16*(2), 21–30. https://ojs.unud.ac.id/index.php/soca/article/view/4129

Jayasooriya, H. J. C., & Aheeyar, M. M. M. (2016). Adoption and Factors Affecting on Adoption of Integrated Pest Management among Vegetable Farmers in Sri Lanka. *Procedia Food Science*, *6*, 208–212. https://doi.org/https://doi.org/10.1016/j.profoo.2016.02.052

Mariyono, J. (2007). The impact of IPM training on farmers' subjective estimates of economic thresholds for soybean pests in central Java, Indonesia. *International Journal of Pest Management*, *53*(2), 83–87. https://doi.org/10.1080/09670870601119106

Mariyono, J. (2016). Integrated disease management for chili farming in Brebes and Magelang - Central Java: Social economic impacts. *Agriekonomika*, *5*(2), 114–124. https://doi.org/10.21107/agriekonomika.v5i2.1686

Mariyono, J. (2019). Farmer training to simultaneously increase productivity of soybean and rice in Indonesia. *International Journal of Productivity and Performance Management*, *68*(6), 1120–1140. https://doi.org/10.1108/IJPPM-10-2018-0367

Mariyono, J., Abdurrachman, H., Suswati, E., Susilawati, A. D., Sujarwo, M., Waskito, J., Suwandi, & Zainudin, A. (2020). Rural modernisation through intensive vegetable farming agribusiness in Indonesia. *Rural Society*, *29*(2), 116–133. https://doi.org/10.1080/10371656.2020.1787621

Norton, G. W., Alwang, J., & Issa, M. S. (2016). Impacts of IPM on vegetable production in the tropics. In R. Muniappan & E. A. Heinrichs (Eds.), *Integrated Pest*

Management of Tropical Vegetable Crops (pp. 289–304). Springer Netherlands. https://doi.org/10.1007/978-94-024-0924-6_14

Raut, N., Sitaula, B. K., Vatn, A., & Paudel, G. S. (2011). Determinants of adoption and extent of agricultural intensification in the central mid-hills of Nepal. *Journal of Sustainable Development*, *4*(4), 47–60.

Riar, A., Mandloi, L. S., Poswal, R. S., Messmer, M. M., & Bhullar, G. S. (2017). A Diagnosis of Biophysical and Socio-Economic Factors Influencing Farmers' Choice to Adopt Organic or Conventional Farming Systems for Cotton Production . In *Frontiers in Plant Science* (Vol. 8, p. 1289). https://www.frontiersin.org/article/10.3389/fpls.2017.01289

Saeed, M. F., Shaheen, M., Ahmad, I., Zakir, A., Nadeem, M., Chishti, A. A., Shahid, M., Bakhsh, K., & Damalas, C. A. (2017). Pesticide exposure in the local community of Vehari District in Pakistan: An assessment of knowledge and residues in human blood. *Science of The Total Environment*, *587–588*, 137–144. https://doi.org/https://doi.org/10.1016/j.scitotenv.2017.02.086

StataCorp. (2013). *Stata: Release 13 Statistical Software*. College Station, StataCorp.

Supriatna, A. (2006). Penerapan Teknologi Pengendalian Hama Terpadu (Pht) Pada Perkebunan Rakyat Jambu Mete (Studi Kasus Petani Jambu Mete di Propinsi Nusa Tenggara Barat). *SOCA: Jurnal Sosial Ekonomi Pertanian*, *6*(1), 11–20. https://ojs.unud.ac.id/index.php/soca/article/view/4114

Supriatna, A., & Sadiin, I. (2004). Kinerja Pengendalian Hama Padi Sawah Pasca Introduksi Teknologi Pengendalian Hama Terpadu. *SOCA: Jurnal Sosial Ekonomi Pertanian*, *4*(1), 1–10. https://ojs.unud.ac.id/index.php/soca/article/view/4034

Susanti, H., Budiraharjo, K., & Handayani, M. (2018). Analisis Pengaruh Faktor-Faktor Produksi Terhadap Produksi Usahatani Bawang Merah Di Kecamatan Wanasari Kabupaten Brebes. *Agrisocionomics: Jurnal Sosial Ekonomi Pertanian*, *2*(1), 23–30. https://doi.org/10.14710/agrisocionomics.v2i1.2673

Suswati, E., Agustin, N. K., & Mariyono, J. (2006). Adverse Health Impacts of Pesticide Use on Indonesian Rice Production: An Economic Analysis. *SOCA: Jurnal Sosial Ekonomi Pertanian; Vol. 6, No. 2 Juli 2006*, *6*(2), 1–10. https://ojs.unud.ac.id/index.php/soca/article/view/4143

van den Berg, Henk, Phillips, S., Dicke, M., & Fredrix, M. (2020). Impacts of farmer field schools in the human, social, natural and financial domain: a qualitative review. *Food Security*, *12*(6), 1443–1459. https://doi.org/10.1007/s12571-020-01046-7

Williamson, S., Ball, A., & Pretty, J. (2008). Trends in pesticide use and drivers for safer pest management in four African countries. *Crop Protection*, *27*(10), 1327–1334. https://doi.org/https://doi.org/10.1016/j.cropro.2008.04.006