Agriekonomika

Jurnal Sosial Ekonomi dan Kebijakan Pertanian
http://journal.trunojoyo.ac.id/agriekonomika
Agriekonomika Volume 6, Nomor 2, 2017

AGRO-ECOLOGICAL AND SOCIO-ECONOMIC ASPECTS OF CROP PROTECTION IN CHILI-BASED AGRIBUSINESS IN CENTRAL JAVA

✉Joko Mariyono
Program Studi Magister Manajemen, Universitas Pancasakti

Received: 10 Desember 2016; Accepted: 25 Oktober 2017; Published: 31 Oktober 2017
DOI: http://dx.doi.org/10.21107/agriekonomika.v6i2.2294

ABSTRAK
The purpose of this study is to analyze the socio-economic and agro-ecological aspects of chili production in three selected communities of three districts-Magelang, Brebes, and Rembang-that represent distinct agro-ecosystems of chili cultivation within Central Java province. This is to answer a problem statement that chili farming still faces crop protection aspects as limiting factors in chili production. This study uses quantitative descriptive methods. Data were compiled from a survey of 160 chili farmers in 2010-2011. The results show that yield loss due to pests and diseases was considerable, and some of these problems were becoming difficult to control. The three top pests were thrips, mites, and whitefly; and the top three diseases were Anthracnose, Gemini-viruses, and Phytophthora. During the wet season, risk of anthracnose was very high; in the dry season, risk of yield lost to Gemini-viruses and Phytophthora was high. The potential losses could reach 100%. There is a crucial need to solve the problems by enhancing farmers' knowledge and involving research institutions focusing on crop protection strategy.

Keywords: Chili, Pests and Diseases, Pesticides, Central Java

INTRODUCTION

Vegetable production plays an important role in agriculture economy in Indonesia. Intensive vegetable farming improves farmers' welfare (Mariyono, et al., 2017). In particular, chili farming provides more income and employment than cereal and staple crops sectors (Mariyono & Bhattarai, 2011); Mariyono & Sumarno, 2015); Bhattarai & Mariyono, 2016)). The multiplier benefits of chili cultivation, such as employment creation, agribusiness development, local transportation, etc., accrue to the wider rural community as well as to chili growing communities. Thus sifting from subsistence to commercial chili farming and adopting better technologies are expected to improve farmers' livelihood (Mariyono, 2017).

As a commercial crop, it has been cultivated in developing countries over couple past decades. Food and Agriculture Organization (FAO) reported that annual worldwide production of chili is around 21 million t. The top-ten chili producing countries, accounting for more than 85% of world production in 2007, were India (36%) , China (11%), Ethiopia (5%), Myanmar (6%), Mexico (5%), Vietnam (4%), Peru (8%), Pakistan (6%), Ghana (4%), and Bangladesh (8%). Among the vegetables cultivated in Asia, chili occupied the largest crop acreage, about 2.5 million ha (FAOSTAT, 2009). Even though Indonesia is not mentioned in the top-ten chili production countries in the world, chili is produced on about 200,000 ha, with annual production of close to 1 million t —about 5 percent of global supply.

Chili-planted area is the highest

✉ Corresponding author :
Address : Jalan Halmahera km-1, Tegal, Jawa Tengah, Indonesia
Email : mrjoko28@gmail.com
Phone : +62 81 328 175 833

p-ISSN 2301-9948 | e-ISSN 2407-6260

among other vegetables. But, the per hectare production averages for the Indonesia are low by regional and international standards. There is still scope for more use of high yielding cultivars and better management to increase national production without encroaching on grain production areas (Kuntariningsih & Mariyono, 2013b).

Farmers' motivation of growing chili is because the demand for chili increases along with population growth and income. It increases from 2.45 kg/capita in 1988 to 2.88 kg/capita in 1990, and 3.16 kg/capita (Bank of Indonesia, 2007). Although the need tends to increase, the chili demand for daily needs fluctuated caused by the retail price in the market. The fluctuation is either caused by some factors that influence the demand side, or by other factors, which influence the supply side (Mariyono, 2016a). It could be explained that the price equilibrium exists when the supply of chili is lower that its demand. This will cause the price to be very high. On the contrary, if the supply of chili is greater than its demand, the price will be very low.

Because of disproportion of supply volume and consumer needs frequently occurred on vegetables, price fluctuation of chili is higher than other secondary crops. High fluctuation in price of chili does not provide beneficial circumstance for vegetables agribusiness. It has adverse effect on the decision for investment as a result of uncertainty in return. The fluctuation in price often makes higher loss for farmers than traders/collectors, because farmers are not capable of managing sale to obtain better price. Price fluctuation also triggers asymmetric market information, and this results in high marketing margin as traders take advantage from this situation as they can provide misleading price information to the farmers. The price received by the farmers and price transmission from consumer's area to producer's region is low. Thus, it is understandable that the share of market price for traders is almost 50% of the total chili price (Sugiarti, 2003). This condition is not conducive for efforts to develop agribusiness and to increase produce's quality competitiveness characterized by the ability to respond to effective market dynamics (Irawan, 2007). It is suggested that farmers adjust cropping pattern based on the cropping patterns of other chili producing areas (Negoro & Mariyono, 2014).

Improvement in chili production is still required because Indonesia's chilli productivity level (about 5 t/ha) is still very low, compared to other countries in Asia (Mustafa, Ali, & Kuswanti, 2006). One of the main limiting factors is yield lost to pests and diseases.

Major chili pests are thrips (*Thrip sparvispinus* [Karny]) and yellow tea mite [*Polyphago-tarsonemus latus* (Banks)]. Thrips particularly cause problems during prolonged dry periods. Other important pests are tropical armyworm [*Spodoptera litura* (Fabricius)], oriental fruit fly (*Bactroceru dorsalis* [Hendel]), cotton bollworm (*Helicoverpa armigera* [Hiibner]) and jassids (probably *Empoasca* spp.). Armyworms and bollworms may appear together and cause an extreme damage. The widely distributed fruit fly is especially damaging in fruit production regions. The jassids are widespread, but yield losses have not been determined. Aphids (*Myzus* spp. and Aphis spp.) are important virus vectors.

Major diseases are anthracnose, caused by *Colleto-trichum* spp., and virus diseases. Anthracnose fruit rot can be severe during rainy periods. Other diseases are *Cercospora* leaf spot (*Cercosporu capsici* [Heald & Wolf]), bacterial wilt (*Pseudomonas solanacearum* [Smith]) Smith] and southern blight (*Sclerotium roffsii* [Saccardo]). *Cercospora* leaf spot is widely distributed and generally occurring, while bacterial wilt and southern blight are less regularly observed. Reduced effectiveness of pesticides, mentioned by farmers, may be caused by pest resistance and/or due to counterfeit pesticides.

Based on the fact that pests and diseases play significant roles in affecting chili production resulting in price instability in the market, there is a need to understand the problems. The objective of this study is to explore and analyze the social-economic and agro-ecological aspects of crop protection in three selected communities of three districts—Magelang, Brebes, and Rembang—that represent distinct agro-ecosystems of chili cultivation within Central Java province.

METHODOLOGY

Samples and Data Collection

This study is based on a primary survey conducted at three locations in Central Java during 2010-2011. The primary survey has three main parts: a household survey, community surveys, and group discussions with selected key informants.

The survey integrated qualitative and quantitative survey methods to meet the study objectives. As a part of the quantitative approach, a rigorous household survey was carried out through face-to-face interviews with 160 farmers from three villages to collect information on the socioeconomics of chili farming, and level of pesticides. The samples of survey were selected using purposive random sampling, where farmers who cultivated chili during last three years were considered as population. Data were collected using structured questionnaire to record and document the main information related to crop protection aspects.

Central Java is one of the largest chili-producing areas in Indonesia. However, compared to other largest chili-producing provinces, the average productivity of chili is low in Central Java (BPS, 2015). Within Central Java, the three largest districts (or regions) producing chili are Brebes, Magelang, and Rembang. Those three districts have distinctive variations in agro-ecology and chili production characteristics.

Data Analysis

Data were collected from secondary and primary sources. For the purpose of assessment, three major forms of descriptive data were analyzed: sample mean, frequency, and weighted rank. Analyses on frequency were conducted by counting the number of farmers who provided responses on a specific category of issue/response in the questionnaire. Once the frequency was obtained, the percentage of those from the sub-total of each district and total samples in the province was calculated. If the frequency of a certain variable is higher than the others, then this particular variable is considered more important.

Mean value of a particular variable was estimated by calculating the sample average of the variable. Standard deviation (*SD*) of such variables was also calculated to provide information on their variation across the sample surveyed in each category. Mean value and SD were respectively calculated using the formulae:

$$\overline{X} = \frac{\sum_{i=1}^{N} X_i}{N} \quad (1)$$

$$SD = \sqrt{\frac{(X_i - \overline{X})^2}{N-1}} \quad (2)$$

Where X_i is the variable of i[th] to be analyzed, *N* is the number of samples. To provide information on the significance, statistical *t*-test was provided as reported by the SPSS software package, which is formulated as:

$$t_{test} = \frac{x_{ij} - x_{ik}}{SD_{jk}}, \text{ for } k \neq j \quad (3)$$

Refers to the different districts, SD_{jk} and is the standard deviation obtained from x_j and x_k. In this case, if value of *t*-test is greater than the value t-table at 95% confidence interval, then the mean of the particular variables is significantly different from other survey sites. The statistical analysis was done with the SPSS software package. For certain important factors, analyses on weighted rank were conducted by calculating the score reported by farmers. The weighted average rank is formulated as

$$\overline{R} = \frac{\sum n * S}{N} \quad (4)$$

Where n is number of farmers responding to each category, S is score, and N is total sample. A higher score was given for a particular variable when farmers mentioned that such a variable was more important than others. For example, if there are five choices, and a farmer provides a first rank for a certain variable in a list, then the variable is scored one. If the farmer put it in the second rank, then it is scored two, and so forth. If the farmer did not mention anything, then the score for this particular factor is zero. Thus, a higher value of weighted average rank means the response is more important and mentioned by many farmers during the survey. For consistency in data analysis and ease in reporting the results, the ranks are inverted: the first rank is converted to five and lowest rank is converted to one. Thereby, the higher the score for a factor, the higher the importance of the particular factor among the range of other factors listed by the farmers.

Data analyses were conducted by comparing across the three sites, and by crop season. Selected important variables, within a group of chili-growing farmers, are analyzed in detail, especially issues related to the control of pests and diseases.

The quantitative analyses are supplemented with qualitative narratives and frequency of cases across locations and groups. The significant difference of each mean variable across the three districts was indicated by M, B, and R, which stand for Magelang, Brebes, and Rembang.

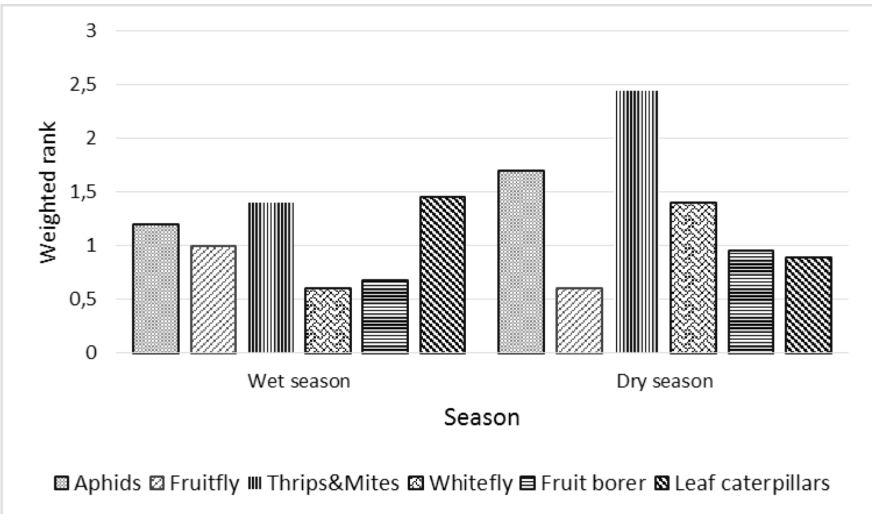
RESULTS AND DISCUSSION

Description of Study Sites

Brebes Regency is situated in the northwestern coastal area of Central Java. The regency borders West Java Province and it is also linked closely with the Bandung and Jakarta vegetable markets. Brebes is the largest chili-producing region in Central Java. Magelang Regency is in the southern region of Central Java, bordering Yogyakarta Province; it is the second largest chili-producing region in Central Java. Rembang Regency is in the northern coastal area of Central Java, which borders with East Java Province.

Agro-ecological Aspects

Controlling chili pests and diseases is not an easy task because of the complex relationship that exists between pests and



Source: Data Analysis, 2013

Figure 1
Farmers' Ranking of Chili Pests by Importance

their habitat (Mariyono, 2008). Appropriate and timely control methods can minimize losses. This section summarizes key findings on pest and disease levels and current control measures adopted by farmers in the survey sites.

Insect Pests

Major insect pests reported by the farmers include: aphids (*Aphis gossypii* and *Myzus persicae*), fruit fly (*Drosophila melanogaster* and *Bactrocera* sp.), thrips (*Scirtothrips dorsalis*), mites (*Polyphagotarsonemus latus*), whitefly (*Bemisia tabaci* and *Aleurodicus dispersus*), fruit borer (*Helicoverpa armigera*), and various caterpillars including army worm (*Spodotera* spp.) cutworms (*Agrotis* spp.) leaf rollers, and leaf folders.

In general, insect pests were less prevalent during the wet season. In the dry season, farmers gave higher weighted average ranks for several pests such as thrips, mites, and aphids (Figure 1). The weighted rank (importance) of particular insects varied by location (Table 1).

Diseases

Major diseases reported by farmers are illustrated in Figure 5.2. Because farmers grow more chili in the dry season, disease incidence in the dry season was more critical than in the wet season. Overall, farmers gave a lower weighted rank value to CMV, bacterial wilt and *Phytophthora,* which means they are less detrimental to chili compared to anthracnose and Gemini-viruses (Figure 2) and the actual severity of individual disease varies by crop season (Table 2).

Combining results from all three sites, the average yield loss from anthracnose and Gemini-viruses, two most important diseases of chili in the survey sites, was higher during the wet season than in the dry season (Figure 3).

Yield Loss

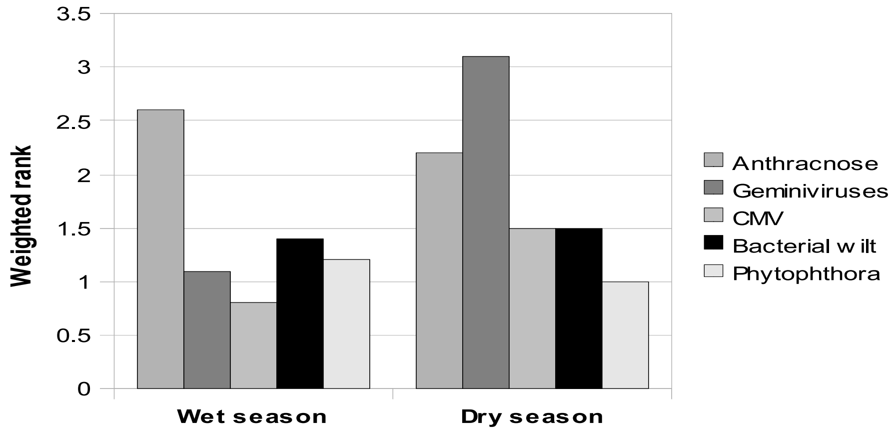
Among the three surveyed sites, the highest yield loss due to disease was in Magelang, where farmers perceived that more than 50 percent of yield loss is due to disease (Table 3). Forty farmers each in Magelang and Brebes reported that anthracnose was the most critical disease of chili in wet season and, on an average, could lead to more than 54 percent of the yield loss. In Rembang and Brebes, the average

Table 1
Relative Importance of Insect Pests as Ranked by Farmers

Season	Pests	Magelang (N=49)			Brebes (N=60)			Rembang (N=51)		
		$\overline{R}$	n	%	$\overline{R}$	n	%	$\overline{R}$	n	%
Wet	Aphids	2.98	38	77	0.37	6	10	0.04	1	2
	Fruit fly	2.06	25	51	0.88	11	18	0.10	1	2
	Thrips & Mites	1.80	25	50	1.87	29	48	0.06	1	2
	Whitefly	1.78	25	50	0.17	3	5	0.00	0	0
	Fruit borer	0.33	4	8	1.43	18	30	0.08	1	2
	Caterpillars	2.71	40	81	1.20	19	32	0.08	1	2
Dry	Aphids	3.14	38	77	0.10	2	3	2.12	27	53
	Fruit fly	0.55	9	18	0.17	2	3	1.31	18	36
	Thrips& Mites	3.71	40	81	1.73	27	45	1.94	26	52
	Whitefly	1.47	40	81	0.00	0	0	2.57	29	57
	Fruit borer	0.16	2	4	2.03	25	42	0.51	12	33
	Caterpillars	1.67	29	59	0.22	6	10	1.06	30	50

Source: Data Analysis, 2013

Note: Higher rank = more important; N = total sample of households surveyed in each community; n = number of farmers giving response to each factor in each community (also equivalent to frequency). $\overline{R}$ = Weighted rank value for each of the insect pest as noted in the methodology section earlier.



Source: Data Analysis, 2013

Figure 2
Farmers' Ranking of Chili Diseases by Importance

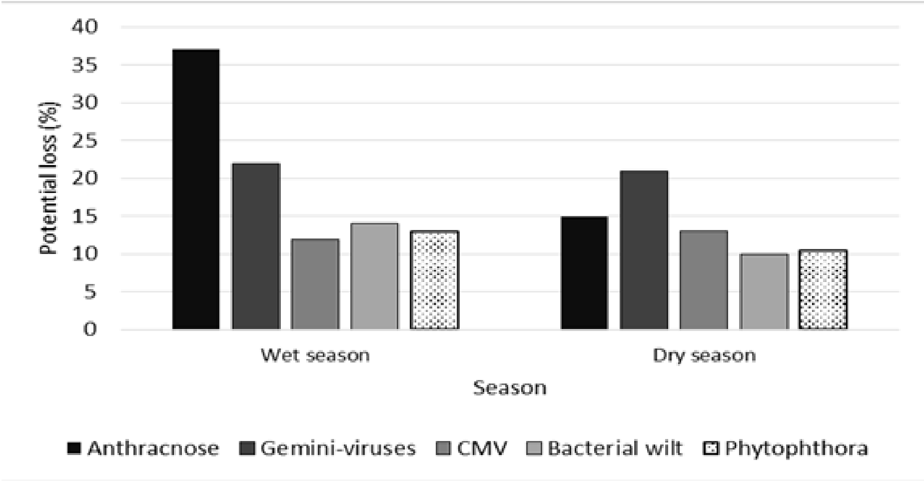
yield loss due to anthracnose was around 20-25 percent, as perceived by the farmers. Yield lost to gemini-viruses was highest in Magelang, in both wet and dry seasons, which was more than 30-40 percent per year. In Rembang, only a few farmers grew chili in the wet season, thus only a few farmers provided information on yield loss to diseases.

Consistent with the rank of diseases, the average yield lost to Gemini-viruses in the dry season was the highest, largely in Magelang. In Rembang and Brebes, yield lost to anthracnose was still the highest in the dry season, even though the yield loss was around half of that in the wet season. In Rembang, around 90 percent of farmers stated that Gemini-viruses and anthracnose as the major diseases in dry season chili cultivation. Estimations of yield loss due to other diseases were almost similar across the diseases, which was around 12 percent per season basis, except for yield lost to CMV in Magelang during the dry season. CMV disease was more critical in Magelang in the wet season, with

Table 2
The Importance of Diseases as Ranked by Farmers

Season	Diseases	Magelang			Brebes			Rembang		
		$\overline{R}$	n	%	$\overline{R}$	n	%	$\overline{R}$	n	%
Wet	Anthracnose	4.63	46	94	3.05	40	67	0.18	2	4
	Gemini-viruses	2.82	35	71	0.62	21	35	0.10	2	4
	CMV	0.55	10	20	1.55	35	58	0.14	2	4
	Bacterial with	1.86	31	63	2.33	38	63	0.04	1	2
	Phytophthora	1.39	26	40	1.92	40	66	0.00	0	0
Dry	Anthracnose	1.59	22	55	1.80	29	48	3.49	50	98
	Gemini-viruses	4.00	40	36	1.33	24	40	4.63	49	96
	CMV	0.47	6	30	1.25	24	39	3.06	48	94
	Bacterial wilt	1.35	20	44	1.33	23	38	2.12	42	83
	Phytophthora	1.27	17	41	1.22	21	36	0.78	30	59

Source: Data Analysis, 2013.
Higher rank is more important; N= total sample in each community; n= number of farmers giving response. $\overline{R}$ = Weighted rank value for each disease as noted in the methodology section



Source: Data Analysis, 2013

Figure 3
Farmers' Perception of Potential Yield

an average loss of about 33 percent per household. This is not surprising, because in some cases, yield lost due to CMV can reach up to 80 percent, and occasionally cause complete crop failure (Herison, Rustikawati, & Sudarsono, 2007).

Pesticide Use

The number of sprays also varied by type

Table 3
Farmers' Perception of Different Percentages of Yield Lost to Diseases

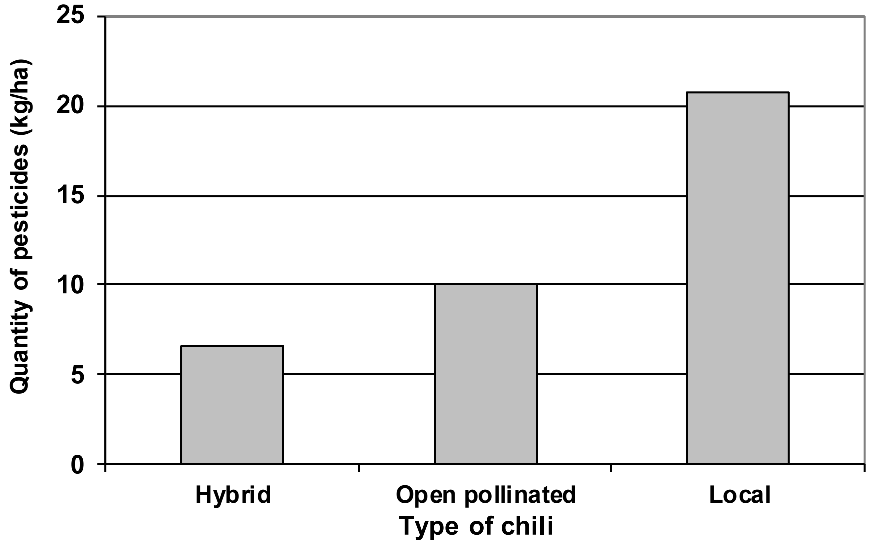
Season	Potential yield lost to individual diseases	Magelang (N=49)			Brebes (N=60)			Rembang (N=51)		
		n	Mean	SD	n	Mean	SD	n	Mean	SD
Wet	Anthracnose	40	54.25^{BR}	17.49	40	22.05	14.06	2	25.00	.00
	Gemini	33	30.24^{B}	14.63	20	10.10	8.24	2	15.00	7.07
	CMV	10	13.70	9.38	35	10.37	10.48	2	17.50	3.54
	Bacterial wilt	29	14.24	8.85	38	13.39	15.23	1	5.00	-
	Phytophthora	25	13.20	10.85	40	10.35	8.79	-	-	-
	Other diseases	-	-	-	1	2.00	-	-	-	-
Dry	Anthracnose	22	15.73	10.73	26	12.81	7.47	46	15.78	8.26
	Gemini	34	40.00^{BR}	18.26	22	12.05	13.72	46	11.89	7.56
	CMV	4	33.75^{BR}	18.87	21	12.24	10.08	44	9.16	7.58
	Bacterial wilt	19	17.63^{BR}	11.83	22	10.41	7.71	43	6.65	8.46
	Phytophthora	17	19.53^{BR}	13.44	21	8.81	10.16	28	5.86	2.62
	Other diseases	1	20.00	-	3	25.00	22.91	-	-	-

Source: Data Analysis, 2013

Note: The summation of all these losses does not equal 100 percent because not all of these diseases occur in a farmers' field at the same time.

N = number of farmers survey in each site; n = number of farmers reporting for this particular factor (disease)

Significant difference of mean across sites is indicated by superscript M, B and R.



Source: Data Analysis, 2013

Figure 4
Quantity of Pesticide Use in Chili, by Types of Chili

of chili variety cultivated (Figure 4). Farmers growing local varieties sprayed more often. Brebes, where most farmers grow open pollinated and local varieties, had the highest frequency of sprays per week as well as the highest total number of sprays per growing season. Despite more severe pest and disease problems in Magelang, the number of sprays there was less than Brebes; this is due largely to cultivation of hybrid varieties, which are relatively more resistant to common pests and diseases.

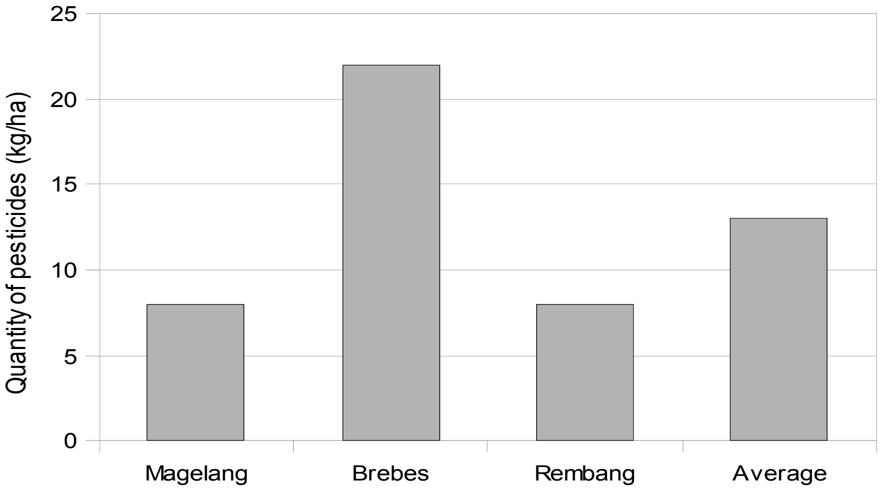
About 30 percent of chili farmers, using mixed sprays applied about 23 kg/ha of pesticides; the rest used single sprays, applying about 5.5 kg/ha of pesticides. Pesticide use in Brebes was the highest among the three sites, both in total use and in mixed spray. Magelang farmers applied about 6.6 kg/ha using single sprays.

The quantity of pesticides applied varies by application method. Total quantity of pesticide use was about12 kg/ha of chemical formulation. In Brebes, the quantity was about 22 kg/ha, in contrast to Rembang, where farmers used chemical formulations of only about 5.5 kg/ha. In Brebes, chili cultivation is very intensive, and agrochemicals are advertised and aggressively promoted by private input dealers and pesticide agents (Luther et al., 2007). Since promotion of the Green Revolution, pesticides have been aggressively recommended to farmers (Mariyono, 2015).

The choice of pesticide depended on the type of chili variety grown (see Figure 4). Local varieties received the highest number of sprays and highest quantity of pesticides, especially in Brebes, where no farmers grew hybrids. Clearly, local varieties need more protection from pests and diseases, which prompts farmers to apply more pesticides. Public sector agencies should consider developing and providing local or open pollinated varieties resistant to common pests and diseases (Bhattarai & Mariyono, 2016). Traders also prefer local varieties already linked into the supply chain rather than new resistant varieties without an established consumer base.

Socio-economic Aspects

An important socio-economic aspect of crop protection in chili production is alternative control measures conducted by farmers. Level of education, experiences and knowledge of farmers determine the farmers' decision to select alternative methods.



Source: Data Analysis, 2013

Figure 5
Quantity of Pesticide Use, by Sites

Success or failure in crop protection could vary across regions and farmers.

About two-thirds of the total number of farmers surveyed adopted alternative control measures such as growing pest- and disease- resistant varieties, sowing seed early to avoid early-stage infestations, and picking infected plants (Table 4).

In Magelang, 79 percent of farmers selected pest- and disease-resistant chili varieties to protect from loss. In Brebes, 43 percent practiced early sowing, and 27 percent picked infected plants to prevent disease. Fewer farmers in Rembang used alternative controls, possibly due to a lack of awareness, training, and other support services.

Farmers reported that the effectiveness of alternative measures varied widely, depending on location, farmer experience and knowledge. Most farmers have a positive attitude towards alternative methods and some of them already are using combinations of such methods. More training and local demonstrations can encourage other chili farmers to explore and apply alternative technology to reduce the high cost of pesticides.

As farmers seem willing to apply alternative control methods, public institutes should provide more alternative choices for controlling pest and diseases and reducing inputs—including developing resistant chili varieties for location-specific needs. For example, studies to identify sources resistant to CMV conducted by Herison et al. (2007) would be useful for the projects. Recent research in Indonesia by Pamekas (2007) on application of crab shell offers a practical alternative measure to control anthracnose, one of the most detrimental chili diseases. This was done by soaking red chili fruit in 20 mg/ml of crab shell extract, then extracting and drying the seed. In the following year, seedlings grown from the treated seed were free from anthracnose caused by *Colletotrichum capsici*. The same study also suggested farmers should periodically spray crab shell water on soil around the crop plant; also another study reported the usefulness and efficacy of this method in controlling anthracnose infections.

Alternative controls become more important when pesticides do not work as expected. Gemini-viruses were spreading fast in the survey areas. Farmers, particularly in Magelang and Rembang, should be encouraged to adopt border plantings, low-cost nylon net barriers, and net houses for nurseries to restrict the spread of whitefly, the virus vector. For other diseases like anthracnose, practical alternative techniques need to be developed urgently in collaboration with farmers and local agricultural offices. However, analyses on alternative control measures should be analyzed first before mass dissemination (Kuntariningsih & Mariyono, 2013a; Mariyono, 2016).

Most chili farmers grow local varieties, which are produced on-farm or bought from local shops. Commercial cultivars are not commonly used. Only recently a Taiwanese hybrid cultivar has become popular in the districts of Magelang. Since early 1991 there have been two local seed companies that produce seeds of two cultivars. Locally produced seeds have a variable quality without any guarantee. Neither seed cleaning nor grading is applied and the germination capacity is uncertain. Seed-borne disease such as anthracnose and viruses may exist. Farmers' selection criteria for seed production vary from plants with high yields to fruits with specific size and shape.

The level of farmer knowledge as to chili crop management is illustrated information on how to use of pesticides and fertilizers. Farmers lack information concerning the *symptomatology* of chili pests and diseases. Symptoms are often difficult to distinguish, because different causal agents, such as viruses, thrips and aphids, may give similar symptoms. Farmers usually refer to these particular symptoms with the general term leaf curl diseases. Pesticides are not applied according to target pests or diseases; instead, the advice of neighboring farmers or pesticide shops is followed. It seems that farmers need a training package like integrated pest management (Mariyono, 2008). This will equip farmers with knowledge and skill such that they can correctly anticipate pests and diseases (Mariyono & Negoro, 2016).

Economic motivation is one of the key motive and rationality for using pesticides by farmers, and so the level and intensity of pesticides use for a crop. Hence, pesticide use decision is strongly related to price of pesticides and ex-ante price of

Table 4

Adoption of Other Methods to Control Disease/limit Damages, and Effectiveness

Particulars		Number and percentage of farmers							
		Magelang (N=49)		Brebes (N=60)		Rembang (N=51)		Average (N=160)	
		n	%	n	%	n	%	n	%
Total number of farmers adopting alternative methods		42	86	56	93	7	14	105	66
The kind of control method	Resistant variety (1)	33	79	5	9	0	0	38	36
	Early sowing (2)	3	7	24	43	0	0	27	26
	Picking sick plants (3)	1	2	15	27	7	100	23	22
	Weed control (4)	2	5	5	9	0	0	7	7
	Integration of (1) and (4)	0	0	1	2	0	0	1	1
	Integration of (2) and (3)	0	0	1	2	0	0	1	1
	Integration of (3) and (4)	0	0	4	7	0	0	4	4
	Integrated methods	1	2	0	0	0	0	1	1
	Other methods	2	5	0	0	0	0	2	2
Farmers' perception on the alternative control methods (%)	100	1	2	1	2	0	0	2	2
	75	10	24	13	23	0	0	23	22
	50	9	21	6	11	0	0	15	14
	25	17	40	5	9	5	71	27	26
	0	0	0	0	0	2	29	2	2

Source: Data Analysis, 2013

N = total sample in each community; n = number of sample giving response crop, and price of other agricultural inputs. For example, a study by Rahman (2003) in Bangladesh suggested that some farmers treated fertilizers as substitute to pesticides; and he found that an increase in fertilizer price increased pesticide use by rice farmers in Bangladesh. Likewise, an increase in pesticide price reduces its demand. It has been reported that an increase in the prices of rice (Mariyono, 2008) and soybean (Mariyono, 2008b) in Indonesia induced farmers to use more pesticides to get more farm income and profit. Likewise, a study suggested that high price of pesticides minimized level of pesticides use in India, but level of availability of family members in spraying led to increase use of pesticides (Selvarajah & Thiruchelvam, 2007). But, their study did not find any significant relationship between strength of spray with mixtures of pesticides use, with farmers' education, or experience in production of the crop. Farmers' decision to pesticides use on crop is in fact also same as buying an insurance, i.e., as a preventive mechanism against crop failure due to pests and disease attack.

Overall, there is variation in agro-ecological and socio-economic aspects across regions and seasons. Magelang was different from two other regions in terms of severity and pests and diseases problems. This is because farmers in Magelang grew chili year round such that the problem of pests and diseases accumulated from time to time. Different season has a different problem. But the importance of such problems were similarly important.

CONCLUSION

To sum up, this study showed the important agro-ecological and socio-economic extents of crop protection in chili production. Agro-ecologically, the extents of damage associated with several major insect pests and diseases of chili. Among the eight major insect pests reported by farmers during the dry season, thrips, mites, and whitefly infestations were most severe. Likewise, among five diseases noted by farmers, the three most important—anthracnose (*Colletotrichum capsici*), Gemini-viruses, and *Phytophthora*—were more serious than the others. During the wet season, risk of anthracnose was very high; in the dry season, risk of yield loss by Gemini-viruses and *Phytophthora* was high. Within a province, the severity of insect pest and disease outbreaks varied by location and by season.

Socio-economically, the yield loss associated with pests and diseases perceived by farmers were high across regions. Different pests and diseases led to different severity of damage; and this led to different actions that varied among regions. Most farmers controlled pests and diseases with chemical pesticides. On average farmers applied approximately 12 kg/ha of pesticide on chili in a three- to four-month period), and the frequency of spray was about 23 times over each growing season. Overall, farmers in Brebes, who cultivate the local variety of chili, applied a greater quantity of pesticides and sprayed more than farmers in the other two survey sites. However, some farmers did use alternative methods to control pests and diseases. Based on the study results, the following set of recommendations are proposed to enhance productivity of chili in Central Java. *Develop and distribute disease-resistant cultivars:* There is an urgent need for the public sector to develop new disease-resistant chili lines and introduce them through on-farm demonstrations. Our survey revealed that farmers have been locked into growing only a few chili varieties that are now well-established in the local supply chain. Although farmers prefer the existing varieties, the introduction of new lines would enhance the gene pool and offer greater choice for farmers and consumers. Disease-resistant lines could lead to reduced pesticide uses, lower production costs, and low risk in chili farming. *Training in integrated pest and disease management:* Training in the proper use of pesticides and bio-control agents, integrated pest and disease management methods, seed selection/breeding, and nursery management can help farmers improve chili productivity and sustainability. *Promote low-cost bar-*

riers to control spread of pests and diseases: Gemini-viruses are spreading fast in the survey areas. Farmers, particularly in Magelang and Rembang, should be encouraged to adopt border plantings, low-cost nylon net barriers, and net houses for nurseries to restrict the spread of whitefly, the vector of viruses. For other diseases like anthracnose, practical alternative techniques need to be developed urgently in collaboration with farmers and local agricultural offices.

ACKNOWLEDGMENT

The author thanks the farmers in all sites of study who provided worth time and information related to crop protection aspects. All interpretation and errors are the responsibility of the author

REFERENCES

Bank of Indonesia. (2007). *Lending Model Information System for Small-Scale Enterprises: Medicinal Plant Cultivation*. Jakarta.

Bhattarai, M., & Mariyono, J. (2016). The economic aspects of chilli production in Central Java. *Economic Journal of Emerging Markets*, *8*(2), 85–97. https://doi.org/10.20885/ejem

BPS. (2015). *Statistik Indonesia*. Jakarta: Badan Pusat Statistik. Retrieved from *www.bps.go.id*

FAOSTAT. (2009). FAOSTAT Online. Retrieved March 20, 2010, from http://faostat.fao.org/default/aspx?lang-en

Herison, C., Rustikawati, & Sudarsono. (2007). Aktivitas Peroksidase, Skor ELISA dan Respon Ketahanan 29 Genotipe Cabai Merah Terhadap Infeksi Cucumber Mosaic Virus (CMV). *Akta Agrosia*, *10*(1), 1–13.

Irawan, B. (2007). Fluktuasi Harga, Transmisi Harga dan Marjin Pemasaran Sayuran dan Buah. Analisis Kebijakan Pertanian. *Analisis Kebijakan Pertanian*, *5*(4), 358–373.

Kuntariningsih, A., & Mariyono, J. (2013a). Dampak Pelatihan Petani Terhadap Kinerja Usahatani Kedelai Di Jawa Timur. *Sosiohumaniora*, *15*(2), 139–150. https://doi.org/10.24198/sosiohumaniora.v15i2.5739

Kuntariningsih, A., & Mariyono, J. (2013b). Socio-Economic Factors Affecting Adoption of Hybrid Seeds and Silvery Plastic Mulch. *Jurnal Sosial Ekonomi Pertanian Dan Agribisnis*, *9*(2), 279–308.

Luther, G., Palada, M., Wang, T. C., Dibiyantoro, A., Mariyono, J., Ameriana, M., Bimantoro. (2007). *Chili Integrated Disease Management Rural Appraisal in Central Java. Integrated Disease Management (IDM) for Anthracnose, Phytophthora blight, and Whitefly Transmitted Gemini-viruses in Chili Pepper in Indonesia*. Taiwan.

Mariyono, J. (2008). Direct and indirect impacts of integrated pest management on pesticide use: A case of rice agriculture in Java, Indonesia. *Pest Management Science*, *64*(10), 1069–1073. https://doi.org/10.1002/ps.1602

Mariyono, J. (2008a). Dynamic Model of Pest Attacks and Pesticide Use: Optimal Pest Control in Plant Protection. *International Journal of Ecological Economics and Statistics*, *10*(8), 5–18.

Mariyono, J. (2008b). National Dissemination of Integrated Pest Management Technology through Farmers' Field Schools in Indonesia: Was It Successful? *Journal of Agricultural Technology*, *4*(1), 11–26.

Mariyono, J. (2008c). The Impact of Integrated Pest Management Technology on Insecticide Use in Soybean Farming in Java, Indonesia: Two Models of Demand for Insecticides. *Asian Journal of Agriculture and De-*

velopment, *5*(1), 43–56.

Mariyono, J. (2015). Green revolution- and wetland-linked technological change of rice agriculture in Indonesia. *Management of Environmental Quality: An International Journal*, *26*(5), 683–700. https://doi.org/10.1108/MEQ-07-2014-0104

Mariyono, J. (2016a). Impacts Seed Technology Improvement on Economic Aspects of Chilli Production in Central Java - Indonesia. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi Dan Pembangunan*, *17*(1), 1–14. https://doi.org/10.23917/jep.v17i1.1453

Mariyono, J. (2016b). Integrated Disease Management for Chili Farming in Brebes and Magelang - Central Java: Social Economic Impacts. *Agriekonomika*, *5*(2), 114–124.

Mariyono, J. (2017). Moving to commercial production: a case of intensive chili farming in Indonesia. *Development in Practice*, *27*(8), 1103–1113. https://doi.org/10.1080/09614524.2017.1360841

Mariyono, J., & Bhattarai, M. (2011). Revitalizing Indonesian Rural Economy through Intensive Farming of High Value Vegetables: A Case Of Chili Farming In Central Java. In B. P. Afianto, B.E.; Yusuf, A.A.; Resosudarmo (Ed.), *Indonesia's Regional Economy in the Globalization Era. IRSA Book Series on Regional Development No. 9* (pp. 71–89). Surabaya.

Mariyono, J., Kuntariningsih, A., Dewi, H. A., Latifah, E., Daroini, P. B., Negoro, A. A., … Luther, G. (2017). Pathway analysis of vegetable farming commercialization. *Economic Journal of Emerging Markets*, *9*(2), 115–124. https://doi.org/10.20885/ejem.vol9.iss2.art1

Mariyono, J., & Negoro, A. A. (2016). Impact of Farmers' Knowledge on Joint Productions of Rice and Soybean in Central Java, Indonesia. *Journal Animal Science and Agronomy Panca Budi*, *1*(1), 7–16.

Mariyono, J., & Sumarno, S. (2015). Chilli production and adoption of chilli-based agribusiness in Indonesia. *Journal of Agribusiness in Developing and Emerging Economies*, *5*(1), 57–75. https://doi.org/10.1108/jadee-01-2014-0002

Mustafa, U., Ali, M., & Kuswanti, H. (2006). Indonesia. In M. Ali (Ed.), *Chili (Capsicum spp.) Food Chain Analysis: Setting Research Priorities in Asia* (p. 253). Taiwan: AVRDC - The World Vegetable Center.

Negoro, A. A., & Mariyono, J. (2014). Peran Sistem Informasi Dan Teknologi Luar Musim Dalam Bisnis Berbasis Komoditas Sayuran. In *Prosiding Seminar Nasional PERHORTI 2014*. Malang: PERHORTI.

Pamekas, T. (2007). Potensi Ekstrak Cangkang Kepiting untuk Mengendalikan Penyakit Pascapanen Antraknosa pada Buah Cabai Merah. *Akta Agrosia*, *10*(1), 72–75.

Rahman, S. (2003). Farm-Level Pesticide Use in Bangladesh: Determinants and Awareness. *Agriculture, Ecosystems and Environment*, *95*(1), 241–252.

Selvarajah, A., & Thiruchelvam, S. (2007). Factors Affecting Pesticide Use by Farmers in Vavuniya District. *Tropical Agricultural Research*, *19*(1), 380–388.

Sugiarti, S. (2003). Usahatani dan Pemasaran Cabai Merah di Kabupaten Rejang Lebong. *Akta Agrosia*, *6*(1), 30–34.