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SOCIO-ECONOMIC FACTORS AFFECTING ADOPTION OF HYBRID SEEDS AND SILVERY PLASTIC MULCH FOR CHILI FARMING IN CENTRAL JAVA

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ABSTRAK

Transfer teknologi pertanian tidak akan berdampak jika petani tidak mengadopsi teknologi tersebut. Dengan demikian, adopsi teknologi yang ditransfer merupakan salah satu tahapan penting dalam proses pembangunan pertanian dan pedesaan. Makalah ini menganalisis faktor sosial ekonomi yang mempengaruhi adopsi teknologi modern untuk usahatani cabai oleh petani di Jawa Tengah. Cabai merupakan sayuran bernilai tinggi yang relatif lebih menguntungkan dibanding sayuran lainnya dan menyediakan tingkat pendapatan dan lapangan kerja yang lebih tinggi dibanding padi. Namun budidaya cabai memerlukan modal lebih tinggi. Data untuk penelitian ini dikumpulkan dari survai lapangan pada 160 petani di tiga kabupaten di Jawa Tengah, yaitu Magelang, Brebes dan Rembang pada tahun 2009-2010. Teknologi cabai yang dianalisis di sini adalah penerapan benih hibrida dan plastik mulsa perak. Hasil analisis menunjukkan bahwa tingkat pendidikan formal dan akses terhadap kredit merupakan faktor penting yang mempengaruhi petani cabai untuk mengadopsi teknologi tersebut. Tetapi, pengalaman dalam usahatani sayuran memiliki dampak negatif. Dengan demikian, temuan penelitian ini menunjukkan bahwa jika teknologi pertanian cabai diperkenalkan kepada masyarakat petani yang masih muda dan memiliki akses terhadap kredit, maka teknologi tersebut lebih memungkinkan diadopsi oleh masyarakat tani.

Kata kunci: *Usahatani Cabai, Adopsi Teknologi Cabai, Faktor Sosial Ekonomi, Model Logit, Jawa Tengah*

INTRODUCTION

Adoption of new technology and innovation has driven technological change in the agricultural sector, and its pace in Asia has increased tremendously after initiation of the Green Revolution in late 1960. Study of adoption of technology is important to understand factors associated with application of a technology (a new crop, a high yielding variety, or new production technology). Since the history, adoption and widespread diffusion of agricultural technology are important components for progress of farming and rural development as such. This is more so recently in development and wider use of ranges of modern agriculture technologies (Huang et al., 2004).

In fact, successful adoption of technology "can be a powerful force in reducing poverty" (de Janvry and Sadoulet, 2002), as agriculture sector has large-scale multiplier effect on a whole economy (Khan and Thorbecke, 1988). This also considered as developmental impacts of the farming. One of the most important determinants of the effectiveness of such impact is the level of adoption of technology and innovation and on their profitability (Griliches, 1957). Innovation should be backed up with innovative research with its faster completion, widespread adoption by intended users, and higher turnover of benefits[1]. In fact,

[1] Innovation can be considered as any new technology or management practices, or new developed ideas that are superior in performances but not yet in use among

more evident the research results are, the easier it is to justify adoption and implementation innovation, and also with justification of continued investment in the research. A common problem, and also one of the very critical requisites for agricultural development process, is how to speed up the rate of adoption of a research program's innovations (Rogers, 1995). Nevertheless, speeding up the rate of adoption of new technologies requires knowledge of various factors that influence adoption decision of an individual member operating in a society with complex forces. Thus, in addition to innovation or new technology being a superior on its merit itself, individuals' decision to adopt particular technology also requires a compatible of the innovation with various underlying factors in the society such as socio-economic, local institutions, public policy factors affecting the adoption and diffusion of the innovation.

In spite of general acknowledgment of the central role of technological change and technology adoption in influencing economic growth, productivity and competitiveness, there is a lack of understanding on actual path how economic forces influence technological change in agriculture (Doss, 2006; Martin and Warr, 1994; Feder et al., 1985). Technological change can be influenced by a variety of factors, but its determinants and actual process of technological change taking in a place are still less understood topic in the literature of development economics. They are also some of the very widely discussed and debated public policy issues in the rural development sector.

In Indonesia, chili crop acreage very sharply fluctuates year to year, depending upon market price, level of pest and disease attacks, weather conditions, and several other factors. In 2011, it was cultivated on about 240,000 ha, with annual production of close to 1.5 million ton. Chili is one of important vegetables in Indonesia, providing income, employment, and nutritional benefits to millions of smallholder farmers, rural laborers, and consumers. A large part of national level production of chili is consumed in a fresh form, as an Indonesian consumes chili in the meals daily. Figure 1 shows that among the vegetables grown in Indonesia, chili-planted area and production were the highest (BPS, 2012).

Chili in fact also provides the greatest share in terms of vegetable sector values in Indonesia (Vos and Duriat, 1995). Chili production uses about 20% of the vegetable land and produces 12% of the total vegetable output, with a low average yield than other vegetables in general (White et al., 2007). By regional and international standards, average productivity of chili is low in Indonesia (Ali, 2006), which suggests a huge scope for high yielding cultivars and better management practices to increase national level production through enhancing productivity, and without encroaching on grain production areas (Johnson et al., 2008).

Chili acreage started increasing in Indonesia in the early 1980s, from around 50,000 ha in 1975 to 240,000 ha in 2011, as shown in Figure 2. Annual chili-cultivated area has fluctuated widely over the last 25 years. The area reached a peak of around 230,000 ha in 1990 and about 240,000 ha in 2011. The dynamics of chili-sown areas determines the chili production level in Indonesia. The total national production of chili was approximately 200,000 ton in the 1970s which increased to nearly seven folds (1.5 million ton) in 2011. Production of chili increased dramatically during the mid-1980s, when a substantial improvement in irrigation infrastructure and intensification of paddy took place in Indonesia, all of which favored crop intensification and acreage expansion of chili.

However, the annual productivity of chili in Indonesia is very volatile due to pest and disease outbreaks, variation on extreme weather conditions. Improvements in chili cultivation practices, availability of improved quality of crop varieties, and improvement in irrigation infrastructure are some of the reasons for the recently observed improvement in chili productivity in Indonesia (Mariyono and Bhattarai, 2009). There was a dramatic drop in chili production from 1.1 million ton in

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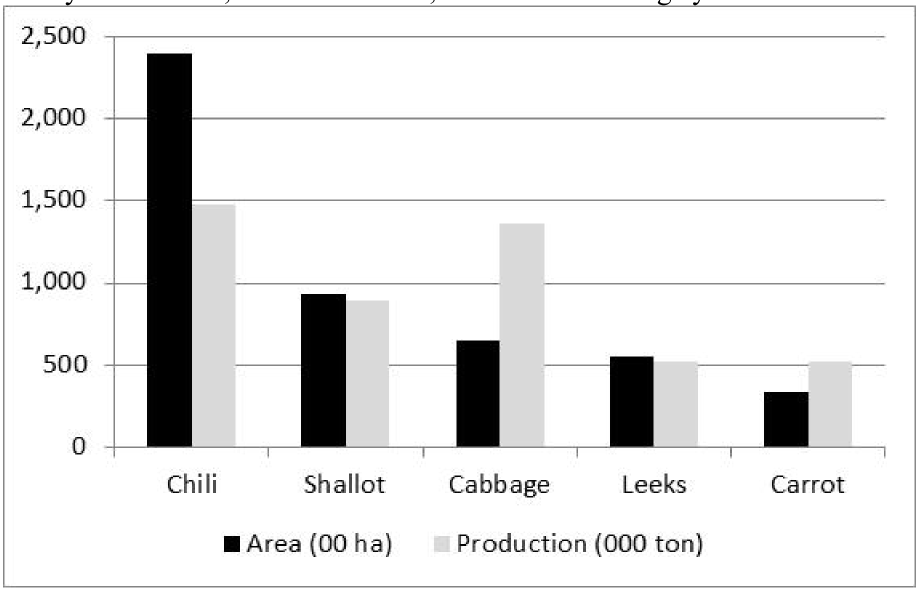
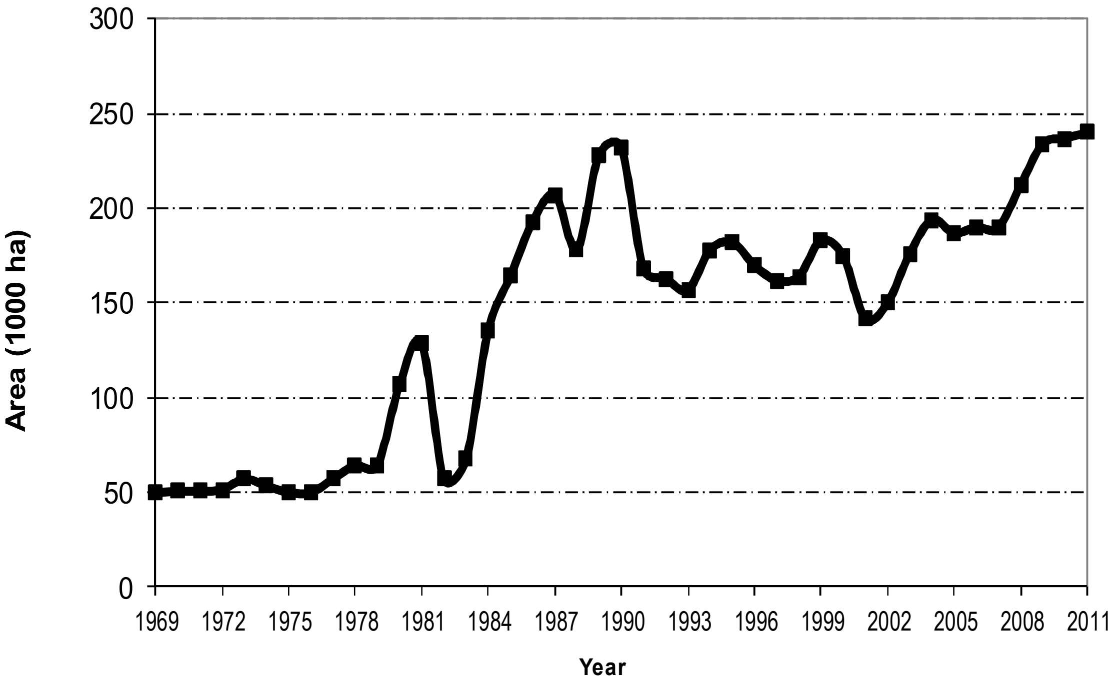
majority of the farmers. Rogers (1995) defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption.

1998/99 to only about 600,000ton in 2001, which was largely because of a long drought



Source: BPS (2012)

Figure 1. Area and production of top-five vegetables in Indonesia, 2011



Source: BPS (2012); FAOSTAT (2009) and Ferrari (1994)

Figure 2. The dynamics of areas-sown to chili in Indonesia

and a substantial decline in chili-planting areas. Chili production was very high in certain years. However, sustaining such large leaps in production over the long term may be a difficult task. The sharp fluctuations of crop acreage and productivity are indications of unstable chili markets and fluctuating market demand and the overall regional supply situation in a season (Mustafa et al., 2006). In fact, this indicates a standard cobweb phenomenon of farmers' decision to grow chili with market prices at any moment of time.

Chili is an important cash crop in Indonesia, which provides a significant contribution to the local and national economy. With increased pace of adoption of the modern technology, chili farming is expected to contribute more in the rural economy of Indonesia. Nevertheless, the introduction of new technology that has met with only partial success was also reflected by low level of national productivity of chili in Indonesia. Some of the constraints on enhancing adoption of chili by an ordinary farmer are like lack of credit, limited access to technological and market information, inadequate holding of farm-size, insufficient human capitals, chaotic supply of complementary inputs, and inappropriate transportation infrastructure (Ali, 2006; Mariyono and Bhattarai, 2009). In this context, using statistical modeling approach, we evaluate in this paper why some farmers are willing to grow chili compared to their counterparts several other farmers in the communities who do not grow chili. Then, extending the model, we also analyze factors affecting adoption of selected improved technologies on chili farming. Usually, only selected numbers of farmers in a community grow chili and majority of others grow other alternate crops such as rice, soybean, maize and peanut.

The major objective of this paper is to analyze socio-economic factors affecting farmers' decision to adopt recent improved crop management technologies on chili farming and to discuss policy implications related to constraints and concerns of chili farmers.

LITERATURE REVIEW

Without successful adoption and diffusion process, innovation or generated new technologies become useless and the agricultural sector virtually becomes stagnant. Therefore, adoption and diffusion of innovation of new agricultural technology has attracted considerable attention among development economists for a long time, as livelihoods of majority of the population in developing countries depends upon agricultural and because new and improved technologies would provide opportunity to increase productivity and farm income substantially than the case earlier. The literature on adoption and diffusion of agricultural technologies are very vast, especially for cereals and food crops, and related crop management practices in the tropics, we do not attempt to provide review all of the literature here, but only selected studies closely related to the issues discussed in this study. A good reviews and syntheses of the literatures on technology adoption in agriculture can be found in Feder et al. (1985), Sunding and Zilberman (2001) and Doss (2006).

Since Griliches (1957) pioneering work on adoption of hybrid corn in the USA in 1957, majority of the adoption studies have been conducted to answer one of the questions: what determines whether a particular producer adopts or rejects an innovation, or a new technology package (Ghadim and Panell, 1999). In those studies, factors affecting adoption of agricultural innovation are grouped into socio-economic elements, farm characteristics, and policy factors. The factors affecting technology adoption in agriculture can be grouped in four major categories, they are: technology specific factors, farmers (adopter) specific socio-economic factors, agro-ecology specific factors, and broader institutional and public policy factors (Doss 2006; Langyintuo and Mekuria, 2005; CIMMYT, 1993)

Several of the past studies have illustrated that farmers' wealth status, education, farm size, and frequency of contacts with extension staff are significant factors affecting the farmers' decision to adopt or not a particular agriculture technology in the context of development (Doss, 2006; Feder et al., 1985). Some studies have also clearly demonstrated that the factors affecting adoption improved agricultural technology and management recommendations by poor farmers are not the same as for richer farmers to adopt, thus farmers' wealth level is a key aspect of the technology adoption process in the developing countries.

Rogers (1995), one of the pioneers on analyzing complex set of factors affecting adoption and diffusion of agricultural technology, specially social and cultural factors and communication methods involved in technology adoption process, suggested that adoption of technologies is dependent on some social and economic characteristics, e.g. compatibility with the existing values and norms, complexity, observability, trial-ability, and relative advantage. These findings are relevant to technologies not only in agricultural sector but in a variety of disciplines. El-Osta and Morehart (1999) identified age of farm operator, farm size and specialization as important factors in increasing likelihood of technology adoption in dairy production in five states in the US. Caswell et al. (2001) reported that high levels of farm operator education are likely to persuade adoption of management advanced technologies. Fernades-Cornejo et al. (2001), emphasizing on genetically modified soybean and corn, and precise agriculture reported three important factors affecting adoption, namely: education, contract and farm size. Others say lack of adequate inputs and up-to-date information may be complications to adoption (Feder and Slade, 1984). Most of the past studies on technology adoption are relevant to cereal or food crop production in the case of developing countries, or technologies in the case of high value crops in the context of developed countries, but technology adoption in vegetables sector in general, and factors leading to adoption a particular high value vegetable versus alternate cereal crops has not been assessed in details and rigorously. Thereby in this study, we focused on chili, which is one important high value vegetable, and factors affecting to related adoption of particular technologies.

As noted earlier, unlike the case of cereal and staple crops, very limited studies are carried out on issues related to factors affecting technology adoption on vegetable sector, and almost none on technology adoption within a particular type of a vegetable. A summary of limited available vegetables sector technology adoption related literatures are provided in Table 1. It appears that issues related to adoption of IPM technologies are more frequently included within the literature on vegetable sector adoption than that of the other technologies.

In vegetable sector, very limited studies are available that analyze factors and process of adoption of new technologies. Most of the past studies on adoption of agricultural technologies, at least in the context of Asia, are related to cereal (rice, wheat, maize) or other dominant crops. Large part of these studies analyzes factors responsible for adoption of improved varieties of particular crops. In reality, issues and process of production of vegetables and specially farmers' adoption decision for high value crop, including chili, are also directly linked to agricultural intensification and crop diversification process in a region. We believe that the literature on the subject have not addressed this issue rigorously, and which is one of the major emphases of this study that focuses on single vegetable crop, but a dominant vegetable in Asia (Ali, 2006).

RESEARCH METHODOLOGY

Model of Analysis

We used a standard technology adoption framework for analyzing factors explaining farmers' chili production decision in the selected sites in Central Java province of Indonesia (CIMMYT, 1993; Langyintuo and Mekuria, 2005). The factors included in this study for explaining farmers' behavior on technology adoption include mostly farmers' socioeconomic characteristics and policy factors.

Table 1. Relevant literatures on adoption of technologies applied in vegetables

Author(s), year	Model used	Kind of technology	Locations	Important findings
Fernades-Cornejo et al., 1994	Logit	IPM technique	USA	Farm size, operator and unpaid family labor.
Mauceri et al., 2005	Ordered Probit	IPM Technique	Ecuador	Farmers field school participation and attending field day
Nozmoi et al., 2007	Logit	Hybrid varieties	Kenya	Education, farm size, land type financial availability
Wang et al., 2006	Linear probability model	New production technologies on fruits and vegetables	China	Education and distance to urban market
Selvaraj, 2009	Direct comparison	Hybrid varieties tomato	India	Adaptability of varieties, profitability, and market acceptance
Yang et al., 2008	Simple regression	IPM technology	China	Farmer field school provide more likely for farmer to adopt technology

Since the pioneering studies of Griliches (1957, 1958), logistic curve, by assuming that the adoption increases slowly at first and then rapidly to move toward a maximum level, is the widespread procedure used to evaluate the rate of adoption. Cross-section data analysis provides useful information on the patterns of adoption across farmers' groups, their decision-making process, and individual preferences.

The model is to analyze factors affecting farmers' adoption of chili-related improved technologies consisting of plastic mulches, and hybrid varieties. Following Verbeek (2003), logit form of regression model was used to analyze adoption of chili-related technologies as the following equation.

$$\ln \frac{P\{Z=1 \mid X\}}{P\{Z=0 \mid X\}} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon$$

where Z is chili-related technologies, and *Xs* are socio-economic factors.

Thus, the results from the logit regression model provide information on marginal impacts of socioeconomic factors selected in Table 2 on probability of adoption of a components of technology. In this study, we focus on two technology sets selected for the analysis, they are silvery plastic mulching and hybrid varieties.

Silvery plastic mulching is the process or practice of covering the soil/ground to make more favorable conditions for plant growth and for increased crop productivity. In technical sense, mulch means 'covering of soil'. When compared to other mulches, plastic mulches are completely impermeable to water; it therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface. In this manner it plays a positive role in water conservation. The suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt, which is important in countries with high salt content water. Plastic mulch is also able to suppress the growth of weeds. A study of Gul et al. (2009) shows that plastic mulches significantly increase biological yield of maize than that of the hand weeding, and black plastic mulch might have also attributed to increase in plant height, leaf area, and leaf area index, as well as to lowering fresh weed biomass in the field .

Hybrid seeds are bred to improve the characteristics of the resulting plants, such as better yield, greater uniformity, improved color, disease resistance, and so forth. Today, hybrid seed is predominant, and is one of the main contributing factors to the dramatic rise in agricultural outputs during the last half of the 20th century. Hybrid seeds cannot be saved, as the seeds from the first generation of hybrid plants do not reliably produce true copies, therefore, new seeds must be purchased for each planting. In vegetable sector, hybrid seeds have made significant impact in most crops in most of the developed countries, and its uses in the developing countries is at the fast pace (Griliches, 1957).

Data and Variables

We carried out empirical assessment on chili in the three districts, with one community in each district in Central Java province, which each represents a distinct agro-ecology and socio-economic setting of chili farming in Indonesia, so the level of crop intensification and application of technologies on chili farming.

We collected cross-sectional data from three locations in Central Java in Indonesia during 2009-2010. Three villages each from three districts (Magelang, Brebes, and Rembang) were selected for the detailed farm household survey. Primary data were collected at farm household level. Household level information was collected using one-to-one interview with structured questionnaires, and group level qualitative data were collected from group discussion among farmers to support the primary data. Definition and measurement of key variable affecting farmers' decision to adopt particular chili production technologies, as used in the adoption analyses in this paper, are in Table 2.

Table 2. Definition, measurement and statistics of selected variables

Variables	Definition	Measure	Mean	St. Dev.
Dependent variables:				
Plastic mulching	Chili farmers who were applying plastic mulching to cover chili bed	1=yes	0.35	0.48
Hybrid verities	Chili farmers who were growing hybrid varieties of chili, such as TM999, TW, LADO	1=yes	0.43	0.50
Explanatory variables:				
Age of household head	Age of household head	Year	44.60	11.10
Education of household head	Time (year) spent for formal education	Year	7.64	2.80
Experience in vegetable farming	Time spent for vegetable farming	Year	10.70	9.81
Family member	Number of family members in a household	Number	4.11	1.26
Number of plots	Number of plots (land parcels)	Numeral	2.74	1.79
Wealth ranking	Social status in the village 1= very poor, 2=poor, 3=medium, 4=rich, 5=very rich	Score	3.01	0.73
Access to credit	Whether farmers accessing credit for farming	1=yes; 0= no	0.29	0.46

Source: Authors' survey in 2009-2010. Total chili grower = 160.
Standard deviation of percentage of chili acreage of total sample is high because of high variation across sites.

RESULTS AND DISCUSSION

Descriptive Analysis

In Table 3, we provided selected socio-economic characteristics of surveyed households. Overall, socioeconomic characteristics of chili farmers largely varied across locations. On average, farmers were around 40 years old in all sites. Farmers' education level in Magelang was slightly higher than those on Brebes and Rembang. Family members in all sites were almost similar, which was 3-4 people per household. In terms of experience, farmers in Rembang is the lowest. Experience of farmers in vegetable farming other than chili includes yard-long bean, cucumber, shallot, choi sum, and baby corn.

Related to motivation of cultivating chili, farmers reported that although chili farming is a profitable enterprise, chili cultivation is also risky due to high fluctuations of market prices and high levels of crop loss from pests and diseases. Table 4 shows that in all three sites, economic motives were the main drivers affecting the farmers' decision to grow chilli. Other reasons for growing chili were agro-climatic conditions; possession of suitable land; and suitable microclimate and soil. A previous study by Noorhadi and Suhadi (2003) reported similar factor set for vegetable farming in Indonesia. Other reasons, such as good fit with the local cropping pattern followed and government incentive, were less important in influencing farmers' decision to grow chili.

Econometric Analysis

As presented in Table 5, the results from logit form of regression model are significant at 99% confident level, despite of relatively low coefficient of determination, noted by pseudo R^2. Older and more educated chili farmers are more likely to apply plastic mulching and to grow hybrid varieties of chili. Unexpectedly, farmers with more experience in vegetable farming are less likely to adopt these technologies. But, it could be justifiable that farmers with less experience in vegetable farming are possibly more responsive toward new technology. But when they get more experience, they realize that such technologies are not suitable to the local ecosystem. In our sample, only one location that farmers apply such technologies, and they are relatively less experience in vegetable farming than those from other places.

Farmers with greater family member are more likely to adopt both technologies. One possible explanation is that such technologies needs more labor to apply. As the wage of labor is relatively high and the labor is scarce in the area, the availability of family members is the only feasible source of labor. Farmers with more plots are more likely to adopt both technologies. Farm with more plots could be a representation of larger scale of land. This is particularly true if the plots are located closely each other and plot size of Javanese farming is relatively similar. In other words, farmers with relatively larger scale of chili farming are more likely to apply foliar fertilizers and cultivate hybrid varieties. Wealth status significantly impacts the probability of chili farmers to adopt hybrid technology. It could be the case since farmers have not been able to produce hybrid technology. They should purchase it if they would like to grow hybrid one.

Importantly, chili farmers who dare to get credit are more likely to adopt technologies. This is very important finding because credit is required to finance such technologies which are relatively more expensive than conventional ones. In our study sites, farmers reported that credit is available and there is no difficulty to access credit. None other than problem related to credit is the courage and risk bearing capacity of farmers to access credit. Only those farmers who take a more risk by accessing the credit to buy technologies adopted on chili will get more return.

Table 3. Households' characteristics, 2009-2010

Characteristics	Number and percentage of farmers											
	Magelang (N=49)			Brebes (N=60)			Rembang (N=51)			Average (N=160)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Age (year)	49	41.80	9.91	60	43.47	12.05	51	44.75	9.70	160	43.36	10.70
Education (year)	49	9.78^{BRN}	3.04	60	7.03	2.07	51	7.02	2.50	160	7.87	2.82
Vegetable experience (year)	49	10.69^{RN}	7.01	60	16.18^{MR}	12.26	51	6.04	4.81	160	11.27	9.79
Total family members	49	3.86	1.02	60	4.14	1.43	51	4.35	1.16	159	4.12	1.24

Note: Vegetable experience means a number of years of farmers' experience in growing vegetables other than chili, such as yard-long bean, cucumber, shallot, choi sum. n is number of farmer respondents in each location and in each group, N is number of farmers in each group and location' Significant different of mean across sites is indicated by superscript M, B and R. Mean comparison is tested at 95 % of confidence interval.

Table 4. Reasons for growing chili in Central Java, 2009-2010

Reason	Indicators		
	Weighted rank ($\overline{R}$)	# respondents (n = 160)	% of response
Chili is more profitable than other crops	6.63	150	94
Good fit with climatic condition	4.32	137	86
Good fit with the soil	4.00	127	79
Personal interest in chilli farming	2.86	97	61
Past experience in chili cultivation	2.83	91	57
Following neighboring cultivation patterns	2.27	73	46
Good fit with cropping pattern	1.14	45	28
Government incentive/ encouragement*	0.21	6	4

Note: * subsidies to encourage farmers to grow chili; N = total sample in each community (=160); n = number of farmers giving response to individual cases. $\overline{R}$ = Weighted rank value for each reason[2]. Higher the rank value = the more important the factor.

[2] The weighted average rank is formulated as $\overline{R} = \frac{\sum n * S}{N}$, where n is number of farmers responding to each category, N is total sample and S is score, which is higher score is more important.

Table 5. Logit model for adoption of chili-related technologies

	Silvery plastic mulching		Hybrid varieties	
Explanatory variables	Coef.	z	Coef.	z
Intercept	-5.195	-3.08[c]	-3.466	-2.25[b]
Age of household head	0.038	1.54[a]	0.030	1.30[n]
Education of household head	0.385	4.00[c]	0.270	3.15[c]
Experience in vegetable farm	-0.118	-3.83[c]	-0.075	-2.81[c]
Family member	0.276	1.59[a]	0.278	1.71[a]
Wealth ranking	-0.131	-0.46[n]	-0.462	-1.67[a]
Number of plots	0.254	2.13[b]	0.174	1.56[a]
Access to credit	3.672	3.11[c]	2.859	3.50[c]
Log likelihood		-75.2777		-81.5804
Number of observations		159		159
LR test: $\chi^2_{(7)}$		69.71[c]		54.48[c]
Pseudo R^2		0.3165		0.2503

Note: [a]) significant at 0.1, [b]) significant at 0.05, [c]) significant at 0.01, [n]) insignificant
Source: data analysis

CONCLUSIONS AND IMPLICATIONS

Chili cultivation provides more income and employment than other crops, and the whole rural community is benefited due to more employment created in the rural communities. Using econometric modeling approach, we have evaluated the impacts of some of these factors on farmers' decision to adopt modern agronomic technologies. Within chili growers, level of formal education and access to credit are the important factors affecting chili farmers to adopt advanced chili-related technologies. But surprisingly, experience in vegetable farming has negative impact. Thus, the study findings suggest that if chili farming technology is introduced to farmers' community where farmers are still young, access to credit, then such technologies is likely to be adopted by many farmers in the community.

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